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Preface

Based on the Norwegian KLEMS database, this report investigates the structural development in the market economy of mainland Norway over the period of 1997-2014. All the findings in this report have a number of implications for both theoretical and empirical works in the future.

The author wants to thank Lise Dalen Mc Mahon, Ann Lisbet Brathaug, Tore Halvorsen for their valuable comments.

Statistisk sentralbyrå, 23.03.2018

Lise Dalen Mc Mahon

Abstract

Using the Norwegian KLEMS database, this report investigates the structural development in the market economy of mainland Norway over 1997-2014. The findings largely confirm the trends that have been identified by many other studies: an increasing share was found in output and employment of services at the expense of goods production; services had become the largest sector in terms of output and employment; productivity growth in goods production sector was higher than in services sector over the entire period.

However, when considering the changes between two subperiods (i.e. 1997-2006, and 2006-2014), productivity performance in the goods production sector was weaker in the first subperiod, while much stronger in the second, than in the services sector.

Moreover, a more detailed sector analysis reveals very substantial heterogeneity both within the goods production sector and among the services sector, leaving the traditional distinction between goods and services outdated. In particular, the characterization of services as stagnant in terms of productivity growth and input structure is no longer true.

Based on the calculated input intensity measures, an increased share of skilled labour in value added is found for the total market economy of mainland Norway over the entire period, as well as for almost all the sectors, at least for the latter period (2008-2014). For the total market economy, the shares in value added of both Software and R&D capital increased, while those of Hardware decreased, for the whole period 1997-2014. With a few exceptions, this finding also holds for almost all the sectors, at least for the latter period (2008-2014).

Finally, the test results show that the complementarity hypothesis between the use of ICT capital and skilled labour is not supported by the Norwegian data. On the other hand, the existence of complementarity between the use of IPP capital and highly skilled labour seems to be suggestive. Furthermore, the complementarity relationship between R&D and highly skilled labour is strongly suggestive based on the Norwegian data.

Sammendrag

Ved hjelp av KLEMS-databasen, belyser denne rapporten strukturutviklingen i markedsøkonomien i fastlands-Norge i perioden 1997-2014. Funnene bekrefter i stor grad trender som har blitt presentert i mange andre studier. Tjenestenæringenes andel av produksjon og sysselsetting har økt på bekostning av vareproduksjon. Tjenester har blitt den største grupperingen både når det gjelder produksjon og sysselsetting. Produktivitetsveksten i vareproduksjonsnæringene er samlet sett høyere enn i tjenestenæringene over hele perioden.

Når man ser på endringene mellom to delperioder (dvs. 1997-2006 og 2006-2014), var produktivitetsutviklingen i vareproduksjonsnæringene svakere enn i tjenestenæringen i første delperiode, mens den var mye sterkere i den andre perioden.

Videre viser en mer detaljert næringsanalyse betydelig heterogenitet både innenfor samlet vareproduksjon og blant tjenestenæringene, og visker ut det det tradisjonelle skillet mellom varer og tjenester. Spesielt er beskrivelsen av at tjenester genererer liten produktivitetsvekst og har uendret inputstruktur ikke lenger dekkende.

Basert på de beregnede målene for inputintensitet, er det funnet at en høyere andel høyt utdannet arbeidskraft bidrar positivt til verdiskapingen for den samlede markedsøkonomien i Fastlands-Norge for hele perioden. Dette gjelder på nesten alle næringsområder, i hvert fall for årene 2008-2014. For den totale markedsøkonomien økte bidraget til verdiskapingen både fra IKT Software og FoU-kapital, mens bidraget fra IKT Hardware gikk ned for hele perioden 1997-2014. Med noen få unntak gjelder dette funnet for nesten alle områder, spesielt gjelder det for 2008-2014.

Endelig viser testresultatene at hypotesen om komplementaritet mellom bruk av IKT-kapital og faglært arbeid ikke støttes av norske data. På den annen side synes det å være en tydelig komplementaritet mellom bruk av IPP kapital og høyt kvalifisert arbeid. Videre har komplementaritetsforholdet mellom FoU og høyt kvalifisert arbeid sterkt støtte i de norske data.

Contents

1. Introduction

For the last century, there has been a substantial structural development taking place in the Norwegian economy. For example, at the beginning of the 1900s, primary sector[1] accounted for roughly half of the total labour employment. Then the shift of labour from primary into secondary and tertiary sectors continued until the share of secondary sector reached its top in the 1970s.[2] Since then, the tertiary sector, also called services sector, has been growing fast in the Norwegian economy. However, labour productivity growth in services sector is found lower than in either primary or secondary sector (e.g. Skoglund, 2013).

The stylised observations witnessed in a small country like Norway are in line with the empirical regularities found in many other western countries (see e.g. Kuznets, 1971; Maddison, 1980). In particular, all studies shared a common view as regards the services sector, i.e. due to limited scope for innovation and technical change, productivity growth in this sector is much lower than in both primary and secondary sectors (e.g. Baumol, 1967).

Based on detailed industry level data, however, recent studies have found that although a continuing shift of output and employment can be observed from the secondary to services sector, the conventional view of a stagnant services sector is no longer true, because productivity growth within this sector reveals very considerable heterogeneity with a number of services industries having already even higher productivity growth than some traditional goods-producing industries (e.g. Triplett and Bosworth, 2006; Jorgenson *et al*., 2005; Timmer *et al*., 2010).

Recent evidences also suggest that along with economic growth, technical change seems to have favoured special production inputs and affected the production structures in a rather asymmetric way. Specifically, the last decades have been characterized by a growing importance of skilled labour and information and communication technology (ICT) assets in production (e.g. Jorgenson *et al*. 2005). One appealing explanation in the literature to this phenomenon is that there exists complementarity between increased use of skilled labour and ICT capital (e.g. O'Mahony *et al*., 2008; Timmer *et al*., 2010).

The purpose of this paper is twofold. First, we examine whether the above-mentioned stylised observations still hold for the market economy of mainland Norway during the period 1997-2014. Since the primary sector has become rather small in Norway,[3] our main focus will be on the structural development as regards secondary and services sectors. In particular, we will look at the increasing share of services in output and employment at the expense of secondary sector and at comparative productivity growth in these two sectors.

Second, we will investigate changes in the structure of production technologies that occurred in the market economy of mainland Norway during the period 1997-2014, with special focus on the changes in production input composition of skilled labour and knowledge based capital in general, and the ICT asset in particular. By means of Norwegian industry level data, we will test the hypothesis of the existence of complementarity between skilled labour and the ICT assets that was once employed to explain the prevalence of knowledge intensification featuring many countries' recent economic growth (see e.g. Berman *et al*. 1998).

[1] Here the primary sector includes agriculture, forestry, and fishery.

[2] Secondary and tertiary sectors are sometimes referred to as manufacturing and services sectors, respectively.

[3] See Section 3.

In our analysis we rely on a recently compiled Norwegian KLEMS database (see Liu, 2017). This database provides output and input statistics at a detailed industry level over the period 1997-2014 for the market economy of mainland Norway. Importantly, it contains new, more sophisticated measures of labour, capital and intermediate inputs that facilitate tracking of sectoral trends in both labour and multi-factor productivity. Thanks to its richness, the Norwegian KLEMS database also allows us to greatly broaden the analysis of structural development by incorporating changes in the use of factor inputs in the production process.

The remainder of the paper is organized as follows. A brief description of the Norwegian KLEMS database is given in Section 2. Section 3 is devoted to changes in sectoral output and employment shares. In Section 4 we discuss trend in labour and multi-factor productivity. Section 5 studies patterns in the use of various types of labour and capital inputs, in particular, skilled labour and knowledge based capital. Moreover, the hypothesis of the existence of complementarity between the use of ICT assets and skilled labour is tested by using Norwegian data. Section 6 concludes the paper.

2. The Norwegian KLEMS database

The current Norwegian KLEMS database was compiled based principally on official statistics, such as annual Norwegian national accounts data, including annual Supply and Use tables. The database provides detailed production input measures including capital (K), labour (L), energy (E), materials (M) and services (S), as well as the output measure, at the disaggregated industry level, for the market economy of mainland Norway over the period 1997-2014 (see Liu, 2017).

For each industry, the labour inputs are further decomposed into hours worked and changes of labour composition, and the capital inputs are grouped into Information and Communication Technology (ICT) capital (consisting of Hardware (ITH), Software (ITS)), Research and Development (R&D) capital, and all other assets (Other), including all assets rather than ICT and R&D capital. These further classifications make it possible for the decomposition of productivity growth into various detailed components.

The variables in the database are organized by means of the modern growth accounting methodology (see Jorgenson and Griliches, 1967; Diewert, 1976; Caves *et al*., 1982; Jorgenson *et al*., 1987, 2005). Being well-founded in the neo-classical production theory, the modern growth accounting offers a clear conceptual framework, within which the interactions among different variables in the growth accounts can be analysed in an internally consistent way. As such, the framework of the modern growth accounting has become an international standard now (see Schreyer, 2001, 2009).

The Norwegian KLEMS database is meant to be used primarily for analysing productivity trend over time in Norwegian economy. Nonetheless, the database can serve for undertaking research in many other areas, such as in skill creation, capital development, technological progress and R&D activities, as well as in economic growth more generally.

For the purpose of this paper, by drawing upon the Norwegian KLEMS database, useful statistical indicators will be derived as regards the changes of output and employment, labour and multifactor productivity, and input composition among different sectors that occurred in the market economy of mainland Norway for the period 1997-2014.

Table 2.1. Industries/Sectors in the market economy of mainland Norway

Industries		Sectors	
Code	Description	Abbreviation	Description
KNR2326	Computer and electronics	ELECOM	ICT production (including Electrical machinery manufacturing and post and communication services)
KNR2327	Electrical equipment		
KNR2353	Post and distribution		
KNR2361	Telecommunication		
KNR2362	Information services		
KNR2310	Food products, beverages and tobacco	MEXELEC	Manufacturing (excluding Electrical machinery)
KNR2312	Fish farming		
KNR2313	Textiles, wearing apparel, leather		
KNR2315	Manufacture of wood and wood products		
KNR2316	Wood processing		
KNR2317	Graphic production		
KNR2318	Production of coal and refined petroleum		
KNR2319	Chemical raw goods		
KNR2320	Chemical products		
KNR2321	Production of pharmaceutical products		
KNR2322	Rubber and plastic products		
KNR2323	Other chemical and mineral products		
KNR2324	Metal raw goods		
KNR2325	Metal products		
KNR2328	Machinery and equipment		
KNR2329	Production of transport equipment		
KNR2330	Building of ships		
KNR2331	Building of oil platforms and modules		
KNR2332	Other industry production		
KNR2333	Repair/installation of machinery/equipment		
KNR2301	Agriculture, Hunting	OTHERG	Other production (including Agriculture, mining, utilities and construction)
KNR2302	Forestry		
KNR2303	Fishing		
KNR2304	Aquaculture		
KNR2305	Mining and quarrying		
KNR2335	Production of electricity		
KNR2336	Transport and sale of electricity		
KNR2337	Other energy, district heating and gas		
KNR2341	Building development		
KNR2342	Construction		
KNR2344	Wholesale/retail trade, repair of motor v.	DISTR	Distribution (including Trade and transportation)
KNR2346	Passenger transport		
KNR2347	Goods transport		
KNR2350	Domestic maritime transport		
KNR2351	Air transport		
KNR2352	Services connected to transport		
KNR2307	Service activities incidental to oil and gas	FINBU	Finance and business services (excluding housing services)
KNR2358	Publishing business		
KNR2364	Financial services		
KNR2367	Managing real estate		
KNR2370	Architecture/legal/accounting/consulting		
KNR2372	Research and Development		
KNR2373	Marketing/veterinary and other services		
KNR2377	Leasing, travel and other business services		
KNR2338	Water supply, sewerage, waste	PERS	Personal services (including Hotels, restaurants and community, social and personal services)
KNR2356	Hotel and restaurant		
KNR2385	Education/training		
KNR2386	Health services		
KNR2387	Social welfare services		
KNR2390	Cultural/sports/leisure activities		
KNR2394	Membership and other private activities		
KNR2397	Paid household works		

Source: Statistics Norway and EU KLEMS database (www.euklems.net)

The market economy of mainland Norway as defined in the Norwegian KLEMS database comprises 57 industries, the names and the corresponding codes of which are listed in Table 2.1. Formally, it is constructed by excluding from the total Norwegian economy all nonmarket activities (consisting of central and local government activities, such as education, health, defense, and public administration, and activities of NPISHs), the offshore industry extracting oil and gas (KNR2306), the pipeline transport of oil and gas (KNR2348), and the maritime transport (KNR2349). Finally, the industries that provide owner-occupied housing services (KNR2368), as well as private renting (KNR2369), are also excluded.

Traditionally, the main distinction in sectoral studies is among primary, secondary, and tertiary (services) sectors. However, since the importance of primary sector has rapidly declined while services sector has become by far the largest sector in Norway, the traditional taxonomy is not sufficient any more for our purpose.

Therefore, a more detailed view of the services sector is essential. Moreover, in order to study the development of the ICT-goods producing sector which has played an important role in recent economic growth, a special focus on this sector is also worthwhile.

In this paper, the market economy of mainland Norway is subdivided exhaustively into six sectors: ICT production; Manufacturing excluding ICT production; Other goods production (with traditional primary sector included); Distribution services; Finance and business services; Personal services.

In Table 2.1 the detailed description and the corresponding abbreviations of these six sectors are listed. Meanwhile, the precise composition of each sector in terms of the industry codes is also presented. Note that the sector definition/classification applied here is in accordance with that in the EU KLEMS database (see O'Mahony and Timmer, 2009; Timmer *et al.*, 2010), which is of potential use for comparable analysis in the future.

3. Changes in output and employment

A country's economic growth has been usually accompanied with mobilisation of economic resources across different sectors. For instance, the shift of economic resources (output and employment) from primary to secondary sector featured prominently in the earlier literature on modern economic growth (e.g. Kuznets, 1971; Maddison, 1980), and is still an important characteristic of growth in developing countries (Chenery *et al*., 1986; Temple, 2005).

Currently, however, the shift from primary to secondary sector has lost its prominence in advanced economies because of its tiny share in total economy. For example, in 2014, primary sector employs about 4 percent of the total labour force, and accounts for less than 2 percent of total value added in the market economy of mainland Norway. On the other hand, the shift from secondary to services sector has dominated the process of structural development since the 1970s, and therefore, is our focus in this paper.

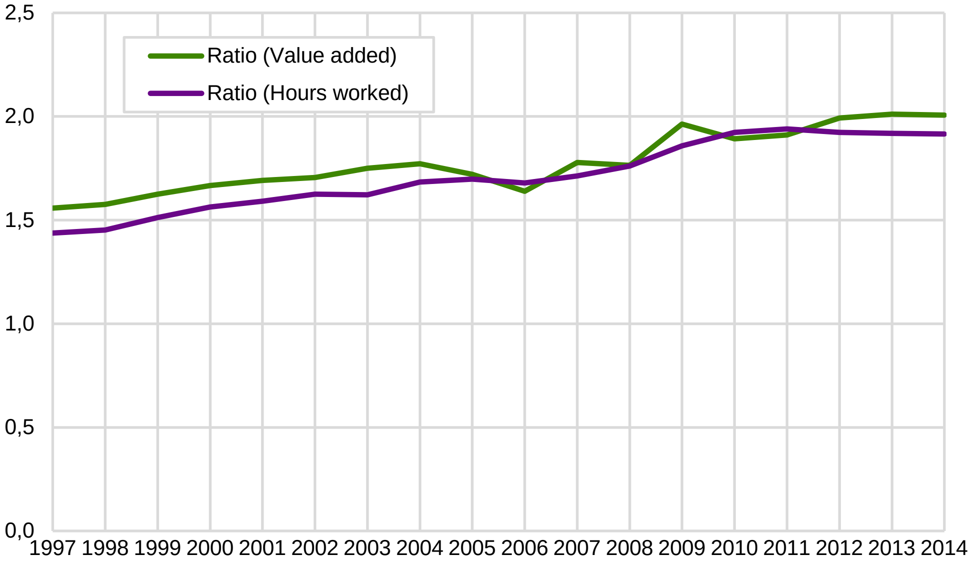
In Figure 3.1 we report the ratio of value added and hours worked in (aggregate) services sector (the sum of three services sectors, i.e. Distribution, Finance and business, and Personal services) to those in (aggregate) goods production sector (the sum of two goods production sectors, i.e. Manufacturing, and Other goods production) over the period from 1997 to 2014.[4]

Compared with goods production, the importance of market services has gradually but steadily increased over the period 1997-2014. This is in accordance with the empirical regularities found in many other studies, i.e. the increase in the shares of services came at the expense of traditional goods production (e.g. Kuznets, 1971; Maddison, 1980; Jorgenson and Timmer, 2009). At the same time, the figure

[4] The ICT production sector (ELECOM) incorporates some part of services, such as information services. If this sector is included in goods production in a broad sense, the calculated ratios will be slightly lower. However, the trend over time is almost the same as shown in Figure 3.1.

makes clear that services had become a very sizable sector in its entirety. In 2014, the output of this (aggregate) market services sector was double (and the employment almost double) that of the (aggregate) goods production sector.

Figure 3.1. Ratio of services over goods production, 1997-2014



Source: Calculations are based on Norwegian KLEMS database, July 2017.

The growing importance of market services is the result of many interacting demand factors (Schettkat and Yokarini, 2006). For instance, higher per capita income leads to higher demand for services in general. There is also an increasing marketization of traditional household production activities, such as dining outside the home, paying cleaning and care assistance from the market. Moreover, many manufacturing firms are outsourcing aspects of business services, such as accounting, canteen, trade and transport activities, etc.

Table 3.1. Share of value added and hours worked by sector (%)

	Value added		Hours worked	
	1997	2014	1997	2014
Total market economy of mainland Norway	100	100	100	100
ICT production (ELECOM)	7.76	6.86	6.06	5.57
Goods	36.06	30.99	38.54	32.39
Manufacturing (MEXELEC)	19.00	12.89	18.58	13.76
Other goods (OTHERG)	17.06	18.10	19.96	18.62
Services	56.18	62.16	55.40	62.05
Distribution (DISTR)	24.78	20.23	27.59	25.46
Finance and business (FINBU)	22.39	33.56	16.56	23.26
Personal (PERS)	9.01	8.37	10.89	13.33

Source: Calculations are based on Norwegian KLEMS database, July 2017.

Table 3.1 presents the shares of sector value added and hours worked as a percentage of the total in the market economy of mainland Norway for the six sectors in 1997 and 2014. Despite the main trends as reflected by the total market economy in Figure 3.1, the more detailed figures in Table 3.1 reveals striking differences that appeared both within the goods production sectors and among the three services sectors.

Within the goods production sectors, both shares of sector value added and hours worked in Manufacturing sector had decreased from 1997 to 2014.[5] While the share of hours worked in Other goods production sector reduced, its value added share had actually increased, though with a small margin (from 17.1 in 1997 to

[5] This is also true for the ICT production sector (see Table 3.1).

18.1 per cent in 2014). This implies a slightly increased labour productivity in Other goods production sector over the period 1997-2014.

Among the three services sectors, the shares of both sector value added and hours worked in Distribution services sector had decreased; on the contrary, those in Finance and business services sector had increased over the period 1997-2014. In fact, the increases in this specific sector is the largest among all sectors in the total market economy, including the goods production and the ICT production sectors.

As for Personal services sector, although its share of hours worked had increased substantially, its value added share actually had decreased over the whole period 1997-2014, indicating a reduced labour productivity in this sector.

The ICT production sector is singled out from the total market economy because of its exceptional performance in driving productivity growth in recent years.[6] As shown in Table 3.1, the shares of both sector value added and hours worked in this sector are small compared to those for other sectors, and these shares had shrunk from 1997 to 2014.

4. Changes in productivity

4.1. Labour productivity

One of the empirical regularities documented by the literature (see e.g. Kuznets, 1971; Maddison, 1980; Skoglund, 2013) is the slow growth of labour productivity in services compared to industry. Traditionally, manufacturing activities have been regarded as the locus of innovation and technological change and thus the central source of economic growth. This was the key to post-World War II growth in Europe through realisation of economies of scale, capital intensification and incremental innovation (Crafts and Toniolo, 1996).

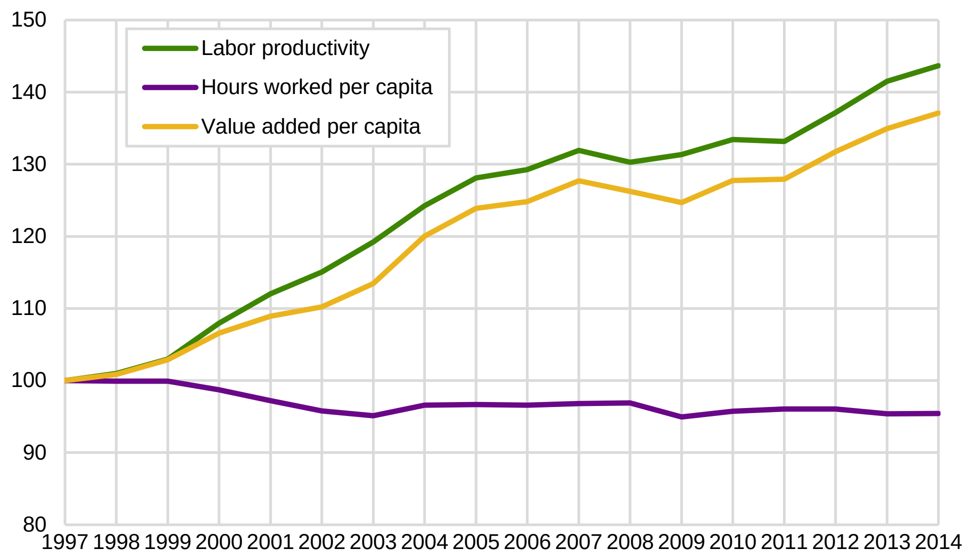
More recently, rapid technological change in computer and semi-conductor manufacturing seemingly reinforced the predominance of innovation in the manufacturing sector. By contrast, productivity growth in services was assumed to be low or even zero. Baumol’s cost disease theory suggests that productivity improvements in services are less likely than in goods-producing industries because most services are labour-intensive, making it difficult to substitute capital for labour in service industries (Baumol, 1967).

In a seminal study, Triplett and Bosworth (2006) show that after 1995 fifteen out of twenty-two two-digit series industries in the USA experienced acceleration in labour productivity that at least equalled the economy-wide average. Hence the authors titled their study ‘Baumol’s Disease has been Cured’.

In this paper we will look for similar patterns in Norway and study sectoral trends in productivity both for the entire period 1997-2014, and for two subperiods as well (1997-2006, and 2006-2014). The Norwegian KLEMS database provides the opportunity to examine trends in both labour and multi-factor productivity (MFP). The MFP provides a measure of the efficiency of labour and other inputs and is often used as an indicator of technological change.

[6] As we will show later in Section 4, although the production of ICT goods and services makes up only a minor part of total value added (see Table 3.1), its productivity growth is the highest among all the six sectors.

Figure 4.1. Trends of labour productivity, hours worked per capita, and value added per capita (1997=100), total market economy



Source: Calculations are based on Norwegian KLEMS database, July 2017.

As shown in Figure 4.1, over the entire period 1997-2014, the fact that hours worked per capita had been gradually decreasing, together with an enhanced value added per capital, leads to increased labour productivity in the market economy of mainland Norway. In 2014, the labour productivity measured by value added per hour worked was roughly 150% of the level in 1997 for the total market economy of mainland Norway.

But the picture painted by the total market economy in Figure 4.1 may hide some significant divergences among the sectors that make up it. As shown in Table 4.1 and Figure 4.2, sectors are highly diverse in terms of their labour productivity performance, although in general the overall average annual labour productivity growth in (aggregate) goods production sector is larger than that in (aggregate) services sector over the entire period (2.1 vs. 1.5 percent).

Table 4.1. Labour productivity growth (%), value added based

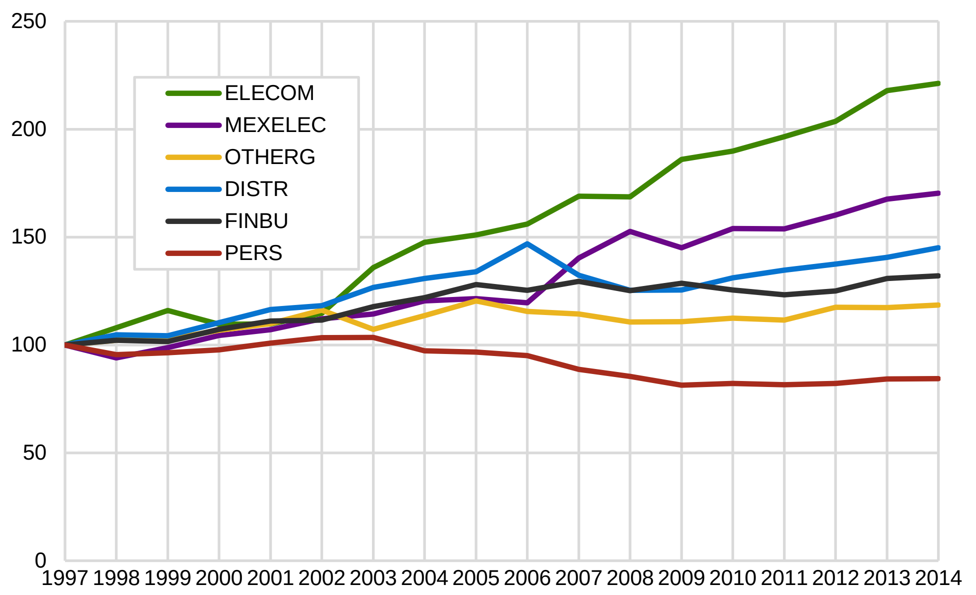
	1997-2014	1997-2006	2006-2014
Total market economy of mainland Norway	2.15	2.89	1.33
ICT production (ELECOM)	4.90	5.21	4.51
Goods	2.11	1.86	2.41
Manufacturing (MEXELEC)	3.28	2.04	5.02
Other goods (OTHERG)	1.02	1.66	0.34
Services	1.50	2.82	0.09
Distribution (DISTR)	2.30	4.35	-0.21
Finance and business (FINBU)	1.60	2.59	0.70
Personal (PERS)	-0.92	-0.52	-1.41

Notes: Average annual compound growth rates.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

Table 4.1 provides average annual growth rates for the period 1997-2014, as well as two sub-periods of 1997-2006 and 2006-2014. Figure 4.2 presents the corresponding trends of labour productivity for the six sectors with 1997 indexed to 100, where the average growth rate for the whole period (1997-2014) is applied.

As shown in Figure 4.2, by far the fastest growth in labour productivity is found in the ICT production sector, with annual average growth rates of 4.9 per cent over the whole period, leading to its productivity level more than doubled in 2014 compared to 1997. During the same period, the second fastest growth sector is Manufacturing, compared with which, all the three services sectors have lower productivity growth. Moreover, the productivity growth in Personal services sector is even negative.

Figure 4.2. Labour productivity by sector (1997=100)



Source: Calculations are based on Norwegian KLEMS database, July 2017.

Considering the two subperiods (1997-2006 and 2006-2014), the overall labour productivity performance for (aggregate) goods production sector was weaker than (aggregate) services sector in the first subperiod (1.9 vs. 2.8 percent). However, during the second subperiod, its performance was much stronger (2.4 vs. 0.1 percent), thanks in part to the good performance by the Manufacturing sector, and in part to the bad performance by Distribution services sector.

Indeed, except for the Manufacturing sector, average labour productivity growth for all the other sectors decreased from the first subperiod (1997-2006) to the second (2006-2014). The labour productivity growth for Distribution sector even (from positive) becomes negative. As a result, even if the labour productivity growth for Manufacturing sector more than doubled its growth (from 2.0 to 5.0 percent), the labour productivity growth for the total market economy of mainland Norway had more than halved from the first subperiod 1997-2006 (2.9 percent) to the second 2006-2014 (1.3 percent).

4.2. Multi-factor productivity

As mentioned above, technical change is usually measured as the growth in multi-factor productivity (MFP). Similar with Table 4.1, Table 4.2 provides average annual MFP growth rates for the period 1997-2014, as well as two sub-periods of 1997-2006 and 2006-2014.

Table 4.2 shows that there is also a large cross-sectional variation in the average rates of MFP growth among the sectors, although, again, the overall average annual MFP growth in (aggregate) goods production sector is larger than that in (aggregate) services sector over the entire period (1.9 vs. 0.7 percent).

For the entire period 1997-2014, the sector ranking is broadly the same as that for labour productivity growth as shown in Table 4.1. The only exception is the sector ranking between Finance and business services, and Other goods production sectors. The annual average growth rate for Finance and business sector is lower in terms of MFP in Table 4.2 (0.3 vs. 1.2 percent), while higher in terms of labour productivity in Table 4.1 (1.6 vs. 1.0 percent), than that for Other goods production sector.

Table 4.2. Multi-factor productivity growth (%), value added based.

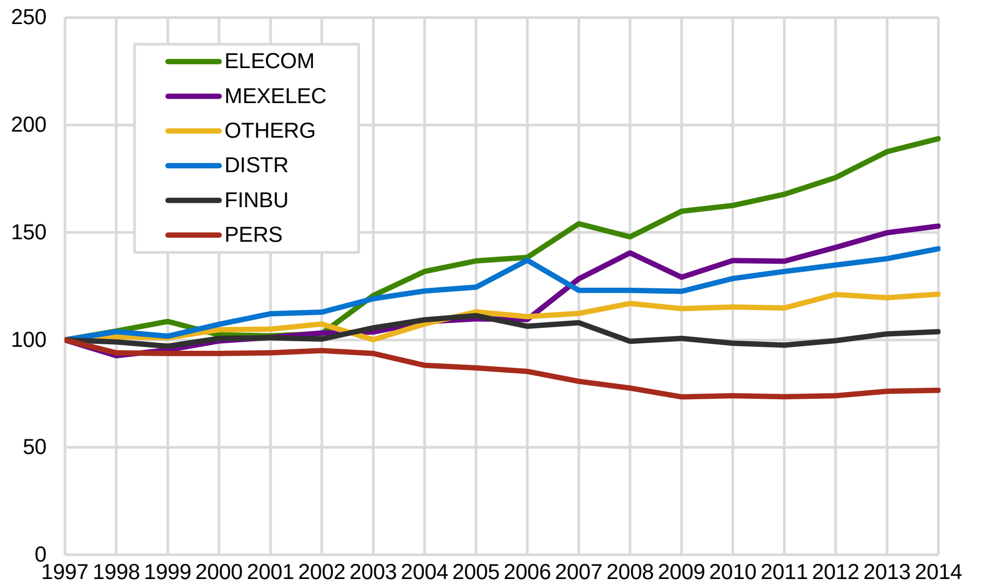
	1997-2014	1997-2006	2006-2014
Total market economy of mainland Norway	1.35	1.55	1.13
ICT production (ELECOM)	4.06	3.81	4.38
Goods	1.85	1.10	2.76
Manufacturing (MEXELEC)	2.58	1.01	4.78
Other goods (OTHERG)	1.17	1.19	1.16
Services	0.72	1.50	-0.12
Distribution (DISTR)	2.15	3.54	0.44
Finance and business (FINBU)	0.27	0.76	-0.18
Personal (PERS)	-1.53	-1.71	-1.30

Notes: Average annual compound growth rates.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

The main reason is as follows. Recall that the estimate of MFP growth is calculated as a residual, in other words, as labour productivity growth deducted by changes of labour composition and capital intensity. While the contribution to average labour productivity growth from changes of labour composition is negative and of a large absolute value for Other goods production sector, it is positive for Finance and business services sector.

On the other hand, the contribution to average labour productivity growth from changes of capital intensity is positive and far larger for Finance and business services sector than that for Other goods production sector. As a result, one ends up with a much lower estimate of MFP growth for the former than for the latter (see Table 8.1 in Liu (2017)).

Figure 4.3. Multi-factor productivity by sector (1997=100), value added based



Source: Calculations are based on Norwegian KLEMS database, July 2017.

Figure 4.3 gives the time trends of MFP level for the six sectors, and all the curves are indexed to 100 in 1997, by using the average growth rate of MFP for the whole period (1997-2014). As shown and consistent with the discussion outlined above, the ranking of MFP level is similar with that of labour productivity level as displayed in Figure 4.2, except that the sector order of Other goods production and Finance and business services sectors is different.

The general positive correlation between the growth of labour productivity and MFP among the sectors are in accordance with the previous findings, where a general positive correlation is also found, even at a more detailed industry level (see Liu, 2017).

Comparison between Figure 4.2 and Figure 4.3 also reveals that except for the Other goods production sector, labour productivity level index is larger than the corresponding MFP level index for all the other sectors, because the average growth of labour productivity is larger than that of the corresponding MFP. And this is because the summed contributions from the change of labour composition and capital intensity are positive for these sectors over the observed period 1997-2014 (see Liu, 2017).

Considering the two sub-periods (1997-2006, and 2006-2014), similar with the revealed pattern by labour productivity, the overall MFP performance for (aggregate) goods production sector was weaker than (aggregate) services sector in the first subperiod (1.1 vs. 1.5 percent). However, during the second subperiod, its performance was much stronger (2.8 vs. -0.1 percent), thanks also in part to the good performance by the Manufacturing sector, and in part to the bad performance by Distribution services sector.

On the other hand, over the two subperiods, the detailed change patterns of MFP growth among the sectors as shown in Table 4.2 are different from those of labour productivity growth as shown in Table 4.1. There are three sectors, i.e. ICT production, Manufacturing, and Personal services, having increased their MFP growth; while MFP growth for all the other sectors, as well as for the total market economy of mainland Norway, had declined. Even worse for Finance and business services sector, its growth rate had from positive in the first subperiod become negative in the second.

To sum up, the analysis has up to now painted a diversified picture of sectoral development in the market economy of mainland Norway over the period 1997-2014. Although both the shares in value added and in hours worked declined, there is a continuing productivity growth in the ICT production and Manufacturing sectors. And even stronger productivity growth is observed for the last subperiod (2006-2014) for the Manufacturing sector.

However, despite an increase of its share in value added, the Other goods production sector had low productivity growth, and the average growth decreased from the first subperiod to the second.

On the other hand, Finance and business services and Personal services seem to be typically stagnant sectors with low or even no productivity improvements but with increasing shares in employment, which is consistent with the prediction made by Baumol (1967) and in more recent analyses for the USA by Baumol *et al*. (1985) and Nordhaus (2008).

As for Distribution services sector, both its shares in value added and in hours worked declined, but this sector had higher productivity growth even than the Other goods production sector over the entire period. From the first subperiod (1997-2006) to the second (2006-2014), however, this sector suffered a heavy decline in productivity growth, and its average labour productivity growth even (from positive) became negative.

5. Changes in input composition

Structural development not only entails the changes in output, employment, and labour and multi-factor productivity, but also involves shifts in the mix of inputs used in the production process. For instance, one study has found that compared to the USA and other Anglo-Saxon countries, there was a stronger substitution process of capital for labour in continental Europe, and the reason was partly due to higher wage-rental ratios in Europe (Blanchard, 1997).

In the past decades, attention has been focused on the increasing use of inputs that are well suited to the generation, processing and diffusion of knowledge and information, namely, skilled labour and ICT equipment. Berman *et al*. (1998) document the pervasiveness of increasing use of skilled labour in manufacturing production in the OECD countries. As skill premia remined stable or even increased, this was seen by many economists as strong evidence for pervasive skill-biased technological change.

An appealing explanation to this economic phenomenon is the existence of complementarity between increased use of ICT and skilled labour (e.g. O'Mahony *et al*., 2008). For the USA, Jorgenson *et al*. (2005) document large increases in the use of both skilled labour and ICT capital across the economy, which seems to be consistent with this idea. They also found substantial variation in the use of these inputs across detailed industries.

In the previous sections, we have demonstrated that the patterns of structural development revealed solely by either total economy or dichotomous (aggregate) sectors may be misleading. Therefore, in this section we will track the use of skilled labour and the knowledge based capital in general, and the ICT capital in particular, with focus being placed on the six sectors that make up the market economy of mainland Norway. The purpose is to seek common patterns in the knowledge intensification of production and its sector-specific characteristics over the observed period.

5.1. Measures of input intensity

In this paper the value, rather than the more frequently used quantity, measures of inputs are employed as indicators for input intensity. The value measures are also applied by the EU KLMES project (called the cost measures), see Timmer *et al*. (2010). The differences between the two measures (value vs. quantity) will be explained below. Input intensity measures based on the value approach start from the standard national accounting identity that value added equals the cost, namely, the compensation for labour and capital in total.

For the purpose of this paper, skilled labour is represented by those workers with high education attained. For simplicity, all the other workers with other (than high) education are regarded as unskilled labour (UL).[7] High education consists of two levels: Higher S (Short) = Tertiary education, lower degree (*Universitet- og høyskoleutdanning, lavere nivå* in Norwegian); High L (Long) = Tertiary education, higher degree (*Universitet- og høyskoleutdanning*, *høyere nivå* in Norwegian).[8] Simply put, High S refers largely to Bachelors while High L mainly to Masters and/or Doctors.

[7] The definition of skilled vs. unskilled labour applied in this paper is only a relative concept, and has no meaning for any discrimination at all.

[8] For definitions/classifications on the detailed Norwegian educational attainment levels, see Liu (2017).

The capital assets are classified in this paper first into two broad asset categories: the knowledge based capital, and all other assets (Other). The knowledge based capital consists of ICT capital, and R&D capital. In addition, the ICT capital is further divided into two sub-groups: Hardware (ITH) and Software (ITS). The richness of the Norwegian KLEMS database recently compiled allows the detailed and useful distinction between Hardware (ITH) and Software (ITS) for our analysis (see Liu 2017).

Let P and Q denote prices and quantities respectively, indexed (by superscript) for value added and various inputs components, then we have:

(1) $$P^{VA}Q^{VA} = P^{UL}Q^{UL} + P^{High\,S}Q^{High\,S} + P^{High\,L}Q^{High\,L} + P^{ITH}Q^{ITH} + P^{ITS}Q^{ITS} + P^{R\&D}Q^{R\&D} + P^{Other}Q^{Other}.$$

By using identity (1), indicators for input intensity can be derived. For example, the (total) labour input intensity of production $INTS^{L}$ is defined as:

(2) $$INTS^{L} = \frac{P^{UL}Q^{UL} + P^{High\,S}Q^{High\,S} + P^{High\,L}Q^{High\,L}}{P^{VA}Q^{VA}},$$

and the (total) capital input intensity of production $INTS^{K}$ as:

(3) $$INTS^{K} = \frac{P^{ITH}Q^{ITH} + P^{ITS}Q^{ITS} + P^{R\&D}Q^{R\&D} + P^{Other}Q^{Other}}{P^{VA}Q^{VA}}.$$

Likewise, intensity indicators for other different input components in concern can be defined as follows:

(4) $$INTS^{High\,S} = \frac{P^{High\,S}Q^{High\,S}}{P^{VA}Q^{VA}},$$

(5) $$INTS^{High\,L} = \frac{P^{High\,L}Q^{High\,L}}{P^{VA}Q^{VA}},$$

(6) $$INTS^{ITH} = \frac{P^{ITH}Q^{ITH}}{P^{VA}Q^{VA}},$$

(7) $$INTS^{ITS} = \frac{P^{ITS}Q^{ITS}}{P^{VA}Q^{VA}},$$

(8) $$INTS^{R\&D} = \frac{P^{R\&D}Q^{R\&D}}{P^{VA}Q^{VA}},$$

(9) $$INTS^{Other} = \frac{P^{Other}Q^{Other}}{P^{VA}Q^{VA}}.$$

Defined as such, an increase of an input in the share of value added indicates a growing importance of the input in production. Note that this rise can be attributed either to an increase in the price of the input, or to an increase in the quantity used, or to both simultaneously, relative to the other inputs. These indicators are different from simpler measures that are quite often used, such as the share of workers with High L education in total employment: $Q^{High\,L}/(Q^{UL} + Q^{High\,S} + Q^{High\,L})$. The latter indicator is based on quantities alone and ignores price changes.

If, for example, the marginal productivity of skilled labour increases more than that of unskilled labour because of skill-biased technological change, the value shares applied in this paper correct for this. Under the standard assumption that differences in marginal productivity are reflected in relative prices, this is picked up in the value share given in (4) and (5).

Another common alternative indicator is the share of one particular type of labour in total labour compensation, for instance, the share of labour with High L education, $P^{High\ L}Q^{High\ L}/(P^{UL}Q^{UL} + P^{High\ S}Q^{High\ S}+P^{High\ L}Q^{High\ L})$. This indicator corrects for differences in productivity between various types of labour, but does not take into account other inputs such as capital. For example, if labour (both skilled and unskilled) is substituted for capital, the share of skilled workers in labour compensation can increase, while their importance in production actually declines. The value share indicators defined in (4) and (5) take account of substitution effects among labour types and between labour and other inputs.

The empirical implementation of indicators for labour input intensity is relatively straightforward as the hours worked by various types of labour and their relative labour compensation can be directly taken from the Norwegian KLEMS database.[9]

On the contrary, measuring the capital input intensity of production is less straightforward as quantities and prices of capital services are not directly observable. The measure of the relative importance of different capital asset in this paper is based on the concept of capital services introduced by Jorgenson and Griliches (1967). In this approach, capital input is measured through its delivery of services in a specific period (e.g. a year) as measured by its user cost (see Liu, 2017).

5.2. Labour

Table 5.1 and Figure 5.1provide time trends in the share of (total) labour services in value added over the period 1997-2014, by using equation (2). In the market economy of mainland Norway, the overall labour services share dropped gradually from 70 percent in 1997 to 67 percent in 2018, and continued to drop to slightly lower than 67 percent in 2014. This observation reflects a long-run trend of substituting labour by capital as described by Blanchard (1997).

Table 5.1. Labour services of all workers as a percentage of value added (%)

	1997	2008	2014
Total market economy of mainland Norway	69.78	67.02	66.54
ICT production (ELECOM)	63.93	69.20	69.40
Goods			
Manufacturing (MEXELEC)	72.46	66.90	71.67
Other goods (OTHERG)	64.82	60.16	60.38
Services			
Distribution (DISTR)	77.50	75.69	77.22
Finance and business (FINBU)	63.42	60.78	56.92
Personal (PERS)	73.11	79.90	82.35

Notes: Labour includes employees and self-employed.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

Table 5.1 also provides the share of labour services in sector value added for the six sectors that make up the total market economy of mainland Norway in three selected years, i.e. 1997, 2008, and 2014.[10] The corresponding continuous time trends are displayed in Figure 5.2.

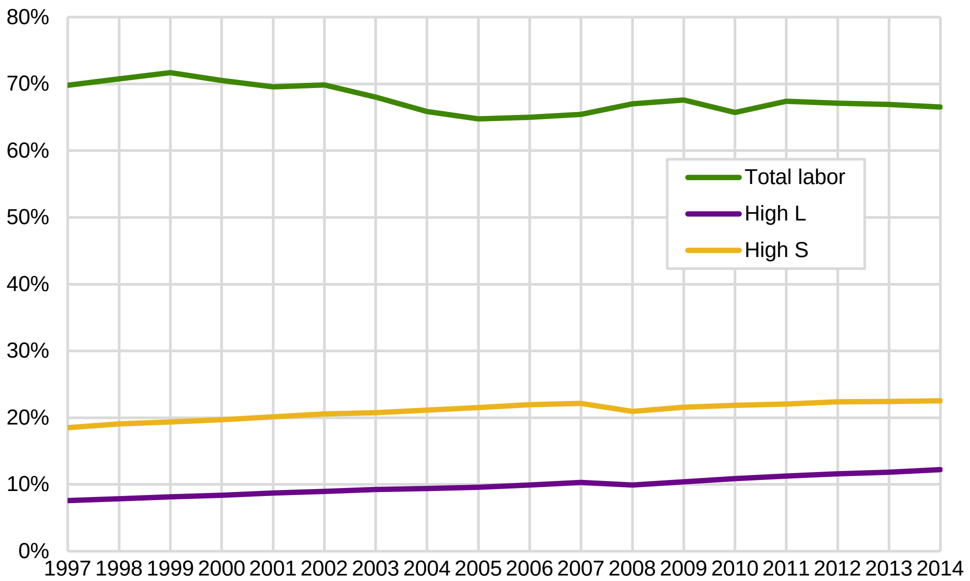
As seen in Figure 5.2, the share of labour services in value added for all the six sectors and in all years are at least larger than 55 percent, reflecting the fact that

[9] Note that labour compensation computed in the Norwegian KLEMS database includes an imputation for self-employed workers. For detailed calculation, see Liu (2017).

[10] The reason for choosing 2008 as subperiod demarcation (instead of 2006 as applied in the previous sections) is that labour input data cross-classified by age, gender, education, and industry before 2008 is of relatively lower quality (see Liu, 2017).

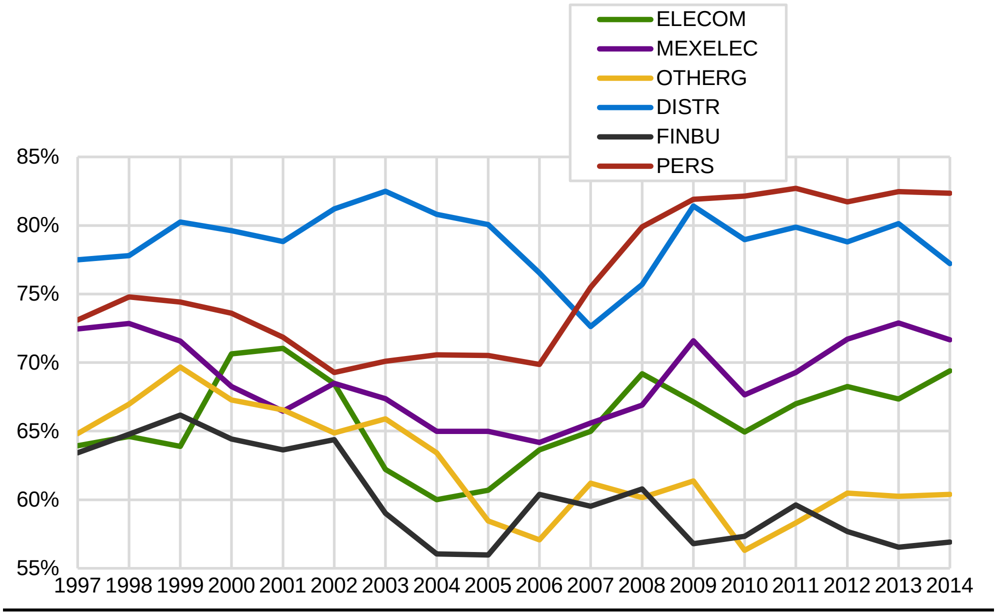
labour cost in value added had been higher than its capital counterpart in the Norwegian economy.

Figure 5.1. Labour services share in value added, 1997-2014, total market economy



Notes: Labour includes employees and self-employed.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

Figure 5.2. Labour services share in sector value added, 1997-2014



Notes: Labour includes employees and self-employed.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

In general, despite ups and downs during the whole period 1997-2014, most of the sectors, and the total market economy as well, showed a lower labour service share in 2014, compared with that in 1997. However, two sectors, ICT production and Personal services sectors, demonstrated an increase of their labour services share over the entire period. The former is a representative sector of new technology with highly paid skilled workers, and the latter is traditionally a typical labour-intensive sector (also see Table 5.1).

Skilled labour

As visualized also in Figure 5.1, for the total market economy of mainland Norway, the value added share of labour series by both High S and High L (calculated by using equations (4) and (5) respectively) had been gradually but increasingly growing during 1997-2014. In 1997, the share of High S and High L is 12.9 and 5.3 percent, while it becomes 15.0 and 8.1 percent in 2014, respectively (see Table 5.2 and Table 5.3).

Table 5.2. Labour services of High S workers as a percentage of value added (%)

	1997	2008	2014
Total market economy of mainland Norway	12.91	14.05	14.99
ICT production (ELECOM)	11.71	23.13	24.12
Goods			
Manufacturing (MEXELEC)	13.66	10.25	12.46
Other goods (OTHERG)	11.75	6.21	6.90
Services			
Distribution (DISTR)	14.51	11.57	12.76
Finance and business (FINBU)	11.57	19.55	18.10
Personal (PERS)	13.58	19.23	22.32

Notes: Labour includes employees and self-employed.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

Table 5.3. Labour services of High L workers as a percentage of value added (%)

	1997	2008	2014
Total market economy of mainland Norway	5.29	6.64	8.13
ICT production (ELECOM)	4.72	12.61	14.74
Goods			
Manufacturing (MEXELEC)	6.00	4.98	7.20
Other goods (OTHERG)	5.73	2.22	2.77
Services			
Distribution (DISTR)	5.69	2.34	3.03
Finance and business (FINBU)	4.41	11.47	12.43
Personal (PERS)	4.42	9.64	11.24

Notes: Labour includes employees and self-employed.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

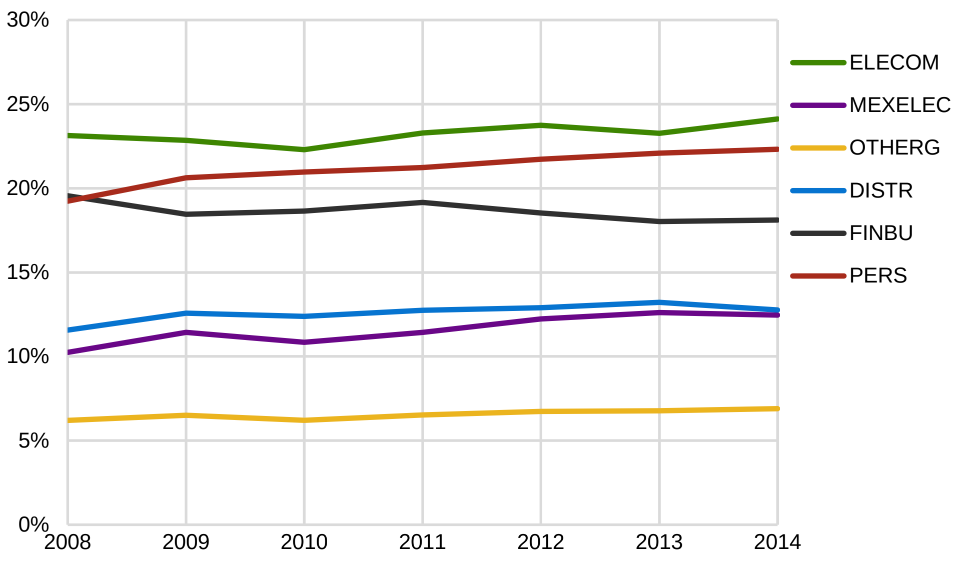
Based also on equations (4) and (5), labour compensation as a share of sector value added for the six sectors is also calculated and provided for 1997, 2008 and 2014, respectively in Table 5.2 for High S and in Table 5.3 for High L. The corresponding continuous time trends are displayed in Figure 5.3 for High S and Figure 5.4 for High L, respectively.

Note that in Figure 5.3 and Figure 5.4, only estimated labour input intensity measures for the time period 2008-2014 are presented, because labour input data cross-classified by age, gender, education, and industry before 2008 is of relatively lower quality (see Liu, 2017).

As shown by Table 5.2 and Table 5.3, labour compensation share in sector value added is higher in 2014 than in 2008 for almost all the sectors, and for the total market economy as well. The only exception is Finance and business services sector for which the labour compensation share of workers with High S education in 2014 is slightly lower than in 2008.

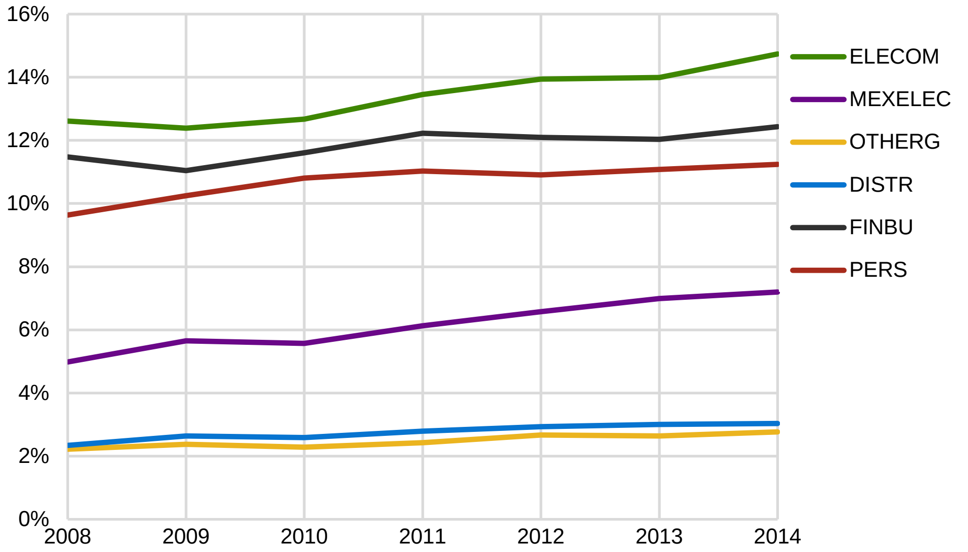
Figure 5.3 and Figure 5.4 show that three sectors (i.e. ICT production, Finance and business services, and Personal services) are highly skilled labour-intensive sectors, compared with the other three sectors (i.e. Manufacturing, Other goods production, and Distribution services). In general, the sector rankings displayed in the two figures are similar. However, Finance and business services and Manufacturing have relatively higher (than Personal services and Distribution services, respectively) rankings of labour services share in Figure 5.4 (for High L), compared with those in Figure 5.3 (for High S).

Figure 5.3. Compensation of High S share in sector value added, 2008-2014



Notes: Labour includes employees and self-employed.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

Figure 5.4. Compensation of High L share in sector value added, 2008-2014



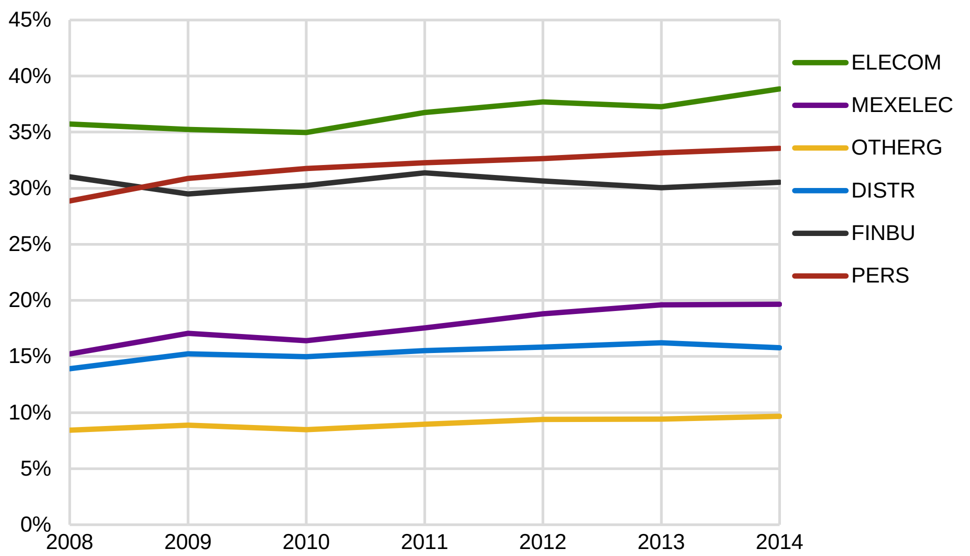
Notes: Labour includes employees and self-employed.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

Table 5.4. Labour services of High (S+L) workers as a percentage of value added (%)

	1997	2008	2014
Total market economy of mainland Norway	18.21	20.69	23.12
ICT production (ELECOM)	16.43	35.74	38.86
Goods			
Manufacturing (MEXELEC)	19.66	15.23	19.66
Other goods (OTHERG)	17.48	8.43	9.67
Services			
Distribution (DISTR)	20.20	13.91	15.79
Finance and business (FINBU)	15.98	31.03	30.54
Personal (PERS)	18.01	28.87	33.56

Notes: Labour includes employees and self-employed.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

Figure 5.5. Compensation of High (S+L) share in sector value added, 2008-2014



Notes: Labour includes employees and self-employed.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

Finally, by combining workers with High S and High L together, labour services share of workers with high education in general (High S + High L) is put in Table 5.4 for three selected years (1997, 2008, and 2014), and the corresponding continuous time trend over the period 2008-2014 in Figure 5.5.

Briefly speaking, the ranking of the three highly skilled labour-intensive sectors (i.e. ICT production, Finance and business services, and Personal services) as shown in Figure 5.5 is the same as that in Figure 5.3 (for High S), simply because the share of High S (Figure 5.3) is considerably larger than the corresponding share of High L (Figure 5.4) for each sector, and in each year.

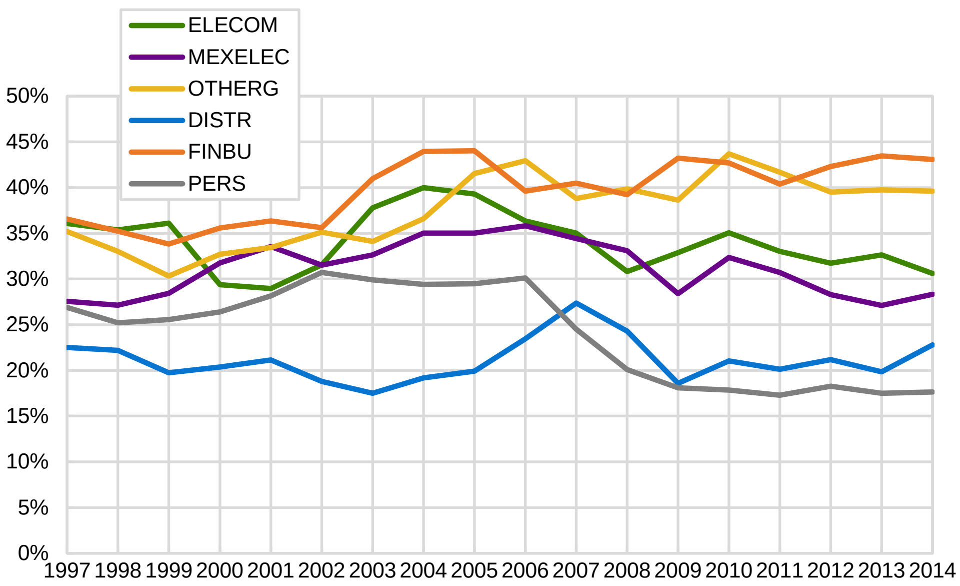
On the other hand, the rank order revealed by Figure 5.5 for the other three sectors (i.e. Manufacturing, Distribution services, and Personal services) looks the same as that by Figure 5.4 (for High L), because the labour services share in value added of Distribution services sector is very low for High L in Figure 5.4. As a result, it drags down the sum of the labour services share of both High S and High L for this sector (as shown in Figure 5.5).

5.3. Capital

Though not being displayed, because of the identity as shown in equation (1), it is easy to imagine that the (total) capital services share in value added for the total market economy of mainland Norway had been gradually increasing during 1997-2014, which is opposite to the trend for (total) labour services share as reflected in Figure 5.1.

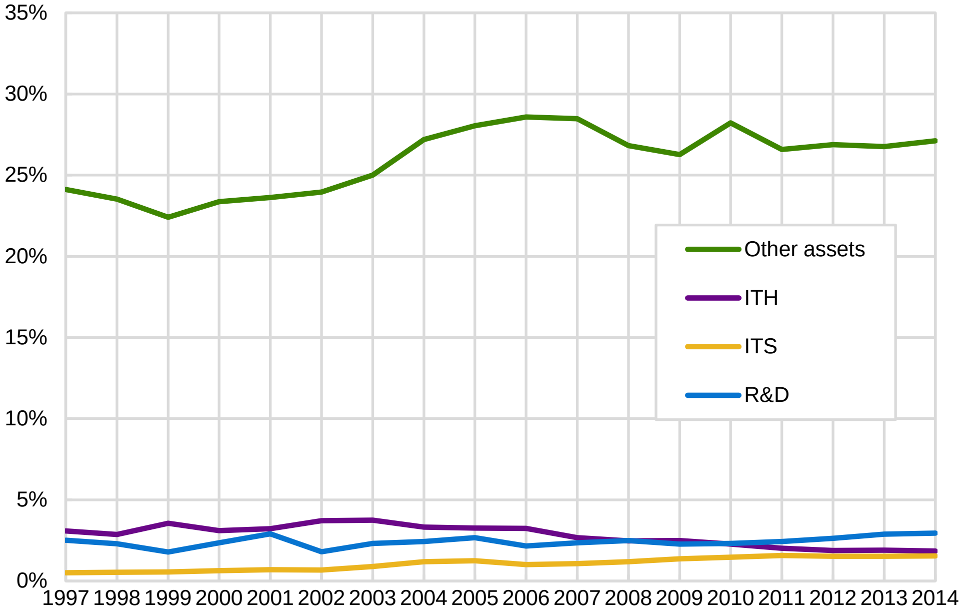
By means of equation (3), Figure 5.6 presents the time trends of capital service share in sector value added for all the six sectors that make up the total market economy of mainland Norway. Also, due to the identity as shown in (1), results derived from Figure 5.6 are mirror images to those from Figure 5.2. For example, the capital services share in sector value added is at most 45 percent for all sectors and in all years during the period 1997-2014.

Figure 5.6. Capital services share in sector value added, 1997-2014



Source: Calculations are based on Norwegian KLEMS database, July 2017.

Figure 5.7. Different capital services share in value added, 1997-2014, total market economy



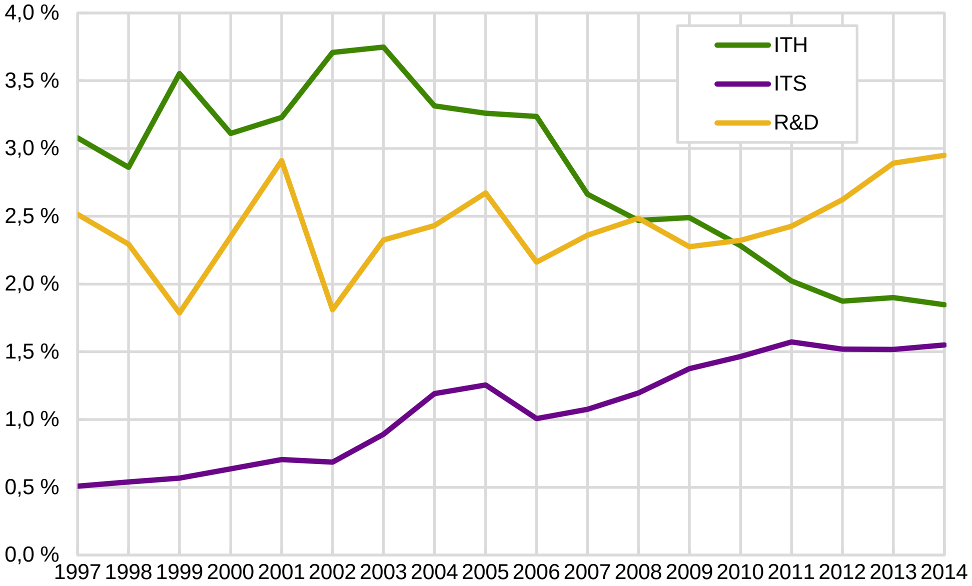
Source: Calculations are based on Norwegian KLEMS database, July 2017.

Similarly, the capital services share is higher in 2014 than in 1997 for the majority of the six sectors, and for the total market economy as well, while lower for the ICT production and Personal services sectors only.

Based on equations (6), (7), (8), and (9), Figure 5.7 provides the time trend of capital services share in value added for the total market economy of mainland Norway according to different capital groups. Not surprising, compared to the knowledge based capital, Other (than the knowledge based) assets dominant in capital services share; and consequently, its curve dwarfs all the other curves in Figure 5.7. Clearly, there exists an increasing trend of capital services share for Other assets for the period 1997-2014 (see also Table 5.4).

To focus on the knowledge based capital, Figure 5.8 presents the same information as shown in Figure 5.7, but with only three groups of assets left: Hardware (ITH), Software (ITS) and R&D. As shown in Figure 5.8, the time trend is generally declining for Hardware (ITH), while increasing for both Software (ITS) and R&D, especially during the latter period.

Figure 5.8. Knowledge based capital (Other assets excluded) services share in value added, 1997-2014, total market economy



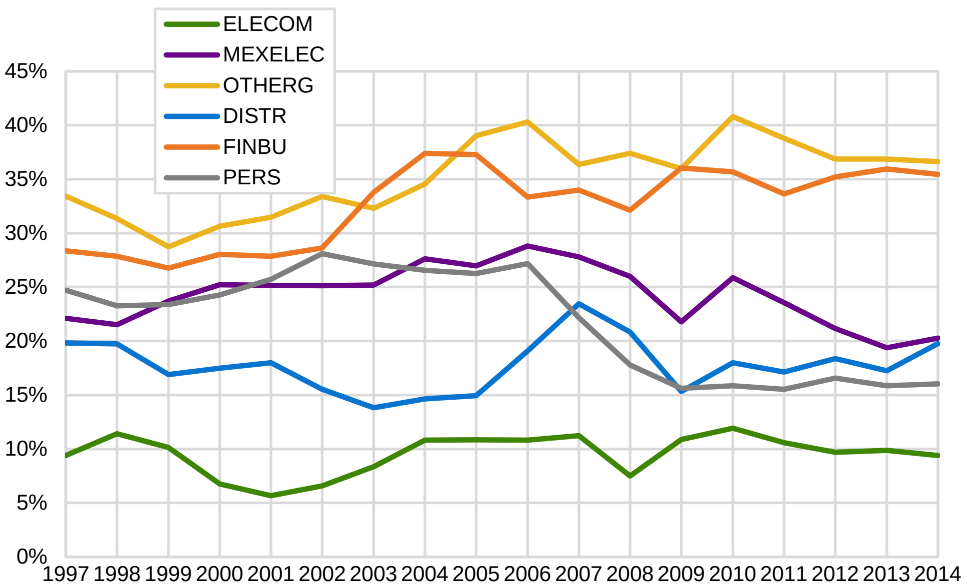
Source: Calculations are based on Norwegian KLEMS database, July 2017.

Up to now, the trend observed is for the total market economy, in the following we will investigate the time trend of different capital services share in sector value added for the six sectors that make up the total market economy.

Other assets

Other assets include mainly buildings, infrastructure, machinery, and equipment etc. Based on equation (9), the time trend of capital services share in value added for all the six sectors over 1997-2014 is displayed in Figure 5.9. And the corresponding shares for three selected years (1997, 2008, and 2014) are provided in Table 5.5.

Figure 5.9. Other (than ICT and R&D) capital services share in sector value added, 1997-2014



Source: Calculations are based on Norwegian KLEMS database, July 2017.

Not against the intuition, the share of Other assets capital services for goods production sector such as Other goods production and Manufacturing, and for Finance and business sector is among the highest. The ICT production sector is of the lowest share among all the sectors.

Table 5.5. Capital services of Other assets as a percentage of value added (%)

	1997	2008	2014
Total market economy of mainland Norway	24.12	26.83	27.12
ICT production (ELECOM)	9.40	7.51	9.39
Goods			
Manufacturing (MEXELEC)	22.11	26.00	20.27
Other goods (OTHERG)	33.44	37.40	36.64
Services			
Distribution (DISTR)	19.82	20.84	19.76
Finance and business (FINBU)	28.35	32.11	35.43
Personal (PERS)	24.71	17.79	16.04

Source: Calculations are based on Norwegian KLEMS database, July 2017.

ICT capital

ICT capital refers literally to Information and Communication Technology assets, which are divided into Hardware (ITH) and Software (ITS) in this paper. The latter consists actually of Software itself and Databases (UN, 2009; Eurostat, 2010). However, in the Norwegian KLEMS database, Databases are not distinguished from Software, and as a consequence, Software (ITH) applied here includes Databases.

As for the input intensity for ICT capital, some simpler measures are frequently used, such as the number of computers per employee, or the share of ICT assets in total investment or capital stock. The measure of the relative importance of ICT capital in this paper is based on the concept of capital services introduced by Jorgenson and Griliches (1967).

Following this approach, capital input is measured through its delivery of services in a specific period (such as a year) as measured by its user cost, reflecting the actual contribution to production process in a specific period from capital assets employed.

By using equation (6), Hardware (ITH) capital services share in sector value added for all the six sectors, and for the total market economy as well, are presented in Table 5.6 for three selected years (i.e. 1997, 2008, and 2014). The corresponding time trend for 1997-2014 is displayed in Figure 5.10.

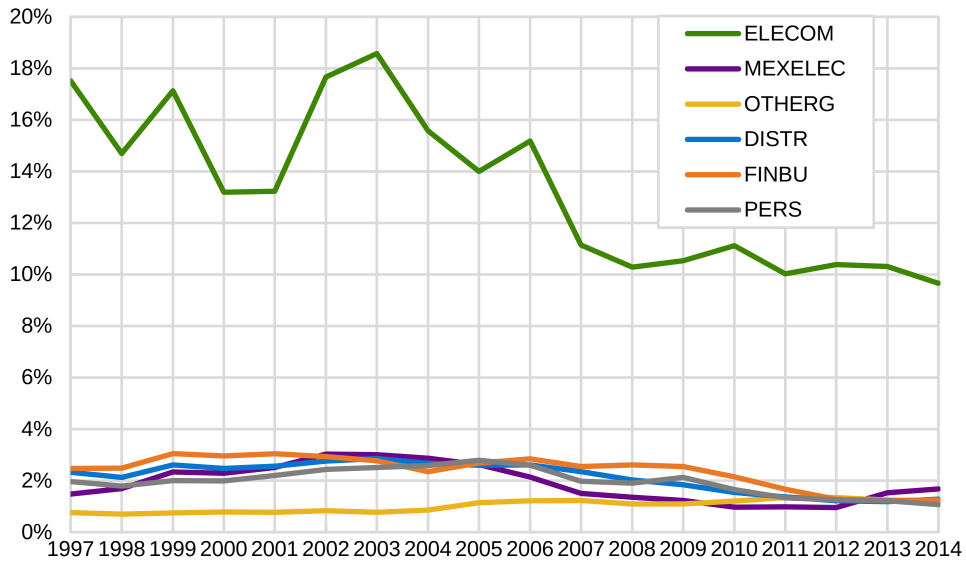
The Hardware (ITH) capital services share in sector value added for the ICT production sector showed a strong decline over the entire period. In 2014, the share (9.7 percent) is almost half of that in 1997 (17.5 percent).

Table 5.6. Capital services of ITH as a percentage of value added (%)

	1997	2008	2014
Total market economy of mainland Norway	3,08	2,47	1,85
ICT production (ELECOM)	17.52	10.29	9.66
Goods			
Manufacturing (MEXELEC)	1.48	1.36	1.68
Other goods (OTHERG)	0.76	1.09	1.12
Services			
Distribution (DISTR)	2.33	2.03	1.29
Finance and business (FINBU)	2.47	2.61	1.24
Personal (PERS)	1.97	1.90	1.07

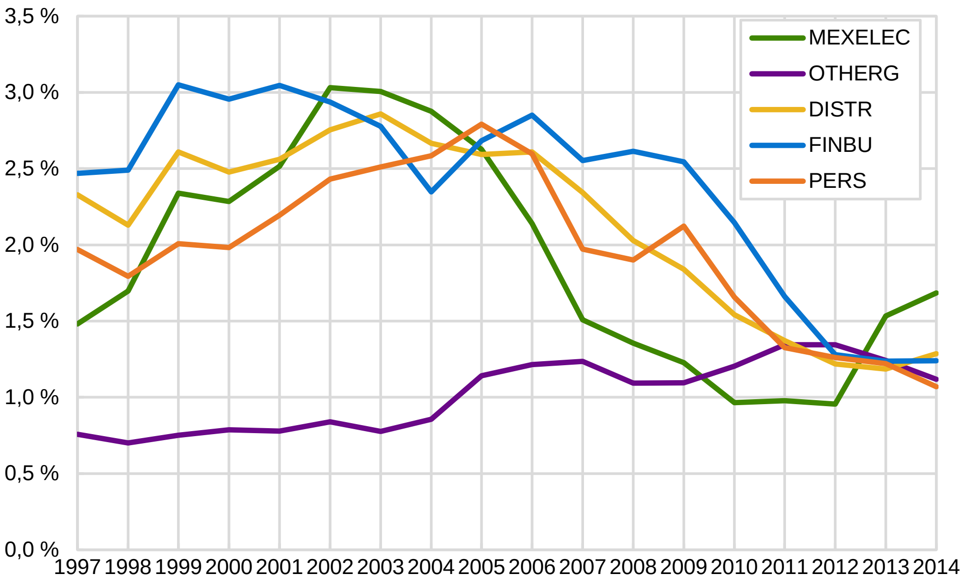
Source: Calculations are based on Norwegian KLEMS database, July 2017.

Figure 5.10. ITH share in sector value added, 1997-2014



Source: Calculations are based on Norwegian KLEMS database, July 2017.

Figure 5.11. ITH share in sector value added (ELECOM excluded), 1997-2014



Source: Calculations are based on Norwegian KLEMS database, July 2017.

Clearly, the Hardware (ITH) share for this sector is far larger than those for any of the other sectors. To make visualization easier, Figure 5.11 provides the same time trend as shown in Figure 5.10, but with the ICT production sector excluded.

Broadly speaking, after having reached the peak around mid-2000, the shares for Finance and business services, Distribution services, Personal services, and Manufacturing sectors, declined rapidly, although the share for Manufacturing sector resumed upturns near the end of the period. As for the Other goods production sector, its share had been gradually increasing over the whole period 1997-2014.

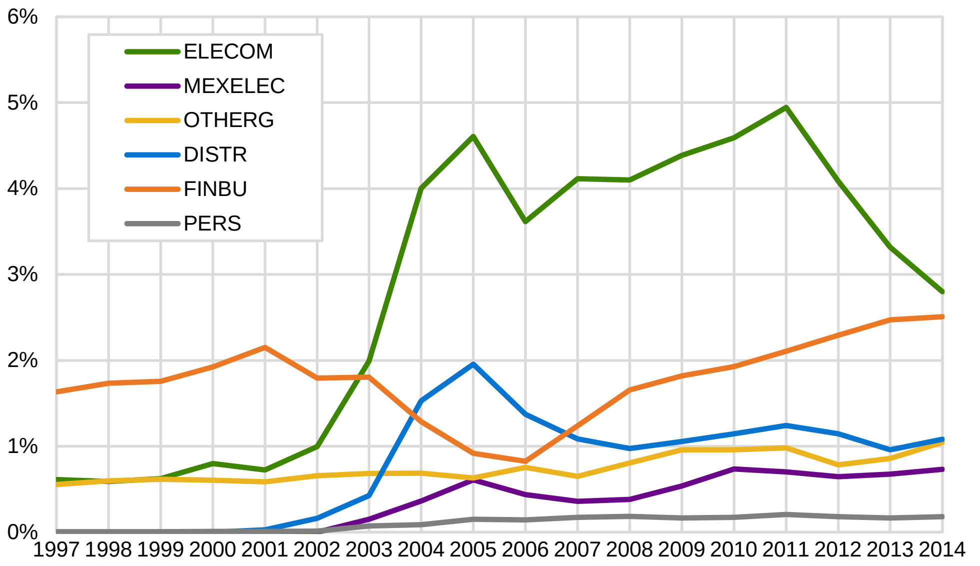
Based on equation (7), Software (ITS) capital services share in sector value added for the six sectors, and for the total market economy as well, are presented in Table 5.7 for 1997, 2008, and 2014. The corresponding time trend for 1997-2014 is displayed in Figure 5.12.

Table 5.7. Capital services of ITS as a percentage of value added (%)

	1997	2008	2014
Total market economy of mainland Norway	0.51	1.20	1.55
ICT production (ELECOM)	0.61	4.10	2.80
Goods			
Manufacturing (MEXELEC)	0.00	0.38	0.73
Other goods (OTHERG)	0.56	0.81	1.05
Services			
Distribution (DISTR)	0.00	0.97	1.08
Finance and business (FINBU)	1.63	1.66	2.51
Personal (PERS)	0.01	0.18	0.18

Source: Calculations are based on Norwegian KLEMS database, July 2017.

Figure 5.12. ITS share in sector value added, 1997-2014



Source: Calculations are based on Norwegian KLEMS database, July 2017.

Over the entire period, the capital services share of Software (ITS) had increased for all the sectors, and for the total market economy as well. However, if focusing on the latter period 2008-2014, the share for the ICT production sector declined, and that for Personal services sector has remained more or less constant.

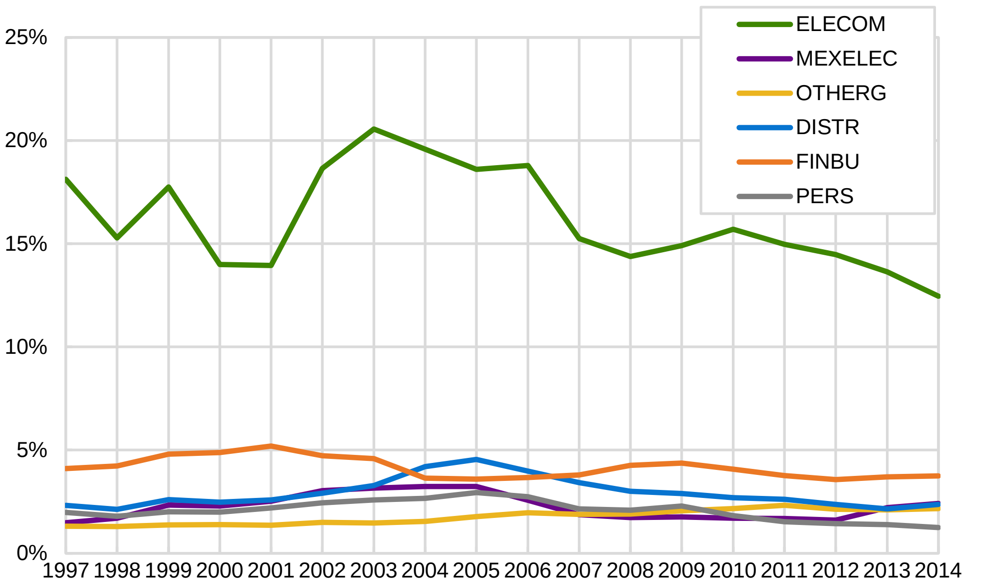
Finally, by combining both Hardware (ITH) and Software (ITS) together, capital services share of ICT (ITH + ITS) capital is presented in Table 5.8 for three selected years (1997, 2008, and 2014), and the corresponding continuous time trend over the period 2008-2014 in Figure 5.13. Again, for easy visualisation, Figure 5.14 displays the same curves as shown in Figure 5.13, but with ICT production sector removed.

Table 5.8. Capital services of ICT (ITH+ITS) as a percentage of value added (%)

	1997	2008	2014
Total market economy of mainland Norway	3.59	3.66	3.40
ICT production (ELECOM)	18.13	14.39	12.46
Goods			
Manufacturing (MEXELEC)	1.48	1.74	2.42
Other goods (OTHERG)	1.31	1.90	2.16
Services			
Distribution (DISTR)	2.33	3.00	2.37
Finance and business (FINBU)	4.10	4.27	3.75
Personal (PERS)	1.97	2.08	1.25

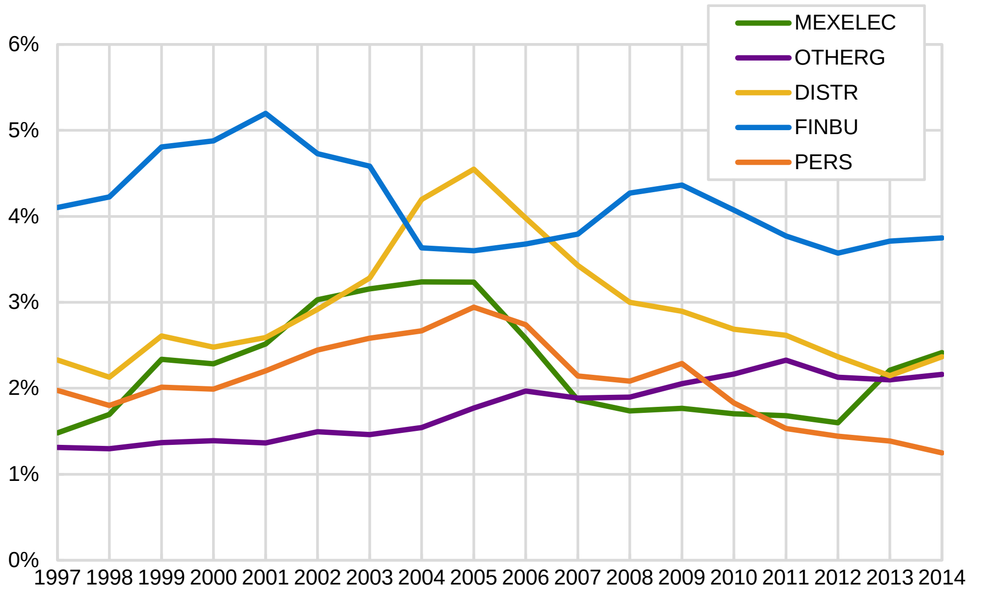
Source: Calculations are based on Norwegian KLEMS database, July 2017.

Figure 5.13. ICT (ITH+ITS) share in sector value added, 1997-2014



Source: Calculations are based on Norwegian KLEMS database, July 2017.

Figure 5.14. ICT (ITH+ITS) share in sector value added (ELECOM excluded), 1997-2014



Source: Calculations are based on Norwegian KLEMS database, July 2017.

As shown in Figure 5.13 and Figure 5.14, the ICT production and Finance and business services are still ICT (ITH + ITS) capital intensive sectors, because these two sectors are more intensive in terms of both Hardware (ITH) and Software (ITS) capital inputs in sector value added, compared to the other sectors (see Figure 5.10, Figure 5.11 and Figure 5.12).

Generally speaking, the capital services share of Hardware (ITH) is higher in magnitude than that of Software (ITS) for each sector and every year. Therefore, the general trend reflected by Figure 5.10 and Figure 5.11 for Hardware (ITH) will dominate that reflected by Figure 5.12 for Software (ITS), especially, for the latter period 2008-2014.

For instance, over the last period 2008-2014, the capital services share of ICT (ITH + ITS) capital for most of the sectors (except for the Other goods production and Manufacturing sectors), as well as for the total market economy, had declined. The share for the Manufacturing sector picked up just before the end of the entire period. Moreover, the share for the Other goods production sector had increased, over not only 2008-2014, but also the entire period 1997-2014 (see Figure 5.14).

R&D capital

R&D capital refers to Research and Development capital. Expenditures on R&D had traditionally been treated as intermediate consumption, although there had long been argued that these expenditures should be considered as capital investments, and therefore incorporated into the asset boundary within the national accounts.

In the latest framework of national accounts, such as SNA2008 and ESA 2010, R&D was for the first time incorporated into the asset boundary and treated as one type of capital under the category of Intellectual Property Products (IPP) (UN, 2009; Eurostat, 2010). Later, implementation of capitalising R&D expenditures in national accounts has been carried out by many countries, including Norway (see Sørensen, 2016).

In the Norwegian KLEMS database, R&D is capitalised and so treated separately as one specific type of the knowledge based capital (see Liu, 2017), which offers the opportunity for better analysing the relationship between use of skilled labour and the knowledge based capital more comprehensively.

Many other indicators have been used to measure the R&D input intensity, such as R&D intensity calculated as the ratio of R&D investment to GDP, the share of firms dealing with R&D within the industry (e.g. Brasch, 2015; Foyn, 2017). All these indicators do not really reflect the actual input flow coming from R&D capital into each round of production process.

In this paper, the relative importance of R&D is based on the concept of capital services introduced by Jorgenson and Griliches (1967). By following this approach, capital input is measured through its delivery of services in a specific period (e.g. a year) as measured by its user cost, and therefore, is a more suitable measure of capital input.

Formally, by using equation (8), R&D capital services share in sector value added for the six sectors, and for the total market economy as well, are calculated and reported in Table 5.9 for 1997, 2008, and 2014. The corresponding time trend for 1997-2014 is displayed in Figure 5.15.

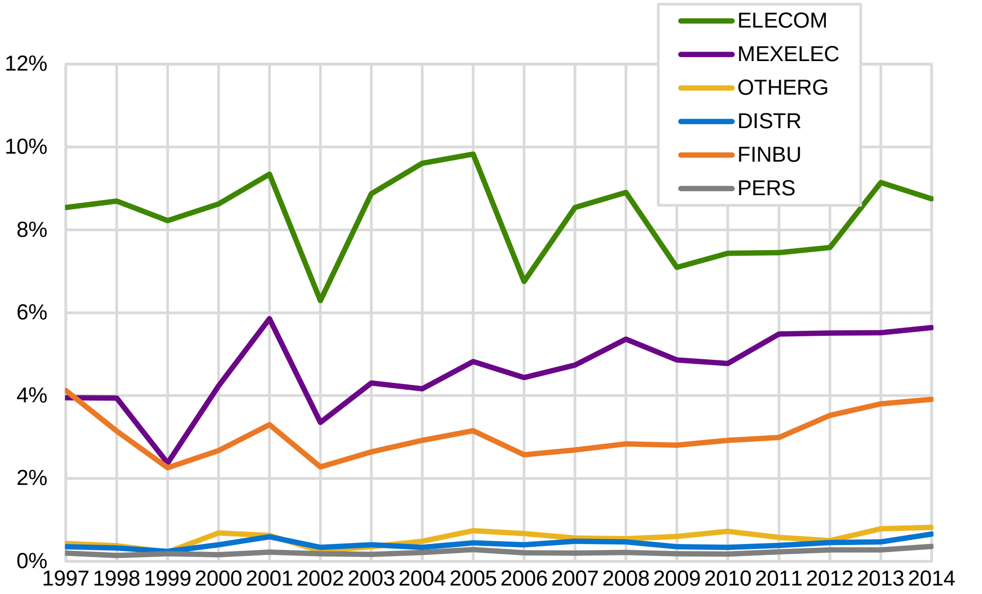
Table 5.9. Capital services of R&D as a percentage of value added (%)

	1997	2008	2014
Total market economy of mainland Norway	2.51	2.49	2.95
ICT production (ELECOM)	8.54	8.90	8.75
Goods			
Manufacturing (MEXELEC)	3.95	5.36	5.64
Other goods (OTHERG)	0.43	0.55	0.82
Services			
Distribution (DISTR)	0.35	0.47	0.66
Finance and business (FINBU)	4.12	2.84	3.91
Personal (PERS)	0.20	0.22	0.36

Source: Calculations are based on Norwegian KLEMS database, July 2017.

As shown in Figure 5.15, three sectors (i.e. ICT production, Manufacturing, and Finance and business services) are more R&D intensive, compared with the other sectors. The general trend of R&D capital services shares for the Manufacturing and Finance and business services sectors had been increasing, especially, over the latter period of 2008-2014. This is also true for the total market economy of mainland Norway.

Figure 5.15. R&D share in sector value added, 1997-2014



Source: Calculations are based on Norwegian KLEMS database, July 2017.

As for the ICT production sector, despite ups and downs, its share increased in 2014 (8.8 percent), if compared with that in 1997 (8.5 percent); while declined slightly, if compared with that in 2008 (8.9 percent).

On the other hand, the time trend of R&D capital services shares for the Other goods production, Distribution services, and Personal services sectors had been gradually but steadily increasing, over the entire period of 1997-2014.

5.4. Intensification of knowledge inputs

Knowledge inputs used by production process include not only skilled labour with accumulated knowledge as part of human capital development, but also the knowledge based non-human capital, with knowledge either physically embodied in new or quality enhanced capital assets, such as Hardware (ITH), or in intangible form such as R&D capital.

The knowledge based (non-human) capital in this paper is narrowly defined as the sum of ICT capital including Hardware (ITH) and Software (ITS), and R&D capital. For our purpose, we now group together Software (ITS) with R&D, and define this new group as the Intellectual Property Products (IPP), because the IPP capital does include among others Software (ITS) and R&D as categorised in the latest framework of national accounts, such as SNA2008 and ESA2010 (UN, 2009; Eurostat, 2010).

Modern economic growth has been featured with the intensification of knowledge inputs into production process over the world. In particular, the past decades have witnessed the increased use of skilled labour and ICT capital in both USA and European countries (see e.g. Jorgenson *et al*., 2005; Timmer *et al*., 2010).

One appealing explanation to this economic phenomenon is that there exists a complementarity between the two knowledge inputs, namely, skilled labour and ICT capital. If this complementary hypothesis holds correct, one would expect that there should be a positive correlation between the input intensity of skilled labour and that of ICT capital.

In the previous sections we have seen that the input intensity of skilled labour had been increasing for the total market economy of mainland Norway over the whole observed period (1997-2014); and for almost all the sectors, at least over the latest period (2008-2014). However, the input intensity of the knowledge based capital revealed a diversified picture both across different capital assets, and among the different sectors.

To test the complementarity hypothesis by means of the Norwegian data, we calculate the sample correlation coefficients between various types of skilled labour and the knowledge based capital, making use of the estimated time trend of input intensity as presented both in Section 4 for labour services share in value added and in this Section for capital services share in value added.

Table 5.10. Correlation coefficient between use of skilled labour and of knowledge based capital

	Knowledge capital (ITC+R&D)			ITC (ITH+ITS)		
	High (S+L)	High S	High L	High (S+L)	High S	High L
Total market economy	0.34	0.23	0.41	-0.79	-0.71	-0.83
ICT production (ELECOM)	-0.69	-0.72	-0.63	-0.85	-0.83	-0.80
Goods						
Manufacturing (MEXELEC)	0.74	0.68	0.78	0.66	0.61	0.70
Other goods (OTHERG)	0.47	0.45	0.48	0.34	0.33	0.34
Services						
Distribution (DISTR)	-0.90	-0.91	-0.83	-0.90	-0.86	-0.92
Finance and business (FINBU)	-0.43	-0.73	0.27	-0.34	0.41	-0.90
Personal (PERS)	-0.86	-0.84	-0.87	-0.86	-0.84	-0.85

	IPP capital (ITS + R&D)			R&D		
	High (S+L)	High S	High L	High (S+L)	High S	High L
Total market economy	0.91	0.82	***0.95***	0.73	0.62	***0.79***
ICT production (ELECOM)	-0.26	-0.24	***-0.26***	0.46	0.41	***0.46***
Goods						
Manufacturing (MEXELEC)	0.76	0.70	***0.81***	0.60	0.55	***0.64***
Other goods (OTHERG)	0.32	0.31	***0.31***	0.39	0.37	***0.40***
Services						
Distribution (DISTR)	0.38	0.27	***0.57***	0.25	0.12	***0.50***
Finance and business (FINBU)	-0.04	-0.75	***0.79***	-0.06	-0.74	***0.75***
Personal (PERS)	0.61	0.63	***0.56***	0.65	0.68	***0.56***

Source: Calculations are based on Norwegian KLEMS database, July 2017.

The calculated results are presented in Table 5.10. Note that the sample correlation coefficients are calculated both for the total market economy of mainland Norway, and for the six sectors that make up it. In addition, the sample time period is chosen as 2008-2014, because the quality of labour services data cross-classified by age, gender, education and industry is higher for this subperiod of time (2008-2014), compared to that before 2008 (see Liu, 2017).

The first row of Table 5.10 is read like this: for the total market economy of mainland Norway, the sample correlation coefficient between the (total) knowledge based capital (ITC + R&D) and High (L+S), High S, and High L, is 0.34, 0.23, and 0.41, respectively; similarly, the sample correlation coefficient between ITC (ITH + ITS) capital, consisting of Hardware (ITH) and Software (ITS), and High (L+S), High S, and High L, is -0.79, -0.71, and -0.83, respectively.

As the results indicate, the hypothesis that there exists a complementarity relationship between the use of skilled labour and ICT capital is not supported by the Norwegian data for this period of 2008-2014. Because many of the calculated correlation coefficients are negative between ICT (ITH + ITS) capital and different types of skilled labour, as shown by the last three columns in the upper panel of Table 5.10.

However, based on the Norwegian data, a complementarity relationship is found suggestive between one type of more highly skilled labour (i.e. Higher L) and the Intellectual Property Products (IPP) capital defined in this paper (i.e. ICT + R&D), as shown by the third column (in bold and italic) in the lower panel of Table 5.10. Moreover, the existence of a new complementarity relationship between the use of High L and R&D capital is considered to be predominantly suggestive, because the last column in the lower panel of Table 5.10 showing the calculated correlation coefficients between High L and R&D is the only column which has all positive numbers (in bold and italic) in Table 5.10.

6. Conclusions

Drawing upon the Norwegian KLEMS database, this paper has studied the structural development in the market economy of mainland Norway over the period of 1997-2014. At the most general level an increasing share was found in output and employment of services at the expense of goods production, and services had become the largest sector in terms of both output and employment in the total market economy of mainland Norway.

In addition, over the entire period 1997-2014, productivity growth in goods production sector was higher than in services sector. These findings largely confirm the trends that have been identified by many other studies (e.g. Kuznets, 1971; Maddison, 1980; Skoglund, 2013; Timmer *et al*., 2010).

However, when considering the changes between two subperiods (i.e. 1997-2006, and 2006-2014), productivity performance in the goods production sector was weaker in the first subperiod, while much stronger in the second, than in the services sector.

Moreover, a more detailed sector analysis reveals very substantial heterogeneity both within the goods production sector and among the services sector, leaving the traditional distinction between goods and services outdated. In particular, the characterization of services as stagnant in terms of productivity growth and input structure is no longer true.

With a declined share in both output and employment, a continuing productivity growth is found in the ICT production and Manufacturing sectors. And even stronger productivity growth is observed for the last subperiod (2006-2014) for the Manufacturing sector. In terms of intensification of knowledge inputs, the ICT production sector was the highest, while Manufacturing sector was among the highest in terms of R&D capital input intensity.

Despite an increase of its share in output, the Other goods production sector kept low productivity growth, and its average growth decreased from the first subperiod (1997-2006) to the second (2006-2014). Despite a steady increase over the entire period, the input intensity in both skilled labour and knowledge based capital in this sector had been among the lowest.

Finance and business services sector had become highly intensive in both skilled labour and knowledge based capital, and demonstrated an increased share in employment while little productivity growth. From the first subperiod (1997-2006) to the second (2006-2014), the MFP growth for this sector even reduced to negative. This sector seems to epitomise a stagnant sector as described by Baumol (1967).

The other typical stagnant sector is Personal services which had revealed no productivity improvements but increased share in employment over the whole period 1997-2014. However, this sector was highly skilled labour intensive, although its knowledge based capital input intensity was among the lowest.

As for the Distribution services sector, over the entire period, both the shares in output and employment had declined, but this sector had productivity growth even higher than the Other goods production sector. It is true that this sector once became one major engine of productivity growth alongside the ICT production and Manufacturing sectors, at least for the first subperiod (1997-2006). From the first to the second subperiod (2006-2014), however, this sector lost the momentum, and its average labour productivity growth even became negative.

Based on the calculated input intensity measures, an increased share of skilled labour in value added is found for the total market economy of mainland Norway over the entire period, as well as for almost all the sectors, at least for the latter period (2008-2014).

For the total market economy, the shares in value added of both Software (ITS) and R&D capital increased, while those of Hardware (ITH) decreased, for the period 1997-2014. With a few exceptions, this finding also holds for almost all the sectors, at least for the latter period (2008-2014).

Finally, the complementarity hypothesis between the use of ICT capital and skilled labour is tested. The results show that it is not supported by the Norwegian data. However, the existence of complementarity between the use of IPP capital and highly skilled labour is suggestive. Furthermore, the complementarity relationship between R&D and highly skilled labour is strongly suggestive based on the Norwegian data.

All the findings in this paper have a number of implications for both theoretical and empirical works in the future. For instance, since reliance conventionally on an aggregate representation of either goods production or services sector in its entirety does not make sense any more, a greater attention should be paid to individual sector or even to disaggregate industries, in order to better understand the drivers of economic growth.

The new evidence of the existence of complementarity between the use of highly skilled labour and R&D capital (instead of ICT capital as found in earlier studies) in recent years calls for further investigation into the linkages among capital investment, education and technological change in general, and those among R&D investment and skill-biased technological change in particular.

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List of figures

List of tables

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