Analysis of knowledge and technology transfer in Switzerland – the perspective of the enterprises

Study elaborated as part of the report «Research and Innovation in Switzerland 2020» Part C, Study 4

ETH zürich

KOF Swiss Economic Institute

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1 Introduction

Innovation arises through the (re-)combination of knowledge – often through combination of new with existing knowledge. Hence, it is not surprising that private enterprises are opening up their innovation processes to external partners, including public research organizations. The literature on open innovation activities shows that such activities can increase the innovation performance of enterprises (Beck and Schenker–Wicki, 2014; Chesbrough, 2006; Laursen and Salter, 2006; Trantopoulos et al., 2017). However, it is unclear under which circumstances knowledge and technology transfer (KTT) with the public research sector plays an important role for private innovation activities and whether it contributes to the competitiveness of the enterprises. Past studies for Switzerland showed that KTT has the potential to increase innovativeness and labour productivity of transfer active enterprises (Arvanitis et al., 2008b, 2008c; Arvanitis and Woerter, 2009).

Since these studies have been conducted, the economic environment has changed substantially. For instance, Switzerland went through a phase of strong currency appreciation, which had a significant impact on the R&D investments of most enterprises (Kaiser et al., 2018). Moreover, the innovative enterprises in Switzerland are exposed to fierce international technological competition, which has accelerated even more with the rise of artificial intelligence (AI). In addition, the recent disruptions in international trade, in particular between the USA and China, will affect the profitability of the innovation activities of many enterprises, since frictionless access to international markets is an important driver for innovation.

Against this background, the study at hand investigates the role of KTT with public research institutions for the innovation activities of Swiss firms. More concretely, we investigate the diffusion of knowledge and technology transfer between the Swiss public research sector, comprising universities, federal technical universities (ETH-Domain), the universities of applied sciences, and research organization according to Art. 15 FIFG[1] (Inspire, CSEM, etc.), and, on the other hand, the private enterprise sector. We also reveal the characteristics of KTT active enterprises, the motivation of enterprises to pursue KTT, and the greatest obstacles to start KTT or to intensify KTT. Moreover, we provide some first econometric estimations in order to investigate the influence of the enterprises' absorptive capacity (Cohen and Levinthal, 1990) for commercially successful KTT, the importance of international KTT activities, and the role of the enterprise organization (e.g. a vibrant innovation culture) for an effective transformation of public research knowledge into marketable goods and services. An in-depth analysis of the obstacle profiles of KTT-active and -inactive enterprises also allows for some first hints at possible governmental interventions to improve the interface between the public research sector and private enterprises.

This empirical analysis of the KTT activities of enterprises in Switzerland was conducted on behalf of the State Secretariat of Education, Research, and Innovation (SERI). The empirical analyses are based on a representative survey among Swiss enterprises with more than five employees comprising the manufacturing, construction, and service sector. The KOF Swiss Economic Institute has conducted such a survey for the third time already. In addition to the most recent survey wave in 2018, there have been surveys in 2005 and 2011. All surveys are based on the KOF enterprise panel, which ensures comparability of the data on KTT across time.

[1] Federal Act on the Promotion of Research and Innovation (RIPA). It comprises institutions that should encourage scientific research, science-based innovation, and support the exploitation of research results.

In accordance with Dosi (1982), we define knowledge and technology transfer between academic institutions and the enterprise sector as any activity aimed at transferring knowledge or technology that may help either the company or the academic institute – depending on the direction of transfer – to further pursue its activities. Thus, we investigate KTT in a broader sense, comprising different «transfer forms» like informal contacts (e.g. attending scientific conferences, citation of scientific publications), education and mobility related forms (e.g. contact of recruited university graduates with their laboratories at the universities, assignment of dissertations in cooperation with universities), research contracts, and consulting activities (see Illustration 1).

In summary, our analyses show the following results: We observe an increase in KTT active companies in the manufacturing sector and among large companies. Informal transfer contacts and education and training activities remain the most important categories of KTT forms. Technology transfer offices and the Swiss innovation funding organization (Innosuisse) gained in importance as mediators and promoters of transfer activities. Institutions of the ETH-Domain and Universities of Applied Sciences are the most frequent public transfer partners. Financial motives (e.g. lack of financial resources, time savings in R&D) have lost importance over time. Access to «tacit» knowledge (i.e. specific embodied knowledge) remains the most important motive for KTT. KTT active enterprises are characterised by higher R&D expenditures, higher educational levels of the employees, an open innovation culture, and export activities. KTT also affects the commercial performance of the enterprises. KTT activities are positively related to an increase in innovativeness and the commercial success of innovative products. The latter, however, requires some specific in-house preconditions: enterprises have to invest sufficient amounts of R&D in order to benefit from the transferred knowledge. They need to have «absorptive capacity» for the research activities in public research institutions. Positive innovation performance effects of KTT activities are also evident in enterprises that combine national and international KTT activities. The organization of an enterprise is important for the transfer success, too. Enterprises in which innovation impulses are initiated top-down and bottom-up show a higher success rate in their innovation activities.

Potential measures to support KTT and to improve commercial results should prioritize attractive framework conditions. An economic environment that stimulates private investments in R&D activities would increase the absorptive capacity of enterprises, raise their probability to engage in KTT, and improve the expectations for successfully marketable products and services. Such generally positive framework conditions for innovation performance could be complemented by specific impulses that take into account the KTT obstacle profile of enterprises. This study shows that enterprises often lack the preconditions for KTT activities; for instance, they are not interested in research projects, or they think that their research questions would not be interesting for the scientific partner. R&D active enterprises that are not engaged in KTT also locate deficiencies at public research institutions. More concretely, they lack information about public research activities, they have difficulties finding suitable contacts at the public research institutions, they detect a lack of entrepreneurial spirit, and they think that secrecy of the internal know-how of the enterprise is hardly guaranteed in such collaborations. Moreover, they assume different priorities between the partners might hinder the transfer success.

The report is structured as follows: In section 2, we introduce the conceptual framework of this study. There we present a graph that gives an overview about the topics we will address. It also contains

references to the relevant literature. Section 3 shows gives a brief overview of the data, while in section 4, we conduct the main analyses and present the results. This section includes information about the incidence of KTT in Switzerland, the applied transfer forms, and an overview of the transfer partners and the role of mediators. Moreover, it also contains the most important drivers for KTT activities, the outcomes of KTT activities, and some policy implication, which are also based on the analyses of the perceived transfer obstacles of the enterprises.

Finally, we want to take the opportunity to thank Dr. Müfit Sabo (SERI) and Daniel Dossenbach (SERI) for their competent accompaniment of the study. We are grateful to all the enterprises that answered our surveys and made this study possible in the first place. Our thanks also go to Gilles Aubert, who contributed with great dedication and professionalism to the successful realization of the survey. A short version of this comprehensive report will be published in the report «Research and Innovation in Switzerland 2020» published by SERI.

2 Conceptual framework

2.1 Literature and analytical framework model

Illustration 1 depicts the conceptual model of knowledge and technology transfer between enterprises and scientific partners. This model emerges from the synthesis of the existing literature (see for instance, Arvanitis et al., 2005; Bozeman, 2000; Todd Davey et al., 2018). Our conceptual model follows recently developed frameworks that perceive the KTT from an integrated perspective consisting of a series of related elements, where the most relevant ones are: the KTT process, influencing factors – such as motives and impediments, supporting mechanisms – such as KTT mediators and the framework conditions (Campanella et al., 2017; Galan-Muros and Davey, 2017).

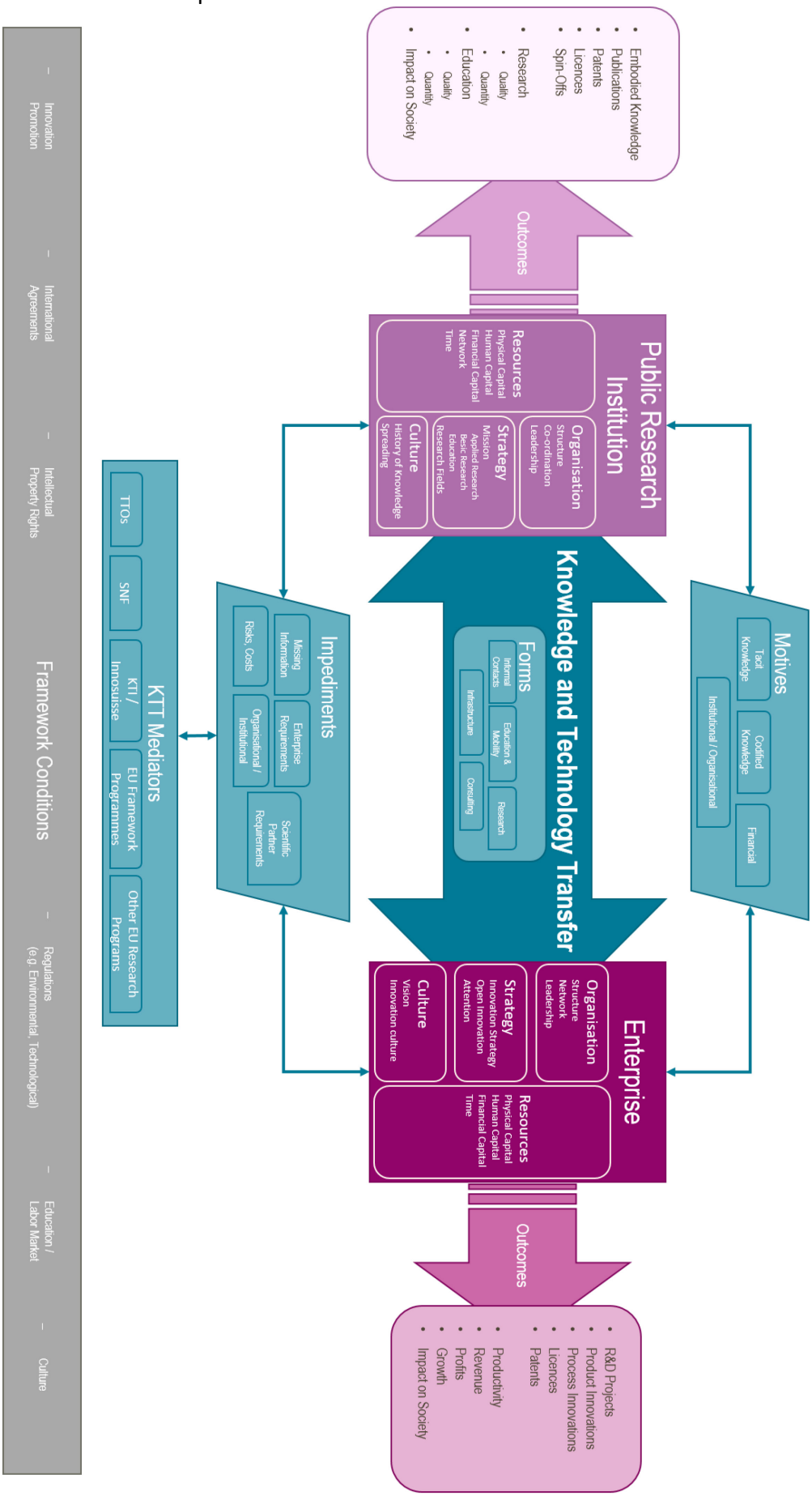
Our conceptual model serves two primary purposes: First, it structures the upcoming analysis, and second, it provides a mental guideline for the reader throughout this analysis.

In this spirit, the study analyzes specific parts of this model in single sections that can be put into perspective by the reader with the help of the depiction above. At the central core of the model, the bidirectional arrow reflects the transfer of knowledge and technology between the two parties of interest: the private enterprise sector and the public research sector (scientific partners). These bidirectional KTT activities can be manifold and are grouped in into five categories («informal contacts», «infrastructure», «education & mobility», «research» and «consulting») according to conceptual work (Galan-Muros and Davey, 2017; Meyer-Krahmer and Schmoch, 1998) and previous empirical studies in this field (Arvanitis et al., 2005, 2008c; Arvanitis and Woerter, 2015).

Both KTT partners have motives for and impediments against KTT activities (Arvanitis et al., 2008a; Bayona et al., 2001; Hagedoorn, 1993). The above-depicted model categorizes the motives into four groups («tacit knowledge», «codified knowledge», «financial motives», and «institutional / organizational motives») and the impediments into five groups («missing information», «lack of requirements on the side of the enterprise» or «the public research institution», «risks / costs»-related impediments, and «organizational/institutional factors»). Since this study takes on the enterprises' point of view, these categories correspond to the motives and impediments of an enterprise.

The characteristics and attributes of both enterprises and public research institutions such as resources and assets influence the motives and impediments to conduct KTT alike (Arora and Cohen, 2015; Arvanitis, 2012; Bekkers and Bodas-Freitas, 2010; Filippetti and Savona, 2017; Hall et al., 2001). For instance, a lack of KTT specialists at the public research institution hampers an enterprise to conduct KTT. Likewise, a shortage of human capital induces an enterprise to engage in KTT in order to raise its human capital stock (Teirlinck and Spithoven, 2013). Furthermore, these attributes also influence which scientific partner is targeted for KTT activities and which transfer forms are chosen. Similarly, the corporate strategy, the organizational structure and processes as well as the innovation culture of a company is not only related to the probability that transfer contacts exist, but also to the choice of the form of transfer activities (Bercovitz and Feldman, 2007; Lin, 2007). Enterprises with a pronounced innovation strategy could opt for more intensive forms of transfer, such as R&D consortia with universities, while enterprises without such strategies would only have occasional and more informal contact with universities (Vuola and Hameri, 2006). Recruiting graduates or staff of the public research institution increases the stock of knowledge (Bolli et al., 2018; Protogerou et al., 2017; Thornhill, 2006; Zucker et al., 1997).

Illustration 1: Conceptual framework



To the right and left of the model, we see the output and outcomes of the KTT activities of both parties. They comprise R&D projects, product and process innovations, licenses, patents, productivity, revenue, profits, and impact on society on the enterprises side. On the other side, a public research institution's outcomes comprise embodied knowledge, publications, patents, licenses, spin-off, the research and education quality and quantity, and the impact on society. These are indicators of a variety of important outcomes of transfer activities (Galan-Muros and Davey, 2017; Guerrero et al., 2015). They are direct results of these KTT activities, or they are influenced by the KTT activities between enterprises and their scientific partners. Literature has studied the effects of KTT on firm performance mostly in forms of isolated activities such as commercialization through patents, licenses and spin-outs (Hagedoorn et al., 2018; Shane, 2004; Steenhuis and De Bruijn, 2002) as well as cooperative R&D (Bekkers and Bodas-Freitas, 2010; Perkmann et al., 2011; Veugelers and Cassiman, 2005), and has often been dominated by literature from the US (Foray and Lissoni, 2010; Hall, 2004; Perkmann and Walsh, 2007; Teixeira and Mota, 2012). The empirical literature usually finds a positive relationship between KTT activities and innovation performance indicators. Based on direct measures for KTT activities, like R&D collaboration or universities as an important external knowledge source, transfer activities are positively correlated with the propensity to innovate, the number of patent applications, R&D intensity, or the introduction of product and process innovations and the sales share of innovative products (see e.g. Becker, 2003 and Fritsch and Franke, 2004 for Germany; Lööf and Broström for Sweden, 2008; Monjon and Waelbroeck, 2003 for France). Adams et al. (2003) found that cooperative R&D agreements stimulated industrial patents for company-financed R&D in industrial labs. However, Mohnen and Hoareau (2003) in a study based on pooled data for France, Germany, Ireland, and Spain found a positive relationship between cooperation with research institution and the propensity of patenting, but not with the R&D intensity of an enterprise. For Switzerland Arvanitis et al. (2008a, 2008b) reported that KTT in general and research-intensive transfer forms in particular, are positively related with the innovation performance of an enterprise. Empirical studies that investigated the effects of KTT on economic performance indicators, like labor productivity, sales productivity or sales growth also found a positive relationship (e.g. Arvanitis et al., 2008b for Switzerland; Belderbos et al., 2004 for the Netherlands; Branstetter et al., 2005 for the U.S.).

The KTT intermediators and promoters work on reducing the impediments and obstacles of both parties in order to induce them to conduct KTT or to incentivize their already existing transfer activities (Todd Davey et al., 2018). We distinguish between the five above-mentioned types of mediators on national (TTOs, SNSF, Innosuisse) as well as international levels (EU Framework Programmes, other EU research programs).

The entire model is embedded into framework conditions that govern the possibilities of knowledge and technology transfer activities. According to literature important framework conditions are intellectual property rights, innovation promotion, regulations, international agreements, the labor market conditions and cultural influences (Bozeman, 2000; Todd Davey et al., 2018).

At last, two things are worth stressing out. First, it is important to see that this model stylizes the relationship between an enterprise and scientific partners and it does not rule out multiple KTT-relationships. In fact, transfers between the public and private sector may complement knowledge and technology transfers between multiple enterprises and vice versa. However, we focus on public-private knowledge and technology transfer decoupled from other knowledge and technology transfers. Only our econometric estimations consider other transfer activities to some extent. Secondly, the bi-directionality of the transfer is important. Although some forms of public-private knowledge and technology transfer seem as if they are a flow from the public research institutes towards the private sector, it is very hard and probably inaccurate to think of this as a unilateral flow. For instance, consulting

activities of public research institutions to a private enterprise, which compensates its partner financially, but additionally gives the consultants insights into the company and their industry. Although this reverse flow of knowledge might not be the primary target of these consulting activities, it is still a by-product of these KTT activities that can hardly be disentangled. A more obvious example for a bidirectional transfer of knowledge and technology is «research co-operation». If employees of private enterprises work together with the staff of public research institutions on a joint research project, an open exchange of knowledge and technologies to achieve the same goals is indispensable. More generally, both parties will have incentives to enter into these knowledge and technology transfer activities. Therefore, most transfer activities result in a bidirectional flow of knowledge.

2.2 Structure of the analysis

Although the model is of a more general nature, we analyze this form of knowledge and technology transfer from an *enterprise's point of view*. **Section 4.1** answers questions with regard to enterprise indicators of KTT. More specifically, it will analyze what portion of enterprises conducts KTT (*Section 4.1.1*), which forms of KTT are cherished most by enterprises (*Section 4.1.2*), which scientific partners are targeted by enterprises to conduct KTT (*Section 4.1.3*) and which mediators and promoters of KTT are most relevant (*Section 4.1.4*). Referencing the conceptual model, the first section of analysis will consider the central horizontal axis of enterprises, scientific partners and the bidirectional arrow of knowledge and technology transfer together with some inspection of the KTT mediators. **Section 4.2** will tackle the question of what drives enterprises to conduct KTT. This twofold analysis will first center on the motives to conduct KTT reported by enterprises (*Section 4.2.1*) and then on specific enterprise characteristics that are associated with higher probabilities to be KTT active (*Section 4.2.2*). **Section 4.3** focuses on the outcomes of KTT for enterprises. Again, this is divided into a section that analyzes the results reported by the enterprises (*Section 4.3.1*) and a section that considers factors related to KTT which are correlated with higher productivity of the enterprise (*Section 4.3.2*). Finally, **Section 4.4** discuses policy implications with respect to perceived impediments of KTT from the enterprise's side (*Section 4.4.1*) and their determinants (*Section 4.4.2*) as well as the role of intermediaries (*Section 4.4.3*). All things considered, our analysis will cover the entirety of the conceptual model from an enterprises point of view. That is, we do not analyze the incidence of KTT for public research institutions and neither their motivations and impediments to conduct KTT as well as how KTT is related to their outcomes.

3 Data and methods

The data for this report were collected through written surveys in 2005, 2011 and 2018. The surveys were based on the KOF Enterprise Panel, which is a stratified random sample of all enterprises in the Swiss economy with more than 5 employees. Since the KOF Enterprise Panel is regularly updated on the basis of the population of enterprises as collected by the Federal Statistical Office (FSO), it provides an adequate representation of the entire Swiss economy. The response rates to the three knowledge and technology transfer surveys ranged from 26% (2018) to 45% (2005). In total, we have an unbalanced panel of 6163 enterprises available for the statistical analysis. In order to take into account possible distortions by enterprises that did not respond to the surveys, we contacted each time a random sample of 500 non-responding enterprises in a series of separate telephone interviews. The answers collected through these non-response analyzes were subsequently integrated into the weighting schemes used in the statistical analysis.

Table A: **Subsector composition**[2]
High-tech manufacturing industries
Chemicals, Pharmaceuticals, Machinery & equipment, Electrical equipment, Electronic and optical products, Medical instruments, Watches / clocks, Vehicles
Low-tech manufacturing industries
Food / beverages / tobacco, Textiles / clothing, Wood, Paper, Printing, Rubber / plastics, Non-metallic minerals, Basic metals, Fabricated metals, Repair / installation, Other manufacturing, Energy, Water / environment
Modern industries
Telecommunications, Publishing / media, Information technology / services, Banks / insurance, Technical commercial services, Other commercial services
Traditional service industries
Wholesale trade, Retail trade, Accommodation / restaurants, Transportation, Real estate / rental & leasing, Personal services

The stratification of the KOF Enterprise Panel takes place on the level of 34 industries, categorized into three sectors and four subsectors (see Table A), and 3 size classes, which results in a total of 34*3=102 cells. Within each of these 102 cells, enterprises are drawn randomly. The stratification of the KOF Enterprise Panel also allows to make statistical statements about enterprises active in industries with relatively small numbers. A simple random sample would primarily contain small enterprises from industries with high numbers of enterprises. Moreover, a stratified random sample allows, if optimally drawn, a marked reduction in the estimated standard errors of all statistics.

The structure of the KOF Enterprise Panel is shown in Table A2 in the appendix. It served as the basis for the 2018 survey. A total of 6'589 questionnaires were sent to the enterprises. Table A2 depicts the 34 industries on the Y-axis and the 3 industry specific size classes on the X-axis. For example, we sent 402 questionnaires to «Machinery & Equipment»: 168 to small enterprises, 208 to medium sized enterprises, and 26 to large enterprises. In contrast, Table A1 in the appendix displays the number of questionnaires actually sent back to KOF, which totaled at 1739. To stick with the example of «Machinery & Equipment», we received answers from 108 enterprises: 46 from small enterprises, 52 from medium sized enterprises, and 10 from large enterprises. Table A3 in the appendix shows the response rates of the 102 cells, that is, the number of responses divided by the number of questionnaires sent. The total response rate for the 2018 survey was 26.4%. In «Machinery & Equipment», the response rate reached a total of 26.9%: 27.4% for small enterprises, 25.0% for medium-sized enterprises, and 38.5% for large enterprises, respectively.

[2] The definition of the industries is based on the 2-digit NOGA classification (see https://www.bfs.admin.ch/bfs/de/home/statistiken/industrie-dienstleistungen/nomenklaturen/noga/publikationen-noga-2008.html).

In order to reverse the stratification of the panel, we rely on sampling weights. Again, this enables us to make statements about the entire economy. Statistics drawn from the stratified random sample would be biased towards an overrepresentation of enterprises from cells with low population numbers.

For every enterprises *i* in cell *h* (h=1,2,…,102) a weight w_{hi} is defined:

$w_{hi} = 1/f_h = 1/(n_h/N_h) = N_h/n_h$

where f_h: sampling rate of cell *h*
n_h: number of enterprises in cell *h* of sample
N_h: number of enterprises in cell *h* of population

Non-response rate: For every enterprise *i* in cell *h* a weight $1/r_{hi}$ is defined, where r_{hi} is the probability that the enterprise *i* responds. This probability is in general unknown and is estimated by a binary (Probit-) model of the non-response rate on the structural characteristics of the enterprises (industry, size class, region, and language). Under consideration of the probability that enterprise *i* responds, the weight looks as follows:

$w_{hi}^* = w_{hi}\ 1/r_{hi}$

4 Analysis

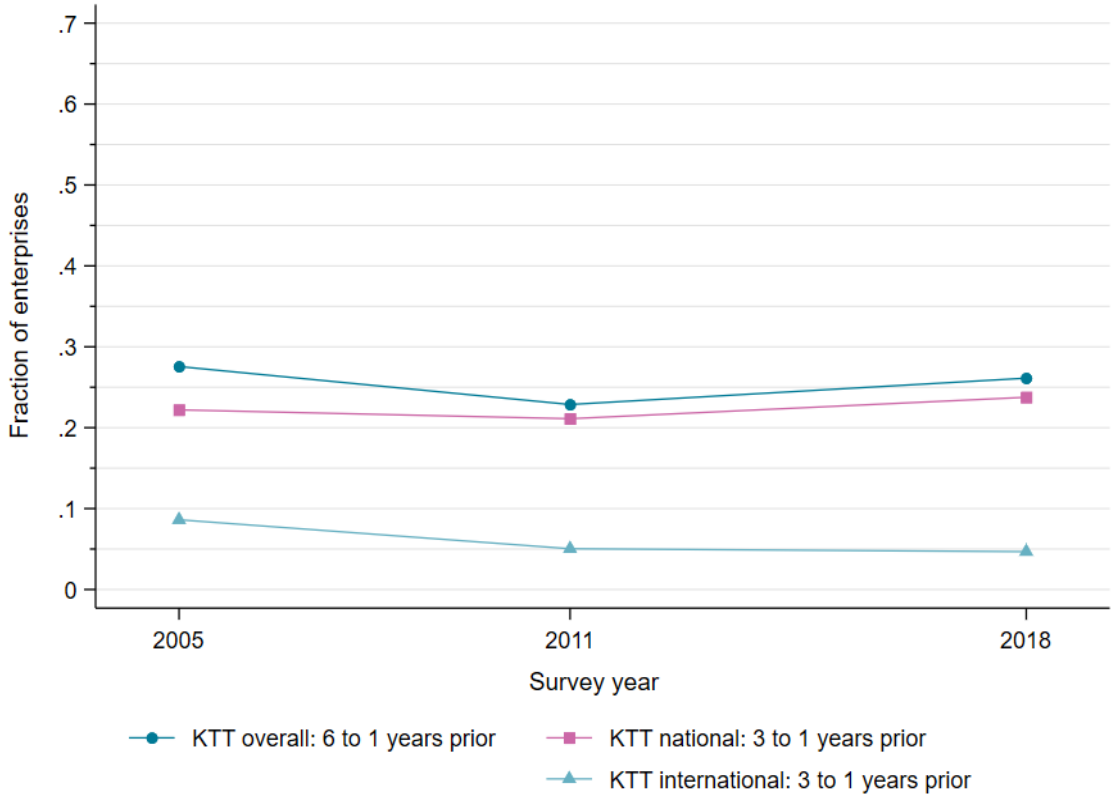
4.1 Indicators of KTT

This chapter is concerned with the question **who** conducts knowledge and technology transfer (*Chapter 4.1.1*) with which **scientific partners** (*Chapter 4.1.3*) and which **transfer forms** are preferably used by the enterprises (*Chapter 4.1.2*). Furthermore, it also sheds light on which **mediators** are the most relevant for the private sector (*Chapter 4.1.4*).

4.1.1 Incidence

This subchapter sheds light on the incidence of KTT in the Swiss private enterprise sector. In other words, we focus on the fraction of enterprises that conducted KTT in a certain period either with national or international scientific partners and overall.

Graph 1.1: Incidence of knowledge and technology transfer, overall[3]



Note: This graphic shows the fraction of enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods.
Basis: All enterprises
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 1.1 shows this information for all enterprises in the three survey periods[4]. If we look at the overall KTT incidence - which comprises any KTT activities in these survey periods be it of national or international nature - we notice two things. About a quarter of all enterprises conduct some sort of KTT with

[3] The exact numbers that this graph is based on can be found in Table A4i on page 141 in the appendix

[4] The observation of transfer activities covers the 6 years prior to the survey year. E.g., the survey period corresponding to the 2018 survey covers the period from the beginning of 2012 to the end of 2017. A slight exception is the 2005 survey. The corresponding questionnaire, as do all others as well, divided the questions of KTT activity into two parts. One that covers the previous 3 years and another that covers everything before 2002. As such, the 2005 survey period covers a much broader and not exactly defined period. However, as we observed from the other two surveys most enterprises tend to ignore this time differentiation and only answer whether they conducted KTT by crossing the box corresponding to the latter period. This yielded significantly higher incidences of KTT for the prior 3 years compared to the 3 years before that. This occurrence was so systematical

scientific institutions and this fraction is fairly stable over the three periods. Most of these transfers are in co-operation with national scientific institutions and only a small fraction of enterprises conducts KTT with scientific partners abroad. We also note that the fraction of enterprises that conduct international KTT is slightly decreasing over time. In fact, it is almost cut in half (from 9% in 2005 to 5% in 2018, see Table A4i in the appendix). In contrast, between a fifth and a quarter of all enterprises conduct national KTT. This fraction is quite constant over time.

Graph 1.2 shows the incidence of KTT in the three sectors manufacturing, construction and services and in the four subsectors high-tech and low-tech manufacturing as well as modern and traditional services[5].

Overall, the incidence of KTT strongly increased in manufacturing over time and especially in the last survey period (+13% points). This increase is also observable in the two subsectors of high-tech and low-tech manufacturing. The low-tech subsector drives the strong increase in the last survey period in manufacturing (+19% points). The raise of the incidence in the high-tech subsector, on the other hand, primarily happens between the 2005 and 2011 survey periods (+12% points). In terms of levels, the high-tech manufacturing subsector is by far the most KTT active. In 2018, half of all enterprises were engaged in some sort of KTT with scientific partners. In contrast, only about a third of all low-tech manufacturing enterprises were engaged in KTT between 2012 and 2017.

The service sector shows the exact opposite trend of manufacturing. The fraction of enterprises that were engaged in any KTT activity with scientific partners steadily declines over the years. The fraction of enterprises that conducted any form of KTT activities with scientific partners sinks from over a third in the 2005 period to under a quarter. The traditional services subsector clearly drives this decline. The incidence in this subsector dropped by 22% points between the first and the last survey period. The modern services subsector, on the other hand, shows a different picture. Its fraction of KTT-active enterprises is completely stable over time at around a third.

The construction sector has the lowest incidence of KTT overall. It also shows no specific trend. While there is an initial decrease in the fraction of KTT active enterprises (-10% points) this fraction increased between the 2011 and the 2018 survey periods (+17% points). This recent increase is so strong that the incidence of KTT overall in 2018 is practically similar in the construction (21%) and service (23%) sectors.

These developments hardly differ for national KTT. For all sectors and subsectors, the previously described facts for the overall KTT activities apply in the exact same manner to the national KTT activities. The only difference is that the national KTT values are slightly below the overall values. The high-tech manufacturing subsector shows the biggest discrepancy between those two variables. This means, that this subsector has the highest fraction of enterprises that solely conduct KTT with international scientific partners. In fact, this subsector also records the highest fraction of enterprises that conduct international KTT (over 15%). All other sectors or subsectors have a low and declining fraction of enterprises conducting international KTT.

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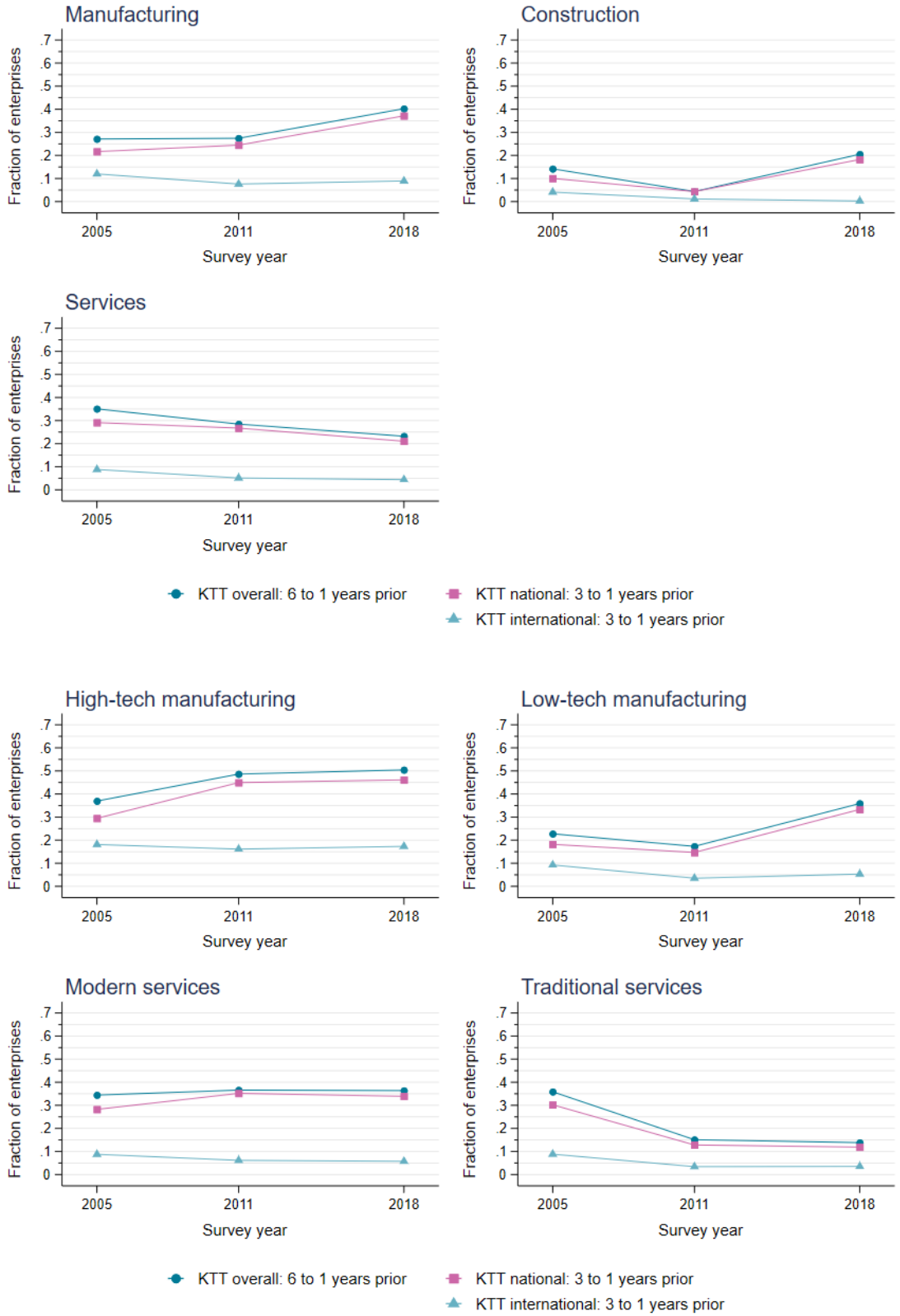
such that there are only few meaningful interpretations. First, the enterprises do not instantly recall their activities that dated back for longer than 3 years or secondly, they simply ignore the time differentiation. An interpretation that KTT activities have a 3-year cyclicality is highly implausible. With this in mind, the inexactly defined prior period in the 2005 survey does not matter for the analyzes. Based on this reasoning, we only report the 3 years prior to the survey year, once we distinguish between national and international KTT. The values for the earlier 3 years are hardly reliable estimates.

[5] The 2005 values stemming from (Arvanitis, Kubli, Sydow, & Wörter, 2005) differ from the reported values in this study. The differences are due to different industry classification standards (NOGA 2002 vs NOGA 2008). The composition of sectors and subsectors from their 2-digit industries used in this study (NOGA 2008) is shown in Table A of Chapter 4.

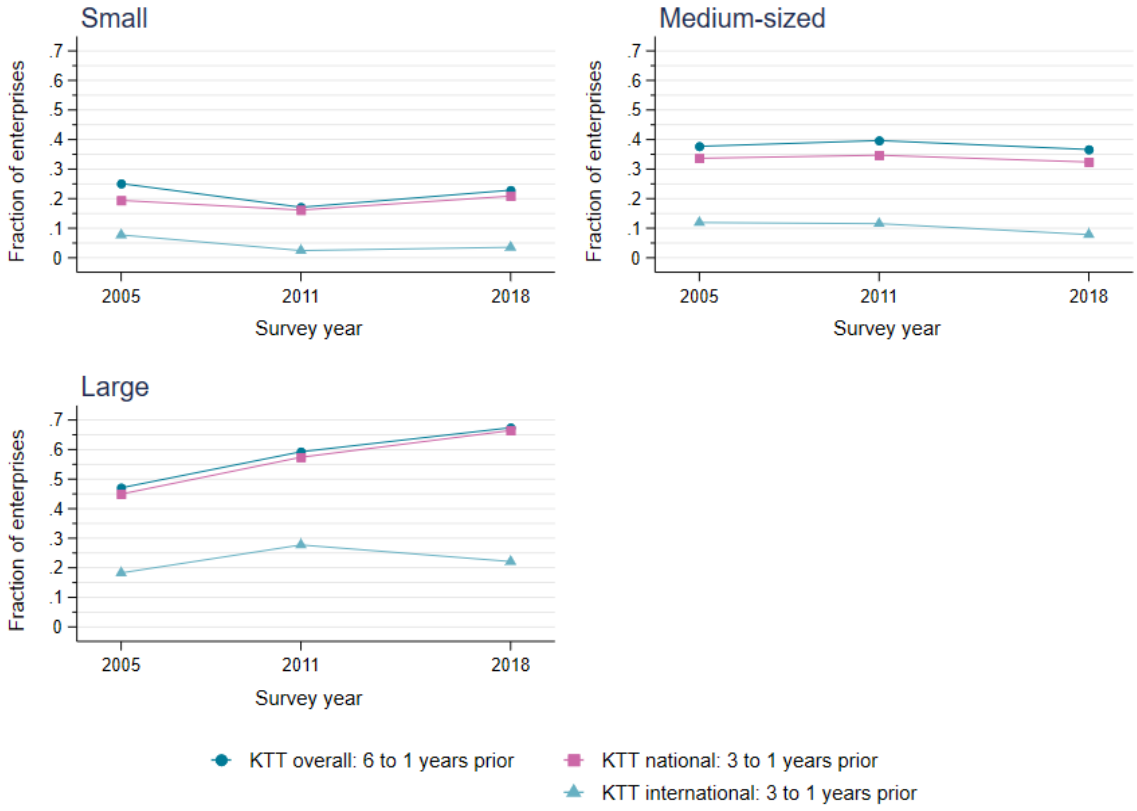
Graph 1.2: Incidence of knowledge and technology transfer, by sector and subsector[6]



Note: This graphic shows the fraction of enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods.
Basis: All enterprises, by sector and subsector
Source: KOF-KTT surveys (2005, 2011, 2018)

[6] The exact numbers that this graph is based on can be found in Table A4i on page 141 in the appendix.

Graph 1.3: Incidence of knowledge and technology transfer, by enterprise size[7]



Note: This graphic shows the fraction of enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods.
Base: All enterprises, by enterprise size
Source: KOF-KTT surveys (2005, 2011, 2018)

Finally, Graph 1.3 shows the incidence of KTT by enterprise sizes (see Table B). The large enterprises stick out primarily. A staggering two-thirds of all large enterprises were engaged in KTT with scientific partners between 2012 and 2017. Almost as much of them were engaged in KTT with national scientific partners in this period. Furthermore, this fraction is steadily increasing over the three survey periods. In fact, these fractions increased by 20% points between the first and the last survey period. Large enterprises are also the most active with respect to international KTT. Between a fifth and a quarter of large enterprises were collaborating with scientific institutions abroad.

International KTT activities also exist within medium-sized enterprises. Yet, the fraction of KTT activities with international scientific institutions is far lower than for large enterprises and slowly decreasing over time. About a third of all medium-sized enterprises are engaged in national KTT. A slightly bigger fraction (5% points) conducts any form of KTT with scientific partners. These fractions are stable over time.

Table B: **Enterprise size classification**[8]	
Small	< 50 employees (full time equivalents)
Medium-sized	50 to 250 employees (full time equivalents)
Large	>= 250 employees (full time equivalents)

[7] The exact numbers that this graph is based on can be found in Table A4i on page 141 in the appendix.
[8] We use the standard definition of enterprise size classes (see https://www.bfs.admin.ch/bfs/de/home/statistiken/industrie-dienstleistungen/unternehmen-beschaeftigte/wirtschaftsstruktur-unternehmen/kmu.html).

At last, small enterprises do not rely heavily on international scientific institutions. The fraction of enterprises that were active in these transfers has fallen from 8% to 4% over the three survey periods. Small enterprises also record the lowest level of activities of national KTT and KTT overall. About a quarter of all small enterprises were conducting any form of KTT and about a fifth of small enterprises were engaged with national scientific partners. These numbers are lower in the 2011 period but recovered in the final survey period.

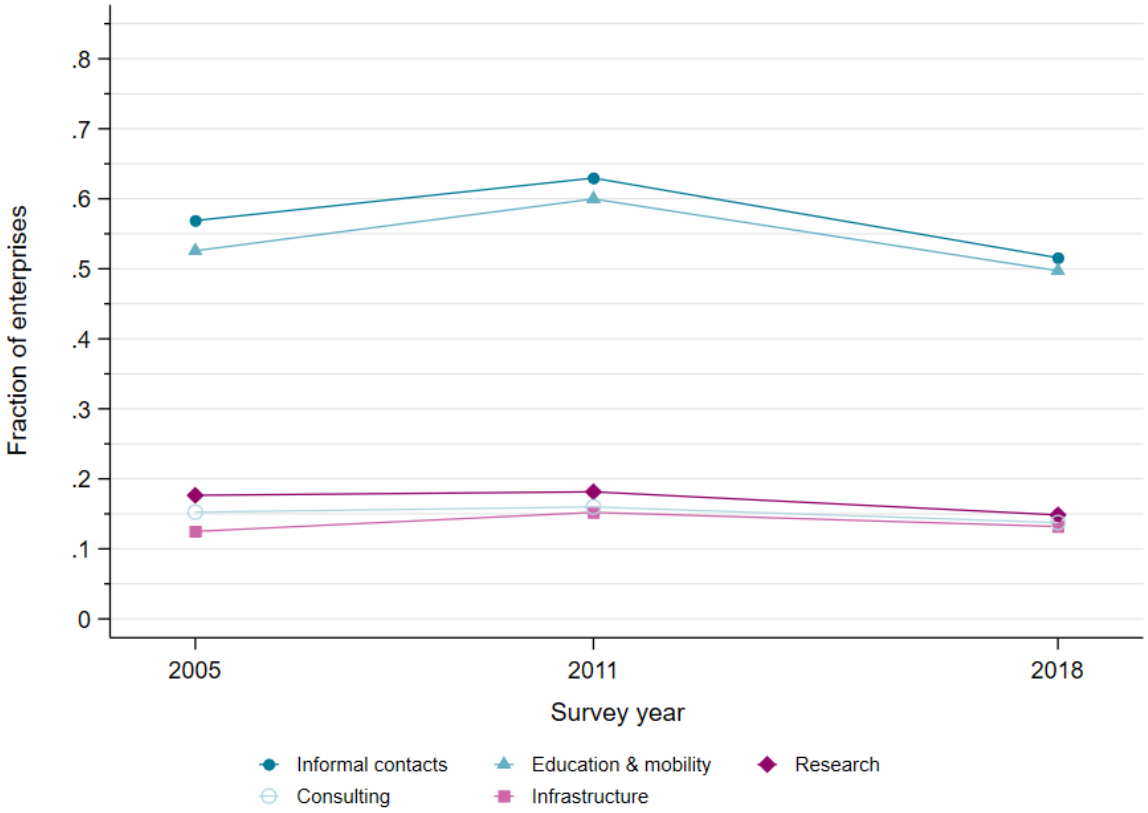
Summarizing these insights, a substantial fraction of enterprises is active in KTT with scientific partners, especially with national partners. The manufacturing sector records an increasing fraction of enterprises conducting national KTT (high-tech and especially low-tech) while the service sector records a declining fraction, which is driven by enterprises in the traditional service subsector. The incidence of national and international KTT is declining in enterprise size. These fractions are stable for small and medium-sized enterprises while large enterprises show a strong increase in the fraction of enterprises that conduct national KTT.

4.1.2 Forms

In this chapter, we investigate the forms of public-private knowledge and technology transfer. We analyze, which transfer forms are preferably used by private enterprises distinguishing between 19 single forms, which are categorized into five groups. In a first step, however, we concentrate on different categories of transfer forms and in a further step, we focus on individual forms.

4.1.2.1 Categories

Graph 2.1: Form categories of knowledge and technology transfer, overall[9]



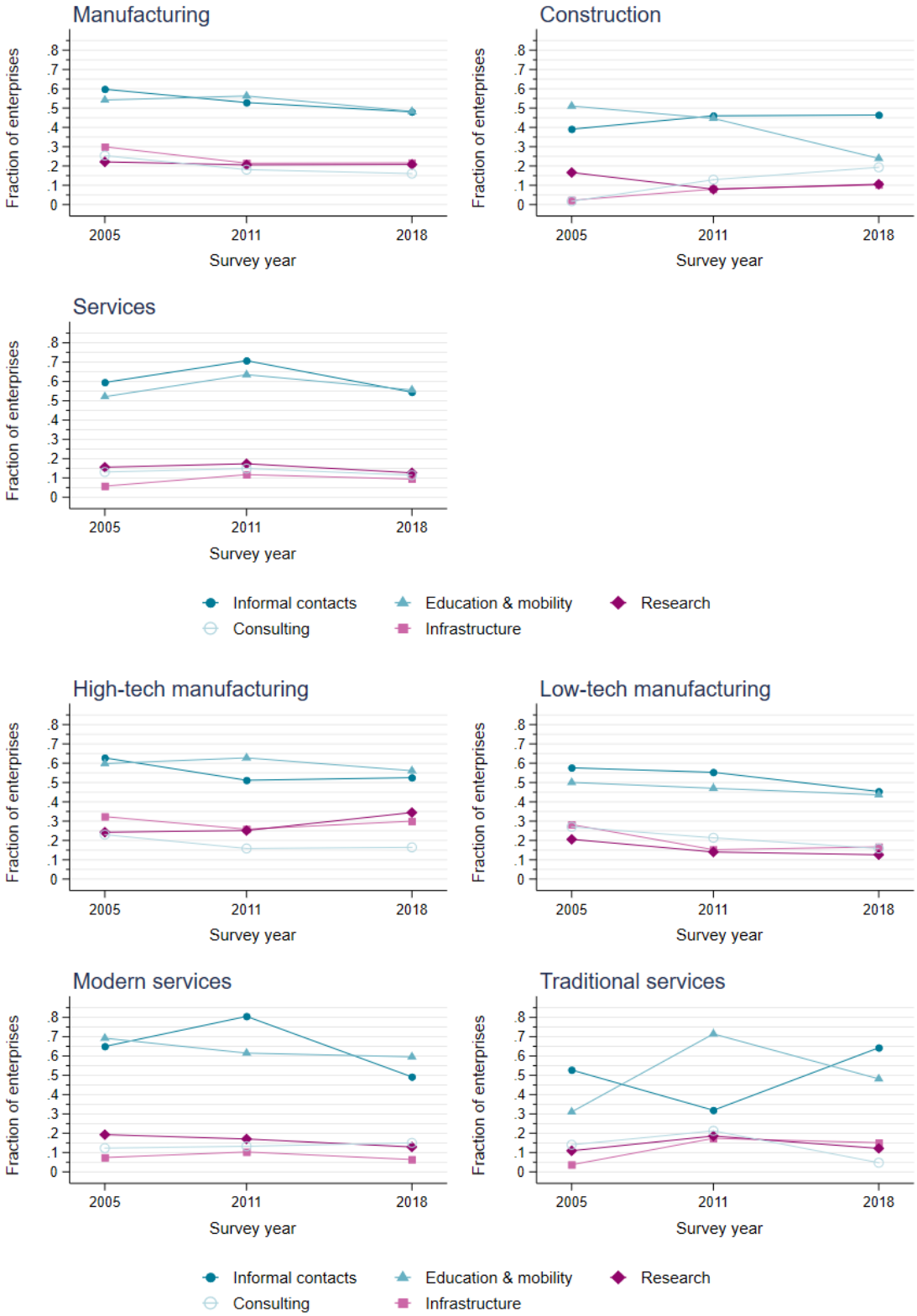
Note: This graphic shows the fraction of enterprises that reported at least one single form of knowledge and technology transfer in the above mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 2.1 depicts the fraction of all KTT-active enterprises that considered a category of transfer forms as highly relevant. More precisely put, it shows the fraction of enterprises that conducted knowledge and technology transfer with scientific institutions, which reported the values 4 or 5 on a 5-point ordinal scale for at least one single forms of a certain category.

For their knowledge and technology transfers with scientific institutions, private enterprises clearly value «informal contacts» and «education & mobility» above the rest. Over half of all KTT-active enterprises reported these two transfer forms as highly relevant. «Research-based transfers», «consulting» and a shared «infrastructure» are all of minor importance. Only around 15% of all KTT-active enterprises reported them as highly relevant. What sticks out as well is the fact that there are no trends. The pecking order remains completely unchanged over the three survey periods and the fractions are fairly stable.

[9] The exact numbers that this graph is based on can be found in Table A5i on page 143 in the appendix.

Graph 2.2: Form categories of knowledge and technology transfer, by sector and subsector[10]



Note: This graphic shows the fraction of enterprises that reported at least one single form of knowledge and technology transfer in the above mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[10] The exact numbers that this graph is based on can be found in Table A5i on page 143 in the appendix.

Graph 2.2 shows the relevance of the five categories of transfer forms by sector and subsector. Again, the two most important transfer categories are «informal contacts» and «education & mobility», irrespective of sector or subsector. However, there are differences across sectors and subsectors that are worth mentioning.

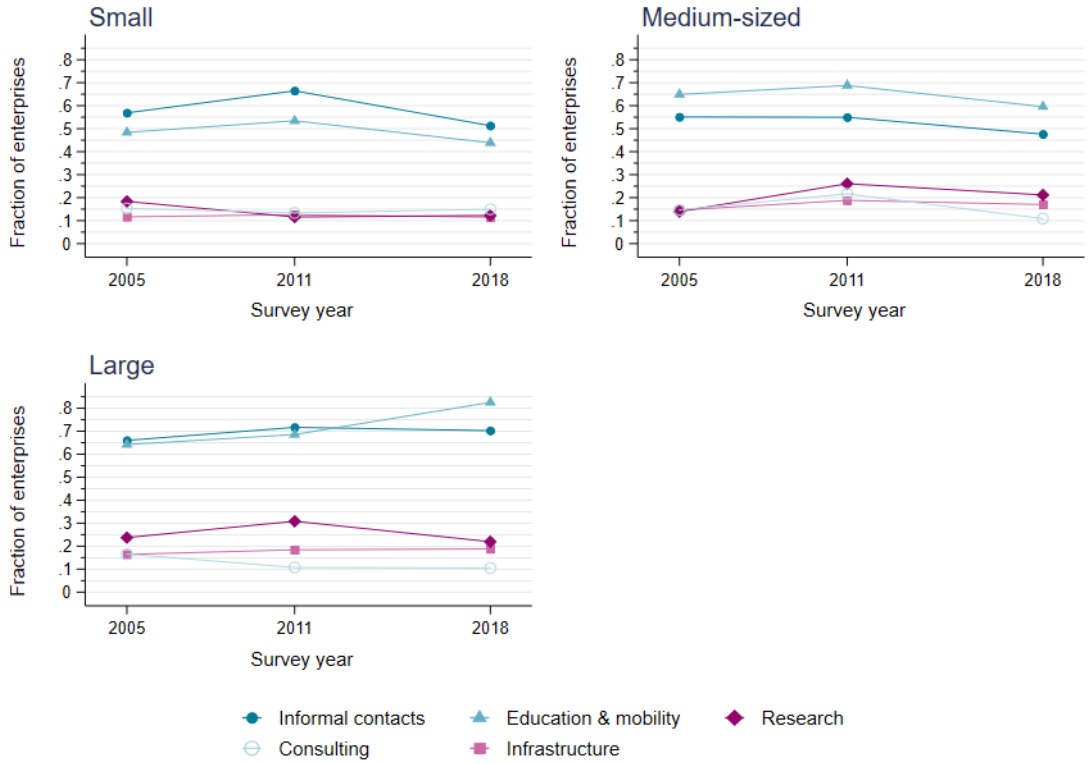
The fraction of KTT-active manufacturing enterprises that see «informal contacts» as highly relevant transfer forms is decreasing over time (-12% points). The high-tech manufacturing enterprises drive this reduction in the earlier survey periods (-12% points) while the low-tech manufacturing subsector drives this decrease in the latter survey periods (-10% points). However, in line with the overall picture, over half of the KTT-active manufacturing enterprises see «informal contacts» and «education & mobility» as highly relevant. This applies to the low-tech manufacturing subsector and especially to the high-tech manufacturing subsector. However, there is a slightly bigger fraction of KTT-active high-tech enterprises, which value «education & mobility» transfers over «informal contacts», while it is generally the other way around. Furthermore, the manufacturing sector sets itself apart in its valuation of the other three categories of transfer forms. Especially the high-tech manufacturing subsector records between a quarter and a third of all KTT-active enterprises that see «infrastructure-based transfers» and «research-based transfers» as highly relevant. No other sector or subsector shows this kind of valuation for these transfer forms.

The service sector closely resembles the overall picture. Over half of all enterprises engaged in KTT see «informal contacts» and «education & mobility» as highly relevant transfer forms. The former category is slightly more important than the latter, except for the last survey period. The other three categories lag behind in terms of relevance by quite a lot. Only between 10% and 20% of all KTT-active service enterprises see these transfers as highly relevant. On a subsector level, the picture for «research-based transfers», «infrastructure-based» transfers», and «consulting» does not differ significantly. However, there is more time variation in the other two transfer categories. The relevance of «informal contacts» is inverted u-shaped in the modern services subsector while it is u-shaped in the traditional services subsector. The maximum of the former subsector is at 81% of all enterprises engaged in KTT with scientific institutions while the minimum of the latter subsector is at 32% of all KTT-active enterprises, both recorded in 2011. In the other periods, both subsectors record between half and two-thirds of all KTT-active enterprises that assess «informal contacts» to scientific institutions as highly relevant. Another picture evolves for «education & mobility». The traditional services subsector shows an inverted u-shaped relation over time with a peak fraction of 71% of all enterprises conducting KTT between 2005 and 2010 that saw these transfers as highly relevant. This corresponds to a 40% points increase to the preceding survey period. This fraction dropped in the latest survey period to roughly a half. Modern services, on the other hand, show a slight decrease over time from 69% to 60% of all KTT-active enterprises.

The construction sector shows two distinct features. First, the fraction of KTT-active enterprises that see «education & mobility» as highly relevant transfer forms has decreased from 51% to 24%. Secondly, it records a steadily increasing valuation of «consulting» from meagre 2% of all enterprises engaged in KTT in the 2005 period to 19% in the 2018 period.

Graph 2.3 shows the fraction of enterprises by enterprise size that reported at least one single form of knowledge and technology transfer within one of the five categories as highly relevant. In general, the picture is similar to the overall case and the one for sectors and subsectors. The most highly valued categorized transfer forms are «informal contacts» and «education & mobility». The remaining three categories of «research-based», «infrastructure-based», and «consulting-based transfer» lag behind with respect to their relevance.

Graph 2.3: Form categories of knowledge and technology transfer, by enterprise size[11]



Note: This graphic shows the fraction of enterprises that reported at least one single form of knowledge and technology transfer in the above mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector
Source: KOF-KTT surveys (2005, 2011, 2018)

Over two-thirds of all large enterprises see «informal contacts» and «education & mobility» as highly relevant categories of knowledge and technology transfer. The relevance of «education & mobility» even increased in the latest survey period. A staggering 83% of all large enterprises that conducted KTT with scientific institutions in that period reported this category of transfer forms as highly relevant. We also note that «informal contacts» are very important to about 70% of all KTT-active large enterprises, a fraction that is stable over time. The other transfer forms are not that important for large enterprises.

Small and medium-sized enterprises (SMEs) show a similar picture. «Informal contacts» and «education & mobility» are the predominant transfer forms, while the other three categories do not find as much appreciation. Only two things seem worth mentioning. The fraction of KTT-active small enterprises that consider «informal contacts» important is greater than for «education & mobility». The exact opposite picture emerges for medium-sized enterprises; a larger fraction cherishes «education & mobility» above «informal contacts».

Summarizing these insights, a clear picture emerges that seems to hold throughout the private sector, irrespective of sector subsector or enterprise size. The categories of «*informal contacts*» and «*education & mobility*» are the most highly valued categories of transfer forms with scientific institutions. «Research-based» and «infrastructure-based transfers» as well as «consulting» lag behind with respect to their appreciation by enterprises engaged in KTT. Despite some notable exceptions, these valuations are stable over these three survey periods.

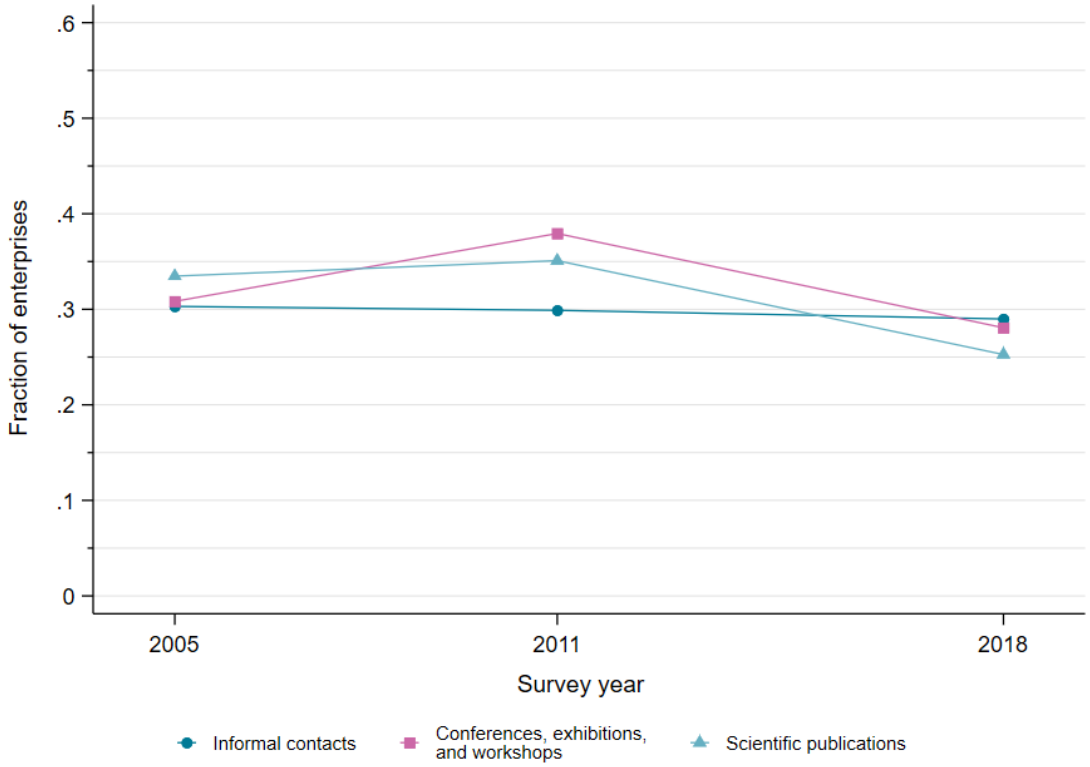
[11] The exact numbers that this graph is based on can be found in Table A5i on page 143 in the appendix.

4.1.2.2 Single Forms

In the previous chapter, we investigated the importance of categorized single transfer forms. In this chapter, we take a step back and ask which single transfer form in a certain category is the most relevant. In this vein, we analyze each of the five categories of transfer forms and look at the fraction of KTT-active enterprises that report a specific single transfer form as highly relevant, starting with «informal contacts».

4.1.2.2.1 Informal Contacts

Graph 2.1.1: Single forms of knowledge and technology transfer in the category «Informal contacts», overall[12]



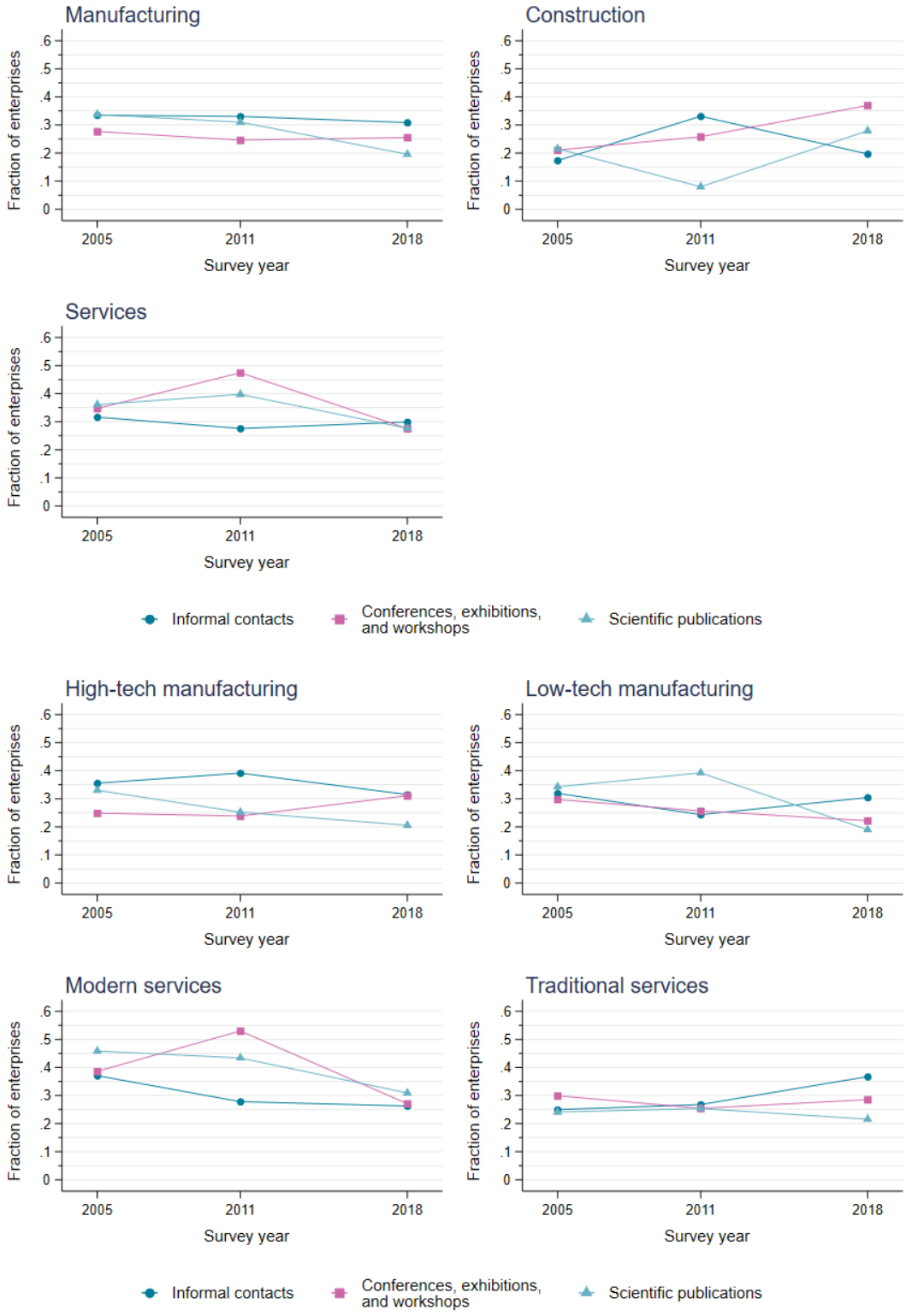
Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Informal contacts» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 2.1.1 shows the fraction of enterprises engaged in KTT with scientific institutions in one of the three survey periods that reported a single transfer form in the category of «informal contacts» as highly relevant.

A first thing to note is that while between 50% and 65% of all KTT-active enterprises highly valued the category of «informal contacts» not one single transfer form in this category nearly reaches this number. Furthermore, we can see that there are small differences in the fraction of enterprises that value a specific single form. The fraction of enterprises that participate in KTT and considers «conferences, exhibitions, and workshops» or «scientific publications» to be highly relevant, fluctuates over time by about 10% points around the baseline value of 30%. The fraction of enterprises that highly values «informal contacts to the staff of scientific institutions», however, is stable at 30% over the three survey periods.

[12] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

Graph 2.1.2: Single forms of knowledge and technology transfer in the category «Informal contacts», by sector and subsector[13]



Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Informal contacts» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector
Source: KOF-KTT surveys (2005, 2011, 2018)

[13] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

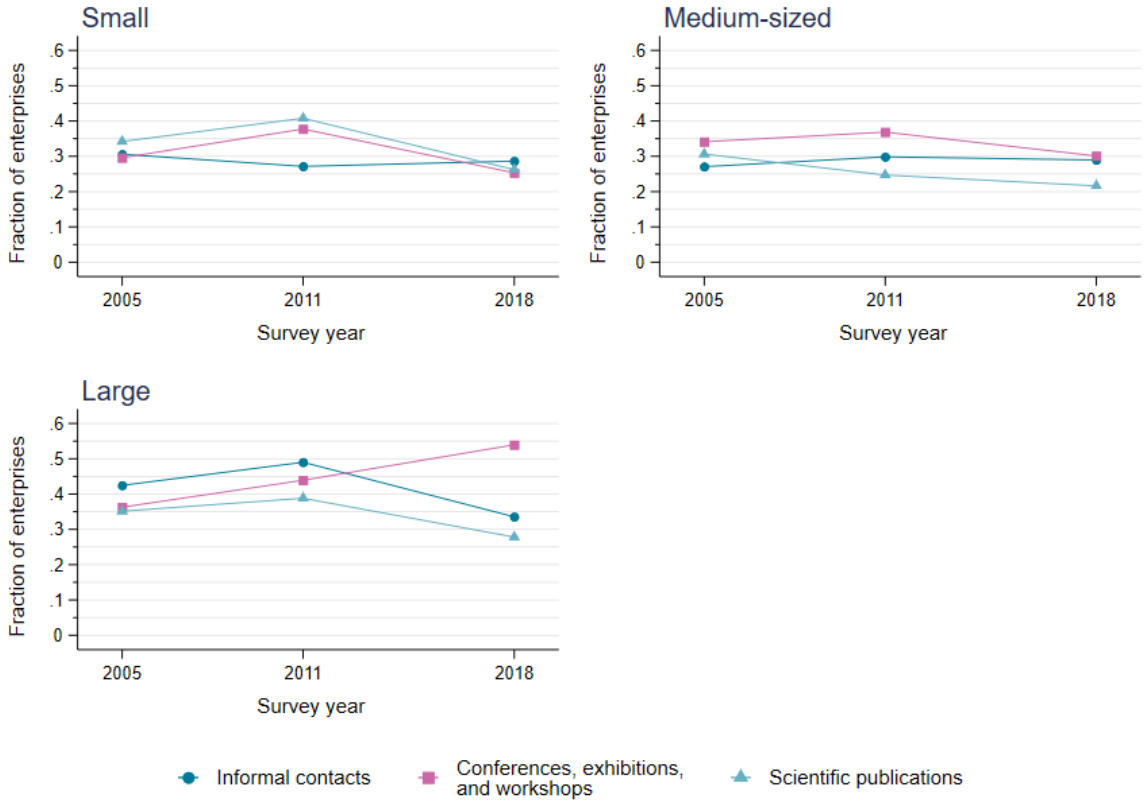
These two insights imply that all three single «informal transfer» forms are similarly relevant and most KTT-active enterprises spread their transfers over multiple «informal transfer» forms.

Graph 2.1.2 depicts the relevance of the three single informal transfer forms for KTT-active enterprises by sector and subsector over the three survey periods.

The manufacturing sector shows a stable development in the fraction of enterprises engaged in KTT that value the three single forms. There is a slightly negative trend in the relevance of «scientific publications», especially in the last survey period (-11% points). In particular, the low-tech manufacturing subsector shows a strong decline in this transfer form in the last survey period (-20% points). About a third of all manufacturing enterprises conducting KTT see «informal contacts to the staff on scientific institutions» as highly relevant and about a quarter reports a high relevance of «conferences, expositions, or workshops» at scientific institutions.

The service sector shows a similar picture, with exception of the 2011 survey period. Around 30% of all KTT-active enterprises see each of the three transfer forms as highly relevant. Between 2005 and 2010 we see an increasing importance in «conferences, expositions, and workshops» relative to the former (+12% points) and especially the latter (+19% points) survey periods. The modern services subsector clearly drives this temporary pattern.

Graph 2.1.3: Single forms of knowledge and technology transfer in the category «Informal contacts», by enterprise size[14]



Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Informal contacts» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size
Source: KOF-KTT surveys (2005, 2011, 2018)

[14] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

The construction sector reports a steady increase in the fraction KTT-active enterprises emphasizing «conferences, expositions, and workshops». «Scientific publications» have first fallen in importance and then risen again in the latter survey period. The opposite is true for «informal contacts».

This graph evidently shows that despite some fluctuations the three informal transfer forms are similarly important within each sector and subsector. Only the 2011 survey period shows an increasing dispersion in their relative relevance.

Graph 2.1.3 depicts the relevance of the three single informal transfer forms by enterprise size. Large enterprises show an interesting picture. Between the first two survey periods, the fraction of KTT-active enterprises that highly value a single transfer form was increasing for all three forms. The importance of «conferences, expositions, and workshops» kept on increasing in the last survey period (+10% points) while the importance of «scientific publications» (-11% points) and especially «informal contacts to the scientific institutions» (-15% points) declined.

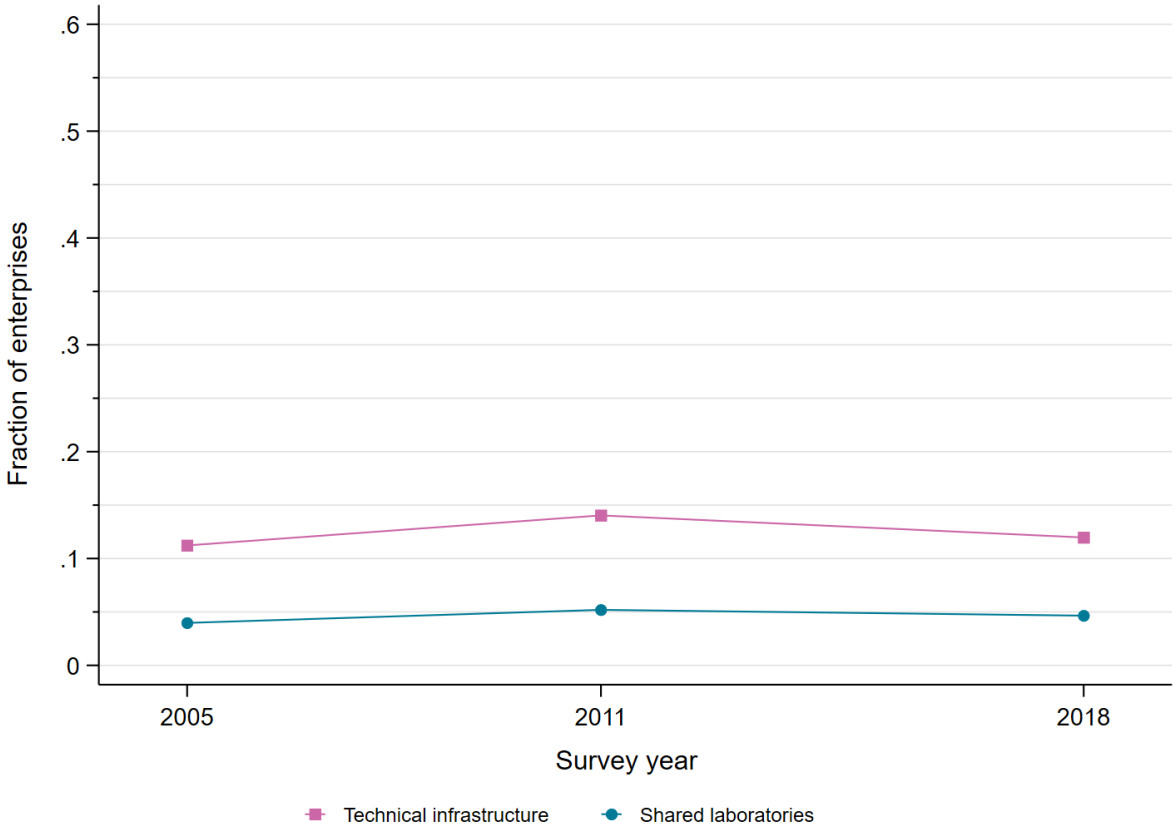
Small and medium-sized enterprises (SMEs) are relatively similar. Around 30% of all KTT-active enterprises see each single informal transfer form as highly relevant. Opposed to small enterprises, a smaller fraction of medium-sized enterprises sees «scientific publications» as highly relevant. The importance of the other two transfer forms are comparable across these enterprise sizes.

Bringing these insights together, we can say that the valuation of the three single informal transfer forms is narrowly dispersed within a certain sector, subsector as well as by enterprise size and overall. Not a single transfer form systematically sets itself apart in terms of relevance from the other two. Furthermore, most enterprises seem to appreciate more than one single informal transfer form. Somehow remarkable is the strongly increasing importance of «conferences, expositions, and workshops» among large enterprises.

4.1.2.2.2 Infrastructure

In this chapter, we look at the single transfer forms in the overall less noticed category of «infrastructure-based transfers». This category distinguishes between two single forms: «Shared laboratories» and utilization of the «technical infrastructure» of scientific institutions.

Graph 2.2.1: Single forms of knowledge and technology transfer in the category «Infrastructure», overall[15]



Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Infrastructure» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

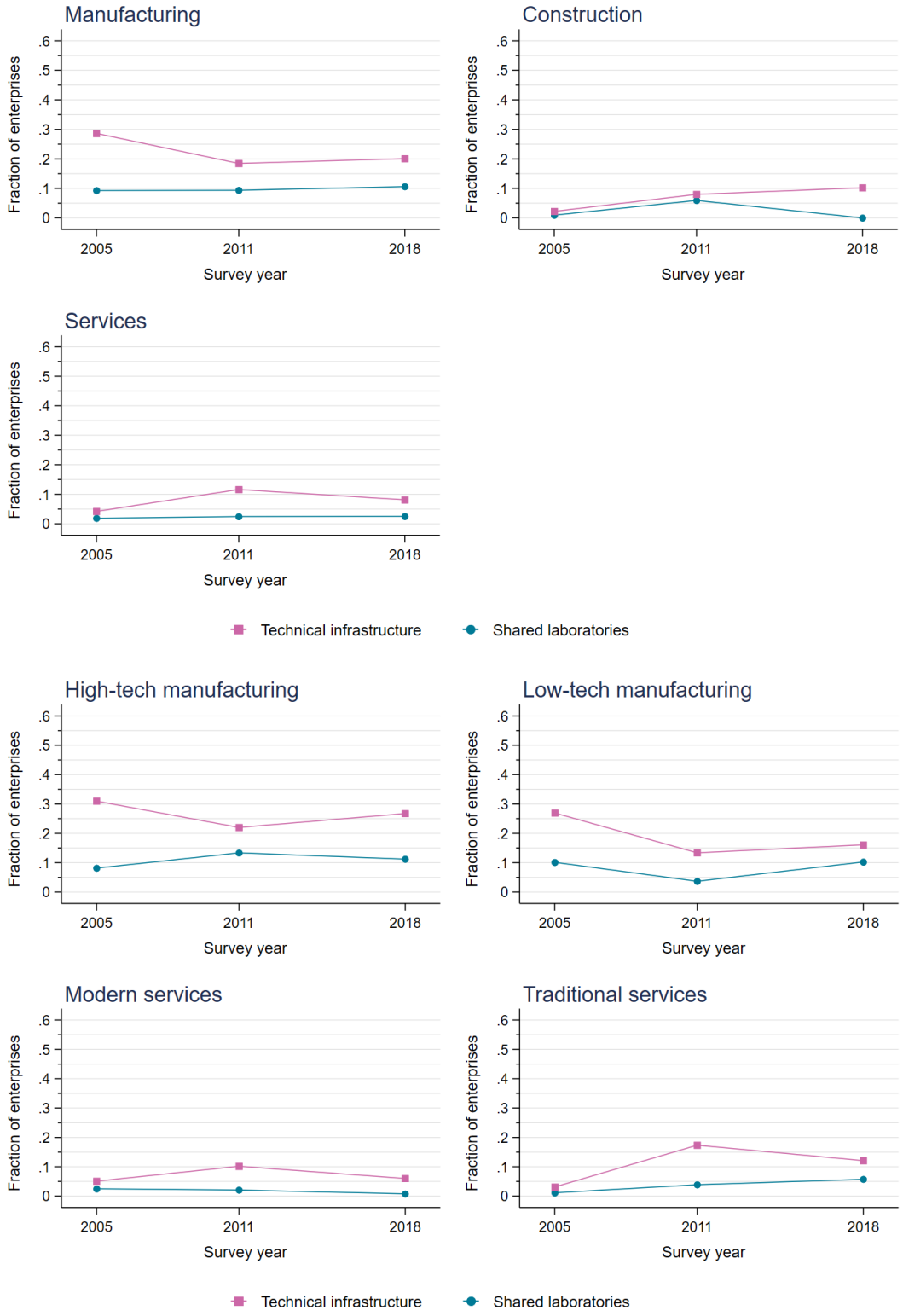
Graph 2.2.1 depicts the fraction of enterprises engaged in KTT with scientific partners in the three survey periods that highly valued a single «infrastructure-based transfer» form.

The previous analysis has shown that «infrastructure-based transfers» are less common overall. As such, it comes as no surprise that this is also true for the single forms in this category. Between 10% and 15% of all enterprises engaged in KTT see the usage of the «technical infrastructure» of scientific partners as highly relevant transfer forms. «Shared laboratories» are an even less common transfer form. About 5% of all KTT-active enterprises reports them as highly relevant.

By comparing this to Graph 2.1 we also note that the values for usage of «technical infrastructure» almost coincide with the ones for the category of «infrastructure-based transfers». This implies that almost all enterprises that report «shared laboratories» as highly relevant also report the usage of «technical infrastructure» of the scientific partner as highly relevant.

[15] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

Graph 2.2.2: Single forms of knowledge and technology transfer in the category «Infrastructure», by sector and subsector[16]



Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Infrastructure» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

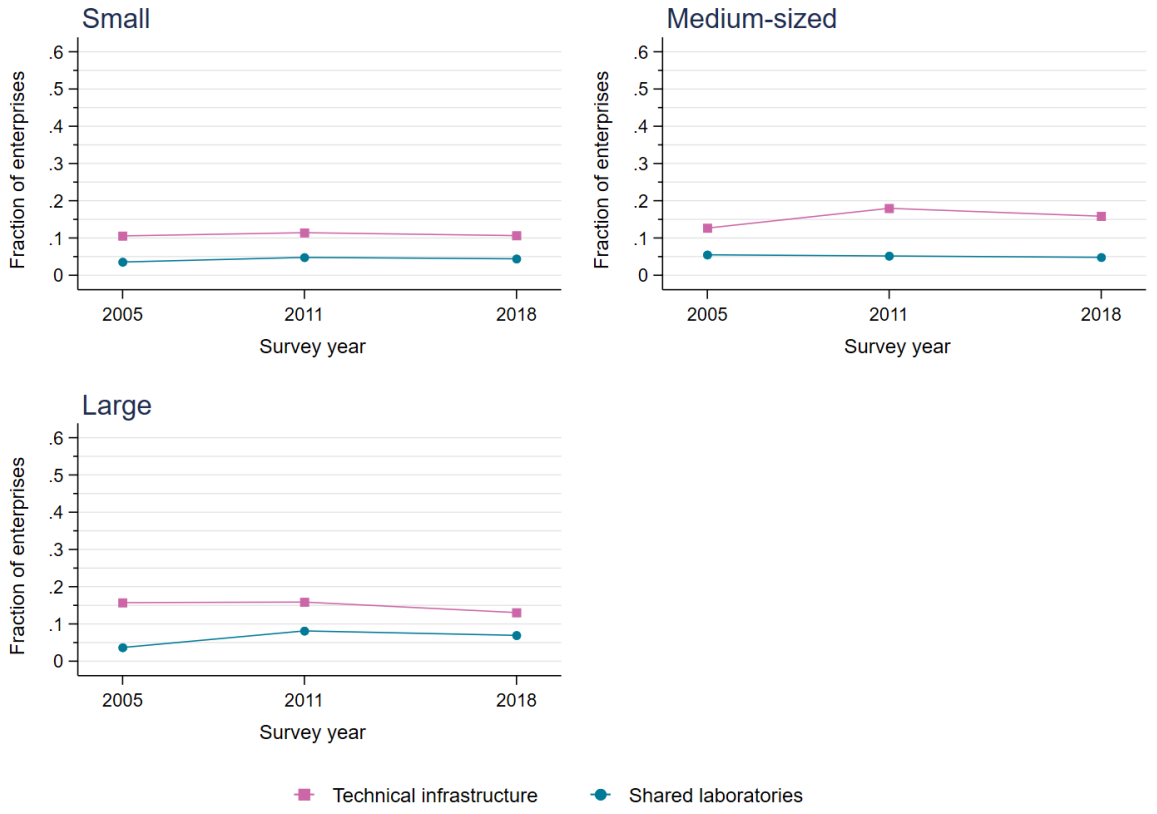
[16] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

Graph 2.2.2 depicts the relevance of single «infrastructure-based transfer» forms by sector and subsector. In each sector and subsector, the usage of «technical infrastructure» is the dominant transfer form. Furthermore, there are some fluctuations over time but overall the fraction of KTT-active enterprises within a sector or subsector that sees a single transfer form as highly relevant is stable over the three survey periods, especially for the less common «shared laboratories».

As is evident from Graph 2.2, the manufacturing sector shows the biggest fraction of KTT-active enterprises that see «infrastructure-based transfers» as highly relevant. This must therefore also hold true for the single forms of this category. The usage of the «technical infrastructure» of the scientific partner is relevant in the manufacturing sector and especially in high-tech manufacturing.

For the enterprises in the service sector as well as the construction sector, these transfer forms are nearly irrelevant, particularly «shared laboratories». What sticks out, though, is that the traditional services subsector cherishes the usage of «technical infrastructure» more than the modern services subsector.

Graph 2.2.3: Single forms of knowledge and technology transfer in the category «Infrastructure», by enterprise size[17]



Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Infrastructure» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size

Source: KOF-KTT surveys (2005, 2011, 2018)

[17] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

Graph 2.2.3 reports the relevance of single «infrastructure-based transfer» forms by enterprise size. Corresponding to the other two graphs, the usage of «technical infrastructure» is more important than «shared laboratories». It is also the case that their valuation is unchanged over these survey periods.

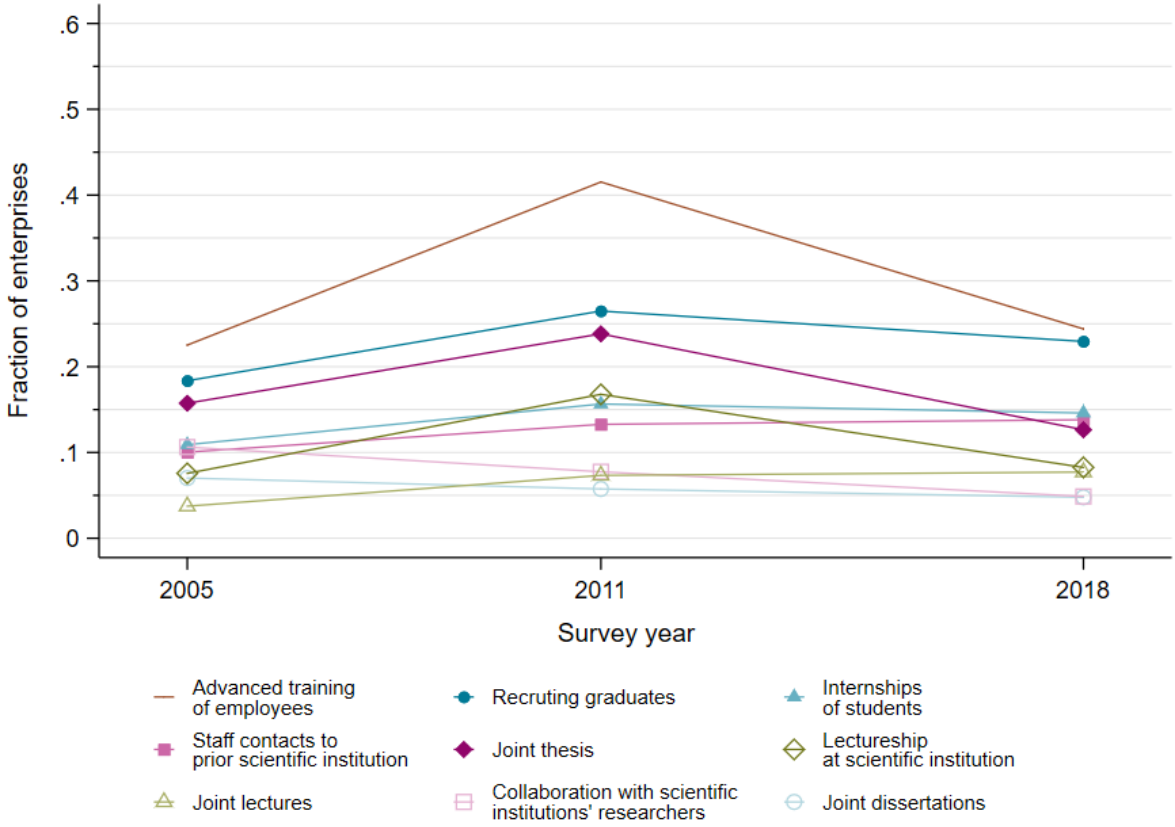
Large and medium-sized enterprises have a slightly higher appreciation for the usage of «technical infrastructure» opposed to small enterprises. When it comes to «shared laboratories», no differences are evident across enterprise size.

Compressing these insights, we note three things. The usage of «technical infrastructure» is more important than «shared laboratories», irrespective of sector, subsector, or enterprise size. Additionally, there are no trends. Otherwise put, the valuation for these two transfer forms is stable over the survey horizon. Finally, almost all enterprises that highly value the usage of «technical infrastructure» also cherish «shared laboratories». Since the fraction that appreciates the latter transfer form is extremely small and since there are only two single forms in this category, this comes as no real surprise.

4.1.2.2.3 Education & Mobility

The category of «education & mobility» comprises nine different single forms: «Recruiting graduates from scientific institutions», «contact of employees with their prior scientific institution», «internships of students», «joint thesis», «joint dissertations», «collaboration with scientific institutions' researchers», «joint lectures», «lectureships of employees», and «advanced training of employees» at scientific institutions.

Graph 2.3.1: Single forms of knowledge and technology transfer in the category «Education & mobility», overall[18]



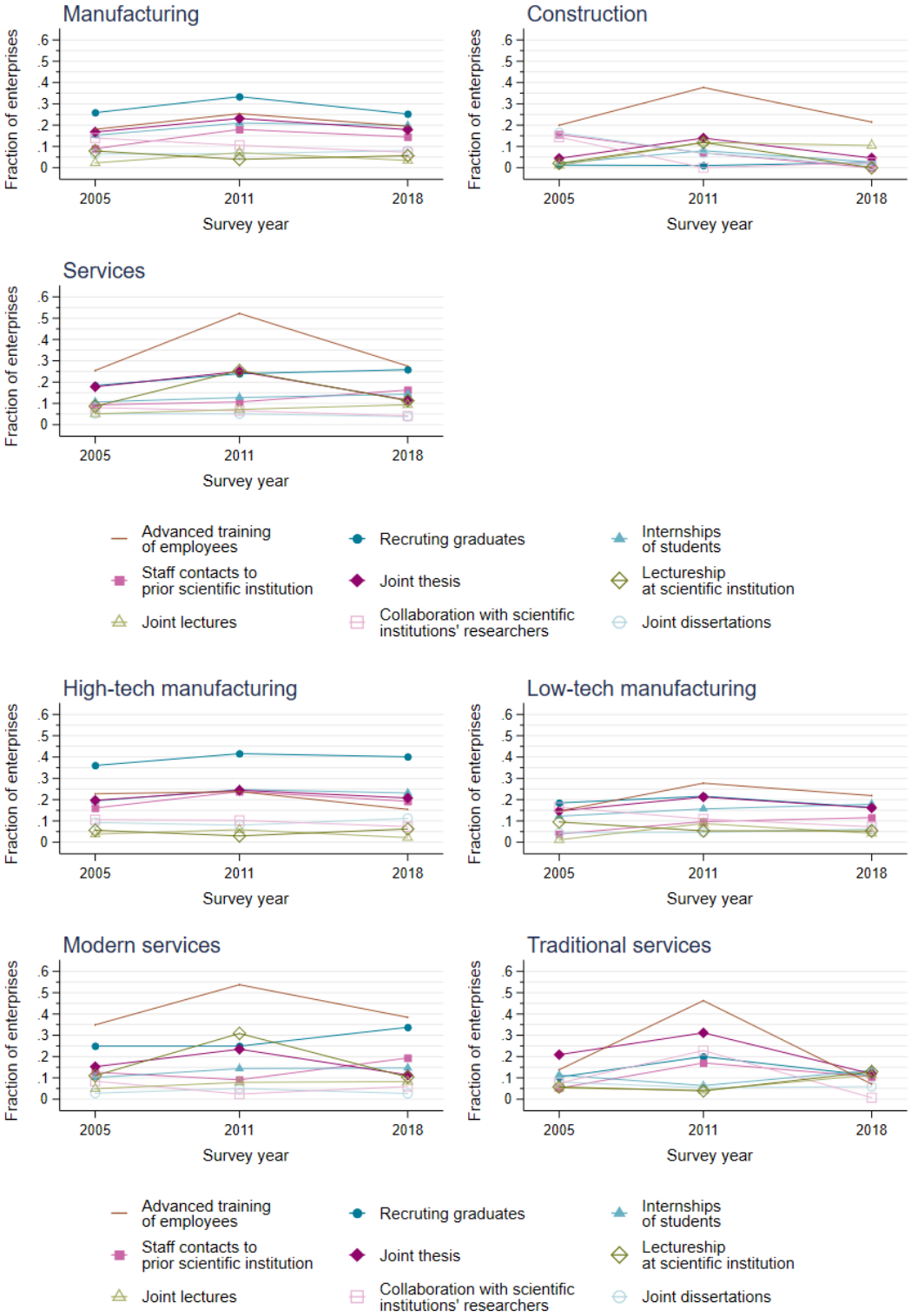
Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Education & mobility» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 2.3.1 depicts the fraction of KTT-active enterprises that see a specific single transfer form in the category of «education & mobility» as highly relevant.

Overall, two single forms are especially relevant: «advanced training of employees» at and «recruiting graduates» from scientific institutions. In this sense, enterprises are most interested in directly improving their human capital. Besides these two transfer forms, all others are of relative similar importance. Comparing this to Graph 2.1 we can also see that no other single form comes close to the values for the combined category of «education & mobility».[19]

[18] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.
[19] A minor exemption is the fraction of enterprises that report «advanced training opportunities» as highly relevant in the 2011 period.

Graph 2.3.2: Single forms of knowledge and technology transfer in the category «Education & mobility», by sector and subsector[20]



Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Education & mobility» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[20] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

Graph 2.3.2 depicts the relevance of the single transfer forms in the category of «education & mobility» by sector and subsector. Since these graphs are pretty «noisy» we only mention the things that stick out and refer the reader to Chapter 7.2.2.2 in the appendix for detailed information about these graphs.

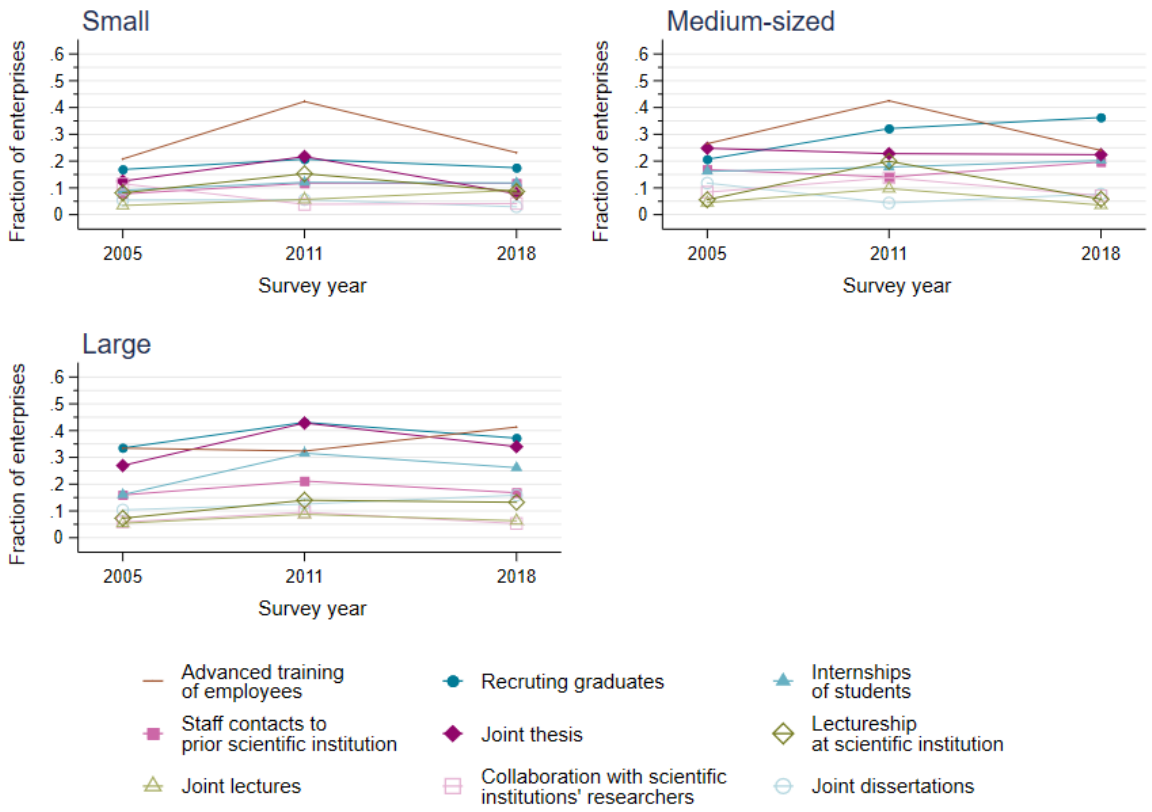
The enterprises in the manufacturing sector (between 25% and 35% of all KTT-active enterprises) and in particular, in the high-tech manufacturing (between 35% and 45% of all KTT-active enterprises) subsector show the highest appreciation for «recruiting graduates».

The construction sector as well as the service sector value «advanced training of employees» above all others, particularly between 2005 and 2010. In this period, nearly 55% of all KTT-active modern services enterprises and over 45% of all traditional services enterprises reported this transfer form as highly relevant.

The modern services subsector also reports a high valuation of «recruiting graduates». About a quarter of all KTT-active enterprises in this subsector initially reported this transfer form as highly relevant. This fraction has increase up to 34% in the latest survey period.

Besides that, it also is worth mentioning that no real trends are visible and most single transfer forms receive a stable valuation over the three survey periods.

Graph 2.3.3: Single forms of knowledge and technology transfer in the category «Education & mobility», by enterprise size[21]



Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Education & mobility» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size
Source: KOF-KTT surveys (2005, 2011, 2018)

[21] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

Graph 2.3.3 shows the fraction of KTT-active enterprises by enterprise size that reported a single transfer form in the category of «education & mobility» as highly relevant.

Small enterprises prefer «advanced training opportunities of employees» at scientific institutions. Medium-sized enterprises also report a preference for this transfer form. The same holds true for «joint thesis», «internships of students» or «contacts of employees to their former scientific institution», especially in the latest survey period. However, there is one clear trend for medium-sized enterprises. The KTT-active fraction that reported «recruiting graduates» as highly relevant steadily increased over the survey period (+15% points). In the latest survey period, this transfer form was the most cherished among medium-sized enterprises with 36% of all KTT-active enterprises reporting them as highly relevant.

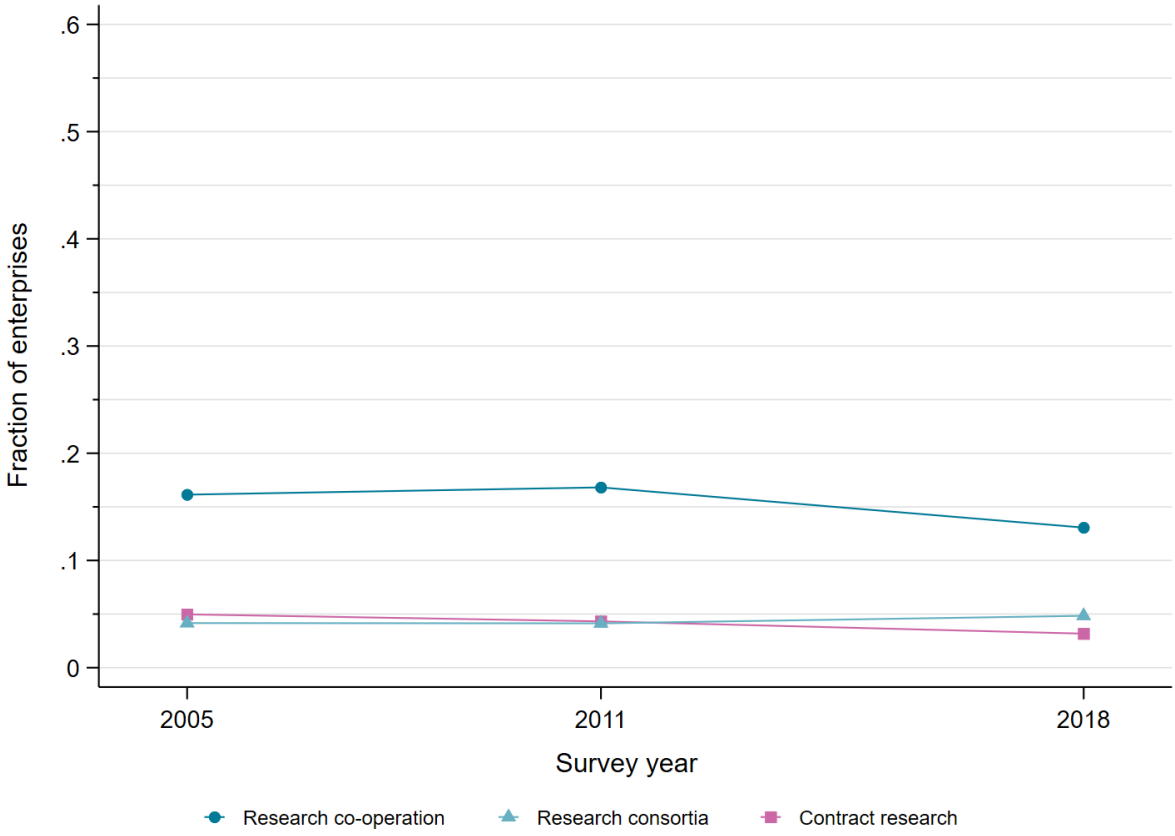
Large enterprises also show a high appreciation for «advanced training opportunities» for their employees and «recruiting graduates». They really set themselves apart from SMEs in terms of the fraction of enterprises engaged in KTT that report «internships of students» and particularly «joint thesis» as highly relevant. As such, they do not only want to recruit graduates but are interested in integrating students before their graduation. This might be motivated by the possibility to early detect talented students.

Putting things together, two things are apparent. Increasing the human capital stock by means of «recruiting graduates» and «advanced training opportunities of employees» hold the highest relevance throughout sectors, subsectors and enterprise size. Furthermore, many single transfer forms in the category of «education & mobility» are relatively unimportant for the transfer of knowledge and technology. These comprise «joint lectures», «lectureships of employees», «joint dissertations», and «collaboration with scientific institutions' researchers» like industrial sabbaticals.

4.1.2.2.4 Research

The «research-based transfers» category comprises three single transfer forms: «Research co-operation» with a scientific institution, «research consortia» with the participation of at least one scientific institution, and «contract research» executed by a scientific institution.

Graph 2.4.1: Single forms of knowledge and technology transfer in the category «Research», overall[22]



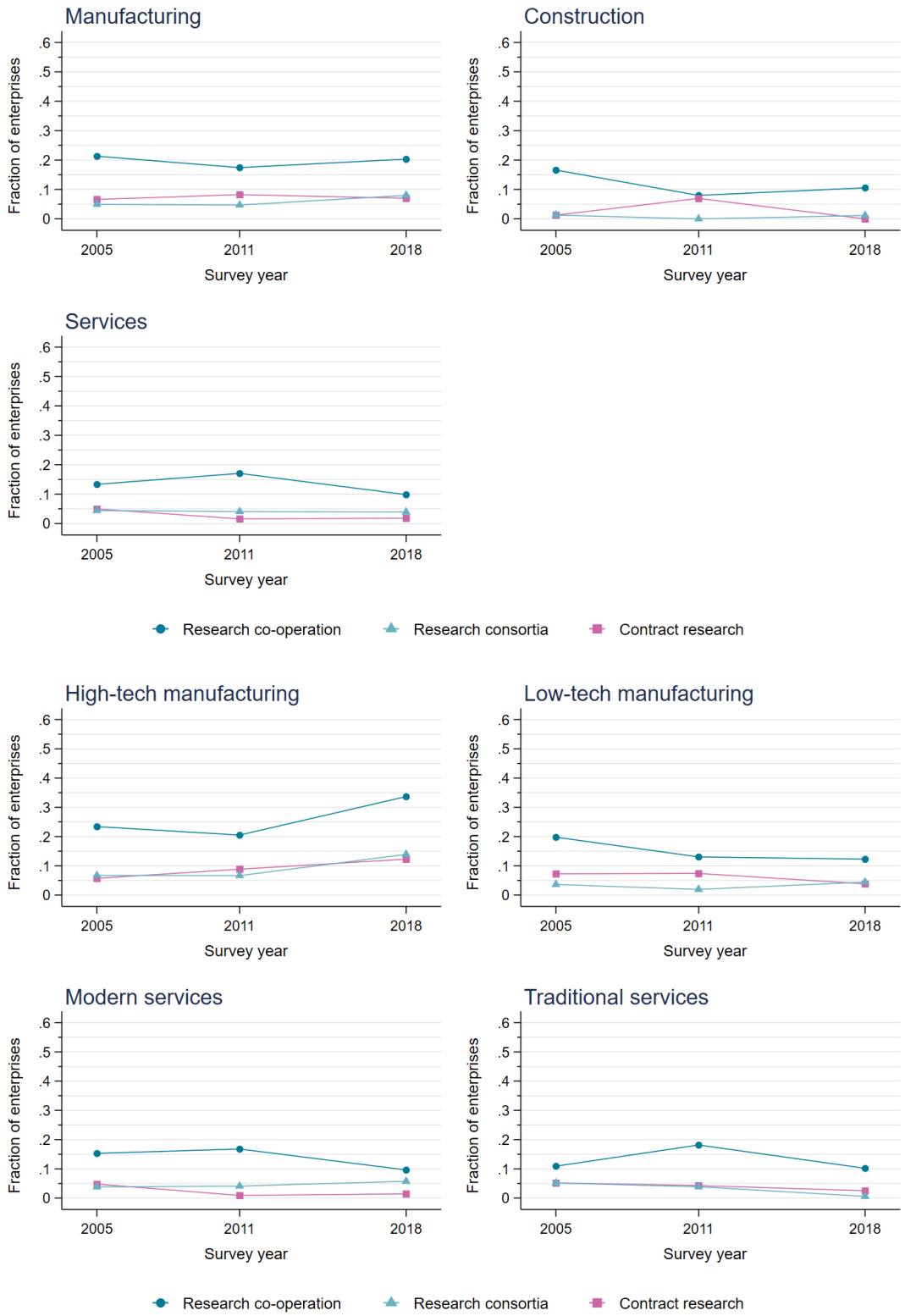
Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Research» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 2.4.1 shows the fraction of KTT-active enterprises, which reported a specific single «research-based transfer» form with scientific institutions in one of the three survey periods as highly relevant.

«Research co-operation» is clearly the most important transfer form in this category. About 15% of all KTT-active enterprises reported this single transfer form as highly relevant opposed to only roughly 5% for «research consortia» and «contract research». These fractions are relatively stable over the three survey periods.

[22] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

Graph 2.4.2: Single forms of knowledge and technology transfer in the category «Research», by sector and subsector[23]



Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Research» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

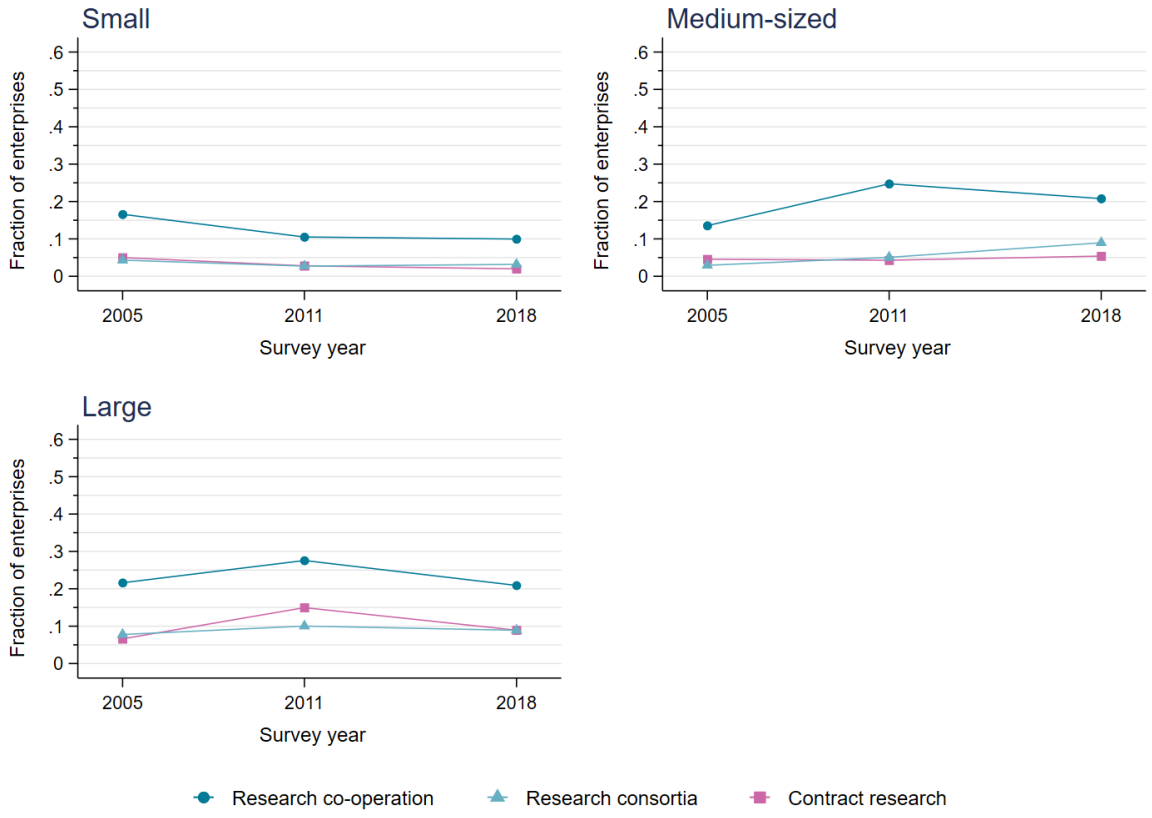
[23] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

Graph 2.4.2 depicts the relevance of the single «research-based transfer» form by sector and subsector. In all cases, «research co-operation» records the biggest fraction of KTT-active enterprises reporting them as highly relevant. «Research consortia» and «contract research» show lower fractions that are comparable among each other.

In line with Graph 2.2, the manufacturing sector shows the highest appreciation for «research-based transfer» forms. This is particularly pronounced in the high-tech manufacturing subsector. A quarter of all high-tech manufacturing enterprises engaged in KTT reported «research co-operation» as highly relevant. This fraction has risen in the latest survey period to 35%. Besides that, no clear trends are observable in any sector or subsector for all single forms.

Almost no construction enterprise has a high valuation for «contract research» and especially «research consortia». The fraction of KTT-active service enterprises with a high valuation of «contract research» also tends towards zero, particularly for the modern services subsector. Additionally, «research consortia» have become close to irrelevant for the traditional services subsector.

Graph 2.4.3: Single forms of knowledge and technology transfer in the category «Research», by enterprise size[24]



Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Research» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size

Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 2.4.3 shows the fraction of KTT-active enterprises that highly valued a single «research-based transfer» form in one of the three survey periods by enterprise size. Again, «research co-operation» is

[24] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

the most frequent high-valued transfer form. «Research consortia» and «contract research» lag behind in terms of their relevance but are comparable to each other in terms of their level. This holds irrespective of enterprise size. Furthermore, no clear trends are observable.

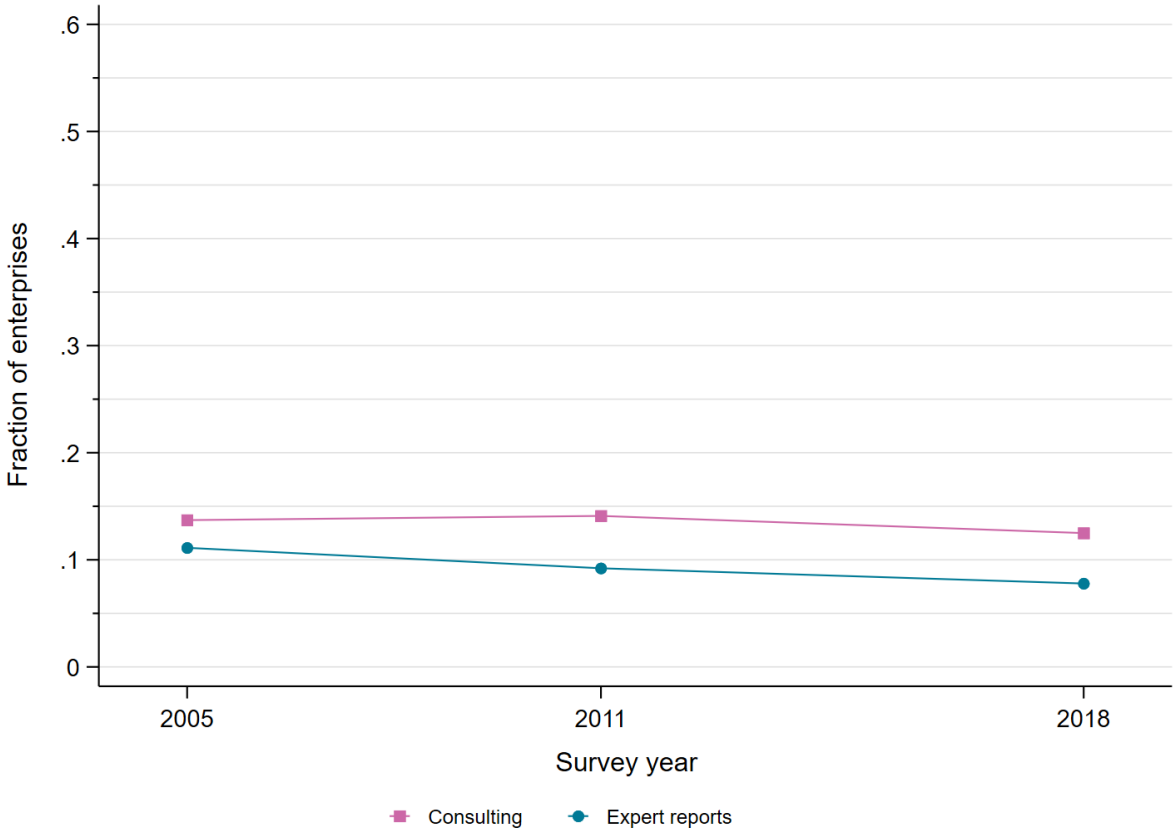
The fraction of enterprises engaged in KTT that report «research co-operation» as highly relevant is slightly decreasing in enterprise size. This is more pronounced between medium-sized and small enterprises than between large and medium-sized enterprises. The same holds true for «research consortia» and «contract research» but these differences are even smaller.

A clear picture emerges from the summary of these findings. «Research co-operation» is the only single research-based transfer form that is relevant, irrespective of sector, subsector, or enterprise size. Additionally, the valuations for each transfer form are stable over the three survey periods.

4.1.2.2.5 Consulting

The last category of transfer forms is «consulting». It comprises of only two single forms: expertise in form of «expert reports» of scientific institutions and «consulting» services of scientific institutions.

Graph 2.5.1: Single forms of knowledge and technology transfer in the category «Consulting», overall[25]



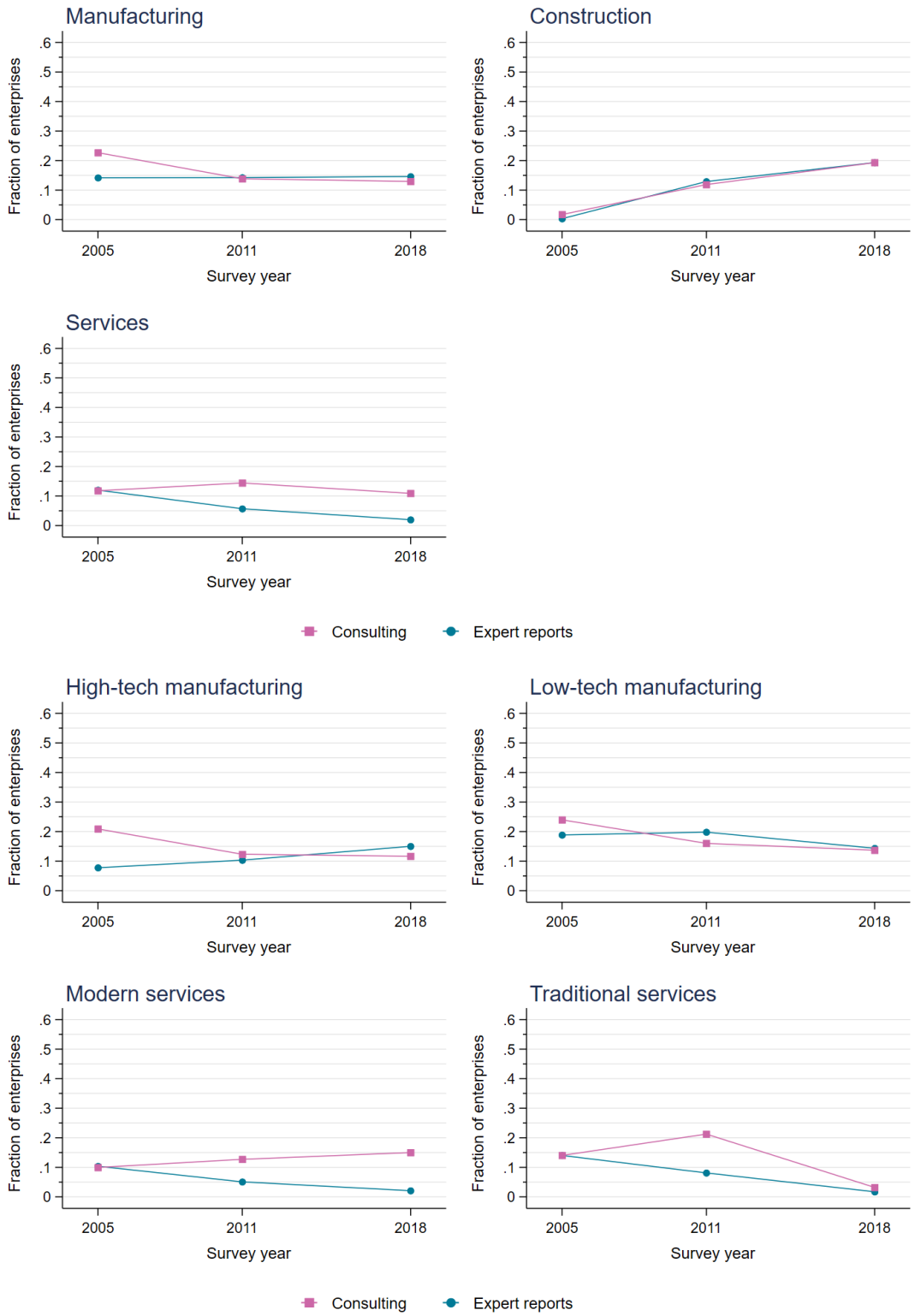
Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Consulting» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 2.5.1 depicts the fraction of KTT-active enterprises that reported a specific single «consulting-based transfer» form in one of the three survey periods as highly relevant. Consulting is highly relevant to a slight bigger fraction of all enterprises opposed to «expert reports». These fractions are stable over the survey horizon.

Graph 2.1 shows that the fraction of KTT-active enterprises reporting the category of «consulting-based» transfer forms as highly relevant is incredibly close to the fraction for the single transfer form «consulting». This implies that only a small fraction of enterprises that reported «expert reports» as highly relevant did not do so for «consulting». In other words, private enterprises that are interested in «consulting-based transfer» forms use both of these single transfer forms simultaneously.

[25] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

Graph 2.5.2: Single forms of knowledge and technology transfer in the category «Consulting», by sector and subsector[26]



Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Consulting» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[26] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

Graph 2.5.2 depicts the relevance of «consulting-based transfer» forms by sector and subsector. The manufacturing sector shows a similar relevance of «consulting» and «expert reports». About 15% of all KTT-active manufacturing enterprises see these transfer forms as highly relevant. These fractions are somewhat more stable and slightly higher in low-tech manufacturing opposed to high-tech manufacturing. In the latest survey period, they are about the same for both subsectors. Comparing this to Graph 2.2, the values for «consulting» as a single transfer form and as a category almost coincide for the manufacturing sector and its two subsectors. This implies that almost every enterprise that has a high valuation for «expert reports» also has a high valuation for «consulting». This is especially pronounced in the 2011 and 2018 survey periods, where the fractions for each single form almost coincide. They represent the same fraction of enterprises.

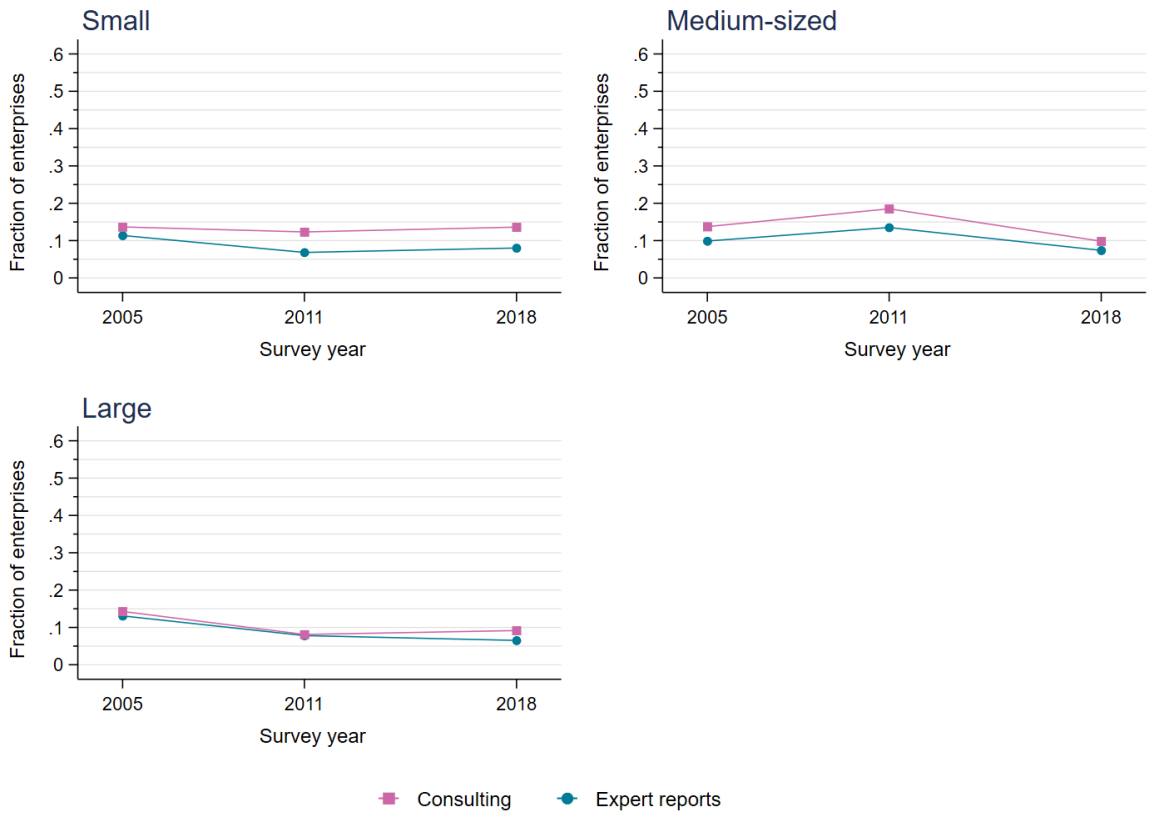
This is even more drastic for the construction sector. The fraction of KTT-active enterprises with a high valuation of «expert reports» is almost completely the same as for «consulting». Furthermore, these values coincide with the values reported for the category of «consulting-based transfer» forms. This implies an almost perfect overlap, indicating that construction enterprises use the «consulting» services from research institutes usually in combination with «expert reports». Graph 2.5.2 show us that the construction sector records an increase in the fraction of KTT-active enterprises with a high valuation of these transfer forms from almost 0% to 20%.

The service sector shows a trend in the opposite direction. While the values for «consulting» remain relatively stable, «expert reports» has become less relevant over the survey horizon. Particularly the traditional services subsector records a decrease by 12% points. The fraction of KTT-active traditional services enterprises that highly value «consulting» has also vastly dropped between the two last survey periods (-18% points).

Graph 2.5.3 portrays the relevance of the single «consulting-based» transfer forms by enterprise size. Opposed to large enterprises, a bigger fraction of SMEs sees «consulting» as highly relevant. The valuation for «expert reports» is almost identical across enterprise sizes. No trends are evident.

Putting these findings together, we note two things. First, there are no trends overall and by enterprise size. However, on a sector and subsector level the valuations for «expert reports» and «consulting» seem to change over the survey periods. Particularly the construction sector sees an increase in the relevance of both transfer forms. Secondly, there are massive overlaps. Almost all enterprises with a high appreciation of «expert reports» also report «consulting» as highly relevant. This is especially pronounced for construction enterprises.

Graph 2.5.3: Single forms of knowledge and technology transfer in the category «Consulting», by enterprise size[27]



Note: This graphic shows the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the category «Consulting» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size

Source: KOF-KTT surveys (2005, 2011, 2018)

[27] The exact numbers that this graph is based on can be found in Table A5ii on page 144 in the appendix.

4.1.3 Partners

After the discussion of the transfer forms, we turn our attention towards the public research institutions that enterprises choose as partners of knowledge and technology transfer. This section is divided into two parts. *Section 4.1.3.1* shows the fraction of enterprises that conducts KTT with a specific institution or a specific type of institution, which we refer to as domains. *Section 4.1.3.2* tackles the question of how diverse these partnerships are on average for private enterprises. We measure this diversity by means of the number of scientific partners held in a specific survey period.

Table C: Public research institutions[28]

Domain	Institution	Abbreviation
ETH domain	Swiss Federal Institute of Technology in Zurich (ETH Zurich)	ETHZ
	Swiss Federal Institute of Technology in Lausanne (EPFL)	EPFL
	Paul Scherrer Institute	PSI
	Swiss Federal Institute of Aquatic Science and Technology	EAWAG
	Swiss Federal Laboratories for Materials Science and Technology	EMPA
	Swiss Federal Institute for Forest, Snow and Landscape Research	WSL
Universities	University of Bern	UNIBE
	University of Basel	UNIBAS
	University of Fribourg	UNIFR
	University of Geneva	UNIGE
	University of Lausanne	UNIL
	University of Lucerne	UNILU
	University of Neuchâtel	UNINE
	University of St. Gallen	HSG
	University of Italian Switzerland (USI)	USI
	University of Zurich	UZH
Universities of applied sciences (UAS)	Bern Universirty of Applied Sciences	BFH
	University of Applied Sciences Northwestern Switzerland	FHNW
	University of Applied Sciences Eastern Switzerland	FHO
	Lucerne University of Applied Sciences (HSLU)	HSLU
	University of Applied Sciences and Arts Western Switzerland (HES-SO)	HES-SO
	University of Applied Sciences and Arts Southern Switzerland (SUPSI)	SUPSI
	Zurich University of Applied Sciences	ZFH

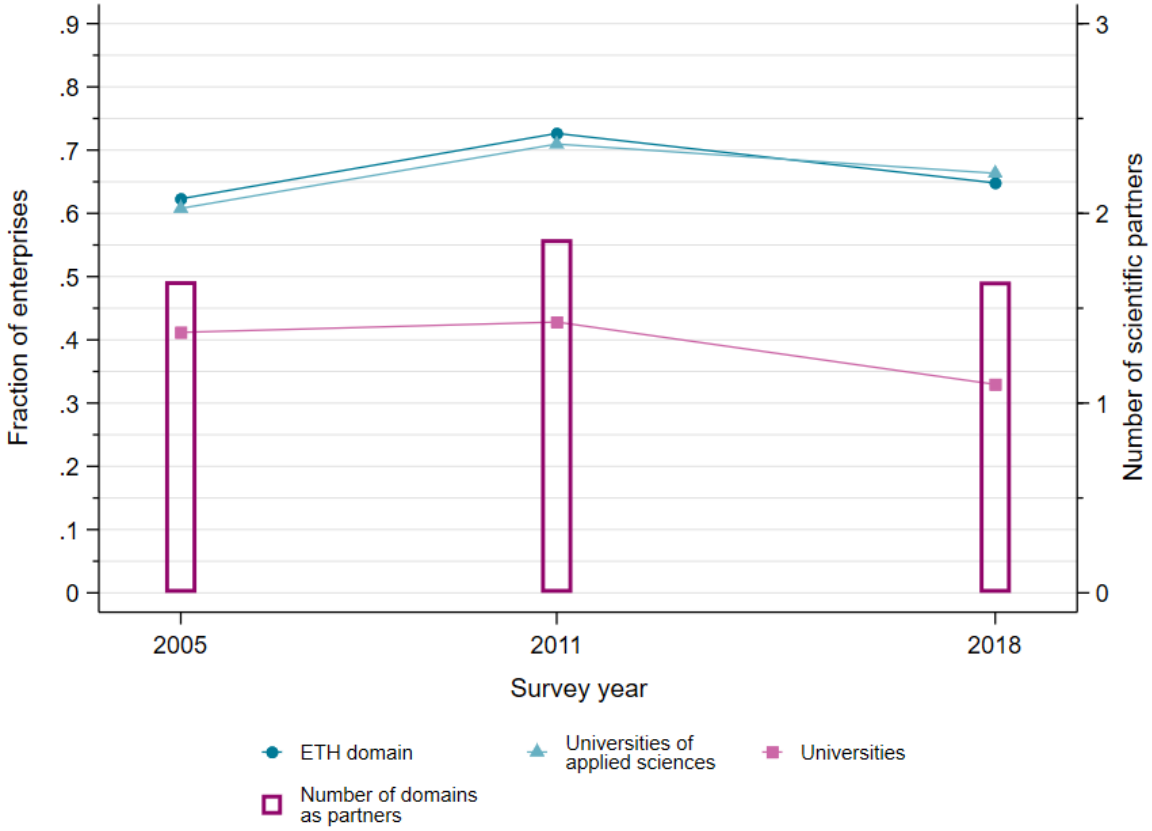
Table C shows the single public research institutions in the middle column that are categorized into three groups, referred to as domains. The ETH domain is on a federal level and comprises six single institutions. The universities domain is on a cantonal level and comprises ten institutions. The universities of applied sciences sector is on a regional level and comprises seven institutions.

[28] Further information on these public research institutions can be found on https://www.swissuniversities.ch/en/organization/members/.

4.1.3.1 Occurrence of KTT partnerships

As mentioned above, we will first look at the occurrence of KTT partnerships. We analyze the fraction of KTT-active enterprises that reported at least one of the previously analyzed five categories of transfer forms in a certain survey period with a specific public research institution. We do not analyze how many different transfer forms were used with a specific scientific partner but whether or not any partnership existed at all.

Graph 3.1.1: Domains as partners of knowledge and technology transfer, overall[29]



Note: This graphic shows the fraction of enterprises that conducted at least one form of knowledge and technology transfer with at least one institution of the respective domains (left scale) and the average number of domains per enterprise with which at least one form of knowledge and technology transfer has been carried out (right scale).
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 3.1.1 shows two things. The connected symbols report the fraction of enterprises engaged in KTT that had at least one partnership with an institution of a certain domain. The vertical bars, on the other hand, show the average number of domains per enterprise that served as KTT partners (right scale). These measures convey information about how diverse the KTT partnerships are across the three domains. The focus of this section, however, remains on whether there were any contacts.

The largest fraction of enterprises conducts knowledge and technology transfer with the ETH domain and universities of applied sciences (UAS). About two-thirds of all KTT-active enterprises maintain transfer activities with either domain. These values were slightly higher in the 2011 survey period and slightly lower in the 2005 period. Universities are less frequently contacted by the private sector. Only

[29] The exact numbers that this graph is based on can be found in Table A6i on page 144 and Table A6ii on page 146 in the appendix.

about 40% of all enterprises maintain KTT activities with institutions in this domain. This fraction decreased in the latest survey period to 33%. As such, twice as much enterprises use the ETH domain or UAS for their KTT activities opposed to universities.

Once we look at the diversity of these contacts, we note, that an enterprise maintains KTT partnerships with more than one domain but less than two, on average. This diversity was slightly higher in the 2011 period as opposed to the other two survey periods.

Graph 3.1.2 depicts which scientific domains were the most popular for private enterprises in their KTT activities and the diversity of these partnerships by sector and subsector. In line with the overall picture, enterprises target the ETH domain and the UAS domain more frequently for their KTT activities than the universities.

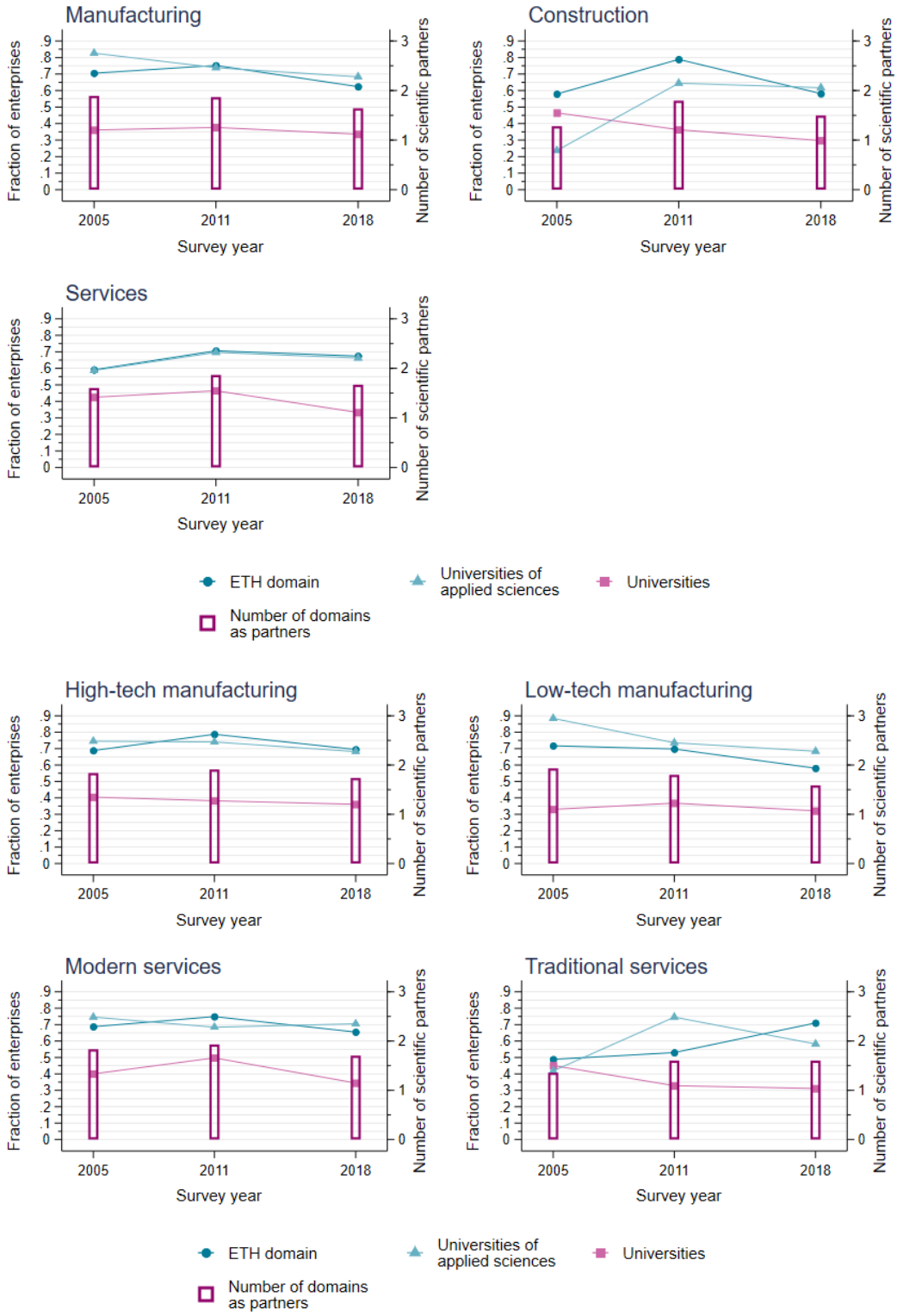
A third of all manufacturing enterprises maintains KTT-relationships with universities. This holds true for the low-tech manufacturing subsector as well as for the high-tech manufacturing subsector. In contrast, over two-thirds of all KTT-active manufacturing enterprises choose institutions in the ETH domain as their partners. In the latest survey period, this fraction has fallen slightly below the two-third threshold. The UAS domain records even higher fractions. In the first survey period, 83% of all KTT-active manufacturing enterprises had partnerships with UAS. The low-tech manufacturing subsector even recorded 88%. These numbers have fallen over the survey horizon and reside at two-thirds in the latest survey period.

The fraction of enterprises in the service sector having partnerships with the ETH domain or UAS and universities were less different at the beginning of our recordings in 2005. The fraction for the two former domains (ETH and UAS) are only 1.5 times bigger than the latter domain. Yet, this gap keeps on increasing over the survey periods. Initially, because the fraction of service enterprises that maintained KTT activities with the ETH domain or the UAS domain increased (+11% points) and later on because the fraction of service enterprises that conducted KTT with universities decreased (-13% points). As such, between 2012 and 2017, two-thirds of all KTT-active services enterprises conducted KTT with the ETH domain, two-thirds with the UAS domain, and only one-third of these enterprises maintained KTT-relationships with universities, just like for the manufacturing sector. On a subsector level, the traditional services enterprises stick out. They set off at roughly the same values but quickly disperse after that.

About two-thirds of all construction enterprises are engaged in KTT partnerships with the ETH domain or UAS in the latest period (2018). However, the picture in the 2005 period looks quite differently. Only about a quarter of KTT-active construction enterprises used UAS as partners while universities were partners for nearly 50% of these enterprises. The most prominent partner was the ETH domain.

If we focus on the diversity of these partners, the first thing that sticks out, is the fact that the average number of domains an enterprise has chosen as partner of KTT always lies between one and two. The manufacturing and services enterprises maintain more diverse relations than the construction enterprises, especially in the earliest period. The KTT-active low-tech manufacturing enterprises in the 2005 period as well as the high-tech manufacturing enterprises and modern services enterprises in the 2011 period had almost two different scientific domains as partners for KTT, on average.

Graph 3.1.2: Domains as partners of knowledge and technology transfer, by sector and sub-sector[30]



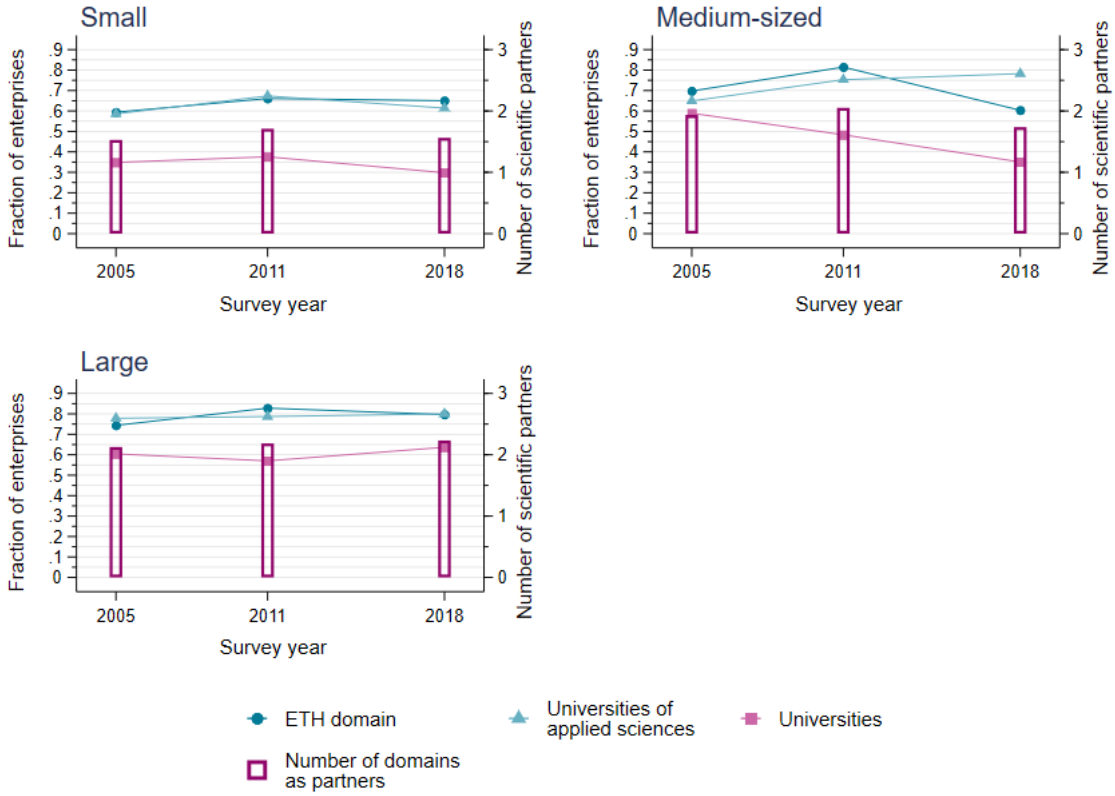
Note: This graphic shows the fraction of enterprises that conducted at least one form of knowledge and technology transfer with at least one institution of the respective domains (left scale) and the average number of domains per enterprise with which at least one form of knowledge and technology transfer has been carried out (right scale).

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[30] The exact numbers that this graph is based on can be found in Table A6i on page 144 and Table A6ii on page 146 in the appendix.

Graph 3.1.3: Domains as partners of knowledge and technology transfer, by enterprise size[31]



Note: This graphic shows the fraction of enterprises that conducted at least one form of knowledge and technology transfer with at least one institution of the respective domains (left scale) and the average number of domains per enterprise with which at least one form of knowledge and technology transfer has been carried out (right scale).
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 3.1.3 shows the popularity of the three domains as partners of KTT as well as the diversity of contacts to them by enterprise size. We note that the ETH domain and the UAS are more frequent partners than universities, irrespective of enterprise size.

Small enterprises show the common pattern previously observed. About twice as much KTT-active enterprises collaborate with the ETH domain or UAS compared to universities. Medium-sized enterprises show a different picture. The fraction of enterprises that transferred knowledge and technology with universities started at about 60% and almost linearly dropped over time to 35% in 2018. The opposite trend holds for UAS. Initially, about two-thirds of all medium-sized enterprises transferred knowledge and technology with a university of applied sciences. This fraction steadily increased over the survey horizon to about 80%. The ETH domain shows the highest fraction in the first two periods. After an initial increase, this fraction decreased to 60% such that in the latest survey period (2018), medium-sized enterprises more frequently transferred knowledge and technology with universities of applied sciences than with the ETH domain.

Large enterprises stick out. Around 80% of all KTT-active large enterprises used the ETH domain as transfer partners and the same holds true for the UAS. These fractions remain stable over time. About 60% of all large enterprises use universities as partners of knowledge and technology transfer.

[31] The exact numbers that this graph is based on can be found in Table A6i on page 144 and Table A6ii on page 146 in the appendix.

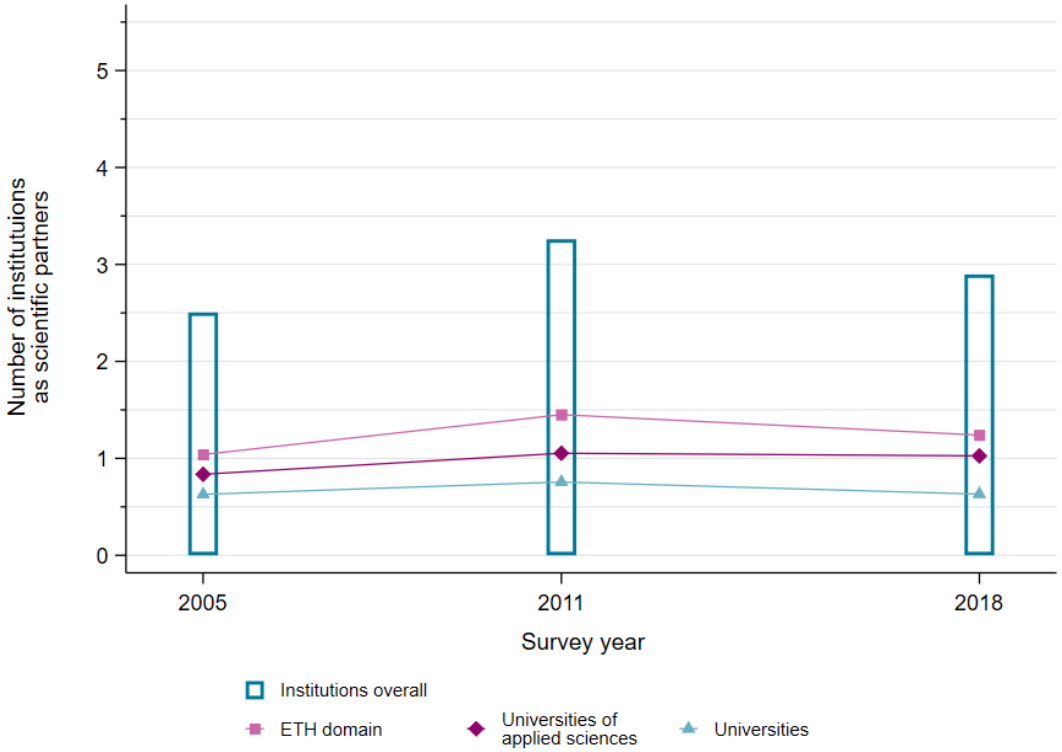
If we look at the diversity of transfer partners, we see that the diversity is increasing in enterprise size. KTT-active large enterprises have more than two domains as transfer partners, on average. Medium-sized enterprises have around two domains as transfer partners, although this diversity dropped in the latest survey period. Small enterprises have far below two transfer partners, on average.

These findings show that the ETH domain and universities of applied sciences are the most frequent partners. Overall, they are of similar popularity although their relative importance differs by sector, subsector, and enterprise size. By contrast, universities are less frequent transfer partners. Again, this differs by sector, subsector, and enterprise size. Especially large enterprises collaborate with universities quite frequently. Furthermore, enterprises maintain diverse relations to scientific domains. On average, they target institutions from more than one domain as transfer partners. Large enterprises even maintain relations to more than two domains, on average.

4.1.3.2 Diversity of KTT partnerships

In this section, we investigate with how many single public research institutions a private enterprise entertains KTT relations, on average. The diversity of partnerships indicates the complementarity of the Swiss education system with respect to the transfer offerings.

Graph 3.2.1: Diversity of knowledge and technology transfer partners, overall[32]



Note: This graphic shows the average number of all public research institutions per enterprise with which at least one form of knowledge and technology transfer has been carried out (bars) and their composition by domains (connected dots).
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

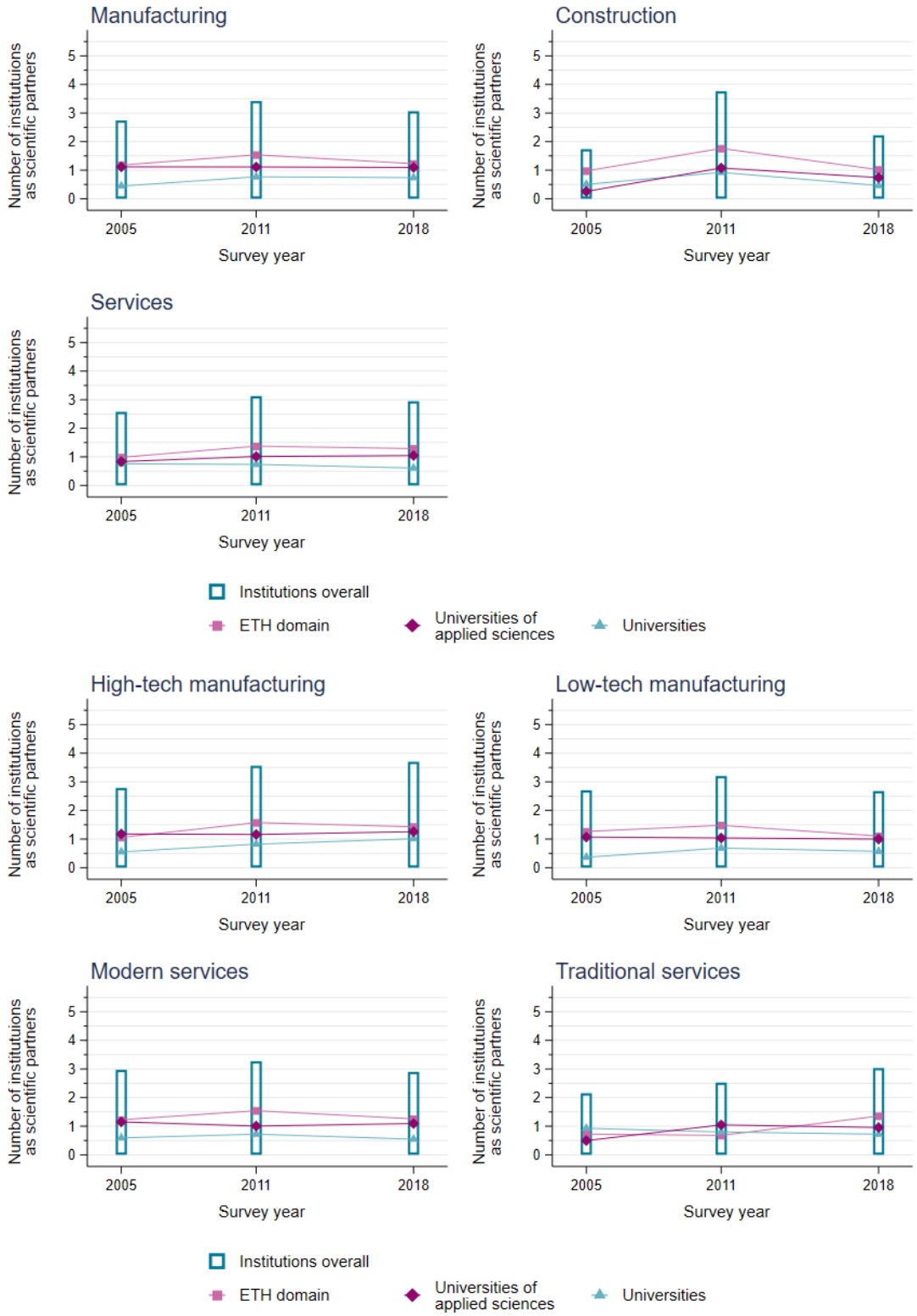
Graph 3.2.1 shows the average number of single public research institutions per private enterprise that were KTT partners in a specific survey period. The vertical bars show the average number of all single scientific partners per enterprise and the connected symbols reflect the average number of scientific partners in a specific domain per enterprise. In that sense, the sum of the values of the symbols equals the value for the vertical bars in a certain period. For instance, in the 2005 survey period, an enterprise that was engaged in KTT had on average contacts to 2.5 public research institutions consisting of 1.1 institution from the ETH domain, 0.8 universities of applied sciences and 0.6 universities.

The overall diversity of partners reached its peak in the 2011 period. Between 2005 and 2010, a KTT-active enterprise transferred knowledge and technology with over three single public research institutions, on average. In the 2018 period, an enterprise held an average of slightly below three scientific partners. The 2005 period records the lowest overall diversity with an average of about 2.5 scientific partners.

As could be expected from the previous subsection, the most diverse relations are kept with the ETH domain followed by the UAS and finally the universities. The diversity of these relations within each domain is relatively stable over time.

[32] The exact numbers that this graph is based on can be found in Table A6ii on page 146 in the appendix.

Graph 3.2.2: Diversity of knowledge and technology transfer partners, by sector and subsector[33]



Note: This graphic shows the average number of all public research institutions per enterprise with which at least one form of knowledge and technology transfer has been carried out (bars) and their composition by domains (connected dots).
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector
Source: KOF-KTT surveys (2005, 2011, 2018)

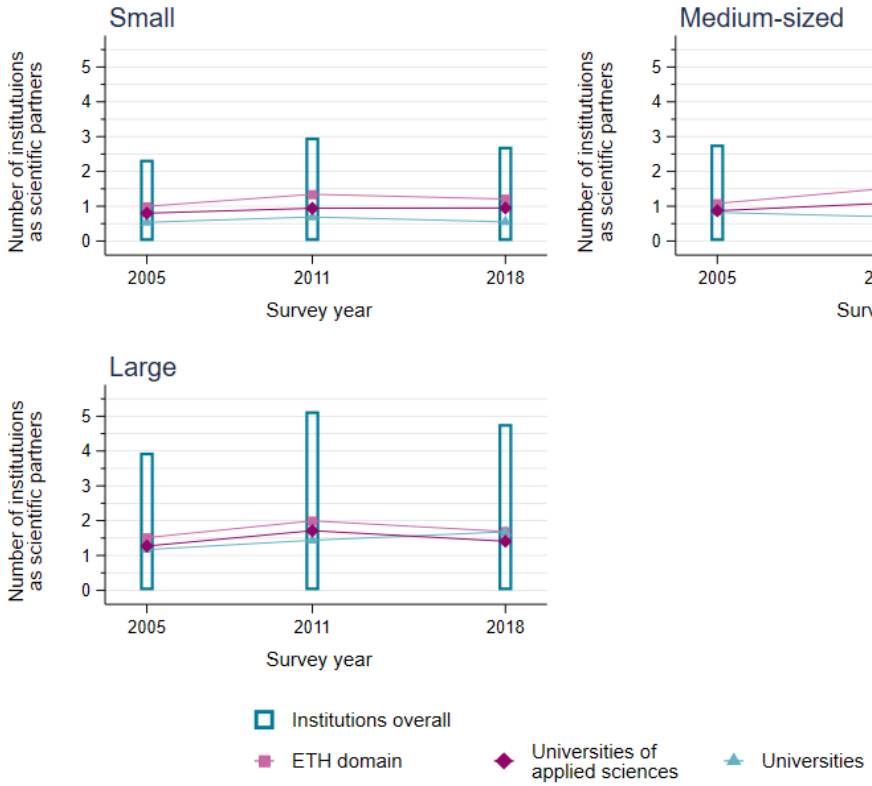
[33] The exact numbers that this graph is based on can be found in Table A6ii on page 146 in the appendix.

Graph 3.2.2 shows the diversity of scientific partners by sector and subsector. In line with the overall picture, the diversity peaked in the 2011 period. However, this is more accentuated in some sectors than in others.

The manufacturing sector records on average between 2.5 and 3.5 institutions as transfer partners per enterprise. The high-tech manufacturing subsector shows a steady increase in diversity over time while the diversity in the low-tech manufacturing subsector first increases and then decreases. A constantly increasing diversity of university partners drives the overall increase in the former sector. Yet, both subsectors still hold the most diverse relations with the ETH domain, followed by the UAS and finally with universities.

Service enterprises have slightly less diverse transfer partners. Especially the traditional services subsector has fewer transfer partners, although their diversity constantly increases and even catches up to the other subsectors in the latest period, except for the high-tech manufacturing subsector. The service sector shows the exact same relative diversity between domains. The traditional services subsector deviates from this picture. The relative diversity per domain constantly changed over time.

Graph 3.2.3: Diversity of knowledge and technology transfer partners, by enterprise size[34]



Note: This graphic shows the average number of all public research institutions per enterprise with which at least one form of knowledge and technology transfer has been carried out (bars) and their composition by domains (connected dots).
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size
Source: KOF-KTT surveys (2005, 2011, 2018)

The construction sector portrays the most accentuated peak. In the 2011 period, a construction enterprise had on average almost four different scientific partners for their KTT activities. An increase in the diversity of partners in the ETH domain and in the UAS domain are responsible for this peak. This is the

[34] The exact numbers that this graph is based on can be found in Table A6ii on page 146 in the appendix.

most diverse relations of any sector or subsector in any period. This might be related to the fact, that only few construction enterprises are having transfer activities. The few that did so, however, collaborated with many different institutions at this specific point in time. Contrasting this maximum, the other two survey periods show the exact opposite: minimal diversity.

Graph 3.2.3 depicts the diversity of scientific partners by enterprise size. In line with Graph 3.1.3, the diversity of transfer partners is increasing in enterprise size with respect to single institutions as well as with respect to domains; the larger the enterprise the larger the average number of public research institutions and the larger the average number of domains that are used as KTT partners.

On average, small enterprises maintain KTT relations with 2.5 to 3 public research institutions. Medium-sized enterprises are in the same range but record a slightly greater average diversity. SMEs also show the relative diversity between domains corresponding to the overall picture. The most diverse partnerships are held with the ETH domain, followed by universities of applied sciences and then universities.

Large enterprises, on the other hand, really set themselves apart from SMEs when it comes to diversity. Between four and five public research institutions are KTT partners, depending on the survey period. On average, they have more than one scientific partner in each of the three domains, even with universities. Between 2005 and 2010, they even managed to collaborate with more than two public research institutions solely in the ETH domain.

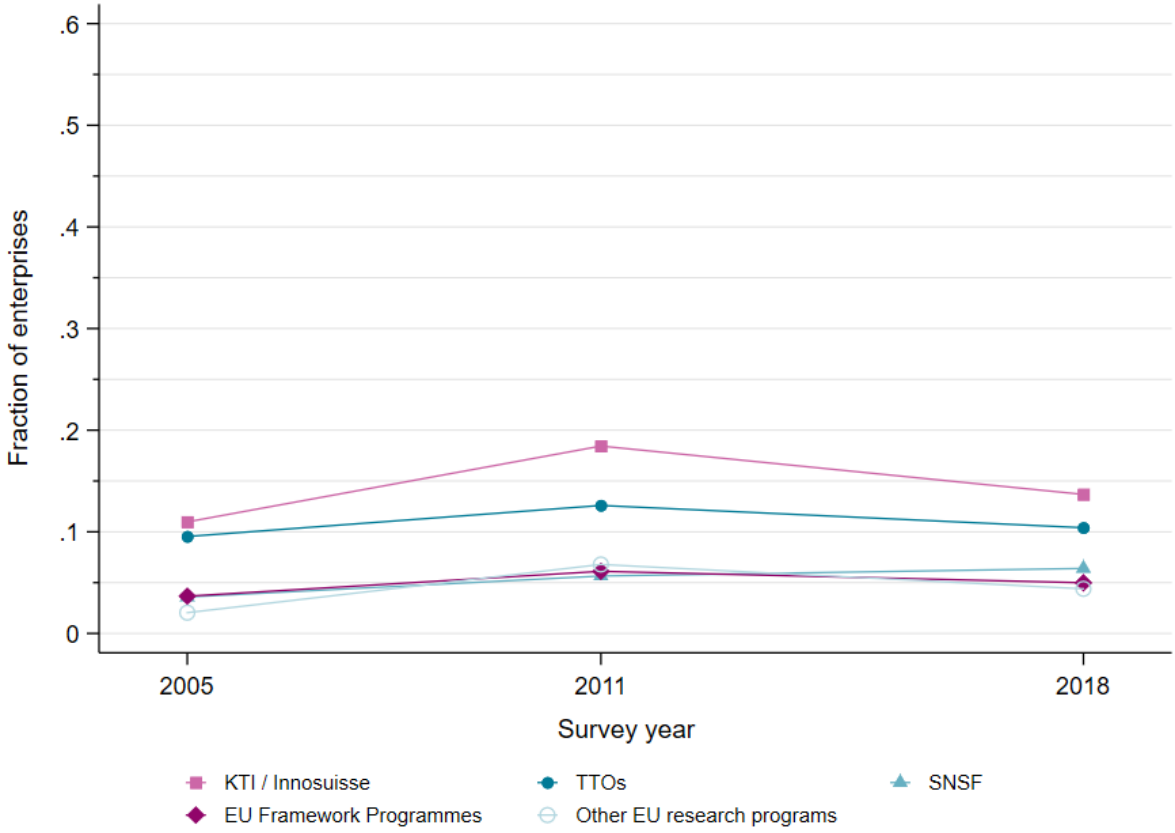
These insights let us conclude the following. The diversity of scientific transfer partners peaked in the 2011 period although there are some notable exceptions on the subsector level. The most diverse transfer relations occur with the ETH domain, followed by universities of applied sciences and finally with universities. Again, there are some exceptions on the sector and subsector level, particularly in the traditional services subsector. Furthermore, the number of transfer partners increases in enterprise size. The greatest differences we see is between SMEs and large enterprises.

4.1.4 Mediators

In this section, we identify the mediators and promoters of knowledge and technology transfers with public research institutions that are very relevant to private enterprises. We distinguish between five types of mediators: the Swiss innovation agency (Innosuisse, formerly known as KTI), technology transfer offices of the public research institutions (TTO), the Swiss National Science Foundation (SNSF), the EU Framework Programmes, and other EU research programs. This subsection comprises two parts. *Section 4.1.4.1* looks at the fraction of KTT-active enterprises that see a specific mediator as highly important. *Section 4.1.4.2* looks at the fraction of KTT-active enterprises that see at least a certain relevance of a specific mediator.

4.1.4.1 High Relevance

Graph 4.1.1: Mediators of knowledge and technology transfer (high relevance), overall[35]



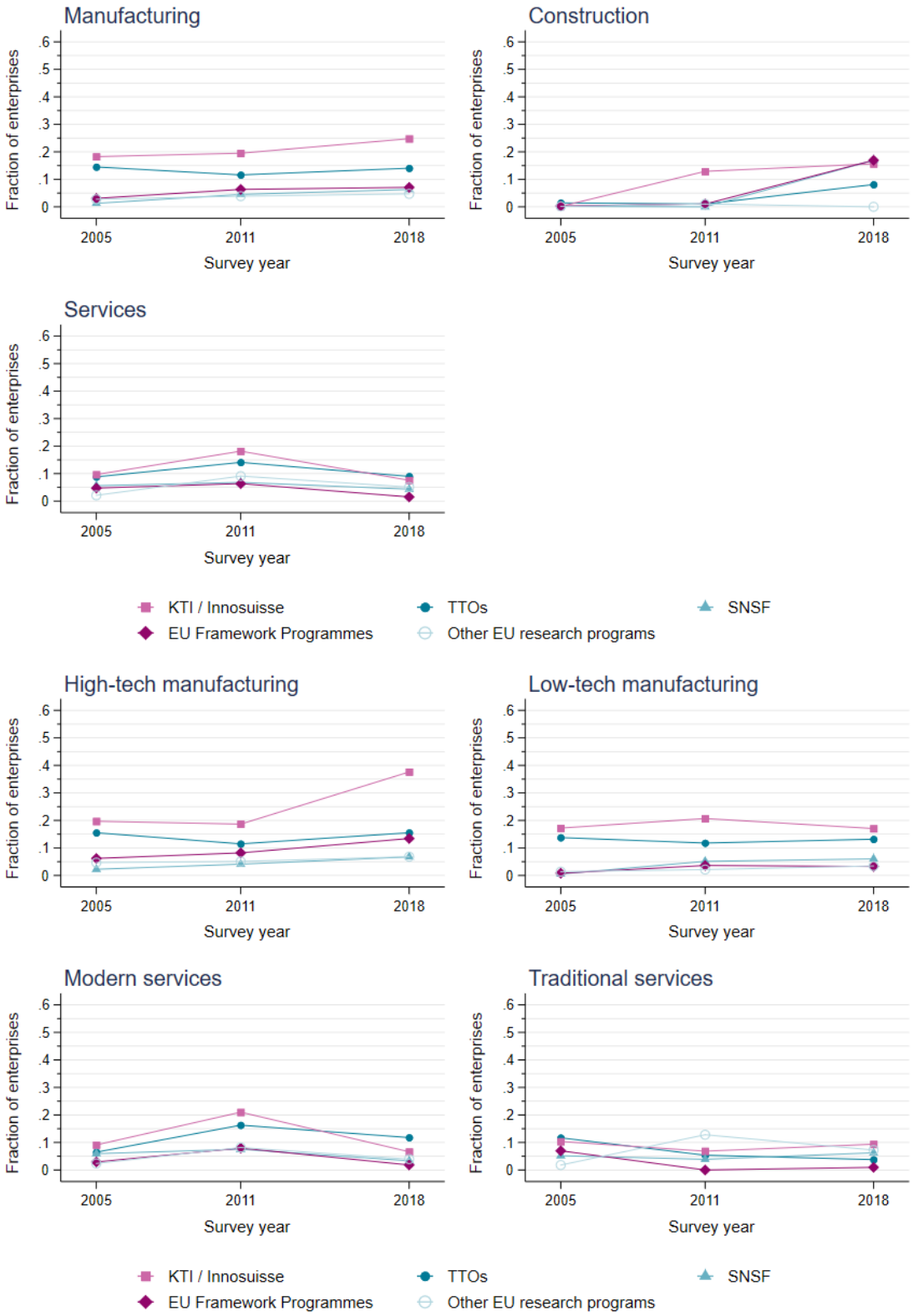
Note: This graphic shows the fraction of enterprises that reported a mediator of knowledge and technology transfer as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 4.1.1 shows the fraction of private enterprises engaged in KTT, which reported one of the five mediators as highly relevant (values 4 or 5 on a 5-point ordinal scale).

Overall, there is not one mediator who is highly relevant to more than 20% of all enterprises. The Innosuisse is the most frequently mentioned highly relevant mediator, followed by TTOs. Between 10% and 20% of all KTT-active enterprises have a high valuation for these two types of mediators. The SNSF, the EU Framework Programmes and other EU research programs are highly relevant to about 5% of all KTT-active enterprises only.

[35] The exact numbers that this graph is based on can be found in Table A7i on page 147 in the appendix.

Graph 4.1.2: Mediators of knowledge and technology transfer (high relevance), by sector and subsector[36]



Note: This graphic shows the fraction of enterprises that reported a mediator of knowledge and technology transfer as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[36] The exact numbers that this graph is based on can be found in Table A7i on page 147 in the appendix.

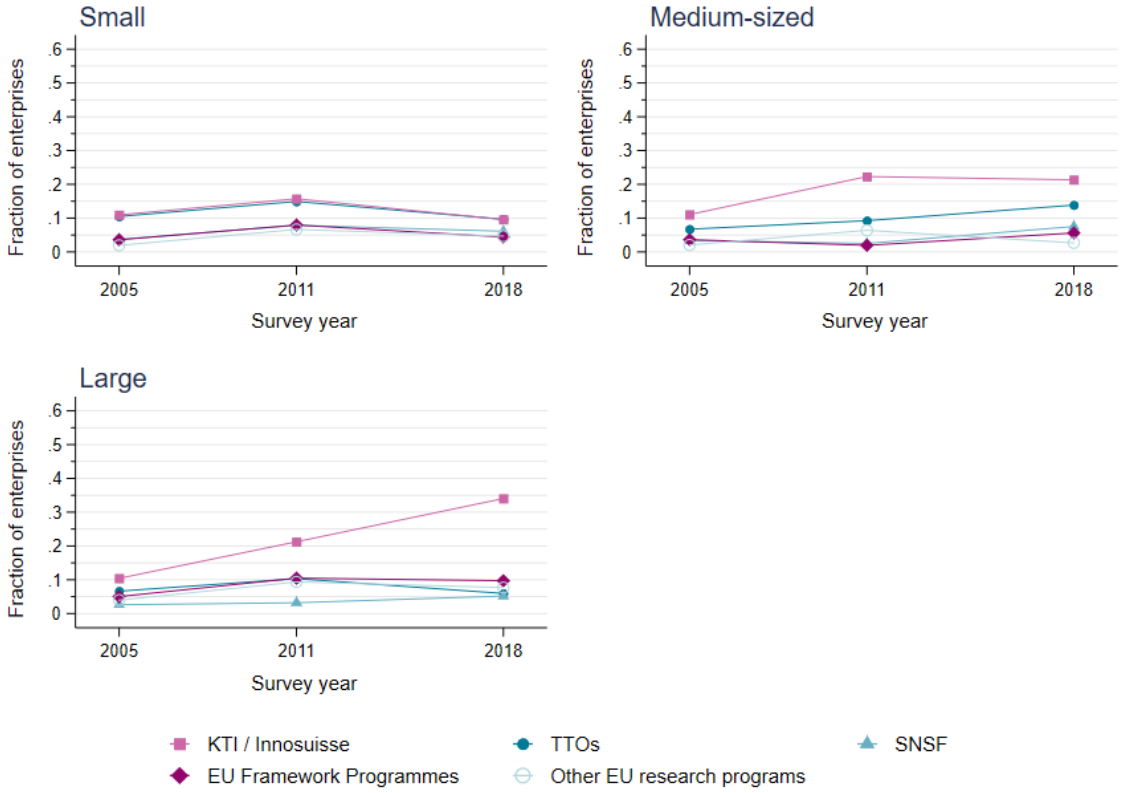
Graph 4.1.2 depicts the fraction of KTT-active enterprises with a high valuation for a specific mediator in each of the three survey periods by sector and subsector. In most sectors and subsectors, the Innosuisse is the most important KTT mediator. There are, however, some exceptions.

Between a fifth and a quarter of all KTT-active manufacturing enterprises report a high relevance of the Innosuisse. This is by far the biggest fraction for any mediator in any sector. This relevance is even more accentuated in the high-tech manufacturing subsector. In the 2018 survey period, nearly 40% of all high-tech manufacturing enterprises engaged in KTT highly appreciated the service of Innosuisse. This fraction is about 20% for the low-tech manufacturing subsector. The TTOs are also of some relevance for the manufacturing sector as are the EU Framework Programmes for high-tech manufacturing enterprises since the 2011 survey period.

The service sector shows a lower appreciation for KTT mediators. Only in the 2011 survey period, over 10% of KTT-active enterprises reported the Innosuisse or TTOs as highly relevant. In all other cases, these fractions were below 10%. In the last two periods, the EU Framework Programmes were hardly relevant for the traditional services subsector.

The construction sector shows an interesting picture. In the first survey period, hardly any mediator was of a high relevance. The same holds true for the next period, except for the Innosuisse. In the latest period, the EU Framework Programmes and the Innosuisse were highly relevant to more than 15% of all KTT-active construction enterprises.

Graph 4.1.3: Mediators of knowledge and technology transfer (high relevance), by enterprise size[37]



Note: This graphic shows the fraction of enterprises that reported a mediator of knowledge and technology transfer as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size
Source: KOF-KTT surveys (2005, 2011, 2018)

[37] The exact numbers that this graph is based on can be found in Table A7i on page 147 in the appendix.

Graph 4.1.3 shows the fraction of KTT-active enterprises by enterprise size that see a certain mediator as highly relevant for the transfer activities with public research institutions. Again, the Innosuisse seems to be the most appreciated mediator irrespective of enterprise size.

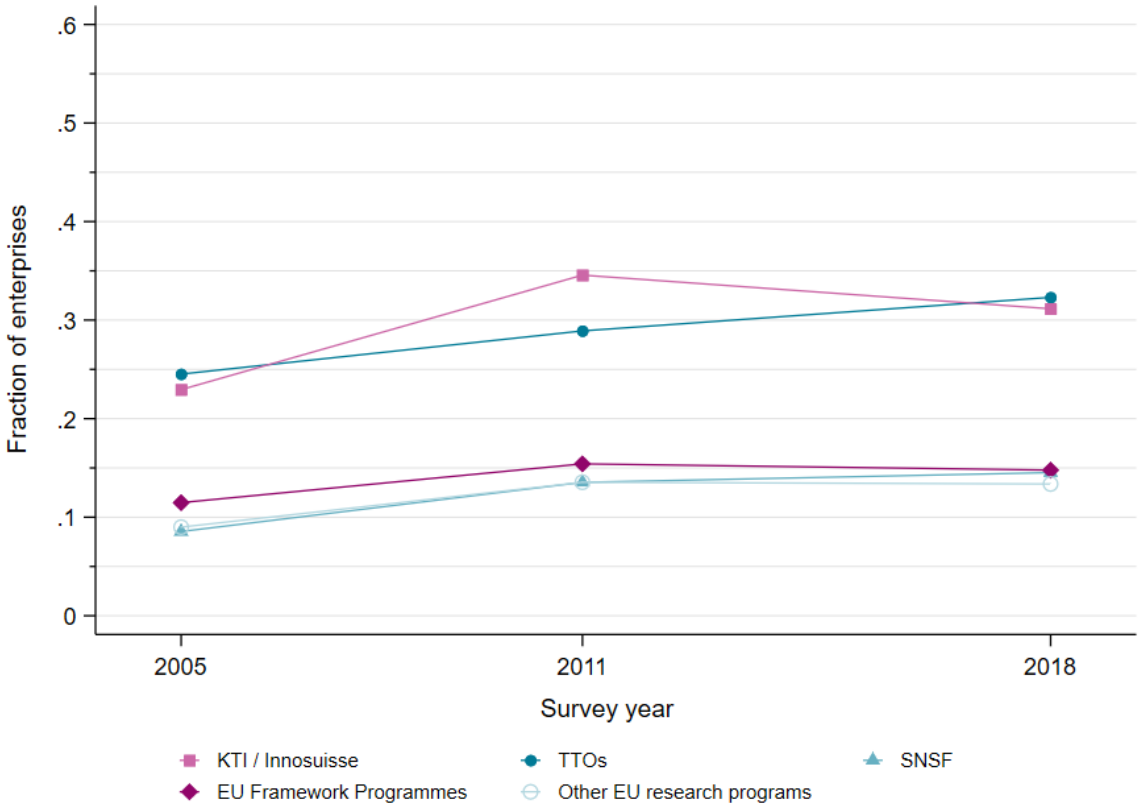
Small enterprises do not show a high valuation for any mediator. Medium-sized enterprises primarily cherish the Innosuisse. Most recently, they also highly valued TTOs more frequently. Large enterprises record a steady increase in the fraction of enterprises that see the Innosuisse as highly relevant. This fraction increased by 24% points to 34% of all KTT-active large enterprises. Besides the Innosuisse, large enterprises rarely show a high appreciation for the other four mediators.

Overall, we can say that private enterprises seldom show a high valuation for mediators and promoters of knowledge and technology transfer with public research institutions. The only exception is the Innosuisse that is highly cherished by a substantial fraction of the high-tech manufacturing subsector and by large enterprises.

4.1.4.2 Medium Relevance

The previous subsection showed that a high relevance of KTT mediators is rare. In this subsection, we focus our analyses on the enterprise responses that assign medium to high level of relevance to the mediators.

Graph 4.2.1: Mediators of knowledge and technology transfer (medium relevance)[38]



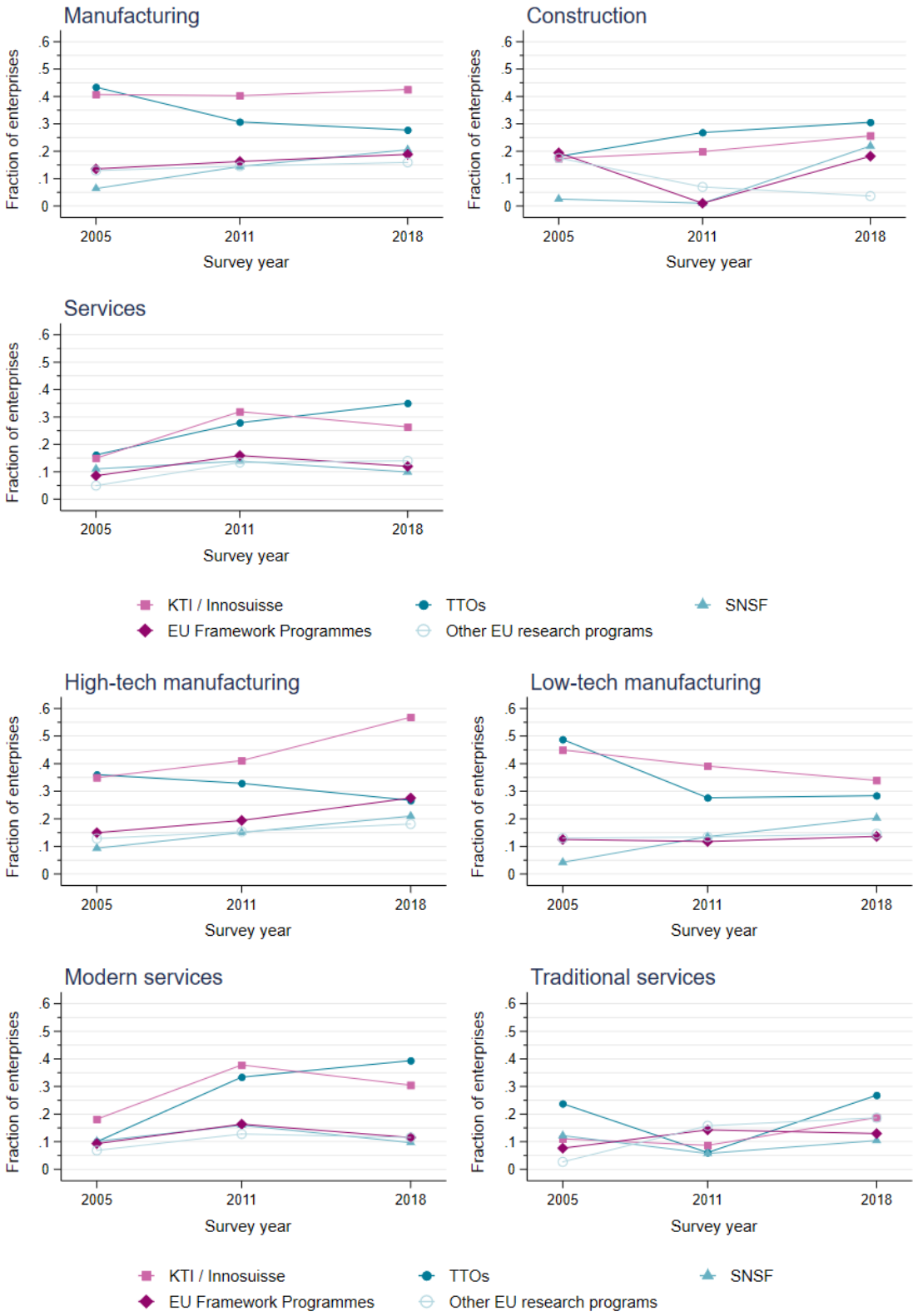
Note: This graphic shows the fraction of enterprises that reported a mediator of knowledge and technology transfer as reasonably relevant (values >= 3 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 4.2.1 shows the fraction of KTT-active enterprises that reported at least a medium level of relevance of a certain KTT mediator (values 3, 4, or 5 on a 5-point ordinal scale). In comparison with Graph 4.1.1 we see a substantial difference between the fraction of enterprises that sees mediators as highly relevant and the fraction that sees at least a medium level of relevance in them. This difference implies that there are many enterprises reporting the value three on our five-point ordinal scale implying a medium relevance.

Over a quarter of all KTT-active enterprises assign a medium to high level of importance to TTOs. This fraction has risen over time and stands at a third in the latest survey period. If we compare this to the fraction that only shows a high valuation for TTOs, we see that between 15% and 22% KTT-active enterprises see TTOs as moderately relevant[39]. There is also a significantly larger fraction of enterprises showing at least some valuation for the Innosuisse. Approximately, the same fraction of enterprises sees at least some relevance in the Innosuisse as in TTOs. The other three mediators still receive about the same appreciation with around 15% of all enterprises attaching at least some relevance to them.

[38] The exact numbers that this graph is based on can be found in Table A7ii on page 147 in the appendix.
[39] The difference between the values in Graph 4.2.1 and Graph 4.1.1 corresponds to the fraction of KTT-active enterprises that reported 3 on the 5-point ordinal scale implying a medium relevance.

Graph 4.2.2: Mediators of knowledge and technology transfer (medium relevance), by sector and subsector[40]



Note: This graphic shows the fraction of enterprises that reported a mediator of knowledge and technology transfer as reasonably relevant (values >= 3 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[40] The exact numbers that this graph is based on can be found in Table A7ii on page 147 in the appendix.

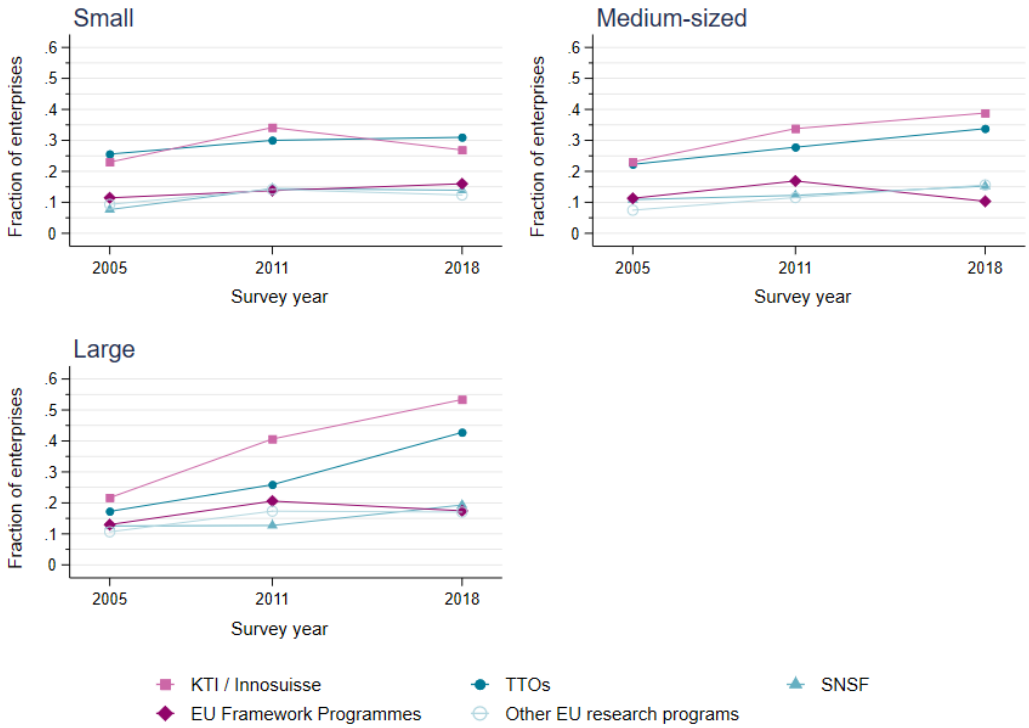
Graph 4.2.2 depicts the fraction of enterprises by sector and subsector that value the KTT mediators at least moderately. The Innosuisse remains the most frequently appreciated mediator, although there are some differences between sectors and subsectors.

In the manufacturing sector, about 40% of all KTT-active enterprises cherish the Innosuisse at least moderately. While this fraction remains stable over time for the whole sector, the high-tech manufacturing subsector shows a steady increase up to over 55% in the most recent period (+22% points) while the low-tech manufacturing subsector shows the exact opposite trend (-11% points). Meanwhile the relevance of TTOs decreased substantially for the whole manufacturing sector (-15% points) as well as for both subsectors. In comparison with Graph 4.1.2 we can clearly see that this reduction is attributable to the reduced medium rating for TTOs.

The service sector, on the other hand, shows the exact opposite trend. TTOs have steadily gained in importance. This is clearly attributable to the increase in medium valuation. While this increase also applies for the Innosuisse, these fractions have dropped in the latest period. The modern services subsector shows the exact same picture. The traditional services subsector generally shows the lowest appreciation for mediators. TTOs are the only mediators that receive some appreciation except for the 2011 period. This appreciation mostly reflects a medium relevance.

The construction sector also shows the highest esteem for TTOs, followed by the Innosuisse. By comparing the two graphs for some and high relevance of mediators, we see that there exists substantial differences with respect to TTOs. This implies that the construction sector assesses relatively frequently a medium relevance to TTOs.

Graph 4.2.3: Mediators of knowledge and technology transfer (medium relevance), by enterprise size[41]



Note: This graphic shows the fraction of enterprises that reported a mediator of knowledge and technology transfer as reasonably relevant (values >= 3 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size

Source: KOF-KTT surveys (2005, 2011, 2018)

[41] The exact numbers that this graph is based on can be found in Table A7ii on page 147 in the appendix.

Graph 4.2.3 finally depicts this information by enterprise size. Again, there are substantial differences compared to high relevance only. Many enterprises think of mediators as moderately important, especially TTOs. Overall, the Innosuisse remains the most relevant although its relative importance compared to TTOs decreases in enterprise size.

Concluding both subsections, we can see that there are few enterprises with a high valuation for mediators and promoters of knowledge and technology transfer. However, there exists a reasonable fraction of enterprises, which show at least a medium level of appreciation for mediators. The most relevant mediators are the Innosuisse and TTOs.

4.2 Drivers of KTT

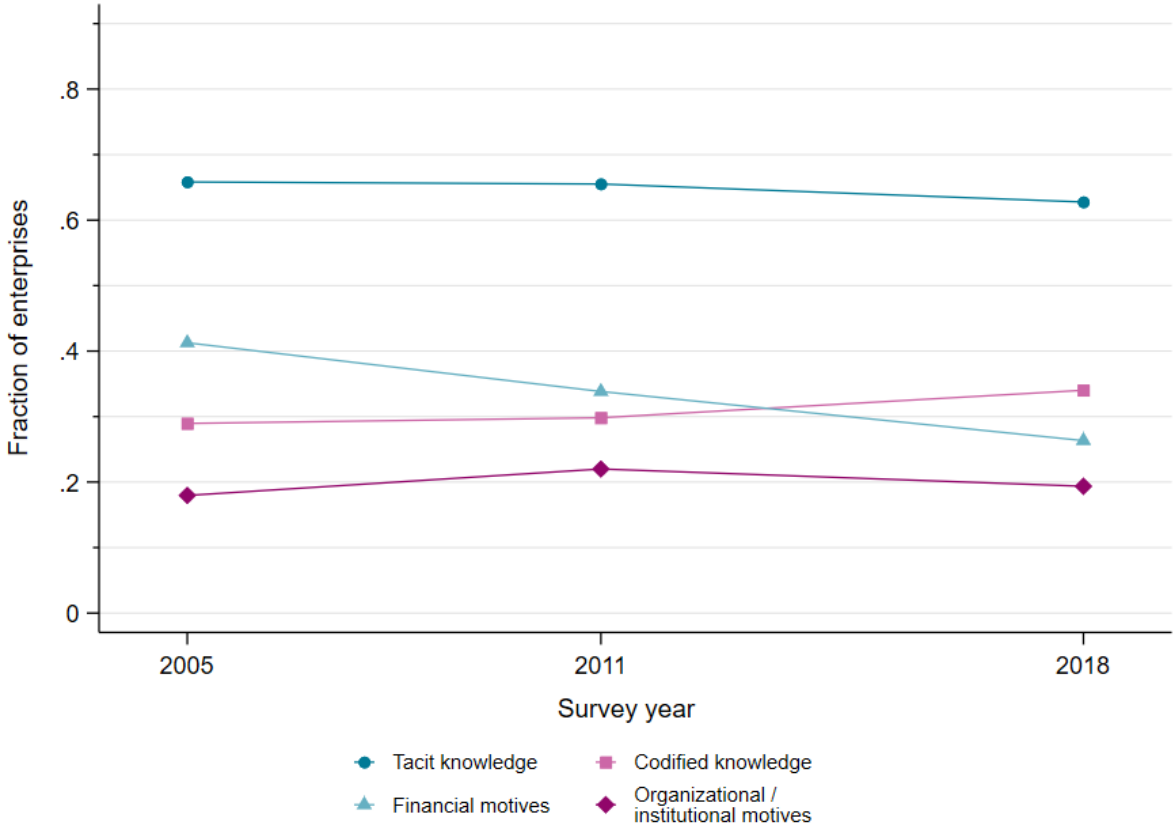
In this section, we investigate what drives enterprises to engage in knowledge and technology transfer activities. *Section 4.2.1* analyzes the self-reported motives of KTT-active enterprises. *Section 4.2.2* is concerned with the enterprise characteristics that correlate with a higher probability of conducting KTT.

4.2.1 Motives

This subsection focuses on the perspective of the enterprises and asks which motives KTT-active enterprises report as drivers of their transfer activities. The structure of this section is of a similar fashion to the section that is concerned with transfer forms. We will first analyze categories consisting of single motives and in a later stage look at the single motives within a certain category. We distinguish between 16 single motives that are categorized into four groups: «Tacit knowledge», «codified knowledge», «financial motives», and «organizational or institutional motives».

4.2.1.1 Categories

Graph 5.1: Motive categories for knowledge and technology transfer, overall[42]



Note: This graphic shows the fraction of enterprises that reported at least one single motive for knowledge and technology transfer in the above mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 5.1 shows the fraction of KTT-active enterprises that reported at least one single motive in one of the four categories as highly relevant (values 4 or 5 on a 5-point ordinal scale).

[42] The exact numbers that this graph is based on can be found in Table A8i on page 149 in the appendix.

«Tacit knowledge» is the one prevalent motivation for private enterprises to enter into knowledge and technology transfer activities with public research institutions. Two thirds of all KTT-active enterprises see at least one single motive in the category of «tacit knowledge» as a highly relevant motive. This fraction is completely stable over the survey horizon.

The other three categories are less important. However, we can still note some interesting developments. «Financial motives» were the second most important motive category but steadily decreased in their relevance (-15% points) over time. On the other hand, «codified knowledge» was the third most important motive category but remained equally relevant over time. In the latest period, «codified knowledge» overtook «financial motives» in importance. This indicates that KTT is less about getting a low-cost access to knowledge and more about transferring tacit and «codified knowledge». «Tacit knowledge» refers to the stickiness of knowledge in terms of, e.g., experience, which can only be transferred through personal contact (e.g. by training), and «codified knowledge» refers to «off the shelf» technological artefacts that might complement in-house knowledge of the enterprise. «Organizational and institutional motives» are of minor importance.

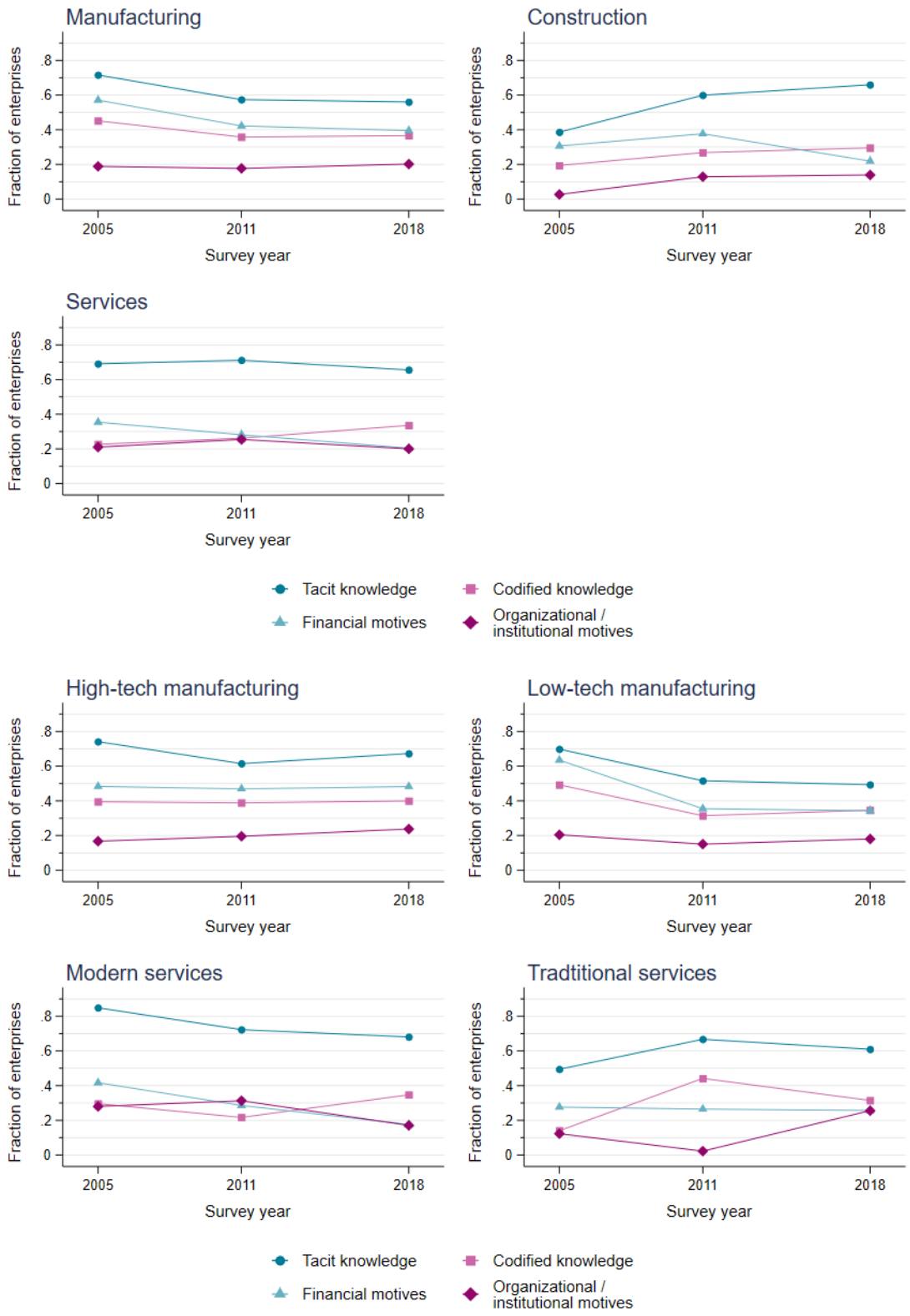
Graph 5.2 portrays the fraction of KTT-active enterprises that see a certain motive category as highly relevant when split by sector and subsector. «Tacit knowledge» is still the most prevalent motive for KTT, irrespective of sector or subsector. Another common aspect is that the relevance of each category is fairly stable over the three survey periods, at least in most sectors and subsectors.

The manufacturing sector shows a clear picture. «Tacit knowledge» is the most important motive, followed by «financial motives», then «codified knowledge», and finally «organizational and institutional motives». There are no major trends for any category. The same holds true for the two subsectors high-tech and low-tech manufacturing. The latter subsector, though, records a sharp decline in the relevance of «financial motives» between the first two survey periods.

The service sector shows a different picture. While «tacit knowledge» is undoubtedly the most important motive, the other three categories are similarly relevant. Less than half of the services enterprises think of «codified knowledge», «financial motives», or «organizational and institutional motives» as relevant motives compared to «tacit knowledge». Both subsectors (modern services, traditional services) show similar pictures.

The construction sector is also similar. «Tacit knowledge» is the most important motive, followed by «financial motives», «codified knowledge», and finally «organizational and institutional motives». «Tacit knowledge» became an even more prevalent motive while the fraction of KTT-active enterprises that see «financial motives» as highly relevant decreased in the latest survey period.

Graph 5.2: Motive categories for knowledge and technology transfer, by sector and subsector[43]



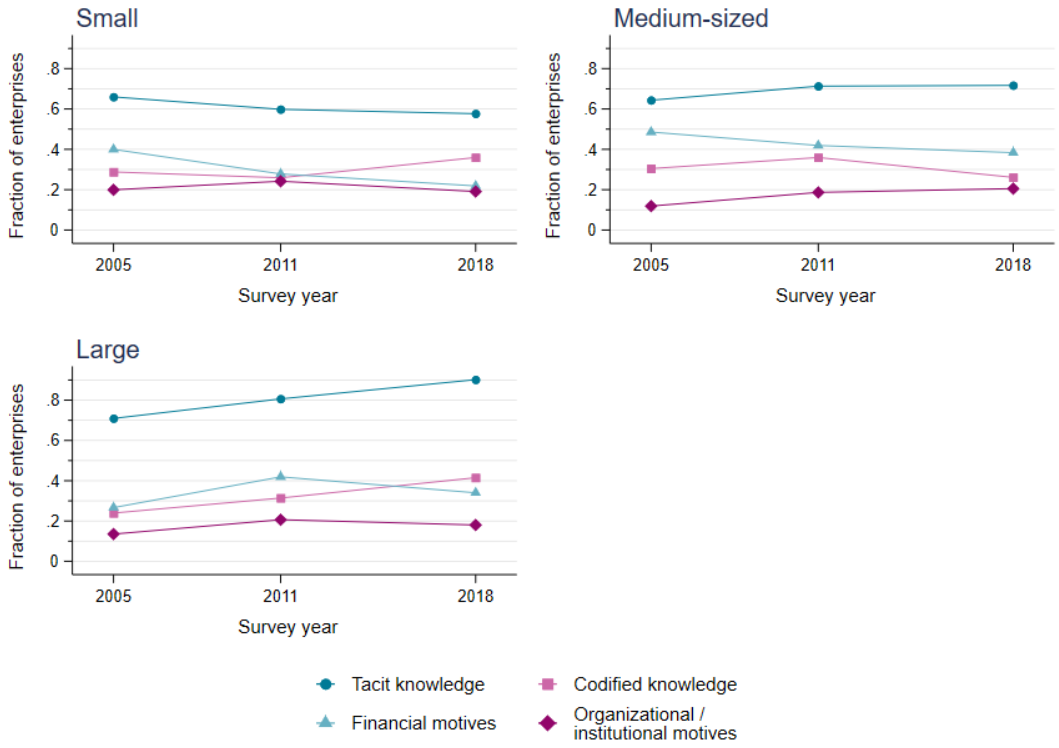
Note: This graphic shows the fraction of enterprises that reported at least one single motive for knowledge and technology transfer in the above mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[43] The exact numbers that this graph is based on can be found in Table A8i on page 149 in the appendix.

Graph 5.3: Motive categories for knowledge and technology transfer, by enterprise size[44]



Note: This graphic shows the fraction of enterprises that reported at least one single motive for knowledge and technology transfer in the above mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 5.3 depicts the relevance of the four motive categories by enterprise size. The fraction of enterprises that see «tacit knowledge» as a highly relevant motive is increasing in enterprise size. SMEs and large enterprises all start out at about two-thirds of all KTT-active enterprises that reported this category as highly relevant but their paths took off in different directions after that. While the fraction of small enterprises slightly decreased, medium-sized enterprises recorded a slight increase. Large enterprises, on the other hand, recorded a much steeper increase. Between 2012 and 2017, 90% of all large enterprises engaged in KTT thought of «tacit knowledge» as a highly relevant motive.

Medium-sized enterprises are more driven by «financial motives» than large or small enterprises. While «codified knowledge» initially is the third most important motive, it has gained in significance over the years for small and large enterprises. However, this is not the case for medium-sized enterprises. Here, the meaning of «codified knowledge» for KTT remains rather stable across time. They are less inclined to look for «off the shelf» solution to their innovation challenges, they need more tailor-made components contained in the «tacit knowledge» of the KTT partner. «Organizational and institutional motives» are of minor importance for any enterprise size.

Thus, a clear picture emerges. Enterprises are mostly motivated by «tacit knowledge» independent of the sector or the size of an enterprise. «Financial motives» and «codified knowledge» are also important but vary across size, sector, subsector, and particularly over time. «Organizational and institutional motives» are minor drivers for KTT.

[44] The exact numbers that this graph is based on can be found in Table A8i on page 149 in the appendix.

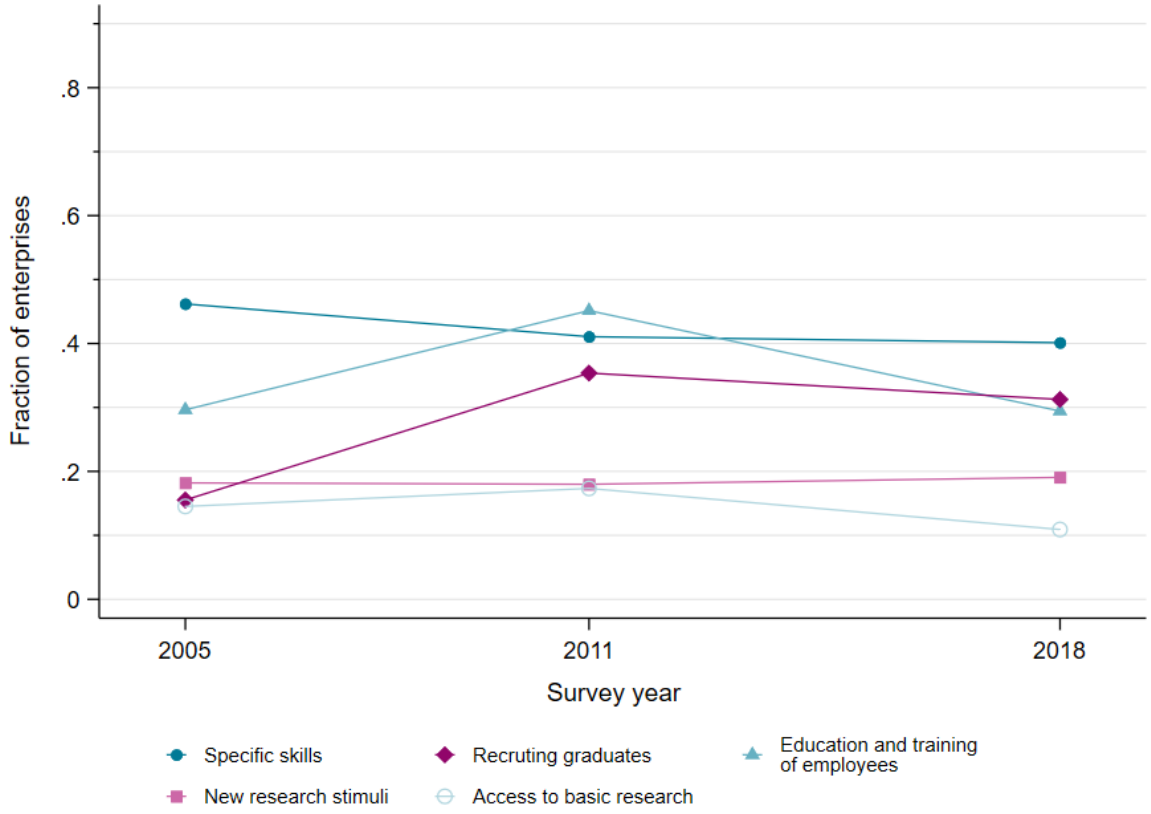
4.2.1.2 Single motives

In this section, we investigate the single motives. We analyze which single motives in a certain category are most relevant and which motives drive the developments of the overall categories.

4.2.1.2.1 Tacit knowledge

The most prevalent motive category, «tacit knowledge», comprises five single motives: «Access to specific skills» as a complement of internal know-how, «new research stimuli», «education and training opportunities» for employees, «recruiting graduates», and «access to basic research» of the scientific partner.

Graph 5.1.1: Single motives for knowledge and technology transfer in the category «Tacit knowledge», overall[45]

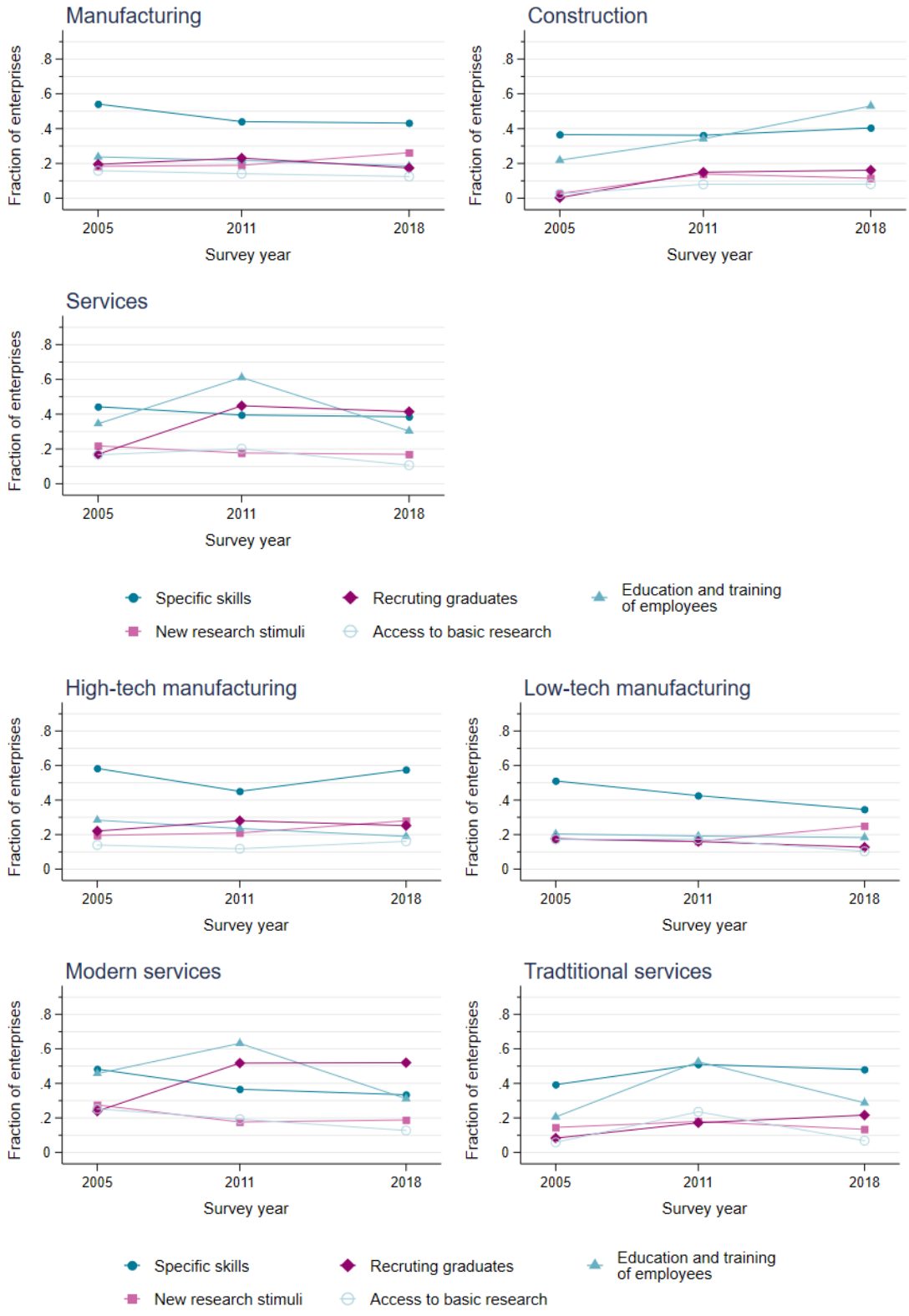


Note: This graphic shows the fraction of enterprises that reported a specific single motive for knowledge and technology transfer in the category «Tacit knowledge» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 5.1.1 shows the fraction of KTT-active enterprises that reported a specific single motive in the category of «tacit knowledge» as highly relevant. Three single motives seem to matter most. «Access to specific skills» is mentioned by more than 40% of all KTT-active enterprises as an important motive. Education and training opportunities for employees is a highly relevant driver for around 30% and even 50% in between 2005 and 2010. «Recruiting graduates» is also a highly important motive for more than 30% of all KTT-active enterprises, except for the first period. This is also in line with Graph 2.1 and especially Graph 2.3.1 that showed the relevance of «education & mobility» and particularly the relevance of training opportunities and «recruiting graduates» as highly relevant transfer forms. «New research stimuli» and «access to basic research» do not seem to be that important drivers for KTT.

[45] The exact numbers that this graph is based on can be found in Table A8ii on page 150 in the appendix.

Graph 5.1.2: Single motives for knowledge and technology transfer in the category «Tacit knowledge», by sector and subsector[46]



Note: This graphic shows the fraction of enterprises that reported a specific single motive for knowledge and technology transfer in the category «Tacit knowledge» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

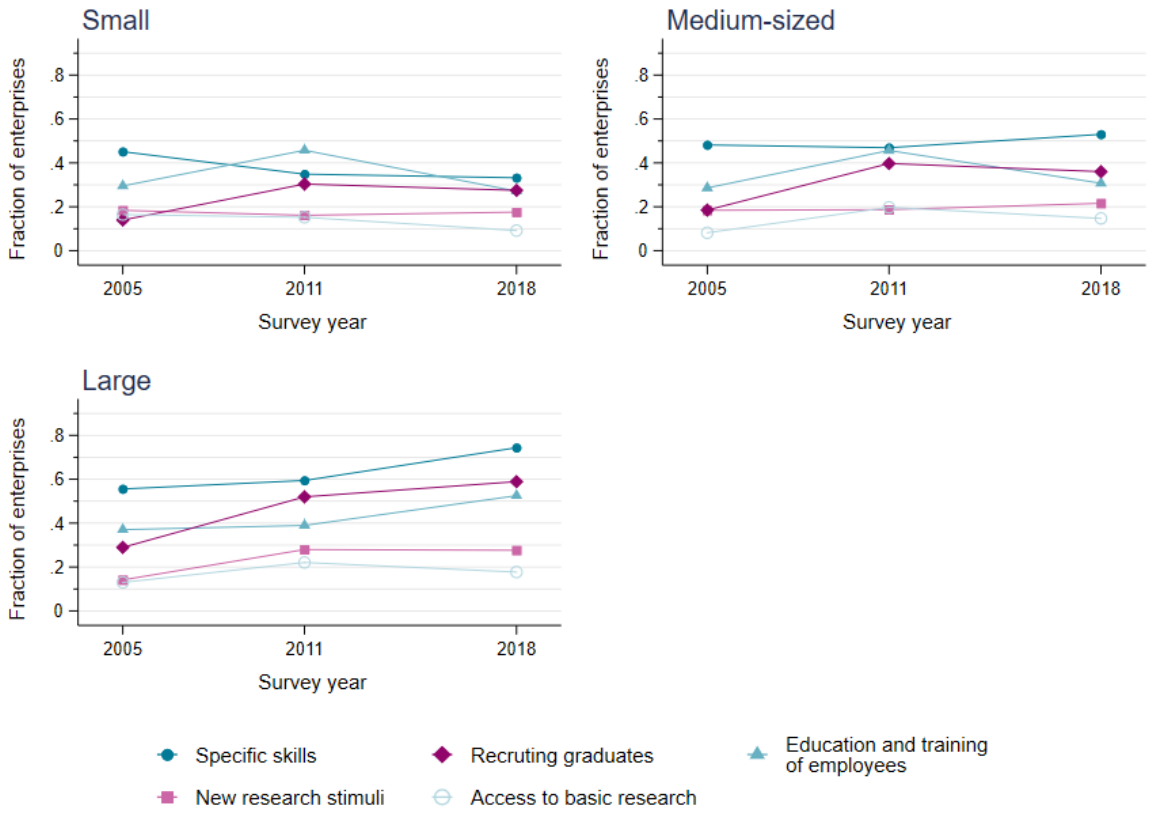
[46] The exact numbers that this graph is based on can be found in Table A8ii on page 150 in the appendix.

Graph 5.1.2 shows the relevance of single «tacit knowledge» motives by sector and subsector. The manufacturing sector is mostly driven by «access to specific skills». This valuation for specific skills is stable over time. The high-tech manufacturing subsector sees «specific skills» as an even more important motive than does the low-tech manufacturing subsector. The latter subsector even records a falling fraction of KTT-active enterprises that see «specific skills» as an important motive. The other four motives are far less important in manufacturing.

The service sector, on the other hand, also sees «recruiting graduates» and especially «education and training opportunities» for employees as important motives. The former motive is more relevant in the modern services subsector, while the latter motive is important in both subsectors, although it has lost relevance in the latest survey period.

«Access to specific skills» and «education and training opportunities» are the most important motives in the construction sector. The latter motive continuously gained in importance over the years and became the most important driver in the latest period, while the relevance of specific skills has remained stable over time.

Graph 5.1.3: Single motives for knowledge and technology transfer in the category «Tacit knowledge», by enterprise size[47]



Note: This graphic shows the fraction of enterprises that reported a specific single motive for knowledge and technology transfer in the category «Tacit knowledge» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size
Source: KOF-KTT surveys (2005, 2011, 2018)

[47] The exact numbers that this graph is based on can be found in Table A8ii on page 150 in the appendix.

Graph 5.1.3 finally shows the relevance of these single motives by enterprise size. In line with the overall picture, «access to specific skills», «recruiting graduates», and «education and training of employees» are the most important drivers, irrespective of enterprise size.

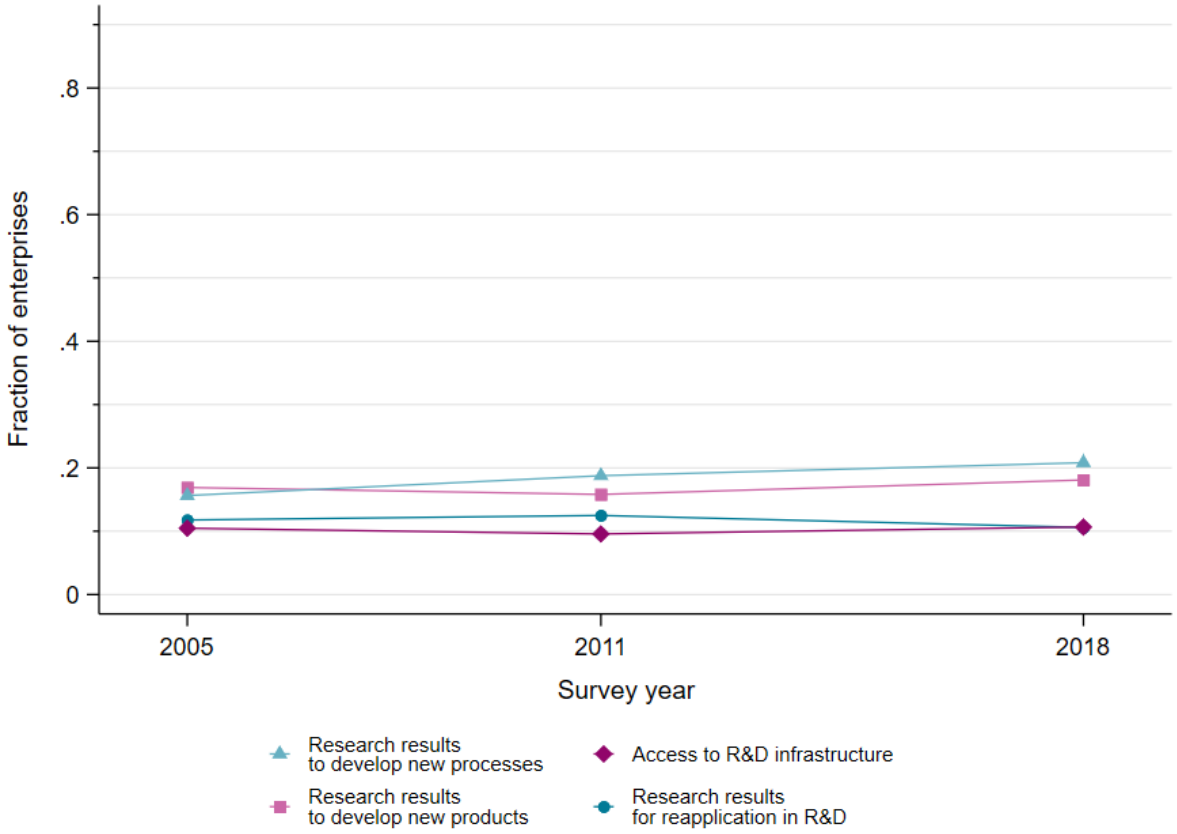
While small and medium-sized enterprises show similar values, large enterprises show comparatively higher values. Especially «access to specific skills» and «recruiting graduates» are more frequently mentioned as highly relevant motives to conduct KTT.

In sum, we see that among the motivation category «tacit knowledge», the single items «access to specific skills», «recruiting graduates», or «education and training opportunities» for employees are the most important in 2018. However, there are some important fluctuations over time, where in particular «recruiting graduates» gained in importance. There is also important variation between sectors, subsectors, and enterprise size classes. Most notable, the increasing importance of «recruiting graduates» in the modern service sector and in the group of large enterprises, as well as the strong increase of the importance of «education and training of employees» in the construction sector.

4.2.1.2.2 Codified Knowledge

The next motive category is «codified knowledge», which comprises four single motives: Access to «research results for further application in R&D», to «develop new products», or to «develop new processes», and «access to the R&D infrastructure» of public research institutions

Graph 5.2.1: Single motives for knowledge and technology transfer in the category «Codified knowledge», overall[48]



Note: This graphic shows the fraction of enterprises that reported a specific single motive for knowledge and technology transfer in the category ««Codified knowledge»« as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods

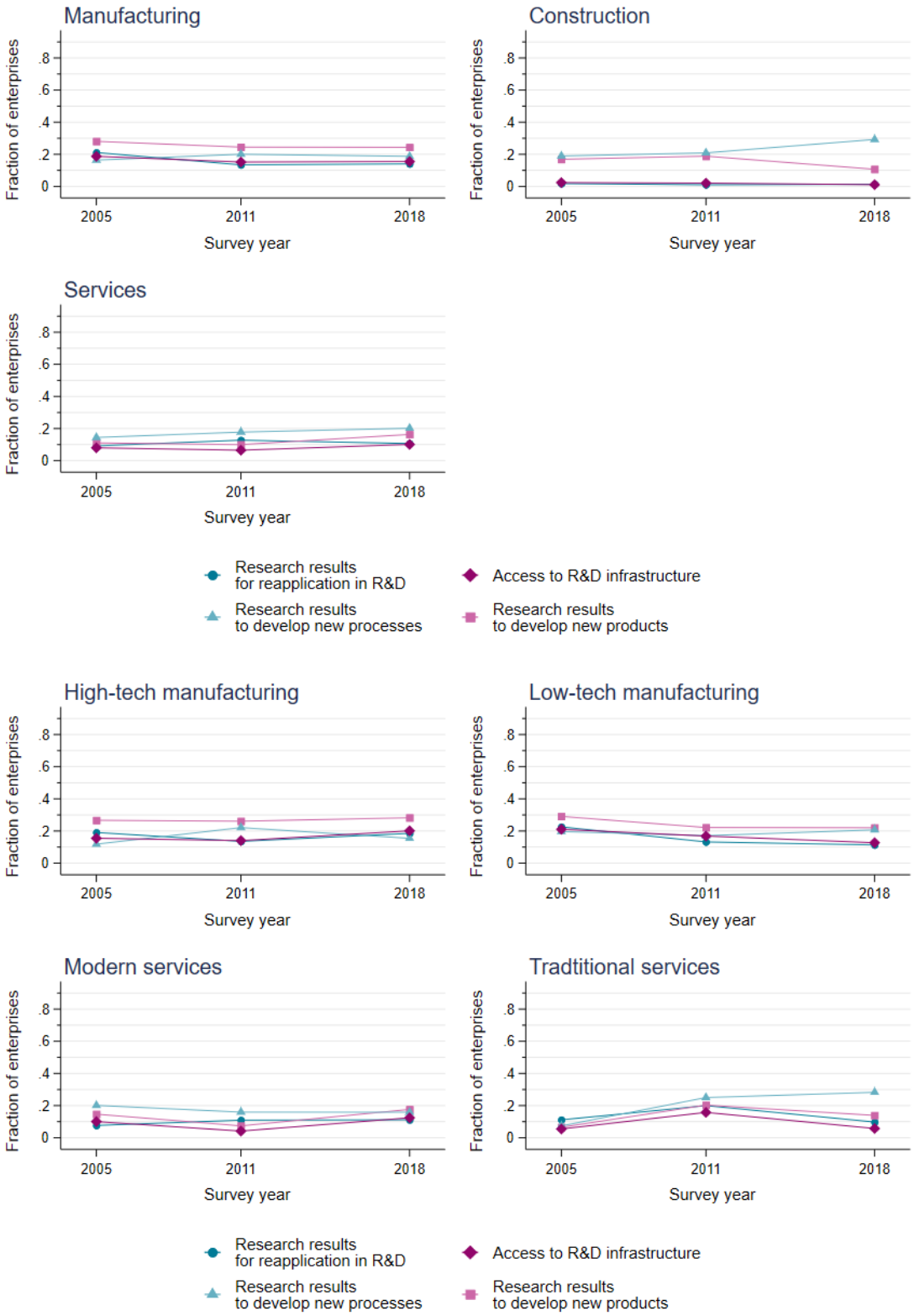
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 5.2.1 depicts the fraction of KTT-active enterprises that reported one of the four single motives in the category of «codified knowledge» as highly relevant.

First, we see that no single motive is quite as relevant as the motives in the category «tacit knowledge». Approximately between 10% and 20% of all KTT-active enterprises reported any of these four motives as highly relevant. Second, access to «research results in order to develop new products» or «processes» is slightly more relevant than «access to the R&D infrastructure» of the partner or «access to research results» for further application in in-house R&D. Third, the relevance of each motive has remained rather stable over time.

[48] The exact numbers that this graph is based on can be found in Table A8ii on page 150 in the appendix.

Graph 5.2.2: Single motives for knowledge and technology transfer in the category «Codified knowledge», by sector and subsector[49]



Note: This graphic shows the fraction of enterprises that reported a specific single motive for knowledge and technology transfer in the category ««Codified knowledge»« as highly relevant (values >= 4 on a 5-point ordinal scale)

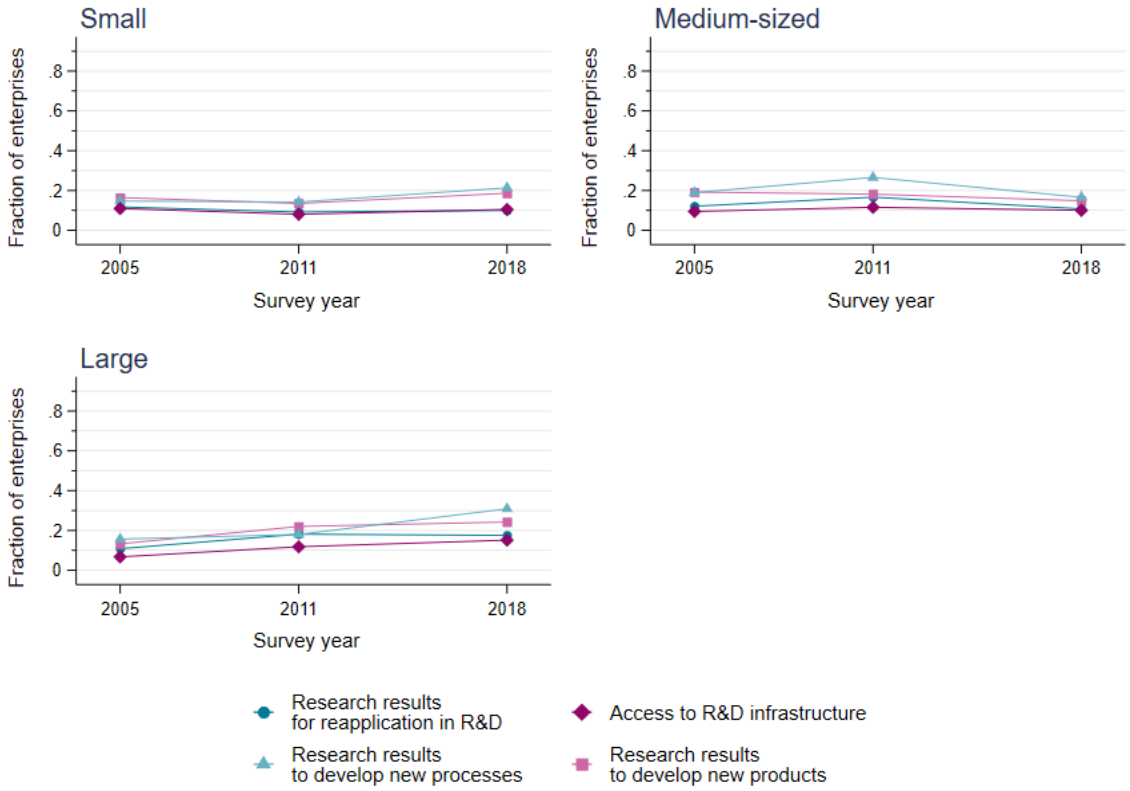
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[49] The exact numbers that this graph is based on can be found in Table A8ii on page 150 in the appendix.

Graph 5.2.2 shows the relevance of the four single «codified knowledge» motives by sector and subsector. We see that these motives remain equally relevant over time. However, we see that the importance of «research results to develop new process» increased in the service and construction sector, but hardly so in the manufacturing sector. Furthermore, there are also no substantial difference in the relevance of these motives across sectors. An exception is the lower importance of «research results to develop new products» between the service sector compared to the manufacturing sector. In addition, «access to R&D infrastructure» and access to «research results for further application in R&D» are of no relevance in construction.

Graph 5.2.3: Single motives for knowledge and technology transfer in the category «Codified knowledge», by enterprise size[50]



Note: This graphic shows the fraction of enterprises that reported a specific single motive for knowledge and technology transfer in the category ««Codified knowledge»« as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 5.2.3 shows the relevance of the four single items by enterprise size. There are hardly any trends detectable, with the exemption of large enterprises. Here, we see that most of the motives are of increasing importance across time. Moreover, the level or importance, in particular for «research results for reapplication in R&D» and «research results to develop new products» is higher in the group of large enterprises as compared to SMEs.

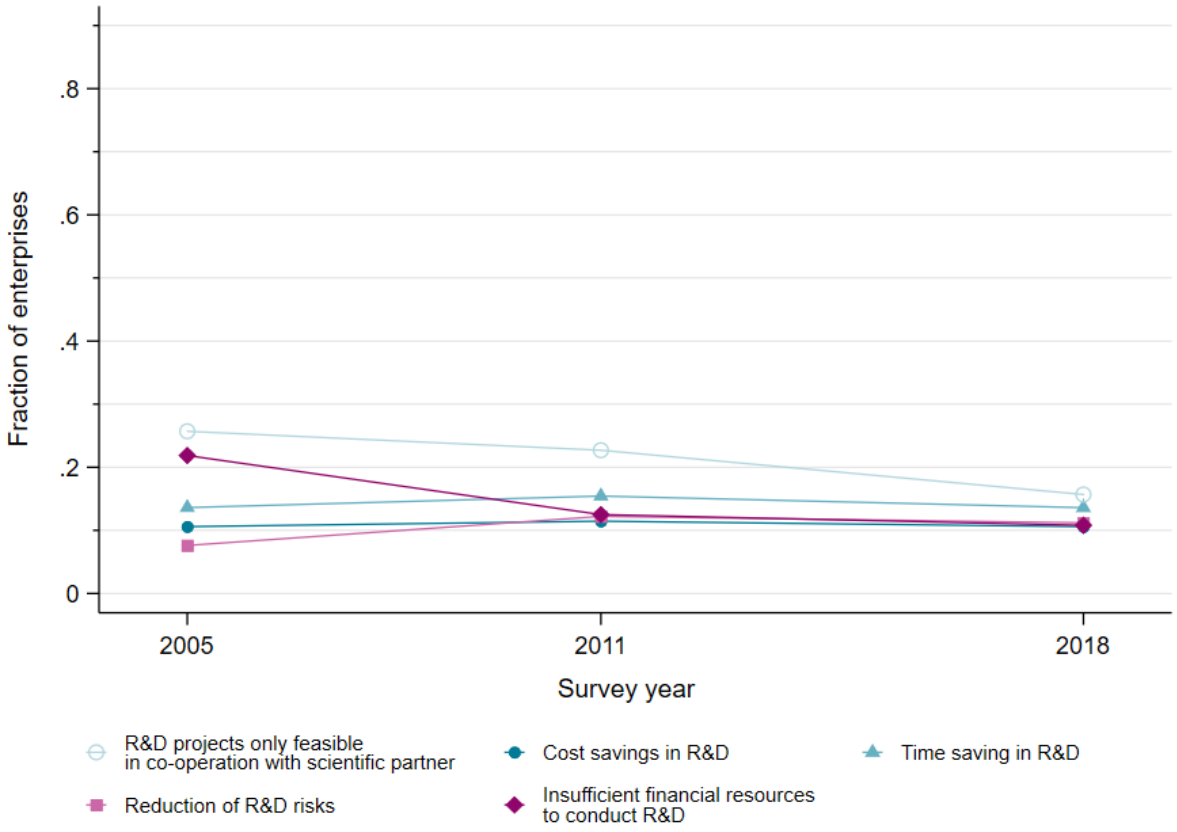
In line with the overall picture from the categorized single «codified knowledge» motives, we can say that «codified knowledge» incentivizes enterprises to conduct KTT, yet to a much lower level than «tacit knowledge». Furthermore, the importance of these motives fluctuates less over time.

[50] The exact numbers that this graph is based on can be found in Table A8ii on page 150 in the appendix.

4.2.1.2.3 Financial motives

Another important category are «financial motives», which comprise five single motives: «Cost savings» in R&D, «reduction of the technical R&D risk», «time saving» in R&D, «insufficient financial means» for independent R&D, and the fact that certain «R&D projects are only feasible in co-operation with public research institutions».

Graph 5.3.1: Single motives for knowledge and technology transfer in the category «Financial motives», overall[51]

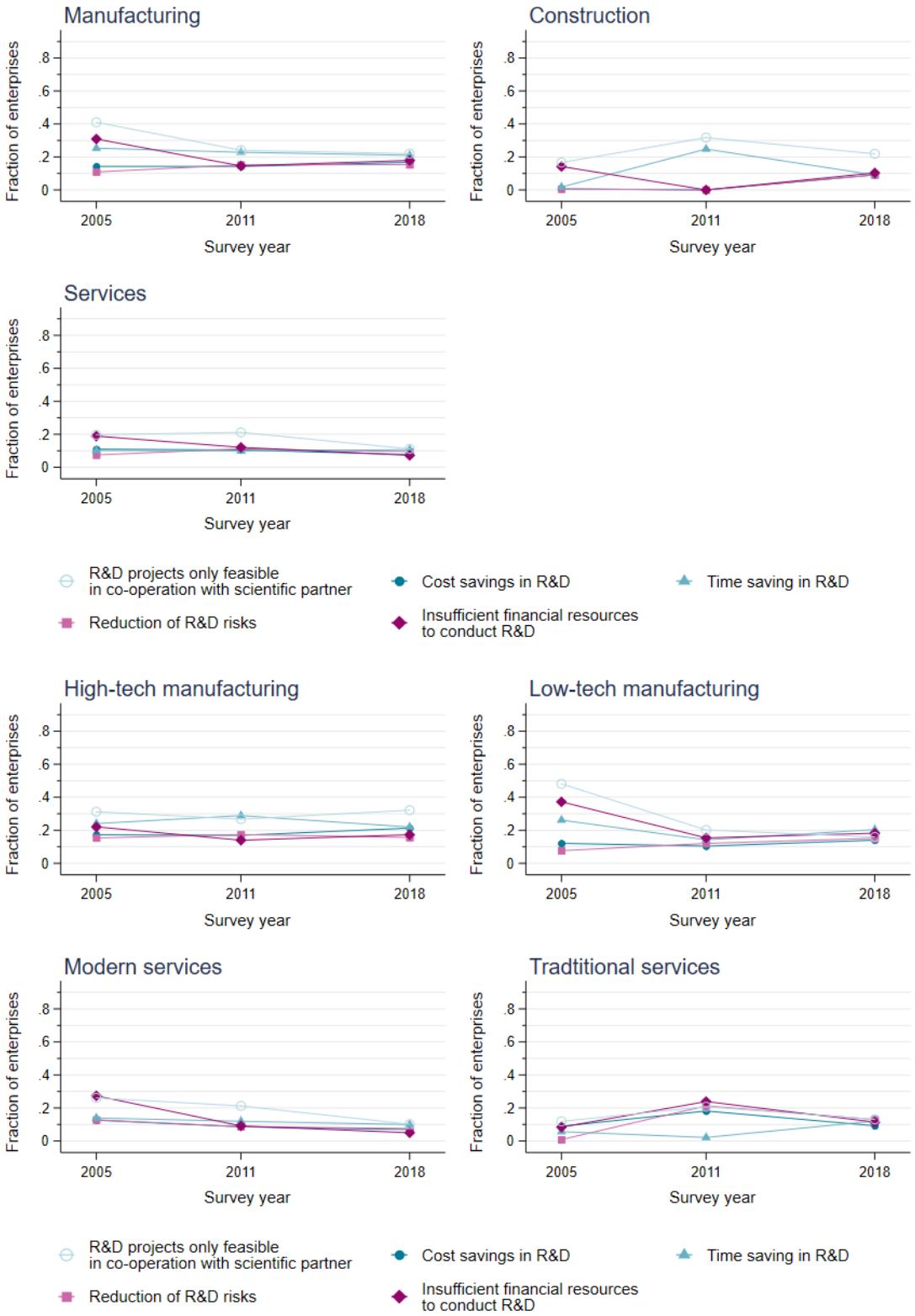


Note: This graphic shows the fraction of enterprises that reported a specific single motive for knowledge and technology transfer in the category «Financial motives» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 5.3.1 depicts the fraction of KTT-active enterprises that reported one of the five single «financial motives» as highly relevant. «Infeasibility of R&D projects without the co-operation of a scientific partner» is the most frequently mentioned highly relevant motive. Yet, its relevance is declining over time. The other four «financial motives» are less relevant. An exception is the motive «insufficient financial resources» in the earliest period. The other three single motives are only highly relevant to around 10% of all KTT-active enterprises. These fractions are relatively stable across time. There is also a trend towards lower differences in the importance of the single motives. While the spread in 2005 was about 20% points, it narrowed down to less than 10% points in 2018.

[51] The exact numbers that this graph is based on can be found in Table A8ii on page 150 in the appendix.

Graph 5.3.2: Single motives for knowledge and technology transfer in the category «Financial motives», by sector and subsector[52]



Note: This graphic shows the fraction of enterprises that reported a specific single motive for knowledge and technology transfer in the category «Financial motives» as highly relevant (values >= 4 on a 5-point ordinal scale)

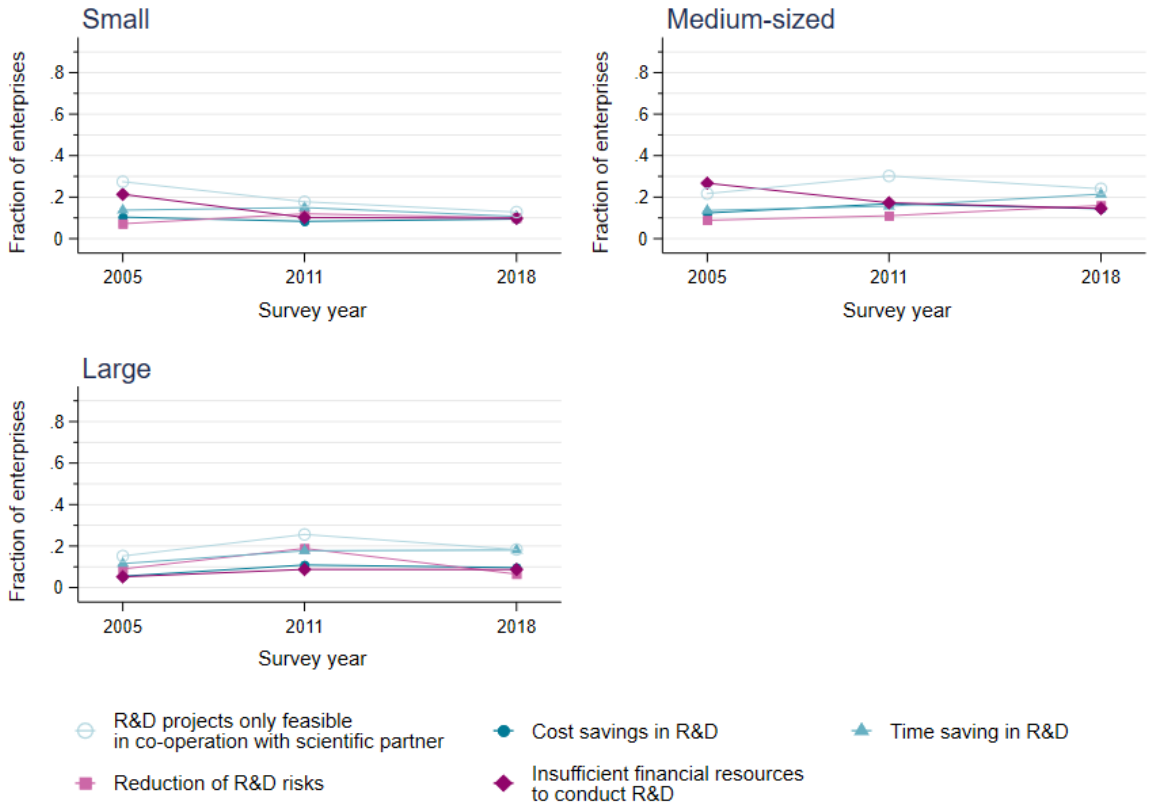
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[52] The exact numbers that this graph is based on can be found in Table A8ii on page 150 in the appendix.

Graph 5.3.2 shows the relevance of these motives by sector and subsector. «Infeasibility without a scientific partner» is again the most relevant motive, particularly in the low-tech manufacturing subsector in the earliest period. After that, it has quickly declined in importance in that subsector. All five «financial motives» are slightly more relevant in manufacturing than in the service sector, primarily in the first survey period. We also observe that the differences in the importance of the motives narrow down in the course of time. This is valid for all sectors and subsectors with the exception of high-tech manufacturing and the construction sector.

Graph 5.3.3: Single motives for knowledge and technology transfer in the category «Financial motives», by enterprise size[53]



Note: This graphic shows the fraction of enterprises that reported a specific single motive for knowledge and technology transfer in the category «Financial motives» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 5.3.3 shows the relevance of the «financial motives» by enterprise size. Between the first two survey periods, small and medium-sized enterprises recorded a declining importance of «insufficiency of financial means» as motives for KTT. Between the latter two periods, the importance of a «reduction in R&D risks» has fallen for large enterprises. Besides these minor declines all other «financial motives» remain equally important over time, particularly «cost» and «time saving». It is also interesting that small enterprises are no more motivated by «financial motives» than medium-sized and large enterprises. For medium-sized and large enterprises an «infeasibility of R&D projects without scientific partners» and the increase of «time saving» motives stand out from the rest of the motives.

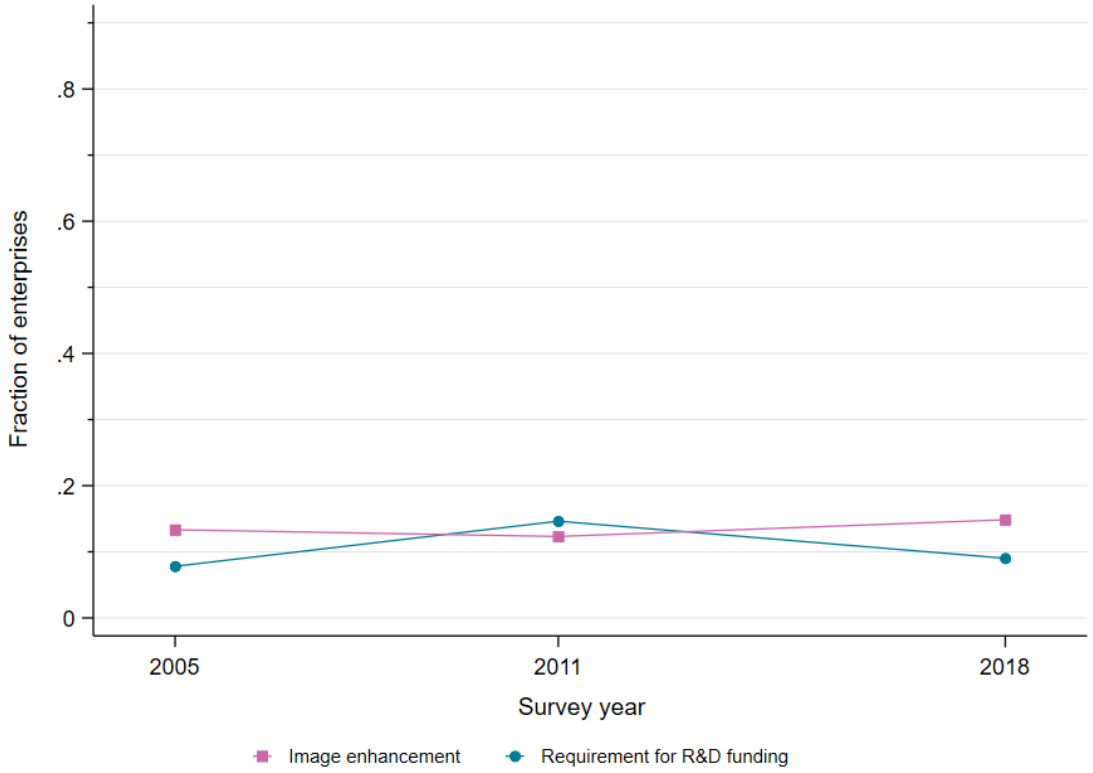
[53] The exact numbers that this graph is based on can be found in Table A8ii on page 150 in the appendix.

In conclusion, we can say that «financial motives» have some relevance for enterprises to engage in KTT with public research institutions. No single financial motive stands out from the rest. The relevance of each single motive is relatively stable over the three survey periods across sectors, subsectors or enterprise size. Yet, Graph 5.1 shows a steady decrease in the relevance of the «financial motives» category, which stems from a steady decrease of the relevance of «infeasibility of R&D projects without a scientific partner» and a reduction in the relevance of «insufficient financial resources» in the group of small enterprises. Since small enterprises have a great weight in the overall trend, they drive the decline of the category «financial motives».

4.2.1.2.4 Organizational / institutional motives

At last, we shed light on which single motives in the category of «organizational and institutional motives» are most relevant. This category comprises of only two single motives: «Enhancement of the enterprise image» and «co-operation as a necessary requirement for R&D funding».

Graph 5.4.1: Single motives for knowledge and technology transfer in the category «Organizational / institutional motives», overall[54]

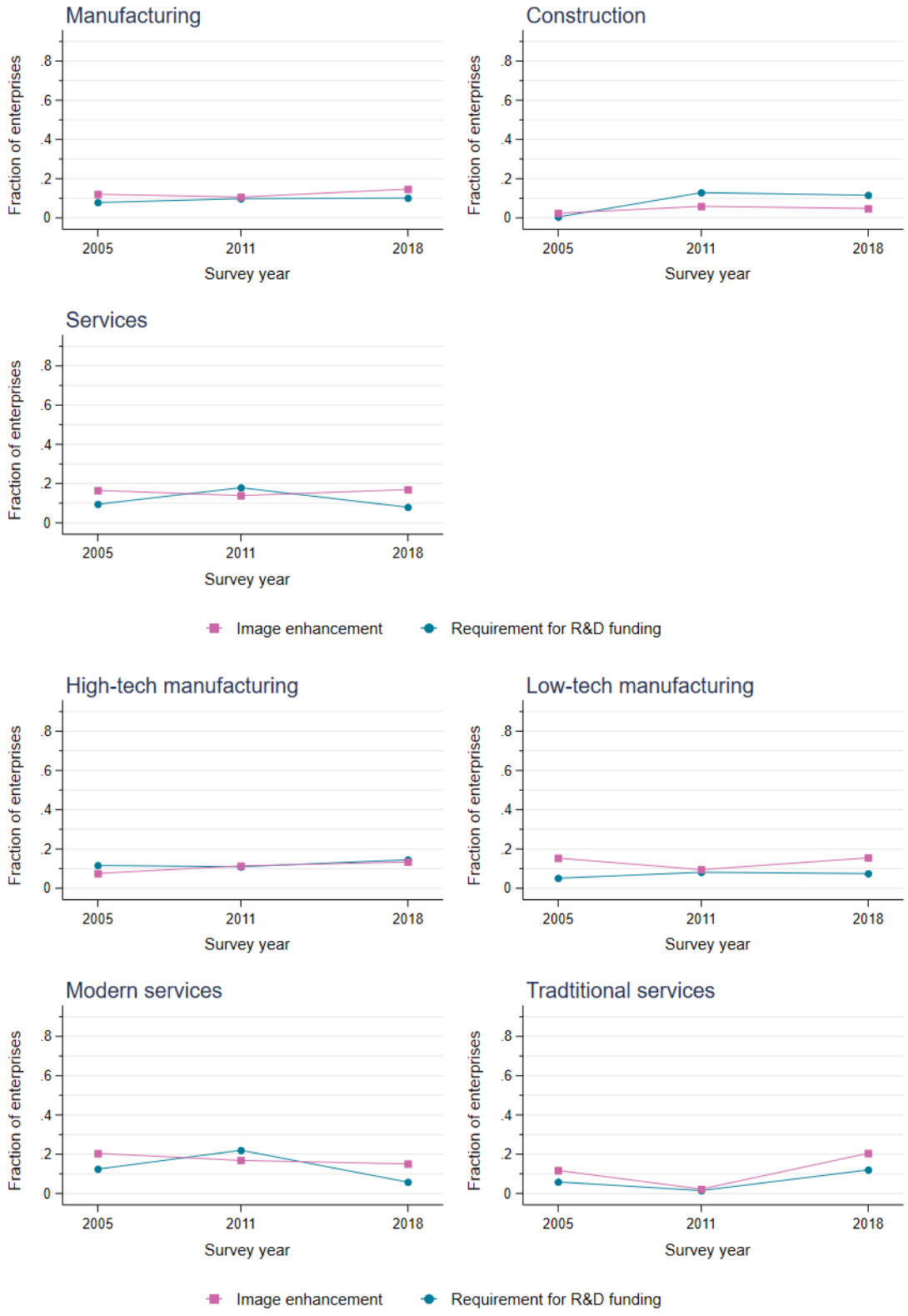


Note: This graphic shows the fraction of enterprises that reported a specific single motive for knowledge and technology transfer in the category «Organizational / institutional motives» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods
Source: KOF-KTT surveys (2005, 2011, 2018)

Graph 5.4.1 depicts the fraction of private enterprises engaged in KTT with public research institutions, which reported one of the two single motives as highly relevant. At first sight, we note that «image enhancement» and «co-operation as a requirement for R&D funding» are highly relevant to about the same fraction of enterprises. Image enhancement seems to be a marginally more relevant driver for KTT than co-operation as a funding requirement. Overall, they remain highly relevant for around 10% to 15% of all enterprises.

[54] The exact numbers that this graph is based on can be found in Table A8ii on page 150 in the appendix.

Graph 5.4.2: Single motives for knowledge and technology transfer in the category «Organizational / institutional motives», by sector and subsector[55]



Note: This graphic shows the fraction of enterprises that reported a specific single motive for knowledge and technology transfer in the category «Organizational / institutional motives» as highly relevant (values >= 4 on a 5-point ordinal scale)

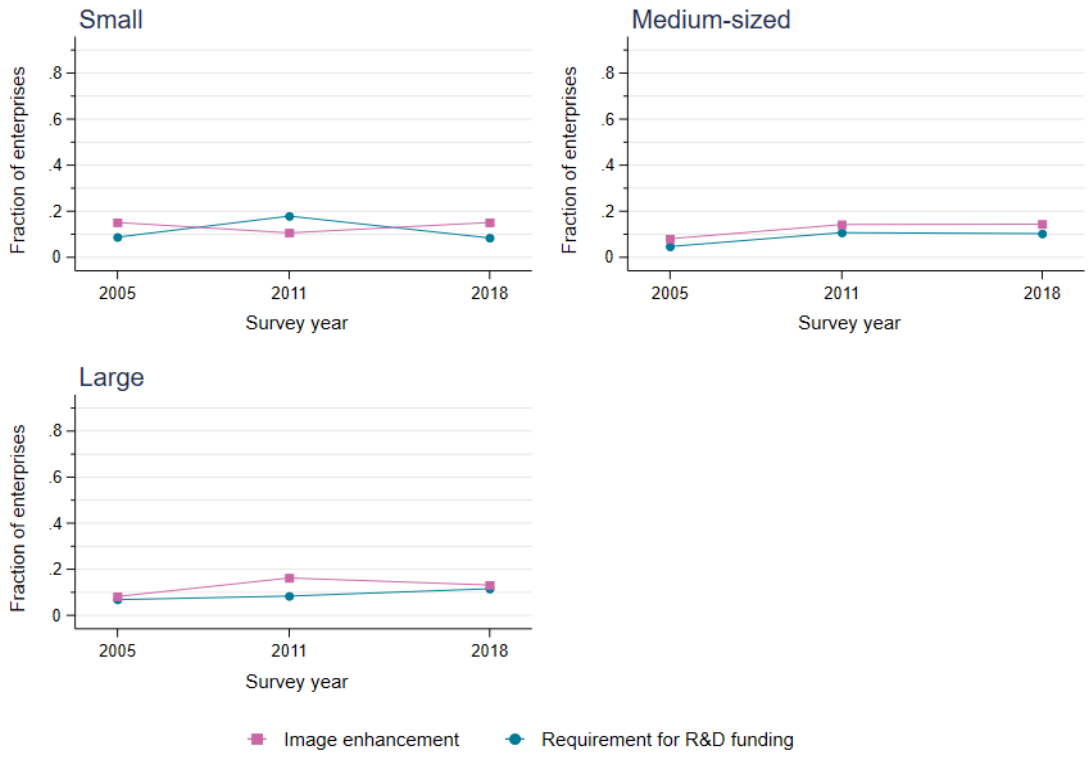
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[55] The exact numbers that this graph is based on can be found in Table A8ii on page 150 in the appendix.

Graph 5.4.2 shows the relevance of the two single «organizational and institutional motives» by sector and subsector. «Image enhancement» is marginally more relevant than «co-operation as a funding requirement», irrespective of sector or subsector, with the exception of the construction sector and the high-tech sector, where it is the other way around in at least the latest survey period. Furthermore, there are hardly any significant trends and fluctuations neither on sector nor on subsector level. Only in the traditional service sector, we see a strong increase in importance for both types of motives, although starting from a very low level.

Graph 5.4.3: Single motives for knowledge and technology transfer in the category «Organizational / institutional motives», by enterprise size[56]



Note: This graphic shows the fraction of enterprises that reported a specific single motive for knowledge and technology transfer in the category «Organizational / institutional motives» as highly relevant (values >= 4 on a 5-point ordinal scale)
Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size
Source: KOF-KTT surveys (2005, 2011, 2018)

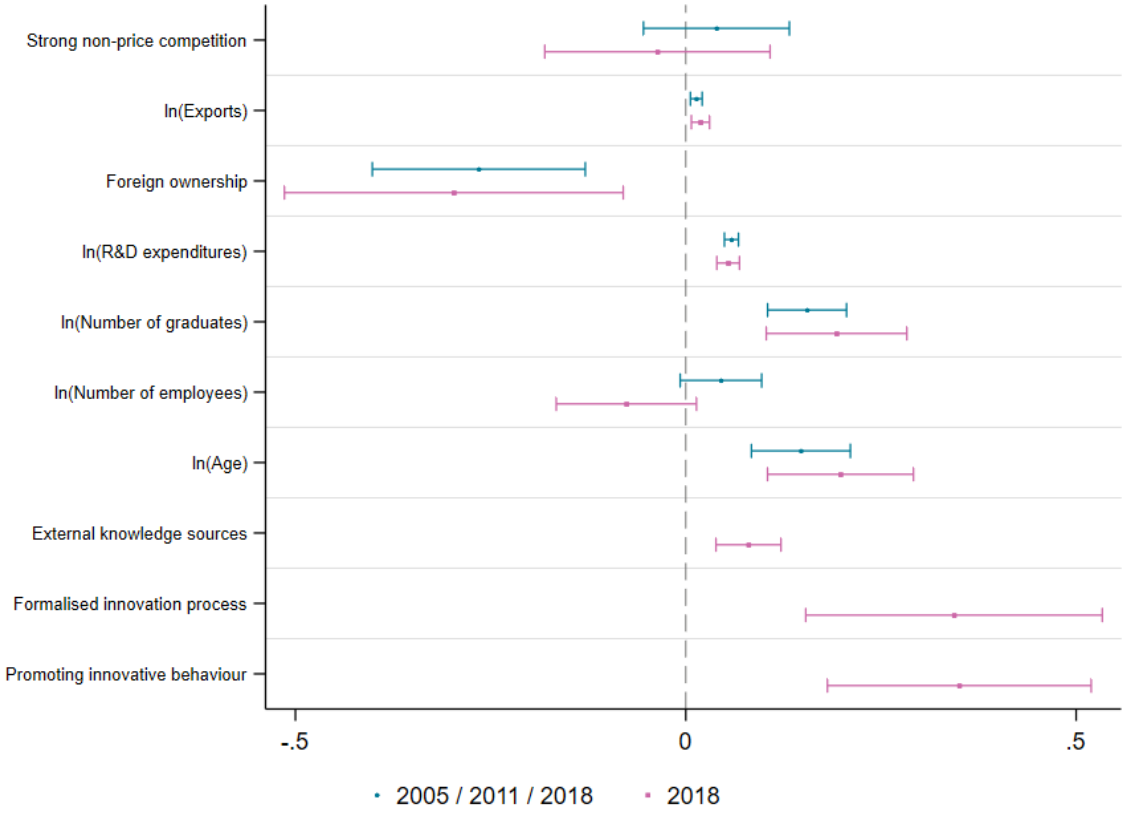
Graph 5.4.3 depicts this information by enterprise size. We see no trends or significant fluctuations of the relevance of both «organizational and institutional motives» for either size category. Furthermore, SMEs as well as large enterprises see «image enhancement» as a slightly more relevant motive than «co-operation with public research institutions as a requirement for R&D funding». Additionally, the same fraction of SMEs and large enterprises see them as highly important drivers of their KTT activity.

Summarizing these insights, we can say that around 10% to 20% of all private enterprises see an «image enhancement» or the «co-operation with public research institutions as a funding requirement» as highly relevant motives. While the former motive is marginally more important than the latter, these fractions are stable over the survey periods. Comparing this to Graph 5.2.1 and Graph 5.3.1 we see that half of the motives related to «codified knowledge» and many of the «financial motives» are only relevant to about 10% to 20% of all KTT-active enterprises as well.

[56] The exact numbers that this graph is based on can be found in Table A8ii on page 150 in the appendix.

4.2.2 Enterprise Characteristics

Graph 5.4: Determinants of knowledge and technology transfer, enterprise characteristics[57]



Note: This graphic shows the pooled OLS estimates and the corresponding 90% confidence intervals of the determinants equation. If the confidence interval does not include nil, we call the effect significant different from zero. This is the case for ln(Exports) or ln(R&D expenditures).

Variables: The dependent variable is a dummy capturing whether an enterprises conducted knowledge and technology transfer with a domestic public research institutions three to one year prior to the survey year. Additional covariates cover 33 industry dummies, time dummies, and technology field dummies. Graduates stem from the ETH domain, from universities, or from universities of applied sciences.

Basis: The turquoise values are based on observations from all three survey periods. The magenta values are solely based on observations from the latest survey period since the additional covariates were only queried in the 2018 survey.

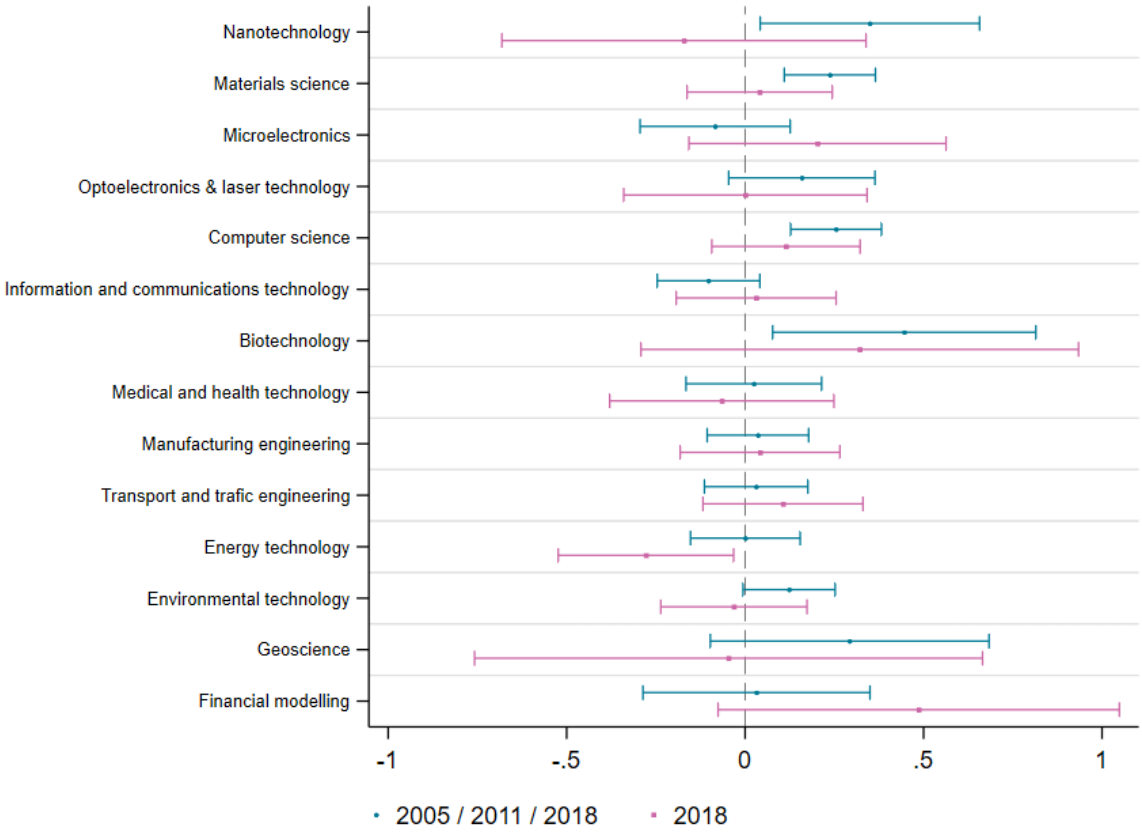
Source: KOF-KTT surveys (2005, 2011, 2018)

On the basis of our econometric estimations (see Graph 5.4), we see that older enterprises, enterprises with higher R&D expenditures, exporting enterprises, and enterprises with a higher proportion of university graduates (including universities of applied sciences) are on average more likely to carry out KTT than enterprises in which these characteristics are absent or less pronounced.

This result suggests that the absorptive capacity, that is the ability to understand and implement the transferred knowledge and technologies, and international competition are key factors in the use of scientific research. However, foreign-owned enterprises have, on average, a lower probability of conducting KTT. In other words, the subsidiaries of international corporations only occasionally transfer knowledge and technology with public research institutions. Enterprises that highly emphasize innovation activities in their strategic orientation have a higher probability to conduct KTT as well. Formalized innovation strategies and promotion of innovative behavior significantly go hand in hand with a higher transfer probability. KTT-active enterprises also show a fundamental openness in their innovation process and the experience of integrating external ideas and findings associated with it.

[57] The exact numbers that this graph is based on can be found in Table A11 on page 156 in the appendix.

Graph 5.5: Determinants of knowledge and technology transfer, technology fields[58]



Note:	This graphic shows the pooled OLS estimates and the corresponding 90% confidence intervals of the determinants equation. If the confidence interval does not include nil, we call the effect significant different from zero. This is the case for ln(Exports) or ln(R&D expenditures).
Variables:	The dependent variable is a dummy capturing whether an enterprises conducted knowledge and technology transfer with a domestic public research institutions three to one year prior to the survey year. Additional covariates cover 33 industry dummies, time dummies, and the previously mentioned enterprise characteristics. Graduates stem from the ETH domain, from universities, or from universities of applied sciences.
Basis:	The turquoise values are based on observations from all three survey periods. The magenta values are solely based on observations from the latest survey.
Source:	KOF-KTT surveys (2005, 2011, 2018)

The technological orientation of the company is important (see Graph 5.5). Enterprises that deal with nanotechnology, the development of new materials, computer science or biotechnology have a higher transfer probability. Surprisingly, this does not apply to «future technologies» such as microelectronics, medical and health technology or energy technology. For the time being, the reasons for this are unclear. Differences between the research orientation of enterprises and public research institutions in these areas or a lack of information about the respective research activities could be decisive.

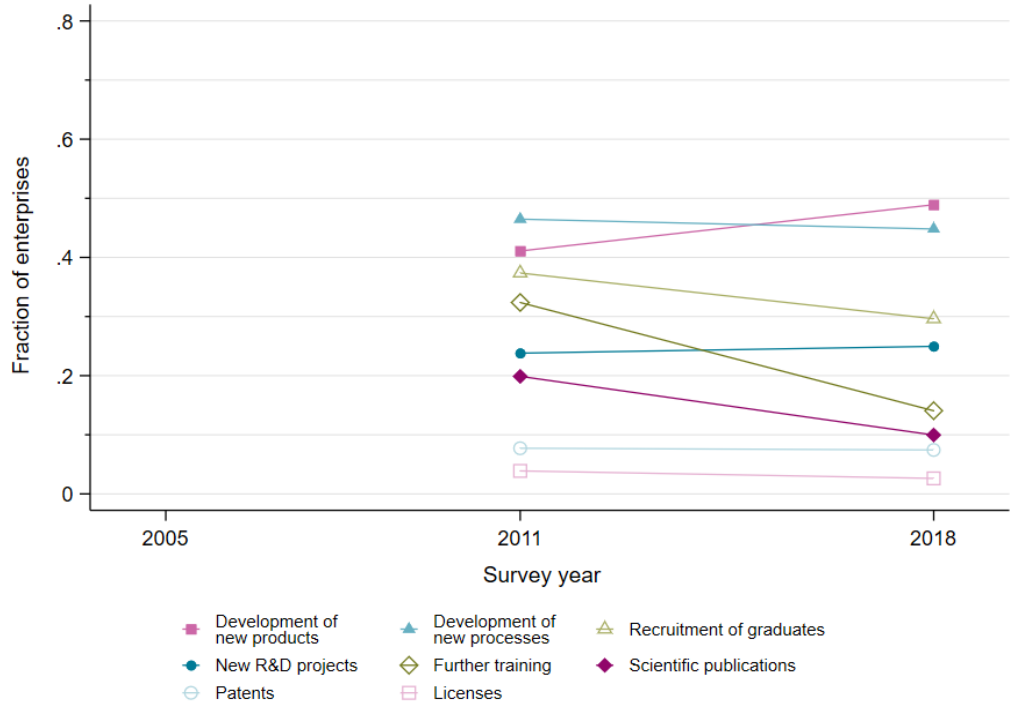
[58] The exact numbers that this graph is based on can be found in Table A11 on page 156 in the appendix.

4.3 Outcomes of KTT

4.3.1 Enterprise Indicators

This subsection investigates the results within the enterprise of the knowledge and technology transfer activities with public research institutions based on what private enterprises reported in the survey. We distinguish between eight results from the KTT activities: «New R&D projects», «development of new products», «development of new processes», «scientific publications», «patents», «licenses», and increases in the stock of human capital by means of «recruiting graduates» or «further training opportunities».

Graph 6.1: Results from knowledge and technology transfer, overall[59]



Note: This graphic shows the fraction of enterprises that reported that knowledge and technology transfers with scientific partners resulted in a specific outcome. The 2005 survey posed these questions in an ordinal manner (5-point ordinal scale) while the latter two surveys posed these questions in a binary way. These methodological differences renders the first period incomparable to the latter two and was subsequently dropped.

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods

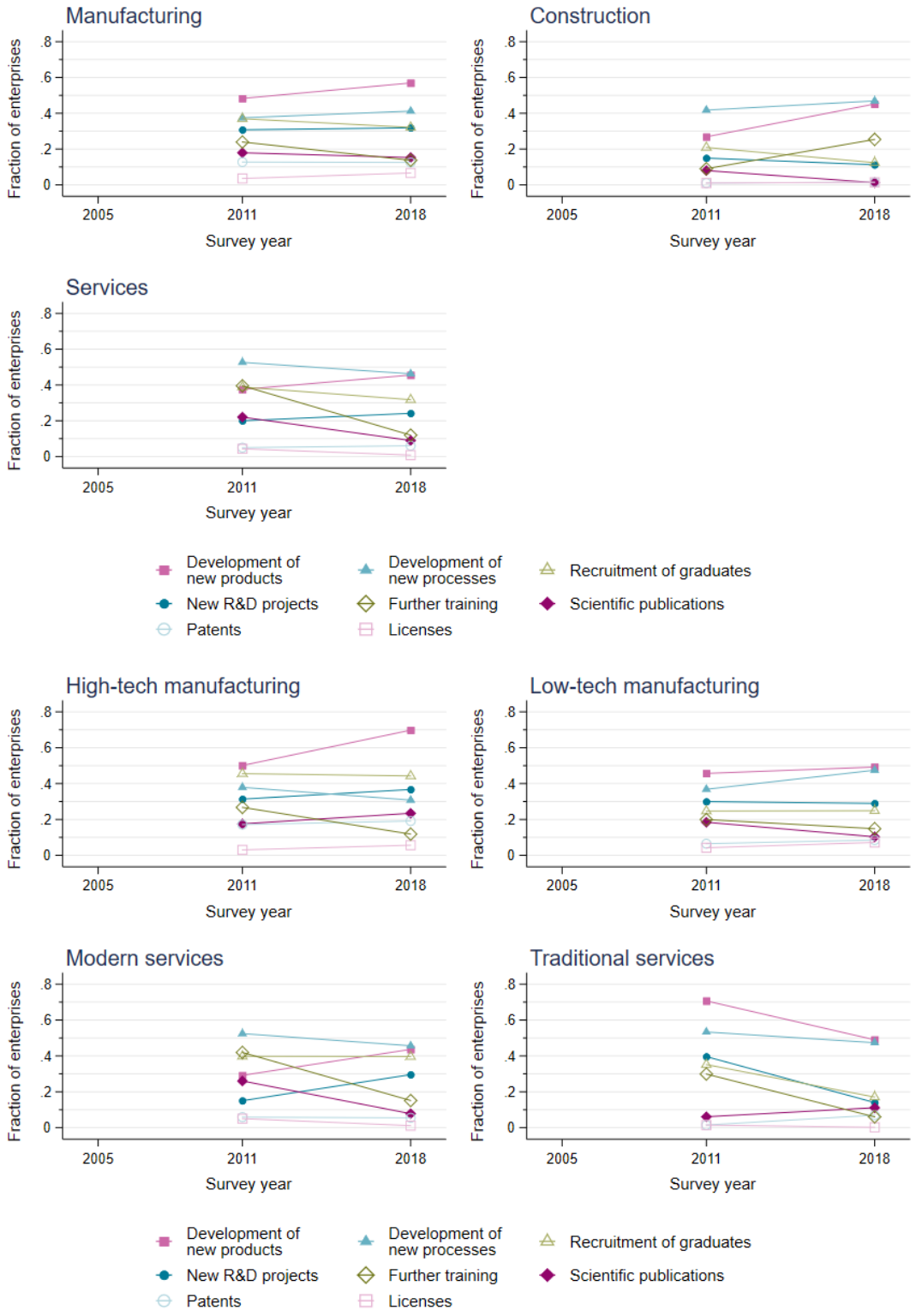
Source: KOF-KTT surveys (2011, 2018)

Graph 6.1 depicts the fraction of private KTT-active enterprises that reported a specific result of their transfer activities with public research institutions in one of the three survey periods. Due to methodological differences, only the latter two periods are comparable.

Between 40% and 50% of all KTT-active enterprises reported that their transfer activities with public research institutions resulted in either the «development of new products» or «processes». Between 30% and 40% «recruited graduates» because of their KTT activities. Between 2005 and 2010, over 30% of all KTT-active enterprises reported «further training of employees» as an outcome of KTT. This fraction dropped to below 15% in the latter period. «New R&D projects» also resulted for more than 20% of all KTT-active enterprises. «Scientific publications», «patents», and «licenses» seldom result from knowledge and technology transfer with public research institutions. Hence, new products and new process remain the two most frequently reported results of KTT activities.

[59] The exact numbers that this graph is based on can be found in Table A9 on page 151 in the appendix.

Graph 6.2: Results from knowledge and technology transfer, by sector and subsector[60]



Note: This graphic shows the fraction of enterprises that reported that knowledge and technology transfers with scientific partners resulted in a specific outcome. The 2005 survey posed these questions in an ordinal manner (5-point ordinal scale) while the latter two surveys posed these questions in a binary way. These methodological differences renders the first period incomparable to the latter two and was subsequently dropped.

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector and subsector

Source: KOF-KTT surveys (2011, 2018)

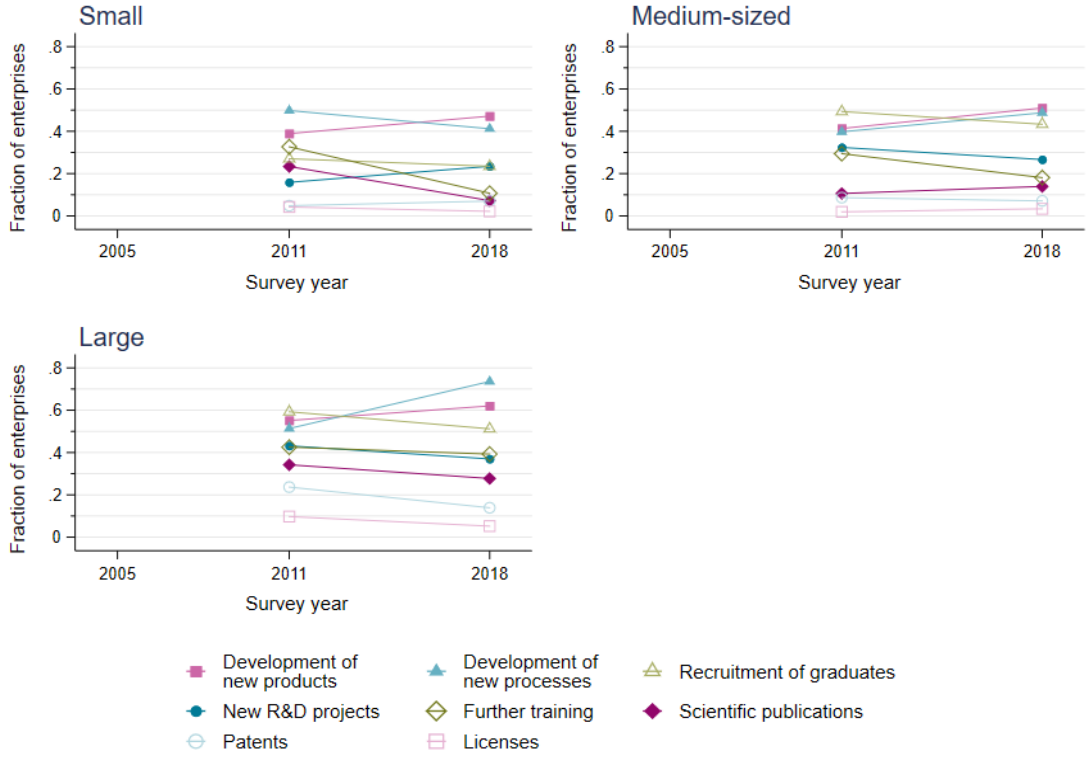
[60] The exact numbers that this graph is based on can be found in Table A9 on page 151 in the appendix.

Graph 6.2 shows the fraction of KTT-active enterprises that reported a specific result of their transfer activities by sector and subsector.

The «development of new products» is a frequent result in manufacturing and especially in the high-tech manufacturing subsector. Nearly 70% of all KTT-active high-tech manufacturing enterprises reported the «development of new products» resulting from their transfer activities with public research institutions. The «development of new processes», «new R&D projects», and the «recruitment of graduates» are also frequent results of KTT in the manufacturing sector. The latter result is particularly prevalent in high-tech manufacturing.

In the service sector, the «development of new processes» is the most frequent result. The «development of new products» is a prevalent outcome of KTT in this sector as well. While 70% of all KTT-active traditional services enterprises stated such an outcome in the earlier period, the respective fraction amounts to 30% of all KTT-active modern services enterprises. These fractions have converge in the latter period such that about 50% of modern services as well as traditional services enterprises reported the «development of products» as an outcome of KTT. The «recruitment of graduates» is the third most prevalent outcome of KTT in the services sector. This is particularly the case for the modern services subsector.

Graph 6.3: Results from knowledge and technology transfer, by enterprise size[61]



Note: This graphic shows the fraction of enterprises that reported that knowledge and technology transfers with scientific partners resulted in a specific outcome. The 2005 survey posed these questions in an ordinal manner (5-point ordinal scale) while the latter two surveys posed these questions in a binary way. These methodological differences renders the first period incomparable to the latter two and was subsequently dropped.

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by enterprise size

Source: KOF-KTT surveys (2011, 2018)

[61] The exact numbers that this graph is based on can be found in Table A9 on page 151 in the appendix

The «development of new processes» is also the most frequently mentioned result of KTT in the construction sector. The «development of new products» is the second most often reported outcome. All other factors are quite scarce results in the construction sector, although «further training» was more frequently mentioned in the latest survey period.

Graph 6.3 depicts the fraction of KTT-active enterprises that reported one of the eight factors as resulting from their transfer activities with public research institutions by enterprise size. The «development of new products» or processes is reported by between 40% and 50% of all SMEs engaged in KTT. These two results are an even more frequent outcome of KTT in the group of large enterprises. While about 50% of all large enterprises reported them as results of their KTT activity, these fractions increased to 60% for the «development of new products» and up to 70% for the «development of new processes». «Recruitment of graduates» is also a frequent result in medium-sized and particularly large enterprises. «Further training of employees» and «new R&D projects» are reported by around 40% of KTT-active large enterprises. About 30% of large enterprises also register «scientific publications» resulting from their KTT activities.

Overall, the «development of new products» or «processes» are the most frequent results for private enterprises. Their relative importance depends on the sector and subsector. «Recruitment of graduates» is also often registered as an outcome of knowledge and technology transfer with public research institutions, particularly by large enterprises. «Patents» and «licenses» rarely result from KTT.

4.3.2 Performance: Analytical (econometric) Results

4.3.2.1 Indicators of innovation performance and overall firm performance

In order to measure the performance of Swiss enterprises, we use seven different indicators in the following econometric analyzes.[62] These indicators measure the ability of firms to develop innovative products and processes, the success of these innovations on the market, and the competitiveness of firms. We examine the effect of KTT on these indicators and thus on the innovation and overall performance of firms.

More specifically, we use two binary variables to measure the ability of firms to introduce innovations: product innovations (yes/no; [*Productinno*]) and process innovations (yes/no; [*Processinno*]). Three measures quantify the commercial success generated with innovative products: the (logarithm of) sales with new products [*ln(Sal_new)*], the (logarithm of) sales with improved products [*ln(Sal_impr)*], and the (logarithm of) sales with innovative products [*ln(Sal_inno)*]. The sales of innovative products are thereby simply the sum of the sales of new and improved products. In order to measure the competitiveness of firms, we use (the logarithms) of total sales[*ln(Sales)*] and value added [(*ln(Valadd*)]. Moreover, our econometric models always take into account employment, investment, and other important control variables such as the qualification of employment or the export intensity of firms (see the footnotes in the figures and tables for the estimated models).

4.3.2.2 Knowledge transfer activities are associated with a higher innovative capacity and higher commercial success of Swiss firms

Our results show that KTT plays an important role for innovation among Swiss enterprises. However, appropriate framework conditions are necessary for commercial success. Graph 6.4 shows in lines (1) and (2) that KTT is significantly positively associated with the introduction of new innovative products and processes. In lines (3) to (7), however, it becomes apparent that KTT alone is not significantly positively related to the commercial success of firms. Here the standard error is too large to show a statistically significant relationship (see also Table E). Thus, KTT alone increases the probability of being innovative, but does not automatically go hand in hand with higher commercial success.

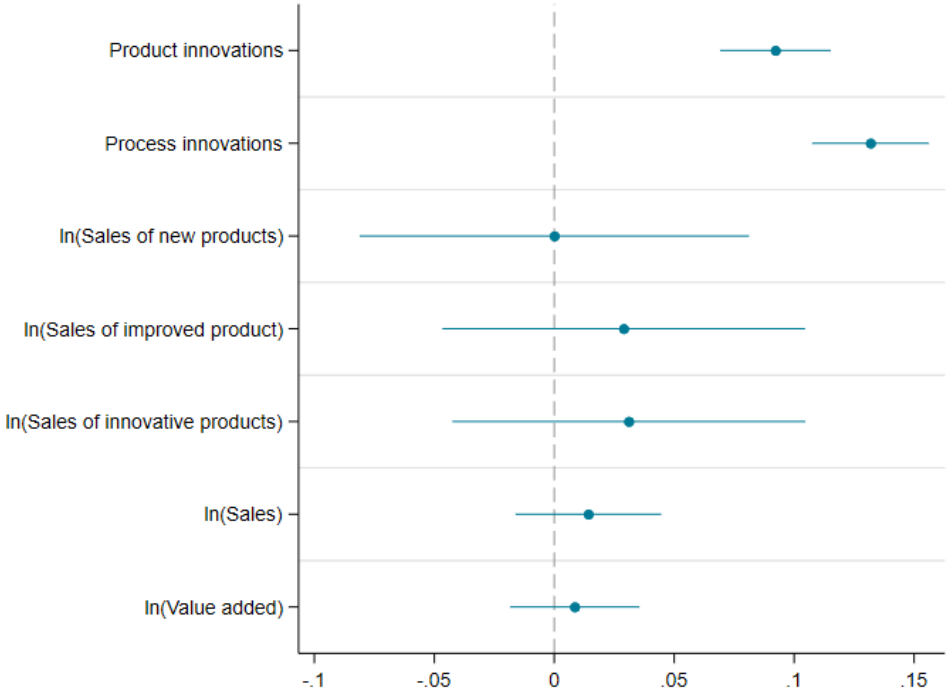
Table E: KTT and firm performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable:	Productinno	Processinno	ln(Sal_new)	ln(Sal_impr)	ln(Sal_inno)	ln(Sales)	ln(Valadd)
Estimation method:	Logit	Logit	R.E.	R.E.	R.E.	R.E.	R.E.
KTT	0.631***	0.770***	0.000	0.029	0.031	0.014	0.009
	(0.096)	(0.096)	(0.049)	(0.046)	(0.045)	(0.018)	(0.016)
Observations	5,867	5,867	2,781	2,716	3,192	5,867	5,867

«KTT» is a binary variable (0/1), which measures the knowledge transfer 6 to 1 years prior in domestic as well as 3 to 1 years prior in foreign. All estimations contain the explanatory variables ln(R&D expenditures), ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies; (1) and (2) are estimated using random effects logit, (3) to (7) are estimated using standard random effects; *** p<0.01, ** p<0.05, * p<0.1

[62] The terms firm and enterprise are used interchangeably.

Graph 6.4: KTT and firm performance



Note: The knowledge and technology transfer (KTT) is a binary variable (0/1) that measures the knowledge transfer 6 years to 1 year before the survey year in domestic and 3 years to 1 year before the survey year abroad. The Y-axis represents the dependent variables of the seven estimates: Product innovations, process innovations, turnover with new products, turnover with improved products, turnover with innovative products, total turnover and value added. The ranges indicate the 90% confidence intervals of the correlation of KTT with the dependent variables. If the confidence interval does not include the zero line, the effect is considered to be significantly different from zero. Not shown are the explanatory variables ln(R&D expenditures), ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies. All equations are estimated with random effects.

Graph 6.5 shows that a contribution of KTT to the commercial success of a firm requires in-house R&D investments.[63] This is indicated by the steeper slope of the red line, the marginal effect of knowledge transfer in the presence of R&D activities. Knowledge transfer activities strengthen the positive link between R&D activities and sales of new products. The baseline effect of R&D activities correlates positively with innovation success (blue line) even without KTT. However, the main interest lies in the fact that KTT turns the relationship between R&D activities and the dependent variables «sales of innovative products», «sales» and «value added» significantly more positive (see the significantly positive interaction terms in Table F). In the presence of KTT, R&D activities are much more strongly correlated with sales of innovative products and with competitiveness (value added). Knowledge transfer is thus associated with a higher performance impact of the firm's own R&D activities. Seen from the opposite perspective, we can state that knowledge transfer requires so-called absorptive capacity, expressed in terms of financial resources spent on R&D activities, in order to positively influence the performance of firms (Cohen and Levinthal, 1990). A firm must already have technological knowledge and know-how in order to be able to profitably use transfer activities with universities (Zahra and George, 2002). Only if the knowledge transferred by the university falls on fertile ground, i.e., if the new knowledge is properly understood, adequately used and implemented, it will sustainably improve corporate success.

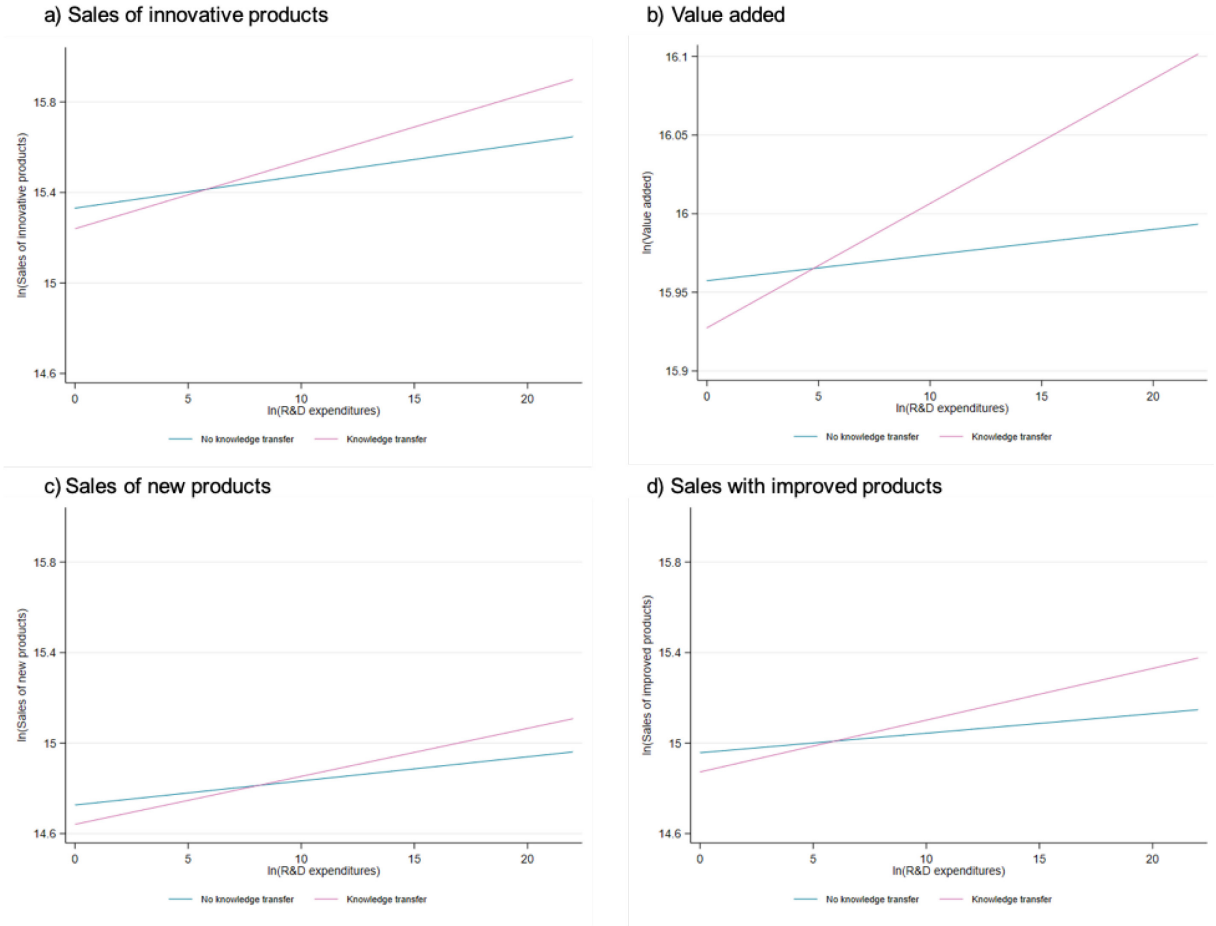
[63] In the underlying analyzes for Graph 6.5 and Table F, the KTT variable is interacted with R&D activities. Those firms that have no R&D expenditure were coded as «0».

Table F: Marginal effects of knowledge transfer in interaction with R&D activities

Dependent variable:	(1) Productinno	(2) Processinno	(3) ln(Sal_new)	(4) ln(Sal_impr)	(5) ln(Sal_inno)	(6) ln(Sales)	(7) ln(Valadd)
Estimation method:	Logit	Logit	R.E.	R.E.	R.E.	R.E.	R.E.
KTT	0.681***	0.964***	-0.086	-0.085	-0.091	-0.018	-0.030
	(0.121)	(0.129)	(0.076)	(0.070)	(0.067)	(0.025)	(0.022)
ln(1+R&D exp.)	0.176***	0.081***	0.011**	0.009*	0.014***	0.003	0.002
	(0.011)	(0.010)	(0.005)	(0.005)	(0.005)	(0.002)	(0.002)
KTT *ln(1+R&D exp.)	-0.010	-0.030**	0.011	0.014**	0.016**	0.005**	0.006***
	(0.014)	(0.013)	(0.007)	(0.007)	(0.006)	(0.003)	(0.002)
Observations	5,867	5,867	2,781	2,716	3,192	5,867	5,867

All estimations contain the explanatory variables ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies; (1) and (2) are estimated using random effects logit, (3) to (7) are estimated using standard random effects; *** p<0.01, ** p<0.05, * p<0.1

Graph 6.5: Marginal effects of knowledge transfer in interaction with R&D activities

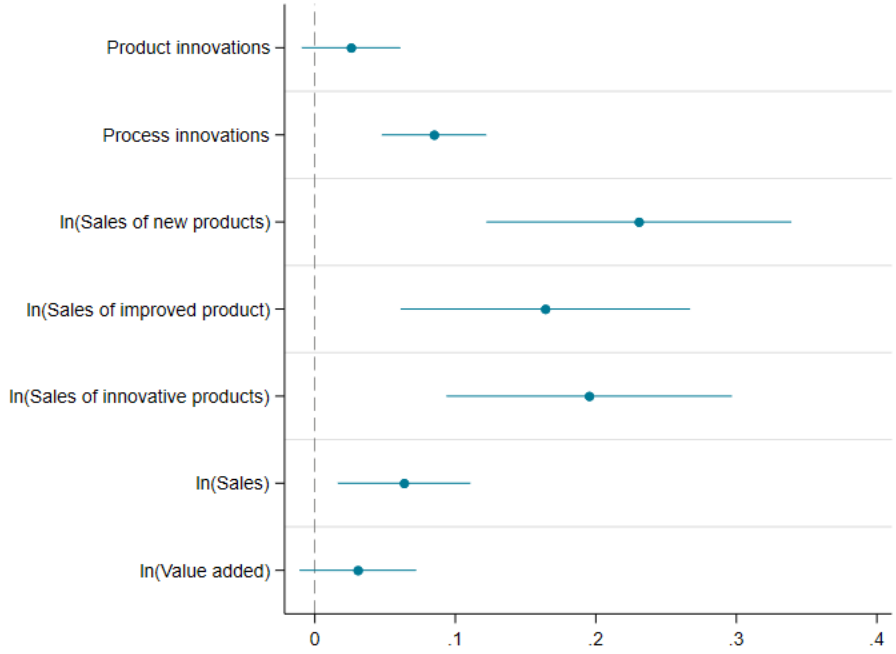


Note: All models are estimated with random effects and include the explanatory variables ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies.

4.3.2.3 Combined knowledge transfer with domestic and foreign institutions correlates positively with the innovation performance of firms

Graph 6.6 shows that a very broad network of knowledge transfer activities, extending from the national to the international level, provides a much stronger impulse for innovation success among firms. In particular, it shows that combined KTT has a significantly positive coefficient in all regressions shown in lines (2) to (6). The respective coefficients are shown in Table G. This result implies that a combined national and international design of knowledge transfer does indeed show stronger associations than a purely national or purely international knowledge transfer.

Graph 6.6: Combined KTT (at national and international level) and firm performance



Note: The combined KTT is a binary variable (0/1) which only assumes the value «1» if there was knowledge transfer at the domestic and international level at the same time 3 years to 1 year before the time of the survey. The Y-axis represents the dependent variables of the seven estimates. The ranges indicate the 90% confidence intervals of the correlation of KTT with the dependent variables. If the confidence interval does not include the zero line, the effect is considered to be significantly different from zero. Not shown are the explanatory variables ln(R&D expenditure ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies. All equations are estimated with random effects.

Singular forms of knowledge transfer, with a purely national or a purely international orientation, show much weaker relationships when looked at in separate regressions, especially with respect to commercial success. It is also important to note that if intensive knowledge transfer is carried out together with R&D activities, an additional positive impulse for commercial success can be observed, as already illustrated in the case with the generic KTT in Graph 6.5. A combination of intensive KTT with R&D activities shows the comparatively strongest positive correlation with innovation performance and competitiveness. Thus, KTT seems to be most successful commercially when it is pursued very intensively and at the same time encounters pronounced efforts invested into in-house R&D activities.

Table G: Combined KTT (at national and international level) and firm performance

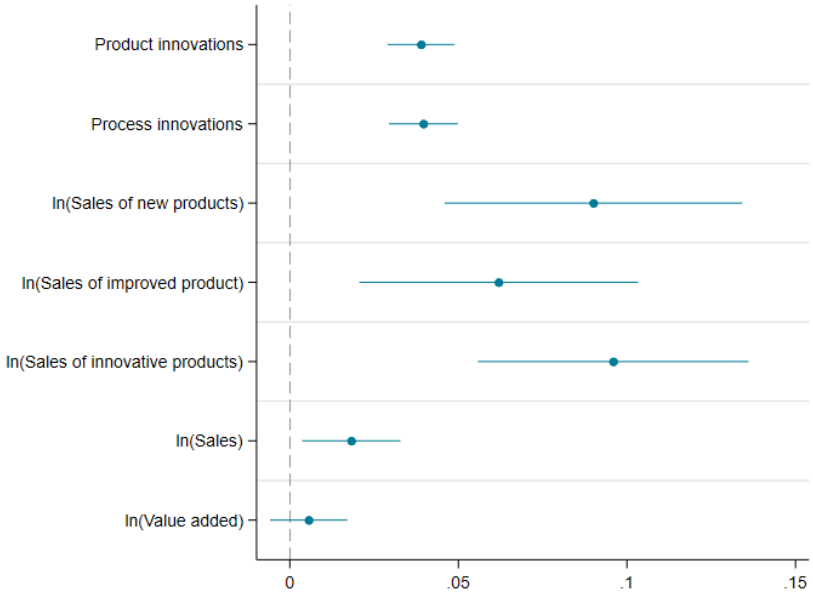
Dependent variable:	(1) Productinno	(2) Processinno	(3) ln(Sal_new)	(4) ln(Sal_impr)	(5) ln(Sal_inno)	(6) ln(Sales)	(7) ln(Valadd)
Estimation method:	Logit	Logit	R.E.	R.E.	R.E.	R.E.	R.E.
KTT combined	0.416**	0.443***	0.231***	0.164***	0.195***	0.064**	0.031
	(0.171)	(0.142)	(0.066)	(0.063)	(0.062)	(0.029)	(0.025)
Observations	5,826	5,826	2,761	2,698	3,171	5,826	5,826

"KTT combined» is a binary variable (0/1), which takes the value «1» if there is knowledge transfer 3 to 1 years prior in domestic and at the same time also in foreign. All estimations contain the explanatory variables ln(R&D expenditures), ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies; (1) and (2) are estimated using random effects logit, (3) to (7) are estimated using standard random effects; *** p<0.01, ** p<0.05, * p<0.1

4.3.2.4 Knowledge transfer and open innovation: both are positively related to innovation performance

A central question is whether or not KTT has effects that are comparable to the broader, so-called Open Innovation activities. By open innovation we mean the importance of the knowledge of customers, suppliers, competitors, etc. for the innovation activities and the innovation success of firms (Beck and Schenker–Wicki, 2014; Chesbrough, 2003; Laursen and Salter, 2006). The knowledge transfer surveys determine the extent to which these external knowledge sources are central to a firm's innovation process.

Graph 6.7: Open Innovation (without KTT) and the performance of firms



Note: «Open Innovation» measures the number of knowledge sources such as customers, suppliers or competitors, but excludes universities. The Y-axis represents the dependent variables of the seven estimates. The ranges indicate the 90% confidence intervals of the correlation of KTT with the dependent variables. If the confidence interval does not include the zero line, the effect is considered to be significantly different from zero. Not shown are the explanatory variables ln(R&D expenditure ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies. All equations are estimated with random effects.

The results in Graph 6.7 show that Open Innovation also correlates positively with the commercial success of innovative products and services, whereas for KTT this is only the case in combination with internal R&D activities. Interestingly, unlike KTT, Open Innovation does not interact positively with firms' R&D activities. Thus, Open Innovation does not require that the firm already has a strong

knowledge base. This suggests that KTT, which is targeted at the firm's R&D process, is more complex than Open Innovation, which is easier to apply directly to the innovation process, without first passing through the R&D department. In general, however, it should be noted that both open innovation and KTT are associated with significantly higher firm performance compared to closed and non-KTT-active firms. However, in order to achieve productivity gains, KTT needs to be combined with R&D activities; Open Innovation shows no significant correlations in this case. The coefficient of Open Innovation in last column in Table H illustrates this statistical insignificant relationship.

Table H: Open Innovation (without KTT) and firm performance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable:	Productinno	Processinno	ln(Sal_new)	ln(Sal_impr)	ln(Sal_inno)	ln(Sales)	ln(Valadd)
Estimation method:	Logit	Logit	R.E.	R.E.	R.E.	R.E.	R.E.
Open innovation	0.232***	0.228***	0.090***	0.062**	0.096***	0.018**	0.006
	(0.037)	(0.036)	(0.027)	(0.025)	(0.024)	(0.009)	(0.007)
Observations	1,681	1,681	672	640	753	1,681	1,681

"Open Innovation» measures the number of knowledge sources such as customers, suppliers or competitors, but without universities. All estimations contain the explanatory variables ln(R&D expenditures), ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies; (1) and (2) are estimated using random effects logit, (3) to (7) are estimated using standard random effects; *** p<0.01, ** p<0.05, * p<0.1

4.3.2.5 Broad spectrum of forms of KTT is relevant for innovation activities of Swiss enterprises

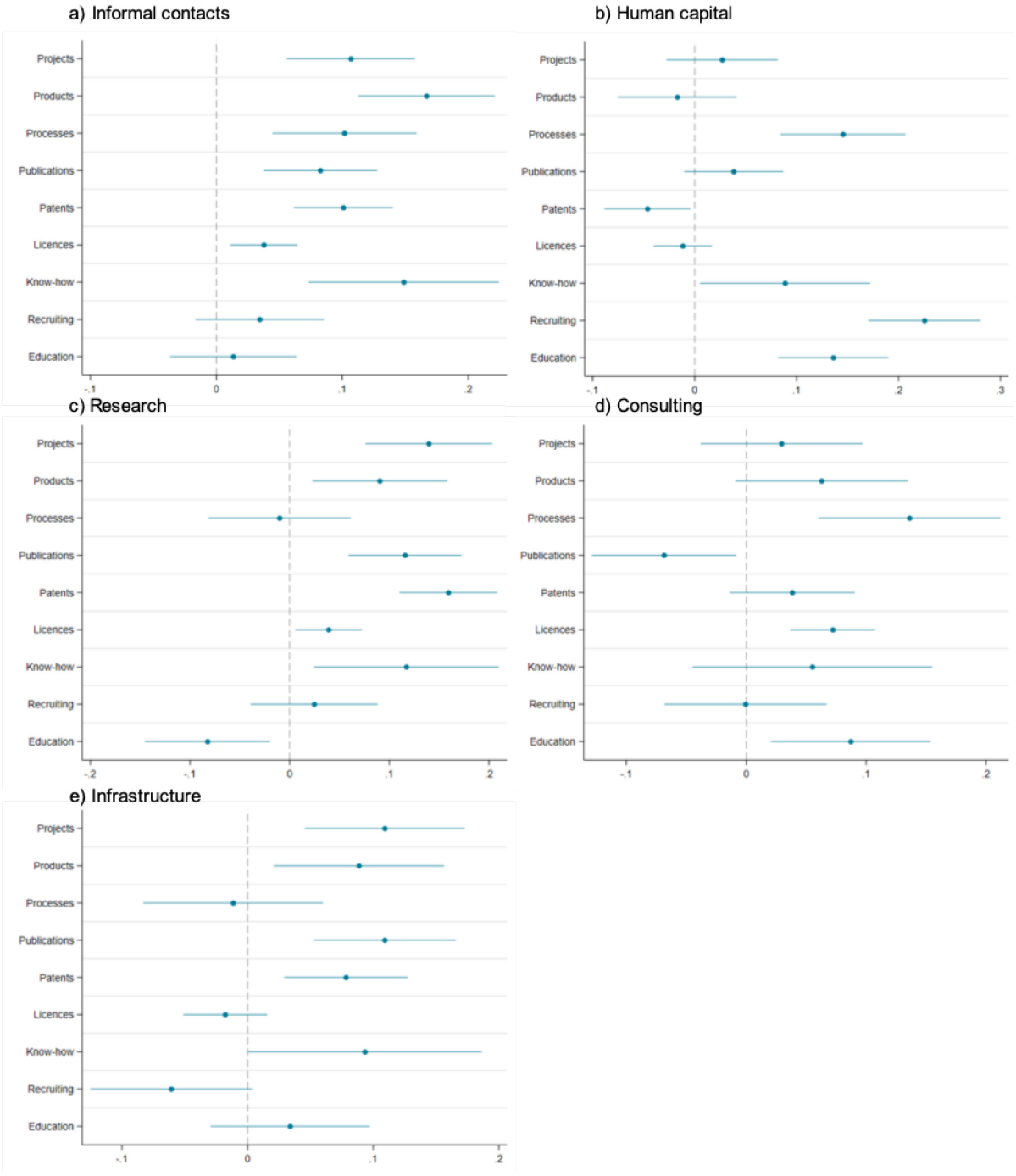
Knowledge transfer can take various forms. Graph 6.8 shows the connections between five different forms of knowledge transfer and nine indicators for results that can arise from successful knowledge transfer. It shows that the spectrum of different forms of knowledge and technology transfer that go hand in hand with significantly positive results is very broad. Forms of knowledge transfer that address the use of research activities and technical infrastructure at public research institutions are positively related to the introduction of new projects, products, publications, patents and know-how. Forms of knowledge transfer, which mainly refer to informal contacts and network activities of enterprises, correlate positively with the generation of new projects, products, processes, publications, patents and licenses as well as with an increase in know-how in the enterprises. KTT forms, which focus on training and further education and personnel labor mobility, occur together with the introduction of new processes and an increase in the enterprises' human capital resources.

Table I: Forms and results of knowledge transfer

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent var:	Projects	Products	Process	Publ.	Patents	Licenses	Know-how	Recruit.	Education
Estim. meth:	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit
Inf. contacts	0.604***	0.826***	0.564***	1.488***	1.194***	1.014**	0.837***	0.211	0.064
	(0.178)	(0.165)	(0.210)	(0.536)	(0.365)	(0.437)	(0.255)	(0.188)	(0.199)
Education	0.153	-0.103	0.838***	0.735	-0.525	-0.227	0.417	1.293***	1.000***
	(0.193)	(0.175)	(0.244)	(0.547)	(0.323)	(0.432)	(0.269)	(0.263)	(0.256)
Infrastructure	0.547***	0.451**	-0.075	1.616***	0.539*	-0.292	0.623*	-0.370	0.254
	(0.206)	(0.213)	(0.242)	(0.596)	(0.312)	(0.385)	(0.354)	(0.243)	(0.242)
Research	0.603***	0.487**	-0.093	1.309**	1.139***	0.553	0.836**	0.131	-0.524**
	(0.201)	(0.213)	(0.245)	(0.557)	(0.351)	(0.384)	(0.356)	(0.231)	(0.254)
Consulting	0.194	0.334	0.745***	-1.121*	0.391	1.000***	0.275	0.073	0.511*
	(0.226)	(0.226)	(0.277)	(0.648)	(0.314)	(0.365)	(0.367)	(0.244)	(0.262)
Observations	935	935	935	932	932	932	479	932	932

The displayed explanatory variables are binary variables (0/1), which consist of the questions to the 5 forms of knowledge transfer. All estimations contain the explanatory variables ln(R&D expenditures), ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies; (1) to (9) are estimated by Logit; *** p<0.01, ** p<0.05, * p<0.1

Graph 6.8: Forms and results of knowledge transfer

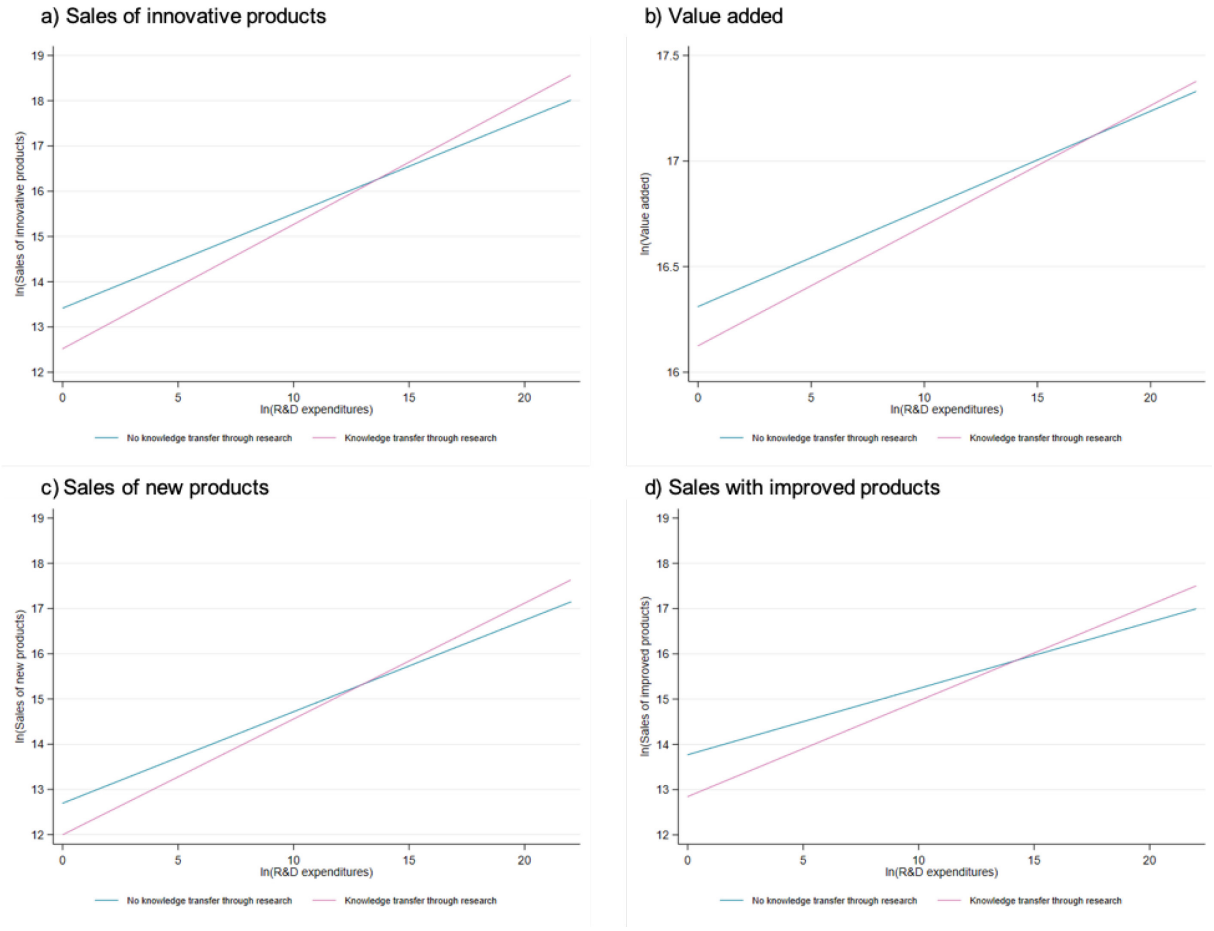


Note: The five explanatory variables shown are binary variables (0/1) composed of blocks of questions on the five forms of knowledge transfer. The Y-axis represents the dependent variables of the nine estimates, which are also binary variables (0/1). The ranges indicate the 90% confidence intervals of the correlation of KTT with the dependent variables. If the confidence interval does not include the zero line, the effect is considered to be significantly different from zero. Not shown are the explanatory variables ln(R&D expenditure ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies. All equations are estimated with random effects.

Academic consulting and the preparation of expert reports are positively associated with the introduction of new processes and licenses as well as with the employment of university graduates (including university of applied sciences graduates). The correlations between the specific forms and results of knowledge transfer show no definite statistical patterns (see Table I). The coefficients in this table do

not indicate a systematic distribution towards either one particular form or result of KTT. We therefore conclude that there is no dominant form of knowledge transfer. Instead, a broad commitment to knowledge transfer seems to be of primary importance.

Graph 6.9: Marginal effects of knowledge transfer in relation to research collaborations in interaction with R&D expenditure



Note: All models are estimated with random effects and include the explanatory variables ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies.

Graph 6.9 complements the information in Graph 6.8 by using the same dependent variables that are used in Graph 6.4 to Graph 6.7. This allows us to examine whether KTT forms also have an impact on the commercial success of innovative products and services. These latter variables are objective measures of the performance of enterprises, while in Graph 6.8, we look at the subjective assessments of the transfer results by the participating firms.

Graph 6.9 supports the above statement that KTT requires the accompaniment of R&D activities in order to be effective (see Graph 6.5). The relationship between R&D expenditures and the four dependent variables varies when we divide firms into those with KTT in the form of research (i.e. research collaborations, contract research, and research consortia) and those without KTT in the form of research. To highlight the intensity of the R&D expenditures, firms without R&D activities were excluded. Graph 6.9 shows that KTT in the form of research makes the relationship between R&D expenditure and innovation performance much more positive. We therefore conclude that in order to be successful, KTT in

the form of research requires a high level of in-house knowledge capacity provided by high R&D spending. The same result is visible in Table J, where the interaction term is significantly positively related to four of the five firm performance variables (columns 3 to 7).

Table J: Knowledge transfer through research in interaction with R&D expenditures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable:	Productinno	Processinno	ln(Sal_new)	ln(Sal_impr)	ln(Sal_inno)	ln(Sales)	ln(Valadd)
Estimation method:	Logit	Logit	R.E.	R.E.	R.E.	R.E.	R.E.
KTT Research	-1.569	1.203	-0.774	-0.945**	-1.027**	-0.755***	-0.230
	(1.577)	(1.077)	(0.481)	(0.452)	(0.436)	(0.223)	(0.184)
ln(R&D exp.)	0.270***	-0.038	0.199***	0.142***	0.203***	0.092***	0.042***
	(0.080)	(0.056)	(0.027)	(0.026)	(0.024)	(0.012)	(0.010)
KTT Res.*ln(R&D exp.)	0.140	-0.067	0.060*	0.067**	0.076**	0.054***	0.014
	(0.122)	(0.078)	(0.034)	(0.032)	(0.031)	(0.016)	(0.013)
Observations	1,103	1,137	946	912	1,018	1,141	1,141

All estimations contain the explanatory variables ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies; (1) and (2) are estimated using random effects logit, (3) to (7) are estimated using standard random effects; *** p<0.01, ** p<0.05, * p<0.1

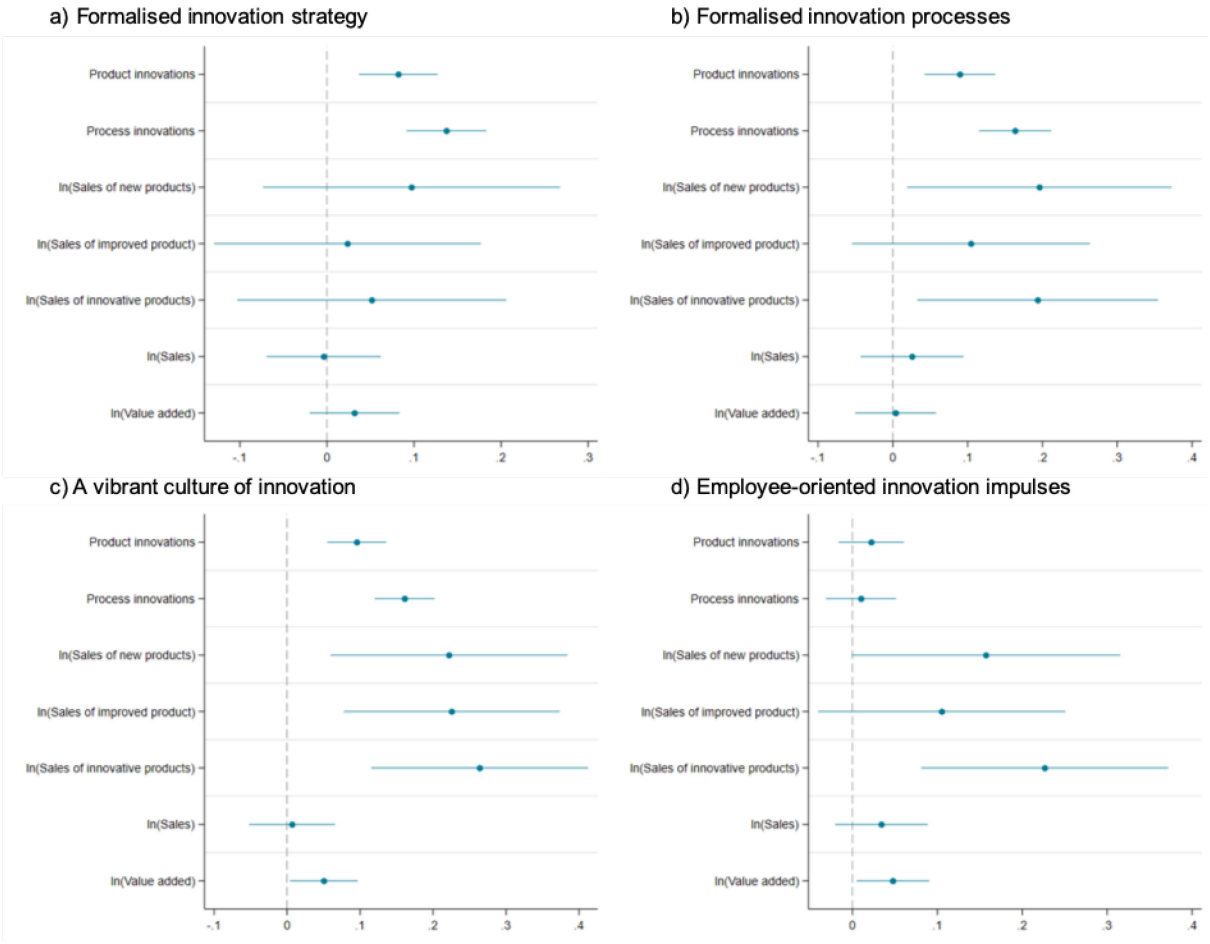
4.3.3 Innovation strategy, KTT, and firm performance

In order to be able to make conclusions regarding the success of innovative firms, the question arises as to what connection exists between KTT, the innovation strategy, and the innovation management of firms.

4.3.3.1 Innovations strategies show are less important for the relationship between KTT and innovation performance

Graph 6.10 shows the connections between different management approaches with regard to the implementation of innovation strategies and processes as well as the innovation culture and the performance of firms. Those firms that have a distinct innovation culture and implement special measures for innovative behavior, such as «innovation events» or «innovation bonuses», are on average more innovative, commercially more successful with their innovative products and more competitive. A similarly positive correlation with innovation performance can be seen in the systematic application of formalized methods in the innovation process (e.g. Stage-Gate-Review). In contrast, while a formalized innovation strategy correlates with a higher probability with regard to the introduction of innovative products and processes (innovation performance), it shows no statistically significant effect with regard to the commercial success of innovative products.

Graph 6.10: Performance and innovation strategies, processes and culture



Note: The four explanatory variables shown are binary variables (0/1), which have been individually estimated in bivariate equations to pre-empt multicollinearity. The Y-axis represents the dependent variables of the seven estimates. The ranges indicate the 90% confidence intervals of the correlation of KTT with the dependent variables. If the confidence interval does not include the zero line, the effect is considered to be significantly different from zero. Not shown are the explanatory variables ln(R&D expenditure ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies. All equations are estimated with random effects.

4.3.3.2 Firms in which innovation impulses are initiated top-down and bottom-up show a higher innovation success

Graph 6.10 also indicates that firms that generate high sales with innovative products rely on the joint initiative of managers and employees alike when implementing their innovation activities. A combination of top-down and bottom-up innovation impulses in the initiation of innovation projects thus shows a stronger correlation with commercial success than innovation impulses coming only from managers or only from employees. In sum, Graph 6.10 suggests that firms with a holistic innovation strategy have a higher innovation performance. This conclusion is visible in Table K, too, where no individual innovation strategy is significantly positively correlated with all of the seven performance variables; only joint reliance on different innovation strategies will make broad innovation success possible.

Table K: Management strategies and firm performance

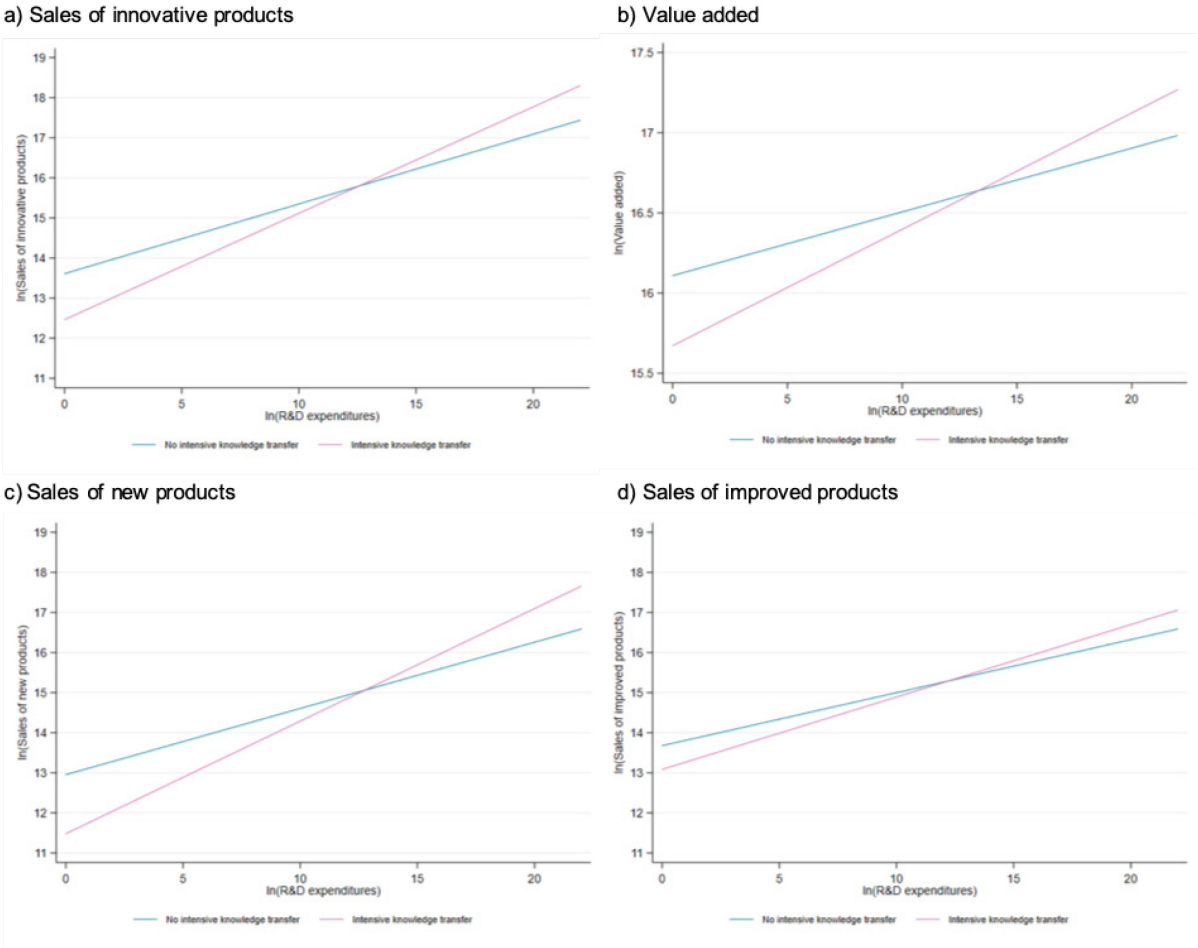
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable:	Productinno	Processinno	ln(Sal_new)	ln(Sal_impr)	ln(Sal_inno)	ln(Sales)	ln(Valadd)
Estimation method:	Logit	Logit	R.E.	R.E.	R.E.	R.E.	R.E.
Form. innovation strategy	0.571***	0.654***	0.097	0.024	0.052	-0.004	0.032
	(0.171)	(0.147)	(0.104)	(0.093)	(0.094)	(0.040)	(0.031)
Form. Innovation process	0.631***	0.758***	0.196*	0.104	0.194**	0.026	0.004
	(0.180)	(0.154)	(0.107)	(0.097)	(0.098)	(0.042)	(0.033)
Innovation culture	0.883***	0.957***	0.250**	0.252***	0.307***	0.023	0.055**
	(0.140)	(0.133)	(0.098)	(0.089)	(0.090)	(0.035)	(0.028)
Innovation impulses	0.141	0.056	0.157	0.105	0.227**	0.034	0.048*
	(0.140)	(0.130)	(0.096)	(0.088)	(0.088)	(0.033)	(0.026)
Observations	1,671	1,671	666	635	747	1,671	1,671

The four displayed explanatory variables are binary variables (0/1), which were estimated in separate bivariate equations to pre-empt the sometimes strong multicollinearity. All estimations contain the explanatory variables ln(R&D expenditures), ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies; (1) and (2) are estimated using random effects logit, (3) to (7) are estimated using standard random effects; *** p<0.01, ** p<0.05, * p<0.1

4.3.3.3 KTT accompanied by R&D expenditures increase competitiveness

Graph 6.11 illustrates the relationship between combined KTT (i.e., KTT at the national and international level) and the performance of firms only within R&D-active firms. This means that we exclude firms without R&D expenditures and look only at the interaction between combined KTT and the amount of R&D expenditure. It is thus not only possible to investigate whether combined KTT determines the presence of R&D activities, but also whether the amount of R&D expenditures has additional effects. Graph 6.11 shows that combined KTT massively increases the relationship between R&D expenditures and both innovation performance and competitiveness. The firm performance resulting from additional R&D expenditures is almost twice as high in association with combined KTT. The coefficients in Table L illustrate this marked increase in firm performance. We therefore conclude that not only the existence of R&D spending, but also the level of R&D spending is crucial for a stronger impact of KTT.

Graph 6.11: Marginal effects of combined knowledge transfer in interaction with R&D expenditures



Note: All models are estimated with random effects and include the explanatory variables ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies.

Table L: Intensive knowledge transfer in interaction with R&D expenditures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable:	Productinno	Processinno	ln(Sal_new)	ln(Sal_impr)	ln(Sal_inno)	ln(Sales)	ln(Valadd)
Estimation method:	Logit	Logit	R.E.	R.E.	R.E.	R.E.	R.E.
KTT intensive	-1.656	-1.009	-1.473***	-0.592	-1.146***	-0.617***	-0.437***
	(1.207)	(0.950)	(0.418)	(0.395)	(0.379)	(0.194)	(0.162)
ln(R&D exp.)	0.203***	-0.055	0.165***	0.132***	0.174***	0.077***	0.040***
	(0.046)	(0.039)	(0.019)	(0.018)	(0.017)	(0.008)	(0.007)
KTT int.*ln(R&D exp.)	0.151	0.112	0.116***	0.048*	0.091***	0.048***	0.033***
	(0.092)	(0.069)	(0.030)	(0.028)	(0.027)	(0.014)	(0.012)
Observations	1,960	1,960	1,557	1,500	1,698	1,960	1,960

All estimations contain the explanatory variables ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies; (1) and (2) are estimated using random effects logit, (3) to (7) are estimated using standard random effects; *** p<0.01, ** p<0.05, * p<0.1

4.4 Policy Implications

The results of the econometric estimations carried out in the last subsection have shown that KTT can increase the innovation performance and competitiveness of enterprises. Thus, KTT is another potential way through which public research institutions create direct benefits for the private sector beyond their basic research and educational functions. On the one hand, a suitable economic policy framework can promote the tendency towards knowledge and technology transfer. On the other hand, it can also increase the effectiveness of KTT on the innovation performance and competitiveness of enterprises. The statistical results presented so far and the subsequent detailed descriptive and econometric analysis of the KTT impediments can provide evidence for an effective economic policy.

4.4.1 Perceived Obstacles

So far, we have analyzed which type of private enterprise conducts transfer activities with public research institutions, which transfer forms they use, and what motivates them for such activities. Moreover, we have presented the results of these transfer activities according to the information provided by private enterprises. This section concludes our conceptual model by shedding light on the transfer obstacles on part of the private enterprises.

4.4.1.1 Categories

Analogous to the transfer forms and the motives for KTT, we distinguish between 26 single impediments that are categorized into five groups: «Missing information», «lack of requirements on part of the enterprise», «lack of requirements on part of the scientific partner», «costs and risks», and «organizational and institutional impediments». This first subsection analyzes the impediment categories while the single impediments within each category are analyzed in the upcoming subsections.

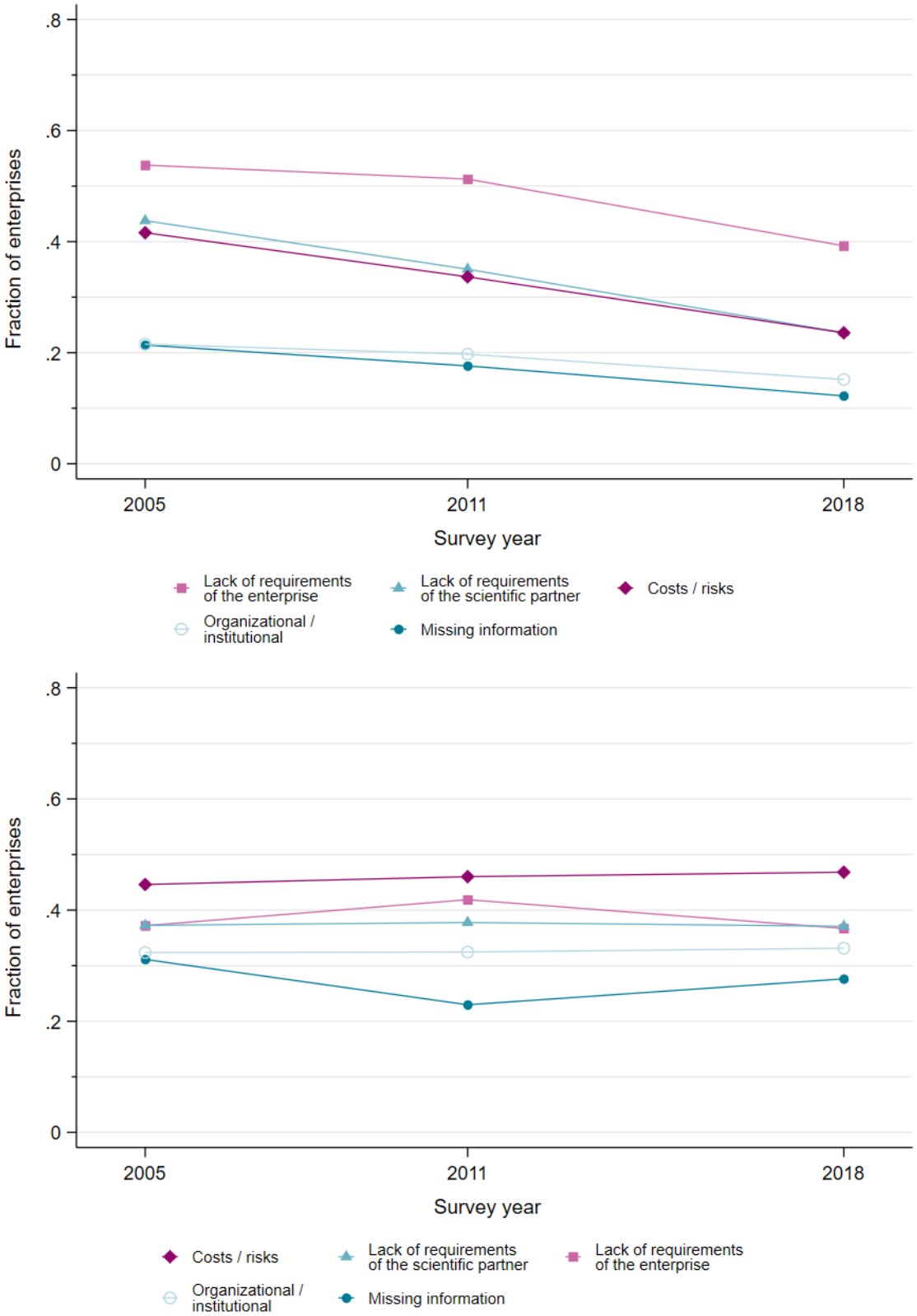
Graph 7.1 depicts the fraction of enterprises that reported at least one single impediment within a certain category as highly relevant (values 4 or 5 on a 5-point ordinal scale). The upper graph shows the fraction of KTT-**in**active enterprises while the lower graph depicts the fraction of KTT-active enterprises that identify a certain category as a highly relevant impediment for their KTT activities with scientific enterprises.

The fraction of KTT-inactive enterprises that reported a certain category of impediments as highly relevant decreases over the survey period. The fraction of KTT-active enterprises, on the other hand, that see a certain category of impediments as highly relevant is stable over these periods.

The most relevant impediments for KTT-active enterprises are the «lack of own requirements» that are necessary to conduct KTT. The «lack of requirements of the scientific partner» and «costs or risks» associated with KTT are also of some relevance to KTT-inactive enterprises, but strongly declining over the survey periods. «Missing information» and «organizational and institutional impediments» play a minor relevance for these enterprises.

KTT-active enterprises, on the other hand, see «costs and risks» associated with KTT as most relevant impediments. About 45% of all KTT-active enterprises report at least one single impediment in this category as a highly relevant hurdle to their transfer activities. «Lacking requirements on part of the enterprises» and «on part of the scientific partner» constitute the second most important categories of impediments for KTT-active enterprises. Contrary to the KTT-inactive enterprises, KTT-active enterprises also see «organizational and institutional impediments» and even «missing information» as somewhat relevant.

Graph 7.1: Impediment categories for knowledge and technology transfer, overall[64]



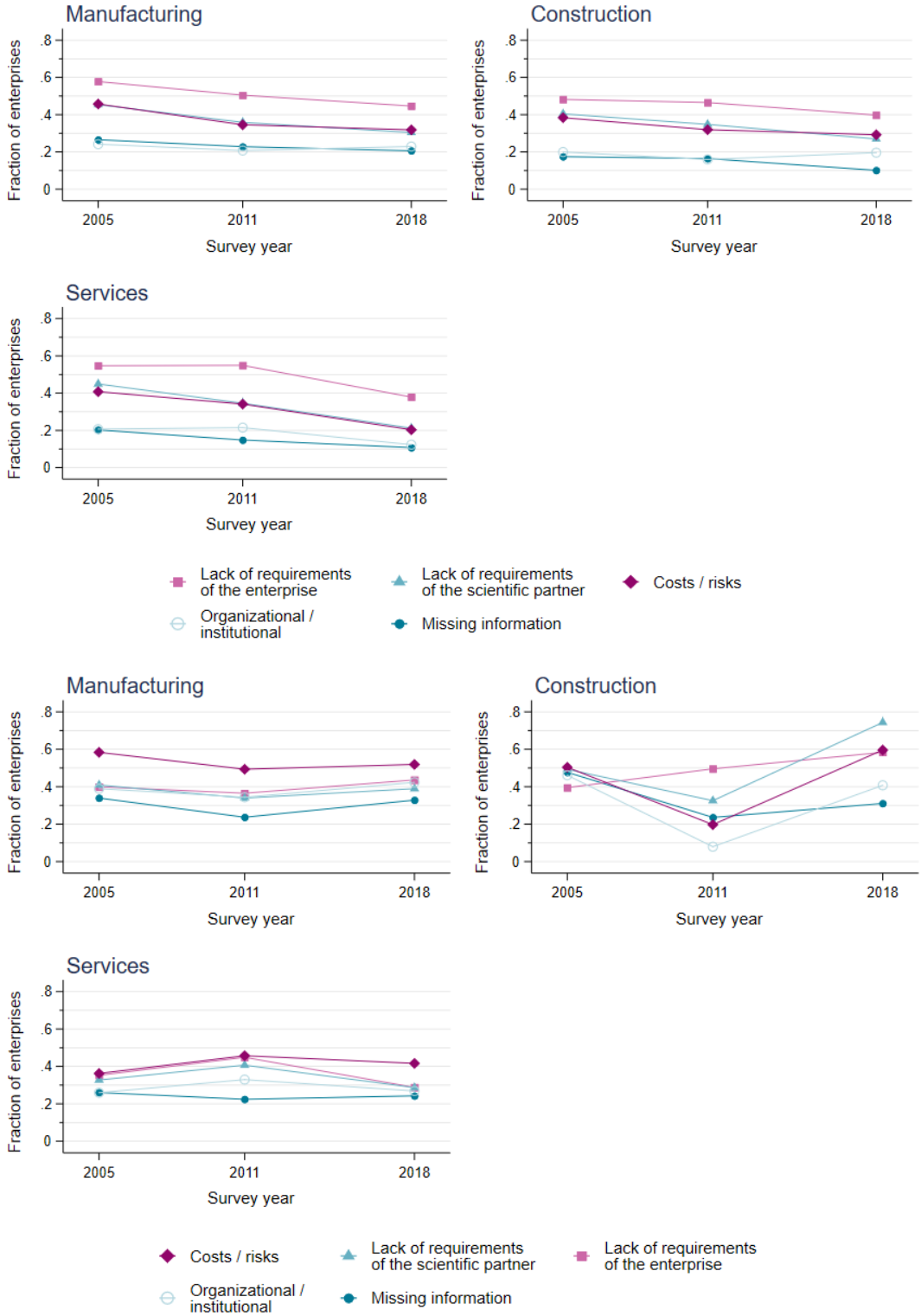
Note: This graphic shows the fraction of enterprises that reported at least one single impediment for knowledge and technology transfer in the above-mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph) and those that were engaged in these transfer activities (lower graph).

Source: KOF-KTT surveys (2005, 2011, 2018)

[64] The exact numbers that this graph is based on can be found in Table A8i on page 152 and Table A10iii on page 154 in the appendix.

Graph 7.2: Impediment categories for knowledge and technology transfer, by sector [65]



Note: These graphics show the fraction of enterprises that reported at least one single impediment for knowledge and technology transfer in the above-mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph) and those that were engaged in these transfer activities (lower graph), by sector

Source: KOF-KTT surveys (2005, 2011, 2018)

[65] The exact numbers that this graph is based on can be found in Table A8i on page 152 and Table A10iii on page 154 in the appendix.

Graph 7.2 depicts the fraction of KTT-inactive (upper graph) and KTT-active enterprises (lower graph) that reported at least one single impediment in a specific category as highly relevant by sector. For each of the three sectors, the fraction of KTT-inactive enterprises that reported a certain category of impediments as highly relevant is regressing over the survey periods. For the manufacturing and services sector, the fraction of KTT-active enterprises that report each category of impediments as highly relevant is rather stable over the three survey periods. In the construction sector, this fraction first fell and then increased again, except for «lacking requirements of the enterprises» themselves.

In line with the overall picture, KTT-inactive enterprises see «lacking own requirements» as most relevant, followed by «lacking requirements of the scientific partner» and «cost and risk-related» impediments. «Missing information» and «organizational and institutional impediments» are of minor relevance. This holds irrespective of sector.

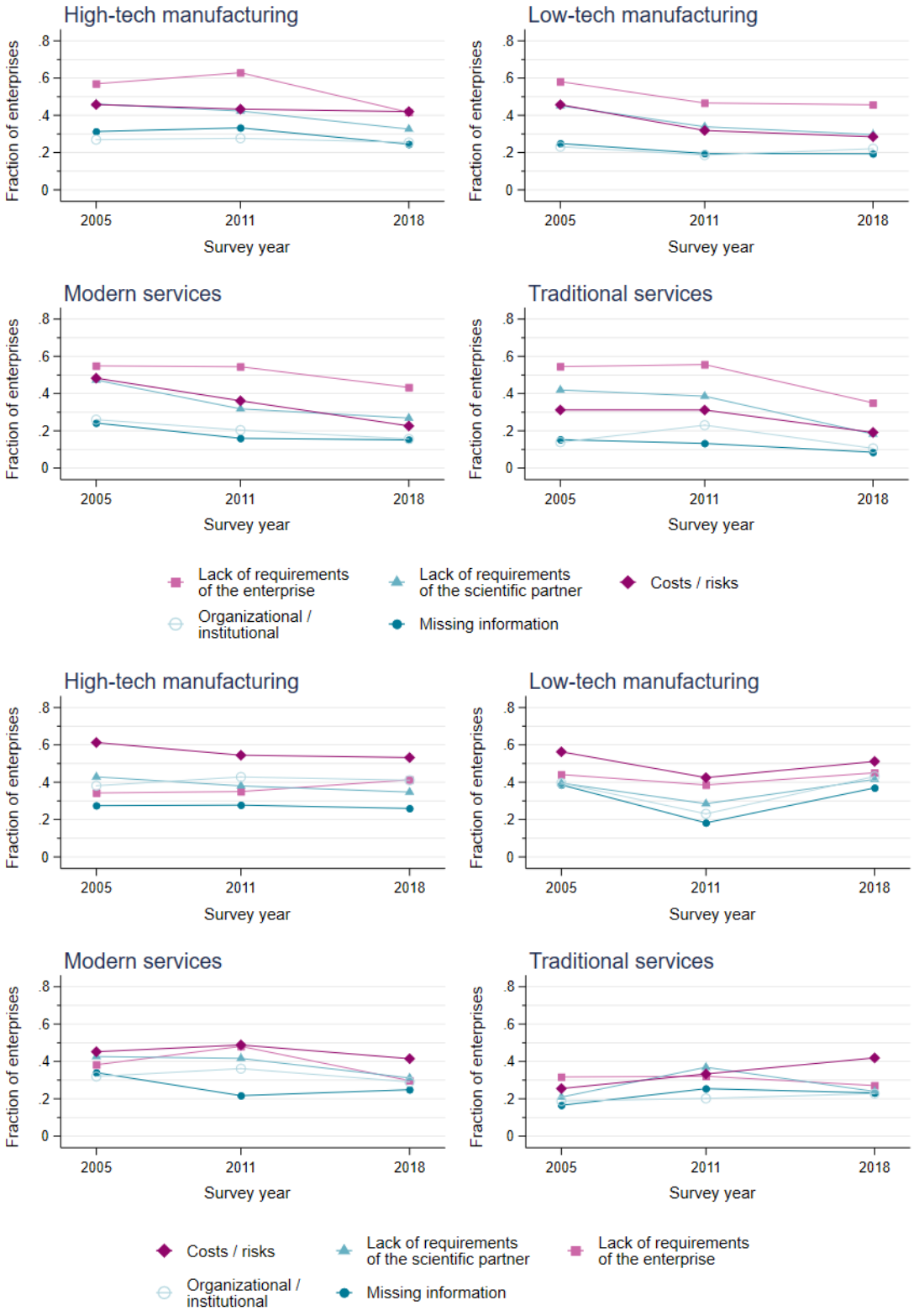
KTT-active enterprises show somewhat more variation across sectors. «Costs and risks» of KTT are the most frequent highly relevant impediment category for the manufacturing as well as for the services sector. The fraction of KTT-active enterprises that reports them as highly relevant is slightly bigger in the manufacturing sector, especially in the first survey period. The fraction of KTT-active construction enterprises that see «costs and risks», «lacking requirements of the scientific partner», or «organizational and institutional impediments» as highly relevant first decreases and then sharply increases in the latter two periods. «Lacking requirements within the enterprises» show a steady increase in the KTT-active construction enterprises that see this category of impediments as highly relevant.

Graph 7.3 shows these fractions by subsector. Each subsector behaves in the same way as their sector and therefore in the same fashion as the overall picture for KTT-inactive enterprises. For KTT-active enterprises, there are no major differences either.

Graph 7.4 shows the fraction of KTT-inactive (upper graph) and KTT-active enterprises (lower graph) by enterprise size, which reported at least one single impediment in one of the five categories as highly relevant. In line with the overall picture, the relevance of the impediments decreased over time for KTT-inactive enterprises and is stable for KTT-active enterprises, irrespective of enterprise size. There are also no massive differences across enterprise size with respect to the relative importance of a certain category of impediments. In fact, they closely correspond to the overall picture.

We can therefore conclude that the fraction of enterprises that reported a certain category of impediments as highly relevant regresses for KTT-inactive enterprises and is stable for KTT-active enterprises over the three survey periods, irrespective of sector, subsector, or enterprise size. KTT-inactive enterprises primarily see «their lack of requirements» for KTT as the most important impediment while KTT-active enterprises see «costs and risks» associated with KTT as most relevant.

Graph 7.3: Impediment categories for knowledge and technology transfer, by subsector[66]



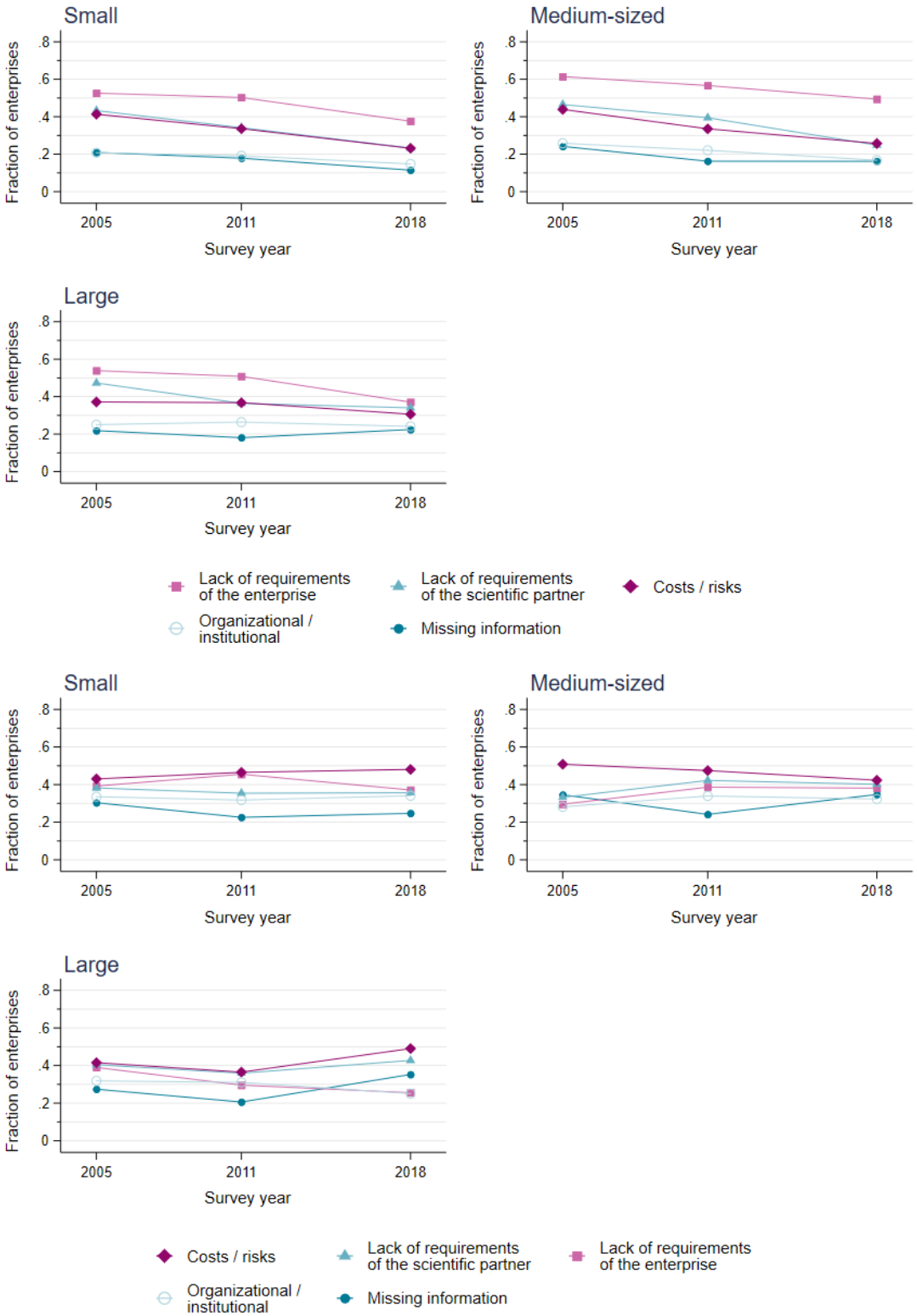
Note: These graphics show the fraction of enterprises that reported at least one single impediment for knowledge and technology transfer in the above-mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph) and those that were engaged in these transfer activities (lower graph), by subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[66] The exact numbers that this graph is based on can be found in Table A8i on page 152 and Table A10iii on page 154 in the appendix.

Graph 7.4: Impediment categories for knowledge and technology transfer, by enterprise size[67]



Note: These graphics show the fraction of enterprises that reported at least one single impediment for knowledge and technology transfer in the above-mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph) and those that were engaged in these transfer activities (lower graph), by enterprise size

Source: KOF-KTT surveys (2005, 2011, 2018)

[67] The exact numbers that this graph is based on can be found in Table A8i on page 152 and Table A10iii on page 154 in the appendix.

4.4.1.2 Single Impediments

In this section, we dig a little deeper and investigate every single impediment within each category.

4.4.1.2.1 Missing Information

We first look at a category that is of rather minor relevance, especially for KTT-inactive enterprises. The category of «missing information» comprises three single impediments: «Difficulties in finding the right contact persons» at the scientific partner, a «lack of information about the scientific partners' research activities», and an «inadequate equipment of the interface» to the scientific partner.

Graph 7.1.1 depicts the fraction of KTT-inactive (upper graph) and the fraction of KTT-active (lower graph) enterprises that reported one of the three single impediments in the category of «missing information» as highly relevant in one of the three survey periods.

The fraction of KTT-inactive enterprises that report a specific impediment as highly relevant slightly decreases of the survey horizon for all three impediments. They all seem to be equally relevant in the last two survey periods. Around 10% of all KTT-inactive enterprises report them as highly relevant.

For KTT-active enterprises, these fractions are rather stable over the survey periods. «Finding the right contact person» seems to be the most relevant single impediment for these enterprises. An «inadequate interface equipment» records the lowest fraction of KTT-active enterprises that see that as a major hurdle for their KTT activities.

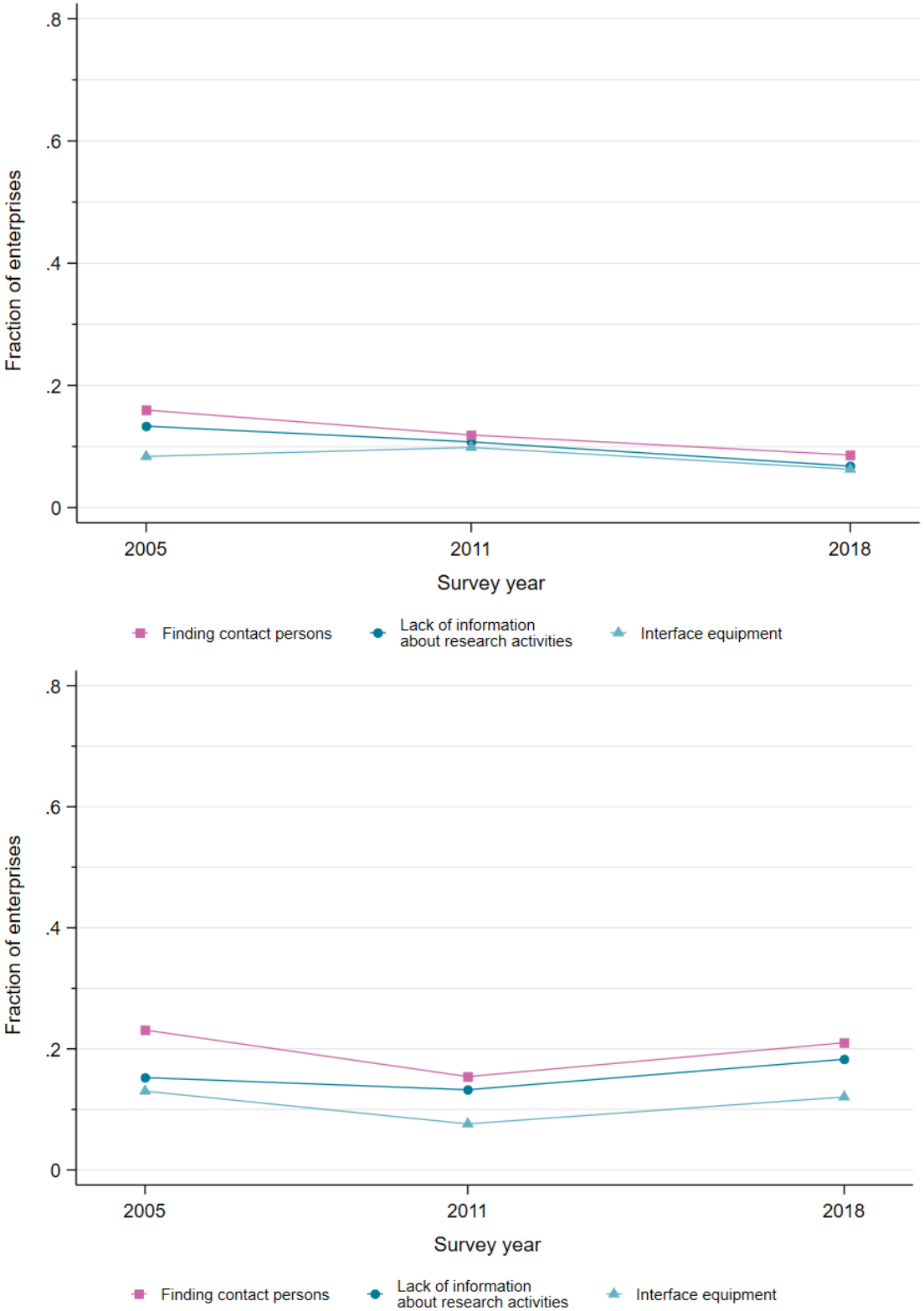
Graph 7.1.2 depicts the relevance of the three single impediments in the category of «missing information» for KTT-active (lower graph) and KTT-inactive (upper graph) enterprises by sector. The picture is not much different from the overall case.

Each sector shows minimal decreases in the fraction of KTT-inactive enterprises that report a certain impediment as highly relevant. Furthermore, they seem about equally relevant in the construction and service sector and a bit more important in the manufacturing sector.

The manufacturing and services sector show quite stable fractions of KTT-active enterprises that see a single impediment as highly relevant. The KTT-active construction enterprise show some more variation in the fraction of enterprises that see a specific impediment as highly relevant. The fraction that sees problems in «finding the right contact person» and an «inadequate interface equipment» first decreased and then increased again. A «lack of information about the research activities of the scientific partner» record steady values.

Graph 7.1.3 depicts this information by subsector. For KTT-inactive enterprises, the picture is similar across subsectors and corresponds to the overall values. KTT-active enterprises show slightly more variation in their fraction of enterprises that are hindered by a certain impediment than on a sector level. Except for the KTT-active low-tech manufacturing enterprises, that are more hindered by «finding the right contact person» or a «lack of information about research activities of their partner», these differences are only minor.

Graph 7.1.1: Single impediments for knowledge and technology transfer in the category «Missing information», overall[68]



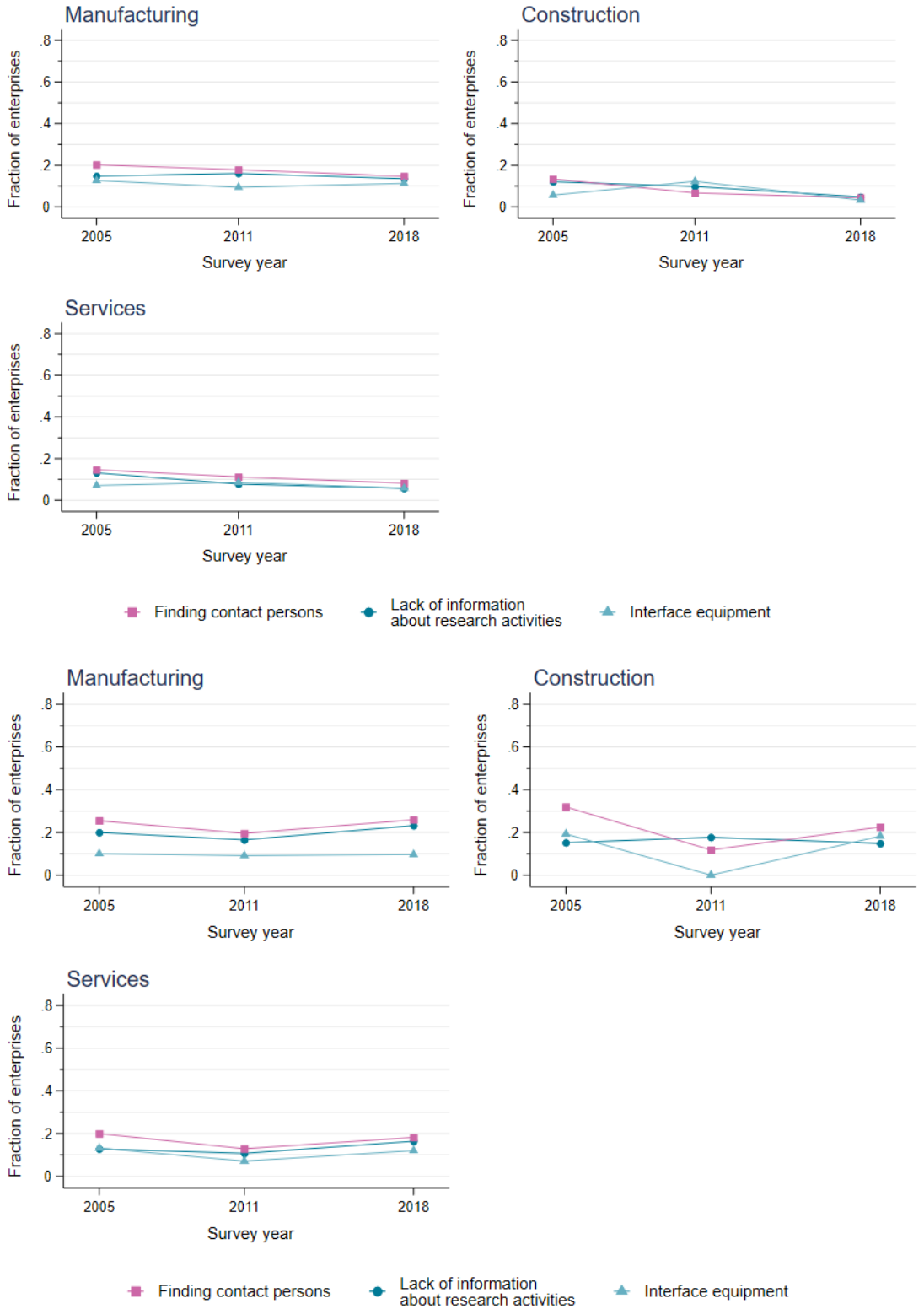
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Missing information» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph)

Source: KOF-KTT surveys (2005, 2011, 2018)

[68] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.1.2: Single impediments for knowledge and technology transfer in the category «Missing information», by sector[69]



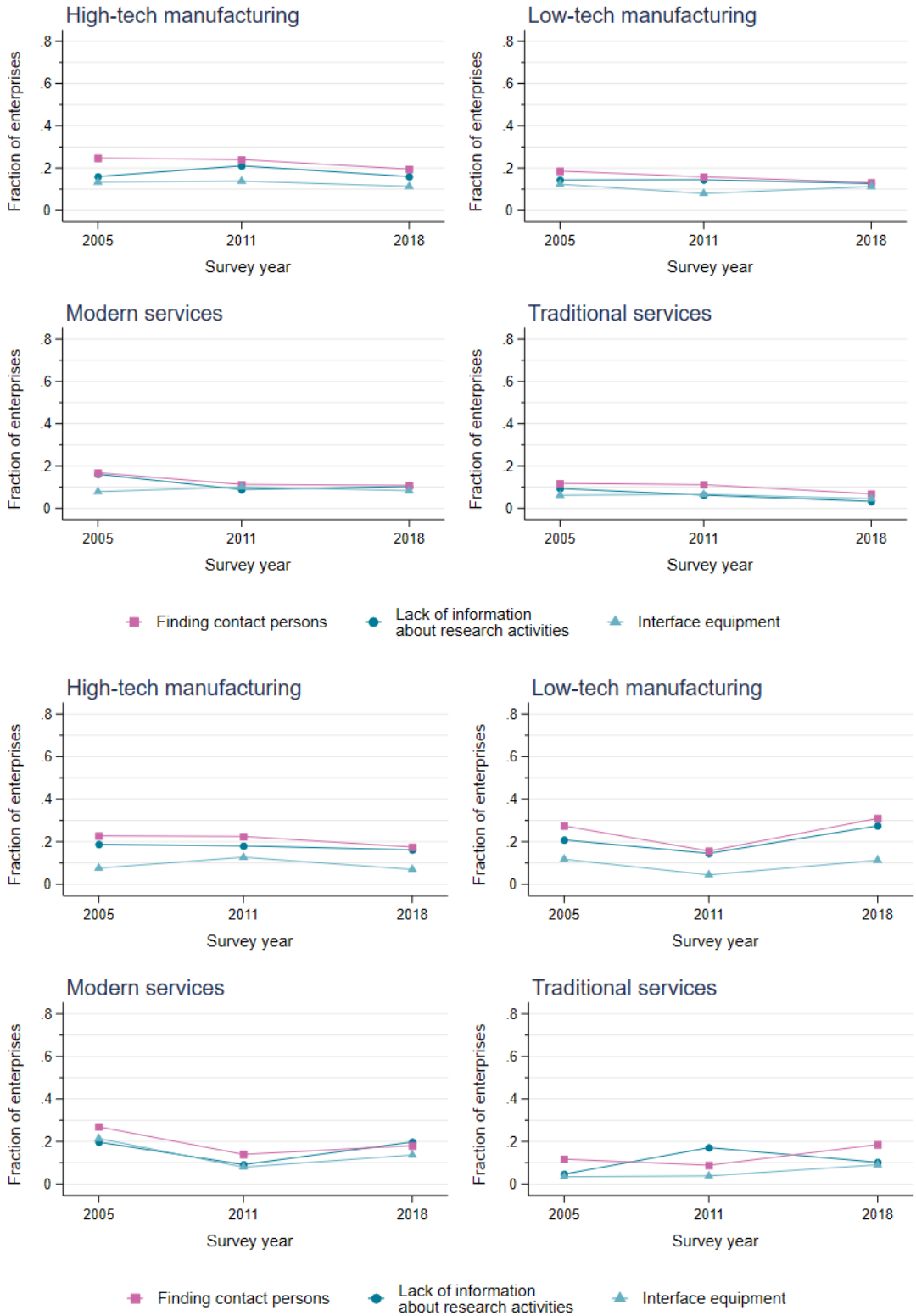
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Missing information» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by sector

Source: KOF-KTT surveys (2005, 2011, 2018)

[69] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.1.3: Single impediments for knowledge and technology transfer in the category «Missing information», by subsector[70]



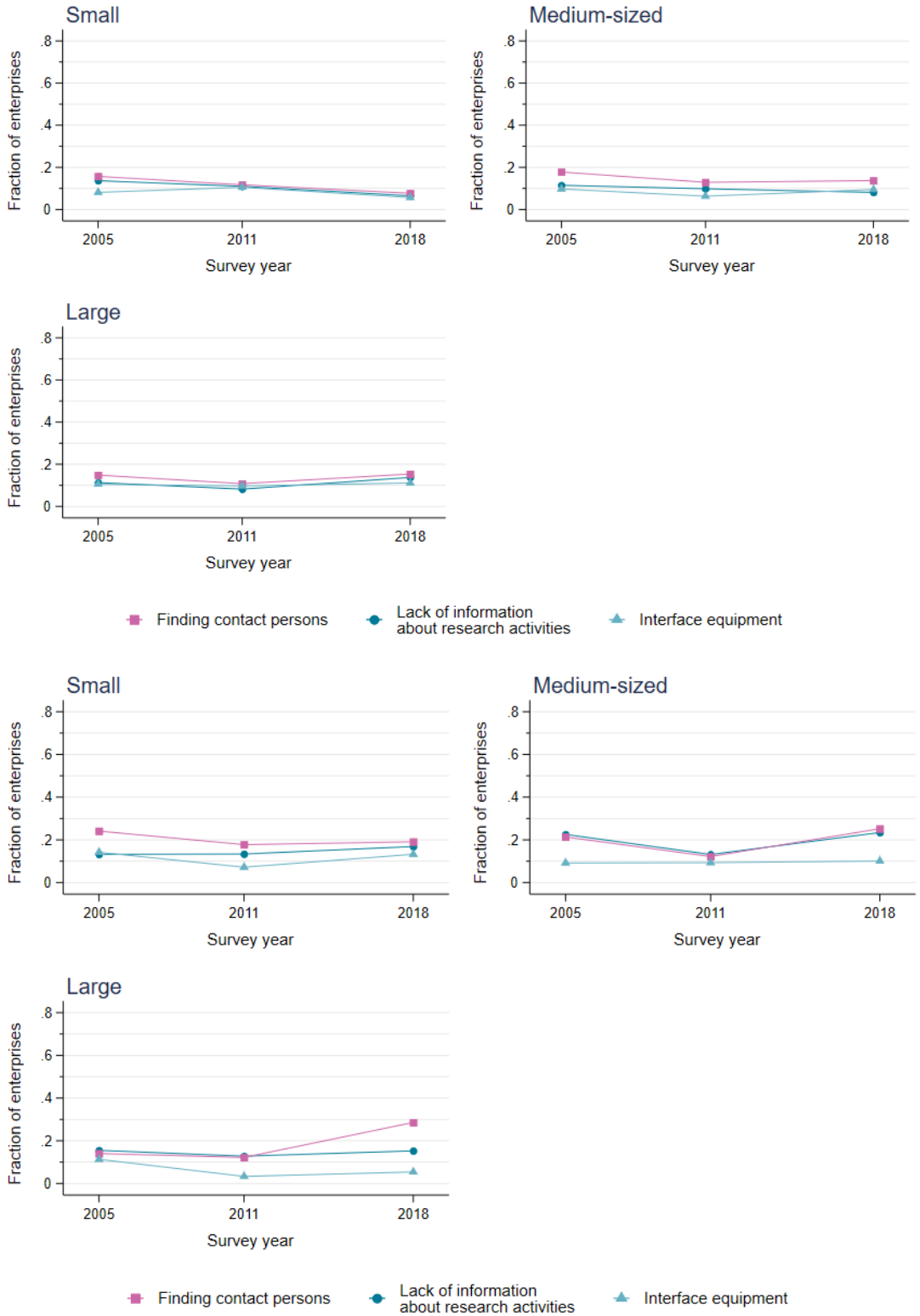
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Missing information» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[70] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.1.4: Single impediments for knowledge and technology transfer in the category «Missing information», by enterprise size[71]



Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Missing information» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by enterprise size

Source: KOF-KTT surveys (2005, 2011, 2018)

[71] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.1.4 finally depicts this information by enterprise size. KTT-inactive enterprises see the three «missing information» impediments as equally important, irrespective of enterprise size. The relevance of all three impediments is slightly decreasing for small KTT-inactive enterprises but stable for medium-sized enterprises and large enterprises.

For large KTT-active enterprises, an «inadequate interface equipment» is nearly irrelevant. In the most recent period, more large KTT-active enterprises were hindered in their activities by «finding the right contact person». For medium-sized KTT-active enterprises, «interface equipment issues» are not as relevant as «finding the right contact person» or a «lack of information about research activities». For small KTT-active enterprises, all three impediments are of equally low importance.

Overall, we see that no single impediment in the category of «missing information» constitutes an overly important impediment. This relevance is even slightly decreasing over the survey periods for KTT-inactive enterprises and stable for KTT-active enterprises.

4.4.1.2.2 Lack of requirements of the enterprise

As we have seen in section 4.4.1.1, a «lack of requirements of the enterprise» are very relevant, especially for KTT-inactive enterprises. This category of impediments comprises four single impediments: a «lack of qualified personnel», a «lack of technical equipment», a «lacking interest in scientific projects», and the assumption that the enterprise's «R&D questions are uninteresting for public research institutions».

Graph 7.2.1 depicts the fraction of KTT-inactive (upper graph) and KTT-active enterprises (lower graph) that report a specific single impediment in the category of «lack of requirements of the enterprise» as highly relevant.

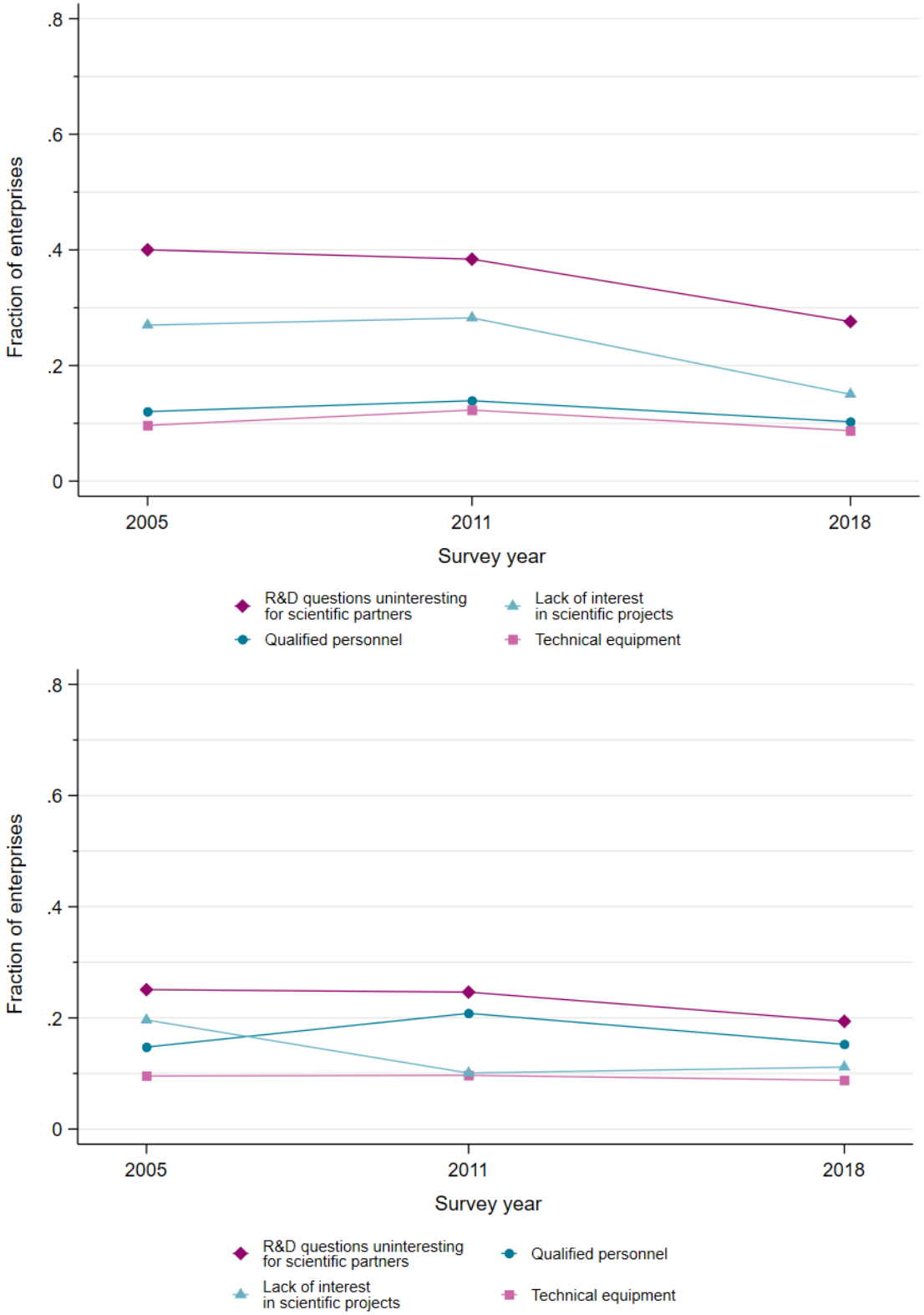
In line with Graph 7.1, there are some lacking «requirements of the enterprise» that hinder a larger fraction of KTT-inactive enterprises than KTT-active enterprises. The belief that the «R&D questions of the enterprise are uninteresting for public research institutions» and a «lack of interest in scientific projects» are far more prevalent for KTT-inactive enterprises than for KTT-active enterprises. This relevance has decreased in latest survey period, though. This reduction is also the reason for the falling importance of the overall category. A «lack of qualified personnel» is less often a highly relevant impediment for either type of enterprises.

Graph 7.2.2 shows the relevance of these four single impediments for KTT-active (lower graph) and KTT-inactive enterprises (upper graph) by sector.

In every sector, KTT-inactive enterprises are mostly hindered to conduct KTT by the belief that their «R&D questions are uninteresting for science». The fractions reporting this impediment as highly relevant have dropped over time for each sector. This reduction was the strongest in the services sector. Consulting Graph 7.2.3, we see that this decline is massively influenced by the traditional services subsector. A «lack of interest» is an important impediment to KTT-inactive enterprises, particularly for the services sector. The fraction of KTT-inactive services enterprises reporting a «lack of interest in scientific projects» dropped in the latest period, though.

KTT-active enterprises see these impediments as less frequently as highly relevant. There are no major fluctuations in the fraction of KTT-active enterprises, which reported a certain requirement for KTT on their side as highly relevant. A «lack of interest in scientific projects» or the belief that their «R&D questions are uninteresting to public research institutions» are marginally more prevalent for KTT-active enterprises than a «lack of qualified personnel» or «technical equipment», irrespective of sector or subsector.

Graph 7.2.1: Single impediments for knowledge and technology transfer in the category «Lack of requirements of the enterprise», overall[72]



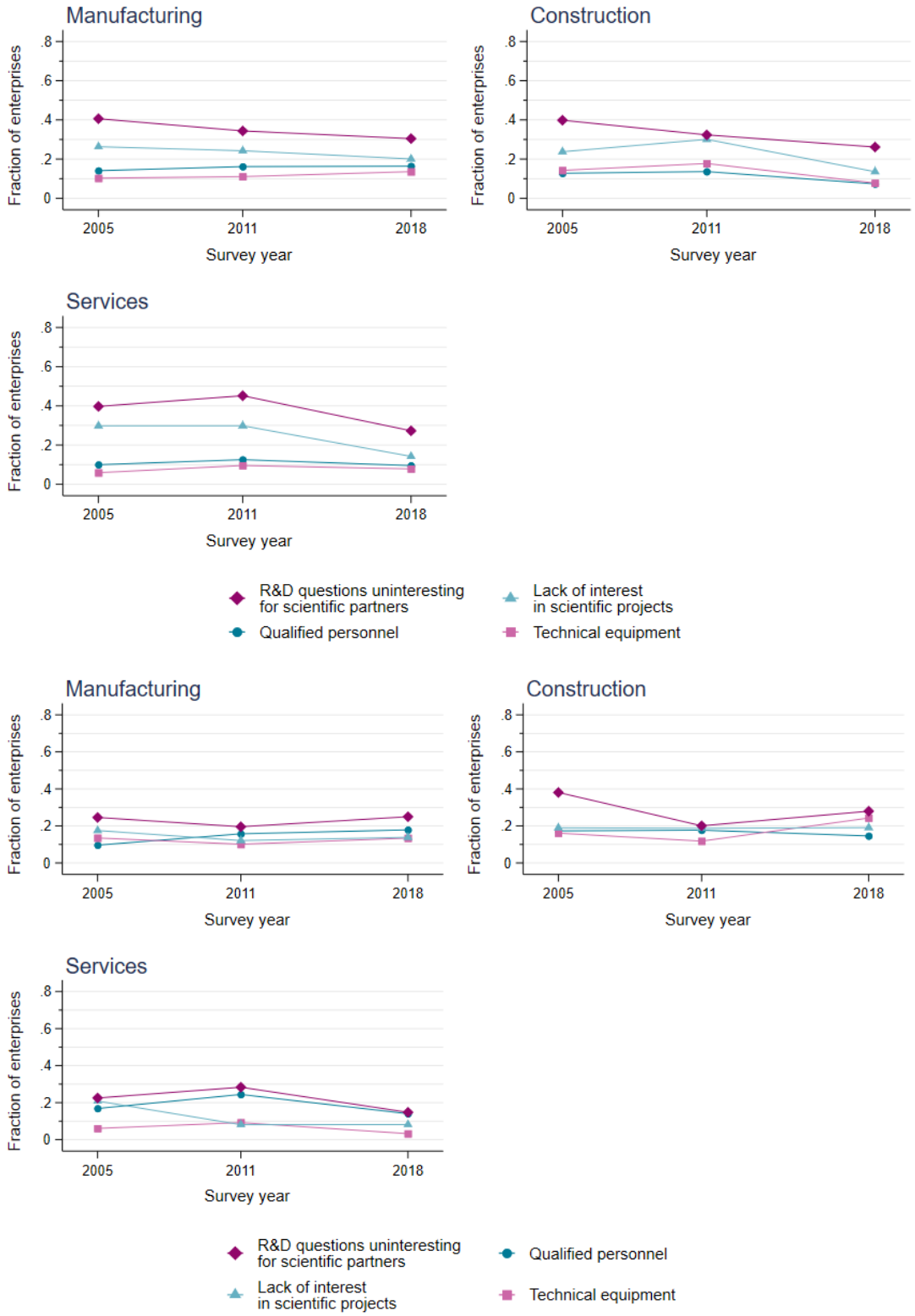
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Lack of requirements of the enterprise» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph)

Source: KOF-KTT surveys (2005, 2011, 2018)

[72] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix

Graph 7.2.2: Single impediments for knowledge and technology transfer in the category «Lack of requirements of the enterprise», by sector[73]



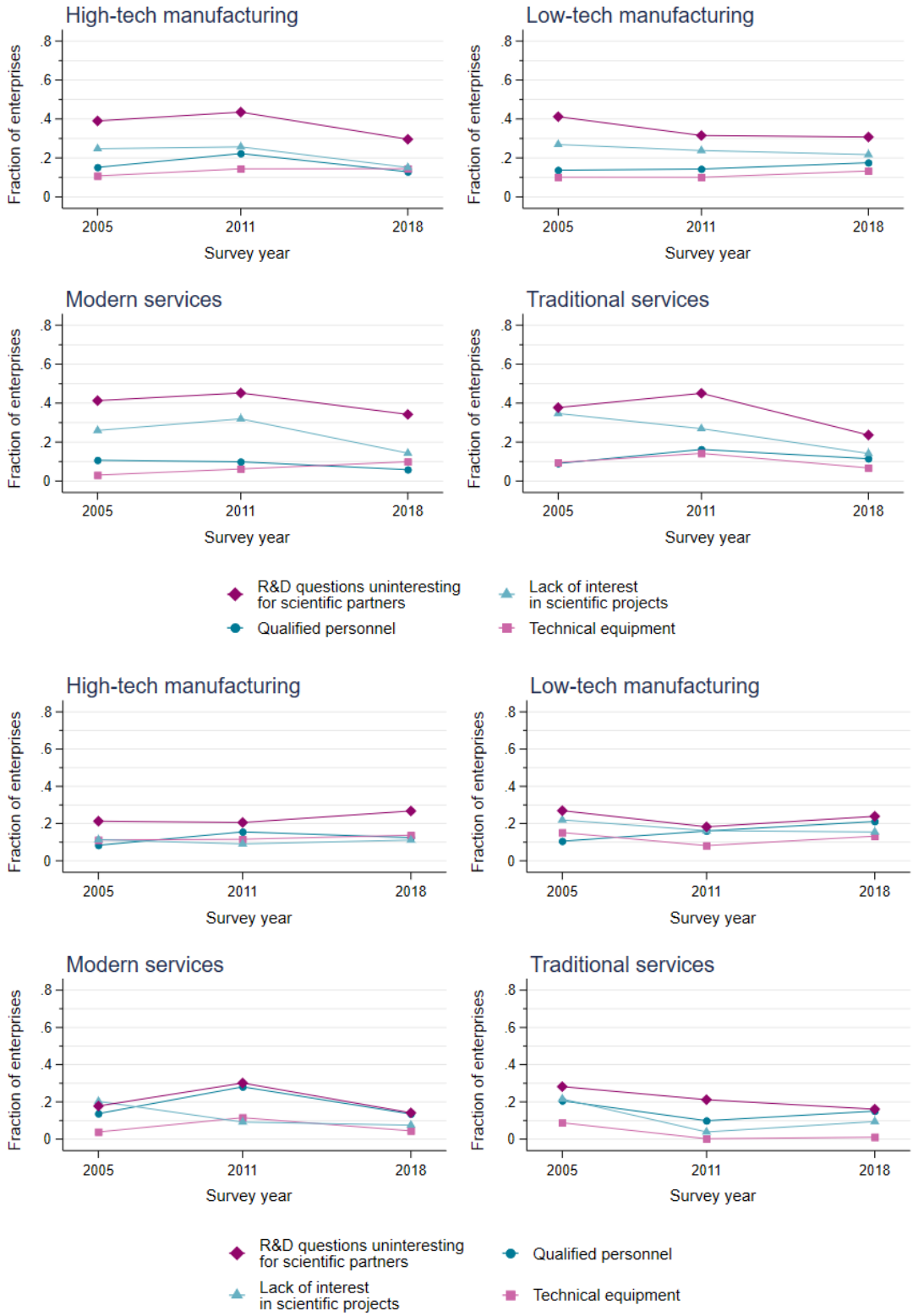
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Lack of requirements of the enterprise» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by sector

Source: KOF-KTT surveys (2005, 2011, 2018)

[73] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.2.3: Single impediments for knowledge and technology transfer in the category «Lack of requirements of the enterprise», by subsector[74]



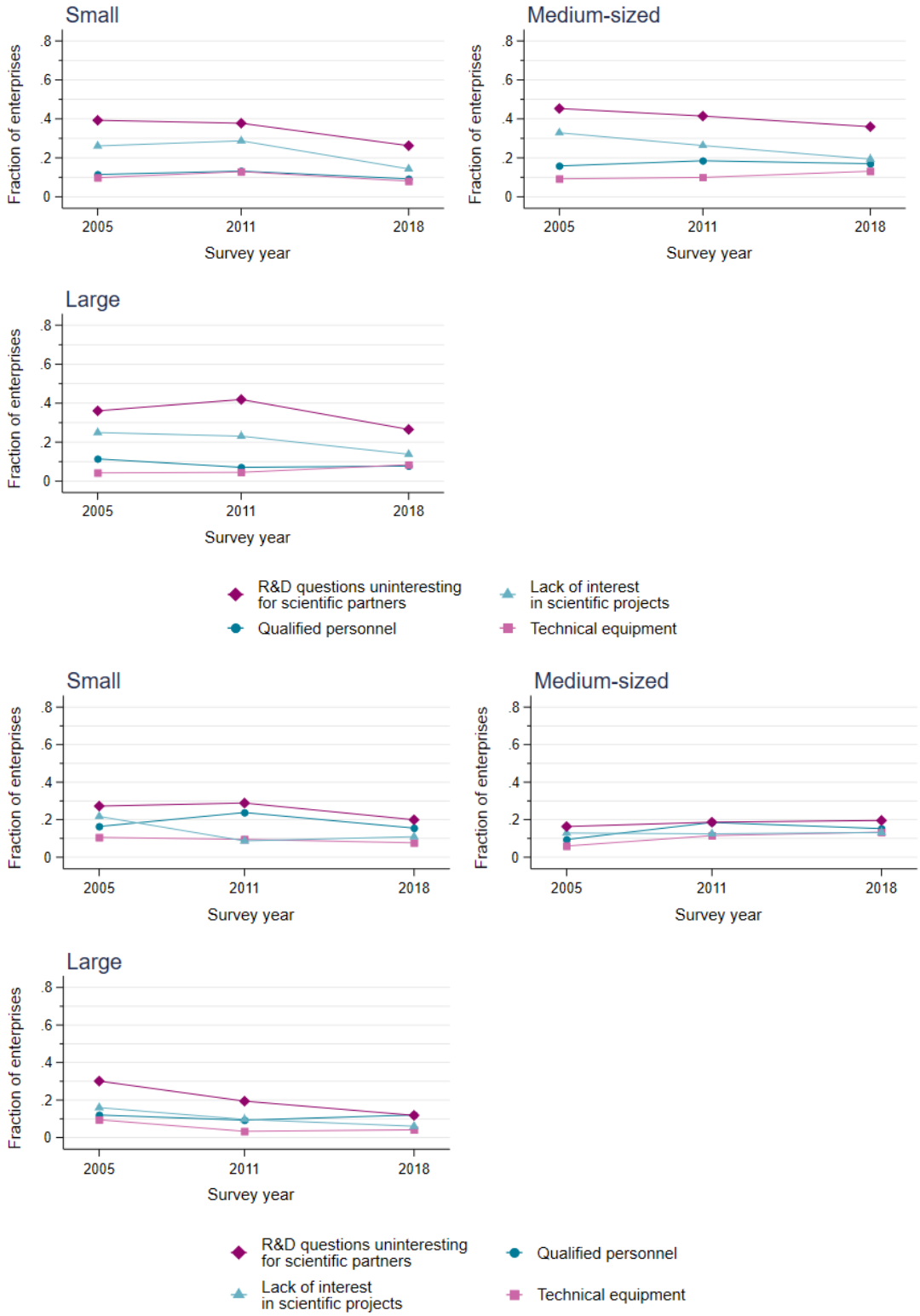
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Lack of requirements of the enterprise» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[74] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.2.4: Single impediments for knowledge and technology transfer in the category «Lack of requirements of the enterprise», by enterprise size[75]



Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Lack of requirements of the enterprise» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by enterprise size

Source: KOF-KTT surveys (2005, 2011, 2018)

[75] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.2.4 depicts these fractions by enterprise size. The reduction in the fraction of KTT-inactive enterprises in the last period that see their «R&D questions as uninteresting to public research institutions» mostly stems from small and large enterprises and only to a small extent from medium-sized enterprises. Irrespective of enterprise size, though, this is the most prevalent impediment. While a «lack of interest in scientific projects» is an important impediment for each enterprise size as well, large KTT-inactive enterprises see a «lack of technical equipment» or «qualified personnel» as nearly irrelevant.

The KTT-active enterprises show rather stable values for each single impediment over the survey horizon. Small KTT-active enterprises see a «lack of interest on their side» or a believed «lack of interest on the public research institution's side» as slightly more relevant impediments than a «lack of qualified personnel» or a «lack of technical equipment». For medium-sized KTT-active enterprises, all four impediments are similarly relevant. The same holds true for large enterprises, except for a slightly larger fraction that sees a potential lack of interest on the public research institutions side as highly relevant. This fraction is decreasing over the survey periods.

Summarizing this descriptive information, we see that a «lack of their resources» do not hinder enterprises as much as a «lack of interest» in knowledge and technology transfers, be it from their side or presumed from the public research institutions side. This is more pronounced for KTT-inactive enterprises than it is for KTT-active enterprises. The prevalence of KTT-inactive enterprises that see «lacking interests» as major impediments has fallen in the latest period, though.

4.4.1.2.3 Lack of requirements of the scientific partner

Besides «lacking requirements to conduct KTT on part of the enterprise», a «lack of requirements on the part of the public research institutions» hinder enterprises as well. This category of impediments, which is especially relevant for KTT-active enterprises, comprises four single items: A «lack of KTT specialists» within public research institutions, a «lack of entrepreneurial thinking» of their staff, an «uninteresting research orientation» of the public research institutions for the private enterprises, and a «lack of commercial exploitation» of their research results.

Graph 7.3.1 shows the fraction of KTT-inactive (upper graph) and KTT-active enterprises (lower graph) that reported a specific «lacking requirement of the scientific partner» as a highly relevant impediment. A «lack of commercial exploitation» of the public research institutions' research results and an «uninteresting research orientation» of the public research institution for the private enterprise are the most relevant single impediments.

Both of these two single impediments record a declining fraction of KTT-inactive enterprises that see them as highly relevant. They are the main drivers of the declining importance of lacking «requirements of the scientific partner» for enterprises not engaged in KTT as depicted in Graph 7.1. A «lack of KTT specialists» and a «lack of entrepreneurial thinking» on the public research institutions' side are only highly relevant to around 10% of all KTT-inactive enterprises.

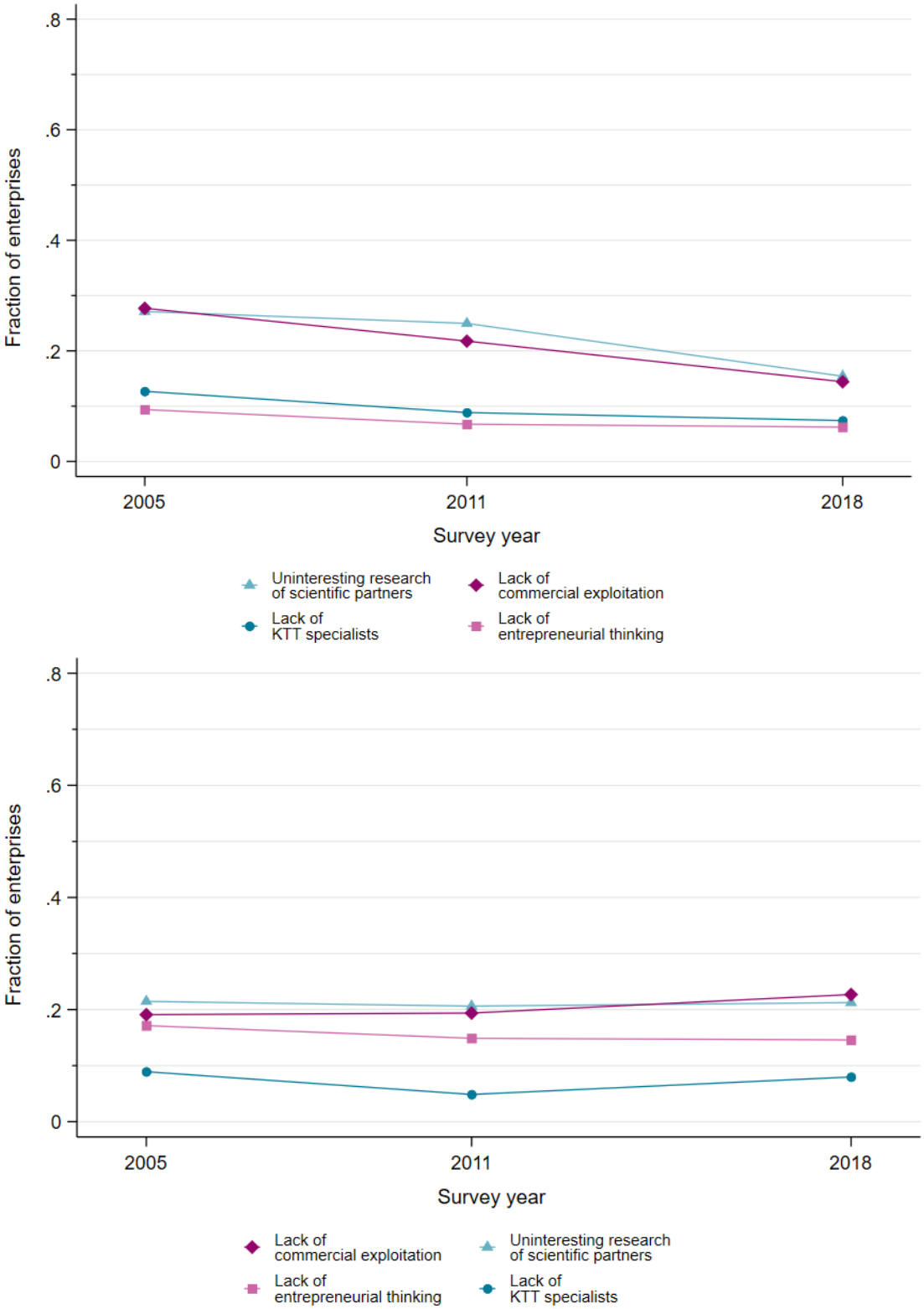
In contrast with KTT-inactive enterprises but in line with Graph 7.1, enterprises that were engaged in KTT hardly show any difference in the relevance of a single impediment in this category over the survey periods. While a «lack of commercial exploitation» and a lack of interest in the research of public research institutions is highly relevant for about 20% of all KTT-active enterprises, they are relatively seldom hindered in their transfer activities by a «lack of KTT specialists» within the public research institutions.

Graph 7.3.2 depicts the relevance of the four single items referring to the category a «lack of requirements of the scientific partner»« by sector, while Graph 7.3.3 depicts the same information by subsector.

A «lack of commercial exploitation» and a «lack of interest in the research of the public research institutions» are the most frequently mentioned highly relevant impediments for KTT-inactive enterprises, irrespective of sector or subsector. Furthermore, in each sector and subsector the fraction of KTT-inactive enterprises that see these two impediments as highly relevant is slightly falling over the survey periods, except for the high-tech manufacturing subsector that records stable fractions. A «lack of entrepreneurial thinking» on the side of the public research institution and a «lack of KTT specialist» are less prevalent impediments and equally relevant across the survey periods and across sectors and subsectors.

When it comes to KTT-active enterprises, the construction sector records higher fractions of enterprises that see these impediments as highly relevant, especially in the latest survey period. The most prevalent impediments for construction enterprises engaged in KTT with public research institutions are a «lack of commercial exploitation» of research results and their «lack of interest in the research orientation of their scientific partner». In the manufacturing and services sector, these two impediments are the most prevalent as well. The fraction of enterprises that report them as highly relevant in these sectors is around 20% and stable over the three survey periods. A «lack of KTT specialists» is nearly irrelevant for the services sector and particularly for modern services enterprises.

Graph 7.3.1: Single impediments for knowledge and technology transfer in the category «Lack of requirements of the scientific partner», overall[76]



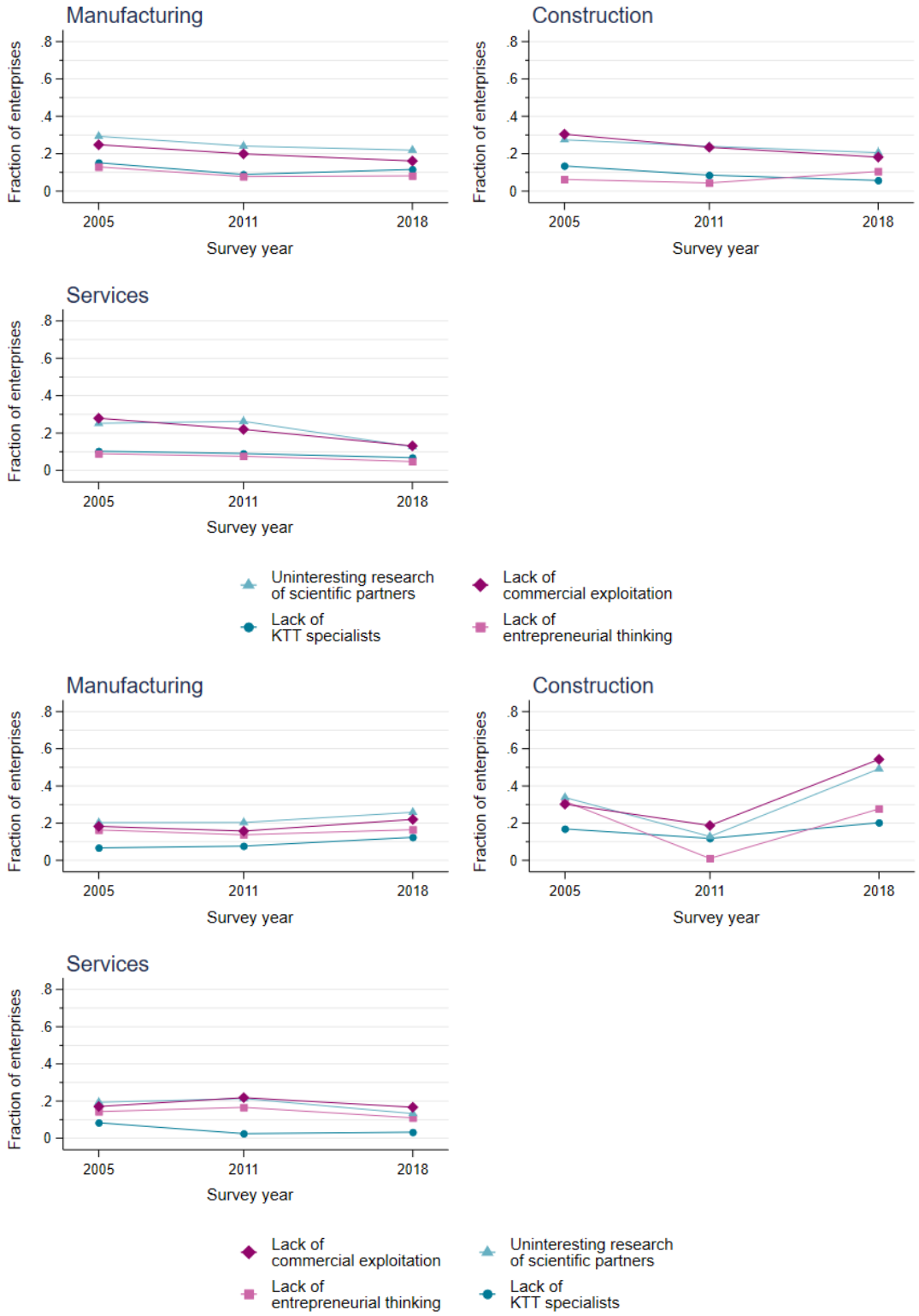
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Lack of requirements of the scientific partner» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph)

Source: KOF-KTT surveys (2005, 2011, 2018)

[76] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.3.2: Single impediments for knowledge and technology transfer in the category «Lack of requirements of the scientific partner», by sector[77]



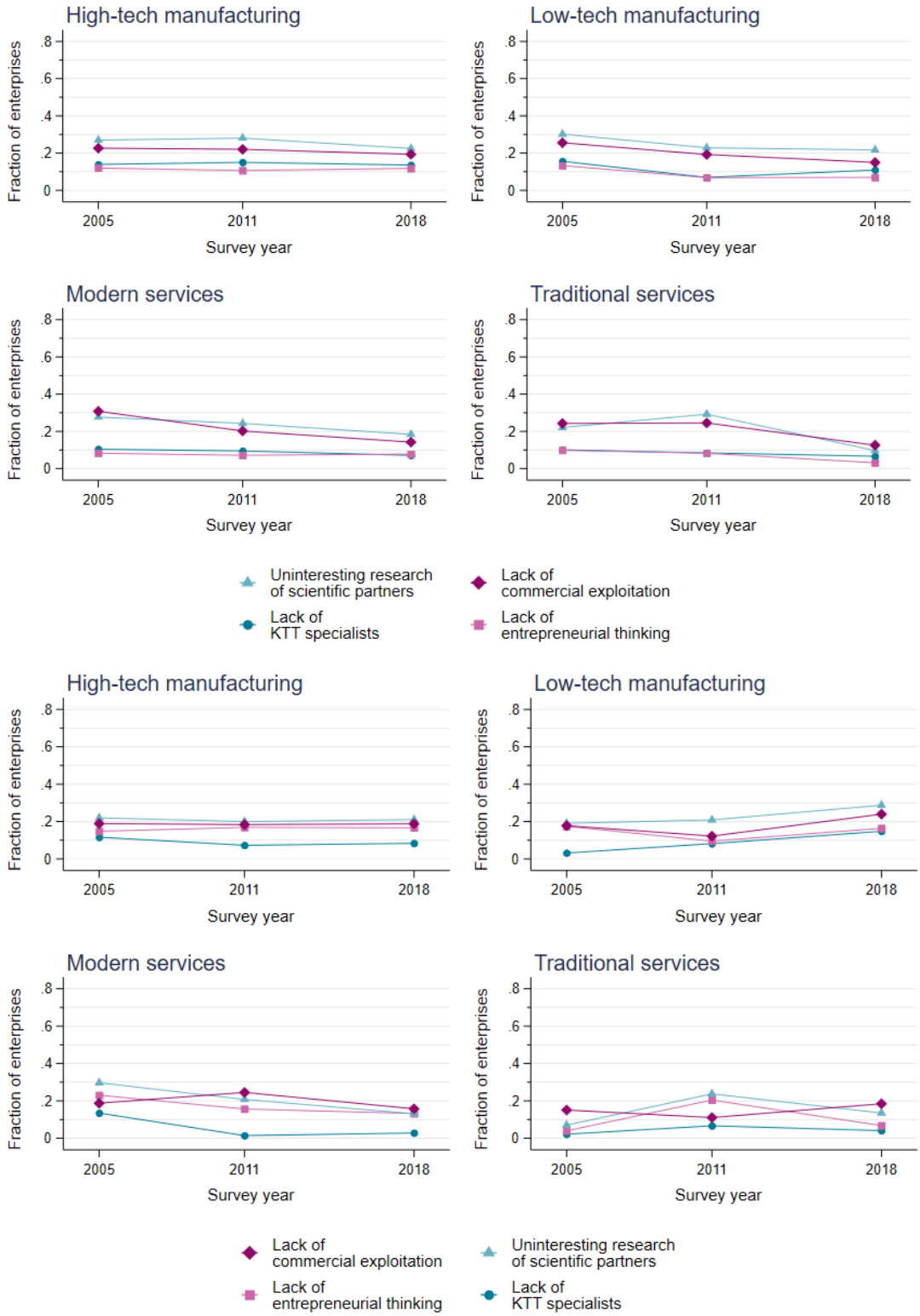
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Lack of requirements of the scientific partner» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by sector

Source: KOF-KTT surveys (2005, 2011, 2018)

[77] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.3.3: Single impediments for knowledge and technology transfer in the category «Lack of requirements of the scientific partner», by subsector[78]



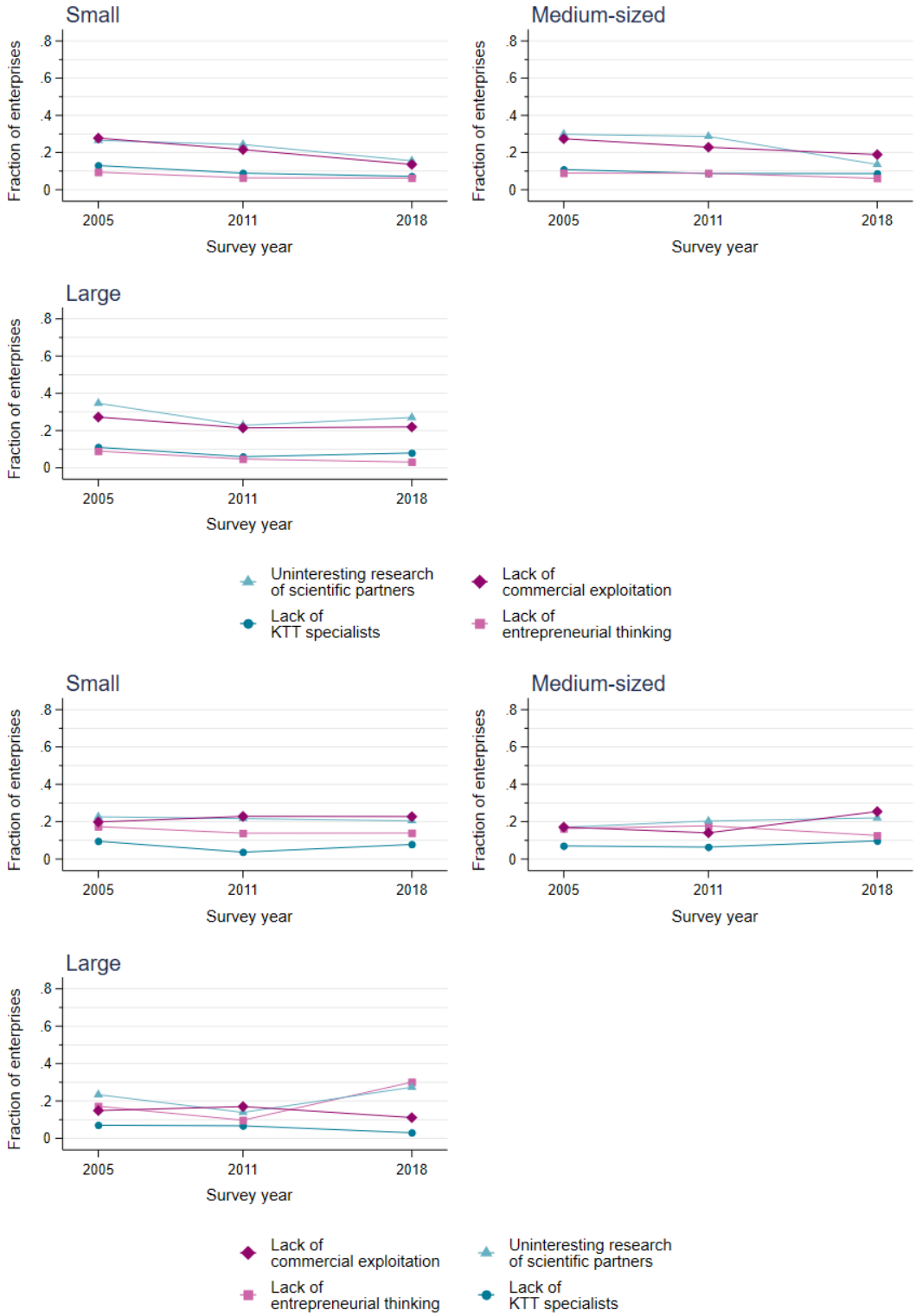
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Lack of requirements of the scientific partner» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[78] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.3.4: Single impediments for knowledge and technology transfer in the category «Lack of requirements of the scientific partner», by enterprise size[79]



Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Lack of requirements of the scientific partner» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by enterprise size

Source: KOF-KTT surveys (2005, 2011, 2018)

[79] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.3.4 presents the relevance of the four single impediments in the category «lack of requirements of the scientific partner»« by enterprise size. For KTT-inactive enterprises, this relevance does not depend on enterprise size. SMEs as well as large enterprises show similar levels and tendencies as the overall picture suggests. Only the item «uninteresting research of the scientific partner» is more important for large enterprises, although it also shows a decreasing tendency across time. The same holds true for KTT-active enterprises for the first two survey periods. Between 2012 and 2017, though, large enterprises were more frequently hindered than SMEs by a «lack of interest in the research orientation of their scientific partners» and especially a «lack of entrepreneurial thinking» within these institutions. On the other hand, large enterprises reported a «lack of commercial exploitation» of research results less often as highly relevant opposed to SMEs.

The enterprises' responses for the single items in the category «lack of requirements of the scientific partner» show that a «lack of commercial exploitation» of research results and a «lack of interest in the research orientation of public research institutions» are more prevalent impediments for KTT-inactive enterprises than the other two items in this category. Furthermore, their relevance is declining over the survey periods. This holds true irrespective of sector, subsector, or enterprise size. KTT-active enterprises, on the other hand, do not record declining fractions that see these impediments as highly relevant. For most sector, subsectors and enterprise sizes, a «lack of interest in the research orientation of public research institutions» and a «lack of commercial exploitation» of their research results are more prevalent impediments for KTT-active enterprises than a «lack of KTT specialists».

4.4.1.2.4 Costs / risks

«Costs and risks» associated with knowledge and technology transfers constitute an important category of impediments as well, particularly for KTT-active enterprises. They comprise seven single impediments: «No guaranteed secrecy», the necessity of «substantial follow-up work», a «lack of financial resources on the part of the enterprise», a «lack of financial resources on the part of the public research institution», an «insufficient efficiency of the transfer partner», «technological dependency», and «uncertainty about the collaboration result».

Graph 7.4.1 shows the fraction of KTT-active (lower graph) and KTT-inactive enterprises (upper graph) that see a specific single impediment in the category of «costs and risks» as highly relevant.

KTT-inactive enterprises primarily see a «lack of their own financial resources» as a highly relevant impediment to conduct KTT. The fraction that reports this impediment as highly relevant has fallen over the survey periods. This single impediment is also responsible for the falling prevalence of «costs and risks» as impediments to conduct KTT overall (see Graph 7.1). The other six impediments are highly relevant to a much smaller fraction of KTT-inactive enterprises and of comparable relevance.

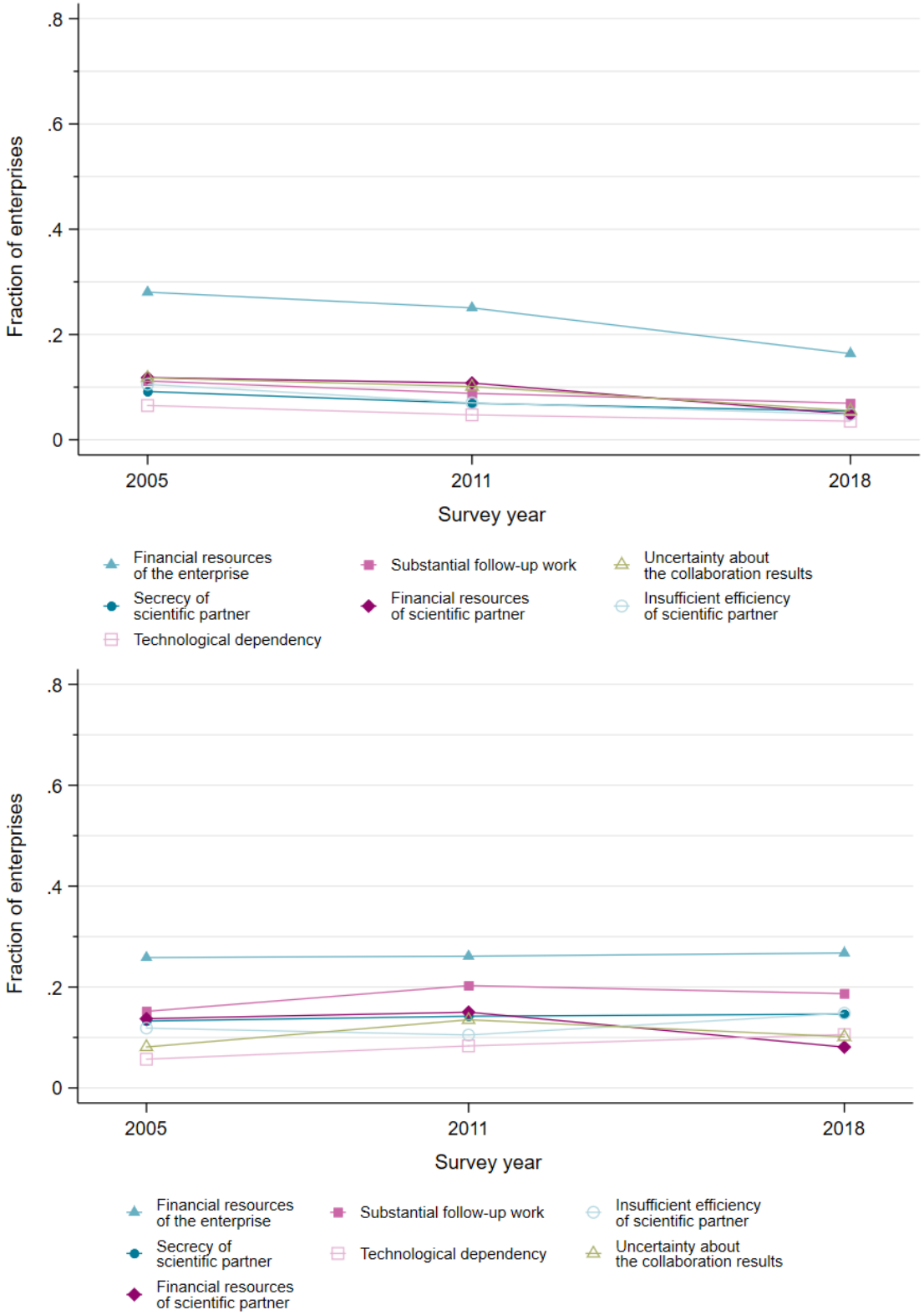
KTT-active enterprises record stable fractions that see these impediments as highly relevant. The most prevalent is a «lack of financial resources on the enterprise's side» as well. «Substantial follow-up work» are of some importance as well. The other impediments are highly relevant to less than 15% of all KTT-active enterprises.

Graph 7.4.2 and Graph 7.4.3 depict this information by sector and subsector.

For KTT-inactive enterprises, the story is not much different across sectors and subsectors. A «lack of own financial resources» hinders enterprises the most in conducting KTT. The fraction of KTT-inactive enterprises that report this impediment as highly relevant falls for manufacturing enterprise between the first two survey periods, while it falls for the other two sectors between the latter two survey periods. The other six single impediments are less relevant and loose in importance across time, irrespective of sector or subsector, with the exception of the construction sector. Here, these impediments hardly changed their importance across time.

For KTT-active enterprises, a «lack of own financial resources» is the most prevalent impediment as well, especially in the construction sector. The fraction of KTT-active enterprises that report one of the other six impediments as highly relevant are smaller, irrespective of sector. These fractions are more dispersed over the six impediments than for KTT-inactive enterprises within a specific sector. The steady increase in importance of «substantial follow-up work» for the enterprises in the construction sector is worth mentioning. We see a similar picture for the subsectors. «Lack of financial resources of the enterprise» and «substantial follow-up work» are the most important obstacles in all sub-sectors. The former obstacles gained importance in the traditional services sector across all times and in the low-tech manufacturing sector in the last period. High-tech manufacturing enterprises reported a constantly decreasing importance of «lack of financial resources of the enterprise» as an important obstacle for KTT. Modern services enterprises also reported a decreasing importance of this single impediment between the last two survey periods. ««Substantial follow-up work»« gained in importance in the high-tech subsector across time.

Graph 7.4.1: Single impediments for knowledge and technology transfer in the category «Costs / Risks», overall[80]



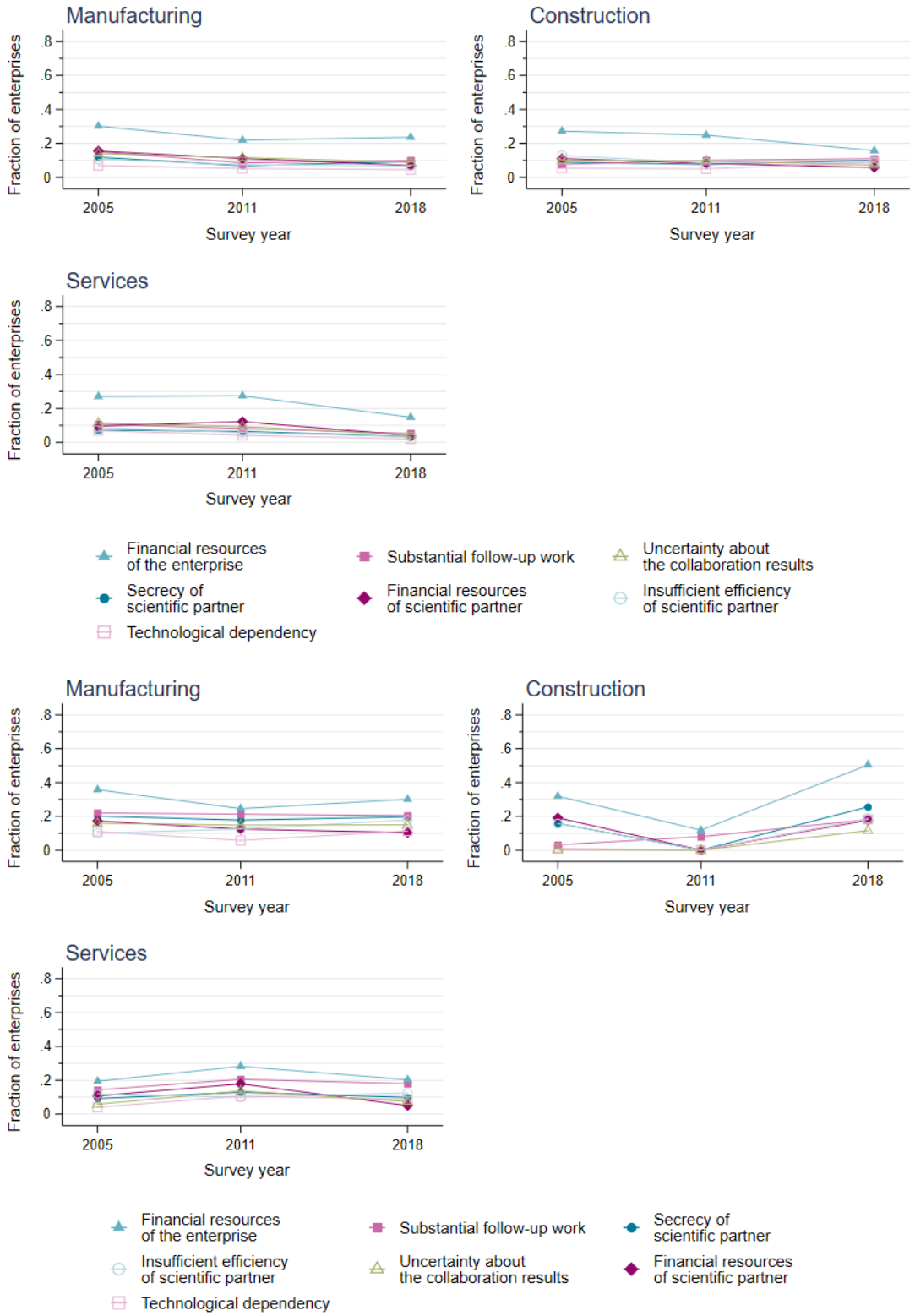
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Costs / Risks» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph)

Source: KOF-KTT surveys (2005, 2011, 2018)

[80] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.4.2: Single impediments for knowledge and technology transfer in the category «Costs / Risks», by sector[81]



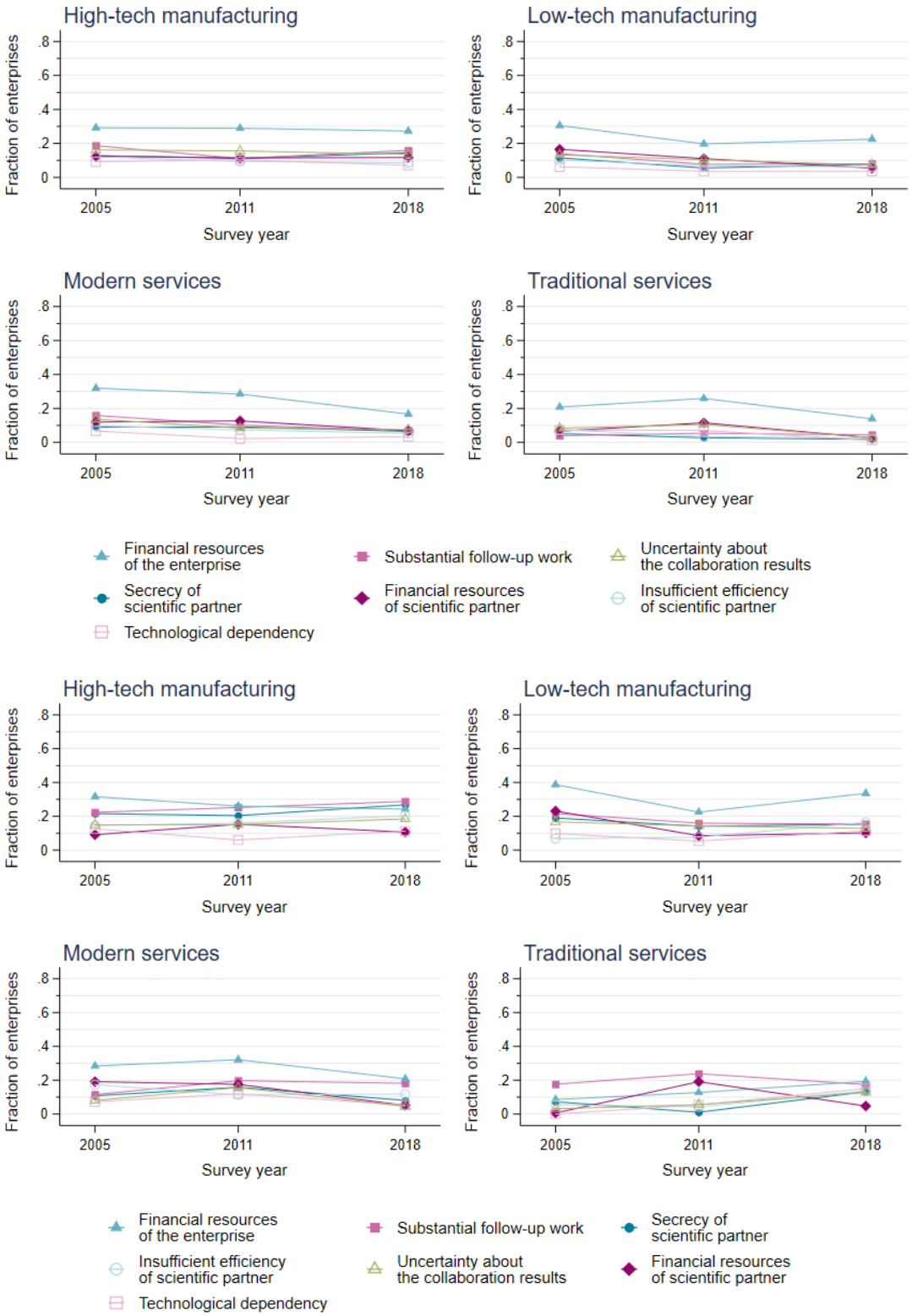
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Costs / Risks» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by sector

Source: KOF-KTT surveys (2005, 2011, 2018)

[81] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.4.3: Single impediments for knowledge and technology transfer in the category «Costs / Risks», by subsector[82]



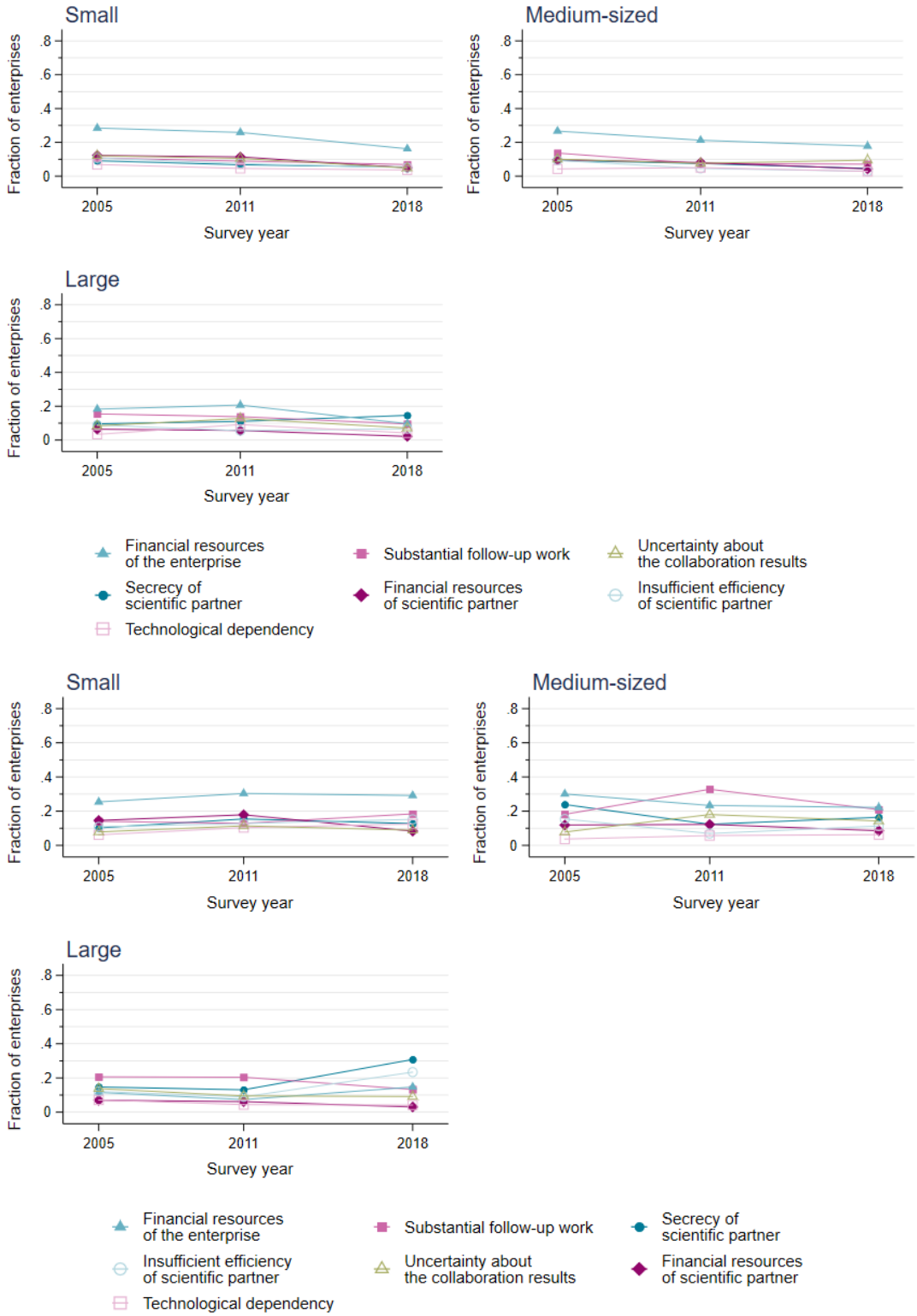
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Costs / Risks» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[82] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.4.4: Single impediments for knowledge and technology transfer in the category «Costs / Risks», by enterprise size[83]



Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Costs / Risks» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by enterprise size

Source: KOF-KTT surveys (2005, 2011, 2018)

[83] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.4.4 shows this information by enterprise size. The picture for KTT-inactive SMEs is similar to the overall case. Large KTT-inactive enterprises less frequently report a «lack of own financial resources» as highly relevant opposed to SMEs. «No guaranteed secrecy» has gained in importance for large KTT-inactive enterprises and became the most important obstacle in the survey period 2018.

For KTT-active enterprises, the picture differs by enterprise size. Small enterprise see a «lack of their own financial resources» as most relevant. «Substantial follow-up work» is quite relevant for medium-sized and large enterprises. In the last survey period, large KTT-active enterprises quite frequently reported a «lack of secrecy of their scientific partners» as highly relevant. The same holds true for an «insufficient efficiency of their partners».

We can therefore conclude the following. A «lack of financial resources of the enterprises» is the most prevalent single impediment in the category of «costs and risks». However, its importance decreased over time for KTT-inactive enterprises. KTT-active enterprises, on the other hand, show a steady assessment of this single impediment. In the last survey period, large enterprises were increasingly concerned with a «lack of secrecy», especially the ones that were engaged in KTT.

4.4.1.2.5 Organizational / institutional impediments

The last category of impediments are of «organizational and institutional» nature. This category comprises eight single impediments: «Authorization procedures and legal restrictions», a «lack of administrative support» from the public research institutions, a «lack of commercialization support», «property rights issues», «management problems of the scientific partner», «differing priorities», a «lack of trust», and the risk of «losing reputation».

Graph 7.5.1 shows the fraction of KTT-active (lower graph) and KTT-inactive enterprises (upper graph) that report a single «organizational and institutional impediment» as highly relevant. In line with Graph 7.1, these impediments are more prevalent for enterprises that are engaged in KTT opposed to those that are not.

For KTT-inactive enterprises, «authorization procedures and legal restrictions» are slightly more often mentioned as a highly significant impediment relative to the other seven. Less than 10% of all KTT-inactive enterprises see these seven single impediments as highly relevant. For half of them this fraction drops to below 5% with a loss of reputation being the least relevant.

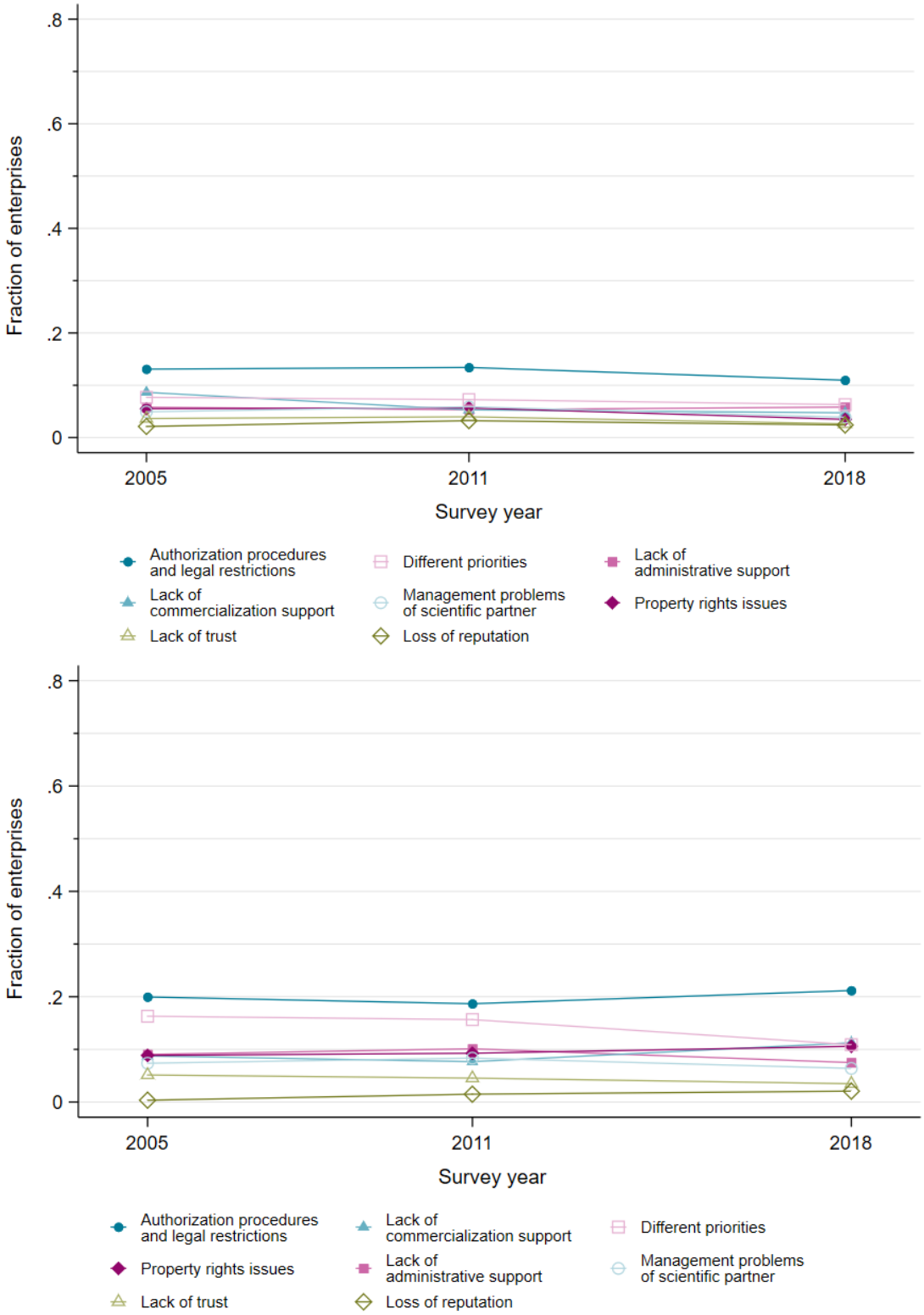
For KTT-active enterprises, «authorization procedures and legal restrictions» are also the most prevalent impediment. About 20% of enterprises engaged in KTT report them as highly relevant. «Different priorities» are also relatively common impediments for KTT-active enterprises but lost in importance in the latest survey period. The other «organizational and institutional impediments» are highly relevant to less than 10% of all KTT-active enterprises. As for KTT-inactive enterprises, a «loss of reputation» is nearly irrelevant.

Graph 7.5.2 and Graph 7.5.3 depicts the prevalence of the eight «organizational and institutional impediments» for KTT-active (lower graph) and KTT-inactive enterprises (upper graph) by sector and subsector.

The picture is the same for KTT-inactive enterprises, irrespective of sector or subsector. «Authorization procedures and legal restrictions» are a marginally more prevalent impediment than the other seven. The other impediments are equally irrelevant across sectors and subsectors. Furthermore, the fraction of KTT-inactive enterprises that see a specific «organizational and institutional impediment» as highly relevant are relatively stable over time. Only in the construction sector, we see a partly increasing tendency in some of the obstacles, most importantly, in «authorization procedures and legal restrictions».

KTT-active enterprises also see «authorization procedures and legal restrictions» as the most relevant «organizational and institutional impediment», irrespective of sector or subsector. This impediment is most prevalent in the manufacturing sector and more recently in the construction sector. Over 20% of KTT-active manufacturing enterprises mention «different priorities» as highly relevant. The same holds true for the construction sector between 2012 and 2017. Additionally, the construction sector also reported the same fraction of enterprises that saw a «lack of administrative support» as highly relevant in the latest survey period. A «loss of reputation», on the other hand, remains the most irrelevant impediment across sectors and subsectors.

Graph 7.5.1: Single impediments for knowledge and technology transfer in the category «Organizational / institutional impediments», overall[84]



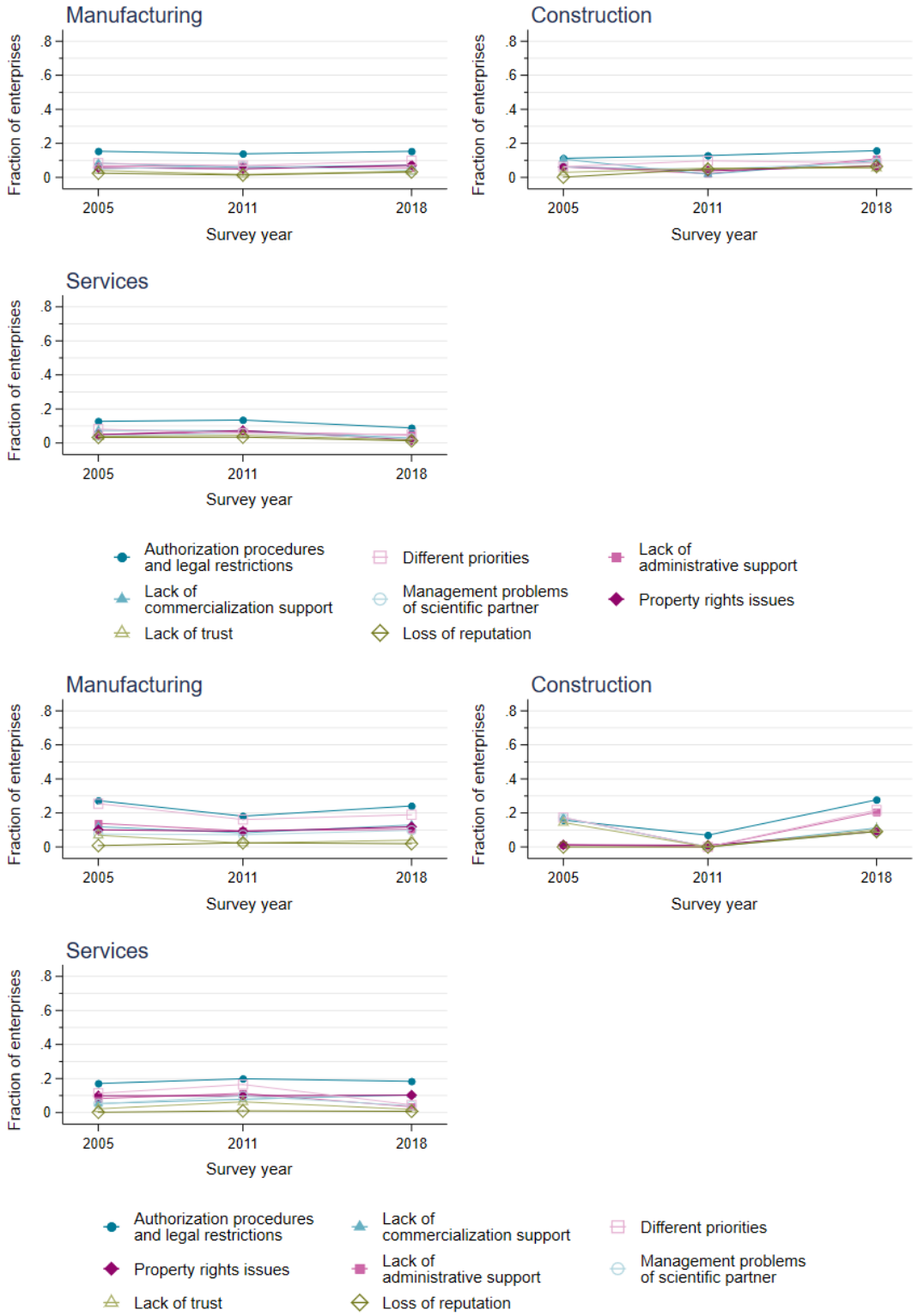
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Organizational / institutional impediments» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph)

Source: KOF-KTT surveys (2005, 2011, 2018)

[84] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.5.2: Single impediments for knowledge and technology transfer in the category «Organizational / institutional impediments», by sector[85]



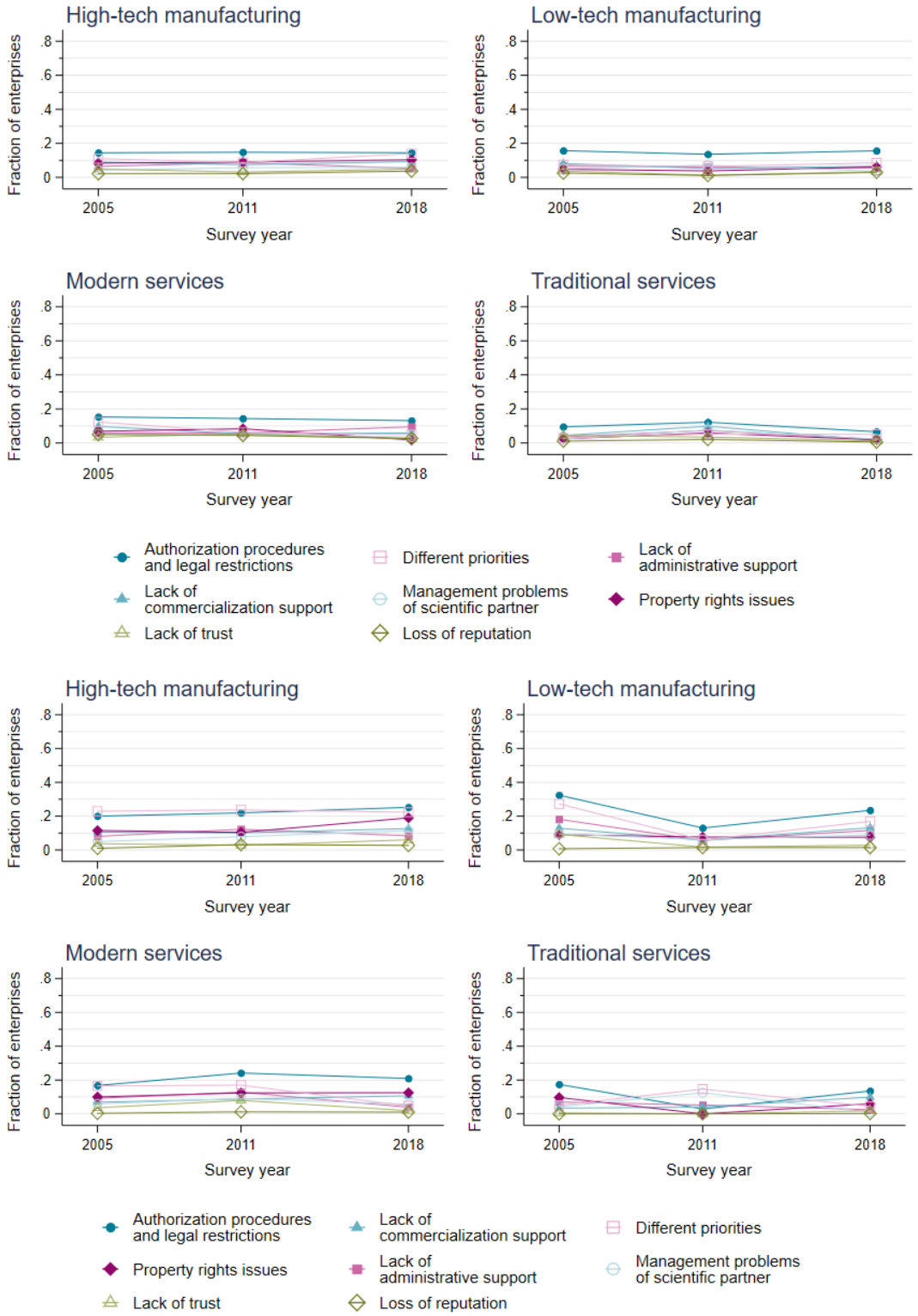
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Organizational / institutional impediments» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by sector

Source: KOF-KTT surveys (2005, 2011, 2018)

[85] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.5.3: Single impediments for knowledge and technology transfer in the category «Organizational / institutional impediments», by subsector[86]



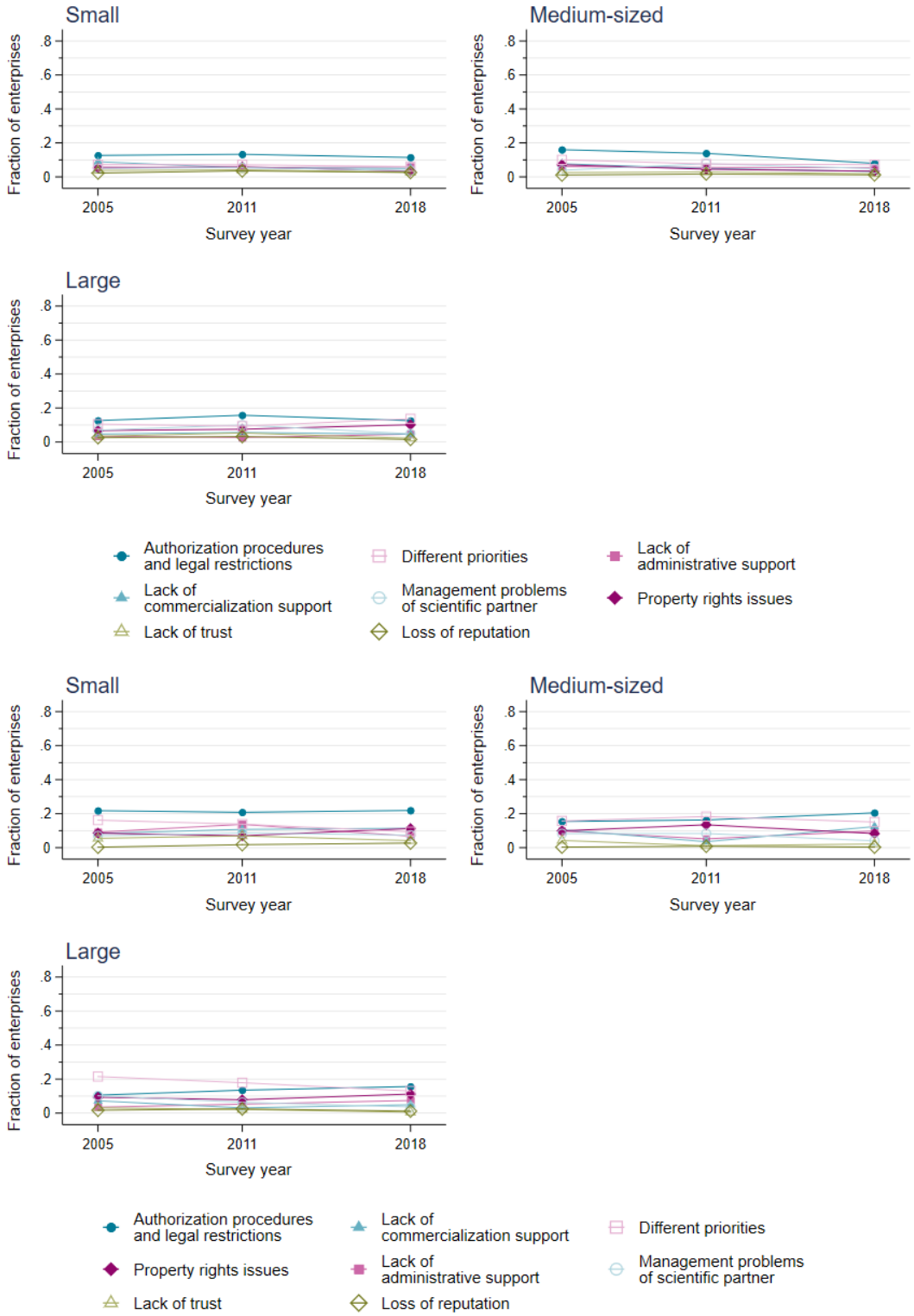
Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Organizational / institutional impediments» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by subsector

Source: KOF-KTT surveys (2005, 2011, 2018)

[86] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

Graph 7.5.4: Single impediments for knowledge and technology transfer in the category «Organizational / institutional impediments», by enterprise size[87]



Note: This graphic shows the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the category «Organizational / institutional impediments» as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods (upper graph), and those that were engaged in these transfers activities (lower graph), by enterprise size

Source: KOF-KTT surveys (2005, 2011, 2018)

[87] The exact numbers that this graph is based on can be found in Table A10ii on page 153 and Table A10iv on page 155 in the appendix.

At last, Graph 7.5.4 show this information by enterprise size. There are hardly any differences across enterprise size for KTT-inactive enterprises. For KTT-active enterprises, there are some minor differences across enterprise size. For SMEs, «authorization procedures and legal restrictions» are most important. Medium-sized enterprises also frequently mention «different priorities» as highly relevant. The same holds true for large enterprises engaged in KTT, although the fraction that sees «different priorities» as highly relevant is falling over the survey periods.

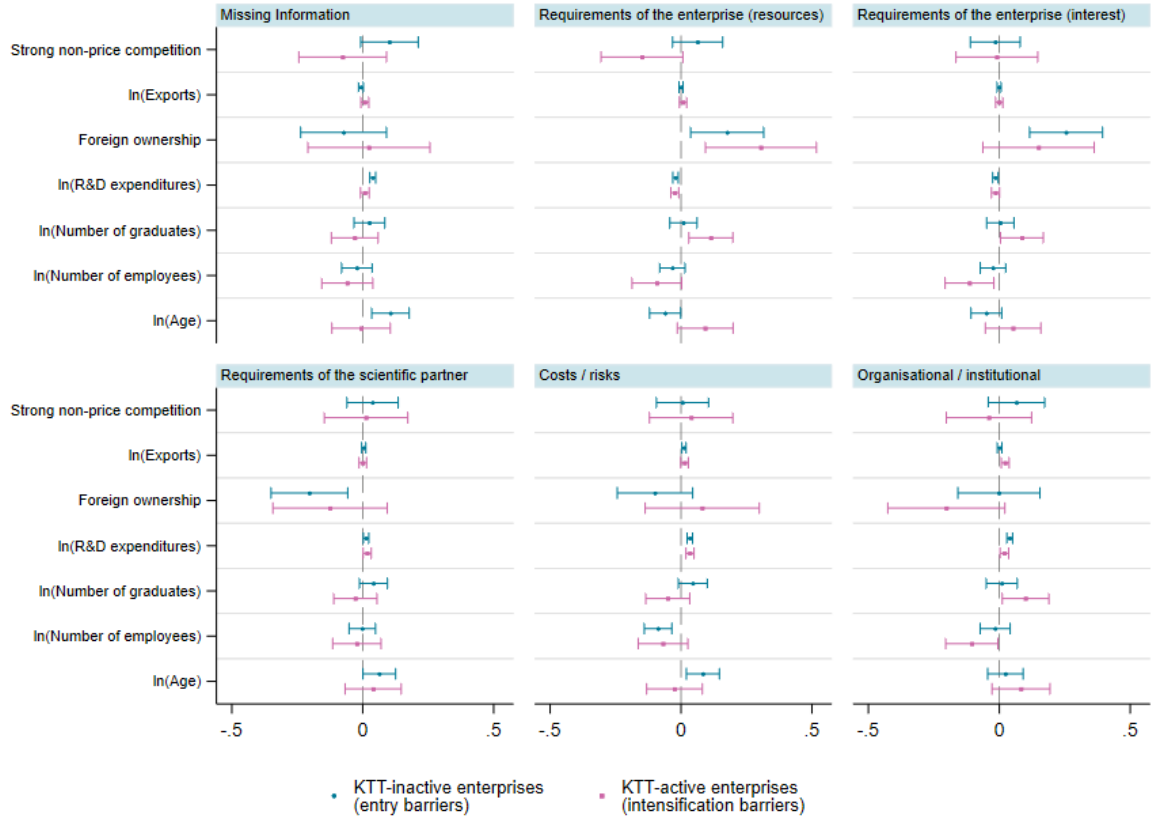
Summarizing these insights, we can say that no single «organizational and institutional impediment» is utterly important for enterprises not engaged in knowledge and technology transfer with public research institutions. «Authorization procedures and legal restrictions» marginally stick out from the rest of the impediments for these enterprises. This «organizational and institutional impediment» is also the most relevant for enterprises engaged in KTT activities. Furthermore, these enterprises see «different priorities» as relevant impediments, especially in the first two survey periods. A «lack of trust» and a «loss of reputation» are nearly irrelevant impediments for both KTT-active and KTT-inactive enterprises.

4.4.2 Impediments: Enterprise characteristics and technological activities

In order to draw meaningful economic policy conclusions, the subjective responses of the respondents, driven by unobserved circumstances, are insufficient. To show us which factors drive enterprises' perception of impediments, more in-depth analyses are necessary. In this subsection, we will tackle this question such that we can define the economic policy framework in a more precise manner.

Graph 7.5 and Graph 7.6 show which types of enterprises are particularly affected by a certain category of impediments. We distinguish between KTT-inactive enterprises and KTT-active enterprises. For the former, the impediments identified represent an entry barrier to KTT, whereas for the latter they are intensification barriers.

Graph 7.5: Enterprise characteristics and perceived impediments[88]



Note:	This graph shows the pooled OLS estimates of the influences on perceived impediments equations and the corresponding 90% confidence intervals. If the confidence interval does not include the nil, the effect is deemed significantly different from zero.
Basis:	All enterprises that are not engaged in KTT with public research institutions in a certain survey period (entry barriers) and those that were engaged in KTT (intensification barriers)
Variables:	The dependent variables are dummies indicating whether an enterprise perceived at least one single impediment in the six above-mentioned groups (columns) as highly relevant impediments. Additional covariates include 33 industry dummies, time dummies, and 14 technology field dummies.
Source:	KOF-KTT surveys (2005, 2011, 2018)

High R&D expenditures are a key determinant of WTT. Nevertheless, there is a number of R&D-active enterprises, which do not conduct KTT. From an economic policy point of view, their perceived impediments are a primary concern. Enterprises with higher R&D expenditures identify a «lack of information», «lacking requirements of public research institutions», «costs and risks» associated with these transfer activities and «organizational and institutional impediments» significantly more often

[88] The exact numbers that this graph is based on can be found in Table A12i on page 157 and Table A12ii on page 158 in the appendix.

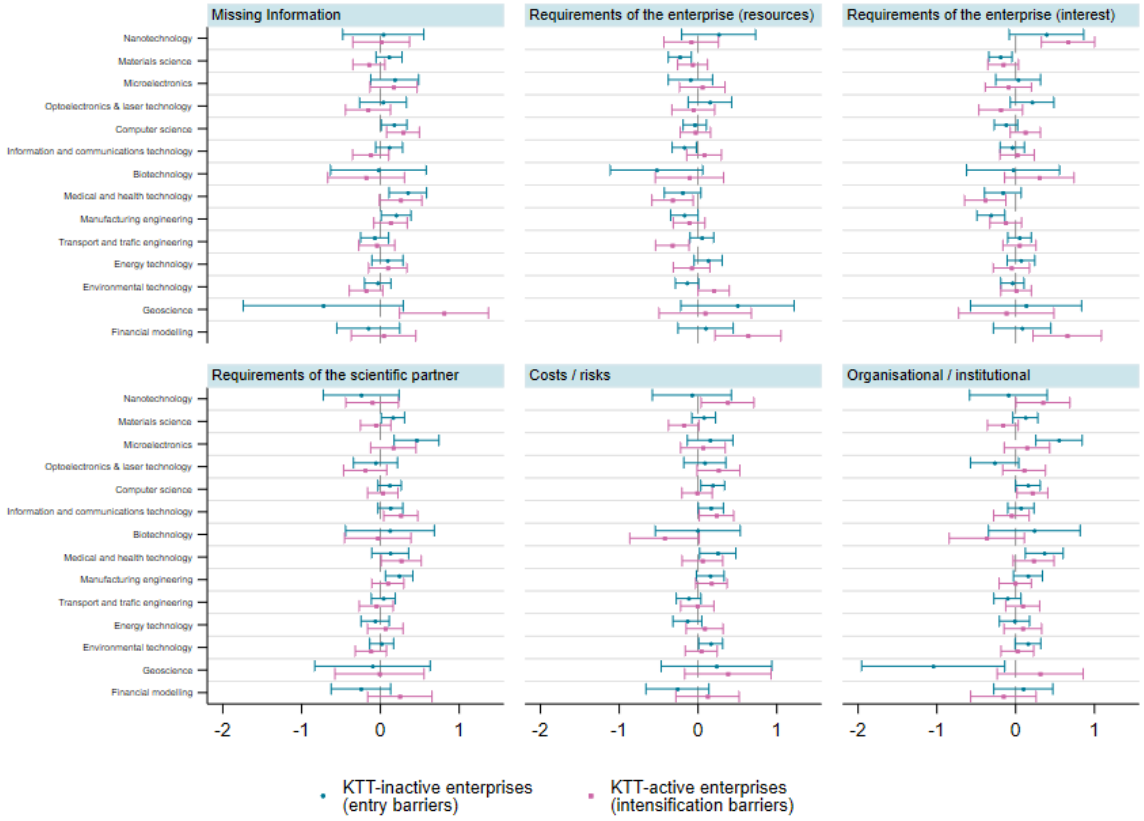
as highly relevant categories of impediments (see Graph 7.5). On the other hand, the higher the R&D expenditures, the significantly lower the probability of identifying lacking «requirements of the enterprise» as highly relevant. On a single impediment basis, a «lack of secrecy», a «lack of administrative support», and «management problems of the public research institutions», as well as presumed «different priorities», and a «lack of trust» are significantly more often mentioned as highly relevant entry barriers with increasing R&D expenditures. Economic policy measures that target these impediments have a high probability of increasing the proportion of transfer-active enterprises that profit the most from knowledge and technology transfer with public research institutions (see Section 4.3.3.3).

While microelectronic enterprises often consider a «lack of requirements of public research institutions» and «organizational and institutional impediments» to be important entry barriers, enterprises in the computer science industry are primarily concerned with «costs and risk» aspects. The medical technology enterprises lack transfer-relevant «information» and see «costs and risks» and «institutional and organizational impediments» as essential barriers to enter KTT activities. Manufacturing engineering enterprises lack information. Additionally, they often see a «lack of requirements of the public research institutions» as important impediments. It is interesting to note that no technology field is significantly more hindered in entering KTT activities by a «lack of requirements in their own enterprise».

The econometric estimates have shown that the performance of an enterprise is related to the extent or intensity of KTT. Therefore, we should be interested primarily in factors that increase the intensity of the KTT. The perception of impediments by KTT-active enterprises can serve as an indicator in this respect. Graph 7.6 shows KTT-active enterprises that are more R&D-intensive identify «a lack of requirements of the public research institution», «costs and risks» and «organizational and institutional impediments» relatively more often as relevant intensification barriers. In particular, the «lack of KTT specialists» at public research institutions, the «lack of entrepreneurial thinking» in these institutions and «no guaranteed secrecy» are the main intensification barriers for R&D-intensive enterprises. For enterprises with KTT experience, the likelihood of identifying «lacking internal resources» as relevant intensification barriers decreases with R&D expenditures. Support aimed at overcoming the aforementioned impediment categories would not only induce more enterprises to engage in KTT, but would also intensify existing relationships.

Graph 7.6 also shows that information and communication technology and medical and health technology are the only technological fields that have a positive correlation between KTT-active enterprises and the impediment category «lack of requirements at universities». Enterprises in nanotechnology, environmental technology, and, above all, enterprises dealing with financial modelling (e.g. banks and insurance enterprises) often find «lacking requirements in their own enterprise» as relevant impediments once they are engaged in KTT activities. In the case of nanotechnology enterprises, these impediments are related to the enterprise's «lack of interest» in scientific projects. For enterprises that focus on environmental technologies, a lack of their own resources stand in the way of intensification. Enterprises that deal with mathematical financial models see both of these «internal impediments» as important. Similarly, «costs and risks» related to KTT and «organizational and institutional impediments» only become relevant for nanotechnology enterprises once they are engaged in KTT activities. In the field of computer science, a «lack of information» and «organizational and institutional» impediments remain important. Overall, the relationships between technological orientation and the assessment of impediment categories are of a lower statistical significance. This indicates that measures to intensify KTT are less technology-specific than measures to reduce barriers to entry into KTT.

Graph 7.6: Influences on perceived impediments, technology fields[89]



Note: This graph shows the pooled OLS estimates of the influences on perceived impediments equations and the corresponding 90% confidence intervals. If the confidence interval does not include the nil, the effect is deemed significantly different from zero.

Basis: All enterprises that are not engaged in KTT with public research institutions in a certain survey period (entry barriers) and those that were engaged in KTT (intensification barriers)

Variables: The dependent variables are dummies indicating whether an enterprise perceived at least one single impediment in the six above-mentioned groups (columns) as highly relevant impediments. Additional covariates include 33 industry dummies, time dummies, and the previously mentioned enterprise characteristics.

Source: KOF-KTT surveys (2005, 2011, 2018)

[89] The exact numbers that this graph is based on can be found in Table A12i on page 157 and Table A12ii on page 158 in the appendix.

4.4.3 Role of intermediaries for KTT

4.4.3.1 KTT-active firms, which consider Innosuisse to be important, show a stronger correlation between R&D expenditures and firm performance

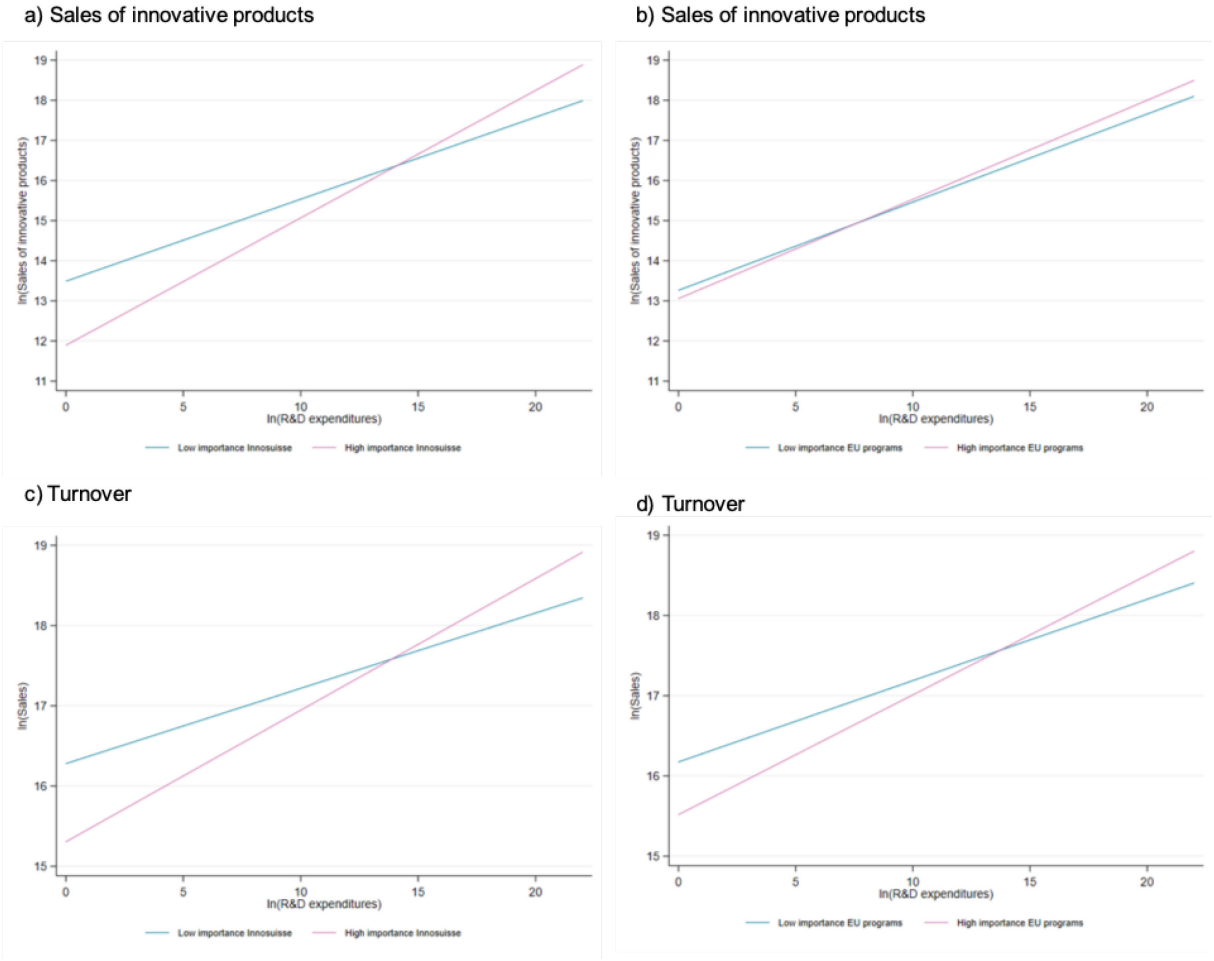
The analysis presented so far has shown that the R&D activities of firms are an essential factor in translating the results of knowledge transfer into commercial success. Innovation agencies such as Innosuisse, which provide financial resources for innovation projects through their funding measures, can thus trigger additional R&D expenditure in firms (Beck et al., 2016). Graph 7.7 shows that those KTT-active firms that attach great or very great importance to Innosuisse in terms of knowledge transfer and at the same time have high R&D expenditures show a significantly higher innovation performance. The relationship between R&D expenditures and the commercial success of innovative products as well as with total sales is significantly stronger for firms that attach great importance to Innosuisse. Both Graph 7.7 a) and c) as well as columns 3 to 6 of Table M illustrate these significantly stronger marginal effects of R&D spending in the presence of Innosuisse. Similarly, positive correlations can be found for those firms that attach great or very great importance to EU programs, although these are statistically weaker and less broadly based when compared to Innosuisse (see Graph 7.7 b) and d) and columns 3 to 6 in Table M). In general, it can therefore be said that KTT-active firms, which consider innovation promotion agencies to be important or very important, can use their R&D activities more effectively in terms of commercial success.

Table M: Innovation support through Innosuisse and EU-programs and R&D expenditures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable:	Productinno	Processinno	ln(Sal_new)	ln(Sal_impr)	ln(Sal_inno)	ln(Sales)	ln(Valadd)
Estimation method:	Logit	Logit	R.E.	R.E.	R.E.	R.E.	R.E.
Innosuisse	-1.331	-0.407	-1.664***	-1.628***	-1.598***	-0.974***	-0.035
	(1.755)	(1.154)	(0.545)	(0.496)	(0.489)	(0.247)	(0.206)
ln(R&D exp.)	0.287***	-0.048	0.198***	0.134***	0.204***	0.094***	0.046***
	(0.079)	(0.054)	(0.026)	(0.025)	(0.023)	(0.012)	(0.010)
Innosuisse*ln(R&D exp.)	0.114	0.017	0.115***	0.121***	0.113***	0.070***	-0.002
	(0.136)	(0.084)	(0.038)	(0.035)	(0.034)	(0.018)	(0.015)
EU Program	-1.023	-0.186	-0.129	-1.279*	-0.208	-0.657*	-0.109
	(2.572)	(1.604)	(0.740)	(0.672)	(0.677)	(0.359)	(0.301)
ln(R&D exp.)	0.310***	-0.035	0.213***	0.147***	0.220***	0.101***	0.044***
	(0.079)	(0.053)	(0.025)	(0.024)	(0.023)	(0.012)	(0.010)
EU Progr.*ln(R&D exp.)	0.060	-0.025	0.022	0.102**	0.028	0.048**	0.008
	(0.187)	(0.108)	(0.049)	(0.045)	(0.045)	(0.024)	(0.020)
Observations	1,141	1,141	946	912	1,018	1,141	1,141

Innosuisse and EU programs are binary variables (0/1), which show whether firms rate them as highly important in knowledge transfer. Innosuisse and EU programs were estimated in separate estimations to preempt high multicollinearity. All estimations contain the explanatory variables ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies; (1) and (2) are estimated using random effects logit, (3) to (7) are estimated using standard random effects; *** p<0.01, ** p<0.05, * p<0.1

Graph 7.7: Marginal effects of R&D spending and the importance of innovation promoting institutions



Note: Innosuisse and EU programs are binary variables (0/1) which indicate whether they have a high importance in knowledge sharing. Innosuisse and EU programs have been estimated in individual bivariate equations to pre-empt the high multicollinearity. Note: All models are estimated with random effects and include the explanatory variables ln(employment), ln(employment with tertiary degree), ln(investment), ln(exports), ln(firm age), foreign ownership, time and industry dummies.

5 Conclusion

The present study has shown that in Switzerland public-private KTT bears the potential to increase the innovative success of an enterprise and its competitiveness. Thus, the institutions of higher education's contribution to society goes beyond their primal mission of education and basic research. Under the right conditions, KTT between public research institutions and private enterprises also increases the commercial success of innovative products and services. In this way, it promotes a sustainable corporate development and reduces the probability of financial shortages ("Valley of Death"), which can occur during the development phase, especially in younger enterprises.

Against this background, the study shows that R&D investments are a distinctive feature of KTT-active enterprises. They hint at a better understanding of public research institution's research and, similar to an open innovation culture or a high proportion of well-educated employees, increase the likelihood of conducting KTT. Internal factors are a necessary but not a sufficient requirement. Suitable prerequisites for KTT at the public research institutions and at the interface to the enterprises must also be in place. Missing information about research activities at universities, difficulties in finding suitable contacts, a lack of entrepreneurial thinking at universities, no guaranteed secrecy or lack of exclusivity and different priorities contribute to the fact that R&D-active enterprises do not carry out KTT.

An R&D-investment-friendly environment improves the probability of a successful KTT and thus increases the public research institutions' benefit for the private sector. Such an environment also includes Innosuisse's funding and promotion activities and access to international innovation funding institutions (e.g. those of the EU). They have the potential to increase the commercial success of innovative products and services. Measures aimed at establishing an open innovation culture within the enterprise (e.g. through informational actions or by promoting participation in international co-operation projects) also promote KTT. Additionally, well-educated graduates are an essential factor for the successful transfer of knowledge and technology. They «transport» the knowledge gained from their prior institutions of higher education directly to the enterprises and increase their understanding of scientific research. Furthermore, the present study shows that access to international markets not only creates incentives for KTT, but also increases the commercial usability of scientific knowledge for an enterprise.

For more concrete economic policy measures, it should be borne in mind that transfer barriers are technology-specific. Microelectronics enterprises, for example, are affected by other factors than ICT enterprises. Technologies with a great future potential should be of primary interest.

KTT takes place in a technologically dynamic environment. New developments, for example in the areas of digitisation, environmental technologies or medical and health technologies, are also changing the technological profiles and needs of enterprises. This can strongly influence the importance and effectiveness of KTT. Therefore, the structural dynamics of the private sector, e.g. the continuous tertiarisation of the economy, should also be closely monitored with regard to their significance for the KTT.

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Appendix

Part I: Methodological tables

Table A1: Structure of the responses to the 2018 survey

Industry / sector	NOGA 2008	Small	Medium-sized	Large	Total
		Number of firms			
Manufacturing		*441*	*296*	*66*	*803*
Food / beverages / tobacco	10, 11, 12	47	30	6	83
Textiles / clothing	13, 14, 15	7	9	2	18
Wood	16	14	13	5	32
Paper	17	4	5	2	11
Printing	18	5	6	5	16
Chemicals	19, 20	32	8	0	40
Pharmaceuticals	21	15	2	2	19
Rubber / plastics	22	12	10	2	24
Non-metallic minerals	23	13	12	2	27
Basic metals	24	7	4	4	15
Fabricated metals	25	69	60	11	140
Machinery & equipment	28	46	52	10	108
Electrical equipment	27	26	15	1	42
Electronic and optical products	261, 262, 263, 264, 2651, 266, 267, 268	39	25	2	66
Repair / installation	33	4	5	0	9
Medical instruments	325	23	3	2	28
Watches / clocks	2652	26	4	0	30
Vehicles	29, 30	5	3	1	9
Other manufacturing	31, 321, 322, 323, 324, 329	5	7	2	14
Energy	35	35	10	6	51
Water / environment	36, 37, 38 , 39	7	13	1	21
Construction	41, 42, 43	*73*	*84*	*18*	*175*
Services		*410*	*284*	*67*	761
Wholesale trade	45, 46	*61*	*58*	*16*	135
Retail trade	47, 95	*78*	*21*	*0*	99
Accommodation / restaurants	55, 56	33	25	9	67
Transportation	49, 50, 51, 52, 79	62	43	2	107
Telecommunications	53, 61	10	2	2	14
Publishing / media	58, 59, 60	7	5	1	13
Information Technology / services	62, 63	17	13	10	40
Banks / insurance	64, 65, 66	51	28	5	84
Real estate / rental & leasing	68, 77, 81	24	15	0	39
Technical commercial services	71, 72	17	33	15	65
Other commercial services	69, 70, 73, 74, 78, 80, 82	50	40	6	96
Personal services	96	0	1	1	2
Total		*924*	*664*	*151*	*1739*

Table A2: Structure of the sample of the 2018 survey

Industry / sector	NOGA 2008	Small	Medium-sized	Large	Total
		Number of firms			
Manufacturing		*1'573*	*1'166*	*256*	*2'995*
Food / beverages / tobacco	10, 11, 12	214	175	21	410
Textiles / clothing	13, 14, 15	24	28	4	56
Wood	16	38	37	21	96
Paper	17	16	14	7	37
Printing	18	22	18	23	63
Chemicals	19, 20	105	35	6	146
Pharmaceuticals	21	100	21	2	123
Rubber / plastics	22	33	49	22	104
Non-metallic minerals	23	42	38	9	89
Basic metals	24	26	16	10	52
Fabricated metals	25	189	179	39	407
Machinery & equipment	28	168	208	26	402
Electrical equipment	27	94	48	7	149
Electronic and optical products	261, 262, 263, 264, 2651, 266, 267, 268	140	109	10	259
Repair / installation	33	21	21	3	45
Medical instruments	325	41	23	4	68
Watches / clocks	2652	142	51	5	198
Vehicles	29, 30	40	17	3	60
Other manufacturing	31, 321, 322, 323, 324, 329	28	17	13	58
Energy	35	66	30	13	109
Water / environment	36, 37, 38 , 39	24	32	8	64
Construction	41, 42, 43	*270*	*254*	*72*	*596*
Services		*1'519*	*1'144*	*332*	*2'995*
Wholesale trade	45, 46	187	196	73	456
Retail trade	47, 95	341	106	4	451
Accommodation / restaurants	55, 56	121	93	50	264
Transportation	49, 50, 51, 52, 79	195	173	6	374
Telecommunications	53, 61	34	13	2	49
Publishing / media	58, 59, 60	27	17	3	47
Information technology / services	62, 63	45	48	47	140
Banks / insurance	64, 65, 66	188	118	16	322
Real estate / rental & leasing	68, 77, 81	110	90	6	206
Technical commercial services	71, 72	51	57	77	185
Other commercial services	69, 70, 73, 74, 78, 80, 82	210	226	34	470
Personal services	96	10	7	14	31
Total		*3'362*	*2'564*	*660*	*6'586*

Table A3: Response rates of the 2018 survey

Industry / sector	NOGA 2008	Small	Medium-sized	Large	Total
		Percentage of firms			
Manufacturing		*28.0*	*25.4*	*25.8*	*26.8*
Food / beverages / tobacco	10, 11, 12	22.0	17.1	28.6	20.2
Textiles / clothing	13, 14, 15	29.2	32.1	50.0	32.1
Wood	16	36.8	35.1	23.8	33.3
Paper	17	25.0	35.7	28.6	29.7
Printing	18	22.7	33.3	21.7	25.4
Chemicals	19, 20	30.5	22.9	0.0	27.4
Pharmaceuticals	21	15.0	9.5	100.0	15.4
Rubber / plastics	22	36.4	20.4	9.1	23.1
Non-metallic minerals	23	31.0	31.6	22.2	30.3
Basic metals	24	26.9	25.0	40.0	28.8
Fabricated metals	25	36.5	33.5	28.2	34.4
Machinery & equipment	28	27.4	25.0	38.5	26.9
Electrical equipment	27	27.7	31.3	14.3	28.2
Electronic and optical products	261, 262, 263, 264, 2651, 266, 267, 268	27.9	22.9	20.0	25.5
Repair / installation	33	19.0	23.8	0.0	20.0
Medical instruments	325	56.1	13.0	50.0	41.2
Watches / clocks	2652	18.3	7.8	0.0	15.2
Vehicles	29, 30	12.5	17.6	33.3	15.0
Other manufacturing	31, 321, 322, 323, 324, 329	17.9	41.2	15.4	24.1
Energy	35	53.0	33.3	46.2	46.8
Water / environment	36, 37, 38 , 39	29.2	40.6	12.5	32.8
Construction	41, 42, 43	*27.0*	*33.1*	*25.0*	*29.4*
Services		27.0	24.8	20.2	25.4
Wholesale trade	45, 46	32.6	29.6	21.9	29.6
Retail trade	47, 95	22.9	19.8	0.0	22.0
Accommodation / restaurants	55, 56	27.3	26.9	18.0	25.4
Transportation	49, 50, 51, 52, 79	31.8	24.9	33.3	28.6
Telecommunications	53, 61	29.4	15.4	100.0	28.6
Publishing / media	58, 59, 60	25.9	29.4	33.3	27.7
Information technology / services	62, 63	37.8	27.1	21.3	28.6
Banks / insurance	64, 65, 66	27.1	23.7	31.3	26.1
Real estate / rental & leasing	68, 77, 81	21.8	16.7	0.0	18.9
Technical commercial services	71, 72	33.3	57.9	19.5	35.1
Other commercial services	69, 70, 73, 74, 78, 80, 82	23.8	17.7	17.6	20.4
Personal services	96	0.0	14.3	7.1	6.5
Total		*27.5*	*25.9*	*22.9*	*26.4*

Part II: Descriptive tables

Incidence

Table A4i: Incidence of knowledge and technology transfer, by sector, subsector, enterprise size and overall

2005		KTT overall: prior to 2005	KTT national: 2002 - 2004	KTT International: 2002 - 2004
Sector	Manufacturing	0.27	0.22	0.12
	Construction	0.14	0.10	0.04
	Services	0.35	0.29	0.09
Subsector	High-tech manufacturing	0.37	0.29	0.18
	Low-tech manufacturing	0.23	0.18	0.09
	Modern services	0.34	0.28	0.09
	Traditional services	0.36	0.30	0.09
Size	Small	0.25	0.19	0.08
	Medium-sized	0.38	0.34	0.12
	Large	0.47	0.45	0.18
Total		0.28	0.22	0.09

2011		KTT overall: 2005 - 2010	KTT national: 2008 - 2010	KTT international: 2008 - 2010
Sector	Manufacturing	0.27	0.24	0.08
	Construction	0.04	0.04	0.01
	Services	0.28	0.27	0.05
Subsector	High-tech manufacturing	0.49	0.45	0.16
	Low-tech manufacturing	0.17	0.15	0.04
	Modern services	0.37	0.35	0.06
	Traditional services	0.15	0.13	0.03
Size	Small	0.17	0.16	0.02
	Medium-sized	0.40	0.35	0.12
	Large	0.59	0.57	0.28
Total		0.23	0.21	0.05

2018		KTT overall: 2012- 2017	KTT national: 2015 - 2017	KTT international: 2015 - 2017
Sector	Manufacturing	0.40	0.37	0.09
	Construction	0.21	0.18	0.00
	Services	0.23	0.21	0.04
Subsector	High-tech manufacturing	0.50	0.46	0.17
	Low-tech manufacturing	0.36	0.33	0.05
	Modern services	0.36	0.34	0.06
	Traditional services	0.14	0.12	0.04
Size	Small	0.23	0.21	0.04
	Medium-sized	0.37	0.32	0.08
	Large	0.67	0.66	0.22
Total		0.26	0.24	0.05

Note: These tables show the fraction of enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods.
Basis: All enterprises, by sector, subsector, enterprise size and overall
Source: KOF-KTT surveys (2005, 2011, 2018)

Table A4ii: Incidence of knowledge and technology transfer, by 2-digit industry (NOGA) and overall

		2005			
Sector	**2-digit industries (NOGA)**	Number of observations	KTT overall: prior to 2005	KTT national: 2002 - 2004	KTT international: 2002 - 2004
Manufacturing	Food / beverages / tobacco	124	0.34	0.31	0.11
	Textiles / clothing	41	0.20	0.18	0.14
	Wood	44	0.17	0.17	0.01
	Paper	34	0.26	0.22	0.03
	Printing	72	0.14	0.14	0.00
	Chemicals	66	0.40	0.31	0.27
	Pharmaceuticals	34	0.58	0.57	0.31
	Rubber / plastics	58	0.30	0.26	0.19
	Non-metallic minerals	47	0.32	0.19	0.04
	Basic metals	42	0.25	0.04	0.06
	Fabricated metals	172	0.29	0.22	0.15
	Machinery & equipment	238	0.37	0.29	0.17
	Electrical equipment	73	0.26	0.22	0.11
	Electronic and optical products	157	0.37	0.27	0.19
	Repair / installation	39	0.36	0.27	0.13
	Medical instruments	0	-	-	-
	Watches / clocks	54	0.26	0.26	0.04
	Vehicles	32	0.39	0.24	0.28
	Other manufacturing	95	0.04	0.03	0.01
	Energy	46	0.27	0.23	0.05
	Water / environment	5	0.81	0.81	0.80
Construction	Construction	271	0.14	0.10	0.04
Services	Wholesale trade	171	0.39	0.33	0.12
	Retail trade	1	0.00	0.00	0.00
	Accommodation / restaurants	0	-	-	-
	Transportation	154	0.28	0.25	0.01
	Telecommunications	18	0.33	0.33	0.02
	Publishing / media	71	0.21	0.11	0.01
	Information technology / services	14	0.55	0.50	0.00
	Banks / insurance	179	0.26	0.26	0.05
	Real estate / rental & leasing	11	0.37	0.04	0.32
	Technical commercial services	130	0.46	0.38	0.14
	Other commercial services	88	0.24	0.20	0.08
	Personal services	0	-	-	-
Total		2581	0.28	0.22	0.09

		2011			
Sector	**2-digit industries (NOGA)**	Number of observations	KTT overall: 2005 - 2010	KTT national: 2008 - 2010	KTT international: 2008 - 2010
Manufacturing	Food / beverages / tobacco	86	0.25	0.23	0.04
	Textiles / clothing	23	0.20	0.20	0.05
	Wood	27	0.11	0.07	0.00
	Paper	23	0.25	0.25	0.02
	Printing	46	0.13	0.13	0.01
	Chemicals	62	0.45	0.42	0.25
	Pharmaceuticals	27	0.81	0.81	0.32
	Rubber / plastics	50	0.45	0.40	0.09
	Non-metallic minerals	29	0.18	0.14	0.02
	Basic metals	26	0.44	0.43	0.19
	Fabricated metals	147	0.17	0.14	0.04
	Machinery & equipment	144	0.52	0.48	0.20
	Electrical equipment	50	0.43	0.38	0.13
	Electronic and optical products	112	0.54	0.49	0.12
	Repair / installation	24	0.12	0.04	0.10
	Medical instruments	0	-	-	-
	Watches / clocks	40	0.04	0.04	0.01
	Vehicles	15	0.64	0.64	0.07
	Other manufacturing	64	0.03	0.02	0.00
	Energy	35	0.36	0.32	0.05
	Water / environment	3	0.84	0.84	0.13
Construction	Construction	200	0.04	0.04	0.01
Services	Wholesale trade	135	0.17	0.14	0.05
	Retail trade	2	0.00	0.00	0.00
	Accommodation / restaurants	0	-	-	-
	Transportation	141	0.13	0.12	0.02
	Telecommunications	8	0.09	0.09	0.00
	Publishing / media	37	0.12	0.12	0.01
	Information technology / services	6	0.00	0.00	0.00
	Banks / insurance	120	0.11	0.10	0.02
	Real estate / rental & leasing	11	0.00	0.00	0.00
	Technical commercial services	88	0.52	0.50	0.08
	Other commercial services	61	0.36	0.35	0.07
	Personal services	0	-	-	-
Total		1842	0.23	0.21	0.05

		2018			
Sector	**2-digit industries (NOGA)**	Number of observations	KTT overall: 2012 - 2017	KTT national: 2015 - 2017	KTT international: 2015 - 2017
Manufacturing	Food / beverages / tobacco	78	0.40	0.37	0.05
	Textiles / clothing	18	0.47	0.47	0.02
	Wood	31	0.24	0.24	0.03
	Paper	11	0.16	0.16	0.08
	Printing	14	0.15	0.15	0.00
	Chemicals	40	0.56	0.53	0.13
	Pharmaceuticals	18	0.67	0.67	0.33
	Rubber / plastics	24	0.70	0.69	0.03
	Non-metallic minerals	26	0.32	0.28	0.08
	Basic metals	15	0.59	0.48	0.52
	Fabricated metals	131	0.35	0.31	0.07
	Machinery & equipment	106	0.50	0.47	0.15
	Electrical equipment	41	0.48	0.48	0.15
	Electronic and optical products	65	0.59	0.55	0.21
	Repair / installation	9	0.10	0.10	0.00
	Medical instruments	27	0.54	0.44	0.28
	Watches / clocks	28	0.20	0.09	0.00
	Vehicles	9	0.14	0.14	0.14
	Other manufacturing	13	0.26	0.26	0.00
	Energy	50	0.45	0.45	0.06
	Water / environment	20	0.45	0.34	0.01
Construction	Construction	168	0.21	0.18	0.00
Services	Wholesale trade	131	0.19	0.18	0.07
	Retail trade	97	0.19	0.14	0.00
	Accommodation / restaurants	66	0.06	0.06	0.00
	Transportation	105	0.17	0.11	0.06
	Telecommunications	14	0.07	0.07	0.02
	Publishing / media	13	0.01	0.01	0.01
	Information technology / services	39	0.39	0.32	0.09
	Banks / insurance	81	0.31	0.28	0.06
	Real estate / rental & leasing	39	0.06	0.06	0.01
	Technical commercial services	62	0.52	0.52	0.07
	Other commercial services	92	0.22	0.19	0.03
	Personal services	2	0.00	0.00	0.00
Total		1683	0.26	0.24	0.05

Note: These tables show the fraction of enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods.

Basis: All enterprises, by 2-digit industry (NOGA) and overall

Source: KOF-KTT surveys (2005, 2011, 2018)

Forms

Categories

Table A5i:Form categories of knowledge and technology transfer, by sector, subsector, enterprise size and overall

2005		Informal contacts	Infrastructure	Education & mobility	Research	Consulting
Sector	Manufacturing	0.60	0.30	0.54	0.22	0.25
	Construction	0.39	0.02	0.51	0.17	0.02
	Services	0.59	0.06	0.52	0.16	0.13
Subsector	High-tech manufacturing	0.63	0.32	0.60	0.24	0.23
	Low-tech manufacturing	0.58	0.28	0.50	0.21	0.27
	Modern services	0.65	0.07	0.69	0.19	0.12
	Traditional services	0.53	0.04	0.31	0.11	0.14
Size	Small	0.57	0.12	0.48	0.18	0.15
	Medium-sized	0.55	0.15	0.65	0.14	0.15
	Large	0.66	0.16	0.64	0.24	0.17
Total		0.57	0.12	0.53	0.18	0.15

2011		Informal contacts	Infrastructure	Education & mobility	Research	Consulting
Sector	Manufacturing	0.53	0.21	0.56	0.21	0.18
	Construction	0.46	0.08	0.45	0.08	0.13
	Services	0.71	0.12	0.63	0.17	0.15
Subsector	High-tech manufacturing	0.51	0.26	0.63	0.25	0.16
	Low-tech manufacturing	0.55	0.15	0.47	0.14	0.21
	Modern services	0.81	0.10	0.62	0.17	0.13
	Traditional services	0.32	0.17	0.71	0.19	0.21
Size	Small	0.66	0.13	0.53	0.12	0.13
	Medium-sized	0.55	0.19	0.69	0.26	0.22
	Large	0.72	0.18	0.69	0.31	0.11
Total		0.63	0.15	0.60	0.18	0.16

2018		Informal contacts	Infrastructure	Education & mobility	Research	Consulting
Sector	Manufacturing	0.48	0.22	0.48	0.21	0.16
	Construction	0.46	0.10	0.24	0.11	0.19
	Services	0.54	0.09	0.56	0.13	0.11
Subsector	High-tech manufacturing	0.53	0.30	0.56	0.34	0.16
	Low-tech manufacturing	0.45	0.17	0.44	0.13	0.16
	Modern services	0.49	0.06	0.60	0.13	0.15
	Traditional services	0.64	0.15	0.48	0.12	0.05
Size	Small	0.51	0.12	0.44	0.12	0.15
	Medium-sized	0.48	0.17	0.60	0.21	0.11
	Large	0.70	0.19	0.83	0.22	0.11
Total		0.52	0.13	0.50	0.15	0.14

Note: These tables show the fraction of enterprises that reported at least one single form of knowledge and technology transfer in the above-mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, , by sector, subsector, enterprise size and overall

Source: KOF-KTT surveys (2005, 2011, 2018)

Single forms

Table A5ii: Single forms of knowledge and technology transfer, by sector, subsector, enterprise size and overall

2005		Sector			Subsector				Size			Total
		Manufacturing	Construction	Services	High-tech manufacturing	Low-tech manufacturing	Modern services	Traditional services	Small	Medium-sized	Large	
Informal contacts	Informal contacts	0.33	0.17	0.32	0.36	0.32	0.37	0.25	0.31	0.27	0.42	0.30
	Conferences, exhibitions, and workshops	0.28	0.21	0.35	0.25	0.30	0.39	0.30	0.30	0.34	0.36	0.31
	Scientific publications	0.34	0.22	0.36	0.33	0.34	0.46	0.24	0.34	0.31	0.35	0.33
Infrastructure	Shared laboratories	0.09	0.01	0.02	0.08	0.10	0.03	0.01	0.04	0.05	0.04	0.04
	Technical infrastructure	0.29	0.02	0.04	0.31	0.27	0.05	0.03	0.11	0.13	0.16	0.11
Education & mobility	Recruiting graduates	0.26	0.01	0.18	0.36	0.18	0.25	0.10	0.17	0.21	0.34	0.18
	Staff contacts to prior scientific institution	0.09	0.16	0.09	0.16	0.04	0.13	0.05	0.08	0.17	0.16	0.10
	Internships of students	0.15	0.02	0.11	0.19	0.12	0.10	0.11	0.09	0.16	0.16	0.11
	Joint thesis	0.17	0.04	0.18	0.20	0.15	0.15	0.21	0.13	0.25	0.27	0.16
	Joint dissertations	0.06	0.16	0.05	0.09	0.04	0.03	0.08	0.05	0.12	0.10	0.07
	Collaboration with scientific institutions' researchers	0.14	0.14	0.08	0.11	0.16	0.08	0.08	0.12	0.08	0.06	0.11
	Joint lectures	0.02	0.01	0.05	0.04	0.01	0.05	0.05	0.03	0.05	0.05	0.04
	Lectureship at scientific institution	0.08	0.02	0.09	0.06	0.10	0.11	0.06	0.08	0.06	0.07	0.08
	Advanced training of employees	0.18	0.20	0.25	0.23	0.15	0.35	0.14	0.21	0.26	0.33	0.23
Research	Research co-operation	0.21	0.17	0.13	0.23	0.20	0.15	0.11	0.17	0.14	0.22	0.16
	Contract research	0.07	0.01	0.05	0.06	0.07	0.05	0.05	0.05	0.05	0.07	0.05
	Research consortia	0.05	0.01	0.04	0.07	0.04	0.04	0.05	0.04	0.03	0.08	0.04
Consulting	Expert reports	0.14	0.00	0.12	0.08	0.19	0.10	0.14	0.11	0.10	0.13	0.11
	Consulting	0.23	0.02	0.12	0.21	0.24	0.10	0.14	0.14	0.14	0.14	0.14

2011		Sector			Subsector				Size			Total
		Manufacturing	Construction	Services	High-tech manufacturing	Low-tech manufacturing	Modern services	Traditional services	Small	Medium-sized	Large	
Informal contacts	Informal contacts	0.33	0.33	0.28	0.39	0.24	0.28	0.27	0.27	0.30	0.49	0.30
	Conferences, exhibitions, and workshops	0.25	0.26	0.47	0.24	0.26	0.53	0.25	0.38	0.37	0.44	0.38
	Scientific publications	0.31	0.08	0.40	0.25	0.39	0.43	0.25	0.41	0.25	0.39	0.35
Infrastructure	Shared laboratories	0.09	0.06	0.02	0.13	0.04	0.02	0.04	0.05	0.05	0.08	0.05
	Technical infrastructure	0.18	0.08	0.12	0.22	0.13	0.10	0.17	0.11	0.18	0.16	0.14
Education & mobility	Recruiting graduates	0.33	0.01	0.24	0.42	0.22	0.25	0.20	0.21	0.32	0.43	0.26
	Staff contacts to prior scientific institution	0.18	0.07	0.11	0.24	0.10	0.09	0.17	0.12	0.14	0.21	0.13
	Internships of students	0.21	0.08	0.13	0.25	0.16	0.14	0.06	0.12	0.18	0.32	0.16
	Joint thesis	0.23	0.14	0.25	0.24	0.21	0.23	0.31	0.22	0.23	0.43	0.24
	Joint dissertations	0.07	0.07	0.05	0.08	0.05	0.05	0.05	0.06	0.04	0.13	0.06
	Collaboration with scientific institutions' researchers	0.11	0.00	0.07	0.10	0.11	0.02	0.23	0.04	0.14	0.10	0.08
	Joint lectures	0.07	0.12	0.07	0.06	0.09	0.08	0.04	0.06	0.10	0.09	0.07
	Lectureship at scientific institution	0.04	0.12	0.25	0.03	0.05	0.31	0.04	0.15	0.20	0.14	0.17
	Advanced training of employees	0.25	0.38	0.52	0.24	0.28	0.54	0.46	0.42	0.43	0.32	0.42
Research	Research co-operation	0.17	0.08	0.17	0.21	0.13	0.17	0.18	0.11	0.25	0.28	0.17
	Contract research	0.08	0.07	0.02	0.09	0.07	0.01	0.04	0.03	0.04	0.15	0.04
	Research consortia	0.05	0.00	0.04	0.07	0.02	0.04	0.04	0.03	0.05	0.10	0.04
Consulting	Expert reports	0.14	0.13	0.06	0.10	0.20	0.05	0.08	0.07	0.14	0.08	0.09
	Consulting	0.14	0.12	0.14	0.12	0.16	0.13	0.21	0.12	0.19	0.08	0.14

2018		Sector			Subsector				Size			Total
		Manufacturing	Construction	Services	High-tech manufacturing	Low-tech manufacturing	Modern services	Traditional services	Small	Medium-sized	Large	
Informal contacts	Informal contacts	0.31	0.20	0.30	0.32	0.30	0.26	0.37	0.29	0.29	0.34	0.29
	Conferences, exhibitions, and workshops	0.26	0.37	0.28	0.31	0.22	0.27	0.29	0.25	0.30	0.54	0.28
	Scientific publications	0.20	0.28	0.28	0.21	0.19	0.31	0.22	0.26	0.22	0.28	0.25
Infrastructure	Shared laboratories	0.11	0.00	0.03	0.11	0.10	0.01	0.06	0.04	0.05	0.07	0.05
	Technical infrastructure	0.20	0.10	0.08	0.27	0.16	0.06	0.12	0.11	0.16	0.13	0.12
Education & mobility	Recruiting graduates	0.25	0.02	0.26	0.40	0.16	0.34	0.11	0.18	0.36	0.37	0.23
	Staff contacts to prior scientific institution	0.14	0.00	0.16	0.19	0.12	0.19	0.11	0.12	0.20	0.17	0.14
	Internships of students	0.20	0.03	0.14	0.23	0.18	0.15	0.14	0.12	0.20	0.26	0.15
	Joint thesis	0.18	0.05	0.12	0.21	0.16	0.11	0.12	0.08	0.22	0.34	0.13
	Joint dissertations	0.08	0.01	0.04	0.11	0.06	0.03	0.06	0.03	0.08	0.16	0.05
	Collaboration with scientific institutions' researchers	0.07	0.02	0.04	0.07	0.07	0.06	0.01	0.04	0.07	0.05	0.05
	Joint lectures	0.03	0.10	0.09	0.02	0.04	0.08	0.11	0.09	0.04	0.06	0.08
	Lectureship at scientific institution	0.06	0.00	0.11	0.06	0.05	0.10	0.13	0.09	0.06	0.13	0.08
	Advanced training of employees	0.19	0.21	0.28	0.15	0.22	0.38	0.07	0.23	0.24	0.41	0.24
Research	Research co-operation	0.20	0.11	0.10	0.34	0.12	0.10	0.10	0.10	0.21	0.21	0.13
	Contract research	0.07	0.00	0.02	0.12	0.04	0.01	0.03	0.02	0.05	0.09	0.03
	Research consortia	0.08	0.01	0.04	0.14	0.04	0.06	0.01	0.03	0.09	0.09	0.05
Consulting	Expert reports	0.15	0.19	0.02	0.15	0.14	0.02	0.02	0.08	0.07	0.07	0.08
	Consulting	0.13	0.19	0.11	0.12	0.14	0.15	0.03	0.14	0.10	0.09	0.13

Note: These tables show the fraction of enterprises that reported a specific single form of knowledge and technology transfer in the above-mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector, subsector, enterprise size and overall

Source: KOF-KTT surveys (2005, 2011, 2018)

Partners

Occurence

Table A6i: Domains as partners of knowledge and technology transfer, by sector, subsector, enterprise size and overall

2005		ETH domain	Universities	Universities of applied sciences
Sector	Manufacturing	0.71	0.36	0.83
	Construction	0.58	0.47	0.24
	Services	0.59	0.42	0.59
Subsector	High-tech manufacturing	0.69	0.40	0.75
	Low-tech manufacturing	0.72	0.33	0.88
	Modern services	0.69	0.40	0.75
	Traditional services	0.49	0.45	0.42
Size	Small	0.59	0.35	0.59
	Medium-sized	0.70	0.59	0.65
	Large	0.74	0.60	0.78
Total		0.62	0.41	0.61

2011		ETH domain	Universities	Universities of applied sciences
Sector	Manufacturing	0.75	0.38	0.74
	Construction	0.79	0.36	0.64
	Services	0.71	0.46	0.70
Subsector	High-tech manufacturing	0.79	0.38	0.74
	Low-tech manufacturing	0.70	0.37	0.74
	Modern services	0.75	0.50	0.68
	Traditional services	0.53	0.33	0.75
Size	Small	0.66	0.38	0.67
	Medium-sized	0.81	0.48	0.75
	Large	0.83	0.57	0.79
Total		0.73	0.43	0.71

2018		ETH domain	Universities	Universities of applied sciences
Sector	Manufacturing	0.62	0.34	0.68
	Construction	0.58	0.30	0.62
	Services	0.67	0.33	0.66
Subsector	High-tech manufacturing	0.69	0.36	0.68
	Low-tech manufacturing	0.58	0.32	0.68
	Modern services	0.65	0.34	0.71
	Traditional services	0.71	0.31	0.58
Size	Small	0.65	0.30	0.61
	Medium-sized	0.60	0.35	0.78
	Large	0.80	0.64	0.80
Total		0.65	0.33	0.66

Note: These tables show the fraction of enterprises that conducted at least one form of knowledge and technology transfer with at least one institution of the respective domains.

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector, subsector, enterprise size and overall

Source: KOF-KTT surveys (2005, 2011, 2018)

Diversity

Table A6ii: Diversity of knowledge and technology transfer partners, by sector, subsector, enterprise size and overall

2005		Number of partners (Domains)	Number of partners (Institutions)	Number of partners (ETH domain)	Number of partners (Universities)	Number of partners (Universities of applied sciences)
Sector	Manufacturing	1.89	2.74	1.18	0.45	1.12
	Construction	1.28	1.74	0.97	0.50	0.26
	Services	1.60	2.58	0.98	0.76	0.84
Subsector	High-tech manufacturing	1.84	2.79	1.06	0.55	1.18
	Low-tech manufacturing	1.93	2.71	1.27	0.37	1.07
	Modern services	1.83	2.97	1.23	0.59	1.15
	Traditional services	1.36	2.15	0.72	0.93	0.50
Size	Small	1.53	2.34	1.00	0.54	0.80
	Medium-sized	1.94	2.78	1.08	0.82	0.87
	Large	2.13	3.96	1.51	1.17	1.27
Total		1.64	2.50	1.04	0.63	0.84

2011		Number of partners (Domains)	Number of partners (Institutions)	Number of partners (ETH domain)	Number of partners (Universities)	Number of partners (Universities of applied sciences)
Sector	Manufacturing	1.87	3.42	1.54	0.77	1.11
	Construction	1.80	3.76	1.76	0.92	1.08
	Services	1.87	3.13	1.38	0.74	1.01
Subsector	High-tech manufacturing	1.91	3.56	1.58	0.82	1.16
	Low-tech manufacturing	1.80	3.20	1.48	0.68	1.04
	Modern services	1.93	3.27	1.54	0.72	1.01
	Traditional services	1.60	2.52	0.68	0.80	1.05
Size	Small	1.71	2.98	1.34	0.69	0.94
	Medium-sized	2.05	3.29	1.50	0.70	1.08
	Large	2.19	5.14	1.99	1.44	1.71
Total		1.86	3.26	1.45	0.76	1.05

2018		Number of partners (Domains)	Number of partners (Institutions)	Number of partners (ETH domain)	Number of partners (Universities)	Number of partners (Universities of applied sciences)
Sector	Manufacturing	1.64	3.06	1.23	0.74	1.10
	Construction	1.50	2.22	1.02	0.47	0.74
	Services	1.67	2.95	1.29	0.61	1.05
Subsector	High-tech manufacturing	1.74	3.70	1.43	1.01	1.26
	Low-tech manufacturing	1.59	2.68	1.11	0.57	1.00
	Modern services	1.70	2.90	1.26	0.55	1.09
	Traditional services	1.60	3.03	1.35	0.72	0.96
Size	Small	1.56	2.71	1.21	0.55	0.95
	Medium-sized	1.74	2.99	1.22	0.61	1.16
	Large	2.23	4.78	1.69	1.68	1.41
Total		1.64	2.90	1.24	0.63	1.03

Note: These tables show the average number of domains, public research institutions and public research institutions per domain per enterprise with which at least one form of knowledge and technology transfer has been carried out.

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector, subsector, enterprise size and overall

Source: KOF-KTT surveys (2005, 2011, 2018)

Mediators

High relevance

Table A7i: Mediators of knowledge and technology transfer (high relevance), by sector, sub-sector, enterprise size and overall

2005		TTOs	KTI / Innosuisse	SNSF	EU Framework Programmes	Other EU research programs
Sector	Manufacturing	0.15	0.18	0.01	0.03	0.03
	Construction	0.01	0.00	0.00	0.00	0.00
	Services	0.09	0.10	0.06	0.05	0.02
Subsector	High-tech manufacturing	0.16	0.20	0.02	0.06	0.05
	Low-tech manufacturing	0.14	0.17	0.01	0.01	0.01
	Modern services	0.06	0.09	0.06	0.03	0.02
	Traditional services	0.12	0.10	0.05	0.07	0.02
Size	Small	0.11	0.11	0.04	0.04	0.02
	Medium-sized	0.07	0.11	0.03	0.04	0.02
	Large	0.07	0.10	0.03	0.05	0.04
Total		0.10	0.11	0.04	0.04	0.02

2011		TTOs	KTI / Innosuisse	SNSF	EU Framework Programmes	Other EU research programs
Sector	Manufacturing	0.12	0.20	0.05	0.06	0.04
	Construction	0.01	0.13	0.00	0.01	0.01
	Services	0.14	0.18	0.07	0.06	0.09
Subsector	High-tech manufacturing	0.11	0.19	0.04	0.08	0.05
	Low-tech manufacturing	0.12	0.21	0.05	0.04	0.02
	Modern services	0.16	0.21	0.08	0.08	0.08
	Traditional services	0.05	0.07	0.04	0.00	0.13
Size	Small	0.15	0.16	0.08	0.08	0.07
	Medium-sized	0.09	0.22	0.03	0.02	0.06
	Large	0.10	0.21	0.03	0.10	0.09
Total		0.13	0.18	0.06	0.06	0.07

2018		TTOs	KTI / Innosuisse	SNSF	EU Framework Programmes	Other EU research programs
Sector	Manufacturing	0.14	0.25	0.06	0.07	0.05
	Construction	0.08	0.16	0.17	0.17	0.00
	Services	0.09	0.08	0.04	0.02	0.05
Subsector	High-tech manufacturing	0.16	0.38	0.07	0.13	0.07
	Low-tech manufacturing	0.13	0.17	0.06	0.03	0.03
	Modern services	0.12	0.07	0.03	0.02	0.04
	Traditional services	0.04	0.09	0.06	0.01	0.07
Size	Small	0.10	0.10	0.06	0.04	0.05
	Medium-sized	0.14	0.21	0.08	0.06	0.03
	Large	0.06	0.34	0.05	0.10	0.08
Total		0.10	0.14	0.06	0.05	0.04

Note: These tables show the fraction of enterprises that reported a mediator of knowledge and technology transfer as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector, subsector, enterprise size and overall

Source: KOF-KTT surveys (2005, 2011, 2018)

Medium relevance

Table A7ii: Mediators of knowledge and technology transfer (mediocre relevance), by sector, subsector, enterprise size and overall

2005		TTOs	KTI / Innosuisse	SNSF	EU Framework Programmes	Other EU research programs
Sector	Manufacturing	0.43	0.41	0.06	0.14	0.13
	Construction	0.18	0.17	0.03	0.19	0.18
	Services	0.16	0.15	0.11	0.09	0.05
Subsector	High-tech manufacturing	0.36	0.35	0.09	0.15	0.13
	Low-tech manufacturing	0.49	0.45	0.04	0.13	0.13
	Modern services	0.10	0.18	0.10	0.09	0.07
	Traditional services	0.24	0.11	0.12	0.08	0.03
Size	Small	0.26	0.23	0.08	0.11	0.09
	Medium-sized	0.22	0.23	0.11	0.11	0.07
	Large	0.17	0.22	0.13	0.13	0.11
Total		0.25	0.23	0.09	0.11	0.09

2011		TTOs	KTI / Innosuisse	SNSF	EU Framework Programmes	Other EU research programs
Sector	Manufacturing	0.31	0.40	0.14	0.16	0.15
	Construction	0.27	0.20	0.01	0.01	0.07
	Services	0.28	0.32	0.14	0.16	0.13
Subsector	High-tech manufacturing	0.33	0.41	0.15	0.19	0.15
	Low-tech manufacturing	0.28	0.39	0.14	0.12	0.13
	Modern services	0.33	0.38	0.16	0.16	0.13
	Traditional services	0.06	0.09	0.06	0.14	0.16
Size	Small	0.30	0.34	0.14	0.14	0.14
	Medium-sized	0.28	0.34	0.12	0.17	0.12
	Large	0.26	0.41	0.13	0.21	0.17
Total		0.29	0.35	0.14	0.15	0.14

2018		TTOs	KTI / Innosuisse	SNSF	EU Framework Programmes	Other EU research programs
Sector	Manufacturing	0.28	0.43	0.21	0.19	0.16
	Construction	0.31	0.26	0.22	0.18	0.04
	Services	0.35	0.26	0.10	0.12	0.14
Subsector	High-tech manufacturing	0.27	0.57	0.21	0.28	0.18
	Low-tech manufacturing	0.28	0.34	0.20	0.14	0.15
	Modern services	0.39	0.30	0.10	0.11	0.12
	Traditional services	0.27	0.19	0.10	0.13	0.19
Size	Small	0.31	0.27	0.14	0.16	0.12
	Medium-sized	0.34	0.39	0.15	0.10	0.16
	Large	0.43	0.53	0.19	0.17	0.17
Total		0.32	0.31	0.15	0.15	0.13

Note: These tables show the fraction of enterprises that reported a mediator of knowledge and technology transfer as reasonably relevant (values >= 3 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector, subsector, enterprise size and overall

Source: KOF-KTT surveys (2005, 2011, 2018)

Motives

Categories

Table A8i: Motive categories for knowledge and technology transfer, by sector, subsector, enterprise size and overall

2005		Tacit knowledge	Codified knowledge	Financial motives	Institutional / organizational motives
Sector	Manufacturing	0.72	0.45	0.57	0.19
	Construction	0.39	0.19	0.31	0.03
	Services	0.69	0.23	0.35	0.21
Subsector	High-tech manufacturing	0.74	0.40	0.48	0.17
	Low-tech manufacturing	0.70	0.49	0.63	0.20
	Modern services	0.85	0.30	0.42	0.28
	Traditional services	0.49	0.14	0.28	0.12
Size	Small	0.66	0.29	0.40	0.20
	Medium-sized	0.64	0.30	0.49	0.12
	Large	0.71	0.24	0.27	0.14
Total		0.66	0.29	0.41	0.18

2011		Tacit knowledge	Codified knowledge	Financial motives	Institutional / organizational motives
Sector	Manufacturing	0.57	0.36	0.42	0.18
	Construction	0.60	0.27	0.38	0.13
	Services	0.71	0.26	0.28	0.25
Subsector	High-tech manufacturing	0.61	0.39	0.47	0.20
	Low-tech manufacturing	0.52	0.31	0.35	0.15
	Modern services	0.72	0.22	0.29	0.31
	Traditional services	0.67	0.44	0.26	0.02
Size	Small	0.60	0.26	0.28	0.24
	Medium-sized	0.71	0.36	0.42	0.19
	Large	0.81	0.31	0.42	0.21
Total		0.66	0.30	0.34	0.22

2018		Tacit knowledge	Codified knowledge	Financial motives	Institutional / organizational motives
Sector	Manufacturing	0.56	0.37	0.40	0.20
	Construction	0.66	0.30	0.22	0.14
	Services	0.66	0.34	0.20	0.20
Subsector	High-tech manufacturing	0.67	0.40	0.48	0.24
	Low-tech manufacturing	0.49	0.35	0.34	0.18
	Modern services	0.68	0.35	0.18	0.17
	Traditional services	0.61	0.31	0.26	0.26
Size	Small	0.58	0.36	0.22	0.19
	Medium-sized	0.72	0.26	0.38	0.21
	Large	0.90	0.42	0.34	0.18
Total		0.63	0.34	0.26	0.19

Note: These tables show the fraction of enterprises that reported at least one single motive for knowledge and technology transfer in the above-mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector, subsector, enterprise size and overall

Source: KOF-KTT surveys (2005, 2011, 2018)

Single motives

Table A8ii: Single motives for knowledge and technology transfer, by sector, subsector, enterprise size and overall

2005		Sector			Subsector				Size			Total
		Manufacturing	Construction	Services	High-tech manufacturing	Low-tech manufacturing	Modern services	Traditional services	Small	Medium-sized	Large	
Tacit knowledge	Specific skills	0.54	0.37	0.44	0.58	0.51	0.48	0.39	0.45	0.48	0.56	0.46
	New research stimuli	0.18	0.03	0.22	0.20	0.17	0.28	0.15	0.18	0.18	0.14	0.18
	Education and training of employees	0.24	0.22	0.35	0.28	0.20	0.46	0.21	0.30	0.29	0.37	0.30
	Recruiting graduates	0.20	0.00	0.17	0.22	0.18	0.24	0.08	0.14	0.18	0.29	0.16
	Access to basic research	0.16	0.03	0.17	0.14	0.17	0.25	0.06	0.16	0.08	0.13	0.15
Codified knowledge	Research results for reapplication in R&D	0.21	0.02	0.09	0.19	0.23	0.08	0.11	0.12	0.12	0.11	0.12
	Research results to develop new products	0.28	0.17	0.11	0.27	0.29	0.15	0.07	0.16	0.19	0.13	0.17
	Research results to develop new processes	0.16	0.19	0.14	0.12	0.20	0.20	0.07	0.15	0.19	0.16	0.16
	Access to R&D infrastructure	0.19	0.02	0.08	0.15	0.21	0.10	0.05	0.11	0.09	0.07	0.10
Financial motives	Cost savings in R&D	0.14	0.01	0.11	0.17	0.12	0.13	0.09	0.10	0.12	0.06	0.11
	Reduction of R&D risks	0.11	0.01	0.08	0.15	0.08	0.13	0.01	0.07	0.09	0.09	0.08
	Time saving in R&D	0.25	0.02	0.10	0.24	0.26	0.14	0.06	0.14	0.14	0.12	0.14
	Insufficient financial resources to conduct R&D	0.31	0.14	0.19	0.22	0.37	0.27	0.08	0.21	0.27	0.05	0.22
	R&D projects only feasible in co-operation with scientific partners	0.41	0.17	0.20	0.31	0.48	0.26	0.12	0.27	0.22	0.15	0.26
Institutional / Organizational motives	Requirement for R&D funding	0.08	0.00	0.09	0.12	0.05	0.12	0.06	0.09	0.05	0.07	0.08
	Image enhancement	0.12	0.02	0.17	0.08	0.15	0.20	0.12	0.15	0.08	0.08	0.13

2011		Sector			Subsector				Size			Total
		Manufacturing	Construction	Services	High-tech manufacturing	Low-tech manufacturing	Modern services	Traditional services	Small	Medium-sized	Large	
Tacit knowledge	Specific skills	0.44	0.36	0.40	0.45	0.43	0.37	0.51	0.35	0.47	0.59	0.41
	New research stimuli	0.19	0.14	0.18	0.21	0.16	0.18	0.18	0.16	0.19	0.28	0.18
	Education and training of employees	0.22	0.34	0.61	0.24	0.19	0.63	0.53	0.46	0.46	0.39	0.45
	Recruiting graduates	0.23	0.15	0.45	0.28	0.16	0.52	0.17	0.30	0.40	0.52	0.35
	Access to basic research	0.14	0.08	0.20	0.12	0.17	0.19	0.24	0.15	0.20	0.22	0.17
Codified knowledge	Research results for reapplication in R&D	0.13	0.01	0.13	0.14	0.13	0.11	0.20	0.09	0.17	0.18	0.12
	Research results to develop new products	0.24	0.19	0.10	0.26	0.22	0.07	0.20	0.14	0.18	0.22	0.16
	Research results to develop new processes	0.20	0.21	0.18	0.22	0.17	0.16	0.25	0.14	0.27	0.18	0.19
	Access to R&D infrastructure	0.15	0.02	0.07	0.14	0.17	0.04	0.16	0.08	0.12	0.12	0.10
Financial motives	Cost savings in R&D	0.14	0.00	0.11	0.17	0.10	0.09	0.18	0.08	0.17	0.11	0.11
	Reduction of R&D risks	0.15	0.00	0.11	0.17	0.12	0.09	0.21	0.12	0.11	0.19	0.12
	Time saving in R&D	0.23	0.25	0.10	0.29	0.14	0.12	0.02	0.15	0.16	0.18	0.15
	Insufficient financial resources to conduct R&D	0.15	0.00	0.12	0.14	0.15	0.09	0.24	0.10	0.17	0.09	0.13
	R&D projects only feasible in co-operation with scientific partners	0.24	0.32	0.21	0.27	0.20	0.21	0.21	0.18	0.30	0.26	0.23
Institutional / Organizational motives	Requirement for R&D funding	0.10	0.13	0.18	0.11	0.08	0.22	0.01	0.18	0.11	0.08	0.15
	Image enhancement	0.11	0.06	0.14	0.11	0.10	0.17	0.02	0.11	0.14	0.16	0.12

2018		Sector			Subsector				Size			Total
		Manufacturing	Construction	Services	High-tech manufacturing	Low-tech manufacturing	Modern services	Traditional services	Small	Medium-sized	Large	
Tacit knowledge	Specific skills	0.43	0.40	0.38	0.58	0.35	0.33	0.48	0.33	0.53	0.74	0.40
	New research stimuli	0.26	0.11	0.17	0.28	0.25	0.19	0.13	0.18	0.22	0.28	0.19
	Education and training of employees	0.19	0.53	0.30	0.19	0.18	0.31	0.29	0.27	0.31	0.53	0.29
	Recruiting graduates	0.17	0.16	0.41	0.25	0.13	0.52	0.22	0.27	0.36	0.59	0.31
	Access to basic research	0.12	0.08	0.11	0.16	0.10	0.13	0.07	0.09	0.15	0.18	0.11
Codified knowledge	Research results for reapplication in R&D	0.14	0.01	0.11	0.19	0.11	0.11	0.10	0.10	0.11	0.18	0.11
	Research results to develop new products	0.24	0.11	0.16	0.28	0.22	0.18	0.14	0.19	0.15	0.24	0.18
	Research results to develop new processes	0.19	0.29	0.20	0.15	0.21	0.16	0.28	0.21	0.17	0.31	0.21
	Access to R&D infrastructure	0.16	0.01	0.10	0.20	0.13	0.12	0.06	0.11	0.10	0.15	0.11
Financial motives	Cost savings in R&D	0.17	0.09	0.08	0.21	0.14	0.07	0.09	0.09	0.14	0.10	0.11
	Reduction of R&D risks	0.15	0.09	0.09	0.16	0.15	0.08	0.13	0.10	0.16	0.07	0.11
	Time saving in R&D	0.21	0.09	0.11	0.22	0.20	0.10	0.12	0.11	0.21	0.18	0.14
	Insufficient financial resources to conduct R&D	0.18	0.10	0.07	0.17	0.18	0.05	0.11	0.10	0.15	0.09	0.11
	R&D projects only feasible in co-operation with scientific partners	0.22	0.22	0.11	0.32	0.16	0.10	0.13	0.13	0.24	0.18	0.16
Institutional / Organizational motives	Requirement for R&D funding	0.10	0.12	0.08	0.15	0.07	0.06	0.12	0.08	0.10	0.12	0.09
	Image enhancement	0.15	0.05	0.17	0.13	0.15	0.15	0.20	0.15	0.14	0.13	0.15

Note: These tables show the fraction of enterprises that reported a specific single motive for knowledge and technology transfer in the above-mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector, subsector, enterprise size and overall

Source: KOF-KTT surveys (2005, 2011, 2018)

Results

Table A9: Results from knowledge and technology transfer, by sector, subsector, enterprise size and overall

2011		New R&D projects	Development of new products	Development of new processes	Scientific publications	Patents	Licenses	Recruitment of graduates	Further training
Sector	Manufacturing	0.31	0.48	0.37	0.18	0.13	0.04	0.37	0.24
	Construction	0.15	0.27	0.42	0.08	0.01	0.01	0.21	0.09
	Services	0.20	0.38	0.53	0.22	0.05	0.04	0.39	0.40
Subsector	High-tech manufacturing	0.31	0.50	0.38	0.18	0.17	0.03	0.46	0.27
	Low-tech manufacturing	0.30	0.46	0.37	0.18	0.06	0.04	0.25	0.20
	Modern services	0.15	0.29	0.52	0.26	0.06	0.05	0.40	0.42
	Traditional services	0.40	0.71	0.53	0.06	0.01	0.01	0.35	0.30
Size	Small	0.16	0.39	0.50	0.23	0.05	0.04	0.27	0.33
	Medium-sized	0.32	0.41	0.40	0.11	0.09	0.02	0.49	0.29
	Large	0.43	0.55	0.51	0.34	0.24	0.10	0.59	0.43
Total		0.24	0.41	0.46	0.20	0.08	0.04	0.37	0.32

2018		New R&D projects	Development of new products	Development of new processes	Scientific publications	Patents	Licenses	Recruitment of graduates	Further training
Sector	Manufacturing	0.32	0.57	0.41	0.15	0.13	0.07	0.32	0.14
	Construction	0.11	0.45	0.47	0.01	0.01	0.01	0.12	0.25
	Services	0.24	0.46	0.46	0.09	0.06	0.01	0.32	0.12
Subsector	High-tech manufacturing	0.37	0.70	0.31	0.23	0.19	0.06	0.44	0.12
	Low-tech manufacturing	0.29	0.49	0.47	0.10	0.09	0.07	0.25	0.15
	Modern services	0.30	0.44	0.46	0.08	0.06	0.01	0.40	0.15
	Traditional services	0.14	0.49	0.47	0.11	0.07	0.00	0.17	0.06
Size	Small	0.23	0.47	0.41	0.07	0.07	0.02	0.23	0.11
	Medium-sized	0.27	0.51	0.49	0.14	0.07	0.03	0.43	0.18
	Large	0.37	0.62	0.74	0.28	0.14	0.05	0.51	0.39
Total		0.25	0.49	0.45	0.10	0.07	0.03	0.30	0.14

Note: These tables show the fraction of enterprises that reported that knowledge and technology transfers with scientific partners resulted in a specific outcome. The 2005 survey posed these questions in an ordinal manner (5-point ordinal scale) while the latter two surveys posed these questions in a binary way. These methodological differences renders the first period incomparable to the latter two and was subsequently dropped.

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector, subsector, enterprise size and overall

Source: KOF-KTT surveys (2011, 2018)

Impediments

KTT-inactive enterprises

Categories

Table A10i: Impediment categories for knowledge and technology transfer, by sector, sub-sector, enterprise size and overall

2005		Missing information	Lack of requirements of the enterprise	Lack of requirements of the scientific partner	Costs / risks	Organizational / institutional impediments
Sector	Manufacturing	0.27	0.58	0.45	0.46	0.24
	Construction	0.17	0.48	0.40	0.38	0.20
	Services	0.20	0.55	0.45	0.41	0.21
Subsector	High-tech manufacturing	0.31	0.57	0.46	0.46	0.27
	Low-tech manufacturing	0.25	0.58	0.45	0.46	0.23
	Modern services	0.24	0.55	0.47	0.48	0.26
	Traditional services	0.15	0.55	0.42	0.31	0.14
Size	Small	0.21	0.53	0.43	0.41	0.21
	Medium-sized	0.24	0.61	0.47	0.44	0.26
	Large	0.22	0.54	0.47	0.37	0.25
Total		0.21	0.54	0.44	0.42	0.22

2011		Missing information	Lack of requirements of the enterprise	Lack of requirements of the scientific partner	Costs / risks	Organizational / institutional impediments
Sector	Manufacturing	0.23	0.50	0.36	0.35	0.21
	Construction	0.16	0.47	0.35	0.32	0.16
	Services	0.15	0.55	0.35	0.34	0.21
Subsector	High-tech manufacturing	0.33	0.63	0.42	0.43	0.28
	Low-tech manufacturing	0.19	0.47	0.34	0.32	0.19
	Modern services	0.16	0.54	0.32	0.36	0.20
	Traditional services	0.13	0.56	0.39	0.31	0.23
Size	Small	0.18	0.50	0.34	0.34	0.19
	Medium-sized	0.16	0.57	0.39	0.34	0.22
	Large	0.18	0.51	0.36	0.37	0.26
Total		0.18	0.51	0.35	0.34	0.20

2018		Missing information	Lack of requirements of the enterprise	Lack of requirements of the scientific partner	Costs / risks	Organizational / institutional impediments
Sector	Manufacturing	0.21	0.45	0.30	0.32	0.23
	Construction	0.10	0.40	0.27	0.29	0.20
	Services	0.11	0.38	0.21	0.20	0.12
Subsector	High-tech manufacturing	0.24	0.42	0.33	0.42	0.25
	Low-tech manufacturing	0.19	0.46	0.30	0.28	0.22
	Modern services	0.15	0.43	0.27	0.23	0.16
	Traditional services	0.08	0.35	0.18	0.19	0.11
Size	Small	0.11	0.38	0.23	0.23	0.15
	Medium-sized	0.16	0.49	0.25	0.26	0.17
	Large	0.22	0.37	0.34	0.31	0.24
Total		0.12	0.39	0.24	0.24	0.15

Note: These tables show the fraction of enterprises that reported at least one single impediment for knowledge and technology transfer in the above-mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector, subsector, enterprise size and overall

Source: KOF-KTT surveys (2005, 2011, 2018)

Single impediments

Table A10ii: Single impediments for knowledge and technology transfer, by sector, subsector, enterprise size and overall

2005		Sector			Subsector				Size			Total
		Manufacturing	Construction	Services	High-tech manufacturing	Low-tech manufacturing	Modern services	Traditional services	Small	Medium-sized	Large	
Missing information	Lack of information about scientific partners' research activitites	0.15	0.12	0.13	0.16	0.14	0.16	0.09	0.14	0.11	0.11	0.13
	Finding the right contact persons	0.20	0.13	0.15	0.25	0.19	0.17	0.12	0.16	0.18	0.15	0.16
	Equipment of the interface to scientific partners	0.13	0.06	0.07	0.13	0.12	0.08	0.06	0.08	0.10	0.11	0.08
Lack of requirements of the enterprise	Qualified personnel	0.14	0.13	0.10	0.15	0.14	0.11	0.09	0.11	0.16	0.11	0.12
	Technical equipment	0.10	0.14	0.06	0.11	0.10	0.03	0.10	0.10	0.09	0.04	0.10
	Lack of interest in scientific projects	0.26	0.24	0.30	0.25	0.27	0.26	0.35	0.26	0.33	0.25	0.27
	Own R&D questions are uninteresting for scientific partners	0.41	0.40	0.40	0.39	0.41	0.41	0.38	0.39	0.45	0.36	0.40
Lack of requirements of the scientific partner	Lack of KTT specialists	0.15	0.13	0.10	0.14	0.16	0.10	0.10	0.13	0.11	0.11	0.13
	Lack of entrepreneurial thinking	0.13	0.06	0.09	0.12	0.13	0.08	0.10	0.09	0.09	0.09	0.09
	Uninteresting research orientation of scientific partners	0.29	0.27	0.25	0.27	0.30	0.28	0.22	0.27	0.30	0.35	0.27
	Lack of commercial exploitation	0.25	0.30	0.28	0.23	0.26	0.31	0.24	0.28	0.27	0.27	0.28
Costs / risks	Secrecy of scientific partner	0.12	0.09	0.07	0.13	0.11	0.09	0.05	0.09	0.09	0.10	0.09
	Substantial follow-up work	0.15	0.08	0.11	0.19	0.14	0.16	0.04	0.11	0.14	0.15	0.11
	Financial ressources of the enterprise	0.30	0.27	0.27	0.29	0.31	0.32	0.21	0.28	0.27	0.18	0.28
	Financial ressources of scientific partners	0.15	0.11	0.10	0.13	0.17	0.12	0.07	0.12	0.10	0.06	0.12
	Insufficient efficiency of the scientific partners	0.11	0.13	0.09	0.12	0.10	0.10	0.08	0.11	0.09	0.09	0.11
	Technological dependency on external partners	0.07	0.05	0.07	0.09	0.06	0.07	0.07	0.07	0.04	0.03	0.07
	Uncertainty about the collaboration results	0.14	0.10	0.11	0.16	0.13	0.14	0.08	0.12	0.10	0.08	0.12
Organizational / institutional impediments	Authorisation procedures and legal restrictions	0.15	0.11	0.13	0.14	0.16	0.15	0.09	0.13	0.16	0.13	0.13
	Lack of administrative support from the scientific partner	0.07	0.06	0.05	0.06	0.07	0.06	0.04	0.06	0.06	0.03	0.06
	Lack of support for commercial exploitation from the scientific partner	0.08	0.11	0.07	0.09	0.08	0.10	0.04	0.09	0.08	0.05	0.09
	Property rights issues	0.06	0.06	0.05	0.08	0.05	0.07	0.02	0.05	0.07	0.07	0.06
	Management problems at the scientific partner	0.05	0.06	0.04	0.04	0.05	0.05	0.02	0.05	0.04	0.07	0.05
	Different priorities	0.08	0.06	0.08	0.11	0.07	0.12	0.03	0.07	0.10	0.10	0.08
	Lack of trust	0.04	0.03	0.04	0.05	0.04	0.03	0.04	0.04	0.03	0.03	0.04
	Loss of reputation	0.02	0.00	0.03	0.02	0.03	0.05	0.01	0.02	0.01	0.03	0.02

2011		Sector			Subsector				Size			Total
		Manufacturing	Construction	Services	High-tech manufacturing	Low-tech manufacturing	Modern services	Traditional services	Small	Medium-sized	Large	
Missing information	Lack of information about scientific partners' research	0.16	0.10	0.08	0.21	0.14	0.09	0.06	0.11	0.10	0.08	0.11
	Finding the right contact persons	0.18	0.07	0.11	0.24	0.16	0.11	0.11	0.12	0.13	0.11	0.12
	Equipment of the interface to scientific partners	0.09	0.12	0.09	0.14	0.08	0.10	0.07	0.11	0.06	0.10	0.10
Lack of requirements of the enterprise	Qualified personnel	0.16	0.14	0.13	0.22	0.14	0.10	0.16	0.13	0.19	0.07	0.14
	Technical equipment	0.11	0.18	0.10	0.14	0.10	0.06	0.14	0.13	0.10	0.05	0.12
	Lack of interest in scientific projects	0.24	0.30	0.30	0.26	0.24	0.32	0.27	0.29	0.26	0.23	0.28
	Own R&D questions are uninteresting for scientific partners	0.34	0.32	0.45	0.44	0.32	0.45	0.45	0.38	0.41	0.42	0.38
Lack of requirements of the scientific partner	Lack of KTT specialists	0.09	0.08	0.09	0.15	0.07	0.09	0.08	0.09	0.09	0.06	0.09
	Lack of entrepreneurial thinking	0.08	0.04	0.08	0.11	0.07	0.07	0.08	0.06	0.09	0.05	0.07
	Uninteresting research orientation of scientific partners	0.24	0.24	0.26	0.28	0.23	0.24	0.29	0.24	0.29	0.23	0.25
	Lack of commercial exploitation	0.20	0.23	0.22	0.22	0.19	0.20	0.25	0.22	0.23	0.21	0.22
Costs / risks	Secrecy of scientific partner	0.07	0.08	0.07	0.11	0.06	0.09	0.03	0.07	0.07	0.11	0.07
	Substantial follow-up work	0.09	0.10	0.08	0.11	0.08	0.10	0.05	0.09	0.07	0.14	0.09
	Financial ressources of the enterprise	0.22	0.25	0.27	0.29	0.20	0.28	0.26	0.26	0.21	0.21	0.25
	Financial ressources of scientific partners	0.11	0.08	0.12	0.11	0.11	0.13	0.12	0.11	0.08	0.06	0.11
	Insufficient efficiency of the scientific partners	0.07	0.08	0.06	0.09	0.07	0.07	0.04	0.08	0.05	0.06	0.07
	Technological dependency on external partners	0.05	0.05	0.04	0.10	0.04	0.02	0.07	0.05	0.05	0.09	0.05
	Uncertainty about the collaboration results	0.12	0.10	0.09	0.16	0.10	0.08	0.11	0.11	0.08	0.13	0.10
Organizational / institutional impediments	Authorisation procedures and legal restrictions	0.14	0.13	0.13	0.15	0.14	0.14	0.12	0.13	0.14	0.16	0.13
	Lack of administrative support from the scientific partner	0.07	0.02	0.06	0.09	0.06	0.06	0.07	0.05	0.06	0.03	0.05
	Lack of support for commercial exploitation from the scientific partner	0.06	0.02	0.07	0.07	0.05	0.05	0.10	0.05	0.05	0.06	0.05
	Property rights issues	0.05	0.04	0.07	0.09	0.04	0.08	0.06	0.06	0.05	0.08	0.06
	Management problems at the scientific partner	0.07	0.05	0.06	0.06	0.07	0.05	0.08	0.05	0.08	0.10	0.06
	Different priorities	0.07	0.10	0.06	0.09	0.06	0.06	0.05	0.07	0.08	0.09	0.07
	Lack of trust	0.02	0.05	0.05	0.03	0.01	0.05	0.03	0.04	0.03	0.05	0.04
	Loss of reputation	0.01	0.05	0.03	0.02	0.01	0.04	0.02	0.04	0.02	0.03	0.03

2018		Sector			Subsector				Size			Total
		Manufacturing	Construction	Services	High-tech manufacturing	Low-tech manufacturing	Modern services	Traditional services	Small	Medium-sized	Large	
Missing information	Lack of information about scientific partners' research	0.14	0.05	0.06	0.16	0.13	0.10	0.03	0.07	0.08	0.14	0.07
	Finding the right contact persons	0.15	0.04	0.08	0.19	0.13	0.11	0.07	0.08	0.14	0.15	0.09
	Equipment of the interface to scientific partners	0.11	0.03	0.06	0.11	0.11	0.08	0.05	0.06	0.09	0.11	0.06
Lack of requirements of the enterprise	Qualified personnel	0.16	0.07	0.10	0.13	0.18	0.06	0.11	0.09	0.17	0.08	0.10
	Technical equipment	0.14	0.08	0.08	0.14	0.13	0.10	0.07	0.08	0.13	0.08	0.09
	Lack of interest in scientific projects	0.20	0.14	0.14	0.15	0.22	0.14	0.14	0.14	0.19	0.14	0.15
	Own R&D questions are uninteresting for scientific partners	0.30	0.26	0.27	0.30	0.31	0.34	0.24	0.26	0.36	0.27	0.28
Lack of requirements of the scientific partner	Lack of KTT specialists	0.12	0.06	0.07	0.14	0.11	0.07	0.07	0.07	0.09	0.08	0.07
	Lack of entrepreneurial thinking	0.08	0.11	0.05	0.12	0.07	0.08	0.03	0.06	0.06	0.03	0.06
	Uninteresting research orientation of scientific partners	0.22	0.21	0.13	0.22	0.22	0.18	0.10	0.16	0.14	0.27	0.15
	Lack of commercial exploitation	0.16	0.18	0.13	0.19	0.15	0.14	0.13	0.14	0.19	0.22	0.14
Costs / risks	Secrecy of scientific partner	0.09	0.10	0.03	0.14	0.08	0.06	0.02	0.05	0.05	0.15	0.05
	Substantial follow-up work	0.10	0.11	0.05	0.16	0.08	0.07	0.04	0.07	0.07	0.10	0.07
	Financial ressources of the enterprise	0.24	0.16	0.15	0.27	0.22	0.17	0.14	0.16	0.18	0.10	0.16
	Financial ressources of scientific partners	0.07	0.06	0.04	0.12	0.05	0.07	0.03	0.05	0.04	0.02	0.05
	Insufficient efficiency of the scientific partners	0.07	0.09	0.03	0.09	0.06	0.05	0.02	0.05	0.03	0.07	0.05
	Technological dependency on external partners	0.05	0.09	0.02	0.07	0.04	0.03	0.01	0.04	0.03	0.04	0.04
	Uncertainty about the collaboration results	0.09	0.07	0.04	0.14	0.07	0.07	0.03	0.05	0.09	0.07	0.06
Organizational / institutional impediments	Authorisation procedures and legal restrictions	0.15	0.16	0.09	0.14	0.16	0.13	0.07	0.11	0.08	0.13	0.11
	Lack of administrative support from the scientific partner	0.06	0.11	0.05	0.05	0.06	0.10	0.02	0.06	0.05	0.05	0.06
	Lack of support for commercial exploitation from the scientific partner	0.07	0.10	0.03	0.09	0.07	0.06	0.01	0.05	0.03	0.05	0.05
	Property rights issues	0.07	0.07	0.02	0.10	0.06	0.02	0.02	0.03	0.03	0.10	0.03
	Management problems at the scientific partner	0.04	0.09	0.03	0.06	0.04	0.03	0.02	0.04	0.05	0.05	0.04
	Different priorities	0.10	0.08	0.05	0.14	0.09	0.05	0.05	0.06	0.07	0.14	0.06
	Lack of trust	0.04	0.05	0.02	0.05	0.03	0.03	0.01	0.03	0.02	0.02	0.03
	Loss of reputation	0.03	0.06	0.01	0.04	0.03	0.03	0.01	0.03	0.01	0.02	0.02

Note: These tables show the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the above-mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were not engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector, subsector, enterprise size and overall

Source: KOF-KTT surveys (2005, 2011, 2018)

KTT active enterprises

Categories

Table A10iii: Impediment categories for knowledge and technology transfer, by sector, subsector, enterprise size and overall

2005		Missing information	Lack of requirements of the enterprise	Lack of requirements of the scientific partner	Costs / risks	Organizational / institutional impediments
Sector	Manufacturing	0.34	0.40	0.41	0.58	0.39
	Construction	0.48	0.40	0.49	0.50	0.46
	Services	0.26	0.35	0.33	0.36	0.26
Subsector	High-tech manufacturing	0.27	0.34	0.43	0.61	0.38
	Low-tech manufacturing	0.39	0.44	0.40	0.56	0.40
	Modern services	0.34	0.38	0.43	0.45	0.32
	Traditional services	0.17	0.32	0.21	0.25	0.19
Size	Small	0.30	0.39	0.38	0.43	0.34
	Medium-sized	0.35	0.30	0.33	0.51	0.28
	Large	0.27	0.39	0.40	0.42	0.32
Total		0.31	0.37	0.37	0.45	0.32

2011		Missing information	Lack of requirements of the enterprise	Lack of requirements of the scientific partner	Costs / risks	Organizational / institutional impediments
Sector	Manufacturing	0.24	0.37	0.34	0.49	0.34
	Construction	0.24	0.50	0.33	0.20	0.08
	Services	0.22	0.45	0.41	0.46	0.33
Subsector	High-tech manufacturing	0.28	0.35	0.38	0.54	0.43
	Low-tech manufacturing	0.18	0.39	0.29	0.42	0.23
	Modern services	0.22	0.48	0.42	0.49	0.36
	Traditional services	0.25	0.32	0.37	0.33	0.20
Size	Small	0.23	0.46	0.35	0.47	0.32
	Medium-sized	0.24	0.39	0.42	0.47	0.34
	Large	0.21	0.30	0.36	0.37	0.31
Total		0.23	0.42	0.38	0.46	0.32

2018		Missing information	Lack of requirements of the enterprise	Lack of requirements of the scientific partner	Costs / risks	Organizational / institutional impediments
Sector	Manufacturing	0.33	0.44	0.39	0.52	0.42
	Construction	0.31	0.58	0.74	0.60	0.41
	Services	0.24	0.29	0.29	0.42	0.27
Subsector	High-tech manufacturing	0.26	0.41	0.35	0.53	0.41
	Low-tech manufacturing	0.37	0.45	0.42	0.51	0.43
	Modern services	0.25	0.30	0.31	0.41	0.29
	Traditional services	0.23	0.27	0.24	0.42	0.23
Size	Small	0.25	0.37	0.36	0.48	0.34
	Medium-sized	0.35	0.38	0.40	0.42	0.32
	Large	0.35	0.26	0.43	0.49	0.25
Total		0.28	0.37	0.37	0.47	0.33

Note: These tables show the fraction of enterprises that reported at least one single impediment for knowledge and technology transfer in the above-mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector, subsector, enterprise size and overall

Source: KOF-KTT surveys (2005, 2011, 2018)

Single impediments

Table A10iv: Single impediments for knowledge and technology transfer, by sector, subsector, enterprise size and overall

2005		Sector			Subsector				Size			Total
		Manufacturing	Construction	Services	High-tech manufacturing	Low-tech manufacturing	Modern services	Traditional services	Small	Medium-sized	Large	
Missing information	Lack of information about scientific partners' research activitites	0.20	0.15	0.13	0.19	0.21	0.20	0.05	0.13	0.23	0.16	0.15
	Finding the right contact persons	0.25	0.32	0.20	0.23	0.27	0.27	0.12	0.24	0.21	0.14	0.23
	Equipment of the interface to scientific partners	0.10	0.19	0.13	0.08	0.12	0.21	0.03	0.14	0.09	0.11	0.13
Lack of requirements of the enterprise	Qualified personnel	0.10	0.17	0.17	0.08	0.11	0.14	0.21	0.16	0.09	0.12	0.15
	Technical equipment	0.13	0.16	0.06	0.11	0.15	0.04	0.09	0.11	0.06	0.09	0.10
	Lack of interest in scientific projects	0.18	0.19	0.21	0.11	0.22	0.20	0.22	0.22	0.13	0.16	0.20
	Own R&D questions are uninteresting for scientific partners	0.25	0.38	0.23	0.21	0.27	0.18	0.28	0.27	0.16	0.30	0.25
Lack of requirements of the scientific partner	Lack of KTT specialists	0.07	0.17	0.08	0.12	0.03	0.13	0.02	0.10	0.07	0.07	0.09
	Lack of entrepreneurial thinking	0.16	0.32	0.14	0.15	0.17	0.23	0.04	0.17	0.16	0.17	0.17
	Uninteresting research orientation of scientific partners	0.20	0.34	0.19	0.22	0.19	0.30	0.07	0.23	0.17	0.23	0.21
	Lack of commercial exploitation	0.18	0.30	0.17	0.19	0.18	0.19	0.15	0.20	0.17	0.15	0.19
Costs / risks	Secrecy of scientific partner	0.20	0.16	0.09	0.22	0.19	0.11	0.07	0.10	0.24	0.15	0.13
	Substantial follow-up work	0.22	0.03	0.14	0.22	0.22	0.12	0.18	0.14	0.18	0.21	0.15
	Financial ressources of the enterprise	0.36	0.32	0.19	0.32	0.39	0.28	0.09	0.25	0.30	0.12	0.26
	Financial ressources of scientific partners	0.17	0.19	0.11	0.09	0.23	0.19	0.01	0.15	0.12	0.07	0.14
	Insufficient efficiency of the scientific partners	0.10	0.16	0.12	0.15	0.07	0.17	0.06	0.11	0.15	0.12	0.12
	Technological dependency on external partners	0.11	0.01	0.04	0.13	0.10	0.07	0.00	0.06	0.04	0.07	0.06
	Uncertainty about the collaboration results	0.16	0.00	0.06	0.15	0.17	0.08	0.03	0.08	0.08	0.14	0.08
Organizational / institutional impediments	Authorisation procedures and legal restrictions	0.27	0.16	0.17	0.20	0.32	0.17	0.17	0.22	0.15	0.11	0.20
	Lack of administrative support from the scientific partner	0.14	0.01	0.08	0.08	0.18	0.09	0.07	0.09	0.10	0.03	0.09
	Lack of support for commercial exploitation from the scientific partner	0.12	0.17	0.05	0.11	0.13	0.07	0.03	0.08	0.11	0.07	0.09
	Property rights issues	0.10	0.01	0.10	0.12	0.09	0.10	0.10	0.09	0.10	0.09	0.09
	Management problems at the scientific partner	0.08	0.17	0.05	0.05	0.10	0.06	0.04	0.07	0.08	0.10	0.07
	Different priorities	0.25	0.17	0.11	0.23	0.27	0.17	0.05	0.16	0.16	0.21	0.16
	Lack of trust	0.07	0.14	0.02	0.04	0.09	0.04	0.01	0.06	0.04	0.03	0.05
	Loss of reputation	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.00

2011		Sector			Subsector				Size			Total
		Manufacturing	Construction	Services	High-tech manufacturing	Low-tech manufacturing	Modern services	Traditional services	Small	Medium-sized	Large	
Missing information	Lack of information about scientific partners' research	0.17	0.18	0.11	0.18	0.15	0.09	0.17	0.13	0.13	0.13	0.13
	Finding the right contact persons	0.20	0.12	0.13	0.22	0.16	0.14	0.09	0.18	0.12	0.12	0.15
	Equipment of the interface to scientific partners	0.09	0.00	0.07	0.13	0.04	0.08	0.04	0.07	0.09	0.03	0.08
Lack of requirements of the enterprise	Qualified personnel	0.16	0.18	0.24	0.16	0.16	0.28	0.10	0.24	0.19	0.09	0.21
	Technical equipment	0.10	0.12	0.09	0.12	0.08	0.12	0.00	0.09	0.12	0.03	0.10
	Lack of interest in scientific projects	0.12	0.19	0.08	0.09	0.16	0.09	0.04	0.09	0.13	0.10	0.10
	Own R&D questions are uninteresting for scientific partners	0.20	0.20	0.28	0.21	0.18	0.30	0.21	0.29	0.19	0.19	0.25
Lack of requirements of the scientific partner	Lack of KTT specialists	0.08	0.12	0.02	0.07	0.08	0.01	0.07	0.04	0.06	0.07	0.05
	Lack of entrepreneurial thinking	0.14	0.01	0.17	0.17	0.10	0.16	0.20	0.14	0.18	0.10	0.15
	Uninteresting research orientation of scientific partners	0.20	0.13	0.21	0.20	0.21	0.21	0.24	0.22	0.20	0.14	0.21
	Lack of commercial exploitation	0.16	0.19	0.22	0.18	0.12	0.25	0.11	0.23	0.14	0.17	0.19
Costs / risks	Secrecy of scientific partner	0.18	0.00	0.13	0.20	0.14	0.16	0.01	0.15	0.12	0.13	0.14
	Substantial follow-up work	0.21	0.08	0.21	0.25	0.16	0.20	0.24	0.13	0.33	0.20	0.20
	Financial ressources of the enterprise	0.25	0.12	0.28	0.26	0.22	0.32	0.13	0.30	0.23	0.07	0.26
	Financial ressources of scientific partners	0.12	0.00	0.18	0.15	0.09	0.18	0.19	0.18	0.12	0.06	0.15
	Insufficient efficiency of the scientific partners	0.12	0.00	0.10	0.16	0.08	0.11	0.04	0.13	0.07	0.09	0.10
	Technological dependency on external partners	0.06	0.00	0.11	0.06	0.05	0.12	0.05	0.10	0.06	0.04	0.08
	Uncertainty about the collaboration results	0.15	0.00	0.14	0.15	0.14	0.16	0.06	0.11	0.18	0.09	0.14
Organizational / institutional impediments	Authorisation procedures and legal restrictions	0.18	0.07	0.20	0.22	0.13	0.24	0.03	0.21	0.16	0.13	0.19
	Lack of administrative support from the scientific partner	0.09	0.00	0.11	0.12	0.06	0.13	0.05	0.14	0.05	0.05	0.10
	Lack of support for commercial exploitation from the scientific partner	0.08	0.00	0.08	0.10	0.06	0.09	0.04	0.11	0.03	0.03	0.08
	Property rights issues	0.09	0.01	0.10	0.10	0.08	0.12	0.00	0.07	0.13	0.08	0.09
	Management problems at the scientific partner	0.07	0.00	0.10	0.08	0.06	0.09	0.12	0.09	0.08	0.06	0.08
	Different priorities	0.16	0.00	0.16	0.24	0.06	0.17	0.15	0.14	0.18	0.18	0.16
	Lack of trust	0.02	0.00	0.06	0.03	0.02	0.08	0.00	0.07	0.01	0.02	0.05
	Loss of reputation	0.02	0.00	0.01	0.03	0.01	0.01	0.00	0.02	0.01	0.02	0.02

2018		Sector			Subsector				Size			Total
		Manufacturing	Construction	Services	High-tech manufacturing	Low-tech manufacturing	Modern services	Traditional services	Small	Medium-sized	Large	
Missing information	Lack of information about scientific partners' research	0.23	0.15	0.16	0.16	0.27	0.20	0.10	0.17	0.23	0.15	0.18
	Finding the right contact persons	0.26	0.23	0.18	0.18	0.31	0.18	0.19	0.19	0.25	0.29	0.21
	Equipment of the interface to scientific partners	0.10	0.18	0.12	0.07	0.11	0.14	0.09	0.13	0.10	0.05	0.12
Lack of requirements of the enterprise	Qualified personnel	0.18	0.15	0.14	0.12	0.21	0.14	0.15	0.16	0.15	0.12	0.15
	Technical equipment	0.13	0.24	0.03	0.14	0.13	0.04	0.01	0.08	0.13	0.04	0.09
	Lack of interest in scientific projects	0.14	0.19	0.08	0.11	0.15	0.08	0.09	0.11	0.13	0.06	0.11
	Own R&D questions are uninteresting for scientific partners	0.25	0.28	0.15	0.27	0.24	0.14	0.16	0.20	0.20	0.12	0.19
Lack of requirements of the scientific partner	Lack of KTT specialists	0.12	0.20	0.03	0.08	0.15	0.03	0.04	0.08	0.10	0.03	0.08
	Lack of entrepreneurial thinking	0.16	0.28	0.11	0.17	0.16	0.13	0.07	0.14	0.13	0.30	0.15
	Uninteresting research orientation of scientific partners	0.26	0.49	0.13	0.21	0.29	0.13	0.14	0.21	0.22	0.27	0.21
	Lack of commercial exploitation	0.22	0.54	0.17	0.19	0.24	0.16	0.18	0.23	0.25	0.11	0.23
Costs / risks	Secrecy of scientific partner	0.20	0.26	0.10	0.27	0.15	0.08	0.13	0.13	0.16	0.31	0.15
	Substantial follow-up work	0.20	0.18	0.18	0.29	0.15	0.18	0.17	0.18	0.21	0.13	0.19
	Financial ressources of the enterprise	0.30	0.50	0.20	0.24	0.34	0.21	0.19	0.29	0.22	0.15	0.27
	Financial ressources of scientific partners	0.10	0.18	0.05	0.11	0.10	0.05	0.05	0.08	0.09	0.03	0.08
	Insufficient efficiency of the scientific partners	0.18	0.19	0.12	0.20	0.16	0.12	0.14	0.15	0.11	0.23	0.15
	Technological dependency on external partners	0.11	0.18	0.09	0.11	0.11	0.05	0.15	0.12	0.06	0.04	0.11
	Uncertainty about the collaboration results	0.15	0.12	0.07	0.18	0.13	0.04	0.13	0.09	0.14	0.09	0.10
Organizational / institutional impediments	Authorisation procedures and legal restrictions	0.24	0.28	0.18	0.25	0.23	0.21	0.14	0.22	0.20	0.16	0.21
	Lack of administrative support from the scientific partner	0.10	0.20	0.03	0.08	0.12	0.04	0.02	0.07	0.10	0.07	0.08
	Lack of support for commercial exploitation from the scientific partner	0.13	0.11	0.10	0.13	0.13	0.11	0.10	0.11	0.12	0.05	0.11
	Property rights issues	0.12	0.09	0.10	0.19	0.08	0.13	0.06	0.11	0.08	0.11	0.11
	Management problems at the scientific partner	0.10	0.09	0.04	0.11	0.09	0.06	0.01	0.07	0.04	0.04	0.06
	Different priorities	0.19	0.22	0.05	0.22	0.17	0.05	0.04	0.09	0.15	0.13	0.11
	Lack of trust	0.04	0.10	0.02	0.06	0.03	0.02	0.02	0.04	0.02	0.01	0.03
	Loss of reputation	0.02	0.09	0.01	0.03	0.01	0.01	0.00	0.03	0.00	0.01	0.02

Note: These tables show the fraction of enterprises that reported a specific single impediment for knowledge and technology transfer in the above-mentioned categories as highly relevant (values >= 4 on a 5-point ordinal scale)

Basis: All enterprises that were engaged in knowledge and technology transfer activities with scientific partners during the three survey periods, by sector, subsector, enterprise size and overall

Source: KOF-KTT surveys (2005, 2011, 2018)

Part III: Econometric tables

Determinants of propensity to KTT

Table A11: Determinants of knowledge and technology transfer

	(1) Knowledge and technology transfer	(2) Knowledge and technology transfer
Enterprise characteristics		
Strong non-price competition	0.039	-0.036
	(0.057)	(0.088)
ln(Exports)	0.013***	0.019***
	(0.005)	(0.007)
Foreign ownership	-0.265***	-0.297**
	(0.083)	(0.132)
ln(R&D expenditures)	0.058***	0.054***
	(0.005)	(0.009)
ln(Number of graduates)	0.155***	0.193***
	(0.031)	(0.055)
ln(Number of employees)	0.045	-0.076
	(0.032)	(0.055)
ln(Age)	0.147***	0.198***
	(0.039)	(0.057)
Formalised innovation process		0.344***
		(0.115)
Promoting innovative behaviour		0.350***
		(0.103)
External knowledge sources		0.080***
		(0.025)
Technological field		
Nanotechnology	0.350*	-0.171
	(0.187)	(0.310)
Materials science	0.238***	0.041
	(0.078)	(0.124)
Microelectronics	-0.084	0.203
	(0.128)	(0.219)
Optoelectronics & laser technology	0.159	0.001
	(0.125)	(0.207)
Computer science	0.255***	0.114
	(0.077)	(0.126)
Information and communications technology	-0.102	0.031
	(0.087)	(0.136)
Biotechnology	0.446**	0.321
	(0.224)	(0.373)
Medical and health technology	0.024	-0.065
	(0.115)	(0.191)
Manufacturing engineering	0.036	0.042
	(0.086)	(0.136)
Transport and trafic engineering	0.031	0.106
	(0.088)	(0.136)
Energy technology	0.001	-0.278*
	(0.093)	(0.149)
Environmental technology	0.123	-0.031
	(0.078)	(0.124)
Geoscience	0.293	-0.046
	(0.237)	(0.433)
Financial modelling	0.032	0.486
	(0.193)	(0.342)
N	3140	1368

Note: This table shows the pooled OLS estimates of the determinants equation and their corresponding standard errors (in parenthesis).

Basis: Column (1) uses observations from each of the three surveys (2005, 2011, 2018). Column (2) only uses observations form the latest survey since the additional enterprise characteristics were only queried in this survey.

Variables: The dependent variable is a dummy indicating whether an enterprise conducted KTT with domestic public research institutions three to one year prior to the surveys. Additional covariates include 33 industry dummies and time dummies. p < .1 *, p < .05 **, p < .01 ***

Determinants of perceived impediments to KTT

Table A12i: Influences on perceived impediments for KTT-inactive enterprises (entry barriers)

	(1) Missing Information	(2) Requirements of the enterprise (resources)	(3) Requirements of the enterprise (interest)	(4) Requirements of the scientific partner	(5) Costs / risks	(6) Organisational / institutional
Enterprise characteristics						
Strong non-price competition	0.102	0.063	-0.015	0.038	0.006	0.066
	(0.067)	(0.058)	(0.058)	(0.059)	(0.061)	(0.066)
ln(Exports)	-0.007	-0.000	-0.001	0.004	0.011**	0.001
	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Foreign ownership	-0.073	0.176**	0.255***	-0.204**	-0.100	-0.002
	(0.100)	(0.085)	(0.085)	(0.089)	(0.088)	(0.095)
ln(R&D expenditures)	0.038***	-0.021***	-0.015**	0.013**	0.034***	0.040***
	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
ln(Number of graduates)	0.026	0.009	0.004	0.041	0.045	0.010
	(0.036)	(0.032)	(0.032)	(0.032)	(0.034)	(0.036)
ln(Number of employees)	-0.022	-0.033	-0.024	-0.002	-0.088***	-0.016
	(0.035)	(0.029)	(0.030)	(0.031)	(0.032)	(0.035)
ln(Age)	0.106**	-0.061*	-0.049	0.063*	0.083**	0.023
	(0.043)	(0.036)	(0.036)	(0.038)	(0.038)	(0.041)
Technological field						
Nanotechnology	0.037	0.262	0.392	-0.244	-0.078	-0.092
	(0.313)	(0.286)	(0.287)	(0.293)	(0.305)	(0.300)
Materials science	0.110	-0.231***	-0.193**	0.159*	0.073	0.123
	(0.100)	(0.089)	(0.089)	(0.090)	(0.092)	(0.096)
Microelectronics	0.182	-0.096	0.032	0.459***	0.154	0.550***
	(0.185)	(0.171)	(0.173)	(0.173)	(0.176)	(0.179)
Optoelectronics & laser technology	0.034	0.151	0.209	-0.062	0.086	-0.266
	(0.181)	(0.168)	(0.168)	(0.170)	(0.162)	(0.186)
Computer science	0.174*	-0.042	-0.123	0.118	0.187**	0.157*
	(0.099)	(0.090)	(0.090)	(0.090)	(0.092)	(0.095)
Information and communications technology	0.111	-0.174*	-0.043	0.127	0.163*	0.067
	(0.104)	(0.094)	(0.094)	(0.096)	(0.097)	(0.101)
Biotechnology	-0.024	-0.526	-0.032	0.122	-0.002	0.237
	(0.369)	(0.357)	(0.359)	(0.343)	(0.328)	(0.354)
Medical and health technology	0.349**	-0.195	-0.162	0.125	0.250*	0.363**
	(0.145)	(0.141)	(0.142)	(0.142)	(0.140)	(0.146)
Manufacturing engineering	0.200*	-0.173	-0.314***	0.238**	0.155	0.157
	(0.115)	(0.106)	(0.108)	(0.106)	(0.107)	(0.112)
Transport and trafic engineering	-0.073	0.049	0.050	0.037	-0.119	-0.104
	(0.108)	(0.092)	(0.091)	(0.092)	(0.095)	(0.105)
Energy technology	0.090	0.129	0.068	-0.067	-0.135	-0.015
	(0.120)	(0.109)	(0.107)	(0.109)	(0.111)	(0.117)
Environmental technology	-0.033	-0.139	-0.041	0.016	0.161*	0.156
	(0.102)	(0.090)	(0.090)	(0.092)	(0.092)	(0.099)
Geoscience	-0.725	0.501	0.133	-0.100	0.235	-1.046*
	(0.618)	(0.437)	(0.429)	(0.445)	(0.427)	(0.552)
Financial modelling	-0.154	0.097	0.082	-0.247	-0.261	0.097
	(0.243)	(0.213)	(0.222)	(0.230)	(0.243)	(0.228)
N	2207	2210	2210	2195	2196	2183

Note: This table shows the pooled OLS estimates of the influences on perceived impediments equations for KTT-inactive enterprises and the corresponding standard errors (in parentheses). For example, we can see that R&D expenditures are significantly positively correlated to a perception of «missing information» as a highly relevant entry barrier to KTT.

Basis: All columns use observations from enterprises not engaged in KTT with public research institutions in a certain survey period. All three surveys are used.

Variables: The dependent variables are dummies indicating whether an enterprise perceived at least one single impediment in the six above-mentioned groups (columns) as a highly relevant entry barrier. Additional covariates include 33 industry dummies and time dummies.

Source: KOF-KTT surveys (2005, 2011, 2018)

p < .1 *, p < .05 **, p < .01 ***

Table A12ii: Influences on perceived impediments of KTT-inactive enterprises (intensification barriers)

	(1) Missing Information	(2) Requirements of the enterprise (resources)	(3) Requirements of the enterprise (interest)	(4) Requirements of the scientific partner	(5) Costs / risks	(6) Organisational / institutional
Enterprise characteristics						
Strong non-price competition	-0.077	-0.149	-0.009	0.013	0.039	-0.040
	(0.102)	(0.095)	(0.095)	(0.097)	(0.097)	(0.099)
ln(Exports)	0.008	0.008	-0.000	0.000	0.013	0.022**
	(0.009)	(0.009)	(0.008)	(0.009)	(0.009)	(0.009)
Foreign ownership	0.024	0.305**	0.150	-0.125	0.081	-0.202
	(0.142)	(0.129)	(0.129)	(0.133)	(0.133)	(0.136)
ln(R&D expenditures)	0.008	-0.024***	-0.015	0.017*	0.034***	0.019*
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)
ln(Number of graduates)	-0.030	0.114**	0.086*	-0.028	-0.051	0.100*
	(0.054)	(0.051)	(0.050)	(0.050)	(0.051)	(0.054)
ln(Number of employees)	-0.059	-0.092	-0.114**	-0.022	-0.069	-0.105*
	(0.059)	(0.058)	(0.057)	(0.056)	(0.058)	(0.061)
ln(Age)	-0.006	0.092	0.053	0.040	-0.025	0.083
	(0.068)	(0.065)	(0.064)	(0.065)	(0.065)	(0.067)
Technological field						
Nanotechnology	0.011	-0.087	0.665***	-0.104	0.376*	0.346*
	(0.219)	(0.211)	(0.206)	(0.203)	(0.204)	(0.209)
Materials science	-0.146	-0.069	-0.158	-0.060	-0.182	-0.162
	(0.123)	(0.115)	(0.118)	(0.117)	(0.117)	(0.119)
Microelectronics	0.168	0.055	-0.092	0.164	0.062	0.143
	(0.182)	(0.175)	(0.178)	(0.175)	(0.172)	(0.175)
Optoelectronics & laser technology	-0.157	-0.060	-0.190	-0.193	0.260	0.108
	(0.174)	(0.165)	(0.169)	(0.167)	(0.165)	(0.165)
Computer science	0.288**	-0.033	0.123	0.030	-0.012	0.212*
	(0.127)	(0.117)	(0.117)	(0.117)	(0.117)	(0.119)
Information and communications technology	-0.122	0.077	0.019	0.258**	0.235*	-0.054
	(0.140)	(0.134)	(0.132)	(0.132)	(0.133)	(0.137)
Biotechnology	-0.181	-0.109	0.301	-0.033	-0.425	-0.366
	(0.296)	(0.264)	(0.268)	(0.256)	(0.268)	(0.290)
Medical and health technology	0.257	-0.323**	-0.386**	0.265*	0.057	0.228
	(0.164)	(0.160)	(0.159)	(0.155)	(0.157)	(0.158)
Manufacturing engineering	0.129	-0.113	-0.125	0.095	0.170	-0.005
	(0.129)	(0.122)	(0.122)	(0.124)	(0.121)	(0.124)
Transport and trafic engineering	-0.046	-0.326**	0.048	-0.053	-0.009	0.089
	(0.139)	(0.129)	(0.128)	(0.131)	(0.128)	(0.131)
Energy technology	0.094	-0.081	-0.053	0.063	0.084	0.091
	(0.148)	(0.141)	(0.140)	(0.137)	(0.143)	(0.145)
Environmental technology	-0.182	0.199*	0.006	-0.120	0.041	0.022
	(0.129)	(0.121)	(0.118)	(0.120)	(0.123)	(0.126)
Geoscience	0.807**	0.092	-0.119	-0.012	0.379	0.311
	(0.343)	(0.356)	(0.368)	(0.344)	(0.333)	(0.332)
Financial modelling	0.041	0.635**	0.655**	0.247	0.121	-0.155
	(0.249)	(0.255)	(0.264)	(0.248)	(0.244)	(0.253)
N	833	843	834	830	843	837

Note: This table shows the pooled OLS estimates of the influences on perceived impediments equations for KTT-active enterprises and the corresponding standard errors (in parentheses). For example, we can see that enterprise size is significantly negatively correlated with identifying «requirements of the enterprise (interest)» as a highly relevant intensification barrier. In other words, the smaller the enterprise, the more likely it is that a lack of interest in scientific projects hinders it in intensifying its KTT activities.

Basis: All columns use observations from enterprises engaged in KTT with public research institutions in a certain survey period.

Variables: The dependent variables are dummies indicating whether an enterprise perceived at least one single impediment in the six above-mentioned groups (columns) as a highly relevant intensification barrier. Additional covariates include 33 industry dummies and time dummies.

Source: KOF-KTT surveys (2005, 2011, 2018)

p < .1 *, p < .05 **, p < .01 ***

Abbreviations

ETH	Eidgenössiche Technische Hochschule (Swiss Federal Institute of Technology)
FSO	Federal Statistical Office
KTI	Kommission für Technologie und Innovation
KTT	Knowledge and technology transfer
NOGA	Nomenclature Générale des Activités économiques
R&D	Research and development
SERI	State Secretariat for Education, Research and Innovation
SNSF	Swiss National Science Foundation