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Differences in Regional Productivity and Imbalance in Regional Growth

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Abstract

This paper focuses on the relationships between regional productivity and regional economic growth. Historical data show the difference in regional productivity in both geographical and sectoral dimensions. Using a modelling approach, the paper tests the regional spillover effects among three types of municipalities in two selected sectors. The results show that, firstly, there are different impacts on different types of regions; secondly, the spillover of impacts differ with respect to regional spillovers and sectoral spillovers; thirdly, the economic structure and the linkage between the regions also play a role in regional spillovers. Imbalanced growth between the regions is revealed.

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Introduction

The aim of this paper is to investigate the relationship between changes in labour productivity and economic growth in Danish regions at the municipal level. Using historical data, we compare the changes in labour productivity in selected economic sectors before and after the financial crisis of 2008. The study shows that there is a difference in the sector productivity across different types of regions; that is, the productivity in the new and creative economic sectors in the urban regions has increased, but that in the traditional sectors, such as agriculture and some of the industrial sectors, has decreased.

Various studies have been conducted in the fields of new economic geography and regional and urban economics in relation to labour productivity and the relevant factors that explain the differences in regional labour productivity. Most research has focused on the explanation of and correlations between productivity and other economic factors by using

econometric approaches. The differences in human capital, capital stocks and public investment in different regions can explain some of the causes of different labour productivity levels. Other studies have found that agglomeration, externalities, technology changes, R&D inputs and so on have also contributed to the changes in productivity.

Unlike other researchers, we apply a model approach to test and identify the contribution of changes in labour productivity to regional economic growth. Historical data show the differences in regional labour productivity and economic growth, which lead to increases in regional commuting and labour migration; these in turn influence in the long-term changes in labour productivity both in the region in focus and in the neighbouring regions. The scenario analysis in this paper aims to identify how the changing trends in productivity within the selected sectors have direct and spillover effects on regional growth.

Literature Review

A considerable amount of research has focused on regional productivity and attempts to understand the relationship between labour productivity and other economic factors, such as the growth of total factor productivity (TFP), capital stock, different education backgrounds in the labour force, human capital, R&D inputs, and technology changes. Besides these economic factors, some research has explored the relationship between productivity and agglomeration effects, externalities, and localization.

Total factor productivity seems to be a significant factor that affects both the level and the growth rates of productivity. Baier, Dwyer and Tamura (2006) found, using a long-time span data set covering 145 countries, that 14% of economic growth is directly contributed by the growth of TFP. The variance is larger across country groups; specifically, TFP growth accounted for 34% of the average growth in Western countries and 26% in Southern Europe and the newly industrialized countries (NICs). Their evidence shows that, over long periods of time, the growth of output per worker is associated with the accumulation of physical and human capital and technology changes.

Beugelsdijk, Klasing and Milionis (2018) determined, using the 257 regions in the 21 EU countries, that 75% of the differences in regional economic development can be attributed to differences in TFP. They suggested that the analysis could be extended to the regional level in each country and to the sectoral level, as this could reveal more about the TFP differences related to regional economic growth and local dimensions of technology and knowledge.

Bronzini and Piselli (2009) investigated the long-run relationship between total factor productivity, human capital, and public infrastructure between 1980 and 2001 across the Italian regions. Their findings showed that the R&D associated with productivity expansion is rather small; on the other hand, human capital and infrastructure seem to play an important role in explaining regional productivity dynamics. Both have a positive and quite remarkable effect on productivity. They found from their model simulation that, with an increase of 1% in human capital and public infrastructure, productivity will increase by 0.38% and 0.11%, respectively. They also discovered through causality tests that both human capital and public capital are exogenous in the long run.

Ciccone (2002) wrote that “two of the main explanations for special differences in average labour productivity within countries are spatial externalities and increasing returns at the firm level combined with non-tradability or transportation costs”. Ciccone (2002) estimated the regional agglomeration effect for the five large EU countries, that is, France, Germany, Italy, Spain, and the UK. The empirical results suggest that the agglomeration effects in these European countries are only slightly lower than those in the United States and do not vary significantly across countries.

Brulhart and Mathys (2008) extended Ciccone’s (2002) method by applying dynamic panel estimation and using sector-level data. Their results demonstrated that agglomeration contributes significantly to economic growth, with long-term elasticity of 13%.

Azaeri et al. (2016) focused their study on the relationship between agglomeration effects and manufacturing productivity in urban cities. Their results showed that labour density has a negative impact on a country’s economic growth due to the population congestion in large cities; however, output density has a positive effect on urban manufacturing productivity.

Cohen (2010) obtained similar results by applying the econometric method to estimate the effects of public investment in infrastructure and found that investment in public infrastructure has a positive impact on regional productivity. Schutz’s (2017) research explored distinct patterns of innovative activities within three territories in Australia. The proposed analysis was able to discover the key actors of innovative activities in each region by concentrating on the industry linkage structure. Arbia, Battisti and Vaio (2010) implemented a modelling approach to confirm that institutions and geography play a strong and positive role in regional productivity growth.

Whether the contribution is from TFP, human capital and public infrastructure or from externalities, innovative activities, and agglomeration economies, regional spillovers produce changes in regional productivity, causing differences in regional growth. According to the previous studies, there is a positive correlation between productivity growth and economic growth at either the spatial level or the sectoral level. In this paper, we investigate further how changing productivity assumptions in a regional economy can have both inter-sectoral and inter-regional spillover effects. Using regional IO-CGE modelling techniques and Danish regional multitudinous data, we attempt to demonstrate whether there are any spatial variations in the spillover effect size considering the regional typology (urban versus rural/peripheral) and whether there are varied effects on the future course of economic development in the selected sectors considering the regional typology. Naveed et al (2017) argue that agglomeration economies and accessibility to the human capital pool varies across the regions within the country. The urban areas characterise with the large pools of labour, skills and accessibility to knowledge and services therefore, the exogenous shock (for example, labour inflows) do not play important role on the local labour markets and local economy. While, the rural and peripheral areas, characterised by scarce supply of labour and services and an absence of the agglomeration economies, therefore the exogenous shock (for example, labour inflow) play significant role on local economic growth (for example, job creation). Considering the Myrdal’s (1957) and Krugman’s (1991) studies and extended various research by economists and geographers in the last decades, geographical analysis become essential to understand how economic impacts differ based on socioeconomic characteristics of different localities for adopting the urban and rural development policies. This paper employs the urban-rural typology and compares the spillover effects of the productivity increase in rural, urban, and peripheral areas of

Denmark. Based on the scenario experiments, the paper will contribute to the previous literature by explaining the spillover variations of labour productivity across sectors, time, and geography.

Spatiality, Trends and Data

Previous studies have emphasized that labour productivity varies due to socio-economic and demographic differences within regions. Broersma and Oosterhaven (2009) found that the causes of the regional differences in labour productivity are diversification, urbanization, and localization effects. Urbanization and localization are subdivisions of agglomeration effects. Their results showed that high job density in a particular region leads to higher regional productivity growth. The positive agglomeration effect is, however, mitigated by the effect of the job density in neighbouring regions. If a region is surrounded by regions with high job density, then positive spillover effects will spread to its neighbours. Hence, the agglomeration effect of that region will be less without considering the effects of the neighbouring regions.

Our study takes regional heterogeneity into account by grouping 98 Danish municipalities into spatial–economic types, namely urban, rural, and peripheral. The grouping method is based on Hansen et al. (2012) and is widely used in policy practice (e.g., reporting to the Danish parliament) as well as in research (Naveed et al., 2017). This typology groups municipalities by their socio-economic functionality using 14 socio-economic indicators to identify urban versus rural areas. These indicators cover issues of economy, education, demography, development, rural importance, centre–periphery and urbanization. They are grouped into 3 types of municipalities. The *Urban Municipalities* type includes 35 municipalities that are socio-economically connected to the 5 largest cities in Denmark, such as the capital city metropolis (Copenhagen), Aarhus city area, Aalborg, Odense and Kolding and the urban catchment type municipalities (17 municipalities) that are also socio-economically connected to the city municipalities. These 52 municipalities are strongly connected to each other and have urban characteristics. Therefore, they comprise the Urban Municipalities type group. The *Rural* type includes 30 municipalities, and they play a considerable role in the creation of rural–urban balance. These municipalities are less connected to the 5 largest cities and have strong rural activities. The last type, the *Peripheral* type, consists of 17 municipalities, which are mainly characterized by remote rurality, are less connected to other municipalities. These municipalities are in remote areas, such as small island or those on the far edge of the western coastline. We investigate the peripheral type separately from the rural type, as, both structurally and demographically, peripheral-type municipalities are quite different from rural-type municipalities.

Copenhagen metropole is the largest agglomeration in Denmark and encompasses one-third of the Danish population and nearly half of the Danish employment and production. Copenhagen metropole is a gravity centre and creates a clear centre–periphery structure in Denmark. The rest of the production and population are scattered across other municipalities of Denmark. Four other big cities are located on the Jutland Peninsula and Fyn, but none of them are big enough to create gravity field and strong leakages; however, they have spillover effects on a few of the neighbouring municipalities. This spatial typology is demonstrated in Figure 1a in the appendix, in which the *Urban*, the *Rural* and the *Peripheral* type municipalities have clear spatial distribution patterns.

Due to the ‘tadpole’ structure of the Danish economy, with the Copenhagen metropole as the head, national-level processes of economic growth or restructuring have mainly been observed in the Copenhagen metropole. Since 2000, labour productivity has been increasing rapidly in all the municipality types; however, in 2008 and 2009, labour productivity dropped in the whole country due to the global financial crisis. In 2007, the Danish economy reached its peak (OECD, 2008). At the end of 2008, the global financial crisis was also reflected in the Danish economy. The crisis became the foundation for the economic restructuring. Between 2008 and 2010, approximately 140 thousand jobs disappeared. Skills and higher competences became the key factors to survive and compete on the labour market (www.fm.dk/publikationer). Until the end of 2011, the employment figures did not change much; however, the economic situation showed some signs of improvement at the end of 2011 and later. Labour productivity had already reached the 2008 level in 2010, with rapid growth until 2012 and continued steady growth until 2016 (see Figure 2a in the appendix).

Figure 2a shows that, from 2000 to 2008, labour productivity was increasing at about 4% annually in all the types of municipalities, and, after the financial crisis (from 2009), the productivity trend continued to grow but with a lower annual growth rate of about 2%. Figure 2a also shows that the urban and rural regions followed the national productivity trend after 2009; however, the peripheral regions had a slower recovery after the crisis. In the peripheral regions, we observe that the productivity growth started a couple of years later, and they managed to catch up with the other regions with about 7% annual growth from 2010 to 2012. After 2012, all the regions continued to grow more slowly, by about 1% annually, until 2016. In 2016, the regional gap of labour productivity was low, with only a few thousand Danish kroner. According to Figure 2a, the labour productivity level in the peripheral regions in 2016 was about 3–6 thousand kroner higher than that in the urban and rural regions, respectively.

According to the analyses of economic structure and the trends of each municipality type, it is found that knowledge-based business services are mainly concentrated in urban municipalities and machine industry is more representative for the rural and peripheral regions.

Description of Sectors’ Selection for Experiment

The overall development trends of labour productivity clearly point to few possible explanations. It is possible that, due to the financial crisis, there were some structural changes in the Danish economy, and it is also possible that there were changes in the spatial distribution of economic activities, especially in the peripheral regions. Figures 1, 2 and 3 show the regional sectoral concentration in comparison with productivity growth in each type of region.

By calculating the location quotient (LQ) of each sector in each region, we identify the regional concentration of each sector by using the standard LQ equation:

$$LQ_i = \left(e_i/e\right) / \left(E_i/E\right)$$

were,

LQ_i = location quotient for sector *i* in the region
e_i = employment in sector *i* in the region
e = total employment in the local region
E_i = employment in industry *i* in the nation
E = total employment in the nation

Based on the LQ, the regions differ not only by the socio-economic conditions (such as urban, rural, and peripheral) but also by the distribution of economic activities. Figure 1 illustrates the sectors that are concentrated in urban regions. As in many other Western European countries, the urban types of areas in Denmark have high locational concentration of service sectors, which are knowledge intensive, such as IT and information, R&D, financial and insurance services, trade and transport, public services, and other business services. In almost all sectors, productivity increased rapidly during the period 2000–2008, while it started to slow down during and after the financial crisis, from 2009 to 2016.

Among these locally concentrated sectors, most of the sectors experienced a fluctuating annual growth rate of productivity of about 1–2% before and after the financial crisis. A few sectors, such as telecommunications, R&D and some public sectors and services faced a rapid productivity decline of about 4% annually during the period 2009–2016, while only a couple of sectors, the medicine industry and knowledge-based business services, achieved rapid productivity growth after the crisis. The medicine industry is a large cluster located primarily in the Copenhagen metropole area; therefore, we do not include this sector in further analyses in this paper, as it fails to reflect the economic activities in other urban municipalities. However, knowledge-based business services seem to be the sector with the fastest-growing productivity before and especially after the crisis, from 2009 to 2016, and the gross value added (GVA) in this sector increased continuously by about 2% annually during the whole period from 2000 to 2016.

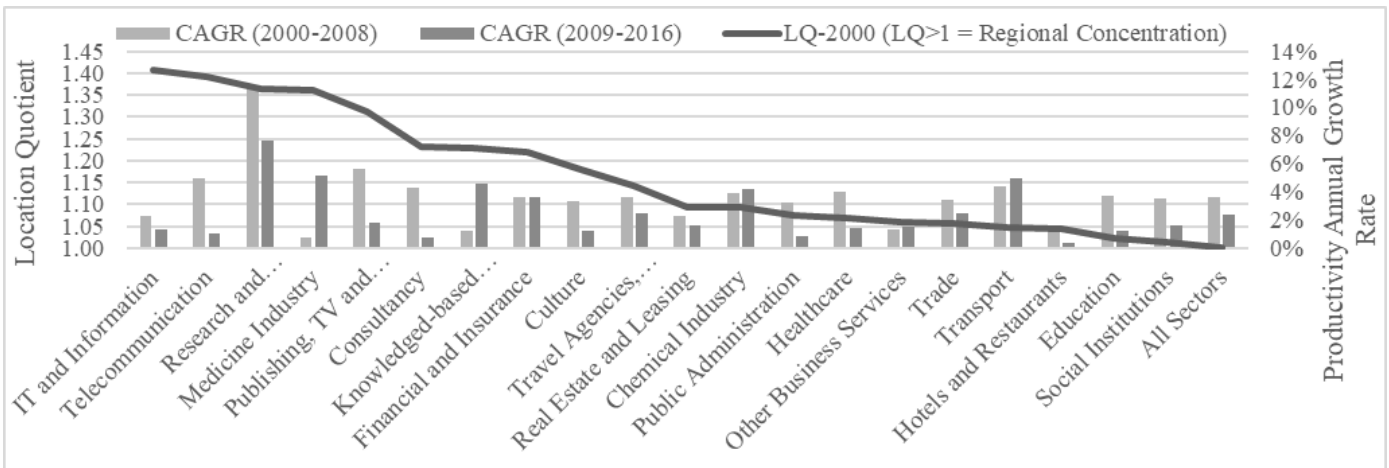

Figure 1. Regional concentration by sector and productivity annual growth rate in urban municipalities

Source: CRT database and own calculation

Note: CAGR is Compound Annual Growth Rate. LQ is Location Quotient

The local concentration of economic activities differs between the rural areas and the urban areas. Rural regions have concentrated mainly on industries and primary sectors. Oil refineries are the most concentrated and emerging sector; however, we do not analyse this sector further in this paper, as oil refineries are only located in a couple of municipalities in Denmark and therefore do not reflect other rural municipalities in Denmark. Figure 2 illustrates the regional concentration of the sectors and the annual productivity growth before and after the crisis in rural-type municipalities. According to Figure 2, the machine industry was emerging before the crisis by rapidly increasing its productivity by about 6% annually. The financial crisis slowed down the productivity growth by 4%, and from 2009 to 2016 productivity increased annually only by a 2% growth rate. The GVA in the machine industry has been increasing by about 3% annually.

According to Figure 2, a few regionally concentrated sectors increased their productivity after the finance crisis in the rural areas. For example, the furniture industry, which expanded its productivity by 5% annually before the crisis between 2000 and 2008, continued with even more rapid annual productivity growth of 9% between 2009 and 2016. Such a trend in productivity is also apparent in the GVA in this sector, with an annual growth rate of more than 7% from 2000 to 2016.

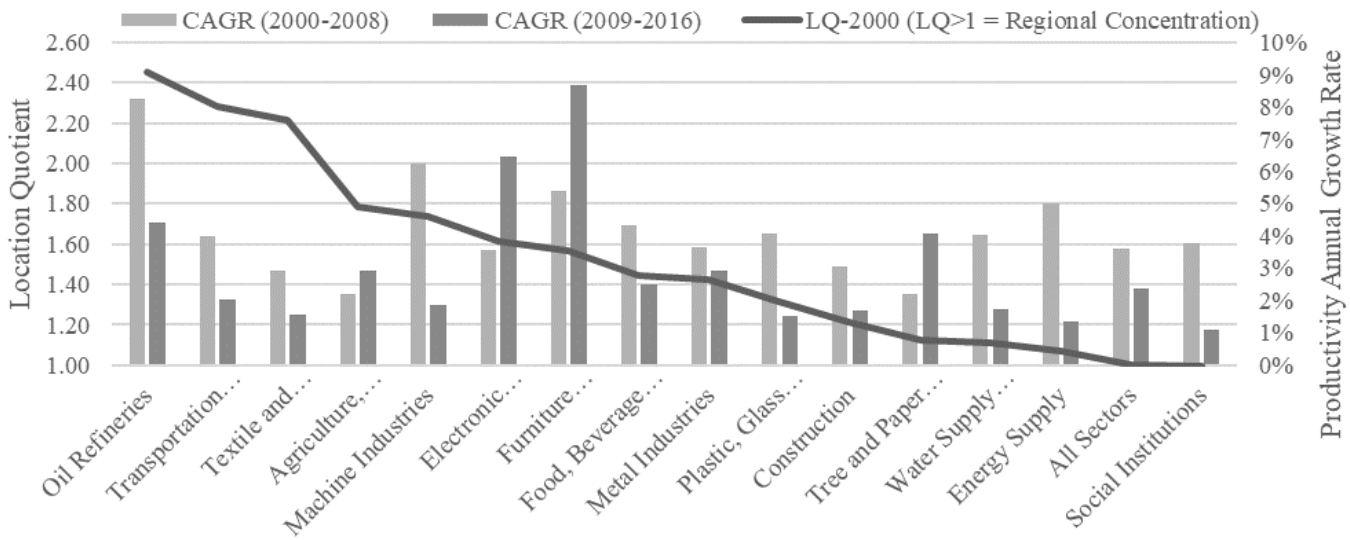

Figure 2. Regional concentration by sector and productivity annual growth rate in rural municipalities

Source: CRT database and own calculation

Note: CAGR is Compound Annual Growth Rate. LQ is Location Quotient

Peripheral municipalities have a similar economic concentration to rural municipalities, as mainly primary and industrial

sectors are concentrated there; however, the rapid growth in productivity in some sectors affected their LQ index after the crisis, causing their increasing concentration in those municipalities. For example, the chemical and leather industries had high productivity growth during 2009 and 2016 and the LQ index changed from LQ<1 in 2000 to LQ>1 in 2016. Some sectors experienced a rapid decrease in productivity after the crisis, and their LQ index changed from concentrated in 2000 to non-concentrated in 2016 (e.g., mining). (Figure 3)

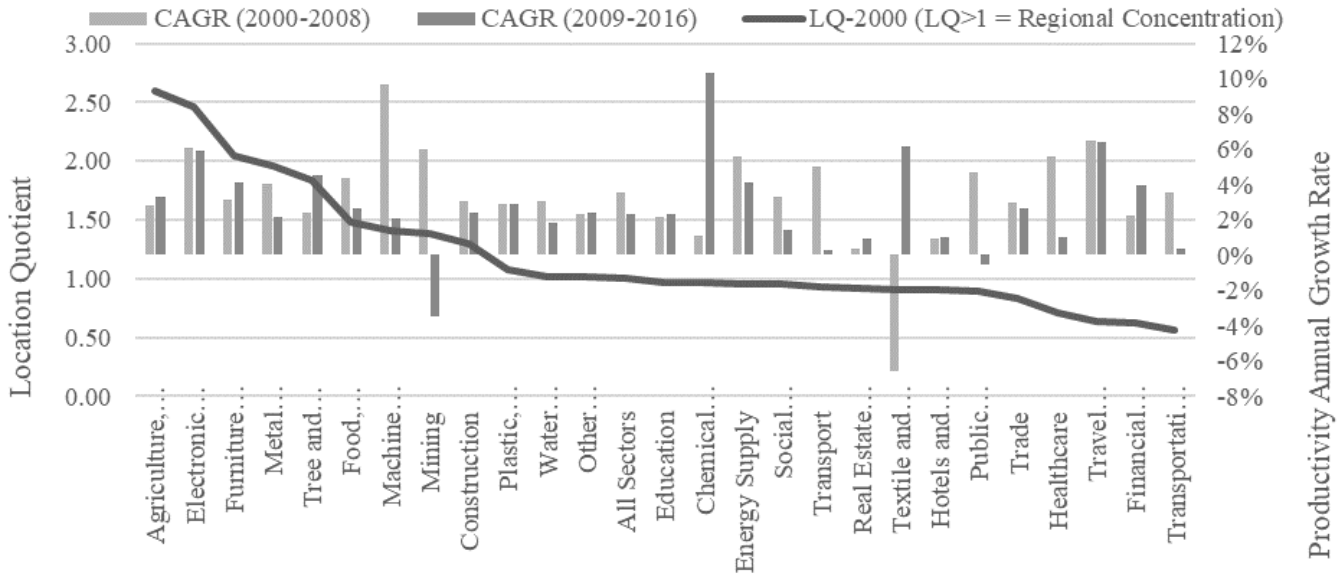

Figure 3. Regional concentration by sector and productivity annual growth rate in peripheral municipalities

Source: CRT database and own calculation

Note: CAGR is Compound Annual Growth Rate. LQ is Location Quotient

Overall, as in the rural municipalities, the machine industry was one of the most rapidly growing sectors in the peripheral municipalities. Even though the productivity growth dropped from 10% annual growth before the crisis to 2% annual growth after the crisis, the GVA of the machine industry in the peripheral municipalities increased by about 5% annually from 2000 to 2016. Despite the slowing down of the productivity growth after the crisis, the LQ index of the machine industry increased from 1.41 in 2000 to 1.68 in 2016.

According to the analyses of economic structure and the trends of each municipality type, the selection of sectors *a* and *b*, is relatively clear. Sector *a* should represent the knowledge-based economy and sector *b* the industrial economy. According to the analyses in the urban areas, it is obvious that either R&D or knowledge-based business services can be selected. The R&D sector in Denmark is mainly a publicly owned sector (i.e., universities, research institutions, etc.); therefore, the development processes within this sector are strongly bound to the political decisions of the welfare system rather than the free market. The knowledge-based business services sector, on the other hand, is privately owned and therefore the productivity changes in this sector reflect the changes in the free market. Even though knowledge-based

business services are mainly concentrated in urban municipalities, their rapid growth in rural and peripheral municipalities, especially after the crisis, implies that this sector is emerging outside the cities.

Based on the analysis of rural and peripheral municipalities, sector *b* is the machine industry. The machine industry is one of the largest industries in Danish rural areas, and the trends have shown rapid growth of production value both in the rural municipalities and in the peripheries since 2000. Although the machine industry is not regionally concentrated in the urban municipalities, both productivity and gross value added have been increasing by about 2%, especially between 2009 and 2016.

Methods and Assumptions

The scenario experiment is implemented in the SAM-K/LINE model, which is a Danish inter-regional macroeconomic model with frameworks of computable general equilibrium (CGE) and the social accounting matrix (SAM) by municipality, model is hereafter called LINE (Madsen & Jensen-Butler, 2004 & 2005; Madsen & Zhang, 2010). The main purpose of this paper is to investigate the relationship between changes in productivity and economic growth in Danish regions. In accordance with this target, a scenario experiment is set up as follows.

Scenario 1 – We assume that the productivity in the selected sector *a* – a knowledge-based sector –will increase by 10% in 2020 compared with the baseline.

Scenario 1 is expressed in the following formular:

$$\mathrm{DiffProd}_{i,\,j} = \mathrm{Emp}_{i,j} \div \mathrm{LabCont}_{i,j} \times \mathbf{1.1} - \mathrm{Prod}_{i,j} \qquad \text{(eq. 1)}$$

were,

$\mathrm{DiffProd}_{i}$ is the difference in production value between the baseline production and the altered production by given sectors *i* (*a* or *b*) and given municipalities *j* (urban, rural, and peripheral).

$\mathrm{Emp}_{i,j}$ is the number of employees in the given sectors *i* (*a* or *b*) and municipalities *j* (urban, rural, and peripheral).

$\mathrm{LabCont}_{i,j}$ is the labour content in the production by given sectors *i* and municipalities *j*.

Here $\mathrm{LabCont}_{i,j} = \mathrm{Emp}_{i,j} \div \mathrm{Prod}_{i,j}$

$\mathrm{Prod}_{i,j}$ is the baseline production by the given sectors *i* and municipalities *j*.

As shown in equation (1) in the scenario 1 experiment, we calculate the difference in the production value between the baseline production in the given sector and municipality and the production with 10% lower labour content (as the labour content is multiplied by 0.90), that is, a 10% increase in productivity. Analysing this scenario, we can observe how much

the productivity gain in sector *a* will contribute to the regional economy (GVA) and employment in the urban and rural–peripheral types of municipalities in Denmark.

Scenario 2 – We assume that the productivity in selected sector b – the machine industrial sector – will increase by 10% in 2020 compared with the baseline.

Same as in equation (1), in scenario 2, we calculate the difference in the production between the baseline production in the given sector and municipality and the production with 10% lower labour content, that is, a 10% increase in productivity in the machine industry.

By analysing this scenario, we can observe how much the productivity gain in sector*b* will affect the regional economy (GVA) and employment in the urban and rural–peripheral types of municipalities in Denmark.

Considering the regional heterogeneity, we set up each scenario experiment for each type of municipality separately. Therefore, in each scenario, we include six experiments (Table 1).

Table 1. Structure of the scenario experiments

Scenario 1 – 10% increase in knowledge-based services	**Scenario2 – 10% increase in the machine industry**
Scenario 1A – in urban municipalities	Scenario 2A – in urban municipalities
Scenario 1B – in rural municipalities	Scenario 2B – in rural municipalities
Scenario 1C – in peripheral municipalities	Scenario 2C – in peripheral municipalities

There are two fixed pre-assumptions in the SAM-K/LINE model, which do not affect the results of the scenario experiments. 1) The SAM-K/LINE baseline model assumptions built on the forecast itself. These assumptions are based on the Aggregated Danish Annual Model (ADAM), which is the Danish official macroeconomic model projecting economic and demographic trends at the national level. These projections are developed at the Danish Ministry of Finance and incorporate future political reforms and expected changes in the country. 2) Even though SAM-K/LINE is a dynamic model that covers the Danish regional economy at the municipality level during the period 1996–2040, we employ only a one-year experiment, that is, a short-term experiment with the fixed assumption that the unemployment is constant and that the labour force is elastic. As these assumptions do not affect the results from each scenario, we do not describe them further.

In the next section, we analyse the results from the two sets of scenarios and try to explain how the productivity change affects the regional economy through the inter-regional and inter-sectoral spillovers and further compare the size of changes in the knowledge-based service sector and the machine industrial sector.

Results from the Scenario Experiments

As presented above, the two sets of scenarios are designed to investigate the productivity changes in two sectors, that is, the knowledge-based service sector (1A–1C in Table 1) and the machine industrial sector (2A–2C in Table 1), and three types of municipalities, specifically ‘urban’, ‘rural’ and ‘peripheral/outskirts. In the following sections, the results are organized so that we first look at the impacts of these six experiments on the overall economy in the different types of municipalities and then describe the inter-regional and inter-sectoral spillovers in more detail.

Overall results

Based on the scenario assumptions, whereby we assume that the productivity in the selected sectors *a* (a knowledge-based sector) and *b* (the machine industrial sector) will increase by 10% in 2020, the overall results show how great an impact each experiment has on the employment in different types of municipalities. Figure 4 shows the job growth in Danish municipalities in the baseline scenario since 2000. According to the figure, the number of total jobs increased in all the municipality types until 2008 and then decreased due to the financial crisis in 2008–2009. The urban type of municipalities appears to have been quite resilient to the economic recovery after the crisis, and the number of jobs has continuously increased, especially after 2013. The rural and peripheral municipalities show a slight increase in the number of jobs until 2013, and, in the baseline scenario, they are expected to grow more in 2020; however, these types of municipalities remain far below the national average.

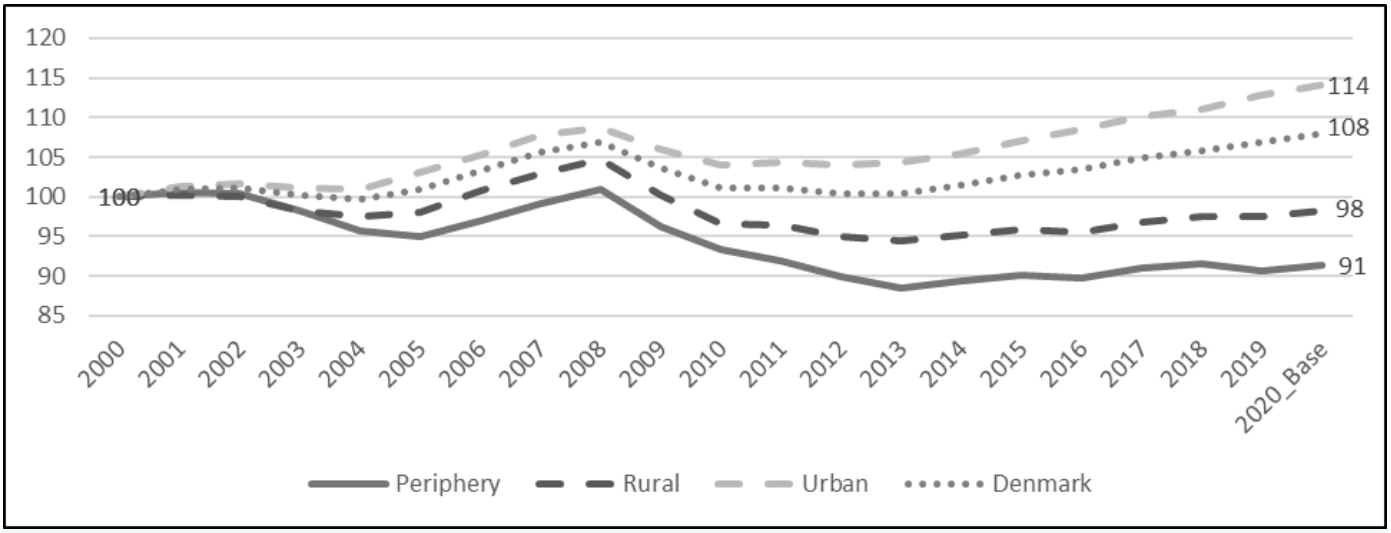

Figure 4. Job growth in Denmark by municipality types between 2000 and 2020 (2000=100 index)

Source: SAM-K/LINE®_version0218

After applying the scenario experiments in the model, in which we assume that the productivity in the two different types of sectors is 10% higher in 2020 than in the baseline scenario, we can see the overall impact in experiments 1C and 2C.

Figure 5 shows the overall results regarding the impact on employment and the comparison between the experiments. The horizontal line in Figure 5 is the baseline employment index (=100). The changes in employment in each experiment will be compared with the baseline employment, which will reveal the changes in the index. Figure 5 also shows that the total effects of experiment 2C are the highest across the municipality types. Such overall impacts of the increasing productivity in the machine industry in peripheral areas indicate that the peripheral areas are generally characterized by strong inter-regional linkages to other neighbouring localities, due to the “thin pool” of labour and the lack of availability of suppliers for the production.

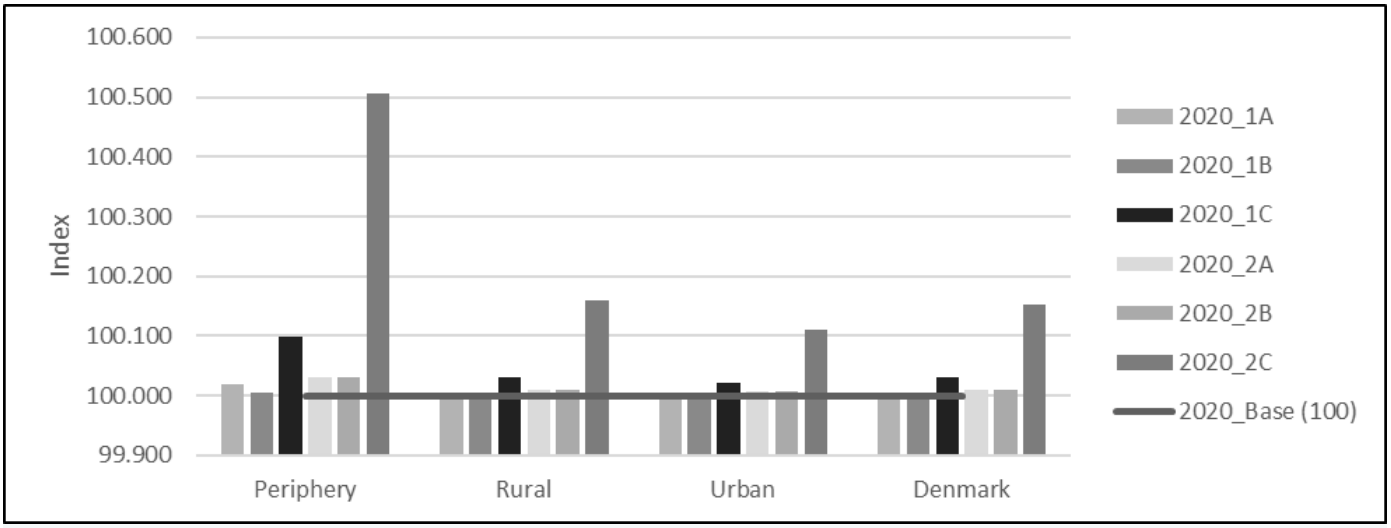

Figure 5. Comparison of the impacts of the experiments in municipality types. 2020_Base is index 100.

Source: SAM-K/LINE®_version0218

Note: 1A, 1B, 1C refers to scenarios 10 % increase in productivity in knowledge-based services in urban, rural and peripheral areas respectively. 2A, 2B, 2C, refers to scenarios 10% increase in productivity in machine industry in urban, rural and peripheral areas respectively.

The economic sector, such as the machine industry, is also characterized as the sector with higher intermediate consumption than the knowledge-based sector, which explains why there is a larger overall spillover effect from the increased productivity in the machine industry in the peripheral type of municipalities internally as well as inter-regionally. The figure also shows that the impacts are relatively smaller in urban and rural areas, which is more explainable as such localities have a better capacity to absorb (Naveed et al., 2017) the various shocks and changes. The detailed inter-regional and inter-sectoral spillover effects are described in the following sections.

Intra- and inter-regional spillovers: Spatial analysis

In this section, the results are shown from the viewpoint of inter-regional spillover effects. Inter-regional spillovers are defined as the extent to which economic exogenous shocks affect the neighbouring localities (Dietzenbacher, 2002). The spillover values differ depending on the strength of the geographical linkages among the municipality types. This section

focuses on the creation of gross value added (GVA). Based on the definition of productivity in this study, we assume that increasing productivity will happen at the expense of the number of jobs in the sector and therefore that the added employment effects cannot be high. However, we can observe the extent to which the productivity increase affects the value creation in the local and the national economy. Table 2 shows the changes in gross value added (GVA) due to implementing scenarios 1A to 1C, which refer to the 10% productivity increase in the knowledge-based service sector in the three types of regions: A – urban; B – rural; and C – peripheral.

Table 2. Regional changes in GVA due to experiments 1A–1C (10% productivity increase in the knowledge-based service sector) (in million DKK)

Type of regions	Periphery (1C)	Rural (1B)	Urban (1A)	Total
Periphery (1C)	109	12	31	152
(%)	0.72	0.08	0.20	1.00
Rural (1B)	9	408	106	523
(%)	0.02	0.78	0.20	1.00
Urban (1A)	28	99	3.565	3,692
(%)	0.01	0.03	0.97	1.00
Total	147	520	3,702	4,369
(%)	0.03	0.12	0.85	1.00

Source: SAM-K/LINE®_version0218

Note: 1A, 1B, 1C refers to scenarios 10 % increase in productivity in knowledge-based services in urban, rural and peripheral areas respectively.

As is apparent from the table, a 10% increase in productivity in the knowledge-based service sector in the peripheral municipalities creates in total 152 m DKK[1] (approximately 20 m EUR) GVA, while 72% of the gain remains in the peripheral municipalities (app. 109 m DKK (app. 14 m EUR)) and 28% of the generated value spills over to the rural and urban types of municipalities (which altogether equal app. 43 m. DKK or 5.6 m EUR). According to the same experiment, increasing productivity in the knowledge-based service sector in rural types of municipalities creates in total an additional 523 m DKK (70 m EUR) in the whole country, from which 78% of the economic gain remains in the rural municipalities (app. 408 m DKK, =55 m EUR) and the remaining 22% spills over to the other municipality types. The third experiment in the urban municipalities, however, shows that 97% of the additional total gain of 3.692 m DKK (=500 m EUR) GVA remains within the urban localities and only 3% spills over to the other municipality types. Overall, after summing the results from these three experiments (1A–1C), the urban municipalities gain 85% of the total effects, while only a 12% gain is observed in the rural municipalities. The size of the economic gain in urban areas is naturally large, as the concentration of knowledge-based services is mainly in the urban type of municipalities in comparison with the rural and

peripheral types of municipalities. However, nearly all the economic gains from the increased productivity in such a sector remain in the urban areas with a unidirectional link from rural to urban as well as from peripheral to urban, and not the reverse.

Table 3 shows the results from the second set of experiments, 2A–2C, which refer to the 10% productivity increase in the machine industrial sector in the three types of regions. As the table shows, the 10% productivity increase in the machine industry in the peripheral municipalities affects the increase in the total GVA by 1,615 million DKK (=200 m EUR), from which only 73% of the added value remains intra-regionally and the rest spills over to the other municipalities, especially to the urban types, with app. 18% of the total value. The same assumption in the rural municipalities leads to an increase in the total GVA of 3,496 million DKK (=468 m EUR). 86% of the added value remains in the rural municipalities (app. 3,009 million DKK) and the rest spills over to the urban municipalities. Both experiments, in peripheral areas and in rural areas, show strong relations to the urban areas, albeit with only unidirectional linkages. This proves that the same assumption for the experiment in the urban municipalities causes an increase in the total GVA of 3,657 million DKK and that 93% of the added value remains intra-regionally, while only 6% of the added value spills over to the rural municipalities.

Table 3. Regional changes in GVA due to experiments 2A–2C (10% productivity increase in the machine industrial sector) (in millions of DKK)

Type of regions	Periphery (2C)	Rural (2B)	Urban (2A)	Total
Periphery (2C)	1,186	141	288	1,615
(%)	0.73	0.09	0.18	1.00
Rural (2B)	49	3,009	438	3,496
(%)	0.01	0.86	0.13	1.00
Urban (2A)	49	203	3,405	3,657
(%)	0.01	0.06	0.93	1.00
Total	1,285	3,354	4,131	8,770
(%)	0.15	0.38	0.47	1.00

Source: SAM-K/LINE®_version0218

Note: 2A, 2B, 2C, refers to scenarios 10% increase in productivity in machine industry in urban, rural and peripheral areas respectively.

In general, to sum up the results from these three experiments, 2A–2C, the primary winner is observed to be the urban municipalities, which gain 47% of the total effects caused by the experiments, while 38% of the total gain is observed in the rural municipalities and only 15% in the outskirts. It is also clear that the total effects from the experiments in the

knowledge-based sector are concentrated within the urban areas (85%; see Table 2), while the total effects from the experiments in the machine industry are closely distributed between rural and urban municipalities. The size of the effects in the rural areas is due to the concentration of the machine industrial sector in such areas. In total, these three experiments indicate similar distribution patterns of the effects, as in the case of GVA (Table 3), for which the effects are distributed mainly between the urban and rural municipalities and the peripheries gain only 12% of the total.

In summary, these results indicate that the machine industrial sector has stronger backward linkages than the knowledge-based service sectors. The spillover effects, however, are unidirectional in both sectors, that is, from rural to urban, from peripheral to urban and from peripheral to rural. The results also indicate that the exogenous changes in the peripheral municipalities have stronger positive effects on the urban and rural municipalities, while the urban municipalities demonstrate the opposite pattern, whereby all the positive effects from the exogenous changes in the economy remain primarily intra-regionally within the urban municipalities. This phenomenon can demonstrate how the gap between the urban and the rural municipalities is constantly widening in both the local economy and the demography.

Inter- and intra-sectoral spillovers: Multiplier analysis

This section focuses on the inter- and intra-sectoral linkages based on the results of the six experiments (1A–1C and 2A–2C). The goal of the analysis is to understand and compare the size of the multipliers and inter-sectoral linkages in knowledge-based services and the machine industrial sector in different geographical settings.

The multiplier effect shows how much the final demand should increase after creating an exogenous shock/alteration in the specific economic condition. For this aspect, we calculate the direct, derived, and total effects. The direct effect is the shock or alteration in the specific condition; that is, in this study, the direct effect is the value from the 10% productivity increase in the given sector. The derived effect is measured as the sum of the indirect effect, which is the measure of sector-to-sector activity/trade, and the induced effect, which is the measure of the wages/income created due to the shock/alteration in the specific economic condition. The total effect is the sum of the direct and derived effects, whereby the derived effect is the sum of the indirect and induced effects. The multiplier is therefore calculated as the total effect divided by the direct effect. This can explain how much the change in the final demand due to the shock/alteration in the economic condition affects the total economy.

As it was clear from the previous section, spillover effects differ by the geographical type of the location where the economic activity is present. This section takes the geographical characteristics into account and studies the size and types of multipliers considering the experiments in urban, rural, or peripheral municipalities.

Table 4 shows the inter- and intra-regional spillover effects from experiments 1A–1C, referring to the 10% productivity increase in the knowledge-based service sector in three types of municipalities. According to the table, the multipliers in the urban regions are the largest, which can be explained by the concentration of knowledge-based services, the pool of required competences and the wide range of trade partners in the urban municipalities.

According to the table, experiment 1A's results show a direct value gain of 1.6 billion DKK with a multiplier of 2.31, which

can be interpreted as indicating that, for each additional million DKK of GVA, 1.31 million DKK is gained. That shows that the total derived effects in the urban municipalities are app. 2 billion DKK, from which app. 24.4% (511 m. DKK) is an intra-sectoral derived effect within the knowledge-based services, while app. 75% of the derived gain spills over to other sectors in the Danish economy. The table also confirms that the smallest multiplier effect is observable when the same experiment is conducted in the peripheral regions (1C). According to the results, each additional million DKK GVA in the knowledge-based services in peripheral municipalities spills over only 0.88 million DKK, which equals about 71 million DKK. From the derived effects, 24% (17 m. DKK) is generated internally in the knowledge-based services, while 76% of the gain is from sector-to-sector activities (inter-sectoral derived effect). In the rural municipalities, the results of the 1B experiment follow the same pattern as the other two experiments. In addition, the intra-sectoral derived effects are similarly 24.2% (61 m. DKK), while the inter-sectoral derived effects are about 75.8%. In summary, the intra-sectoral and inter-sectoral spillover effects of knowledge-based services are nearly the same in all the types of municipalities and do not change by location, while the multiplier size clearly differs by the geographical characteristics of the location, that is, the knowledge-based services have larger derived effects the closer they are to the urban municipalities.

Table 4. Changes in the final GVA due to experiments 1A–1C (a 10% productivity increase in the knowledge-based service sector) (in millions of DKK)

	Periphery (1C)	Rural (1B)	Urban (1A)	Total
Direct effect	81	271	1,602	1,954
Total effect	152	523	3,693	4,368
Derived effect	71 (100%)	252 (100%)	2,091 (100%)	2,414
Intra-sector derived effect	17 (24%)	61 (24.2%)	511 (24.4%)	589
Inter-sector derived effect	54 (76%)	191 (75.8%)	1,580 (75.6%)	1,825
Multipliers	1.88	1.93	2.31	

Source: SAM-K/LINE®_version2018

Table 5 shows the results from the second set of experiments – 2A–2C, referring to the 10% productivity increase in the machine industrial sector in the three types of municipalities. This experiment shows different results regarding the multiplier effects and the intra- and inter-sectoral spillover effects. As mentioned earlier, the machine industrial sector is a manufacturing industry, which requires high intermediate consumption and raw materials to produce the output; therefore, we expected high-level inter-sectoral spillover effects connected to this sector.

Table 5. Changes in GVA due to experiments 2A–2C (a 10% productivity increase in the machine industry sector) (in millions of DKK)

	Periphery (2C)	Rural (2B)	Urban (2A)	Total
Direct effect	900	2,269	2,211	5,380
Total effect	1,615	3,495	3,658	8,768
Derived effect	715 (100%)	1,226 (100%)	1,447 (100%)	3,388
Intra-sector derived effect	106 (14.8%)	165 (13.5%)	184 (12.7%)	455
Inter-sector derived effect	609 (85.2%)	1,061 (86.5%)	1,263 (87.3%)	2,933
Multipliers	1.79	1.54	1.65	

Source: SAM-K/LINE®_version0218

It is interesting to notice in the table that experiment 2C, referring to the 10% productivity increase in this sector in peripheral municipalities, has the largest multiplier effect of 1.79 compared with experiments 2B (rural) and 2A (urban). This can be interpreted as indicating that, if experiment 2C caused the additional direct effect of GVA of 900 m. DKK, then the derived effects were 715 m. DKK. From the derived effects, 14.8% were intra-sectoral derived effects and 85.2% inter-sectoral spillovers, which are much higher figures than in the previous experiments for knowledge-based services and can be explained by the higher intermediate consumption in the production of machinery. The other two experiments, 2B in rural municipalities and 2A in urban municipalities, have similar intra- and inter-sectoral spillover effects, although the inter-sectoral derived effects increase with closeness to the urban municipalities. According to Table 5, experiment 2A produces a smaller multiplier effect than in peripheral areas, which equals app. 1.65 and can be interpreted as showing that each additional 1 million DKK GVA derives 0.65 million DKK GVA. At the same time, app. 87.3% (1,263 m. DKK) of the derived effects are inter-sectoral.

In summary, the 10% productivity increase in the machine industrial sector in peripheral municipalities has larger spillover effects geographically but lower inter-sectoral linkages than that in urban areas, which has lower spillover effects geographically but higher inter-sectoral linkages. We assume that the results in these experiments indicate that different types of activities within the machine industrial sector could be in urban, rural, and peripheral areas; for example, production plants could be in peripheral municipalities, while service, research or similar activities within the machine industry could be in the urban municipalities. Unfortunately, we cannot undertake more detailed analyses of the sector at the plant level.

As explained above, each experiment has different economic and employment effects, and even though the productivity increase means that the number of jobs is assumed to decrease while the gross output increases, then the employment effects in these experiments are due to the additional gain in gross output after the 10% productivity increase in the knowledge-based service sector and the machine industrial sector in the three different types of municipalities.

In summary, the location matters regarding the spillover effects from the changes in the gross output, especially in the machine industrial sectors. The productivity increase in the peripheral municipalities in this sector creates large spillover effects not only by geography but also intersectoral, in terms of both GVA and employment. Meanwhile, in urban and rural

municipalities, the derived effects are mainly due to the sector-to-sector interaction and activities.

On the other hand, the productivity increase in knowledge-based services generates higher economic and employment returns in the urban municipalities. Even though more than half of the spillover effects are inter-sectoral, the intra-sectoral spillover effects are also considerable in terms of both economic (GVA) and employment (FTE) returns.

Discussion and Conclusion

This paper provides evidence that an increase of productivity in some sectors positively affect the regional economic growth. Moreover, the inter-regional effects increase by the distance from the central and urban areas. The paper observes and compares the effects of exogenous shock (a 10% productivity increase) in two selected sectors in three types of regions. There are selected to study the effects of productivity change in knowledge-based services, on the one hand, and machine manufacturing sector in three types of geographical settings, i.e., urban, rural, and peripheral areas. The study has shown that regional productivity grows unevenly with respect to time, sector, and geography. There is a tendency for R&D, the knowledge-based service sector, and the creative economies in urban areas to show faster growth rates than the traditional sectors, such as agriculture and manufacturing. It is obvious that the urban municipalities have an advantage in knowledge-based services; on the other hand, due to relatively cheap labour, the rural municipalities have a relative advantage in the machine industry. The purpose of the scenario analysis is to identify the regional consequences of the modelling calculations and compare the inter-regional and inter-sectoral spillovers of these two sectors in urban, rural, and peripheral municipalities.

Scenario experiment shows from a regional spillover effect point of view, the machine industry has a deep backward linkage and has a greater impact on the other regions than knowledge-based services. The other side of story is that the knowledge-based service sector is more concentrated in the urban areas, as they have a labour force with relatively higher competence than the rural regions. However, the regional spillover effects are not so large, as 97% of activities remain in the urban municipalities. From the geographic perspective, the urban regions gain the most; therefore, they have the highest economic growth.

Regarding sectoral spillovers, even though the urban regions create the most GVA and employment, the municipalities on the outskirts have the highest multiplier. This manifests in the dependence of the peripheral municipalities on the other regions. There are two aspects to consider in this conclusion: 1. The machine industry has, in general, high intermediate consumption, i.e., raw materials, energy, transport, services. This means that the inter-sectoral trade is also high, which proves that any exogenous change in this sector will have impact on other sectors as well. 2. The machine industry plants are mainly located in the peripheral areas in Denmark. As mentioned previously, the peripheral areas are characterised by the scarce labour, skills and even services (Naveed, et al., 2017), therefore, the industry has stronger inter-regional trade links with the areas with bigger pool of labour and services, which in its term explains the higher backward linkages and spillover effects of an exogenous change.

This conclusion could be considered in the regional policy perspective, in terms of promoting the regional cohesion and

balanced economic growth. The level and growth rates of regional productivity, the regional economy and the explanation for regional inequality are always the top issues in regional policies. The EU regional policy has mainly focused on business competitiveness, regional economic growth, job creation, sustainable development, and the improvement of citizens' quality of life. The Danish Government has recently stressed the education effort in training the potential labour force; the Government has also put effort into the regional balance and has more recently decided to move the nearly 4,000 state jobs (i.e., 4,000 working places) from the capital region to the rural and peripheral municipalities. Previous research has shown that public investment in infrastructure, the improvement of human capital, heavy inputs in R&D and encouraging innovation in enterprises, along with other factors, will help in improving regional productivity, enabling regions to maintain high economic growth. However, often policy initiatives affect the economic activities in the urban areas (for example, cluster policies, smart specialisation policies, etc), which benefit to the further economic growth of the urban areas, while ignore the economic activities in the peripheral and rural regions, and furthermore, creating further imbalance in regional economic growth. This study provides the evidence to consider different policy approaches to maintain the balanced economic growth, both in urban and rural/peripheral areas in a country.

Footnotes

[1] The exchange rate for 100 DKK=13.4 EUR in 2019.

Appendices

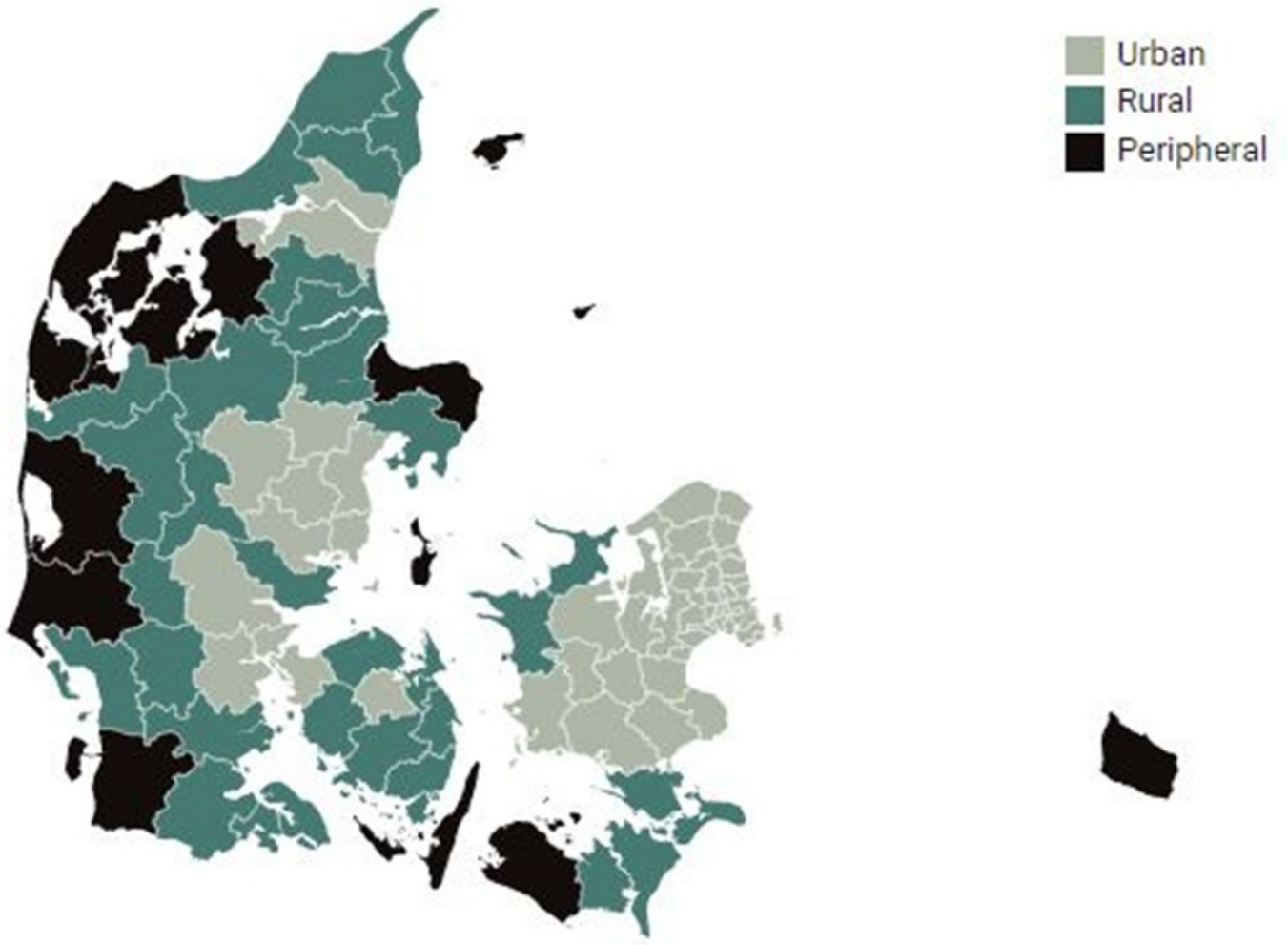

Figure 1a. Municipality Types in Denmark

Source: CRT Database and own calculation

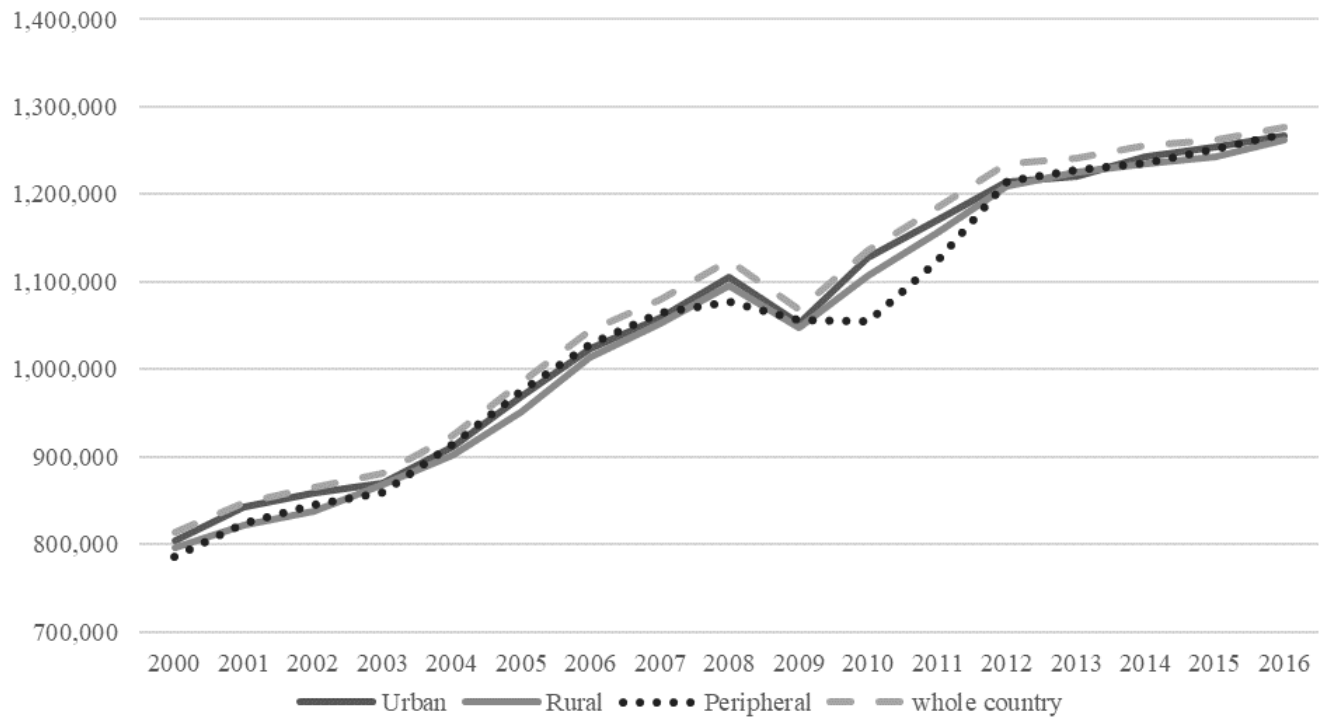

Figure 2a. Labour productivity trend between 2000 and 2016 by spatial typology

Source: CRT database and own calculation

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