Structural Change and Productivity in the Market Economy of Mainland Norway: 1997-2014

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Abstract

Based on a newly compiled Norwegian KLEMS database, this article investigates structural change and productivity in the market economy of mainland Norway for the 1997-2014 period. The findings largely confirm the general trends identified by many other studies. However, detailed sector analyses reveal substantial differences within both goods production and services sectors. In addition, an increased share of skilled labour in value added is found for the total market economy 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. With a few exceptions, this finding also holds for most of the sectors, at least for the latter period (2008-2014). Finally, test results indicate that the complementarity hypothesis between ICT capital and skilled labour is not supported, but that between Intellectual Property Products (IPP), and esp. R&D capital, and highly skilled labour is supported, implying that intangible assets combined with human capital had been playing an increasingly important role in recent economic growth in Norway.

For the last century, there has been a substantial structural change taking place in the Norwegian economy. For example, at the beginning of the 1900s, the primary sector, defined as agriculture, forestry, and fishery, accounted for roughly half of the total employment. A shift of labour from primary into secondary and tertiary sectors then took place, with the share of secondary sector peaking in the 1970s. Since then, the tertiary sector, generally referred to as the services sector, has been growing rapidly. However, labour productivity growth in services sector was found lower than in either primary or secondary sector (e.g. Skoglund, 2013).

The stylized facts observed in a small country like Norway are in line

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with the empirical regularities found in many other western countries (e.g. Kuznets, 1971; Maddison, 1980). In particular, all studies shared a common view as regards the services sector, namely 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 valid. Productivity growth within this sector reveals very considerable differences, with a number of services industries achieving 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 evidence also suggest that, along with the economic growth, technical change seems to have favoured certain 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 article is twofold. By using a newly compiled Norwegian KLEMS database, first I examine whether the above-mentioned stylized observations still hold for the market economy of mainland Norway during the period 1997-2014. The market economy of mainland Norway is a concept routinely used in official statistics at Statistics Norway; it does not include the offshore oil and gas extraction and the maritime sector, as well as all non-market activities.[2] Since the primary sector has become rather small in Norway, the main focus in this article will be on the structural change in the secondary and services sectors. In particular, I will look at the increasing share of services in output and employment at the expense of the secondary sector and at the comparative productivity growth in these two sectors.

Second, I will investigate changes in the structure of production technologies that occurred in the mar-

2 The definition of the market economy of mainland Norway will be discussed in more detail in Section 1.

ket economy of mainland Norway for 1997-2014, with special focus on the changes in the production input composition of skilled labour and knowledge-based capital in general, and the ICT, R&D assets in particular. Using Norwegian industry-level data, the hypothesis of the existence of complementarity between skilled labour and the ICT assets will be tested. This complementarity hypothesis was once employed to explain the prevalence of knowledge intensification featuring many countries' recent economic growth (see e.g. Berman *et al.* 1998).

The article is organized as follows. A brief description of the Norwegian KLEMS database is given in Section 1. Section 2 is devoted to changes in sectoral output and employment shares. In Section 3 the trend in labour and multi-factor productivity is discussed. Section 4 studies patterns in the use of the skilled labour and the knowledge-based capital. Moreover, the hypothesis of complementarity between the use of ICT assets and skilled labour is tested by using Norwegian data. Section 5 concludes the article.

The Norwegian KLEMS Database

The current Norwegian KLEMS database is based principally on official statistics, such as annual 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 (Liu, 2017).

For each industry, labour inputs are further decomposed into hours worked and changes of labour composition, and capital inputs are grouped into broad asset categories classified by the System of National Accounts (SNA) (United Nations, 2009; Eurostat, 2013). 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 (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 analyzed in an internally consistent way. As such, the framework of the modern growth accounting has become an international standard now (Schreyer, 2001, 2009).

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

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

The market economy of mainland Norway is defined by excluding from the total Norwegian economy all non-market activities, and the offshore oil and gas extraction and maritime sector. The former consists of central and local government activities, such as education, health, defense, and public administration, and activities of the NPISHs;[3] and the latter comprises the offshore industry extracting oil and gas (KNR2306), the pipeline transport of oil and gas (KNR2348), and the maritime transport (KNR2349). Due to exposure to the volatile international oil and gas market, the Norwegian offshore oil and gas extraction and maritime sector has experienced substantial swings, and thus necessitates a separate treatment from the economy of mainland Norway.

Finally, the industries that provide owner-occupied housing services (KNR2368), as well as private renting (KNR2369), are also excluded from the total Norwegian economy. In the end, the market economy of mainland Norway comprises in total 57 industries, the names and the corresponding codes of which are listed in Table 1.[4]

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 the purpose. Therefore, a more detailed view of the services sector is essential. Moreover, to study the development of the ICT sector which has played an important role in

3 Although significant progress has been made, difficulties for measuring output of these non-market activities remain (Atkinson, 2005; Schreyer, 2010).

4 KNRxxxx as listed in Table 1 are industry codes applied at Statistics Norway where the standard of industry classification is based on NACE Rev.2.

recent economic growth, a special focus on this sector is also worthwhile.

Given the above concerns, the market economy of mainland Norway is subdivided further into the following exhaustive and mutually exclusive six sectors: ICT production (ELECOM); manufacturing excluding ICT production (MEXELEC); other goods production (with traditional primary sector included) (OTHERG);[5] distribution services (DISTR); finance and business services (FINBU); personal services (PERS).

In Table 1 the detailed description and the corresponding abbreviations of the 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 (O'Mahony and Timmer, 2009; Timmer *et al.*, 2010), which is of potential use for comparative analysis.

Changes in output and employment

A country's economic growth has been usually accompanied with large-scale mobilization of economic resources across different sectors. For instance, the shift of economic resources (output and employment) from primary into secondary sector featured prominently in the earlier literature on 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 into secondary sector has lost its prominence in advanced economies because of the former's tiny share in the total economy. For example, in 2014, the primary sector employed about 4 per cent of the total labour force and accounted for less than 2 per cent of total value added in the market economy of mainland Norway. On the other hand, the shift from secondary into services sector has dominated the process of structural change since the 1970s, and therefore, is the main focus in this article.

Chart 1 shows 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

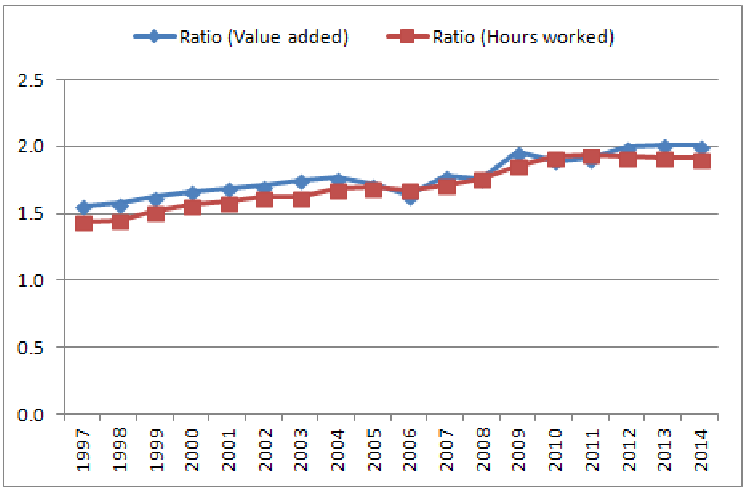
5 Note that other goods production sector (OTHERG) includes electricity (KNR2336), which is in fact a services industry. The average value added share of this industry in other goods production sector is about 8 per cent over the period 1997-2014.

Table 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		

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

Chart 1: Ratio of Services Over Goods Production in Mainland Norway, 1997-2014



Note: Value added in current prices.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

2014.

Note that the ICT production sector is not included in the (aggregate) goods production sector for comparison, because it incorporates some part of services industries, such as information services. However, if this sector is included in a broad sense, the calculated two ratios reported in Chart 1 will be slightly lower. Nevertheless, the trend over time is almost the same as shown in Chart 1.

Compared with goods production, the importance of market services had gradually but steadily increased over the period 1997-2014. This is in accordance with the empirical regularities that have been 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, Chart 1 makes rather clear that services had become a very sizable sector in its entirety. In 2014, the output (in terms of value added) of this (aggregate) market services sector was double (and the employment (in terms of hours worked) almost double) that of the (aggregate) goods production sector.

The growing importance of market services is the result of many interacting 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 2 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 of mainland Norway in Chart 1, the more detailed sector figures in 2 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. While the share of hours worked in other goods production sector had reduced, its value added share had actually increased, though with a small margin (from 17.1 in 1997 to 18.1 per cent in 2014). This implies that the ratio of labour productivity in other goods production sector to that of at least one other sector had increased over the period 1997-2014.[6]

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. In fact, the increases in this specific sector were the largest among all sectors in the total market economy of mainland Norway.

As for personal services sector, although its share of hours worked had increased substantially, its value-added share had actually decreased over the whole period 1997-2014, indicating a reduced labour productivity ratio of this sector to at least one other sector over the same period.

The ICT production sector is singled out from the total market economy of mainland Norway because of its exceptional performance in driving productivity growth in recent years.[7] As shown in Table 2, the shares of both sector value added and hours worked in this sector were small compared to those for other sectors, and these shares had shrunk to some extent from 1997 to 2014.

Changes in Productivity

Labour Productivity

One of the empirical regularities once documented by the literature (e.g. Kuznets, 1971; Maddison, 1980; Skoglund, 2013) is the slow growth of labour productivity in services industry compared to manufacturing in-

6 However, this does not necessarily mean that the absolute level of labour productivity in Other goods production sector had increased, because the absolute level in each sector is determined not only by the ratio of shares of sector value added to hours worked, but also by the labour productivity level of the total market economy of mainland Norway.

7 As will be shown later, although the production of ICT goods and services makes up only a small part of total value added (Table 2), its productivity growth was the highest among all the six sectors.

Table 2: Share of Value Added and Hours Worked by Sector in Mainland Norway, 1997 and 2014 (%)

	Value Added		Hours Worked	
	1997	2014	1997	2014
Total market economy of mainland Norway	100	100	100	100
ICT production (ELECOM)	7.8	6.9	6.1	5.6
Goods	36.1	31	38.5	32.4
Manufacturing (MEXELEC)	19.0	12.9	18.6	13.8
Other goods (OTHERG)	17.1	18.1	20.0	18.6
Services	56.2	62.2	55.4	62.0
Distribution (DISTR)	24.8	20.2	28.0	25.5
Finance and business (FINBU)	22.4	33.6	16.6	23.3
Personal (PERS)	9.0	8.4	10.9	13.3

Note: Value added in current prices.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

dustry. Traditionally, manufacturing activities have been regarded as the locus of innovation and technological change and thus the essentially central source of economic growth. This was also considered as the key to post-World War II growth in Europe through realization of economies of scale, capital intensification and incremental innovation (Crafts and Toniolo, 1996).

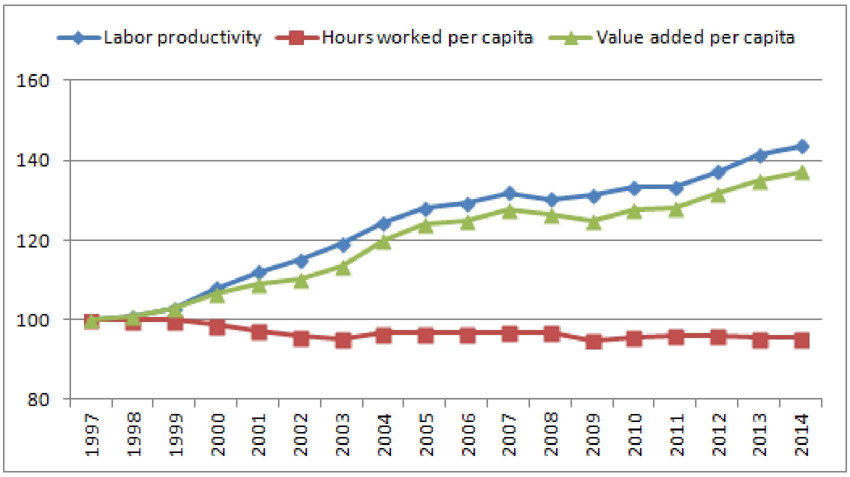
More recently, rapid technological change in ICT production (such as computer and semi-conductor manufacturing) seemingly reinforced the predominance of innovation in the broad manufacturing sector (including ICT production). By contrast, productivity growth in services was usually assumed to be low 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). However, a seminal study by Triplett and Bosworth (2006) shows that after 1995 fifteen out of twenty-two two-digit services industries in the United States had experienced acceleration in labour productivity growth that at least equaled the economy-wide average.

In this article I will look for similar patterns in Norway and study sectoral trends in productivity both for the entire period 1997-2014, and for two sub-periods (1997-2006, and 2006-2014).[8] The Norwegian KLEMS database provides the opportunity for examining the trends in both labour and multi-factor productivity (MFP). The MFP provides a measure of the

8 The year 2006 is chosen as sub-period demarcation for two reasons. First, official statistics at Statistics Norway show that both labour and multi-factor productivity (MFP) growth in the market economy of mainland Norway had decreased significantly since 2006. Second, 2006 is a natural mid-year of the entire period 1997-2014.

Chart 2: Trends of Labour Productivity, Hours Worked per Capita, and Value Added per Capita in the Total Market Economy of Mainland Norway (1997=100)



Note: Value added in volume.
Source: Calculations are based on Norwegian KLEMS database, July 2017.

efficiency of labour and other inputs combined and is often used as an indicator of technological change.

As shown in Chart 2, over the entire period 1997-2014, the fact that hours worked per capita had been gradually decreasing, together with an enhanced value added per capita, lead to increased labour productivity in the market economy of mainland Norway. In 2014, the labour productivity measured by value added per hour worked was above 140% of the level in 1997. But the picture painted by the total market economy of mainland Norway may hide some significant divergences among the sectors that make up it. Indeed, as shown in Table 3 and Chart 3, 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 was larger than that in (aggregate) services sector over the entire period (2.1 vs. 1.5 per cent in 1997-2014).

Table 3 provides average annual growth rates for the period 1997-2014, as well as two sub-periods of 1997-2006 and 2006-2014. Chart 3 presents the corresponding trends of labour productivity for the six sectors with 1997 indexed to 100, where the annual average growth rate for the whole period (1997-2014) is applied.

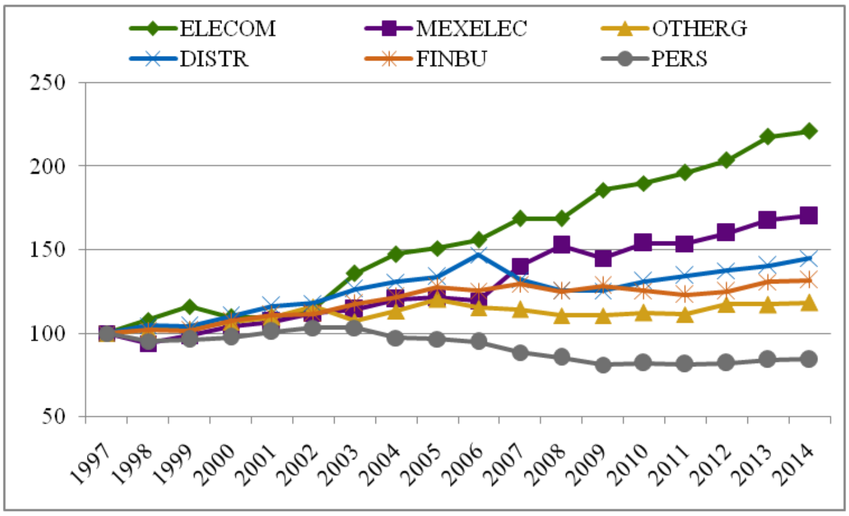
By far the fastest growth in labour productivity is found in the ICT production sector, with annual average growth rates of 4.9 per cent over the whole period, leading to its productivity level in 2014 more than twice than in 1997. During the same period, the second fastest growth sector is manufacturing, compared with which, all the three services sectors had lower productivity growth. Moreover, the productivity growth in personal ser-

Table 3: Labour Productivity Growth in Total Market Economy of Mainland Norway, 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	2.2	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

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

Chart 3: Labour Productivity by Sector of the Total Market Economy of Mainland Norway, Value Added Based (1997=100)



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

vices sector was even negative.

When considering the two sub-periods (1997-2006 and 2006-2014) as shown in Table 3, the overall labour productivity performance for (aggregate) goods production sector was actually weaker than (aggregate) services sector in the first sub-period (1.9 vs. 2.8 per cent). However, during the second sub-period, its performance was much stronger (2.4 vs. 0.1 per cent), thanks in part to the good performance by the manufacturing sector, and in part to the bad performance by the services sectors in general, and by distribution services sector in particular.

Indeed, except for the manufacturing sector, average labour productivity growth for all the other sectors had decreased from the first sub-period (1997-2006) to the second

(2006-2014). The labour productivity growth for distribution sector had even become negative. As a result, even if the labour productivity growth for manufacturing sector more than doubled (from 2.0 to 5.0 per cent), the labour productivity growth for the total market economy of mainland Norway had more than halved from the first sub-period 1997-2006 (2.9 per cent) to the second 2006-2014 (1.3 per cent).

Multi-factor productivity

As mentioned, technical change is usually measured as the growth in multi-factor productivity (MFP). Table 4 provides average annual MFP growth rates for the period 1997-2014, as well as two sub-periods of 1997-2006 and 2006-2014. There is also a large variation in the average rates of MFP growth among the sectors, although, again, the overall average annual MFP growth in the (aggregate) goods production sector was larger than that in the (aggregate) services sector over the entire period (1.9 vs. 0.7 per cent).

For the entire period 1997-2014, the sector ranking is broadly the same as that for labour productivity growth. The only exception is the sector ranking order between finance and business services, and other goods production sectors. The annual average growth rate for finance and business sector was lower in terms of MFP (0.3 vs. 1.2 per cent), while higher in terms of labour productivity in Table 3 (1.6 vs. 1.0 per cent), than that for other goods production sector.

The main reason is as follows. As shown in equation (1), the estimate of (value added-based) MFP growth in sector j ($\Delta \ln A_j^Z$) is empirically calculated as a residual, in other words, as average (value added-based) labour productivity growth ($\Delta \ln z_j$) deducted by contribution from changes of labour composition ($\bar{v}_{L,j}^Z \Delta \ln LC_j$) and that from capital intensity ($\bar{v}_{K,j}^Z \Delta \ln k_j$) in sector j (Liu, 2017).

$$\Delta \ln A_j^Z = \Delta \ln z_j - \bar{v}_{L,j}^Z \Delta \ln LC_j - \bar{v}_{K,j}^Z \Delta \ln k_j \tag{1}$$

While the contribution to average labour productivity growth from changes of labour composition ($\bar{v}_{L,j}^Z \Delta \ln LC_j$) was negative and of a large absolute value for other goods production sector, it was positive for finance and business services sector. Moreover, although the contribution to average labour productivity growth from capital intensity ($\bar{v}_{K,j}^Z \Delta \ln k_j$) was positive for both finance and business services and other goods production sectors, it was far larger for the former than for the latter. As a result, one ends up with a much lower estimate of MFP growth

Table 4: Multi-Factor Productivity Growth in Total Market Economy of Mainland Norway, 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.

($\Delta\ln A_j^Z$) for finance and business services sector than for other goods production sector (Liu, 2017).

Chart 4 gives the trends of MFP level for the six sectors, and all the curves are indexed to 100 in 1997, by using the annual average growth rate of MFP for the whole period (1997-2014). As shown, being consistent with the discussion outlined above, the ranking of MFP level is similar with that of labour productivity, except that the sector order of other goods production and finance and business services sectors is different.

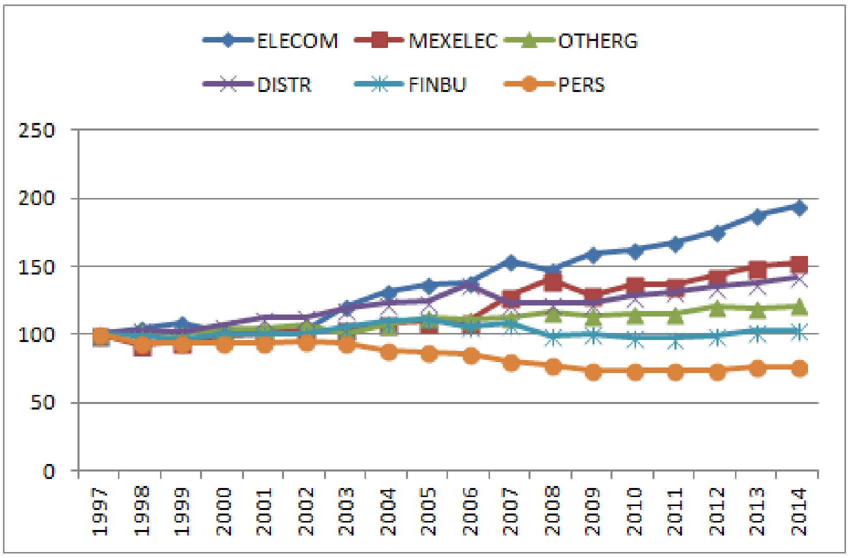
Further comparison between Charts 3 and 4 also reveals that except for the other goods production sector, labour productivity level index is larger than the corresponding MFP level index for all the other sectors, because the average growth of labour productivity ($\Delta\ln z_j$) is larger than that of the corresponding estimated MFP. The latter observation is due to that the summed contributions from the change of labour composition ($\bar{v}_{L,j}^Z\Delta\ln LC_j$) and capital intensity ($\bar{v}_{K,j}^Z\Delta\ln k_j$) are positive for these sectors, while negative for the other goods production sector, over the observed period 1997-2014 (Liu, 2017).[9]

Considering the two sub-periods (1997-2006, and 2006-2014) as shown in Table 4, similar with the revealed pattern by labour productivity growth, the overall MFP performance for the (aggregate) goods production sector was weaker in the first sub-period (1.1 vs. 1.5 per cent), while much stronger during the second sub-period (2.8 vs. -0.1 per cent), than the (aggregate) services sector. This is again owing in part to the good performance by manufacturing sector, and in part to the bad performance by the services sectors, and in particular, by distribution services sector.

On the other hand, over the two sub-periods, the detailed change pat-

9 Also see equation (1).

Chart 4: Multi-Factor Productivity by Sector of the Total Market Economy of Mainland Norway, Value Added Based (1997=100)



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

terns of MFP growth among the sectors are different from those of labour productivity growth. For instance, there was only one sector (manufacturing) having improved labour productivity growth; while there were three sectors, i.e. ICT production, manufacturing, and personal services, having increased their MFP growth. In addition, the MFP growth of finance and business services sector, which was positive in the first sub-period (0.8 per cent), became negative in the second sub-period (-0.2 per cent).

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 decreased, there was continuing productivity growth in the ICT production and manufacturing sectors. And even stronger productivity growth was observed for the second sub-period (2006-2014) for the manufacturing sector. However, despite an increase of its share in value added, other goods production sector had revealed low productivity growth, and its average growth had decreased from the first sub-period to the second.

Both shares of value added and hours worked of finance and business services sector had increased sharply over 1997-2014. In 2014, this sector accounted for about a third of value added and a quarter of hours worked of the market economy of mainland Norway. But this sector experienced relatively low productivity growth. Nonetheless, as shown by Oulton (2016), the aggregate MFP growth can rise when resources (value added) shift towards those sectors supplying intermediate services, even if these supplying sectors themselves have low MFP growth (provided it is positive). In other words, as a large intermediate services provider, finance and business services had contributed positively to the overall MFP growth of the market economy of mainland Norway, both for the entire period and for the first sub-period.

Within finance and business services sector, the financial services industry (KNR2364) is the largest one, accounting for in average about 26 per cent of the sector's value added over the period 1997-2014. However, the current estimation method for the output from this industry, i.e. FISIM (Financial Intermediation Services Indirectly Measured), is rather different from those applied for other industries in national accounts compilation system (United Nations, 2009; Eurostat, 2013). Therefore, any results associated with the financial and business services sector should be interpreted with due caution.

The personal services sector seems to be a typically stagnant sector 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 had declined, but this sector had higher productivity growth even than the other goods production sector over the entire period. From the first sub-period to the second, however, this sector suffered a large decline in productivity growth, and its average labour productivity growth became negative.

Changes in input composition

Structural change not only entails the changes in output, employment, and labour and multi-factor productivity, but also involves changes in the mix of inputs used in the production process. For instance, one study has found that compared to the United States 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 increased use of inputs that are well suited to the generation, processing and diffusion of knowledge and information, namely, skilled labour and ICT equipment. 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 complementarity hypothesis.

In the previous sections, it has been demonstrated that the patterns of structural change revealed solely by either total economy or two (aggregate) sectors may be misleading. Therefore, in this section I will track the use of skilled labour and the knowledge-based capital in general, and the ICT and R&D capital in particular, with focus being placed on the six sectors that make up the market economy of mainland Norway.

Measures of input intensity

Indicators for input intensity in this article are value measures, rather than the more frequently used quantity ones (such as the share of workers with high education in total employment or the number of computers per employee). The value measures are also applied by the EU KLEMS project (where they are referred to as cost measures) (Timmer *et al.*, 2010).

In this article, skilled labour is represented by those workers with high education attained. For simplicity, all the other workers with other than high educational attainment are regarded as unskilled labour (UL).[10] High education consists of two levels: High Ed-short is defined as Tertiary education, lower degree; High Ed-long is defined as Tertiary education, higher degree. Simply put, High Ed-short refers largely to Bachelors while High Ed-long mainly to Masters and/or Doctors.

The capital assets are classified first into two broad asset categories: the knowledge-based capital, and all other assets (other), with the former consisting of ICT and R&D capital. The dichotomous distinction between the knowledge-based capital and all others (other) merits some discussion here. In fact, such a simple categorization does not mean that only the ICT and R&D capital are knowledge-based, while others have no knowledge embodied at all, which is clearly wrong. The purpose of this categorization is to focus on the ICT and related assets, because these assets have been frequently employed for explaining the prevalence of knowledge intensification featuring many countries' recent economic growth (e.g. Berman *et al.*, 1998).

The ICT capital is further divided into two subgroups: IT-hardware and IT-software. IT-hardware con-

10 The definition of skilled vs. unskilled labour applied in this article is only a relative concept. For detailed classifications on the Norwegian educational attainment levels, see Liu (2017).

sists of office and computing equipment, and communications equipment. IT-software is supposed to be treated separately from databases (United Nations, 2009; Eurostat, 2013). However, in the Norwegian KLEMS database, databases are not distinguished from software, and therefore, IT-software applied here includes databases.

R&D capital refers to the asset developed through Research and Development experimental activities. 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 SNA.

In the latest SNA (United Nations, 2009; Eurostat, 2013), 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).[11] Later, implementation of capitalizing R&D expenditures in national accounts has been carried out by many countries, including Norway (see Sørensen, 2016), which offers the opportunity for better analyzing the relationship between the use of skilled labor and the knowledge-based capital more comprehensively than before.

Input intensity measures based on the value approach as in this article start from the standard national accounting identity that value added equals the cost, namely, the compensation for labour and capital in total.

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

$$\begin{aligned} P^{VA}Q^{VA} = P^{UL}Q^{UL} + \\ P^{HighEd-short}Q^{HighEd-short} + \\ P^{HighEd-long}Q^{HighEd-long} + \\ P^{IT-hardware}Q^{IT-hardware} + \\ P^{IT-software}Q^{IT-software} + \\ P^{R\&D}Q^{R\&D} + P^{Other}Q^{Other} \end{aligned} \tag{2}$$

In equation (2), the price applied to value added (P^{VA}) is basic prices which are evaluated from the producer's point of view and thus exclude all taxes from the value of output but include product subsidies. The concept of basic prices is defined and recommended in the SNA (United Na-

11 Intellectual Property Products (IPP) includes among others *computer software and databases* which had already been recommended to be incorporated into the asset boundary by the *System of National Accounts 1993* (United Nations, 1993).

tions, 2009; Eurostat, 2013).[12]

Using equation (2), the input intensity for each input component is defined as its compensation of services divided by total value added. For instance, the input intensity for unskilled labor is calculated as $P^{UL}Q^{UL}$ divided by total value added $P^{VA}Q^{VA}$.

As a share of value added, an increase of an input intensity 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. On the contrary, indicators based on quantities alone usually ignore price changes. Moreover, the value measures of input intensity as defined in this article take account of substitution effects not only among different labour types but also between labour and other inputs, such as various capital 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 drawn from the Norwegian KLEMS database.[13]

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 is based on the concept of capital services introduced by Jorgenson and Griliches (1967). According to this approach, capital input is measured through its delivery of capital services in a specific period (e.g. a year). Being consistent with the entire framework of the modern growth accounting, the capital input intensity as measured in this article is considered to be better than those calculated, e.g. as the ratio of R&D investment to GDP, the share of firms undertaking R&D within an industry (Brasch, 2015; Foyn, 2017).

In the Appendix, the estimated input intensity measures for three selected years (1997, 2008, and 2014) are presented by different labor inputs in Table A1, and by various knowledge-based capital inputs in Ta-

12 As implicitly reflected by equation (2), other taxes (net of subsidies) on production have been allocated to either labour or capital inputs. These taxes (net of subsidies) could include a variety of taxes levied on ownership and use of land, use of fixed assets, total wage bill, licenses, etc. However, without detailed knowledge about the various tax types, taxes on production are practically allocated to capital compensation as they mainly fall on this factor input.

13 Note that labour compensation computed in the Norwegian KLEMS database includes employer's social contributions, in addition to wages/salaries. As for labour compensation of the self-employed, an imputation is made by assuming that the compensation per hour of the self-employed is equal to the compensation per hour worked of employees.

ble A2, both for the total market economy of mainland Norway, as well as for the six sectors.

Skilled Labour

Chart 5 provides the time trend of input intensity for total labor, High Ed-short, and High Ed-long in the market economy of mainland Norway over the period 1997-2014. The valued added share for total labor dropped gradually from 70 per cent in 1997 to 67 per cent in 2008 and continued to shrink to slightly lower than 67 per cent in 2014 (Table A1 in the Appendix). This observation reflects a long-run trend of substituting labour by capital as described by Blanchard (1997). However, the value added share of labour services by both High Ed-short and High Ed-long had been growing during 1997-2014. In 1997, the shares of High Ed-short and High Ed-long were 12.9 and 5.3 per cent, while they became 15.0 and 8.1 per cent in 2014, respectively (see Table A1 in Appendix).

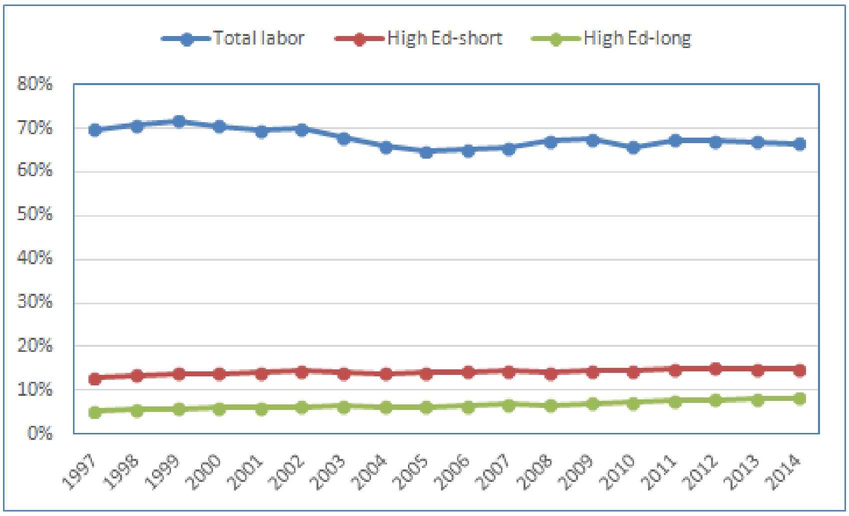
In Chart 6, the time trend of labour input intensity is presented in Panel (a) for High Ed-short and in Panel (b) for High Ed-long workers for the six sectors. Note that only estimated labour input intensity for the period 2008-2014 are presented in Chart 6, because labour input data cross-classified by age, gender, education, and industry before 2008 is of relatively lower quality (Liu, 2017).

In general, labour compensation share with either High Ed-short or High Ed-long education in sector value added was higher in 2014 than in 2008 for almost all the sectors. The only exception is finance and business services sector for which the labour compensation share of workers with High Ed-short in 2014 was slightly lower than in 2008 (see Table A1 in Appendix).

As visualized in Chart 6, three sectors (i.e. ICT production, finance and business services, and personal services) are highly skilled labour-intensive sectors, compared with the other three ones (i.e. manufacturing, other goods production, and distribution services sectors). As for the sector rankings, finance and business services and manufacturing have relatively higher (than personal services and distribution services, respectively) rankings of labour services share in Panel (b) (for High Ed-long), compared with those in Panel (a) (for High Ed-short).

The reason why labour services share of High Ed-short in sector value added for personal services sector is higher than that for financial and business services sector is not because the average labour compensation in the former sector is larger than in the latter one. In fact, the average share of High Ed-short in sector labour com-

Chart 5: Labour Services Share in Value Added Total Market Economy of Mainland Norway, by Skill Level, 1997-2014 (%)



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

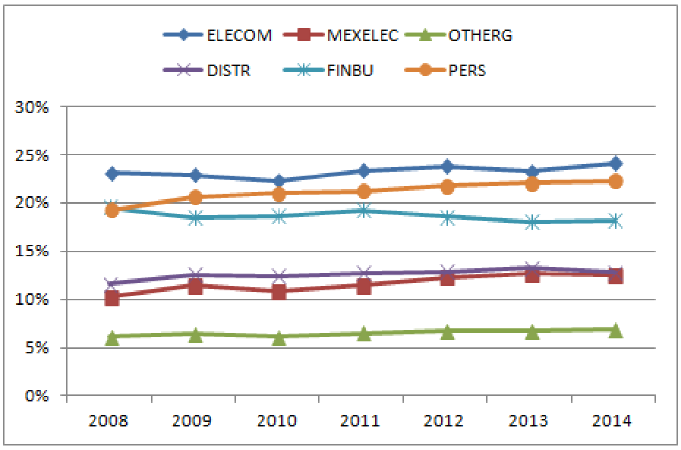
pensation is 25.8 per cent for personal services sector, and 32.2 per cent for financial and business services sector over the period 2008-2014. However, as a typical labour-intensive sector, the average share of labour compensation in sector value added for personal services sector is 81.9 per cent, while that for financial and business services sector is 58.0 per cent over the same period. Consequently,the average labour services share of High Ed-short in sector value added for personal services sector is 21.2 per cent, which is higher than 18.6 per cent for financial and business services sector (Liu, 2017).

Finally, by combining High Ed-short and High Ed-long together, labour services share of workers with high education in general (i.e. High Ed (short + long)) is shown in Panel (c) in Chart 6. 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 Panel (c) is the same as that in Panel (a) (for High Ed-short only), simply because the share of High Ed-short (Panel (a)) is considerably larger than the corresponding share of High Ed-long (Panel (b)) for each sector, as well as in every year.

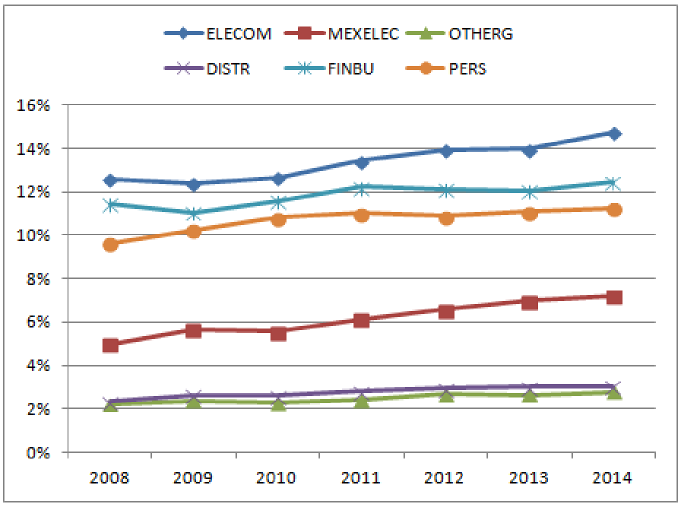
On the other hand, the ranking order revealed by Panel (c) for the other three sectors (i.e. manufacturing, distribution services, and other goods production) looks the same as that by Panel (b) (for High Ed-long only). The reason is that the labour services share in value added of distribution

Chart 6: Compensation of High Education Share in Sector Value Added for Total Market Economy of Mainland Norway, 2008-2014

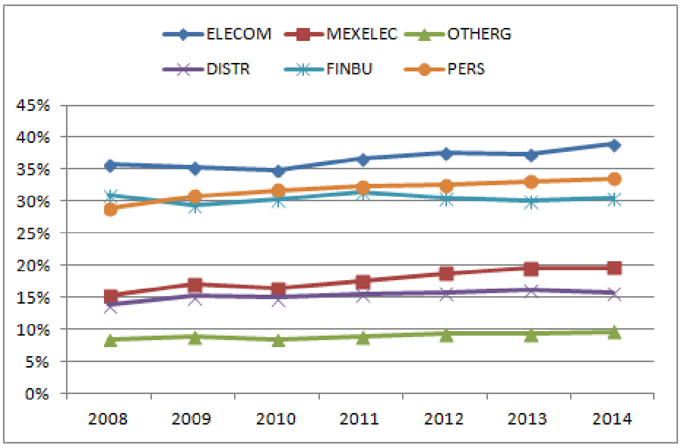
(a) High Ed-short



(b) High Ed-long



(c) High Ed (Short + Long)



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

services sector is so low for High Ed-long that it effectively drags down the sum of the labour services share of both High Ed-short and High Ed-long for this sector below that for manufacturing sector as shown in Panel (c) of Chart 6.

Knowledge-Based Capital

The time trend of capital services share in value added for the total market economy of mainland Norway over the period 1997-2014 is presented in Chart 7 for three knowledge-based capital: IT-hardware, IT-software, and R&D.

In general, the time trend for the total market economy of mainland Norway was declining for IT-hardware, while increasing for both IT-software and R&D, especially during the latter period. The falling share of IT-hardware could be largely related to the nature of the ongoing technological change in the digital economy, which has shifted from investing in ICT hardware to outsourcing ICT services, such as purchasing IT services from cloud computing.

ICT Capital

The time trend of different capital services share in sector value added for IT-hardware, IT-software, and for ICT capital (hardware + software), for each of the six sectors is displayed respectively in Panels (a), (b), and (c) of Chart 8.

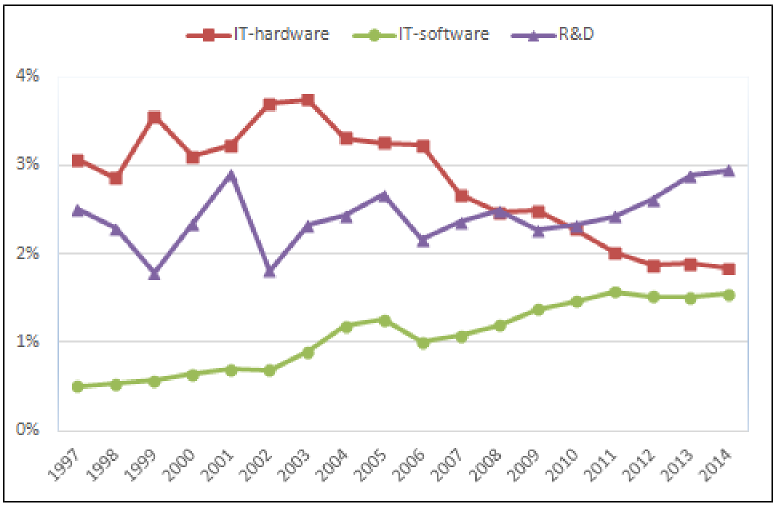
As shown in Panel (a), in terms of the IT-hardware services share in sector value added, for the ICT production sector experienced a heavy decline over the entire period. In 2014, at 9.7 per cent, the share was almost half of that in 1997 (17.5 per cent) (Table A2 in Appendix). In spite of that, the IT-hardware share for this sector is far larger than those for any of the other sectors.

Broadly speaking, after having peaked 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 upturn 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.

As displayed in Panel (b), over the entire period, the capital services share of IT-software had increased for all the sectors, and for the total market economy as well. However, in the latter period 2008-2014, the share for the ICT production sector declined, and that for personal services sector had remained more or less unchanged.

Panel (c) shows that the ICT production and finance and business services are ICT capital intensive sectors, simply because these two sectors are more intensive in terms of both IT-

Chart 7: Capital Services Share in Value Added of Total Market Economy of Mainland Norway, 1997-2014



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

hardware and IT-software capital inputs in sector value added. In general, the capital services share of IT-hardware is higher in magnitude than that of IT-software for each sector and in every year. Therefore, the general trend reflected in Panel (a) for IT-hardware will dominate that reflected in Panel (b) for IT-software, especially for the latter period 2008-2014.

R&D Capital

R&D capital services share in value added for the six sectors is displayed in Chart 9, which shows that 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.

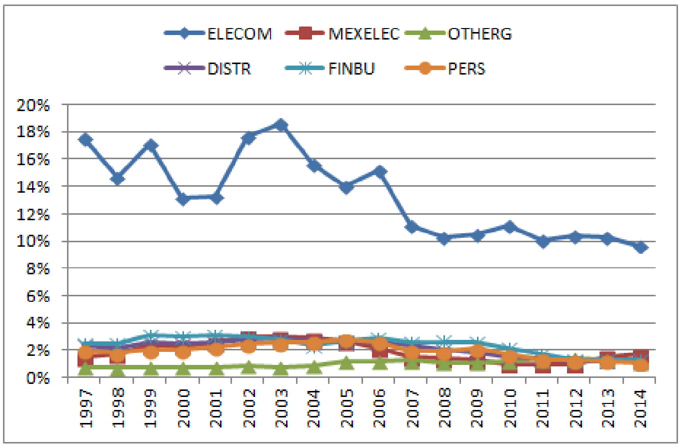
As for the ICT production sector, despite ups and downs, its share increased in 2014 (8.8 per cent), if compared with that in 1997 (8.5 per cent); while declined slightly, if compared with that in 2008 (8.9 per cent). On the other hand, the time trend of R&D capital services shares for the other goods production, distribution services, and personal services sectors had been gradually but steadily increasing, over the entire period of 1997-2014 (also see Table A2 in the Appendix).

Intensification of Knowledge Inputs

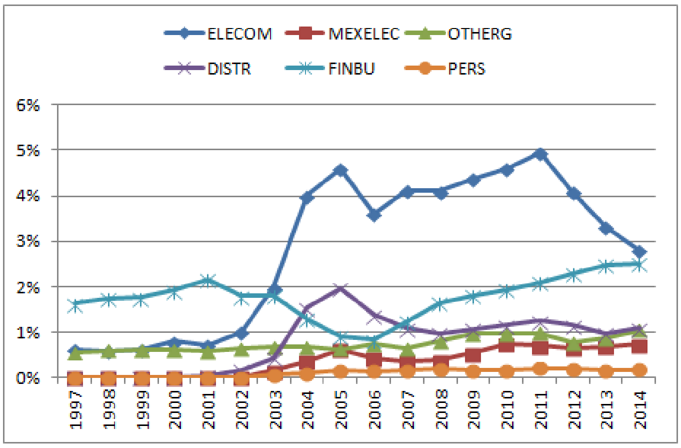
Knowledge inputs used by production process include not only the skilled labour with accumulated knowledge as part of human capital developed, but also the knowledge based non-human capital, with knowledge either physically embodied

Chart 8: ICT Capital Services Share in Sector Value Added for Total Market Economy of Mainland Norway, 1997-2014

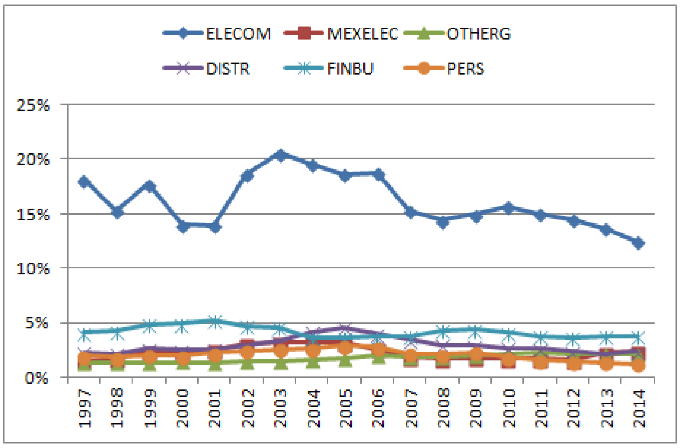
(a) IT-Hardware



(b) IT-Software

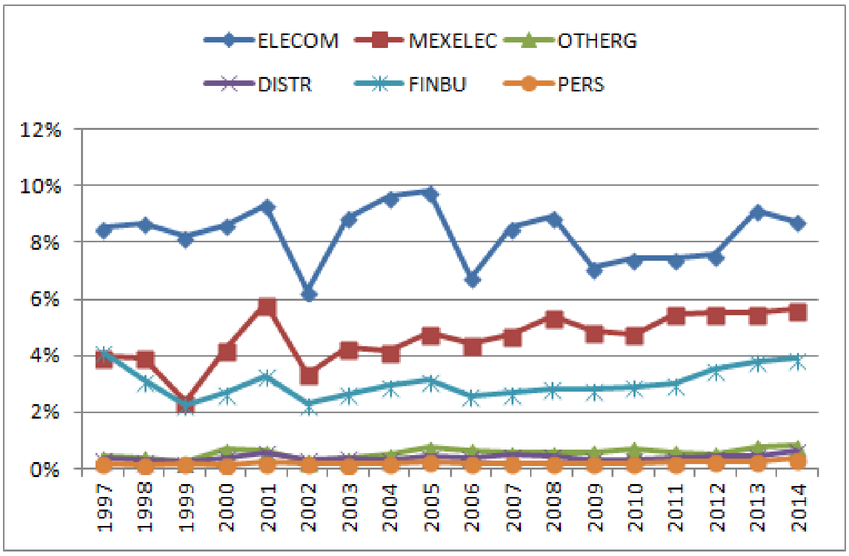


(c) ICT (Hardware + Software)



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

Chart 9: R&D Share in Sector Value Added Total for Market Economy of Mainland Norway, 1997-2014



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

in new or quality-enhanced capital assets, such as IT-hardware, or in intangible forms such as R&D capital.

Modern economic growth has been featured with the intensification of knowledge inputs across the world and over time. In particular, the past decades have witnessed the increased use of skilled labour and ICT capital in both the United States and European countries (Jorgenson *et al.*, 2005; Timmer *et al.*, 2010). One appealing explanation to this economic phenomenon is that complementarity may exist between the two knowledge inputs, namely, skilled labour and ICT capital.

If this complementary hypothesis holds, there should be a positive correlation between the input intensity of skilled labour and that of ICT capital over time. Moreover, from a bottom-up perspective, this positive correlation is expected to hold not only for the total economy, but also for the different sectors that make up it.

In the previous sections it has been demonstrated that the input intensity of skilled labour had been increasing for the total market economy of mainland Norway over the entire observed period (1997-2014); and for almost all the sectors, at least over the latter 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, the sample correlation coefficients are calculated between different types of skilled labour and various knowledge-based capital as defined in this article, making use of the estimated time trend of input intensity as presented both for labour services share and for capital services share in value added in the previous sections.

The calculated results are presented in Table 5. Note that we have grouped IT-software and R&D together and define it as the Intellectual Property Products (IPP), given that the IPP capital does include among others IT-software and R&D, as categorized in the latest SNA (United Nations, 2009; Eurostat, 2013). In addition, the sample 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 sub-period (2008-2014), compared to that before 2008 (Liu, 2017).

The first row of Table 5 shows that for the total market economy of mainland Norway, the sample correlation coefficient between the (total) knowledge-based capital (i.e. ICT (hardware + software) and R&D) and High Ed (short + long), High Ed-short, and High Ed-long, is 0.34, 0.23, and 0.41, respectively. Similarly, the sample correlation coefficient between ICT (hardware + software) capital, and High Ed (short + long), High Ed-short, and High Ed-long, 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, because many of the calculated correlation coefficients are negative between ICT (hardware + software) capital and different types of skilled labour, as shown by the last three columns in the right upper panel of Table 5.

On the other hand, a complementarity relationship is found suggestive between one type of highly skilled labour (i.e. High Ed-long) and the IPP capital (i.e. IT-software + R&D), which is reflected by the third column (in bold) in the left lower panel of Table 5. Moreover, the existence of a complementarity relationship between the use of one highly skilled labour (i.e. High Ed-long) and R&D capital is considered to be strongly suggestive, as the last column in the right lower panel of Table 5 is the only one in which all the calculated correlation coefficients are positive numbers (in bold) in Table 5.

It may be concluded that it is intangibles assets including IPP (i.e. IT-software + R&D), and particularly, it is R&D capital, rather than the ICT capital in its entirety (i.e. IT-hardware together with IT-software), combined with the employment of highly skilled labour (High Ed-long), that had been gaining growing importance during the recent economic

Table 5: Correlation Coefficients Between Use of Skilled Labour and of Knowledge-Based Capital

	Knowledge-based capital (ICT (hardware+software) and R&D)			ICT capital (hardware+software)		
	High Ed (short+long)	High Ed-short	High Ed-long	High Ed (short+long)	High Ed-Short	High Ed-long
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	-0.8
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 (IT-software and R&D)			R&D capital		
	High Ed (short+long)	High Ed-Short	High Ed-long	High Ed (short+long)	High Ed-Short	High Ed-long
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.

growth that had occurred in the market economy of mainland Norway.

Conclusion

Drawing upon a newly constructed Norwegian KLEMS database, this article has studied the structural change and productivity in the market economy of mainland Norway over the period of 1997-2014. At the most general level an increasing share is 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 (aggregate) goods production sector was higher than in (aggregate) services sector. All 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 selected sub-periods (1997-2006, and 2006-2014), productivity performance in the (aggregate) goods production sector was weaker in the first sub-period, while much stronger in the second, than in the (aggregate) services sector.

Moreover, more detailed sector analyses reveal very substantial differences both within the (aggregate) goods production sector and among the (aggregate) 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 valid.

With a decreasing 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 second sub-period (2006-2014) for the manufacturing sector. In terms of intensification of knowledge inputs, the ICT production sector was the highest, while the 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 revealed a trend of low productivity growth, and its average growth even decreased between sub-periods. Even with a steady increase over the latter period (2008-2014), the input intensity in both skilled labour and knowledge-based capital in this sector had been among the lowest.

The finance and business services sector had become highly intensive in both skilled labour and knowledge-based capital and experienced an increased share in employment while very weak productivity growth for the entire period. Nonetheless, as a large intermediate services provider, this sector had contributed positively to the overall MFP growth over the entire period as well as the first sub-period.

Personal services had revealed negative productivity growth and an increased share in employment over the period 1997-2014. This sector seems to epitomize a stagnant sector as described by Baumol (1967). On the other hand, 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 was a major engine of productivity growth alongside the ICT production and manufacturing sectors, for the first sub-period (1997-2006). In the second sub-period (2006-2014), however, this sector abruptly lost the momentum, leading to labour productivity growth becoming negative.

An increased share of skilled labour in value added is found for the total market economy of mainland Norway over the entire period 1997-2014, 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 IT-software and R&D capital increased, while those of IT-hardware decreased, for the entire period 1997-2014. With a few exceptions, this finding also holds for most of the sectors, at least for the latter period (2008-2014).

Finally, tests results indicate that the complementarity hypothesis between the use of ICT capital and skilled labour is not supported by the Norwegian data. But the existence of complementarity between the use of IPP capital and highly skilled labour is suggestive. Furthermore, the complementarity relationship between R&D capital and highly skilled labour is strongly suggestive based on the Norwegian data, which implies that intangible assets, combined with human capital, had been playing an increasingly important role in recent economic growth in the market economy of mainland Norway.

The findings may 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, greater attention should be paid to individual sector or even to detailed industries, with the view of better understanding the drivers of economic growth.

The new evidence of the existence of complementary relationship between the use of highly skilled labour and IPP capital in general, and R&D capital in particular (instead of ICT capital in its entirety as found in earlier studies) also calls for further investigation into the linkages among intangible capital investment, education and technological change that had been taking place in recent years in the market economy of mainland Norway.

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Appendix

Table A1: Labour Compensation a Percentage of Value Added in the Total Market Economy of Mainland Norway, by Type of Education (%)

	High Ed-short			High Ed-long			High Ed (short + long)			Total Labour		
	1997	2008	2014	1997	2008	2014	1997	2008	2014	1997	2008	2014
Total market economy	12.9	14.1	15.0	5.3	6.6	8.1	18.2	20.7	23.1	69.8	67.0	66.5
ICT production (ELECOM)	11.7	23.1	24.1	4.7	12.6	14.7	16.4	35.7	38.9	63.9	69.2	69.4
Goods												
Manufacturing (MEXELEC)	13.7	10.3	12.5	6.0	5.0	7.2	19.7	15.2	19.7	72.5	66.9	71.7
Other goods (OTHERG)	11.8	6.2	6.9	5.7	2.2	2.8	17.5	8.4	9.7	64.8	60.2	60.4
Services												
Distribution (DISTR)	14.5	11.6	12.8	5.7	2.3	3.0	20.2	13.9	15.8	77.5	75.7	77.2
Finance and business (FINBU)	11.6	19.6	18.1	4.4	11.5	12.4	16.0	31.0	30.5	63.4	60.8	56.9
Personal (PERS)	13.6	19.2	22.3	4.4	9.6	11.2	18.0	28.9	33.6	73.1	79.9	82.4

Notes: Labour includes employees and self-employed.

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

Table A2: Capital Compensation of Knowledge-Based Capital as a Percentage of Value Added in the Total Market Economy of Mainland Norway (%)

	IT-Hardware			It-Software			ICT (hardware + software			R&D		
	1997	2008	2014	1997	2008	2014	1997	2008	2014	1997	2008	2014
Total market economy	3.1	2.5	1.9	0.5	1.2	1.6	3.6	3.7	3.4	2.5	2.5	3.0
ICT production (ELECOM)	17.5	10.3	9.7	0.6	4.1	2.8	18.1	14.4	12.5	8.5	8.9	8.8
Goods												
Manufacturing (MEXELEC)	1.5	1.4	1.7	0.0	0.4	0.7	1.5	1.7	2.4	4.0	5.4	5.6
Other goods (OTHERG)	0.8	1.1	1.1	0.6	0.8	1.1	1.3	1.9	2.2	0.4	0.6	0.8
Services												
Distribution (DISTR)	2.3	2.0	1.3	0.0	1.0	1.1	2.3	3.0	2.4	0.4	0.5	0.7
Finance and business (FINBU)	2.5	2.6	1.2	1.6	1.7	2.5	4.1	4.3	3.8	4.1	2.8	3.9
Personal (PERS)	2.0	1.9	1.1	0.0	0.2	0.2	2.0	2.1	1.3	0.2	0.2	0.4

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