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Strukturberichterstattung
Nr. 54/3

Boris Kaiser
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The Productivity Deficit of the Knowledge-Intensive Business Service Industries in Switzerland

Schwerpunktthema:
Wachstum der Schweizer Volkswirtschaft

Study on behalf of the State Secretariat for Economic Affairs SECO

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1. Introduction

„You can see the computer age everywhere but in the productivity statistics.“

– Robert Solow, New York Review of Books, 1987

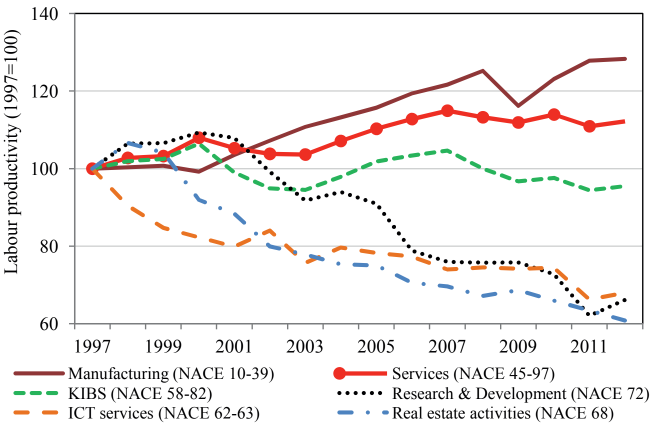
The Swiss economy has been characterized by sound growth rates of GDP and GDP per capita in recent years. But growth has mainly been driven by an increase in labour input, while measured labour productivity growth has remained rather low. The low productivity growth stands in contrast to the good performance in terms of indicators that are thought to increase with labour productivity such as the high and increasing level of human capital or the fact that Switzerland generally ranks among the most innovative countries worldwide. Several studies therefore have searched for explanations for the "Swiss productivity puzzle". These studies can be divided in two categories: studies that attribute the low productivity growth to hard economic factors such as a lack of competition in the domestic market; and studies that attribute it to mismeasurement in the productivity data (see e.g. Bodmer & Borner 2004; Kohli 2005; Siegenthaler 2015). This study belongs to the second group.

Figure 1 provides the motivation for this paper. It plots the evolution of labour productivity, measured in terms of real value added per full-time equivalent (FTE) worker, for different sectors and industries in Switzerland. The figure uses official data from the Swiss productivity statistics. It shows that the service sector has grown less strongly than the manufacturing sector in terms of labour productivity growth. Among service industries, *knowledge-intensive business service* (KIBS) industries have performed particularly poorly.[1] These industries, which are usually most associated with innovation and growth in the service sector, even exhibited a 5% lower level of labour productivity in 2012 compared to 1997. In the same period, labour productivity increased by almost 30% in the manufacturing sector. When looking at individual two-digit industries within the KIBS, the picture becomes even starker: according to the official data, labour productivity declined by more than 30% in some of the KIBS industries. Figure 1 illustrates this using information and communication technology (ICT) services, research and development (R&D) services and real estate activities as examples.

[1] These industries comprise div. 58 to 82 of the classification NACE rev. 2, see Section 4.1 on page 25.

These findings are puzzling for a number of reasons. First, it appears implausible that individual industries have negative labour productivity growth over an extended period of time, especially if these industries are market- and export-oriented as is the case for the KIBS industries. The reason is that declining long-run labour productivity would imply that the allocation of resources across industries becomes increasingly inefficient (Corrado & Slifman 1999). Second, several KIBS industries are generally associated with high levels of innovation and increasingly intensive use of computer technology. The best examples are the ICT service activities: Several studies suggest that the spread and intensified use of ICT has been a major driver of aggregate productivity growth since the mid-1990s (see e.g. Jorgenson et al., 2008). The substantial improvements in computing power and computer software in the last 20 years do not seem to have had a positive impact on productivity in the ICT service industries in Switzerland. Third, human capital has strongly increased in the KIBS industries given the influx of tertiary educated workers, many of whom have immigrated from abroad. In fact, the skill intensity of workers has increased more in the KIBS industries than in most other industries in Switzerland. An increasing use of well qualified workers is usually thought to stimulate productivity growth (Hanushek & Woessmann 2015). Finally, wages have increased at a faster pace in the KIBS industries than in manufacturing and more traditional service activities. Most theoretical models currently employed by economists predict that the strong increase in wages is in fact a direct *consequence*

Figure 1 Labour Productivity by Industry in Switzerland



Source: own calculations, Productivity Statistics, SFSO.

of increased productivity of workers. Overall the poor productivity growth in the KIBS industries appears to be at odds with other economic facts. Could the productivity puzzle of the KIBS industries thus be the result of mismeasurement? In other words, is labour productivity growth *underestimated* as a consequence of measurement error in the data? The objective of this paper is to tackle this question. We examine to what extent mismeasurement of labour productivity may help to explain the poor performance of the Swiss KIBS industries and the Swiss business sector more broadly. Specifically, our study addresses the following questions:

- What are the conceptual and methodological difficulties in the measurement of productivity in the service sector?
- Can the persistent decline in measured productivity be reconciled with evidence taken from other productivity-related indicators?
- What is the effect on measured labour productivity when wage-based deflators are substituted with other deflators?
- What are the potential implications for aggregate productivity statistics and the growth of real GDP given mismeasurement in some KIBS industries?

In addressing these questions, this paper contributes to the limited academic literature on measuring productivity in KIBS industries. So far, only few papers have studied these questions as rigorously as it might be desirable.[2] Furthermore, a better understanding of the productivity deficit of the Swiss KIBS industries is relevant because they represent a substantial and increasing share of nominal value added and employment in the Swiss economy. In 2012, the KIBS industries represented one quarter of total value added and of total FTE employment of the business sector in Switzerland.

To analyse the first question posed above, we take the measurement of labour productivity statistics under scrutiny. In principle, labour productivity measures the change in the value added relative to the change in labour input. The most critical aspect is the calculation of the numerator: The change in nominal (i.e., current-price) value added must be *deflated* with an appropriate price index to obtain a

[2] One reason is that economists outside national statistical offices have only limited insights into the production of macroeconomic data. Early discussions of the measurement issue include Griliches (1992, 1994) who argue that measurement bias in real GDP growth increases over time because the measurement gap tends to grow and because the share of nominal value added attributable to hard-to-measure industries (e.g. services) increases over time. A number of studies attempt to quantify the effect of the measurement bias on real GDP growth. Their estimates typically suggest that average annual growth rates of real GDP is biased downward by 0.1 to 0.4 percentage points (Sichel 1997; Corrado & Slifman 1999; McGuckin & Stiroh 2001; Schreyer 2002; Wölfl 2004).

measure of the change of *real value added*. To obtain an unbiased estimate of labour productivity growth, the price index must reflect only "pure" price changes that occur independently from changes in productivity. That is, price indices should not reflect quality changes of products and services. Separating the two is particularly difficult in the KIBS industries where services are often intangible, bundled together or even unique.

For most Swiss KIBS industries, price data on service output is not (yet) collected such that no appropriate *service producer price indices* (SPPIs) are available which could be used as deflators. Instead, most currently used deflators are based on the evolution of *wages*, i.e. the Swiss Wage Index (SWI). These so-called input-based deflation methods are considered to be inappropriate in the guidelines provided by international organisations (Eurostat 2001, OECD-Eurostat 2014). The reason is that wage-based deflators essentially entail the assumption that price growth and wage growth are perfectly correlated, i.e., any growth in wages is assumed to reflect a change in firms' costs and thus their selling prices. But wage growth may inherently reflect productivity growth. If, for example, the share of high-skilled workers in a given industry increases, the SWI records a rise in the average wage. At the same time, a larger share of high-skilled workers is also expected to raise the amount of human capital per worker and should therefore increase their average value added per hour worked. In such a situation, wage-based deflation will overestimate the increase in prices, which, in turn, leads to an *underestimation* of growth in real value added. Therefore, the use of wage-based deflators may produce a *downward bias* in the measurement of labour productivity growth.

To analyse the empirical questions 2 to 4 posed above, we proceed as follows. First, we summarize data from a wide range of *productivity-related* indicators to assess whether the persistent decline in measured labour productivity may, in fact, be a real phenomenon or whether it is more likely to be the result of statistical mismeasurement. The indicators considered include profitability, business demography, human capital, export activities, investment and innovation activities as well as regulatory and policy-related factors. Second, we perform a set of experimental calculations using alternative deflators in place of wage-based deflators to examine the impact on labour productivity growth in the Swiss KIBS industries. As alternative deflators, we consider (i) a skill-adjusted wage index based on the Swiss Wage Structure Survey (LSE); (ii) SPPIs from other European countries; and (iii) a broad measure of producer prices, the core inflation rate. Finally, we also analyse the impact of potential mismeasurement on the industry-level on *aggregate* labour productivity and economic growth.

The remainder of this paper is structured as follows. The next section reviews the relevant international and national literature on the measurement of labour productivity in service sector industries. Section 3 deals with the conceptual and methodological details of productivity measurement and discusses the particular challenges associated with services. Section 4 contains the empirical analysis for Switzerland. It provides a detailed analysis of Switzerland's current practice in measuring labour productivity in the KIBS industries (Section 4.3). Then, we carry out an assessment of the plausibility of the current labour productivity data by examining productivity-related indicators (Section 4.4). The experimental calculations based on the alternative deflators are presented in Sections 4.5 and 4.6. We complete the empirical analysis by providing an overall assessment of possible explanations for the weak productivity growth in the KIBS industries (Section 4.7). Finally, Section 5 contains concluding remarks.

2. Literature Review

This section summarizes the academic literature on the labour productivity in the service sector that focuses on issues of measurement. We first discuss the body of international literature before we turn to the literature concerned with labour productivity in Switzerland.

2.1. International Literature

As discussed in Wölfl (2004) and Maroto-Sanchez (2012), problems in measuring labour productivity can originate in several areas: in the measure of labour input (denominator), in the measure of nominal output and volume output (numerator), and in the process of aggregating industry-level productivity data to sectors or the whole economy. Arguably, the main challenge in measuring productivity in service industries is to compute *volume series of value added*. This requires price indices that measure only "pure" price changes and exclude price changes attributable to the properties or the quality of services.

2.1.1. Measuring the Volume of Value Added

Early Discussion on Mismeasuring Productivity in the Service Sector

Beginning in the mid-1970s, productivity growth in many developed countries slowed down significantly and remained low until the mid-1990s. An important driver of this development was the considerably lower productivity growth in the service sector compared to the commodities sector (agriculture, manufacturing and construction). In the U.S., the average growth rate over the period 1979–1989 was only 1.0% in the service sector and 2.3% in the commodities sector (cf. Griliches 1992). Explanations typically offered by economists included a slowdown in technological progress and diminishing returns to innovation in service activities. Two contributions by Griliches (1992, 1994) were among the first to discuss in detail the potential role of *mismeasurement* in official productivity data for the service sector. As Griliches (1992) points out, the problem associated with the service sector is twofold: first, it lies in the lack of available data, and second, there is a conceptual difficulty of defining and measuring the quantities of services. As a consequence, it is difficult to deflate *current-price* value added with an appropriate price index in order to obtain the *volume series* of value added.

Griliches (1994) illustrates that productivity was particularly poor in those industries outside manufacturing where output is notoriously difficult to measure. The author defines "unmeasurable" industries as construction, trade, finance, other (business) services and government, while "measurable" industries include agriculture, mining, manufacturing, transportation, communications, and public utilities (cf. Griliches 1994, Figure 1). The author further shows that the potential scope of measurement problems became more severe over time because the share of nominal Gross National Product (GNP) attributable to hard-to-measure industries increased considerably: according to his classification of "measurable" and "unmeasurable" industries, this share increased from about 50% to almost 70% of U.S. GNP over the period 1947 to 1990. More recent data suggests that this nominal share of "unmeasurable" industries further increased to 80% in 2007 (cf. Nakamura 2008, Table 1).

Another development was the increasing importance of information and communication technology (ICT) in the 1990s, which however, did not translate into visible productivity growth in the data. This puzzle is often termed the "computer paradox" because ICT is associated with quality improvements, major innovations, and efficiency gains, but ICT-intensive service industries typically had weak productivity growth during this period. Griliches (1994) comments the "computer paradox" as follows: *"over three-quarters of this investment has gone into our "unmeasurable" sectors [...], and thus its productivity effects, which are likely to be quite real, are largely invisible in the data."* Empirical support for this argument is provided by McGuckin & Stiroh (2001), who estimate that increased measurement bias in productivity growth during the 1990s ranges between 0.7 and 1.6 percentage points a year in computer-intensive service industries.

Differences in Labour Productivity between Europe and the US

Since the mid-1990s, labour productivity growth has been considerably higher in the United States than in most European countries. For example, labour productivity grew by 2.3% a year in the U.S. but only 1.4% a year in the EU15 countries. According to Van Ark et. al (2003), a major driver of this difference is the productivity in three service industries – wholesale and retail trade and trade in financial securities – in which growth is high in the U.S., but not in Europe. Some argue that these differences are at least partly driven by a different choice of deflation methods (Hartwig 2008), while others find that differences in measurement practice are not a significant cause for transatlantic productivity differentials (Inklaar & Timmer 2008; van Ark et al. 2008).

Among OECD countries, Wölfl (2004) documents large variation in measurement methods, which is particularly pronounced in wholesale and retail trade, transport and storage, post and telecommunication and financial services. In some industries, measurement practices are more sophisticated in some countries compared to others. For ICT products, for example, the U.S. and France use hedonic pricing methods to adjust for quality change whereas the UK and Germany use conventional PPI measures. Needless to say, price indices for ICT products fall much faster when the former method is used because quality change is better accounted for. As shown in Schreyer (2002, Figure 1), the investment deflator for computers and peripheral equipment equals –28% a year in the U.S., but only –7% for Germany, in terms of average *annual* rates of change from 1995 to 1999.

Table 1 *The Impact of Deflation Methods on Measured Annual Labour Productivity Growth in France and the US*

Country	Industry	Period	Base	Wage rate/ Empl.	CPI (all items)	CPI (related items)	SPPI	Switzerland*
FRA	Telecommunication	2000-2005	6.4	0.6	2.7	6.3		6.9
		2005-2010	4.7	-2.0	0.2	4.9	8.6	7.4
	Legal and accounting services	2000-2005	-0.2		1.2	1.0		-2.4
		2005-2010	-1.2	-3.3	-0.9	-1.6	-2.7	0.7
USA	Broadcasting and Telecommunication	2000-2005	6.8	2.3	1.9	7.4	6.0	6.9
		2005-2011	5.6	0.4	0.9	5.7	3.1	4.6
	Legal services	2000-2005	-1.6	-0.3	0.5	-1.7	-2.7	-2.4
		2005-2011	-3.0	-1.1	-0.4	-1.9	-4.1	0.1

*Notes: All results based on double deflation. "Base": value added deflator as given in National Accounts. *Data for Switzerland represents growth in real value added per FTE employee.*

Source: Fraisse & Wölfl (2012) and Productivity Statistics, SFSO (Switzerland).

Fraisse & Wölfl (2012) provide an interesting comparison of labour productivity growth statistics based on various deflation methods. Table 1 shows numbers for telecommunication and legal service industries in France and the U.S. For comparison, the rightmost column contains the labour productivity growth in the corresponding industries in Switzerland as provided by official data.

The authors discuss several findings. First, the deflation method has a sizeable impact on measured labour productivity. For example, in the telecommunication industry, annual growth rates differ by up to 5 percentage points for the U.S. and even more so for France. Second, in legal services, SPPIs are often constructed using hourly charge-out rates which may mask some improvements in productivity. Third, deflation based on a CPI for related services may be a good proxy if a SPPI is not available, while the overall CPI is too crude to account for price changes in a narrowly defined industry.

Using a set of case studies, Baily & Zitzewitz (2001) provide an interesting alternative solution to the problem of comparing productivity growth in service industries over time and across countries. Rather than comparing service productivity by adjusting available value added and price measures in national accounts, they compare productivity growth in a set of service industries using reliable and internationally comparable *physical* output measures. For instance, they use vehicle kilometres in public transport, access lines and call minutes in telecom, and revenue passenger kilometres for airlines. These measures provide insights about the extent to which quality change (e.g. by increasing convenience for the customer) matters in creating productivity growth in the service sector. Overall, their results show that increasing service quality and convenience for the customer is often *core* for firms' success in knowledge-intensive business service industries.

Effect on Aggregate Growth and Productivity

Mismeasurement of real value added on the industry level has obvious implications for real GDP and productivity growth of the whole economy. A small number of studies attempt to quantify the effect of mismeasurement on aggregate growth rates. Sichel (1997) performs a decomposition of the "measurement gap" (i.e., the gap between measured and actual real GDP growth) into two components: a within-effect and a between-effect. The within-effect captures the measurement gap that occurs within a sector over time. The between-effect reflects shifts in the output shares between sectors. The calculations are restricted to the *between-effect* and show that a growing size of the unmeasurable sector in the U.S. increased the measurement gap by 0.1 to 0.2 percentage points a year. The author concludes that the rising share of service activities in total output cannot explain much of the productivity slowdown beginning in the 1970s. McGuckin & Stiroh (2001) use a similar approach but reach a different conclusion. They analyse the effect of mismeasurement in 13 computer-intensive, non-manufacturing industries on aggregate productivity growth in the United States. Their estimates suggest that the measurement error in these industries understate aggregate productivity growth by 0.1 to 0.2 percentage point a year (within-effect), while the rising output share of these industries leads to an additional downward bias of 0.3 to 0.5 percentage points (between-effect). Taken together, the combined impact of measurement error on aggregate productivity growth is estimated in the range of 0.3–0.5 percentage points a year during the 1990s.

Other studies argue that the observed long-term decline of productivity in certain service industries is hard to reconcile with the fact that ICT typically plays an important role in these industries. Diffusion of ICT is generally thought to be a very important driver of productivity growth in the recent decades (cf., e.g., Jorgenson et al. 2008). Thus, it is conjectured that the error must be found in the data. Based on this presumption, Corrado & Slifman (1999) perform a thought experiment by assuming zero productivity growth for service industries that display long-term declines in labour productivity and then simulate the effect on aggregate productivity growth. Their calculations imply that annual productivity growth in the period 1977–1997 could have been approximately 0.3 percentage points higher than indicated in the official data. Wölfl (2004) refines the exercise of Corrado & Slifman (1999). She points out that the effect of mismeasuring real value added in some industries on aggregate productivity growth depends on the output share of the mismeasured service industry that is produced for intermediate consumption of other industries. This is because a downward bias in the intermediate consumption of other industries raises the real value added of these industries.[3] In other words, mismeasurement of real value added has an *inter-industry effect*: it leads to a smaller contribution to aggregate productivity growth by mismeasured industries and a greater contribution by other industries. Wölfl (2004) calculates that the zero-productivity growth adjustment proposed by Corrado & Slifman (1999) raises *aggregate* annual productivity growth from 1990 to 2000 by about 0.35 percentage points in Germany and by 0.19 percentage points in France.

Instead of setting labour productivity to zero to gauge the influence of mismeasurement of service value added on aggregate productivity growth, price indices from the same industry in other countries may be used when these indices are con-

[3] This effect only materializes if double deflation is used, see Section 3.2.1

structed with more appropriate methods. Schreyer (2002) examines the effect of applying the U.S. deflator for ICT products to the industry-level data from other OECD countries. For office, accounting and computing machinery in Germany, he estimates that a change in the annual deflator of 10 percentage points translates into a 0.04 percentage point increase in real GDP growth. The author concludes that the impact on aggregate labour productivity growth is therefore likely to be small.

Hartwig (2008) examines how a switch from an input-based to an output-based extrapolator in the U.S. banking industry affected real value added data. For example, real value-added growth of nondepository institutions increased by 6 percentage points in the period 1992–1997. He estimates that the change of method raised real GDP growth by 0.1 percentage points in the same period.

Overall, the literature suggests that the potential downward bias in labour productivity growth that arises from measurement problems in hard-to-measure industries is quantitatively important. The studies discussed above find that aggregate annual labour productivity growth may be understated by 0.1 to 0.5 percentage points per annum. The papers also propose methods to adjust labour productivity growth in order to gauge the quantitative importance of potential mismeasurement of real value added in the service sector on aggregate productivity growth. Some of these methods will be applied in the empirical analysis in Section 4.

Best Practice

Measurement practices of real valued added in market services vary widely between countries. Inklaar et al. (2008) provide a comparison of deflation methods across European countries. The appropriateness of deflation method is defined in terms of the three categories according to the taxonomy of the *Handbook on Price and Volume Measures in National Accounts* (Eurostat 2001). Methods in category A are most appropriate and considered best practice, category B contains acceptable alternatives and methods in category C are deemed unacceptable or conceptually wrong. Table 2 reproduces Table 1 in Inklaar et al. (2008) and shows the share of value added in various service industries that is deflated using either A, B, or C-methods across ten European countries. The top panel shows that, on average, only 10% of value added in market services is deflated by most appropriate methods, while 31% is deflated using inappropriate C-methods. Across industries, usage of inappropriate C-methods is particularly widespread in financial intermediation and business services, where services are very heterogeneous and difficult to measure. Similarly, Crespi et al. (2006) show for the UK that approximately half of value added in these two industries is computed using either input measures (e.g. employment) or unmatched deflation, meaning that the price index is not based on the service output of that industry (e.g. CPI or wages). The bottom panel shows the range of the shares (minimum-maximum) across the ten countries. As can be seen, there is enormous variation in measurement practices. One country in the sample deflates 86% of value added in market services using problematic C-methods, whereas another country deflates only 5% using such methods. Inklaar et al. (2008) conclude from these numbers that there is considerable potential for individual European countries in catching up to best practice measurement. However, the authors concede that the collection of appropriate data is often hindered by resource constraints of national statistical offices.

Table 2 Share of Value Added in Market Services in 10 European Countries Deflated with Different Methods

ISIC rev. 3 code	Industry	A	B	C
			Average	
50-52	Wholesale and retail trade	0	79	21
52	Retail trade	0	79	21
55	Hotels & restaurants	67	26	7
60-63	Transport & storage	9	67	24
64	Post & telecommunications	9	80	11
65-67	Financial intermediation	0	57	43
65	Banking	0	68	32
71-74	Business services	8	44	48
90-93	Social & personal services	15	44	42
All	Market services	10	59	31
			[Minimum-Maximum]	
50-52	Wholesale and retail trade	[0-1]	[0-100]	[0-100]
52	Retail trade	[0-1]	[0-100]	[0-100]
55	Hotels & restaurants	[18-87]	[0-82]	[0-70]
60-63	Transport & storage	[0-34]	[32-100]	[0-60]
64	Post & telecommunications	[0-73]	[27-100]	[0-70]
65-67	Financial intermediation	[0-0]	[0-94]	[6-100]
65	Banking	[0-0]	[0-100]	[0-100]
71-74	Business services	[0-37]	[5-96]	[0-95]
90-93	Social & personal services	[0-48]	[12-93]	[7-89]
All	Market services	[3-15]	[12-83]	[5-86]

Notes: Classification into A, B and C-methods are by national statistical offices, based on Eurostat (2001). A-method is defined as most appropriate, B-method as acceptable and C-method as unacceptable. Average share is calculated based on information for Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Sweden and UK. For each country and each industry we use information on the share of value added deflated using A, B or C-methods, and for each industry (as well as the total average) these shares are averaged across countries.

Source: Inklaar et al. (2008).

Finally, Triplett & Bosworth (2008, Table 2) discuss how the state of practice in the measurement of productivity in service industries has changed over time. They show that considerable progress has been made in the state of data in the United States with respect to the 41 recommendations they proposed four years earlier (Triplett & Bosworth 2004).[4]

2.1.2. Measuring Nominal Output

Generally, nominal output and nominal value added are easier to measure than real output and real value added. However, there is some dispute over what is to be counted as output or intermediate consumption. A strand of the recent literature argues that intangible assets should be consistently treated as investment instead of intermediate inputs.[5] Intangible assets include R&D, software, economic competence (e.g. human capital, strategic planning and managerial skills) and branding. For service industries, intangible assets such as brand names, business models and managerial competence may be more important relative to the manufacturing sector (Triplett & Bosworth 2008). Therefore, registering intangible investment as output is expected to have a larger impact on service sector output relative to manufacturing output.

Nakamura (2008) demonstrates the increasingly important role of intangible investment: in 2007, intangible investment constituted roughly half of overall business investment in the U.S economy. Corrado et al. (2009) consider data for a broad range of intangible assets, including R&D, software and investment in economic competences. They show that output and labour productivity growth in the U.S. would rise if all these types of intangible assets were treated as capital augmenting. In the same spirit, Goodridge et al. (2013) find that a third of the UK productivity gap after the most recent recession can be explained by increased investment in intangible capital during this period.

2.1.3. Measuring Labour Input

Hours worked is generally considered to be the most appropriate measure for labour input in productivity analysis (OECD 2001). Wölfl (2004) demonstrates that the difference between labour productivity growth per person employed and per hour worked can be considerable. For the period 1990–2000, differences range between 0.1 and 0.3 percentage point in annual productivity growth for a selection

[4] For example, great efforts have been made to improve and extend the construction of SPPIs to estimate the volume of value added. Also, the issue of long-term negative productivity growth in some industries has been addressed (although no details are provided as to what has been done).

[5] The most recent revision of the European System of Accounts (ESA) in 2010 included the capitalization of R&D expenditures. However, investments in other intangible assets are still treated as intermediate consumption.

of OECD countries. The difference emerges because the number of persons employed does not take into account changes in actual working hours (e.g. due to overtime work or more vacation days), the share of part-time jobs, or self-employment. Wölfl (2004) argues that adequately measuring labour input may be more important in services than in manufacturing because the share of part-time jobs and the share of self-employed are typically higher.

2.2. Literature on Switzerland

To our knowledge, there exist no previous studies that focus on the measurement of labour productivity growth in service industries in Switzerland. Related to our paper are studies that discuss potential reasons for the Swiss productivity puzzle on the aggregate level such as Abrahamsen et al. (2005), Borner and Bodmer (2004), Brunetti and Zürcher (2002), Dreher and Sturm (2005) and Kohli (2005). Two papers that deal more specifically with measurement issues of labour productivity in Switzerland are discussed below.

Hartwig (2009) analyses measurement issues in Swiss productivity data for the period 1991 to 2005. He performs several plausibility tests with respect to the aggregate series of value added and labour input. He first discusses the discrepancy in the employment statistics between two data sources (BESTA and SAKE), which may be due to atypical employment, self-employment, over-reporting. Based on plausibility tests, the author concludes that the labour input data is likely to be upward-biased. Second, the author shows that a Corrado-Slifman correction, which sets the productivity of all industries with a long-term productivity decline to zero, raises aggregate labour productivity growth in Switzerland by 0.4 percentage points per annum. Third, Hartwig (2009) conjectures that the stability in the wage share of GDP, which is different to most other OECD countries, might point to measurement error in the data. Overall, he concludes that official data may underestimate the numerator and overestimate the denominator such that actual labour productivity growth is higher than the published statistics.

Siegenthaler (2015) argues that the debate about Switzerland's long-term productivity performance was flawed by the lack of a consistent long-term series on hours worked. He produces a new time series on total hours worked covering 1950–2010 by drawing on a wide range of historical data sources. The previously available series on hours worked is shown to underestimate the reduction in annual working time. Therefore, the available data also substantially understate aggregate growth in GDP per hour worked in Switzerland, particularly so in the 1980s and 1990s. Furthermore, given the high quality of Switzerland's exports and the substantial conceptual deficiencies of the historical export and import price index, the author argues that Switzerland's terms of trade might reflect quality gains in exports over imports which are erroneously accounted for as price phenomena when computing GDP. Extending the arguments from previous papers, most notably Kohli (2005), it is suggested that growth in real GDP may be understated. This second argument of the study highlights that the measurement of real value added is particularly prone to the problem of separating changes in prices from changes in quality. The reason is that Swiss exporting firms produce goods and services with high quality, complexity and specificity.

3. Measurement of Labour Productivity: Theory and Practice

This section deals with theoretical and practical aspects in the measurement of labour productivity. We first introduce the concept of labour productivity and highlight its importance for economic analyses. Second, we provide a formal treatment of how measures of labour productivity growth are constructed. Finally, we address the specific issues and challenges associated with price measurement methods for services.

3.1. The Concept of Labour Productivity

Labour productivity is commonly defined as the ratio of a volume measure of value added to a volume measure of labour input:[6]

$$labour\ productivity = \frac{volume\ of\ value\ added}{volume\ of\ labour\ input}.$$

Labour productivity indicates how efficiently labour can be combined with other factors of production to generate output. An increase in labour productivity reflects the *combined influence* of several factors such as changes in capital, changes in labour quality as well as technical and organizational progress within and across firms (cf. Box A below). In practice, of course, changes in labour productivity may also arise from adjustments in capacity utilization or measurement errors in the data.

The general notion of productivity can relate to several concepts: labour productivity, capital productivity, multi-factor productivity (TFP) or the so-called KLEMS

[6] Alternatively, the numerator of labour productivity may be based on *gross output* instead of value added, see OECD (2001). A clear drawback of this productivity measure is that it is very sensitive to substitution between intermediate inputs and labour input.

productivity (capital, labour, energy, material and service inputs). Relative to other measures, *labour* productivity has several advantages. First, it allows for a simple and intuitive interpretation and is related to the most important input factor of production, i.e., labour. Second, labour productivity statistics can be computed on disaggregated levels of the economy, for example on the industry level. In contrast, data constraints make it much more difficult to compute other measures, such as capital productivity or TFP, for individual industries. Labour productivity thus helps to explore the contributions of individual industries and sectors to overall economic growth. Third, economy-wide labour productivity is intimately related to the most common measure of living standards, GDP per capita. The difference is that the former "adjusts" for changes in labour force participation, unemployment and demographic shifts in the population. These adjustment factors have (natural) bounds; for instance, the labour force participation rate cannot exceed 100%. Thus, labour productivity can be considered the only factor that drives growth in GDP per capita in the (very) long run. Finally, from the perspective of public policy, labour productivity statistics play an important role in wage bargaining between firms and labour unions.[7]

Box A: Human capital augmented Solow model

To provide intuition for the interpretation of labour productivity, we briefly consider the human capital augmented Solow model (Mankiw et al. 1992). Gross output (Y) is produced using physical capital (K), human capital (H), labour (L) and technology (A) according to the following aggregate production function:

$$Y_t = K_t^{\alpha} H_t^{\beta} (A_t L_t)^{1-\alpha-\beta}$$

Dividing this equation by L_t and expressing everything in rates of change, the growth rate of labour productivity is given by:

$$lp_t = \alpha \left(\frac{k}{l}\right)_t + \beta \left(\frac{h}{l}\right)_t + (1-\alpha-\beta) a_t$$

where we have defined $x_t \equiv \ln(X_t / X_{t-1})$ for all variables. We see that the sources of labour productivity growth are changes in physical capital per worker (k/l), human capital per worker (h/l) and technology (a).

[7] In Switzerland, labour associations and business associations negotiate average wage increases on an annual basis. Labour productivity growth statistics are considered important indicators for these negotiations.

Of course, there are also drawbacks associated with the concept of labour productivity. In particular, it represents a *partial productivity measure* because it does not shed light on the relative importance of the various sources of growth (i.e., labour quality, capital deepening, technology). Therefore, it is crucial not to misinterpret this measure as an indicator for the productive capacities of workers alone.

3.2. Measurement

The purpose of labour productivity analysis is to *measure changes in labour productivity over time* within an industry, within a sector or in the overall market economy. For this reason, labour productivity (and the variables required to compute it) are generally expressed in *index form.* Denoting labour productivity by LP, the quantity of interest is thus LP_t/LP_{base}, which can be interpreted as one plus the percentage change from the base period up to period t. In this paper, the base period will always be set to $t-1$ for practical reasons such that indices are directly related to period-to-period growth rates. For some industry j, the index of labour productivity can be defined as

$$\frac{LP_t^j}{LP_{t-1}^j} = \frac{VA_t^j/VA_{t-1}^j}{L_t^j/L_{t-1}^j},$$

where the numerator, VA_t^j/VA_{t-1}^j, is the volume index of value added (or, the change in real value added) and the denominator, L_t^j/L_{t-1}^j, is the volume index of labour input. Below, we will discuss in detail how these two quantities are calculated. Unless indicated otherwise, the industry subscript j will henceforth be omitted for ease of notation.

3.2.1. Numerator

The *current-price* (or *nominal*) value added in a given period is conceptually fairly straightforward to measure and is broadly available in national accounts data. However, since the objective of productivity analysis is to measure changes over time, *current-price* time series must be converted into *volume* (or *real*) time series. In other words, changes in volumes must somehow be separated from changes in prices. Formally, the relationship between these concepts can be stated as follows:

$$Nominal\ Index = Volume\ Index \cdot Price\ Index.$$

The construction of a volume index is typically achieved by deflating current-price output and input data with appropriate price indices.[8] A crucial feature of such price indices is that they should (ideally) capture only "pure" price changes, which refers to the difference in the price of a service across time periods that we (would) observe if the *properties and the quality of the service remain constant* (see next section).

Separate Deflation of Output and Input (Double Deflation)

International organisations generally recommend that *output* and *input* series are deflated separately before constructing a volume measure of value added (OECD 2001, OECD-Eurostat 2014). This procedure is referred to as *double deflation*. First, the nominal output series, denoted by Q_t^n/Q_{t-1}^n, obtained from national accounts is deflated by an appropriate producer price index, denoted by P_t/P_{t-1}. Therefore, the volume index of output is

$$\frac{Q_t}{Q_{t-1}} = \frac{Q_t^n/Q_{t-1}^n}{P_t/P_{t-1}}$$

Second, the nominal intermediate input series is deflated with an appropriate price index for inputs. Denote the volume index of intermediate inputs by

$$\frac{M_t}{M_{t-1}} = \frac{M_t^n/M_{t-1}^n}{P_{M,t}/P_{M,t-1}},$$

where M_t^n/M_{t-1}^n is the nominal intermediate inputs series and $P_{M,t}/P_{M,t-1}$ is the appropriate price index. Note that the second step is more complicated because the input price index should take into account the input mix originating from various source industries. In addition, the mix of domestic and imported inputs should be accounted for because price changes may differ substantially. In practice, the price index can be constructed by averaging the output price indices of all source industries weighted by the share of intermediate input costs attributable to each source industry. Formally, the price index for the intermediate input series is given by

$$\frac{P_{M,t}}{P_{M,t-1}} = \sum_k s_{M,t-1}^k \frac{P_t^k}{P_{t-1}^k},$$

where $P_{M,t}^k/P_{M,t-1}^k$, is the output price index of source industry k and $s_{M,t-1}^k$ is the share of source industry k in total intermediate input costs. The computation of the latter imposes quite strong demands on data availability because it requires input-

[8] In some industries, volume indices based on the quantities produced and sold are available directly. Classic examples include the supply of water and electricity.

output tables (IOTs) on the industry level. For many countries including Switzerland, IOTs have only been constructed recently and are typically not available on an annual basis. Therefore, it is often the case in practice that the share is time-constant, i.e., $s^k_{M,t-1} = s^k_M$ for all t. Moreover, the available data typically prevent a separate treatment of domestic and imported inputs in the construction of deflators.[9] As a result, it is implicitly assumed that *the price index of imported inputs is the same as the price index of domestic inputs*. Needless to say, this assumption is strong and inappropriate given that the exchange rates pass-through in most European countries lies between 0.5 and 1 (cf. Campa & Goldberg 2005). Overall, the appropriate deflation of intermediate inputs is a very challenging task with strong data demands.[10]

It is important to note that, in practice, the mode of calculation is somewhat more complex than explained above. The reason is that R&D and financial intermediation services indirectly measured (FISIM) are deflated separately. Appendix A.1 provides more detailed information on these adjustments.

Construction of Real Value Added Series

Once the volume series for output and intermediate inputs are available, the volume series for value added can be constructed. In line with the current practice of the SFSO, we use the *chain-weighted formula*, which expresses all quantities in terms of prices from the base year $t-1$ (see also OECD 2001, p. 33). The standard production accounting framework implies that the volume index of gross value added is given by

$$\frac{VA_t}{VA_{t-1}} = \frac{1}{q_{VA,t-1}}\left(\frac{Q_t}{Q_{t-1}} - q_{M,t-1}\frac{M_t}{M_{t-1}}\right),$$

where $q_{VA,t-1}$ is the nominal share of value added in gross output and $q_{M,t-1}$ is the nominal share of intermediate input expenditures in gross output.[11] These share variables can be easily computed from current-price data in period $t-1$.

[9] For Switzerland an IOT that differentiates between domestic and imported intermediate inputs has been constructed recently. However, detailed import price indices for intermediate inputs are not available.

[10] Some countries such as the United States and Germany deflate domestic and imported inputs separately.

[11] Note that this formula is a discrete-time approximation of the continuous-time Divisia index. The Divisia index is given by $\frac{d \ln VA}{dt} \equiv \frac{1}{q_{VA}}\left(\frac{d \ln Q}{dt} - q_M \frac{d \ln M}{dt}\right)$. Note that the OECD manual (2001) generally recommends the Törnqvist index to compute the volume index of value added, which is

3.2.2. Denominator

The denominator of labour productivity, the volume index of labour input, is conceptually easier to construct than the numerator because no deflation procedure from nominal values to volumes is required. In principle, labour input may be measured in several ways:

- the number of actual hours worked (total hours worked)
- full-time equivalent (FTE) employment
- the number of jobs
- the number of persons employed

The number of persons employed is inferior because a single person may hold jobs in several industries such that a proper assignment of workers to industries is not possible. Both the number of jobs and the number of persons employed introduce a bias because they assign the same weight to part-time and full-time jobs/workers. According to the recommendations in OECD (2001), labour input based on *actual hours worked* is the *preferred measure* because it takes into account changes in labour force participation, unemployment and changes in actual working hours. However, on disaggregated industry level, data on hours worked is often not available (as is the case in Switzerland). In this case, FTE employment is deemed to be the second-best alternative. Although FTE employment treats part-time work adequately, it does not take into account changes in annual working time of FTE workers that can arise, among other things, from shifts in overtime hours, absences, vacation and holidays.[12]

Moreover, the labour input series should meet further criteria (cf. SFSO 2015 for a more detailed discussion). First, the labour series should cover the universe of workers that is employed in all firms which the calculation of value added is based on. These criteria imply, for instance, that the labour series should not include workers who work abroad. It should exclude activities which are not considered economic activities in the sense of the national accounts such as home production. On the other hand, the labour series should, for example, account for changes in

$\frac{VA_t}{VA_{t-1}} = \left(\frac{Q_t}{Q_{t-1}} \cdot \left(\frac{M_t}{M_{t-1}} \right)^{-0.5(q_{M,t}+q_{M,t-1})} \right)^{0.5(q_{VA,t}+q_{VA,t-1})^{-1}}$. This formula provides a better approximation to the continuous-time Divisia index than the chain-weighted Laspeyres-type formula. However, it is more difficult to compute and not (yet) widely used in national statistical offices.

[12] Over several decades, shifts in annual working time may produce a non-negligible bias in FTE-based productivity measures. In the period of interest in this paper, 1997 to 2012, annual working time in Switzerland did not change much, however. Therefore, using FTE employment instead of actual hours worked is unlikely to have an important impact on measured labour productivity.

the incidence of atypical work and include apprentices. Second, the series should be measured using the same reference period as the value added series. In particular, it should provide the average labour input over a year rather than, for instance, employment at the end of the year.

3.2.3. Aggregation

Thus far, the discussion has dealt with the measurement of labour productivity for an *individual industry* of the economy. Once volume series for value added and labour input have been constructed on the industry level, the aggregation to sectors or the entire market economy is relatively straightforward. A detailed description can be found in Appendix A.2.

3.3. Challenges in Measuring Volumes in Services

In service industries, the main challenges for productivity analysis are associated with the appropriate measurement of price changes (Fraisse & Wölfl 2012). A price index should *only* capture price changes that occur over time given that *the properties and the quality of services remain constant*. Such "pure" price changes are easiest to observe for well-specified, homogenous goods that are produced and sold with constant quality over multiple time periods. In contrast, many service products do not meet these requirements such that the measurement of pure price changes is a difficult task. Some distinctive features of many services are:

- *Intangibility*: Many services are intangible and thus harder to define and measure than goods.
- *Uniqueness*: Many services are individually tailored to the needs of the customers and thus difficult to compare across providers and across multiple time periods.
- *Quality change*: The quality of service provision may change over time in ways that are hard to observe, e.g. through better qualifications and skills of workers.
- *Bundles*: Services are often provided in bundles and bundles may vary across providers and time periods.

As a consequence, standard price measurement methods that are designed for homogenous and repeatedly observed products cannot be readily applied to many services. Moreover, it is often difficult to identify quality change in the provision of services. Therefore, the construction of appropriate *service producer price indices* (SPPIs) can be a challenging task.

Two general approaches to construct price indices in service activities can be distinguished: *output-based* methods and *input-based* (*time-based*) methods.[13] The former measure price changes directly from data on final service output. The second approach relies on the time (or the amount of labour input) required to produce the service. Below, we will discuss output-based and input-based methods in greater detail.

3.3.1. Output-Based Methods

There exist a number of different price measurement methods that are employed in the collection of service price data. The appropriateness of a certain method depends on the service products at hand, on its relative merit to other methods, but also on the *amount of resources and costs* that are required to implement it. As discussed in OECD-Eurostat (2014), the most common methods are the following:

1) *Direct use of prices of repeated services*: This pricing method refers to the collection of prices for repeatedly observed and well-defined services. It is the preferred method and ideally based on *actual transaction prices*. Alternatively, *list prices* as specified in firms' catalogues may also be used, but if possible, they should closely reflect actual transaction prices.
2) *Contract pricing*: Prices are observed from long-term contracts with customers that span multiple time periods. This method can be applied if the service is provided in each survey period and if the nature of the service does not change over time. The difference to the above method is that price observations across several time periods are based on a *single* transaction.
3) *Unit value method*: This method can be used only if the total value and the total quantity of some service output are observed. Prices are estimated by dividing the value of total sales by the number of units sold. This method may be practical if there are a large number of small transactions for a homogenous service (such as in telecommunications or postal services) and if the quality of the service remains comparable over time.
4) *Percentage fees*: the method measures the price development of specific services that are related to the transaction of products, for example in real estate

[13] To be precise, there exists a third approach, the margin-based methods. However, this is only relevant for intermediation services such as wholesale and retail trade and financial services. For the KIBS industries, margin-based methods are not relevant.

activities or in the leasing of equipment. The service price index is computed as follows:

Service price index = (1+percentage fee) · (price index of transacted product)

For instance, the price index for real estate agencies could be constructed by multiplying one plus the percentage fee that the agents obtain from selling a property (e.g. 1.02 for a 2% fee) with the average house price index.

5) *Component pricing*: In this method, sub-components of services are priced separately. One challenge lies in combining and aggregating the prices of the individual components to obtain a composite price. One example is telecommunications where services are typically sold in bundles. This method is rarely applied in practice.
6) *Model pricing*: This method is most appropriate when services are largely unique such as in business consulting activities. Firms are asked what price they *would* charge for some well-defined, standard service across multiple time periods. Thus, a virtual price for a *model transaction* is collected rather than an observed price for a *real transaction*. If this method is applied, it is crucial that labour input requirements for the model service are re-estimated in each period to take into account potential changes in labour productivity. This method may be applied in many service industries including legal, consultancy and engineering activities.

3.3.2. Input-Based (or Time-Based) Pricing Methods

Another way to construct a price index is to rely on working time data. The fundamental difference to the above output-based pricing methods is that the *price of final service output is not identified*; instead, the price for the *time spent to provide the service* is used as a proxy. There are two main options: a price index may be based on hourly charge-out rates, or if not available, on hourly wage rates. Charge-out rates are preferable to wages because they directly measure the costs charged to customers. If possible, charge-out rates or wage rates should be collected for different categories of labour (e.g. managers, professionals, support staff and so on). The price index should be constructed such that the composition of labour quality (skill groups) is held fixed by applying labour share weights from the previous period (see OECD-Eurostat 2014, p. 59). This weighting scheme ensures that the price index does not capture any observed changes in the shares of skill groups over time.

It must be stressed that input-based pricing methods are typically deemed inappropriate to deflate value added because they impose very strong assumptions (Eurostat 2001). Essentially, these methods assume that growth in wages or charge-out rates is a perfect proxy for quality-adjusted output price growth. The assumption entirely neglects that wage growth could result from changes in technology, physical capital and human capital instead of higher selling prices (recall Box A).[14] These methods are particularly problematic when the quality of service activities improves, for example, because primary factors of production (labour and capital) can be combined more efficiently or because workers have higher skills. This renders the assumption particularly questionable in KIBS industries because increasing service quality and convenience is the key factor of firms' success in many KIBS industries (Baily and Zitzewitz 2001).[15] If efficiency gains from quality improvements materialize in, say, fewer hours or higher wages, the input-based measure will attribute the increase in factor productivity to price changes. As a result, labour productivity growth will be *underestimated*. The simple example in Box B below illustrates formally how wage-based deflation *can* (but need not) lead to an underestimation of labour productivity growth.

3.3.3. Assessment of Different Deflation Methods

From a methodological perspective, output-based SPPIs in the form of prices of final service output are deemed to be the most appropriate methods for deflating value added data (OECD 2001, Eurostat-OECD 2014). Of course, the appropriateness of SPPIs critically depends on the extent to which quality change is observed and can be adjusted for. Moreover, the optimal choice among output-based methods largely depends on the service industry at hand and on the available information. If services are homogenous and repeatedly observed, real transaction prices are the preferred measure.

Compared to output-based methods, input-based methods can lead to serious biases in the measurement of producer prices if input prices and output prices are not very strongly correlated. Input-based methods are especially problematic when productivity improves. Applying input-based deflation in this case will bias measured labour productivity growth towards zero, since the actual increase in labour productivity is erroneously interpreted as an increase in output prices.

[14] Statistically speaking, it is assumed that wage growth is perfectly correlated with output price growth.

[15] Indeed, quality change may be the most important driver of growth in certain service sector industries. For instance, increasing the service quality (i.e. the quality of the food) is one of the central factors for success in the airline industry (Baily and Zitzewitz 2001).

Box B: A Simple Example for the Bias of Wage-Based Deflation

To demonstrate the potential impact of input-based deflation on the measurement of labour productivity, we provide a very simple example. In a given industry, consider a representative firm with production function $Q_t = A_t L_t^{\alpha}$, where Q_t is a homogenous service output, A_t measures the quality of labour (technology) and L_t the number of hours worked. Since labour is the only input factor, output and value added coincide. The output price P_t and the wage rate w_t are determined exogenously on the market. Assuming perfect competition, the firm's optimal choice of labour input equals $L_t = \left(\frac{w_t}{\alpha P_t A_t}\right)^{\frac{1}{\alpha-1}}$. Further assume that $\alpha = 0.5$, $P_{t-1} = 100$, $A_{t-1} = 1$, $w_{t-1} = 50$

The table below shows numbers for two consecutive periods under the scenario that the firm's output price remains constant ($P_t = 100$) but wages increase by the same rate as the quality of labour ($A_t = w_t = 4\%$). It follows that the optimal choice of labour input remains unchanged at 1 hour.

	Year t-1	Year t	Change
Nominal Output (PY)	100	104	4%
Price (P)	100	100	0%
Output Volume (Q) (=Value Added)	1	1.04	4%
Quality of Labour (A)	1	1.04	4%
Number of Hours (L)	1	1	0%
Wage Rate (w)	50	52	4%
Actual LP growth			4%
LP growth with wage-based deflation			0%

Under this scenario, actual labour productivity growth equals 4% because one unit of labour can produce 4% more output volume in the second period. However, because wage growth also equals 4%, wage-based deflation of nominal value added leads to measured labour productivity growth of [(1.04/1)/(52/50)]/(1/1)–1=0%.

Besides methodological considerations, it is also important to point out that certain methods for price data collection may be considerably more costly than others. Clearly, the amount of work effort and the monetary costs required for planning and implementing price measurement methods must, in each case, be carefully compared to its methodological merits and its potential for improving the state of data.

4. Empirical Analysis for Switzerland

This section contains the empirical analysis for Switzerland. At the core, we investigate the question as to why the knowledge-intensive business service industries (KIBS) have been characterized by poor labour productivity growth. First, we briefly provide the classification of industry groups that will be employed (Section 4.1). Second, we provide some stylized facts on the evolution of labour productivity in Switzerland and illustrate the "productivity puzzle" in the KIBS industries (Section 4.2). Third, measurement methods and current practice in Switzerland are discussed (Section 4.3). Fourth, we try to shed light on industry-level productivity growth using an array of performance indicators that are related to, or indicative of, productivity (Section 4.4). Finally, we perform a set of simulation exercises in which we substitute wage-based deflators with alternative deflators and then calculate the impact on industry-level and aggregate labour productivity growth (Sections 4.5 and 4.6). An overall assessment of the explanations for the weak productivity growth in the Swiss KIBS industries is provided in Section 4.7.

4.1. Industry Definitions

To facilitate the empirical analysis, we categorize two-digit industries into a number of groups. Table 3 presents the industry classification according to NOGA 2008 (equivalent to NACE rev. 2) and shows how industries are grouped.[16] Following the approach of *Eurostat*, industries in the service sector are categorized as either "knowledge-intensive" or "traditional".[17] The latter group of service activities are referred to as the *traditional service industries* (Sect. G-I), which include wholesale and retail trade, transport, and accommodation and food service activities. The former include skill-intensive activities in which innovation and technological progress play an important role. Knowledge intensive industries are split in two groups. First, the *knowledge-intensive business services* (KIBS, Sect. J-N) are market-oriented and include for example ICT services, banking and insurance, research and development, and consulting. Second, the *other knowledge-intensive services* (Sect. O-R) include those industries that have either limited market orien-

[16] Note that we slightly deviate from the categorization by Eurostat which is largely due to the way in which the SFSO aggregates two-digit industries in their productivity statistics. For example, veterinary activities (75) and publishing activities (58) belong to "other knowledge-intensive services" in the Eurostat definition.

[17] See Eurostat, http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Knowledge-intensive_services_%28KIS%29

tation or directly belong to the public sector. For ease of discussion, we will henceforth refer to this category as “nonmarket” services.

Table 3 Industry Classification (NOGA 2008)

Section	Division	Industry description
A	01–03	**Agriculture, forestry and fishing**
B–E	05–39	**Manufacturing industries**
F	41–43	**Construction of buildings and civil engineering**
		Traditional services
G	45	Trade and repair of motor vehicles and motorcycles
G	46	Wholesale trade
G	47	Retail trade
H	49	Land transport and transport via pipelines
H	50–51	Water transport and air transport
H	52	Warehousing and support activities for transportation
H	53	Postal and courier activities
I	55	Accommodation
I	56	Food and beverage service activities
		Knowledge-intensive market services
JA	58–60	Publishing, audiovisual and broadcasting activities
JB	61	Telecommunications
JC	62+63	IT and other information services
K	64	Financial service activities
K	65	Insurance
K	66	Activities auxiliary to financial services and insurance activities
L	68	Real estate activities
M	69	Legal and accounting activities
M	70	Activities of head offices; management consultancy activities
M	71	Architectural and engineering activities
M	72	Scientific research and development
MC	73–75	Other professional, scientific and technical activities
N	77 + 79–82	Administrative and support service activities
N	78	Employment activities
		Other knowledge-intensive / nonmarket services
O	84	Public administration and defence
P	85	Education
QA	86	Human health activities
QB	87	Residential care activities
	88	Social work activities without accommodation
R	90–93	Arts, entertainment and recreation
		Other industries
S	94–96	Other service activities
T	97+ 98	Activities of households as employers and producers
U	99	Activities of extraterritorial organisations

Notes: The aggregation of two-digit industries follows the standard aggregation of the SFSO (BFS-50).

Note that we will generally exclude agriculture (Section A), government activities (Section O) and other industries (Sections S–U) from the discussion.[18]

When examining the aggregate evolution in the KIBS industries, we also exclude the financial sector (Sect. K) in many comparisons. The reason is twofold. First, the financial sector is very important in terms of value added in Switzerland. Therefore, it exerts a strong influence on comparisons that are based on value added measures for the total KIBS industries. The influence would be particularly sizable in the years of the financial crisis in 2008 and 2009 during which the financial sector experienced a substantial contraction. Second, there are several unresolved conceptual problems with respect to the measurement of value added in the financial services industry. These have only recently been discussed more thoroughly in the academic literature. The substantial complexities that arise when discussing the measurement of value added and thus productivity in the financial sector are well beyond the scope of this paper.[19]

4.2. Stylized Facts

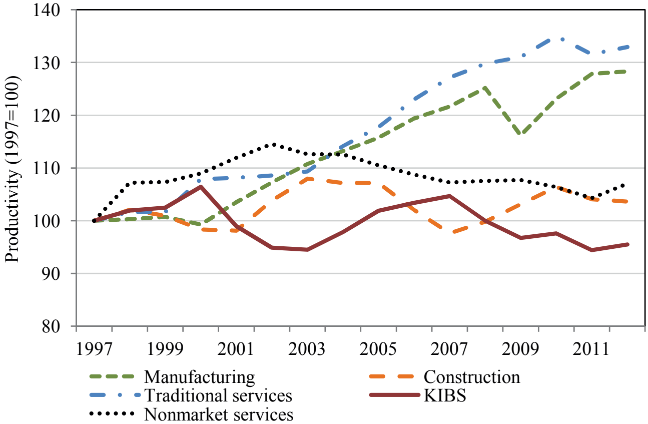
4.2.1. Productivity in Switzerland

As discussed in the introduction, the evolution of productivity measures in the Swiss economy varies markedly across sectors and industries. Figure 2 shows labour productivity for the period from 1997 to 2012 for the groups of industries defined above. As we can see, traditional service and manufacturing industries experienced a sizable increase in productivity over the period considered. In contrast, the data suggests that construction, nonmarket services and especially the KIBS industries were characterized by poor productivity growth.

[18] The reasons for excluding these industries are as follows. First, agriculture is typically of little importance in productivity analysis owing to the small size of the sector and the presence of strong protective government policies (trade barriers, subsidies, transfers). Second, government activities in the narrow sense – that is, public administration, defence and social security – is conceptually difficult to analyse because it is far from clear how output and prices can be measured in the first place. Finally, the "other" industries are excluded because they are somewhat residual given their small share in value added.

[19] The conceptual problems arise because banks' earnings from interest rate differentials between credits and deposits contain both a charge for intermediation services as well as a risk premium associated with credit default risks. The appropriate measurement of the so-called *financial intermediation services indirectly measured* (FISIM) is still subject to an on-going academic discussion, among others in the Intersecretariat Working Group on National Accounts (ISWGNA) Task Force.

Figure 2 Labour Productivity by Industry Group



Source: own calculations, Productivity Statistics, SFSO.

Table 4 provides more detailed information on the accounting data underlying the evolution of productivity displayed in Figure 2. On the left-hand side, the table shows nominal value added per FTE worker in current prices (in CHF) in 1997 and 2012. Generally, these numbers suggest that the level of labour productivity compares favourably in the KIBS industries relative to the other industry groups. It must be borne in mind, however, that the comparison in the cross-section is based on values instead of volumes. The right-hand side of the table shows average annual growth rates of labour productivity, FTE employment, real value added, nominal value added, and the (implicit) deflator of value added. We see that FTE

Table 4 Sources of Labour Productivity Growth in Industry Groups 1997–2012

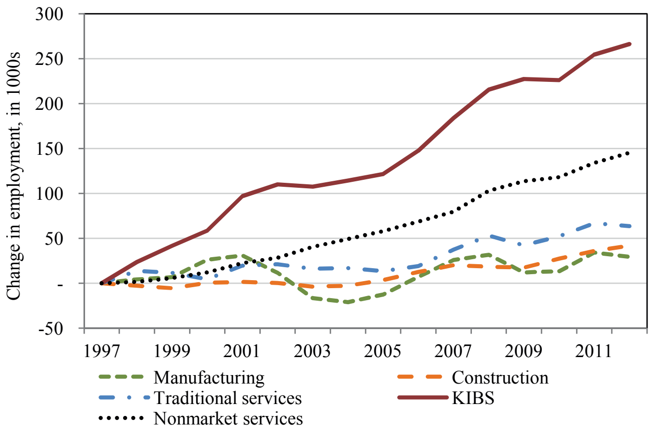
		Nom. VA / FTE empl.		Annual Growth 1997-2012				
NACE	Industry	1997	2012	Lab. prod.	FTE empl.	Real VA	Nom. VA	Def. VA
5-39	Manufacturing	140'479	183'563	1.7%	0.3%	2.0%	2.1%	0.5%
41-43	Construction	75'353	99'496	0.2%	1.0%	1.2%	2.8%	0.7%
45-56	Traditional services	94'728	137'710	1.9%	0.5%	2.4%	3.0%	0.9%
58-82	KIBS	167'335	173'891	-0.3%	2.5%	2.2%	2.8%	1.1%
84-88	Nonmarket services	79'739	102'232	0.5%	2.7%	3.1%	4.4%	1.5%

Source: own calculations, Productivity Statistics, SFSO.

employment grew particularly strongly in KIBS and nonmarket service industries. At the same time, real value added growth in the KIBS industries was similar to the other industry groups. Moreover, the average implicit deflator for value added in the KIBS industries is quite high relative to manufacturing, for example.

The increase of employment in the KIBS industries appears particularly impressive if we consider the cumulative absolute change displayed in Figure 3. Evidently, the KIBS industries experienced a considerable expansion in terms of employment, with an increase of more than 250,000 FTE employees between 1997 and 2012. It is noteworthy that 43% of this increase is attributable to growth in the employment of (high-skilled) immigrants.[20] In the same period, employment in manufacturing, construction and traditional service industries rose only modestly.

Figure 3 Cumulative Absolute Change in FTE Employment (Business Sector)



Source: own calculations, Productivity Statistics, SFSO.

Next, we examine the data for the individual KIBS industries on a more detailed level. Table 5 shows data for two-digit KIBS industries which are grouped according to the standard aggregation of the SFSO. According to the official data presented here, labour productivity decreased substantially in many of these industries. In some cases, the *annual reduction* amounts to more than –2.5% in the pe-

[20] See statistics on employed persons by economic sector and nationality (SAKE), http://www.bfs.admin.ch/bfs/portal/de/index/themen/03/02/blank/key/erwerbstaetige0/ auslaender.Document.100752.xls

riod from 1997 to 2012. This is, for example, the case for research and development, ICT services, real estate activities and other professional, scientific or technical activities. These findings appear to be puzzling, especially in light of the widely held notion that these services intensively rely on innovations and new technology that should have made workers more productive over time. It appears, for instance, very implausible that value added per hour worked has decreased in ICT services given the substantial improvements in computing power and computer software in the last 20 years. In fact, productivity in the ICT services has substantially increased in Germany, France and the UK (see Table 12 below).

Comparing the components of labour productivity growth, it appears that the poor productivity growth in most KIBS industries from 1997 to 2012 results from the fact that the growth in real value added could not keep up with the strong increase in FTE employment, which in turn can be attributed to strong growth in the deflators, i.e., prices.

Table 5 Sources of Labour Productivity Growth in KIBS Industries, 1997–2012

		nom. VA / FTE empl.		Growth 1997-2012				
Div.	Industry	1997	2012	Lab. Prod.	FTE empl.	real VA	nom. VA	def. VA
58 - 60	Publishing, audiovisual and broadcasting activities	115'912	121'356	-1.6%	-0.3%	-2.0%	0.0%	2.0%
61	Telecommunications	319'033	328'863	5.5%	0.8%	6.4%	1.0%	-5.0%
62 - 63	IT and other information services	183'048	170'270	-2.5%	5.8%	3.1%	5.3%	2.1%
64	Financial service activities	235'344	233'571	0.0%	1.3%	1.3%	1.3%	-0.1%
65	Insurance	261'651	396'113	3.3%	0.5%	3.7%	3.3%	-0.4%
68	Real estate activities	182'778	148'206	-3.3%	3.4%	0.0%	1.9%	1.9%
69 - 71	Legal, accounting, management consultancy, architectural, engineering activities	129'465	142'520	-1.6%	2.7%	1.1%	3.4%	2.3%
72	Scientific research and development	421'941	365'567	-2.7%	6.2%	3.3%	5.2%	1.8%
73 - 75	Other professional, scientific and technical activities	86'185	78'524	-2.7%	0.9%	-1.8%	0.3%	2.1%
77 - 82	Employment, administrative and support service activities	72'826	81'686	-0.4%	4.0%	3.5%	4.8%	1.2%

Source: Productivity Statistics, SFSO.

Table 5 also shows the level of labour productivity in the years 1997 and 2012 for each industry. The comparison reveals substantial differences in nominal value added per FTE worker among individual KIBS industries in both periods. Yet again, these numbers must be interpreted cautiously because value added is measured in different prices and not in volumes.

On the whole, the official data suggests that labour productivity growth in Swiss KIBS industries was poor compared to other industry groups such as manufacturing or traditional services. Although there is heterogeneity across individual KIBS industries – labour productivity grew substantially in telecommunications and insurance (see Table 5) – the decline in labour productivity growth is observed in most KIBS industries. Taken at face value, the data leads to the conclusion that the Swiss KIBS industries are characterized by substantial *structural weaknesses* that lead to a long-term decline in labour productivity. Another salient feature of the data is that the most important source for the decline in labour productivity in KIBS industries is the strong increase in industry-specific deflators.

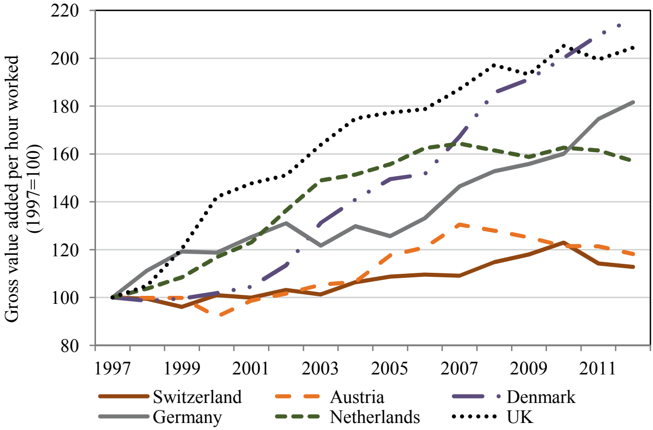
4.2.2. International Comparison

Given the data presented above, it is interesting to compare the performance of KIBS industries with their counterparts in other countries. In this section, we provide an international comparison of changes in labour productivity, employment and the size of the KIBS industries relative to the entire market economy.

Labour Productivity

A comparison of labour productivity growth in Swiss KIBS industries with its counterparts in other countries is provided in Figure 4 and Figure 5. Based on the EU KLEMS database, these figures compare the evolution of real value added per hour worked across countries for the ICT sector (sec. J, div. 58–63) and NOGA sections M and N (div. 69–82), respectively. There are three noteworthy results that emerge from the two figures. First, Switzerland's productivity growth in the KIBS industries is also poor in an international perspective. The deficit appears to be particularly pronounced in the ICT sector, where productivity growth is the lowest among all 18 developed countries for which data is available. Second, the relative weakness of Switzerland in terms of productivity growth in the KIBS industries appears to be smaller since around 2003. Third, there are substantial cross-country differences in the long-run productivity growth in the KIBS industries. For instance, in sections M and N, real value added per hour worked declined by 20% between 1997 and 2012 in Switzerland, Denmark, and Austria, while it grew more than 40% in the UK.

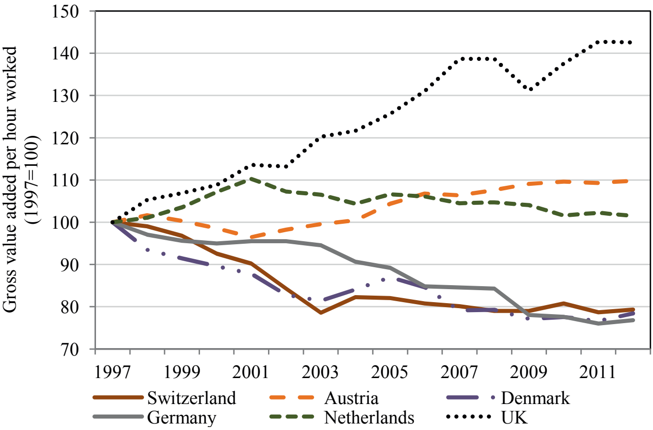
Figure 4 *Labour Productivity Growth in ICT Industries (NACE section J) in Selected Countries*



Notes: Value added per hour worked for Switzerland computed by using official series on labour productivity per FTE employee, adjusted for changes in annual hours worked of full-time employees in total economy according to the statistics on working time (AVOL).

Source: Productivity Statistics, SFSO, and EU KLEMS (OECD Productivity Statistics).

Figure 5 *Labour Productivity Growth in other KIBS Industries (NACE div. 69-82) in Selected Countries*



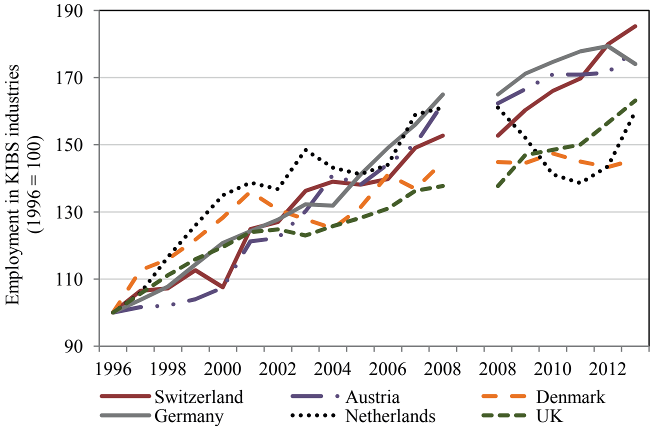
Notes: see Figure 4.

Source: Productivity Statistics, SFSO, and EU KLEMS (OECD Productivity Statistics).

Employment and Employment Share

Did other European countries experience a similar expansion of employment in the KIBS industries as was the case in Switzerland? This question is answered in Figure 6. We exclude the financial sector in this graph for the reasons discussed above. The time series exhibit a break because the data according to NACE rev. 2 is only available since 2008. We estimate employment in KIBS industries prior to 2008 by using a definition of KIBS industries computed directly for the two-digit level of the older classification, NACE rev. 1.2.[21] The figure shows that no country among the developed countries shown has experienced a stronger expansion in employment in the KIBS industries than Switzerland. Switzerland's growth in the number of employees in these industries is particularly remarkable since 2008. Note, however, that the comparison across countries may be confounded by the fact that countries differed substantially in the average GDP growth rate and in the

Figure 6 *Total Employment in KIBS Industries According to Household Survey Data (Excluding the Financial Sector)*



Notes: Industry affiliation is determined by the self-reported industry affiliation of survey participants. The structural break in 2008 is due to the change from NACE rev. 1.1 to NACE rev. 2.

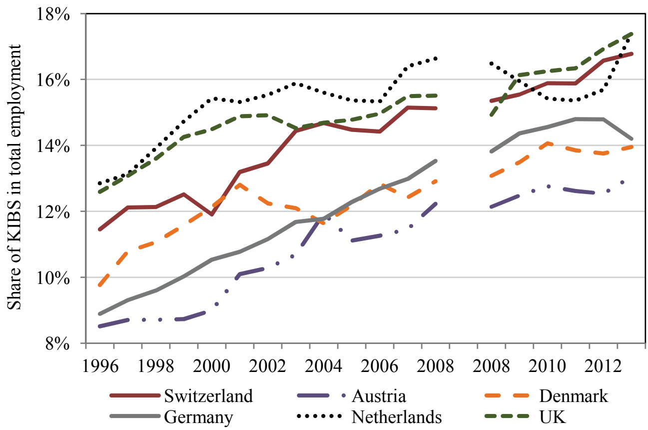
Source: Eurostat, Labour Force Surveys, and SLFS.

[21] See Section B in the Appendix for a list of industries that are considered KIBS industries in the NACE classification rev. 1.2.

dynamics of their labour markets in general. For instance, the strong growth in employment of the KIBS industries in Switzerland may be the result of the fact that the country's domestic economy as a whole was only weakly affected by the recession of 2008/2009.

Given these concerns, Figure 7 shows the development of the *share* of KIBS employment in total employment in a set of European countries. As can be seen, the KIBS industries expanded substantially in all countries considered. However, compared to Switzerland, Germany is the only country in which the percentage point increase in the employment share of the KIBS industries between 1997 and 2013 was larger. Hence, also the relative expansion of employment in the Swiss KIBS industries was remarkable in the 1996–2013 period.[22]

Figure 7 *Share of KIBS Industries in Total Employment According to Household Survey Data (Excluding the Financial Sector)*



Notes: Industry affiliation is determined by the self-reported industry affiliation of survey participants. The structural break in 2008 is due to the change from NACE rev. 1.1 to NACE rev. 2.

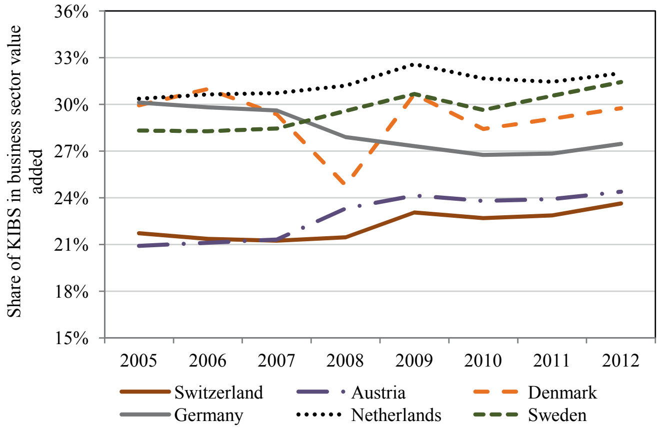
Source: Eurostat, Labour Force Surveys and SLFS.

[22] The internationally high and growing importance of the KIBS industries in Switzerland becomes even more evident when considering the share of KIBS employment *within the service sector*.

Share in Nominal Value Added

Next, we analyse the *relative size* of the KIBS industries in terms of value added over time. Following a similar argument as made with employment above, we do not consider the change in the level of nominal value added because countries differ in average GDP growth rates and in their inflation rates: countries with high inflation experience a larger percentage change in nominal value added. To improve cross-country comparability, we consider the share of nominal value added of KIBS industries in total value added in the *business economy*. Data for EU countries is taken from Eurostat's Structural Business Statistics and is available from 2005 to 2012. The calculation again excludes the financial sector (NACE div. 64–66). Note that our primary interest lies in the *change* and not the level of the

Figure 8 Share of KIBS Industries in Business Sector Value Added (Excluding the Financial Sector)



Notes: The figure shows the share of nominal value added at factor costs in KIBS industries (excluding the financial sector, NACE div. 64–66) as a share of total value added at factor costs in the business sector (NACE 5–82, excluding agriculture and the financial sector). In few cases, missing values for sub-industries were imputed for the countries shown by holding the share of these sub-industries in value added constant.

Source: Structural Business Statistics, Eurostat, and Productivity Statistics, SFSO.

value added share over time.[23] Figure 8 demonstrates that the evolution of the value added share of the Swiss KIBS industries was similar to other countries in the period 2005 to 2012 (with the exception of Germany, in which the KIBS share declined). Note that it increased somewhat in 2008/2009 as KIBS industries proved more resilient to the recession than manufacturing, for example.[24]

Deflators

The use of deflation methods varies widely between countries. It is therefore interesting to ask: How do the Swiss output deflators compare with the output deflators of other countries? The most natural comparison would be to compare implicit output price deflators on the industry level. Unfortunately, Eurostat does not publish these time series for most countries. To explore the differences, we therefore compare the implicit output price deflators of Swiss industries with the *available SPPIs* of other European countries.

Table 6 shows statistics for those KIBS industries where SPPIs are available since 2006 for at least one European country (EU-15/EFTA).[25] Panel A of the table presents the data "as is" *without* adjustment for between-country differences in inflation rates. We see that some deflators (i.e., price changes) are higher for Switzerland compared to the average in other countries. For example, the deflator for information service activities (div. 62) is 0.6% for Switzerland and the average in the group of foreign European countries with SPPIs (6 countries) is -0.1%. If countries are ranked from lowest to highest in terms of the average deflator, Switzerland takes rank 4 out of 7 countries for this industry, see the last column of Table 6. On the whole, Switzerland has comparatively high deflators for some industries, but not consistently so.

[23] The reason is that the level is strongly influenced by the strength and importance of other industries. The lower value added share of the non-financial KIBS industries of Switzerland compared to the other selected countries has mainly two reasons. First, in contrast to most other developed countries, the manufacturing sector still contributes a substantial share to total value added in Switzerland. Second, the low level is also attributable to the exceptional importance of the wholesale trade sector (NACE div. 46) in Switzerland due to the presence of large commodity trading firms. In 2012, this sector's nominal value added had increased to 84% of value added of the entire financial sector including insurance (NACE div. 64–66).

[24] In fact, the productivity data from the SFSO shows that the KIBS share in value added in Switzerland remained stable at around 22% not only since 2005, but since 1997.

[25] Countries with SPPIs in at least one of the industries considered include Belgium, Denmark, Germany, France, Luxembourg, the Netherlands, Finland, Sweden, the United Kingdom, Norway and Spain. We only consider countries in EU-15 and EFTA.

Table 6 International Comparison of Industry-Level Deflators in KIBS Industries

A. No Adjustment for Inflation Rate

		av. deflator 2006-2012			
NACE	Industry	CH[a]	foreign[b]	diff.	Rank of CH[c]
61	Telecommunications	-2.0%	-4.2%	2.17	7 / 7
62	Computer programming, consultancy and related activities	1.6%	0.9%	0.76	8 / 11
63	Information service activities	0.6%	-0.1%	0.75	4 / 7
69	Legal and accounting activities	1.6%	1.9%	-0.31	2 / 3
71	Accounting, bookkeeping and auditing activities; tax consultancy	3.5%	2.2%	1.34	8 / 9
73	Architectural and engineering activities; technical testing and analysis	1.6%	1.0%	0.62	7 / 9
78	Employment activities	1.5%	2.3%	-0.87	2 / 11
80	Security and investigation activities	1.3%	2.8%	-1.53	2 / 9

B. With Adjustment for Inflation Rate

		av. deflator 2006-2012			
NACE	Industry	CH[a]	foreign[b]	diff.	Rank of CH[c]
61	Telecommunications	-2.4%	-1.1%	-1.31	1 / 7
62	Computer programming, consultancy and related activities	1.2%	-0.2%	1.46	11 / 11
63	Information service activities	0.2%	-0.3%	0.51	7 / 7
69	Legal and accounting activities	1.2%	0.1%	1.03	3 / 3
71	Accounting, bookkeeping and auditing activities; tax consultancy	3.1%	0.0%	3.12	9 / 9
73	Architectural and engineering activities; technical testing and analysis	1.2%	-0.4%	1.55	9 / 9
78	Employment activities	1.1%	0.0%	1.05	11 / 11
80	Security and investigation activities	0.8%	0.0%	0.80	9 / 9

Notes: [a] average change of the implicit output deflator; [b] average change across SPPI in the group of EU-15/EFTA countries where SPPI is available; [c] Rank of Switzerland in terms of average deflator among the group of countries with SPPIs. Rank 1 means lowest deflator.

Source: Productivity Statistics for Switzerland (SFSO), Eurostat and OECD.

The comparison in Panel A does not take into account that the *general price level* changes at different speeds across countries. Therefore, it is more adequate to compare deflators across countries that are adjusted for differences in inflation. The comparison reveals the “excess” inflation in the KIBS industries relative to the inflation generally observed in the country.[26] Panel B of Table 6 contains the re-

[26] The inflation-adjustment for Switzerland is carried out as follows:

sults after deflators have been adjusted for the core inflation rate (CPI excluding energy and food) in each country.[27] Here, the overall picture is quite different: the inflation-adjusted deflators for Switzerland are typically much larger than the average inflation-adjusted SPPI-based deflators for other European countries. For instance, for accounting, bookkeeping, auditing and tax consultancy (div. 71), the average annual Swiss deflator is 3.5% *in excess of* Swiss core inflation, while the corresponding average in other European countries is 0.0%, which means that the average price change in this industry equals the core inflation rate in these countries. Compared to the group of countries with SPPIs, the last column shows that Switzerland has the largest deflator (i.e., lowest rank) in all industries except for telecommunications (div. 61). (Note that the deflator for the Swiss telecommunications industry is based on the CPI and not on the SWI, see Table 7.) This finding suggests that deflators in Swiss KIBS industries are larger than virtually all SPPI-based deflators calculated for other European countries.

Summary of the International Comparison

We have seen that labour productivity growth in the Swiss KIBS industries has been weaker than in most comparable European countries. While the evolution of employment and nominal value added has been more or less similar across countries, the deflators used in Switzerland are substantially larger than those used in other European countries. Although we could not compare all deflators due to unavailable data, these findings are an indication that different deflation methods play an important role in understanding cross-country differences in labour productivity in KIBS industries in general and the productivity deficit of Swiss KIBS industries in particular.

4.3. Productivity Measurement in the KIBS Industries

4.3.1. Measurement of Nominal Value Added

In Switzerland, the basis for the measurement of value added in two-digit industries is the *value added survey*, which is conducted annually by the SFSO. The

$$\left(D_{t,CH}^{j}\right)^{infl.-adj.} = \left(\frac{D_{t,CH}^{j}}{1+\pi_{t,CH}}\right)$$

where $\pi_{t,CH}$ is the inflation rate and $D_{t,CH}^{j}$ is the deflator for Swiss industry *j*. The adjustment for the foreign countries is analogous.

[27] Note that the average growth rate of the PPI would be preferable. However, we use the CPI because the comparability between countries is generally superior to that of the PPI.

survey includes a sample of roughly 20'000 firms and the response rates of large, medium and small firms are about 90%, 70% and 60%, respectively.[28] Based on the survey sample, nominal output, intermediate input expenditures and nominal value added are estimated by extrapolation to the *population* of firms on the two-digit industry level. The fact that value added is based on a sample may introduce sampling error. While sampling bias generates variability in the data, it is unlikely to cause long-term changes in the time series and is therefore unlikely to be the driver of the persistent decline in labour productivity observed in the KIBS industries.

4.3.2. Measurement of Real Value Added

The real (volume) value added series are calculated based on the annually-reweighted chain principle (see Section 3.2.1). The industry-specific deflators are described in detail in SFSO (2013).

Below, we briefly comment on the deflation procedure that was changed in 2014 in the course of the introduction of the new European System of National and Regional Accounts (ESA 2010). Subsequently, we devote our attention to the deflators that are used for the KIBS industries.

Deflation Procedure: Single and Double Deflation

In September 2014, the SFSO introduced double deflation with the introduction of ESA 2010. As explained in Section 3.2.1, double deflation means that real value added is measured as the difference between *real* gross output and *real* intermediate inputs (i.e. both quantities are separately deflated). In contrast, when applying a single deflation procedure, *nominal value added* is directly deflated using an appropriate price index. Single deflation implicitly imposes the strong assumption that prices of gross output and intermediate inputs move in tandem. Double deflation is therefore conceptually preferable.

In Swiss national accounts, double deflation is applied only to the data from 2008 onward. Single deflation continues to be used for older time periods. How did the introduction of double deflation affect real value added and thus the productivity statistics? Comparing the old and the new data, the difference in the *aggregate growth* of real value added 2008–2011 appears to be limited between single and double deflation. One reason is that (due to unavailable data) no distinction is

[28] See http://www.bfs.admin.ch/bfs/portal/de/index/infothek/erhebungen__quellen/blank/blank/ews/01.html.

made between domestic and foreign intermediate inputs in the double deflation of industry-level value added. Hence, in Swiss national accounts, input deflators are based on prices of *domestic* industries. Double deflation in Switzerland is therefore a “closed system”, in which a price increase in one industry’s output leads to price increases in intermediate inputs in other industries.

Despite a limited effect on productivity growth on the aggregate level, the introduction of double deflation can have a sizable influence on measured productivity growth in *individual industries*. However, we do not have the data required to isolate the effect of introducing double deflation on the measured productivity performance of the KIBS industries.[29] It is important to highlight, however, that the low growth in labour productivity in KIBS industries is not a consequence of introducing double deflation: the productivity deficit of these industries had already persisted in the old data prior to the revision in 2014.

Overview of Deflators

Table 7 describes the current practice of deflating the value added of the KIBS industries in Swiss national accounts. Based on the available information, we provide our own (crude) evaluation of the deflation methods employed according to the classification of Eurostat (2001) into A, B, and C methods. It is noteworthy that value added is deflated with a wage index in *most* KIBS industries. According to Eurostat (2001), such input-based methods are to be classified as C methods and are thus considered inappropriate (cf. Section 3.3). As shown in the table, wage-based deflators are typically based on a broader industry definition. For example, for research and development (div. 72), value added is deflated using the wage index of the industry group 69–75, which includes a wider range of service activities. This so-called unmatched deflation may generate a considerable bias if wage growth systematically differs across these industries.

[29] It is not possible to just compare the changes in the implicit deflator of value added before and after the switch towards double deflation. The reason is that the introduction of double deflation was carried out in a comprehensive revision of the national accounts in 2014. It is thus not possible to single out the influence of the change toward double deflation on the price series from other changes that occurred within the revision.

Table 7 Deflation Methods in the Non-financial KIBS Industries

Div.	Industry description	Method of deflation	Evaluation	Share of VA in KIBS	SPPI (availability / plans)
58	Publishing activities	CPI	A[a]	≈1.2%	none
59	Motion picture, video and television programme production	WI div. 58–61	C	≈0.5%	none
60	Programming and broadcasting activities	WI div. 58–61	C	≈0.6%	none
61	Telecommunications	CPI	B	5.1%	since 2011
62	Computer programming, consultancy and related activities	WI	C	≈8.0%	~ Oct 2015
63	Information service activities	WI	C	≈0.8%	~ Oct 2015
68	Real estate activities	CPI	B	4.0%	
69	Legal and accounting activities	WI div. 69–75	C	≈5.4%	~ Oct 2015
70	Activities of head offices; management consultancy activities	WI div. 69–75	C[b]	≈7.3%	since 2011(p), 2012(p)
71	Architectural and engineering activities	SPPI	A	≈8.8%	since 2002(p), 2009(p)
72	Scientific research and development	WI div. 69–75	C	3.9%	none
73	Advertising and market research	WI div. 69–75	C	≈1.0%	since 2009(p), ~2016 or later (p)
74	Other professional, scientific and technical activities	WI div. 69–75	C	≈1.1%	none
75	Veterinary activities	CPI	B	≈0.2%	~2016 or later
77	Rental and leasing activities	WI div. 77–82	C	≈0.3%	~2016 or later
78	Employment activities	WI	C	≈3.9%	since 2012(p)
79	Travel agency, tour operator reservation service and related activities	CPI	B	≈0.7%	~2016 or later
80	Security and investigation activities	SPPI	A	≈0.6%	since 2009
81	Services to buildings and landscape activities	SPPI	A	≈3.9%	since 2009(p)
82	Office administrative, office support and other business support activities	WI	C	≈0.8%	none

Notes: CPI=consumer price index; WI=wage index, SPPI=service producer price index. [a] No explicit recommendation in Eurostat (2001). [b] Wage-based deflation may be a B-method if changes in labour quality are accounted for. The last column shows the (expected) starting year of the SPPI for Switzerland, where "(p)" indicates that indices cover only a part of the industry. Due to the data publication guidelines of the SFSO, value added shares are approximated by FTE employment shares where aggregation is more detailed than SFSO-50.

Source: SFSO (2013), own inquiries and calculations.

For a few other KIBS industries, CPI components are used as deflators. These deflators are certainly better than wage-based deflators, but are second-best alternatives to SPPIs. In particular, CPIs may be problematic if a considerable share of services is sold to other businesses as intermediate inputs and if changes in taxes and subsidies are not taken into account. In this case, consumer prices may only partly reflect producer prices. For this reason, CPI-based deflators typically fall under B methods except when all output is sold to households. Finally, SPPIs are used as deflators for a few industries: architectural and engineering, security and investigation and services to buildings and landscape. Although we do not know to what extent quality change is taken into account in these indices – with the benefit of the doubt – we classify them as A methods.

The last column of Table 7 provides information on the current and future availability of SPPIs for the Swiss KIBS industries. As can be seen, a considerable number of SPPIs have only been constructed very recently and therefore could not yet be used as deflators for value added in Swiss national accounts. For a number of industries and sub-industries, data collection on service producer prices is expected to begin in the near future, for example for ICT services (div. 62–63) and legal and accounting services (div. 69). In other words, the state of data in terms of available SPPIs will improve considerably over the forthcoming years.

Table 8 shows the share of nominal value added (in 2012) that is deflated using either A, B, or C-methods.[30] In the non-financial KIBS industries, about 36% of nominal value added is deflated using C methods. If we exclude the financial sector, the share attributable to C methods is 62%. A rough comparison across countries can be made based on the numbers in Table 2. The average share of C methods across ten European countries for "business services" is 48% (without the financial sector).[31] Therefore, Switzerland lies slightly above average with respect to the use of inferior deflation methods in these industries. The last column of Table 8 demonstrates that the share of value added deflated with inappropriate methods is not negligible for the aggregate economy. The 36% share of value added in KIBS industries translates into 11% of value added in the entire market economy (business sector). If wage-based deflation in KIBS industries leads to mismeasurement of labour productivity growth in these industries, aggregate statistics are also affected.

[30] As opposed to Table 7, the calculations in Table 8 are based on the actual shares of nominal value added.

[31] Note that "business services" in the ISIC classification is not quite identical to the KIBS industries in the NACE classification.

Table 8 *Share of A, B, and C Deflation Methods in Nominal Value Added in KIBS Industries*

	in KIBS industries	in business sector
Share of value added deflated with A methods	11.9%	3.6%
Share of value added deflated with B methods	10.0%	3.1%
Share of value added deflated with C methods	36.2%	11.1%
Share of value added non rated (financial sector)	41.9%	13%
Total	100.0%	30.6%

Notes: Numbers are calculated from the results in Table 7.

Next, we investigate whether the type of deflator (WI, CPI, SPPI) is correlated with the size of the average deflator. If wage growth consistently overstates the underlying true price change, we would expect higher average values for wage-based deflators. To test for this empirically, we consider the implicit output deflators of all two-digit non-financial KIBS industries from 1997 to 2012. We find that the average deflator based on CPI or SPPI is 0.28%, while the average deflator based on wage indices is 1.36%.[32]

Wage-Based Deflator: the Swiss Wage Index

The wage-based deflators listed in Table 7 are based on the Swiss Wage Index (SWI) which is constructed annually from register data on accident insurance claims. The index is not computed for individual two-digit industries, but for *industry groups* to ensure that the estimate of wage growth is based on a sufficient number of observations. The industry-level SWI is a Laspeyres index in which the changes in the average wage of male and female workers are weighted by their relative wage bills in a base period. The base period is updated every five years. The industry-level SWI has a structural break in 2011 with earlier years based on NACE rev. 1.2 and years as of 2011 based on NACE rev. 2. Unfortunately, the SFSO cannot provide guidance on the harmonization of the old time series with the new industry classification (see SFSO 2012 for more information).

The appropriateness of the SWI as a deflator for the output of an industry depends on the question as to whether the increases in the SWI reflect output price increases. Apart from the general problem (shared by all wage-based deflation methods) that this relationship may not be close, there are three limitations specific to the SWI that make it unlikely to be an appropriate deflator for output. First, the SWI is not available for *individual* two-digit industries. Therefore, wage-based

[32] This result is robust to the inclusion of aggregate year fixed effects in a linear regression.

deflators are constructed from a broader industry groups and do not match the industry to which they are applied. This unmatched deflation may introduce bias in the estimation of industry-level wage growth.[33]

Second, growth in the industry-specific SWI occurs because the composition of the workforce changes. This is not desirable since a wage measure adjusting for compositional changes better reflects growth in output prices. In fact, the industry-specific SWI accounts *only for changes in the gender composition* of the workforce. From the perspective of productivity analysis, the most important compositional changes in the workforce are thus not accounted for by the industry-specific SWI. An obvious example is that the SWI is influenced by changes in the skill structure of the employees. If, for instance, workers' educational attainment or experience increases in an industry, the wage-based deflator will most likely be too large: higher skills will lead to both higher wages and higher productivity of the average worker. The industry-specific SWI also increases if the job composition of the average worker changes. It is, for instance, increasing if the share of blue-collar workers in an industry declines at the expense of white-collar workers (given that white collar workers earn more than blue-collar workers). Finally, also shifts towards more productive sub-industries (or firms) within industry groups will be reflected in growth of the SWI because wages in more productive sub-industries are higher. Overall, the SWI *almost certainly* reflects growth in productivity.

Third, the wage concept employed for calculating the SWI does not include irregular components of pay, most notably bonuses. Since bonuses have become an increasingly important component of pay in the top segment of the wage distribution in which wages have grown disproportionately strongly in the past two decades[34], this conceptual shortcoming renders the SWI biased towards underestimating actual growth in the wage costs of industries, all else equal.[35] Although the exclusion of bonuses is undesirable when it comes to the measurement of aggregate wage growth, it is, however, unclear whether the SWI would be a better proxy of quality-adjusted output price growth if it included growth in irregular pay for its use as an output price deflator. For instance, if bonuses are the result of increases in labour quality, they reflect quality improvements in output and not pure price

[33] There is, of course, a trade-off between bias and precision: Given the small size of certain industries and small samples of wage data, broader industry groups may be necessary to ensure sufficiently precise estimates.

[34] See the data presented in the press release of the SFSO on April 28, 2014: Schweizerische Lohnstrukturerhebung 2012: Erste Ergebnisse.

[35] Note that certain KIBS industries are particularly affected by this shortcoming because of their particular importance of irregular pay components (such as the financial and R&D sector).

changes. In this case, a wage index including bonuses would be a worse proxy for output prices.

Overall, the shortcomings of the industry-specific SWI as a measure of output price growth are considerable.

4.3.3. Measurement of Labour Input

Industry-level productivity data for Switzerland are based on *FTE employment*. The employment data from 2011 onward are based on the new structural business statistics database (STATENT). STATENT is based on social security registers, which covers all employees and self-employed persons from the age of 18.[36] The data prior to 2008 is retropolated based on the growth rates of FTE employment of an old synthetic employment series that was specifically constructed for productivity analysis (cf. SFSO 2015 for more information).[37] Using the STATENT and the synthesized historical series as the basis for the productivity analysis appears to be the best possible choice. The reason is that the most important alternative data source, the employment statistics (BESTA), has had a systematic downward bias in job growth in the past (see Hartwig 2008 or Siegenthaler 2015).

STATENT provides information on firms' FTE employment, but no information on hours worked. This is a disadvantage as changes in annual hours worked of FTE employees are not accounted for. In the period under study, these changes in annual working times have been limited, though (cf. Siegenthaler 2015). Relative to earlier sources, a strong advantage of the STATENT is its comprehensiveness: nearly the entire universe of Swiss firms is included.[38] The reader is referred to SFSO (2015) for more information on the employment series constructed for the productivity statistics and the pros and cons associated with alternative data sources.

4.4. Evidence from Productivity-Related Indicators

This section investigates empirically whether there are, in fact, reasons to believe that the low labour productivity growth in the KIBS industries is real and not due

[36] More precisely, a person is covered from the beginning of the year in which he or she turns 18 years old. Also note that STATENT might not cover workers with very small annual earnings because there is a small threshold of 2300 CHF below which no social security contributions must be paid.

[37] These sources included the Swiss Labour Force Survey (SAKE), the employment statistics (BESTA), the central migration information system (ZEMIS) and the cross-border worker statistics (GGS).

[38] In contrast, STATENT does not cover employment in private households.

to measurement. For this purpose, we consider an array of empirical indicators that are thought to *influence or be related to* labour productivity. We conduct a comparative descriptive analysis in that we a) look at the evolution of indicators over time; b) compare the performance of industry groups over time; and c) compare the performance of KIBS industries between countries.

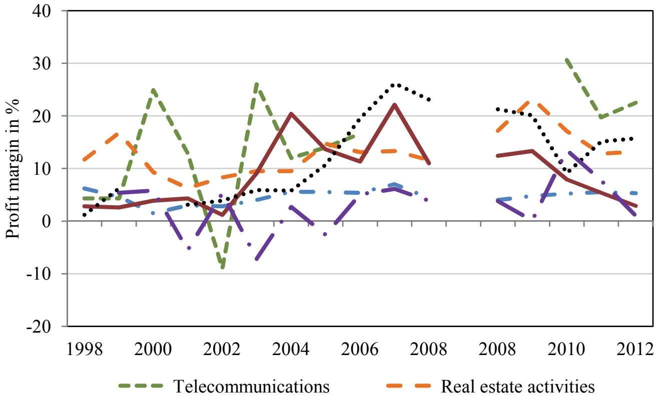
Given the available data, we attempt to answer a number of questions followed below. The indicator(s) considered are presented underneath each question.

- *Profitability:* Have firms in KIBS industries become less profitable?
  - Indicator: net profit margin
- *Business demography:* Has there been a decline in new innovative and productive start-up firms? Have KIBS industries become increasingly fragmented with declining average firm size?
  - Indicator: share of newly founded firms, share of small firms
- *Human capital:* Has there been a brain drain in these industries with increasing shares of low skilled workers? Has wage growth been more sluggish than elsewhere in the economy?
  - Indicators: share of tertiary-educated workers, average wage
- *International Competitiveness:* Have Swiss firms in KIBS industries become less competitive relative to their counterparts in other countries?
  - Indicators: share of exporters, average export share in sales
- *Innovation:* Have KIBS firms lowered their innovation efforts or has the potential for innovation declined?
  - Indicators: share of innovating firms, share of innovative products in turnover
- *Investment and Capital:* Has there been a fall in, say, the use of ICT or other technology-intensive capital goods?
  - Indicators: investment per person employed, investment share in turnover
- *Regulation and policy-related factors:* Are there any aspects of the Swiss regulatory system that could hamper firms' productivity growth?
  - Indicators: obstacles to firms' innovation activities, service trade restrictiveness

4.4.1. Profitability

Profitability illustrates to what extent the capital invested in firms is compensated with a return. If an industry becomes less competitive over time with respect to its counterparts abroad, or if capital and labour employed in the industry become less productive, the profit margin is expected to decline over time. To investigate whether this has been the case in the KIBS industries, we elicit data on industry-level profit margins from the Swiss Business Accounting Statistics. The profit margin is defined as the sum of all profits divided by total revenues in a given industry. Figure 9 illustrates the evolution of profit margins in KIBS industries. Note that the data prior to 2008 is based on NACE rev 1.2, whereas the data as of 2008 is based on NACE rev. 2. We only include industries for which an approximate matching of the time series is possible. Not surprisingly, the profit margins are quite erratic because they are based on a sample of firms and because they reflect fluctuations in the business cycle. However, we do not detect a systematic decline in profit margins over time. Therefore, the profitability of firms in the KIBS industries does not reflect the sharp decline of measured labour productivity documented in Table 5. For example, the ICT service industry exhibits a rather low but very steady profit margin of 5%, while measured labour productivity in this industry declined by 2.5% a year from 1997 to 2012.

Figure 9 Profit Margin in Selected KIBS Industries

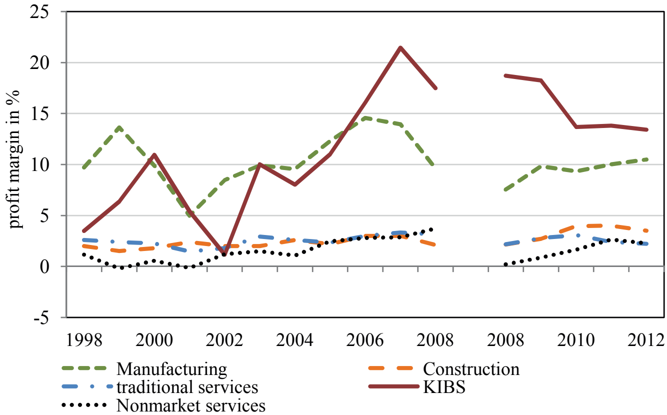


Notes: The profit margin is calculated as total net profits divided by total turnover within an industry. Data until 2008 are based on NACE rev. 1.1. Data from 2008 onwards are based on NACE rev. 2. The figure includes a break in the time series to indicate the limited comparability between these two periods.

Source: Swiss Business Accounting Statistics (SFSO), own calculations.

Figure 10 shows the average profit margins across industry groups, where averages are computed using nominal value added as weights. As we can see, the average profit margin in KIBS industries and manufacturing are much larger than those in construction, traditional services and nonmarket services. That is, KIBS activities are generally more profitable than traditional service activities such as trade, transportation, accommodation and restaurants. Over time, the profit margin in the overall KIBS industries is subject to short-term variation, but it seems to have increased over time. Moreover, it has consistently exceeded the profit margin in the manufacturing sector since 2006 such that there is no evidence that labour productivity in KIBS industries has fallen short of labour productivity in manufacturing. Therefore, these findings on the profitability of firms do not seem to corroborate the official labour productivity data.

Figure 10 Profit Margins in Industry Groups



Notes: see notes of previous figure. Industry-level profit margins are weighted by value added. Individual missing values are imputed using average rates of change in the respective industry group.

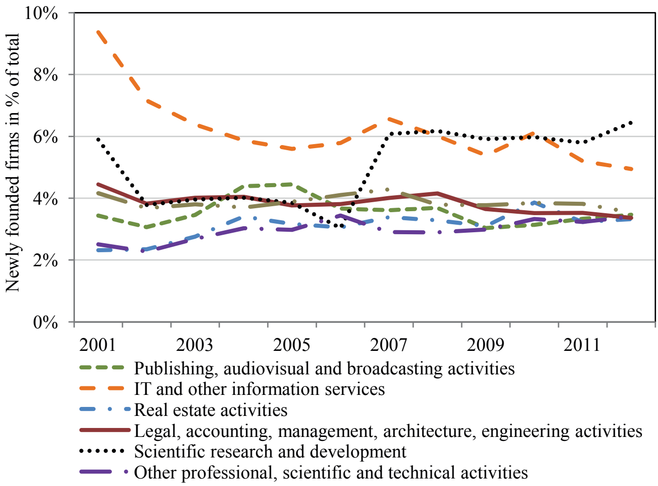
Source: Swiss Business Accounting Statistics (SFSO), own calculations.

4.4.2. Business Demography

The empirical literature in economics suggests that firms' productivity is related to aspects of business demography such as firm age and firm size. Foster et al. (2001) review the existing evidence on the relationship between entries and exits of firms and aggregate productivity growth. Their overview of the literature and their own empirical results suggest that new firms are generally substantially more productive than exiting firms such that entry and exits play an important role in explaining growth of aggregate productivity. Other studies find that innovation activities are highest in the post-entry stage and tend decline with firm age (Hanson 1992; Huergo & Jaumandreu 2004b). The evidence regarding the link between firm size and productivity is more mixed; some studies report a negative relationship (Dhawan 2001; Diaz & Sanchez 2008), while others find a positive relationship (Pagano & Schivardi 2003; Van Biesebroeck 2005).

To study business demography in Swiss KIBS industries, we consider the share of newly entering firms relative to the market size and the share of employment in small firms as a measure of firm size. Figure 11 and Figure 12 shows the share of newly founded firms relative to total firms over time in selected KIBS industries and in aggregate industry groups, respectively. We see in Figure 11 that the dynamics of new entries in the ICT industries has declined but still remains on a high level. Conversely, the rate of new entries has increased in the R&D industry. For the other industries, the share of new firms has remained surprisingly steady over the years. Figure 12 demonstrates that the share of new firms in the KIBS industries is persistently higher than in the other industry groups.

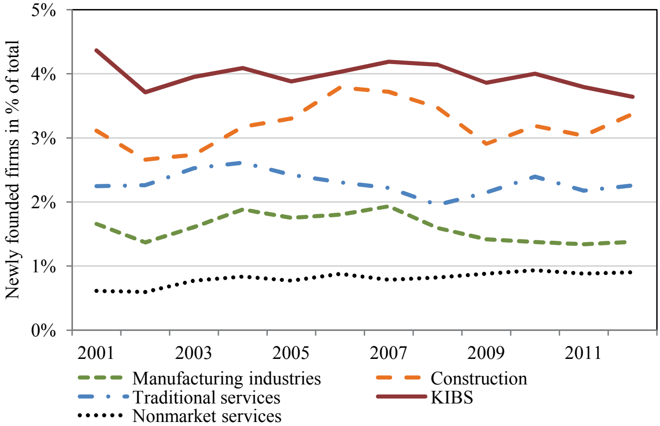
Figure 11 Newly Founded Firms in Selected Service Industries



Notes: The figure shows the ratio of newly founded firms to the total number of firms within an industry. Since the total number of firms is only available for 2005, 2008, 2011 and 2012, the data is linearly interpolated between these years. The total number of firms prior to 2005 is retropolated using the growth rates from the Business Census.

Source: Business Structure Statistics (STATENT, SFSO), Business Demography (UDEMO, SFSO), Business Census (BZ, SFSO), own calculations.

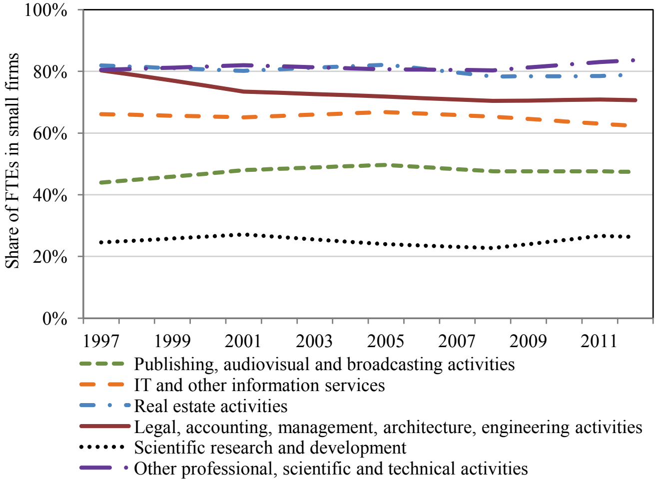
Figure 12 *Newly Founded Firms in Industry Groups*



Notes and Source: see Figure 11.

In Figure 13 and Figure 14, we report the share of total FTE employment that is attributable to small firms with less than 50 employees in KIBS industries and aggregate industry groups, respectively. There are two findings that emerge from Figure 13. First, firm size varies widely between KIBS industries. While the share of employment in small firms is around 80% in real estate activities, it is around 20-30% in R&D and telecommunications. Second and more important, the share of workers in small firms is steady over a longer period of time in most industries. Figure 14 shows the same indicator computed for industry groups. The picture is largely the same; the employment share of small firms is remarkably stable over time. If anything, there has been a slight tendency towards larger firms in the overall KIBS industries. Overall, we find that changes in the distribution of firm size (as measured by employment) are unlikely to be a cause for declining productivity growth.

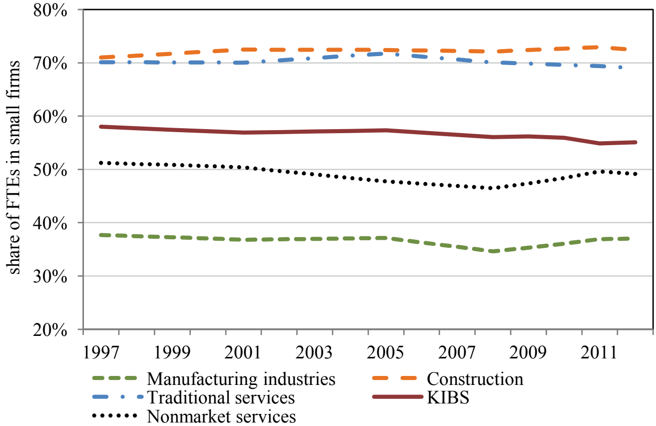
Figure 13 Share of FTE Employment in Small Firms in KIBS Industries



Notes: The figure shows the ratio of FTE employment in small firms (< 50 employees) to total FTE employment within KIBS industries. Data is available for 1998, 2001, 2005, 2008, 2011 and 2012, otherwise linearly interpolated.

Source: Business Structure Statistics (STATENT, SFSO), Business Census (BZ, SFSO), own calculations.

Figure 14 Share of FTE Employment in Small Firms in Industry Groups

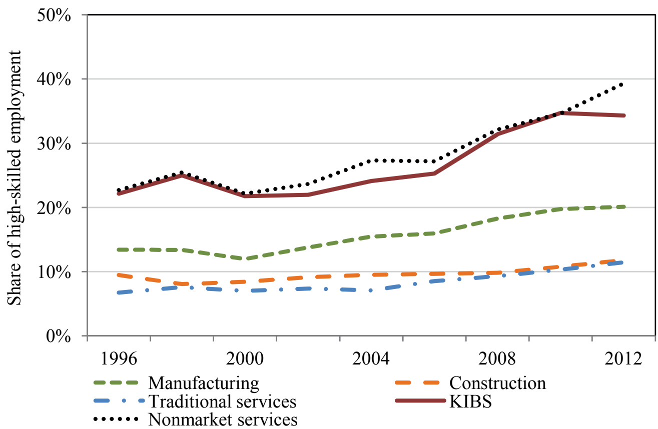


Notes and Source: see Figure 13.

4.4.3. Human Capital and Wages

Next, we examine how the skill composition of workers in KIBS industries has changed relative to other industry groups. Figure 15 presents the share of tertiary-educated workers in total employment, as calculated from the Swiss Wage Structure Survey (LSE). Note that "tertiary-educated" refers to those workers who completed university, college or higher vocational training. We find that both the *level* and the *increase* of skill intensity are largest for nonmarket industries and KIBS industries. Over the period considered, the share of high-skilled labour increased by approximately 13 percentage points in the KIBS industries and 17 percentage points in nonmarket industries compared with 6.7 in manufacturing and 5.3 in traditional services. This suggests that these more knowledge-intensive service activities became considerably more intensive in human capital relative to other activities. Since high-skilled workers are more productive on average, the shift in the skill structure should lead to improvements in labour productivity, ceteris paribus. The decline in labour productivity in the KIBS industries and the lower productivity growth of KIBS industries relative to manufacturing and traditional service industries is hence at odds with the change in observed qualifications of workers across these industry groups.

Figure 15 *Share of Tertiary-Educated Workers*

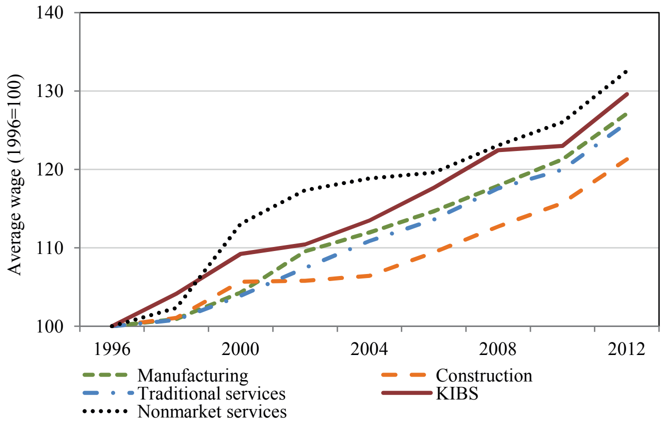


Note: The harmonisation of the old industry classification (NACE rev. 1.2) is conducted using the procedure explained in 4.5.1 (Data).

Source: Swiss Wage Structure Survey, own calculations.

Figure 16 shows the evolution of average wages across industry groups. As can be seen, wages in nonmarket industries and KIBS industries rose more strongly relative to the other sectors. In a competitive, market-oriented environment, economic theory suggests that wages should be closely related to the marginal product of labour and the human capital of the workforce. Therefore, the evolution of wage growth displayed in Figure 16 would imply that labour productivity in the KIBS industries should have increased faster than elsewhere in the market economy (manufacturing, construction and traditional services).

Figure 16 Evolution of Average Wages



Note: The harmonisation of the old industry classification (NACE rev. 1.2) is conducted using the procedure explained in Section 4.5.1.

Source: Swiss Wage Structure Survey, own calculations.

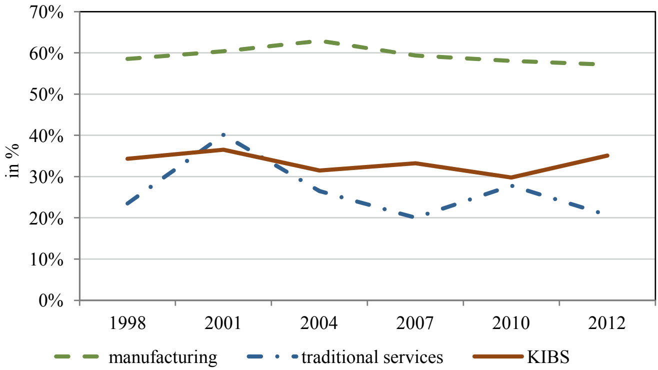
4.4.4. Export Performance

One of the key theoretical predictions of the New Trade Theory is that there is a strong positive relationship between productivity and exporting. Confirming the predictions from the theoretical models, a wealth of firm-level studies documents that exporters are more productive than non-exporters (see Wagner 2007 and Wagner 2012 for surveys on this literature). It is thus interesting whether the observed decline in labour productivity in KIBS industries is mirrored in a poor export performance of Swiss KIBS firms.

Using data from the KOF innovation surveys 1999–2013, Figure 17 shows the share of exporters in KIBS industries, traditional services and manufacturing in

Switzerland. The figure shows that over the period considered, about one third of all Swiss KIBS firms are exporters. The share of exporters is generally higher than in traditional service industries but substantially lower than in manufacturing where two out of three firms engage in exporting. More importantly, however, the share of exporters in KIBS industries neither declines over time nor evolves systematically differently than the share of exporters in the two other industry groups shown.

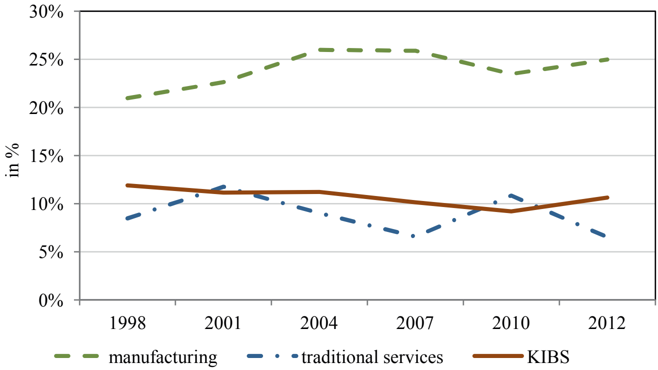
Figure 17 Share of Exporters by Industry



Notes: Results are weighted using the sample (employment) weights of the survey.
Source: KOF innovation surveys, several waves.

Because the above development may mask that the share of sales flowing to foreign markets among *exporters* changes, Figure 18 plots the evolution of the average export share in sales of firms in the three industry groups. This share was 12% in the KIBS industries in 1999 and remained almost stable. The average export share in sales increased somewhat in the manufacturing sector between 1998 and 2004 but also remained stable afterward. The average export share in traditional service sectors evolves very similarly as the corresponding share in the KIBS industries. Overall, we do not observe a systematic decline in the exporting performance of Swiss KIBS industries that we might expect to see for industries characterized by a substantial decrease in labour productivity. Thus, the comparison in export performance across industry groups does not provide an explanation for the observed differences in productivity growth.

Figure 18 *Average Export Share in Sales by Industry*



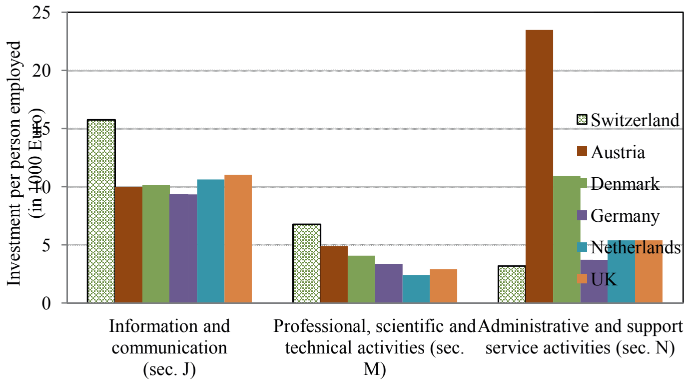
Notes: Results are weighted using the sample (employment) weights of the survey.
Source: KOF innovation surveys, several waves.

4.4.5. Investment and Physical Capital

Another indicator expected to be closely related to productivity growth is the capital intensity of production. As demonstrated in Box A in Section 3.1, labour productivity growth is intimately related to the capital-labour ratio. The intuition behind the result is simple: the larger and the better the capital stock (e.g. equipment and machines) that workers have at their disposal, the more value added they can produce per hour worked. It is conceivable that the long-run decline in the labour productivity of KIBS industries may be caused by insufficient investment activities and/or a depreciating capital stock. It is therefore interesting to look at the evolution of investment in the Swiss KIBS industries over time. The preferred measures – the capital-labour ratio or the physical capital stock – cannot be used because no estimates of capital stocks exist on the industry level.

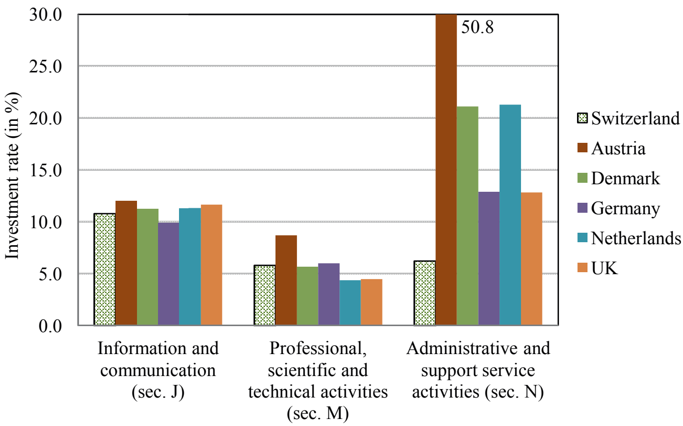
How does investment in Swiss KIBS firms compare with the investment of firms in comparable countries? Figure 19 shows the average amount of investment per person employed in composite KIBS industries for a selection of European countries. The figure refers to the period 2009 to 2012 because the data for Switzerland only spans this time period. The figure shows that investment per person employed is comparatively high in two of the three composite KIBS industries. In Swiss administrative and support service activities (sec. N), the investment performance appears relatively poor in Switzerland, however. Slightly different comments apply when looking at the investment rate (Figure 20). The investment rates (i.e., investment as a share of value added) in ICT activities and in professional, scientific and technical activities (NACE sec. M) appear to be average among the countries

Figure 19 Average Investment per Person Employed for KIBS Industries in Selected Countries, 2009–2012



Source: Eurostat, Structural Business Statistics.

Figure 20 Investment Rate in KIBS Industries in Selected Countries, 2009–2012



Notes: The investment rate refers to the amount of expenditures for investments relative to value added.

Source: Eurostat, Structural Business Statistics.

shown, while the poor investment rate in administrative and support service activities is similar to the first indicator. Overall, investment activities in KIBS industries do not fall short of the activities observed in other developed countries except in section N, whose contribution to overall value added is small.

4.4.6. Innovation Activity

Another indicator potentially correlated with productivity growth in firms is the extent of innovative activities of firms. In general, economists expect that innovative activity can lead to productivity growth and vice versa.[39] A literature survey on the link between productivity growth and innovation by Hall (2011) suggests that there is indeed a positive relationship between innovation and productivity, particularly so in knowledge-intensive industries.

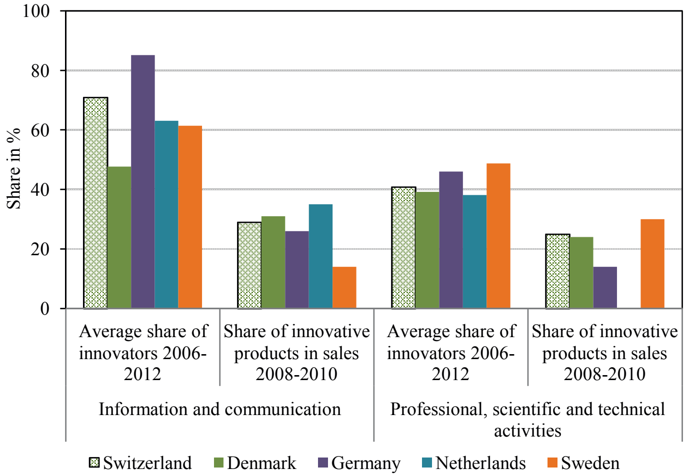
To study the relationship between innovative activity and productivity growth in the service sector, it is generally more appropriate to use measures on firms' innovations regarding products, processes or organization rather than, for instance, patents or R&D expenditures. The reason is that a substantial share of expenditures on process, product or organisational innovations may not be recorded as R&D expenditures or patents, but such innovations may be central for firms' success in the service sector.

Figure 21 provides a comparison of the innovation activities in two composite KIBS industries in Switzerland and other European countries. The figure shows the average share of firms who report product and process innovation activities and the share of innovative products in turnover. The data stem from the Community Innovations Surveys (CIS) 2008, 2010, and 2012, and from the KOF innovation surveys 2008, 2011 and 2013. The KOF innovation surveys are the Swiss equivalent of the CIS surveys in EU countries. First, the figure reveals that a substantial share of firms in Swiss ICT industries perform innovative activities. When averaging the data across the three survey years, 71% of all ICT firms (div. 62-63) and 41% of firms in professional, scientific and technical activities (div. 69–75) report to have product or process innovations in Switzerland. These values are similar (div. 69–75) or above average (div. 62-63) when compared to the shares observed in the other countries shown.

[39] According to Hall (2011, p. 4), there are mainly two main channels by which the presence of more innovative firms can translate into productivity improvements: "First, innovation in existing firms can both increase their efficiency and improve the goods and services they offer, thus increasing demand as well as reducing costs of production. Second, innovating firms are likely to grow more than others and new entrants with better products to offer are likely to displace existing inefficient firms, with a concomitant increase in aggregate productivity levels."

Measuring firms' innovation activities by considering the yes/no-questions on product or process innovation has some disadvantages, though (see Hall 2011). Many studies therefore consider a less noisy measure: the share of sales of innovative products. This indicator is thought to provide a good idea on the importance of innovations for a specific firm. In Figure 21, we compare the average of the firm-specific shares across the two composite industries for the years 2010–2012. The picture is similar to the one provided by the first indicator.

Figure 21 Incidence and Intensity of Innovation Efforts in KIBS Industries in Selected Countries



Source: Eurostat, Community and innovation surveys and KOF innovation surveys (Switzerland).

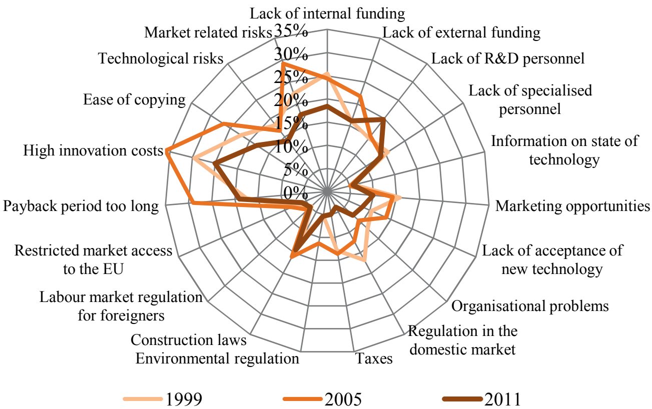
4.4.7. Regulation and Policy-Related Factors

This subsection examines whether there are regulatory or policy-related reasons that might have hampered productivity growth in the KIBS industries.

Obstacles to Innovation

The KOF innovation survey asks firms to assess on a 5-point Likert scale how strongly a number of factors hinder their innovation efforts. Figure 22 displays the share of firms in the KIBS industries that reported at least 4 points for the respective survey item. The results are shown for the years 1999, 2005 and 2011. In all periods, firms perceive high innovation costs, market-related risks and long payback periods to be important obstacles to their innovation efforts. An interesting finding is that most factors seem to have become less relevant in hampering innovation over time. Importantly, factors such as the regulation in the domestic market, environmental regulations, taxes and innovation costs are indeed substantially less important obstacles in 2011 compared to previous years. The only factor that has become more important is the lack of R&D personnel. Overall, these findings suggest that obstacles to innovation activities have become less important over time, especially those factors that are associated with taxes and regulations.

Figure 22 Factors Hampering Innovation Efforts in KIBS Industries

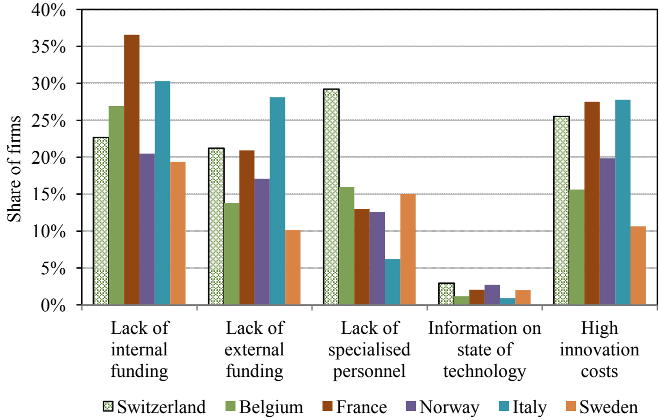


Notes: The figure shows the share of firms that give at least a value of 4 (out of 5) to the survey question as to whether the factor has negative consequences for their innovation efforts.

Source: KOF innovation surveys, waves 1999, 2005, and 2011.

In a next step, we provide an international perspective by comparing survey questions from the CIS survey 2010 and the KOF innovation survey 2011. For the ICT industries, Figure 23 shows that the lack of specialized personnel appears to be the most important factor hampering innovation efforts. In other countries, this factor seems much less important. Similarly, ICT firms in Switzerland consider innovation costs an important obstacle. As shown in Figure 24, similar comments apply to the industries of professional, scientific and technical activities. Again, by far the most important factors seem to be the lack of specialized personnel and high innovation costs. In sum, these findings suggest that policy measures that aim to reduce the shortages of qualified labor may be able to foster innovation in Swiss KIBS industries.

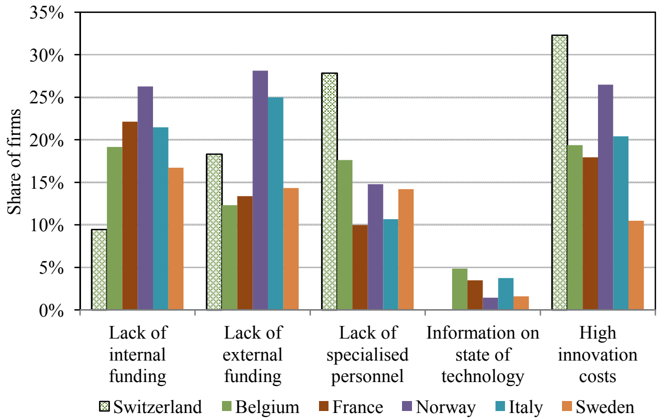
Figure 23 Obstacles to Innovation in the ICT Sector (NACE sec. J) in 2010 for selected countries



Notes: Data for EU countries refer to 2010 and for Switzerland to 2011. The denominator is innovative firms. Highly relevant means 4 on a 4-scale survey item for European countries. The Swiss scale has 5 values and is therefore not directly comparable. We use the average of the shares of firms giving a value of 5 and of firms giving a value of 4 and 5. For Switzerland, the lack of specialized personnel is a composite of three survey items (lack of R&D, specialized, and IT personnel).

Source: Eurostat, community innovation surveys 2010 and KOF innovation survey 2011.

Figure 24 Obstacles to Innovation Efforts Professional, Scientific and Technical Activities (NACE sec. M) in 2010 for Selected Countries



Notes and Source: see Figure 23.

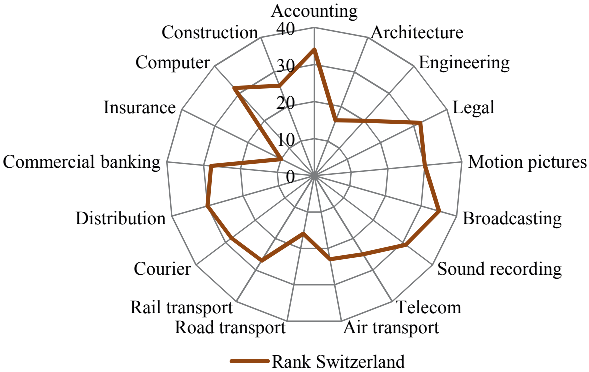
Restrictions to Service Trade

Restricted market access for foreign firms and high barriers to trade in general could be further regulatory factors that could hamper productivity growth in the KIBS industries. The reason is that the implied lack of competition reduces allocative efficiency gains (i.e., forcing prices to converge to marginal costs). As Ahn (2002, p. 5) puts it, competition is thought to have "pervasive and long-lasting effects on economic performance [of firms] by affecting economic actors' incentive structure, by encouraging innovative activities, and by selecting more efficient ones from less efficient ones over time." According to the literature review by Ahn (2002), empirical studies generally confirm the positive link between product market competition and productivity growth. Likewise, the growth reports of the SECO (e.g. SECO 2008) argue that the regulation of domestic markets and the implied lack of competition are important obstacles to innovation and productivity growth in the Swiss economy as a whole.

To examine the restrictiveness of services trade, we consider the new OECD Service Trade Restrictiveness Index (STRI). The overall index is available for 17 industries and combines five policy measures: restrictions on foreign entry, restrictions on the movement of people, other discriminatory measures, barriers to competition, and regulatory transparency (see Grosso et al. 2015). First estimates by Nordås & Rouzet (2015) suggest that high values in the STRI are associated with substantially lower cross-border imports and exports of services in an industry of a country, conditional on other observable characteristics. Figure 25 displays the rank of Switzerland implied by the STRI among all 40 countries for which the index is available.[40] The results indeed suggest that the restrictiveness of services trade may be a cause for the low productivity growth in Swiss KIBS industries. With some exceptions such as insurance, architecture and engineering, Switzerland's regulations with respect to service trade are comparatively restrictive. In 7 out of 17 industries, Switzerland ranks among the 10 most restrictive countries. Moreover, the comparatively low ranking of Switzerland in the STRI cannot be attributed to its small and fragmented market because similar small open economies such as the Belgium, Denmark and the Netherlands generally have much lower values in the STRI in most industries.

[40] These are all 34 current OECD member countries plus Brazil, India, China, Indonesia, Russia and South Africa.

Figure 25 Rank of Switzerland in the Services Trade Restrictiveness Index, 2014



Notes: The figure shows the rank of Switzerland in terms of service trade restrictiveness among 40 countries. 1=least restrictive, 40=most restrictive.
Source: OECD.

4.4.8. Summary

We can sum up the findings of this section as follows. The indicators on the profitability and the business demography of KIBS industries do not point to any structural weaknesses that would cause a persistent fall in labour productivity. The skill intensity of the workforce has increased substantially relative to manufacturing and wage growth has been higher than in manufacturing and traditional services. The export performance of Swiss KIBS industries has remained stable over time. Switzerland's firms in the KIBS industries appear to have similar levels of innovation activities as their counterparts in other developed countries. Furthermore, the finding in Section 4.2.2 that the KIBS industries have a constant share in nominal value added and an increasing share in total employment is inconsistent with a permanent decline in labour productivity, too. The reason is that market-oriented industries with a long-term decline in labour productivity are not expected to attract a constant or even increasing share of the capital. If this were the case, the allocation of resources would become increasingly inefficient (Corrado & Slifman 1999). In a competitive market economy, it is more likely that declining labour productivity leads to a (relative) reduction in investment in these industries, which eventually results in declining employment and value added shares of these industries.

On the other hand, the evidence on investment and innovation obstacles is more mixed: the shortage of skill workers and high innovation costs have been identified as potential obstacles to innovation. Moreover, there are some indications that certain aspects of the regulatory framework, such as trade restrictiveness, might hamper innovation. These factors could have had a negative influence on the evolution of labour productivity. In summary, however, our empirical analysis of productivity-related indicators does not support a persistent long-term decline of labour productivity as shown by the data. Moreover, the analysis could not provide economic reasons why labour productivity growth in Swiss KIBS industries is much weaker than in the other market-oriented sectors in Switzerland (i.e., manufacturing and traditional services).

4.5. Labour Productivity Using Alternative Deflators

The analysis in the last section could not provide support for the view that the low productivity growth in the KIBS industries is attributable to hard economic facts. This section thus turns to the main alternative explanation: it seeks to shed light on the question as to whether the cause for the poor productivity growth in the KIBS industries is to be found in the mismeasurement of real value added. As discussed in Section 3.3, the appropriate deflation of value added is the aspect of measurement that is most prone to measurement error because it is inherently difficult to measure pure price changes in service activities. Moreover, about 36% of nominal value added is deflated using wage-based deflators in Swiss KIBS industries (see Section 4.3.2). As has been discussed in Section 3.3.2, wage-based deflation is prone to underestimate the growth of the volume of value added, and thus, labour productivity. To examine the quantitative relevance of this bias, we substitute wage-based deflators with alternative price indices (to the extent that this is possible) and then re-calculate labour productivity growth. It is important to highlight, however, that these alternative calculations should best be seen as *approximations* or *thought experiments* that are meant to illustrate the quantitative impact of various deflators on productivity statistics. The reason is that we do not have all of the data required to precisely replicate the calculations of the official productivity statistics.[41]

We will consider three types of alternative output price deflators:

1) *Skill-adjusted wage index:* an alternative wage-based deflator that seeks to hold constant any change in the skill composition over time. Importantly, this

[41] In particular, we do not have data on the explicit output price deflators, the share of FISIM in intermediate input costs, the shares of R&D in inputs and outputs and the specific deflators applied to FISIM and R&D. See also Appendix A.1 for a formal description on the treatment of FISIM and R&D in the deflation procedure.

index cannot eliminate the potential bias associated with wage-based deflation, but only reduce it.

2) *Foreign SPPIs:* deflators may be constructed from more appropriate price indices of other countries. An important aspect is to take into account cross-country differences in inflation.
3) *Unmatched deflators:* an output price index may be used that does not match the output of the industry. We will use the core inflation rate.

4.5.1. Skill-Adjusted Wage Index (SAWI)

A major limitation of the Swiss Wage Index as a deflator for value added is the fact that it also captures wage growth attributable to changes in the skill structure of the workforce over time (see Section 4.3.1). If, for example, the share of high-skilled workers in a given industry increases, the SWI records a rise in the average wage. At the same time, a larger share of high-skilled workers is also expected to raise the amount of human capital per worker and should therefore increase labour productivity. If the wage index is used as a deflator for value added in this situation, labour productivity growth is *underestimated* (cf. Section 3.3).

To attenuate the bias that arises due to changes in the skill structure of the labour force, we propose a *skill-adjusted wage index* (SAWI) that only captures wage growth given that the skill structure remains constant over time. The basic idea is taken from OECD-Eurostat (2014).

Econometric Framework

The computation of the SAWI involves the estimation of a *counterfactual average wage* – the wage we would observe if the skill composition had not changed – which requires a microeconometric framework. To formalize the idea of the SAWI, we consider a population of workers consisting of two pooled cross-sections, where we denote the time periods by $T = t$ and $T = t - 1$. Let y be the wage and X the vector of covariates that include demographic characteristics and indicators for skill level. The *unadjusted* wage index for a given industry, which is equivalent to one plus the growth rate from $t - 1$ to t, is:

$$WI_t = \frac{E[y|T = t]}{E[y|T = t - 1]}.$$

Next, we introduce the wage function $E[y|X = x, T = t]$. This function describes the average wage in year t, *conditional* on a set of worker characteristics, $X = x$. The counterfactual wage of interest is given by $E[E[y|X = x, T = t]|T = t - 1]$, which corresponds to the average wage that we would observe in year t if the distribution of skill variables and other characteristics contained in X had remained as in year $t-1$. The SAWI is therefore:

$$SAWI_t = \frac{E[E[y|X=x,T=t]|T=t-1]}{E[y|T=t-1]}.$$

Put simply, the SAWI captures average wage growth if the distribution of worker characteristics is held constant at year $t-1$.

The numerator (i.e., the counterfactual average wage) does not arise from any observed population and must therefore be estimated. We use the so-called semi-parametric reweighting estimator originally proposed by DiNardo et al. (1996). Among the methods available, this estimator is relatively easy to implement, computationally inexpensive and has desirable efficiency properties (Hirano et al. 2003). Moreover, there is no need to model and estimate the wage function, which may be problematic due to misspecification.

To ensure the identification of the estimand, we impose that the covariates in year t must not contain any values that are unobserved in year $t-1$.[42] This assumption can be tested empirically and appropriate adjustments are simple if violations are detected. The results derived in DiNardo et al. (1996) imply that the SAWI can be re-formulated as follows:

$$SAWI_t = \frac{E[y \cdot \Psi(x)|T=t]}{E[y|T=t-1]},$$

where

$$\Psi(x) = \frac{P(T=t-1|X=x)/P(T=t-1)}{(1-P(T=t-1|X=x))/(1-P(T=t-1))}.$$

In other words, re-weighting the data in year t by the factor $\Psi(x)$ produces the counterfactual average wage. Appendix C contains a detailed derivation of the estimator.

Data

We use the data from the Swiss Wage Structure Survey (LSE) for the period 1996 to 2012 to estimate the SAWI for individual two-digit industries. The LSE is conducted bi-annually and represents the most comprehensive source of wage data in Switzerland, with a sample size ranging between 0.6 and 1.7 million employees (depending on the year). The major obstacle to our analysis lies in the inconsistent

[42] This is the so-called *overlapping support assumption*, which can be stated as follows: $supp(X|T=t) \subseteq supp(X|T=t-1)$.

industry codes across years, meaning that the old industry classification (NACE rev. 1.2) must be converted to the new classification (NACE rev. 2).[43] The conversion can be performed with reasonable precision if detailed industry codes are available. Unfortunately, the available data only contains a *grouped* two-digit industry code for the years before 2008; the detailed five-digit code is no longer provided by the SFSO. What complicates matters particularly is that the *grouping* of two-digit industries may generate substantial bias when applying the official conversion key, which is based on the *original* two-digit code. Also, the grouping of industries in the old LSE data is slightly different from wave to wave. Given these circumstances, there are two ways to proceed to estimate wage indices prior to 2008:

- *Option 1:* A matrix of empirical transition probabilities is estimated from the LSE in 2008, which contains both old and new industry codes.[44] Afterwards, wage indices can be estimated for each *new* industry code (NACE rev. 2) by using transition probabilities as weights (along with the sampling weights).
- *Option 2:* Wage indices are estimated for each of the *old* industry codes (NACE rev. 1.2). Afterwards, wage indices are combined and weighted according to the probability weights from the official conversion keys in order to reflect the *new* industry definitions.

It turns out that the first option produces very erratic results that probably arise from the imprecise construction of transition probabilities. In contrast, the estimates obtained from the second option yield more stable and plausible results such that this option is chosen. Moreover, this procedure is also used by the SFSO in the calculation of the wage-based deflators from the SWI.

Covariates

An important issue is to select a suitable set of covariates. Given the available data in the LSE, we select the following:

- highest educational attainment (8 dummy variables)
- skill requirement level of the job (3 dummy variables)
- age (quadratic function)
- gender (1 dummy variable)
- part-time work (1 dummy variable)

[43] For the years prior to 2008, industry codes are based on NACE rev. 1.2; from 2008 onward, industry codes are based on NACE rev. 2.

[44] It bears emphasis that this procedure is considerably more imprecise compared to a re-classification based on the detailed five-digit code.

- job position / management level (4 dummy variables)
- task category (number of dummies depends on industry)[45]
- firm size (3 dummy variables)

The first two covariates are directly related to workers' endowment with skills. Age is intimately related to work experience which is also an important component of human capital. We also include gender because of the substantial and changing differences between the wage distributions of men and women. Part-time work, management level and tasks also constitute potentially important factors in determining wage growth. Finally, we also control for firm size. Although this variable is not directly related to skills, it is included to improve the comparability of average wages over time.[46]

In contrast to the SAWI, the SWI only holds the shares of male and female workers constant. Moreover, while the SAWI is estimated for each two-digit industry, the SWI is computed on the level of *grouped* two-digit industries. In other words, if a relatively more productive (and high-wage) two-digit industry within a group increases its employment share, the SWI will record a wage increase, even if the average wage in each individual industry remains the same.

Implementation Algorithm

The estimation of the SAWI for a given industry *j* is carried out with the following algorithm:

1) Two adjacent waves from the LSE are merged together. Observations belonging to industry *j* are selected.
2) Observations below the 1st percentile and above the 99th percentile of the wage distribution in each year are dropped from the sample. This step increases the robustness to extreme outliers. (Note that a similar trimming is performed in the calculation of the SWI, see SFSO 2012.)
3) The (arithmetic) mean wage in wave *t*-1 is computed using sampling weights.
4) The conditional probability, $P(T = t - 1 | X = x)$, is estimated with a logit model that includes the covariates mentioned above.

[45] The LSE categorizes jobs in terms of 24 tasks. Obviously, not all tasks are relevant in a given industry such that the set of covariates need be industry-specific. To avoid imprecise estimates, we generate dummy variables for those tasks where there are at least ten observations in a given industry in both years. Tasks with fewer observations are pooled in a reference category.

[46] If the LSE sample consists of only few firms within a certain industry, the random sampling bias can cause significant changes in the average within-industry firm size across years. Since wages may vary systematically by firm size, observed wage growth is affected by this bias. Accounting for the change in the firm size distribution corrects for this bias.

5) Observations with estimated probabilities outside the range [0.01,0.99] are discarded from the sample. This step increases the robustness of the estimation procedure and ensures that the common support assumption is satisfied. (Note that in most industries, there are no observations outside this range.)
6) The logit model is re-estimated and the conditional probabilities are re-calculated. The reweighting factor $\widehat{\Psi}(x)$ is computed using the conditional probability, $\hat{P}(T = t-1|X = x)$, and the weighted share of observations belonging to wave $t-1$, $\hat{P}(T = t-1)$.
7) The counterfactual average wage in wave t is estimated using the semi-parametric re-weighting estimator. Sampling weights are used.
8) The estimates from steps 3) and 7) are combined to calculate the SAWI.

Results

First, we present results for the years 1996 to 2010, which are based on the *old* classification NACE rev 1.2. Table 9 compares average annual wage growth based on the SWI and the LSE. Except for "post and telecommunications" and "financial intermediation", the wage growth implied by the unadjusted LSE data is higher than implied by the SWI. For post and telecommunication, the difference is substantial: while wage growth is 1.6% in the SWI, it is 0.1% in the LSE. The differences are hard to explain and may be related to the differences in wage concepts, sampling design, or the representativeness between SWI and LSE. The last column

Table 9 Comparison of Average Annual Wage Growth

NACE rev. 1.2 industry (NOGA 2002)		average annual wage growth 1996-2010		
		SWI	LSE (raw)	LSE (skill-adj.)
21-22	paper products, publishing	0.91%	1.18%	0.74%
64	post and telecommunications	1.61%	0.09%	0.60%
65	financial intermediation	1.91%	2.29%	2.40%
66	insurance	1.65%	1.48%	1.13%
67	auxiliary activities to financial intermediation	1.69%	1.55%	1.40%
70-74	real estate, renting, computer services, R&D, business services	1.52%	1.08%	1.08%
90-93	other social or personal services	1.19%	1.35%	0.81%

Notes: Estimates based on the LSE are own calculations. The skill-adjusted estimates are based on the semi-parametric re-weighting estimator. The estimates based on the SWI are taken from official statistics.

Sources: Swiss Wage Index (SWI, SFSO) and Swiss Wage Structure Survey (LSE).

shows that the adjustment for shifts in the skill distribution over time lowers average wage growth. Except for post and telecommunications and financial intermediation, the SAWI has lower growth rates than the raw wage index calculated from the same data source (the LSE). This difference suggests that the skill intensity in these industries has risen over time such that average wage growth adjusted for this increase is lower.

Next, we transform the wage indices for the period 1996–2008 from the old to the new industry classification by applying the probability weights from the official conversion key. For the period 2008–2012, no conversion is necessary because the LSE includes the new industry codes. The SAWI is then used as an alternative deflator for value added in those KIBS industries where the SWI is used as a deflator. Table 10 illustrates the impact on annual labour productivity growth in Swiss KIBS industries for the period 1997–2012.

Table 10 Annual Labour Productivity Growth 1997-2012 Based on the SAWI

		double deflation	single deflation		
code	industry	original data	original implicit output deflator	SAWI (based on the LSE)	diff.
58-60	Publishing, audiovisual and broadcasting activities	-1.6%	-1.0%	-0.9%	0.1
61	Telecommunications	5.5%	5.0%	-	-
62-63	IT and other information services	-2.5%	-1.9%	-1.6%	0.3
64	Financial activities	0.0%	-0.3%	-	-
65	insurance activities	3.3%	2.8%	-	-
68	Real estate activities	-3.3%	-2.9%	-	-
69-71	Legal, accounting, management, architecture, engineering activities	-1.6%	-1.0%	-0.8%	0.2
72	Scientific research and development	-2.7%	-2.4%	-2.1%	0.2
73-75	Other professional, scientific and technical activities	-2.7%	-2.1%	-2.0%	0.1
77-82	Administrative and support service activities	-0.4%	-0.6%	-0.5%	0.1
	Total KIBS	-0.3%	-0.3%	-0.2%	0.1
	Total non-financial KIBS	-1.0%	-0.6%	-0.4%	0.2

Notes: The table shows the impact on labour productivity growth if deflators based on the SWI are substituted with deflators based on the SAWI. The SAWI estimated by the semi-parametric reweighting estimator.

Sources: Productivity Statistics (SFSO), Swiss Wage Structure Survey (SFSO), own calculations.

We note that the effects on labour productivity growth are relatively benign: annual growth rates of labour productivity in KIBS industries are only raised by 0.1 to 0.3 percentage points. In sum, labour productivity growth increases by 0.2 percentage points in the non-financial KIBS industries and by 0.1 percentage points in the overall KIBS industries. We conclude from these findings that mere shifts in the skill structure of employment can only explain a small fraction of the poor productivity growth measured in the KIBS industries.

4.5.2. Foreign Service Producer Price Indices (SPPIs)

Another possibility is to substitute the wage-based deflators with SPPIs that are collected in other countries (see Schreyer (2002) for an empirical application to ICT deflators). For example, one could deflate nominal value added of the Swiss industry "computer programming, consultancy and related activities" (div. 62) using the French SPPI of the same industry. The choice of source countries depends on several aspects. First, an appropriate SPPI must be available for the source country. Second, the composition of the industry in question across Switzerland and the source country should be roughly comparable. In other words, the underlying weights of the foreign SPPI should match those of Switzerland as closely as possible. Finally, the competitive environment should be comparable such that output price growth may be assumed to be similar.

Availability of SPPI for KIBS industries varies widely. While France and the UK had indices for 12 KIBS industries in 2012, some countries such as Italy and Portugal had none at all.[47] For our analysis, we will consider the SPPIs collected in France, Germany and the UK. These countries have introduced a fair number of SPPIs for KIBS industries and the service activities in these countries should be more or less comparable to their counterparts in Switzerland. Moreover, the statistical offices of these countries have been leading in the development of SPPIs in Europe (cf. OECD-Eurostat 2014). Table 11 shows the years in which SPPIs were introduced across countries. France started many data collections in 2005 and Germany in 2006. For Switzerland, only three SPPIs have been used as deflators thus far.

[47] By and large, it appears that larger countries tend to collect more price data than smaller countries which is probably attributable to differences in the resources of national statistical offices.

Table 11 Availability of SPPIs by Country (Year Since)

code	industry	CH	FR	GER	UK
58	Publishing activities		2008		
59	Motion picture, video and television programme production				
60	Programming and broadcasting activities		2012		
61	Telecommunications		2007	2006	1998
62	Computer programming, consultancy and related activities		2005	2006	1998
63	Information service activities		2005	2006	2009
69	Legal and accounting activities		2005		2010
70	Activities of head offices; management consultancy activities		2010		2010
71	Architectural and engineering activities	2002/ 2009	2005	2006	2009
73	Advertising and market research		2005	2006	2006
74	Other professional, scientific and technical activities				2009
78	Employment activities		2005	2006	1997
80	Security and investigation activities	2009	2005	2006	1997
81	Services to buildings and landscape activities	2009	2010	2006	1997
82	Office administrative, office support and other business support activities				2009

Notes: SPPIs introduced later than 2012 are not considered in the table.
Sources: SFSO and Eurostat.

To derive a price index for Switzerland from its foreign counterpart, we assume that the price change in industry *j* is proportional to the inflation rate in each country. In other words, we calculate the SPPI as follows:

$$\left(\frac{P^j_{t,CH}}{P^j_{t-1,CH}}\right) = \left(\frac{\pi_{t,CH}}{\pi_{t,F}}\right)\left(\frac{P^j_{t,F}}{P^j_{t-1,F}}\right),$$

where the first term on the right-hand side is the ratio of the Swiss core inflation rate (CH) and the core inflation rate in the foreign country (F) as measured by the CPI excluding energy and food. The second term is the SPPI in the foreign country. The motivation to adjust for differences in average inflation is that it takes into account that the *average prices* (i.e., the value of money) change at different rates across countries. Important reasons are differences in inflation expectations and monetary policies across countries. We thus essentially compare the *excess inflation* in output price growth in KIBS industries over core inflation across countries and postulate that this difference may be comparable across countries.

Table 12 shows the impact of applying different inflation-adjusted foreign SPPI on average annual labour productivity growth in Swiss KIBS industries from 2005 to

2012. The first column shows the original data from the SFSO that is based on double deflation from 2008 onward. The second column shows the results from single deflation, where the *original implicit Swiss output deflator* is applied to both output and intermediate inputs. The remaining columns show labour productivity growth when SPPIs from other countries (where available) are applied to output and inputs as alternatives for wage-based deflators. Since we cannot perform double deflation due to data constraints, comparisons have to be made between the original implicit Swiss output deflator and the foreign SPPIs; the original data are merely shown for completeness.[48]

We note that the application of foreign SPPI deflators to the Swiss data raises calculated labour productivity growth considerably in some cases. The effect is most pronounced in "IT and other information services" (div. 62-63), where *annual* labour productivity growth based on foreign SPPIs is between 2.1 and 3.5 percentage points higher than the corresponding number based on the original Swiss output deflators (SWI). The quantitative difference among the results from the French, UK and German SPPIs stem from different magnitudes of price changes in these countries but partly also from different periods of availability of the SPPI data (cf. Table 11): the longer the period for which the SPPI is available, the larger tends to be the measured effect. The bottom of the table shows the aggregate results using the aggregation procedure explained in Appendix A.2. For the overall KIBS industries, average annual labour productivity growth is 0.3–0.4 percentage points higher if Swiss wage-based deflators are substituted with inflation-adjusted foreign SPPIs. If the financial sector is excluded, the effect amounts to 0.5–0.7 percentage points.

It is important that the *quantitative* results in Table 12 are interpreted cautiously. First, we do not employ double deflation, which would be conceptually preferable. Second, our calculations do not account for the share of R&D in output and input costs and for the share of FISIM in input costs. These quantities are deflated separately by the SFSO. Despite these restrictions, the *qualitative* results are meaningful: if SPPIs were available for Switzerland and if average price movements were roughly comparable to those in other countries, the measured productivity growth rate in Swiss KIBS industries would likely be substantially higher.

[48] Double deflation would require the explicit output price deflators *for all industries*. Unfortunately, we do not have this data. Moreover, note that we cannot properly account for FISIM and R&D at this stage which is deflated separately in practice (see Appendix A.1).

Table 12 Annual Labour Productivity Growth 2005-2012 in Switzerland Using Foreign SPPIs (Inflation-Adjusted)

		double deflation	single deflation						
code	industry	original data	original implicit output deflator	French SPPI (inflation-adjusted)	diff.	UK SPPI (inflation-adjusted)	diff.	German SPPI (inflation-adjusted)	diff.
58-60	Publishing, audiovisual and broadcasting activities	-3.3%	-2.1%	-	-	-	-	-	-
61	Telecommunications	3.9%	2.9%	-	-	-	-	-	-
62-63	IT and other information services	-2.0%	-0.7%	1.4%	2.1	1.6%	2.3	2.9%	3.5
64	Financial activities	-3.0%	-3.6%	-	-	-	-	-	-
65	insurance activities	2.3%	3.0%	-	-	-	-	-	-
68	Real estate activities	-3.0%	-2.1%	-	-	-	-	-	-
69-71	Legal, accounting, management, architecture, engineering activities	-0.9%	0.4%	0.8%	0.3	0.7%	0.3	-	-
72	Scientific research and development	-4.4%	-3.6%	-	-	-	-	-	-
73-75	Other professional, scientific and technical activities	-1.2%	0.0%	1.3%	1.3	1.7%	1.8	0.8%	0.8
77-82	Administrative and support service activities	2.5%	2.1%	2.0%	-0.1	3.0%	0.9	2.3%	0.2
	Total KIBS	-0.9%	-0.6%	-0.3%	0.3	-0.2%	0.4	-0.3%	0.3
	Total non-financial KIBS	-0.5%	0.3%	0.7%	0.5	0.9%	0.7	0.9%	0.6

Notes: Effects are calculated from replacing Swiss wage-based deflators by foreign SPPI (where available). The adjustment for inflation differentials is based on the core CPI. Sources: Productivity Statistics (SFSO), Eurostat, OECD, own calculations.

4.5.3. Unmatched Price Indices

For certain service industries, prices are notoriously difficult, or even practically impossible, to measure. A case in point is the industry "Scientific research and development" (div. 72) for which no SPPIs are available because these services are unique and cannot be compared adequately. In such situations, a price deflator may be used that is based on a very broad basket of goods and services, a so-called unmatched price index. The underlying assumption is that prices in a particular industry evolve similarly as *average prices*. While this assumption is certainly strong, it may represent the "best guess" if there exists no useable information on prices in a given industry. From a statistical viewpoint, the average price change can be viewed as the best unbiased predictor given that *no information* is available.[49]

Table 13 Average Annual Labour Productivity Growth 1997-2012 in Switzerland Using Core Inflation

		double deflation	single deflation		
code	industry	original data	original implicit output deflator	Swiss core inflation (PPI)	diff.
58-60	Publishing, audiovisual and broadcasting activities	-1.5%	-1.0%	-0.6%	0.4
61	Telecommunications	5.5%	5.0%	-	-
62-63	IT and other information services	-2.5%	-1.9%	-0.6%	1.3
64	Financial activities	0.0%	-0.3%	-	-
65	insurance activities	3.3%	2.8%	-	-
68	Real estate activities	-3.3%	-2.9%	-	-
69-71	Legal, accounting, management, architecture, engineering activities	-1.6%	-1.0%	-0.1%	0.9
72	Scientific research and development	-2.7%	-2.4%	-1.1%	1.3
73-75	Other professional, scientific and technical activities	-2.7%	-2.1%	-0.9%	1.3
77-82	Administrative and support service activities	-0.4%	-0.6%	0.2%	0.7
	Total KIBS	-0.3%	-0.3%	0.2%	0.4
	Total non-financial KIBS	-1.0%	-0.6%	0.2%	0.8

Notes: Effects are calculated from replacing Swiss wage-based deflators by the Swiss core PPI. Sources: Productivity Statistics (SFSO), Swiss National Bank (SNB), own calculations.

[49] If price changes are generated by a well-defined probability distribution, the average or arithmetic mean represents the best unbiased predictor for a randomly drawn observation.

We compute the impact of substituting wage-based deflators with deflators that are equivalent to the *Swiss core inflation rate in producer prices*. Core inflation is computed by the Swiss National Bank and includes all producer prices except raw material and other items which are prone to strong cyclical movements (meat, tobacco, oil products, metals and gas). Table 13 presents the effect on average annual labour productivity in Swiss KIBS industries for the period 1997 to 2012. The calculations show that annual labour productivity growth remains slightly negative in most industries when core inflation is used as a deflator. However, in comparison to the numbers based on the original output deflator, annual growth rates increase by up to 1.3 percentage points. This is, for example, the case in IT and other information services, scientific R&D and other professional, scientific and technical activities. The average growth rate in the overall KIBS industries rises by 0.4 percentage points and becomes slightly positive (0.2%). If the financial industries (div. 64-65) are excluded, the difference amounts to 0.8 percentage points.

On the whole, these calculations show that a substitution of wage-based deflators with the crude “best guess”-deflator, the core inflation rate in producer prices, would raise measured labour productivity in the KIBS industries considerably. Although labour productivity would still be low, it would be slightly positive.

4.6. Aggregate Effects

In this section, we investigate to what extent changes in the productivity growth of KIBS industries have an impact on *aggregate* growth rates of value added and labour productivity in the overall Swiss business sector. These estimates also give an indication of the potential mismeasurement of real GDP growth arising from measurement problems of output price growth in KIBS industries. The reason is that nominal value added in the business sector amounts to 78–79% of GDP in Switzerland over the period 1997-2012.

4.6.1. Alternative Deflators

First, we examine the effects of substituting deflators in the KIBS industries with alternative deflators on the growth rates of the aggregate market economy. In this exercise, we only substitute deflators of KIBS industries if they are based on wages, whereas original deflators are maintained if they are based on other indices. The aggregation from industry-level data to the level of the business sector follows the standard procedure explained in Appendix A.

The results for the aggregate effects on the level of the Swiss business sector are displayed in Table 14. The top panel shows growth rates of labour productivity and value added if the SAWI and the core inflation are used as substitutes for the conventional wage-based deflators in the KIBS industries. The impact on aggregate productivity growth is negligible when replacing wage-based deflators with the SAWI (+0.03 percentage points). This is a consequence of the low impact of correcting for observed skills in the labour force on average wage growth, but also of the fact that wage growth is generally higher in the LSE compared to the SWI. Using the core inflation rate as an unmatched deflator, however, raises annual aggregate labour productivity in Switzerland by 0.13 percentage points in the period 1997–2012. Given an average growth rate of labour productivity of about 1%, the effect seems quantitatively important. Moreover, note that this effect on labour productivity growth on the level of the business sector arises despite the fact that KIBS industries with wage-based deflators only constitute about 11% of nominal value added of the entire business sector.

The table also shows the impact of replacing the wage-based deflator on the growth rate of value added. The *absolute* effect on the growth rate of aggregate value added is the same as on labour productivity, but the *relative* effect is smaller because average growth rates are roughly twice as high.

Table 14 Effects on Average Growth Rates of the Swiss Business Sector under Different Scenarios

	labour productivity		value added	
1997 - 2012	growth rate	diff.	growth rate	diff.
original Swiss output deflator	1.07%		2.17%	
SAWI	1.09%	0.03	2.19%	0.03
Swiss core inflation (PPI)	1.20%	0.13	2.30%	0.14
2005 - 2012	growth rate	diff.	growth rate	diff.
original Swiss output deflator	0.69%		2.27%	
French SPPIs	0.77%	0.08	2.36%	0.09
German SPPIs	0.79%	0.10	2.37%	0.10
UK SPPIs	0.81%	0.12	2.39%	0.12

Notes: aggregate effects are calculated from the effects presented in the previous sub-section.

The bottom panel of Table 14 displays the aggregate impact of substituting wage-based deflators in the KIBS industries with SPPIs from other countries. These numbers refer to the period 2005–2012 during which labour productivity grew more slowly. The estimated effects on average annual labour productivity growth in the business sector are around 0.1 percentage points. Given an average growth rate of labour productivity of about 0.7%, these effects also appear quite meaningful.

4.6.2. Corrado-Slifman Correction

Another way to examine the potential effect of mismeasurement of real value added in the KIBS industries on aggregate labour productivity is to perform a Corrado-Slifman correction for these industries (see Section 2.1.1). These authors argue that negative long-run labour productivity growth on the industry level is implausible because it would suggest that the allocation of resources across industries becomes worse in the long run (Corrado & Slifman 1999). For this reason, they suggest a thought experiment in which productivity growth should be set to zero for industries with negative long-run growth. This amounts to the assumption that real value added grows at the same rate as labour input. Note that this assumption can be seen as quite defensive because it appears more plausible that some of the KIBS industries with declining labour productivity in Switzerland actually had an increase in labour productivity in the last 15 years (e.g. ICT services).

Table 15 presents the effect on the aggregate growth rates of the Swiss business sector if labour productivity growth of those KIBS industries with negative long-run growth is set to zero. The aggregate growth rates of labour productivity and value added both increase by about 0.2 percentage points. This effect is larger in magnitude than those reported from the application of alternative deflators.

Table 15 Effect of the Corrado-Slifman Correction on Average Growth Rates in the Business Sector

	labour productivity		value added	
1997 - 2012	growth rate	diff.	growth rate	diff.
original Swiss output deflator	1.065%		2.166%	
Corrado-Slifman correction	1.280%	0.214	2.383%	0.217

Notes: The Corrado-Slifman correction resets labour productivity growth to zero for those KIBS industries where long-run labour productivity growth is negative.

It bears emphasis that the Corrado-Slifman correction does not seek to improve the measurement methods underlying the calculation of labour productivity. Therefore, it provides no solution to the measurement problems associated with real value added. However, it can provide a rough idea of the extent to which potential mismeasurement in *a subset of industries* translates into a bias in aggregate productivity statistics and the national accounts more generally.

4.7. Explanations for the Productivity Puzzle

The calculations in the previous two sub-sections merely represent an attempt to gauge the quantitative impact of potential mismeasurement in some of the KIBS industries. If wage-based deflators are replaced by either foreign SPPI or the Swiss core PPI, average labour productivity growth in the overall KIBS industries is lifted by 0.3 to 0.4 percentage points, but remains still low relative to other sectors. Thus, our calculations cannot fully explain the productivity shortfall relative to other industries in Switzerland. One possible explanation for this is that the *entire scope of measurement problems* is not captured by our calculations:

- In the application of foreign SPPI, not all wage-based deflators can be replaced because SPPI are not available for some industries.
- In the overall KIBS industries, the share of value added that is deflated with wage indices is 36%. The simulation exercises therefore only apply to this fraction of the overall value added of the KIBS industries.
- In the financial industries, the adequate measurement of *nominal* value added still remains difficult. This issue could be relevant because the financial industries constitute 42% of value added in the KIBS industries.
- Other deflators used for certain KIBS industries (CPI, SPPI or others) might also be prone to measurement error, especially if quality changes are not properly accounted for. Therefore, labour productivity growth in these industries may also be too low due to mismeasurement.
- Finally, the evolution of labour input, the denominator of labour productivity, may be more prone to measurement error in some industries compared to others.

Therefore, it is unclear how much labour productivity would rise if prices were measured correctly in *all* KIBS industries. According to OECD-Eurostat (2014), properly accounting for quality change continues to be challenging in many service industries even if SPPIs based on modern methods, such as model pricing, are used. It remains a matter of speculation to what extent the “productivity gap” between KIBS industries and, say, manufacturing is attributable to measurement error.

Second, it is conceivable that the relatively poor performance of KIBS industries is at least partly related to “hard” economic factors rather than the result of mismeasurement. Our analysis of productivity-related indicators across industry groups (Section 4.4) does not provide evidence in favour of a productivity shortfall of the KIBS industries relative to manufacturing and traditional services, so there may be additional unobserved factors that play a role. A theoretical growth framework as the one presented in Box A can provide some guidance: the model suggests that labour productivity growth depends on the capital-labour ratio, the human capital intensity and technological progress (innovation). Below, we discuss a number of potential explanations:

- *Capital deepening*: It is possible that industries differ in their potential to increase the capital-labour ratio over time. For instance, if there is limited scope for the automation of tasks or other labour-saving measures in some service industries, the growth rate of the capital-labour ratio, and thus, the growth rate of labour productivity will be lower than elsewhere in the economy.
- *Innovation*: The impact of innovation on productivity runs through two main channels (see Hall 2011). First, innovation increases the efficiency of production and improves the quality of goods and services. Second, innovating firms are likely to grow faster and will therefore displace non-innovating firms. If innovation activities are inherently industry-specific, different levels of innovation activities across industries will lead to different growth paths. If innovation activities had been low in the KIBS industries, there would have been a negative impact on labour productivity.
- *Competition*: Competition can affect the productivity of firms in two ways. First, increasing competitive pressure will typically drive the least efficient firms out of the market and induce a re-allocation towards more efficient firms. This will increase labour productivity in the average firm. Second, more competition can induce a given surviving firm to become more efficient by reducing so-called "X-inefficiencies" that prevail under imperfect competition. Holmes & Schmitz (2010) provide a theory and empirical evidence for these effects. It is possible that the intensity of competition has been lower in the KIBS industries compared to other sectors – e.g. due to trade restrictions (see Section 4.4.7) – and that this has led to slower productivity growth.
- *Initial Productivity Level*: In 1997, the nominal value added per worker was much higher in the KIBS industries than elsewhere in the market economy (cf. Table 4). Although differences in nominal levels are difficult to interpret in the cross-section, this finding could mean that the productivity in KIBS industries had grown faster than the other sectors prior to 1997. The poor productivity performance of the KIBS industries relative to other industries could therefore be the result of a catch-up of other industries. If this were the case, the productivity performance of the KIBS industries would improve if the analysis could be conducted over a longer time period. Unfortunately, older data are not available on the two-digit industry level.

The capital-labour ratio, innovation activities and the competitive environment all provide potential explanations why true labour productivity growth might differ across industries in the long run. At the same time, these factors are difficult to observe empirically. For example, there is no data on physical capital on the industry level in Switzerland. To sum up, it remains difficult to assess the relevance of the above mentioned factors in explaining the weak productivity growth of the Swiss KIBS industries.

5. Conclusions

The knowledge-intensive business service (KIBS) industries of the Swiss economy have been characterized by negative average labour productivity growth over an extended period of time. This finding is puzzling for a number of reasons. First, a long-run decline in productivity among market-oriented industries would imply an increasingly inefficient allocation of resources. Second, these industries typically have high levels of innovation and make intensive use of information technology. One would therefore expect that technological progress should be visible in terms of positive labour productivity growth. Third, the skill intensity and the average wages of workers have increased more than on average. Given these empirical facts, this paper has investigated if and to what extent the apparent weakness in productivity is attributable to measurement error in the data.

This paper has demonstrated that the labour productivity data for the Swiss KIBS industries is prone to mismeasurement because inappropriate deflators are used in the conversion of nominal value added to real value added. Since appropriate service producer price indices (SPPIs) are not (yet) available for most KIBS industries in Switzerland, 62% of value added in non-financial KIBS industries is deflated using wage indices as deflators. In general, this method is problematic because increases in wages not only reflect pure price movements, but also improvements in workers' productivity. As a consequence, measured labour productivity is downward biased.

The most important findings of our empirical analysis are summarized as follows. First, we have examined a range of productivity-related indicators to assess whether the official productivity statistics for the KIBS industries are plausible. We find that (i) average profit margins, the skill intensity of workers and average wages have increased more in KIBS industries than in other industries; (ii) there have been no notable changes in firm demography or service exports; (iii) investment activities are similar to those in other countries; (iv) there are certain obstacles to innovation in the KIBS industries, but they have become less important over time. In summary, our empirical analysis of productivity-related indicators does not support a persistent long-term decline of labour productivity as suggested by the data.

Second, we apply a number of alternative deflators to the data to assess the impact of the wage-based deflators on labour productivity growth in the Swiss KIBS industries. First, we apply a skill-adjusted wage index that corrects for changes in the observed skills of workers. The wage-based deflator currently applied to deflate output in the KIBS industries does not account for such changes. We find that shifts in the skill composition over time only generate a relatively small bias in labour productivity growth. In contrast, when foreign SPPIs from Germany, France and the UK are applied as deflators to Swiss KIBS industries, labour productivity growth increases dramatically in some industries, e.g. in ICT service activities. Similar effects are obtained when wage-based deflators are replaced by an unmatched deflator, the Swiss core inflation in producer prices. On the level of the overall KIBS industries, the alternative deflators raise annual labour productivity growth by 0.3 to 0.4 percentage points but growth rates still remain low when compared to manufacturing and traditional services.

Third, we have studied the quantitative influence of wage-based deflation in KIBS industries on the growth of value added and labour productivity in the Swiss business sector. We calculate these aggregate effects (i) by applying the alternative deflators mentioned above and (ii) by setting productivity growth in those KIBS industries to zero where productivity growth in the 1997–2012 period was negative (Corrado & Slifman 1999). Taken together, these experiments suggest that the mismeasurement of prices in KIBS industries underestimates aggregate growth rates by 0.1–0.2 percentage points. These estimates are in the range of those in earlier studies which perform similar calculations (Sichel 1997; Corrado & Slifman 1999; McGuckin & Stiroh 2001; Hartwig 2009; Schreyer 2002; Wölfl 2004). Because nominal value added in the business sector amounts to 78–79% of GDP in Switzerland, these estimates also give an indication of the potential mismeasurement of real GDP growth arising from measurement problems of output price growth in KIBS industries.

Finally, we have argued that the "productivity gap" of the KIBS industries remains open for two reasons. On the one hand, the full scope of potential measurement errors goes beyond the experimental calculations presented in this paper because we only apply corrections to a selected number of industries and because these industries represent a limited share of total value added. Moreover, productivity may be downward biased even in industries where better price indices are used because capturing quality change continues to be challenging in many service activities. On the other hand, hard-to-measure economic factors such as capital deepening, innovation and the competitive environment may also play a role in explaining why the evolution of labour productivity in the KIBS industries has been so sluggish.

Overall, further research that focuses on the impact of measurement practices on productivity data would be desirable and could help to provide additional guidance as to how the state of data can be improved in the future.

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Appendix

A Calculation of Labour Productivity

A.1 Adjustment for R&D and FISIM

In practice, the mode of calculation for the real intermediate inputs series is somewhat more complicated than displayed in Section 3.2.1. This is because the expenditures for research and development (R&D) and financial intermediation services indirectly measured (FISIM) are deflated separately. For a given industry, the SFSO calculates the series as follows:

$$\frac{M_t}{M_{t-1}} = \frac{1}{M^n_{t-1}} \left(\frac{M^n_t - M^n_{FISIM,t} - M^n_{R\&D,t}}{P_{M,t}/P_{M,t-1}} + VI_{FISIM,t} M^n_{FISIM,t-1} + \frac{M^n_{R\&D,t}}{P_{R\&D,t}/P_{R\&D,t-1}} \right),$$

where $M^n_{FISIM,t}$ and $M^n_{R\&D,t}$ represent nominal intermediate expenditures for FISIM and R&D, respectively. Since industry-level FISIM are not observed, *overall* FISIM expenditures are assigned to individual industries by assuming that the amount of FISIM is proportional to nominal output, i.e., it is assumed for industry j that $M^{n,j}_{FISIM,t} = Q^{n,j}_t / \sum_{j=1}^{J} Q^{n,j}_t \cdot FISIM_t$. The R&D expenditures are elicited from a business survey on R&D expenditures (carried out every four years.) The growth rate of real FISIM is calculated by a volume index ($VI_{FISIM,t}$). This volume index is derived from the growth of overall loans/deposits deflated by the implicit deflator of domestic final demand (except FISIM). An additional correction is applied to the contribution of loans/deposits from abroad that are denominated in foreign currency. Finally, the deflator of FISIM ($P_{R\&D,t}/P_{R\&D,t-1}$) is an implicit deflator that takes into account the individual components of R&D expenditures.

Besides the real intermediate input series, the real output series is also constructed by a separate deflation of R&D nominal output and remaining nominal output. For a given industry, the calculation is as follows:

$$\frac{Q_t}{Q_{t-1}} = \frac{1}{Q^n_{t-1}} \left(\frac{Q^n_t - Q^n_{R\&D,t}}{P_t/P_{t-1}} + \frac{Q^n_{R\&D,t}}{P_{R\&D,t}/P_{R\&D,t-1}} \right),$$

where $Q^n_{R\&D,t}$ is the nominal R&D output and Q^n_t is the overall nominal output.

A.2 Aggregation

Let j denote an industry and J some set of industries (for example, the service sector or the entire business sector). The following exposition shows how productivity data from industry-level, j, is aggregated to the higher level, J. Let the letter g generically denote a growth rate.

The growth rate of real value added in industry j is defined by the equation $\left(1+g_{jt}^{VA}\right) = VA_{jt}/VA_{j,t-1}$ and the share of industry j in total current-price value added in the *previous* period is $s_{j,t-1}^{VA} = VA_{j,t-1}^{n}/\sum_{j\in J} VA_{j,t-1}^{n}$. Then, the aggregate growth rate of real value added is computed as follows:

$$1+g_t^{VA} = \sum_{j\in J} s_{j,t-1}^{VA}\cdot\left(1+g_{jt}^{VA}\right).$$

The growth rate of full-time equivalent (FTE) employment in industry j is defined by the equation $\left(1+g_{jt}^{L}\right) = L_{jt}/L_{j,t-1}$. The weight of industry j corresponds to the share of labour compensation going to industry j: $s_{j,t-1}^{L} = w_{j,t-1}L_{j,t-1}/\sum_{j\in J} w_{j,t-1}L_{j,t-1}$, where $w_{j,t-1}$ is the average wage in industry j in period $t-1$. A simpler and more commonly used approach is to use the share of FTE employment as a weight: $s_{j,t-1}^{L} = L_{j,t-1}/\sum_{j\in J} L_{j,t-1}$. In both cases, the aggregate growth rate of FTE employment is given by:

$$1+g_t^{L} = \sum_{j\in J} s_{j,t-1}^{L}\cdot\left(1+g_{jt}^{L}\right).$$

Recall that labour productivity growth is simply defined by $LP_t/LP_{t-1} = (VA_t/VA_{t-1})/(L_t/L_{t-1})$ for any given period t. Then, combining the two quantities above, we obtain the growth rate of labour productivity on the aggregate level:

$$1+g_t^{LP} = \frac{1+g_t^{VA}}{1+g_t^{L}}.$$

The corresponding index normalized to 100 in the reference period t=0 equals in period t:

$$I_t^{LP} = 100\cdot\prod_{s=1}^{t}(1+g_s^{LP}) \qquad \text{for t} > 0$$

$$I_t^{LP} = 100\,/\prod_{s=t}^{-1}(1+g_s^{LP}) \qquad \text{for t} < 0.$$

B Definition of KIBS Industries in NACE rev. 1.2

Table 16 Definition of KIBS Industries in NACE Classification Revision 1.2

NACE-Code	Industry	Share
22	Publishing	35%
63	Supporting and auxiliary transport activities; activities of travel agencies	25%
64	Post and telecommunications	32%
65	Financial intermediation, except insurance and pension funding	100%
66	Insurance and pension funding, except compulsory social security	100%
67	Activities auxiliary to financial intermediation	100%
70	Real estate activities	100%
71	Renting of machinery and equipment without operator and of personal and household goods	100%
72	Computer and related activities	100%
73	Research and development	100%
74	Other business activities	100%
90	Sewage and refuse disposal, sanitation and similar activities	55%
92	Recreational, cultural and sporting activities	27%

Notes: The share shows the extent to which the individual industry is considered as KIBS industry.

C Skill-Adjusted Wage Index

In this section, we proof that the counterfactual average wage is identified by the reweighting estimator and we briefly explain how it is implemented in practice.

Consider a population of *i.i.d. o*bservations observed in two time periods, where we denote the time periods $T = t$ and $T = t - 1$. Let $y \in \mathbb{R}^+$ be the wage and $X \subset \mathbb{R}^k$ a vector of characteristics of length k. Assume that $supp(X|T = t) \subseteq supp(X|T = t - 1)$.

Theorem: We show that $E[E[y|X, T = t\,]|T = t - 1] = E[y \cdot \Psi(X)|T = t\,]$, *where*

$$\Psi(X) \equiv \frac{P(T = t - 1|X)/P(T = t - 1)}{(1 - P(T = t - 1|X))/(1 - P(T = t - 1))}.$$

Proof:

First, we re-write the expression of the iterated expectation as follows:

$$E[E[y|X, T = t\,]|T = t - 1] \equiv \int_x E[y|X = x, T = t\,]\,dF_{X|T=t-1}(x)$$

$$= \int_x E[y|X = x, T = t\,] \frac{dF_{X|T=t-1}(x)}{dF_{X|T=t}(x)} dF_{X|T=t}(x).$$

Second, we use Bayes' theorem to show that:

$$\frac{dF_{X|T=t-1}(x)}{dF_{X|T=t}(x)} = \frac{P(X|T = t-1)}{P(X|T = t)} = \frac{\frac{P(T = t-1|X)P(X)}{P(T = t-1)}}{\frac{P(X|T = t)P(X)}{P(T = t)}}$$

$$= \frac{P(T = t-1|X)/P(T = t-1)}{(1 - P(T = t-1|X))/(1 - P(T = t-1))} \equiv \Psi(X).$$

The first equality follows from the definition of the cumulative distribution function, the second equality applies Bayes' rule and the third equality simplifies the expression.

Combining these two results, we have

$$E[E[y|X, T = t\,]|T = t-1] = \int_x E[y|X = x, T = t\,]\Psi(x)dF_{X|T=t}(x)$$

$$= E[y \cdot \Psi(X)|T = t\,]. \blacksquare$$

In practice, we use a binary logit model to estimate the propensity score:

$$P(T = t-1|X_i) = \Lambda(X_i\gamma)$$

where $\Lambda(\cdot)$ is the logistic distribution function. Denote $\Lambda(X_i\hat{\gamma})$ the maximum likelihood estimator for the propensity score. Denote N_{t-1} and $N_t$the number of observations in period $t-1$ and t, respectively. The estimator for the unconditional probability is simply $\hat{P}(T = t-1) = N_{t-1}/(N_{t-1} + N_t)$. The estimator for the reweighting factor is

$$\hat{\Psi}(X_i) = \frac{\Lambda(X_i\hat{\gamma})\,/\hat{P}(T = t-1)}{(1 - \Lambda(X_i\hat{\gamma})\,)/(1 - \hat{P}(T = t-1))}$$

and the estimator for the counterfactual mean wage is:

$$\frac{1}{\sum_{i \in T=t} \hat{\Psi}(X_i)} \sum_{i \in T=t} \hat{\Psi}(X_i) \cdot y_i.$$

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