Structural Changes and Growth in Europe: Are Knowledge-intensive Services Changing Paradigm of Expansion of Services as a Long-term Growth-diminishing Factor?

Maja BACOVIC – Zivko ANDRIJASEVIC** – Julija CEROVIC SMOLOVIC**

Abstract

We explored the patterns of structural changes in Europe and found growing relevance of the service sector, particularly knowledge-intensive services. The study shows that labour productivity and TFP growth were lower in the service sector than in the goods sector but were higher in knowledge-intensive services than in other services. GDP per capita growth is positively related to the output's share of knowledge-intensive services as well as GDP growth and TFP growth in high-income countries, but not in medium-income economies. This might be explained by the rapid growth in the earlier stages of development in less-developed countries and its subsequent slowdown. Although knowledge-intensive services are the fastest growing sector in all countries, industry is still the most relevant sector for long-term growth, with the highest TFP and labour productivity growth. The growing knowledge-intensive services sector, with its higher TFP growth than other services, partially overcomes the negative effects of expansion of the service sector on long-term output growth. This study shows that R&D investment growth leads to significantly higher output growth in knowledge-intensive services than in other sectors, which may be used as a relevant policy tool.

Keywords: *structural changes, output growth, labour productivity, TFP, knowledge-intensive services*

JEL Classification: O47, O52

DOI: https://doi.org/10.31577/ekoncas.2022.02.02

* Maja BACOVIC – Julija CEROVIC SMOLOVIC, University of Montenegro, Faculty of Economics, Department for Economic Analysis and Quantitative Economics, Jovana Tomaševica 37, 810 00 Podgorica, Montenegro; e-mail: majab@ucg.ac.me; julija@ucg.ac.me

** Zivko ANDRIJASEVIC, University of Montenegro, Faculty of Philosophy, Department for History, Danila Bojovica bb, 814 00 Niksic, Montenegro; e-mail: ziman@t-com.me

Introduction

The service sector has growing relevance in most European countries. The share of services in total output (gross value-added) has increased over the past few decades in the European Union (28), from 68% in 1995 to 74% in 2019.[1] The expansion of the service sector and its growing relevance leads to the question of its impact on long-term growth, the most important of which is its impact on productivity. Bauer et al. (2020, p. 3) studied labour productivity in the EU15, focusing particularly on service-based economies, and found that productivity growth in Europe is sluggish, with structural changes having a significant effect on long-term labour productivity growth. The empirical analysis of OECD countries presented in OECD (2018) stresses that the shift to services, although moderate, persistently influences a decline in productivity growth. The analysis (OECD, 2018, p. 8) shows that on average across OECD countries labour productivity is about 40% lower in market services than in manufacturing, while TFP growth is also lower in services, averaging 0.7% per year against 1.4% in manufacturing. Morro (2015, p. 260) emphasised the negative effects of a growing share of services in GDP on TFP and GDP growth. Foster-McGregor and Verspagen (2017, p. 92) showed that in New Member States, the average TFP growth was lower in services than in manufacturing. Amil, Giannoplidis, and Lipp-Lingua (2007, p. 1) found that knowledge-intensive services[2] within EU27 recorder stronger employment and rate of turnover growth than other services. Our incentive was to investigate the effects of structural changes on GDP, employment, and productivity growth (labour productivity and TFP) in Europe by disaggregating the service sector into two subsectors: knowledge-intensive and other services. The rationale behind service categorisation is the empirical evidence that knowledge-intensive services "tend to exhibit relatively lower routine content, higher capital intensity, higher R&D intensity, and higher allocative efficiency. As a result, knowledge-intensive services have, on average, higher productivity levels and past growth rates than less-knowledge-intensive ones" (OECD, 2018, p. 25).

In this study, we investigate the impact of individual sectors (agriculture, industry, construction, knowledge-intensive and other services (detailed definitions of service sectors are presented in Section 3.1.) on long-term output and productivity growth (labour productivity and TFP). Furthermore, as determinants

[1] *Source of data*: Eurostat, Gross value added and income by A*10 industry breakdowns [nama_10_a10].

[2] Knowledge-intensive services include water transport, air transport, post and telecommunication, computer and related services and other business services.

of productivity, we investigate the impact of investment in R&D and components of human capital growth on the total output and output produced in specific sectors. We use the growth in the number of tertiary educated employees as an indicator of human capital growth.

The sample consists thirty-one European countries (27 EU member countries and the United Kingdom, Iceland, Norway, and Switzerland) from 1995 to 2019. For the purpose of sensitivity analysis, we split the sample into two subsamples: high-income countries (average annual GDP pc higher than 12.6 thousands[3] EURO (2010) and medium-income countries (average annual GDP pc less than 12.6 thousands EURO (2010)).

In all the countries, structural changes in the economy have occurred since 1995. The output share of agriculture in total output declined from 3.9% in 1995 to 2.3% in 2019 (sample mean), in industry from 21.2% to 20.2%, and in construction from 6.8% to 5.4%, whereas the share of output in knowledge-intensive industries increased from 11.9% to 18%. The share of output from other services declined from 60.3% to 52.7%. The observed trends were similar in high-and medium-income countries, except for the industrial sector, which became more significant in medium-income countries, whereas its share of output declined in high-income countries (Table 1).

T a b l e 1

Sectoral Composition of the Output in Europe, Panel Average

% of total output	All countries		High income countries[4]		Medium income countries[5]	
	1995	*2019*	*1995*	*2019*	*1995*	*2019*
Agriculture	3.9	2.3	2.8	1.6	6.1	3.5
Industry	21.2	20.2	20.7	18.7	22.0	23.0
Construction	6.8	5.4	7.0	5.0	6.0	6.3
Knowledge-intensive services	11.9	18.0	12.4	18.0	10.7	15.4*
Other services	60.3	52.7	60.1	54.4	60.5	51.8*

Note: * Data for 2018, as for 2019 statistics for four countries from the sample were not available. Average of individual sample was presented.

Source: Author's calculations; primary source of data: Eurostat.

This study has two components. We explore the patterns of the structural changes using descriptive statistical analysis. Data on GDP and employment were extracted from the Eurostat database, while labour productivity was calculated as the ratio between gross value-added and number of employees. TFP

[3] Income ranking as defined by the World bank.

[4] Twenty-three countries from the sample.

[5] Nine countries from the sample.

growth was estimated using the growth accounting method as in Bacovic (2021, p. 10). To analyse the determinants of total output growth, we estimate the production function, with expenditures for R&D as an exogenous component of TFP growth and labour divided into employees with tertiary education and other employees (all other levels of education), as an indicator of human capital growth. To evaluate the determinants of output growth in the industry, knowledge-intensive services, and other service sectors, we estimate the sectoral production functions. As in Solow (1957, p. 53), residuals in the estimated production functions at the aggregate and sectoral economy levels provide data on TFP growth (the component determined with exogenous components other than R&D expenditure). TFP growth, estimated by applying an econometric approach, was used to support the accuracy of the TFP growth estimation by applying the growth accounting method.

This study is comprised of five sections. The first section presents the rationale for the research, and the objectives and aims of this study. This was followed by a review of relevant findings available in the literature. The third section presents an empirical analysis of structural changes in Europe and its relationship with selected macroeconomic indicators. The methodology and results of the study were presented in the fourth section, followed by a discussion and conclusions in final part of the study.

1. Literature Review

The structural changes have been intensively studied. The results of Moro (2015) and Foster-McGregor and Verspagen (2017) were presented in the previous section. Leon-Ledesma and Moro (2020, p. 110) investigated the effect of structural transformation on the process of economic growth and found that the structural transformation from goods to services generates an increase in the real investment rate, a decline in the real interest rate, the marginal product of capital, and the acceleration of investment-specific technologies change as the share of services increases. In the post-war US economy, they found that the real investment-output and capital-output ratios display significant upward trends, while the rate of growth of GDP per capita displays a mild decline. Buera and Kaboski (2012, p. 2547) developed a theory in which demand shifts toward more skill-intensive output as productivity increases, thereby increasing the importance of market services relative to home production. Their theory predicts a rising level of skills, skill premiums, and relative price of services linked to this skill premium. They also found that along with productivity growth, the importance of specialised high-skilled labour is greater, leading to a rise in the service economy.

Stiglitz (2016) emphasised the importance of structural transformation for sustainable economic growth in the United States and recommended the active role of the government through active labour market policies. McMillan, Rodrik, and Verduzco-Gallo (2014, p. 6) found that structural change has been reducing growth in Africa and Latin America, with labour moving from low-to high-productive sectors.

Ngai and Pissarides (2007, p. 438) found that different TFP growth across industrial sectors predicts sectoral employment changes with a shift in employment away from sectors with a high rate of technological progress toward sectors with low growth. Eventually, all employment converges to only two sectors: the sector producing capital goods and the sector with the lowest rate of productivity growth.

The relevance of TFP and labour productivity in economic growth has been widely studied. Barro (1998) and Nelson (2000) emphasised the importance of TFP growth for economic growth, with technological progress as its key determinant. Margaritis, Scrimgeour, Cameron, & Tressler (2005, p. 291) found that productivity growth was significant determinant of GDP per capita growth in OECD countries over last two decades of the XX century, but also pointed that productivity growth in services was lower compared to other sectors. Holtgrewe (2015), quoting Baumol (1967) and Scharpf (1986), stressed that the industrial mechanism of productivity increases and does not apply in the service sector, and that in labour-intensive and interactive services, labour productivity cannot be easily increased. Studies by OECD (2018) and Bauer et al. (2020) confirm the relevance of TFP growth also. Antolin-Diaz et.al. (2017, p. 343) show that a decline in the labour productivity growth rate caused a decline in long-run output growth in the United States.

In selection of the sample, panel data models were selected as panel data, as in Sequeira and Campos (2005), "increase the sample size and thus allow higher degrees of freedom and more accurate statistical tests, also to secure a reduction in endogeneity, allowing country-specific effects to be correlated with regressors (fixed-effects models)". It is generally known that one important assumption of classical regression modelling is that there is no exact linear relationship between independent variables (Kennedy, 2008). The violation of that assumption, the multicollinearity, is important to deal with, since it reduces the quality of the observed regression coefficients.

Multicollinearity can be detected (Belsley, 1991; Hill and Adkins, 2001; Farrar and Glauber, 1967). Nevertheless, there are also suggestions that "only use of more economic theory in the form of additional restrictions may help alleviate the multicollinearity problem" (Blanchard, 1987).

2. Structural Changes, Output, Employment and Productivity Growth in Europe – Empirical Analysis

2.1. Sector's Definition, Data and Sample

Sectors were classified according to the NACE[6] classification: agriculture, forestry, and fishing (later agriculture), industry, construction, and service sectors (disaggregated into two subsectors: knowledge-intensive services and other services). According to the classification presented in Amil, Giannoplidis, and Lipp-Lingua (2007), knowledge-intensive services are: water transport, air transport, post and telecommunication, computer and related services and other business services. In this research, by 'other business services' category, we will analyse professional, scientific and technical activities, and administrative and support service activities.

In addition, according to Buera and Kaboski (2012), air transport and business services are also skill-intensive (those industries with at least 12.5 per cent of labour with more than 12 years of education).[7] Other service sectors include land transport and transport via pipelines and warehousing and support activities for transportation, wholesale and retail trade, accommodation and food service activities, financial and insurance activities, real estate activities, public administration, defence, education, human health and social work activities and arts, entertainment and recreation, other service activities, and household and extra-territorial organisations and bodies. The analysis is based on a sample of 31 European countries from 1995 to 2019.[8]

2.2. Empirical Analysis

We estimate the average share of output in specific sectors in relation to the economy's output from a sample and timeframe as presented earlier. We observed that the share of output from agriculture, industry, and construction declined, whereas the share of knowledge-intensive services increased significantly from 11.9% in 1995 to 18% in 2019. The share of other services also declined. The share of employment in knowledge-intensive and other services in total employment increased, whereas the share of employment in other sectors declined (Table 2).

[6] **N**omenclature statistique des **a**ctivités économiques dans la **C**ommunauté **e**uropéenne

[7] They produced list of high-skill industries based on sample of 31 countries from 6 continents, as follows: education, legal services, banking, real estate and accounting, broadcasting and television, air transport and health care. Also, they state that these rankings are remarkably stable over time.

[8] All data were extracted from the Eurostat database and are available on request.

T a b l e 2

Share in Output and Employment (sectoral approach) in Europe, Panel Data Average

	% in total output					% in total employment				
	Agriculture	*Industry*	*Construction*	*Knowledge-intensive services*	*Other services*	*Agriculture*	*Industry*	*Construction*	*Knowledge-intensive services*	*Other services*
1995	**3.9**	**21.2**	**6.8**	**11.9**	**60.3**	**9.9**	**21.7**	**7.0**	**9.4**	**50.6**
2000	3.2	21.6	6.5	12.9	57.6	8.9	20.3	7.0	10.8	51.4
2005	2.8	21.4	6.8	13.7	56.0	7.3	18.7	7.7	11.8	53.1
2010	2.5	20.4	5.9	14.7	56.2	6.4	16.4	7.3	13.3	55.4
2015	2.5	20.4	5.3	15.7	55.6	5.8	15.8	6.7	14.5	56.0
2019	**2.3**	**20.2**	**5.4**	**18.0**	**52.7**	**4.9**	**15.9**	**7.0**	**16.1**	**56.0**
Total	2.8	20.9	6.2	14.2	56.5	7.2	18.2	7.2	12.4	53.6

Source: Author's calculations; *Source of data*: Eurostat data (individual samples).

Statistical analysis showed that the average annual output growth was the highest for knowledge-intensive services (3.9%), while the total output growth was 2.2%. The output growth was 2% for industry, 1.8% for other services, 0.9% for agriculture, and 0.7% for construction. The average annual employment growth (growth in the number of employees) was 0.5% for all sectors, and 2.7% and 1.1% for the knowledge-intensive and other service sectors, respectively. Employment growth was negative in agriculture and industry, –2.3% and –0.9%, respectively).

T a b l e 3

Labour Productivity, Panel Data Average, 1995 – 2019

Year	**Agriculture**		**Industry**		**Construction**		**Knowledge intensive services**		**Other services**	
	Labour productivity, 2010 euro	*Annual growth (in %)*	*Labour productivity, 2010 euro*	*Annual growth(in %)*	*Labour productivity, 2010 euro*	*Annual growth(in %)*	*Labour productivity, 2010 euro*	*Annual growth(in %)*	*Labour productivity, 2010 euro*	*Annual growth(in %)*
1995	16,297		47,332		38,129		42,699		37,749	
1996	16,844	3.4	48,765	3.1	38,743	3.9	43,597	3.3	37,999	1.3
2000	19,861	3.7	56,051	6.8	38,970	1.5	45,228	2.1	39,670	2.3
2005	22,653	–1.4	66,202	3.1	40,379	–0.8	48,342	2.4	41,204	2.4
2010	26,837	–1.4	69,763	9.2	38,366	1.2	48,550	–0.3	42,342	1.5
2015	29,788	1.2	77,837	4.8	39,442	1.2	50,384	0.3	45,414	0.9
2019	27,002	7.2	72,355	0.7	38,256	0.1	58,538	3.5	48,688	0.7
Total	*23,919*	*2.8*	*64,971*	*2.9*	*39,192*	*0.8*	*48,055*	*1.1*	*41,832*	*1.0*

Source: Author's calculations; *Source of data*: Eurostat data (individual samples).

Labour productivity was the highest in the industry, with the highest average annual growth of 2.9%. This is followed by labour productivity in knowledge-intensive services (73% at the industry level), although the average annual growth rate is only 1.1%. Average labour productivity in other services is at the level of 87% of knowledge-intensive services and 64% of industry, with an annual growth rate of 1%. Labour productivity in agriculture was the lowest, at only 36% of that in industry, but the average annual growth rate was 2.8%. Labour productivity in construction was 60% of the industrial productivity, with an average annual growth rate of 0.8% (Table 3).

The average TFP growth was 1.1%, and it was above the average in agriculture (2%) and industry (2%) and lower in services, although it was higher in knowledge-intensive services (1%) than in other service sectors (0.2%). This is confirmed by OECD (2018), as its report shows that all services have lower TFP growth than goods sectors. Contrary to productivity growth, capital stock and employment growth are the highest in the service sector (Table 4).

T a b l e 4

Average Annual Growth: Gross Value Added, Total Fixed Asset (gross), Employment and TFP, Group of Countries, 1995 – 2019

	Total	**Agriculture**	**Industry**	**Construction**	**Knowledge-intensive services**	**Other services**
Gross value added growth	2.2	0.9	2.0	0.7	3.9	1.8
Total fixed asset (gross) growth	2.0	1.2	1.8	1.8	3.3	2.5
Number of employees growth	0.5	–2.3	–0.9	0.2	2.7	1.1
TFP growth[9]	1.1	2.0	2.0	–0.01	1.03	0.2

Source: Author's calculations (Common sample, 228 observations).

Estimation of the contribution of each sector to total output, labour productivity, and employment growth was computed as the weighted growth of each individual sector (the share of the individual sector in total output was used as a criterion).

$$q = \sum_{i=1}^{n} q_i Y_{i,\%Y} \quad \text{for output growth} \quad (1)$$

$$lp = \sum_{i=1}^{n} lp_i LP_{i,\%LP} \quad \text{for labour productivity growth} \quad (2)$$

$$e = \sum_{i=1}^{n} e_i E_{i,\%E} \quad \text{for employment growth} \quad (3)$$

where q and q_i stand for average annual output growth in all sectors and individual sector (*i*); $Y_{i,\%Y}$ stands for the share of output in sector *i* in total output;

[9] TFP growth was estimated applying growth accounting approach, as in Bacovic (2021).

lp and lp_i are labour productivity in the total economy and individual sector i, $LP_{i,\%LP}$ stands for the share of labour productivity in sector i in total labour productivity; e and e_i represent total employment and employment in sector i, respectively; and $E_{i,\%E}$ represents the share of employment in sector i in relation to total employment.

Output growth in other services, due to its high share, has contributed the most to overall output growth (45%[10]). However knowing that its average share in total output is 56%, its contribution to economic growth is weaker in relative terms compared to knowledge-intensive services, industry, and construction. Contribution to the output growth rate from the knowledge-intensive service sector (23.6%), a sector with an average share of 14% in total output, indicates a stronger relevance of knowledge-intensive service growth for total output growth. In industry and construction, the contributions to output growth is 24% and 12%, respectively, and the average shares of total output are 20% and 6.2%, respectively. In relation to labour productivity growth, the contribution from industry was the most significant (39.45%), followed by other service sectors. Both service sectors contribute the most to employment growth, reducing the effects of negative employment growth in agriculture and industry (Table 5).

Table 5

Contribution to the Output Growth, Labour Productivity and Employment (in %)

	Contribution to gross value added growth (Equation 1)	**Contribution to labour productivity growth (Equation 2)**	**Contribution to employment growth (Equation 3)**
Agriculture	0.04	0.11	–0.21
Industry	0.59	0.73	–0.13
Construction	0.12	0.07	0.05
Knowledge-intensive services	0.58	0.18	0.36
Other services	1.11	0.52	0.57
Total economy	2.45	1.85	0.60

Source: Author's calculations (Common sample, 542 observations).

The correlation coefficients between the components of the output structure and output growth, GDP per capita, labour productivity growth, TFP growth, and employment growth are estimated for two subsamples (medium-income countries (Table 6) and high-income countries (Table 7)).

The share in the industrial sector has a strong positive impact on GDP growth, as well as agriculture and construction, in medium-income economies, whereas in high-income economies agriculture and construction are less significant. The

[10] 1.11% in relation to 2.45%.

share of both knowledge-intensive and other services is negatively related to GDP growth in medium-income economies, whereas in high-income economies, the correlation is positive in relation to knowledge-intensive economies, although moderate.

T a b l e 6

Medium-income Countries, Correlation Coefficients

	Share in total output, %				
	Agriculture	*Industry*	*Construction*	*Knowledge-intensive services*	*Other services*
GDP per capita	–0.71	–0.20	–0.34	0.61	0.05
Output growth	0.15	0.23	0.10	–0.10	–0.20
Labour productivity growth	0.34	0.29	0.10	–0.25	–0.20
TFP growth	0.35	0.24	0.09	–0.18	–0.17
Employment growth	–0.20	0.00	0.02	0.16	–0.07

Source: Author's calculations.

T a b l e 7

High-income Countries, Correlation Coefficients

	Share in total output, %				
	Agriculture	*Industry*	*Construction*	*Knowledge-intensive services*	*Other services*
GDP per capita	–0.53	0.11	–0.37	0.56	–0.31
Output growth	0.01	0.23	0.03	0.03	–0.28
Labour productivity growth	0.02	0.24	0.00	–0.03	–0.22
TFP growth	0.00	0.14	0.01	0.04	–0.15
Employment growth	–0.01	0.09	0.06	0.09	–0.19

Source: Author's calculations.

The share of knowledge-intensive industries has a strong positive impact on GDP per capita growth in both the samples. While the share of industry is positively related to GDP per capita growth in high-income countries, the opposite is true in medium-income countries.

Other services are positively (although weakly) related to GDP per capita growth in medium-income countries, whereas the opposite is true in high-income countries. The shares of agriculture and construction are negatively related to GDP per capita growth in both samples.

The share of knowledge-intensive industries has a strong positive impact, whereas the share of other service sectors is negatively related to employment growth in both the samples. In high-income countries, the industry share is positively associated with employment growth, whereas it is neutral in medium-income countries. The share of agriculture has a negative impact on employment growth in both samples.

The share of the industrial sector has a strong positive impact on labour productivity growth in both samples, whereas agriculture and construction are positively associated with labour productivity growth in medium-income countries. Services are negatively related to labour productivity growth. The same applies to TFP growth, except for knowledge-intensive services in high-income countries, where a positive association with TFP growth was observed.

Bacovic et al. (2021, 9. 14)**,** following the approach of McMillan, Rodrik, and Verduzco-Gallo (2014), show that labour productivity growth in Europe was determined mostly through capital accumulation and technological change, while the transition of labour from low-productivity sectors to high-productivity sectors was the most relevant in the knowledge-intensive sector.

3. Model, Data and Results

3.1. Data and Sample

The definition of sectors and the sectoral classification of the service sectors (knowledge-intensive and other services) are presented in Section 2.1. The data used in this study were sourced from the Eurostat database and had an annual frequency (Table 8).

T a b l e 8

List of Variables, Sources and Units

Variable	Description	Unit	Source
Y	gross value added	chain linked volumes (2010), million euros	Eurostat, [nama_10_a64]
K	total gross fixed assets	current replacement costs and previous year replacement costs, million euros	Eurostat, [nama_10_nfa_st]
L	total employment	domestic concept (thousand persons)	Eurostat, [nama_10_a64_e]
L_i	employment in respective sectors (tertiary education level)	percentage of total employment	Eurostat, [lfsi_educ_a]
R	intramural R&D expenditure (GERD)	chain linked volumes (2010), million euros	Eurostat, [rd_e_gerdtot]

Source: Author's compilation

From the original sample of thirty-one European countries, five countries were excluded because of missing data; therefore, the final sample consisted of 26 countries for the period 1995 – 2019.[11]

[11] Some sectoral data were not available for following countries: Luxemburg, Malta, Poland, Sweden and Iceland.

3.2. Model Panel Least Square (Fixed Effects) and Simple OLS

In this study, production functions were estimated for the total economy, industry, knowledge-intensive services, and other services with exogenous variables to explain the impact of structural changes on GDP growth. We define R&D investment as an exogenous factor for TFP.

As human capital growth is an important determinant of economic growth (Becker, et al., 1993), labour (number of employees) is disaggregated into two components: employees with tertiary education and other employees (all other levels of education). We estimated the panel OLS (fixed effects) and simple ordinary least squares (OLS) models.

The aggregate production of an economy is function of capital stock, labour, and TFP:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta}, 0 < \alpha + \beta < 1 \tag{4}$$

where Y_t represents the output of the economy at time t, A_t is TFP, and K_t and L_t represent capital stock and labour, respectively. The constants α and β represent the share of capital and labour in income, respectively.

Further, we split labour into employees with tertiary education ($L_{t,t}^{\gamma}$) and other employees ($L_{o,t}^{\beta}$). TFP is expressed as a function of investment in R&D (GERD) – R_t and other exogenous factors (non-R&D TFP factors) – C_t:

$$A_t = f\left(R_t, C_t\right) = R_t^{\delta} C_t \tag{5}$$

A combination of Equations 4 and 5 is then:

$$Y_t = C_t K_t^{\alpha} L_{o,t}^{\beta} L_{t,t}^{\gamma}, R_t^{\delta}, 0 < \alpha + \beta + \gamma + \delta < 1 \tag{6}$$

where Y_t denotes the output of the economy at time t, C_t is another exogenous factor, *and* K_t , $L_{o,t}$ and $L_{t,t}$ represent capital stock, labour with other education and labour with tertiary or higher education, respectively. R_t represents investment in R&D (GERD). The constants α, β, γ *and* δ represent the elasticities of production with respect to production inputs.

After taking natural logs, the following equation is obtained:

$$LY_t = c + \alpha LK_t + \beta LL_{o,t} + \gamma LLL_{t,t} + \delta LR_t + \varepsilon_t \tag{7}$$

where c is the intercept, α, β, γ and δ are constant elasticities and ε_t is the error term.

Production functions were estimated on the sectoral level as follows.

For industry sector:

$$LY_{t,i} = c + \alpha LK_t + \beta LL_{oi,t} + \gamma LLL_{ti,t} + \delta LR_t + \varepsilon_t \tag{8}$$

where subscript *i* refers to the industry sector, and all other variables have the same explanation as in Equations 6 and 7.

For knowledge-intensive services sector:

$$LY_{t,k} = c + \alpha LK_{k,t} + \beta LL_{k,t} + \delta LR_t + \varepsilon_t \tag{9}$$

where subscript *k* refers to the knowledge-intensive services sector, and all other variables have the same explanation as in Equations 6 and 7.

For other services sector:

$$LY_{to,i} = c + \alpha LK_{to} + \beta LL_{oo,t} + \gamma LLL_{to,t} + \delta LR_t + \varepsilon_t \tag{10}$$

where subscript *o* refers to the knowledge-intensive services sector, while all other variables have the same explanation as in Equations 6 and 7.

3.3. Results and Key Findings

Unit-root tests appropriate for panel data are used to define the properties of the variables. The Levin-Lin-Chu and Im-Pesaran-Shin unit root tests investigate the existence of a unit root with a common process, while the ADF Fisher Chi-Square and PP- Fisher Chi-Square unit root tests consider a unit root with an individual process. We reject the null hypothesis at the 1% level of significance for all aforementioned tests, and the alternative hypothesis of this test indicates stationarity.[12] Therefore, we proceed with further testing of the panel models.

A Lagrange multiplier test (Breusch-Pagan) was performed on the balanced panels (Table 9). The null hypothesis of this test did not consider any evidence of significant differences across municipalities. If the null hypothesis is correct, then a simple OLS regression can be performed. This test shows that a simple OLS regression is adequate for equations (8) and (10). However, two models (Equations 7 and 9) reject the null hypothesis at the 1% significance level. Therefore, we must consider whether the random effects are more appropriate, which was investigated by performing the Hausman test.

The results of the Hausman test (Table 10) were used to select fixed effects and random effects models for the panel data. The random effects model is preferred under the null hypothesis because of its higher efficiency. The alternative hypothesis is that the fixed effects model is at least consistent and preferred. The

[12] The results of the above-mentioned tests are available on request.

results of the test confirm the choice of fixed effects versus random effects model. The null hypothesis was strongly rejected in both models (Equations 7 and 9). Therefore, we use these two models with fixed effects.

T a b l e 9

Lagrange Multiplier Test – (Breusch-Pagan) for Balanced Panels

Model	Chi-square	P-value
Equation 1	38.067	<0.01***
Equation 2	1.5017	0.2204
Equation 3	12.983	<0.01***
Equation 4	0.07232	0.788

Note: *, ** and *** indicate that the coefficients are significant at the 10%, 5% and 1% level of significance, respectively.

Source: Authors' calculation.

T a b l e 10

Hausman Test for Models

Dependent variable	Chi-square	P-value
Equation 1	14.58205	0.0057***
Equation 3	7.58863	0.0553*

Note: *, ** and *** indicate that the coefficients are significant at the 10%, 5% and 1% level of significance, respectively.

Source: Authors' calculation.

Before proceeding with the modelling, we examined the quality of our input data in terms of multicollinearity. To detect possible problems, we calculated the correlation coefficients between variables in all four equations and the variance inflation factor for each predictor (Tables 11 – 14). As can be verified from the tables, no high relations are observed (all correlations are even below the absolute value of 0.20). The VIF is calculated based on the linear relationship between the selected predictor and other independent variables. As Alin (2010) indicated, the threshold value for large linear dependency within independent variables is generally 10. All calculated values of VIF are around 1, which strongly indicates that there is no multicollinearity problem and that we can move on to equation modelling.

T a b l e 11

Correlation Matrix and Variance Inflation Factor (VIF) for Variables in Equation 7

Variables	CSGT	DLOGOE	DLOGTE	DLOGRGT	VIF
CSGT	1.00				1.025591
DLOGOE	0.153967	1.00			1.060016
DLOGTE	0.004777	0.086934	1.00		1.010121
DLOGRGT	0.096621	0.03014	0.086934	1.00	1.032992

Source: Authors' calculation.

Table 12

Correlation Matrix and Variance Inflation Factor (VIF) for Variables in Equation 8

Variables	CSGT	DLOGOEI	DLOGTEI	DLOGRGT	VIF
CSGT	1.00				1.013315
DLOGOEI	–0.01763	1.00			1.033173
DLOGTEI	0.054649	–0.01358	1.00		1.006874
DLOGRGT	0.096621	–0.00211	0.005392	1.00	1.031147

Source: Authors' calculation.

Table 13

Correlation Matrix and Variance Inflation Factor (VIF) for Variables in Equation 9

Variables	CSGH	DLOGEHKS	DLOGRGT	VIF
CSGH	1.00			1.043935
DLOGEHKS	0.054858	1.00		1.006085
DLOGRGT	0.030157	–0.05937	1.00	1.038515

Source: Authors' calculation.

Table 14

Correlation Matrix and Variance Inflation Factor (VIF) for Variables in Equation 10

Variables	CSGS	DLOGTELK	DLOGOELS	DLOGRGT	VIF
CSGS	1.00				1.007752
DLOGTELK	–0.01971	1.00			1.084626
DLOGOELS	0.048266	–0.17366	1.00		1.110685
DLOGRGT	0.095888	0.006729	0.036354	1.00	1.032651

Source: Authors' calculation.

Applying the panel least squares (fixed effects) model, with the economy's output at time t as dependent variable, we estimated the coefficients for the independent variables (Equation 7) as presented in Table 15.

Table 15

Panel Least Square (fixed effects), Equation (7)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Capital stock growth	0.053991	0.028653	1.884308	0.0603
Non-tertiary employment growth	0.467598	0.046124	10.13789	0.0000
Tertiary educated employment growth	0.142189	0.025867	5.496934	0.0000
Investment in R&D growth	0.035949	0.012949	2.776247	0.0058
C	0.016596	0.001663	9.978145	0.0000
R-squared: 0.679020				

Source: Authors' calculation.

All exogenous variables defined in Equation (7) have a positive impact on output growth. A growth in capital stock of 1% leads to output growth of 0.05%. Employment growth (tertiary education) leads to output growth of 0.142%, employment growth (other levels of education) of 0.467, and R&D investment growth of 0.035%. Growth in other exogenous factors contributes to output growth by 0.016%.

Table 16 presents the simple OLS estimation results for Equation 8. The dependent variable is the industry output at time t, and the independent variables are as follows.

T a b l e 16

Simple OLS Estimation, Equation (8)

Variable	Estimate	Std. Error	t-value	Pr(>|t|)
Capital stock growth	0.318493	0.072350	4.4021	1.390e-05 ***
Non-tertiary employment in industry growth	0.581377	0.071598	8.1199	6.339e-15 ***
Tertiary educated employment in industry growth	0.142095	0.053091	2.6764	0.007759 **
Investment in R&D growth	0.068251	0.032215	2.1186	0.034765 *
C	0.018136	0.004358	4.1616	3.899e-05 ***
R-Squared: 0.23126				

Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Source: Authors' calculation.

We conclude that capital stock growth, growth in the number of employees in an industry with both tertiary and non-tertiary education, and investment in R&D have statistically significant positive effects on output growth. A capital stock growth of 1% leads to output growth of 0.31%. Employment growth (tertiary education) leads to output growth of 0.142%, employment growth (other levels of education) of 0.581%, and R&D investment growth of 0.068%. Growth in other exogenous factors of TFP contributes 0.018% to the output growth.

Table 17 presents the panel least-squares (fixed effects) estimation results for equation (9). The dependent variable is the output of knowledge-intensive services at time *t*. The independent variables were as follows.

T a b l e 17

Panel Least Square (fixed effects), Equation (9)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Capital stock growth in knowledge-intensive services	0.085728	0.036602	2.342195	0.0198
Total employment growth	0.544899	0.070688	7.708494	0.0000
Investment in R&D growth	0.129365	0.030245	4.277212	0.0000
C	0.015683	0.003327	4.713821	0.0000
R-squared: 0.348024				

Source: Authors' calculation.

In knowledge-intensive services, capital stock growth of 1% determines an output growth of 0.085%. Employment growth led to output growth of 0.54%. An R&D investment growth of 1% leads to output growth of 0.129%, which is significantly higher than that in other sectors. Growth in the other exogenous factors of TFP contributes 0.0156% to output growth.

For Equation (10), the simple OLS estimation results are presented in Table 18. The dependent variable is the output of other services at time t, and the independent variables are listed below.

Table 18

Simple OLS Estimation, Equation (10)

Variable	Coefficient	Std. Error	t-value	Pr(>|t|)
Capital stock growth in other services	0.0663748	0.0231399	2.8684	0.004407 **
Non-tertiary employment in other services growth	0.6409087	0.0653128	9.8129	<2.2e-16 ***
Tertiary educated employment in other services growth	0.1478331	0.0323546	4.5692	7.071e-06 ***
Investment in R&D growth	0.0744726	0.0179690	4.1445	4.395e-05 ***
Intercept)	0.0069368	0.0021471	3.2309	0.001366 **
R-Squared: 0.32025				

Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Source: Authors' calculation.

We conclude that capital stock growth, growth in the number of employees in other services with both tertiary and non-tertiary education, and investment in R&D have statistically significant positive effects on output growth for other services. Capital stock growth of 1% leads to output growth of 0.06%, employment growth (tertiary education) leads to output growth of 0.14%, employment growth (other levels of education) of 0.64%, and R&D investment growth of 0.074%. Growth in other exogenous factors contributes 0.006% to output growth.

4. Discussion and Conclusion

Dynamic structural changes have been observed in Europe over the past several decades, with a diminishing share of output produced in agriculture, industry, construction, and other services in relation to total output but a growing share of knowledge-intensive services. The dynamics of structural changes vary moderately between medium-and high-income countries, as the share of industry and construction in relation to total output increases in medium-income countries, whereas the dynamics of the agricultural and service sectors are similar in all countries. This process, observed not only in Europe, but also globally, raises many questions regarding its impact on long-term growth and income. The expansion of services has contributed to the growth in GDP and employment. However, their impact on the long-term economic performance remains an issue. Previous research has provided evidence of its negative impact on long-term output growth due to its lower TFP growth compared to the industrial sector.

In this research, we disaggregated services into two subsectors: knowledge-intensive and other (less knowledge-intensive) services. Empirical analysis shows that the expansion of knowledge-intensive services is stronger than that of other services, and that the contribution of knowledge-intensive services to output and productivity growth is significantly higher than that of other services, although still lower than that of the industry sector. The results confirm those of an empirical study conducted in OECD countries (OECD 2018).

Research has shown that GDP growth is negatively related to the growing share of the knowledge-intensive service sector in medium-income countries but positively related in high-income countries, while GDP per capita growth is positively related to the growing share of knowledge-intensive services in all countries. Additionally, the share of knowledge-intensive industries has a strong positive impact on employment growth in all countries, whereas the share of other service sectors has a negative impact. TFP growth in the service sector is lower than that in industry and agriculture, but TFP growth in knowledge-intensive services is significantly higher than that in other services, although it is lower than that in industry. While the industry sector has a strong positive impact on labour productivity and TFP growth as well as agriculture and construction in all countries, the expansion of the knowledge-intensive service sector has a positive impact in high-income countries but a negative impact in medium-income countries. Other service sectors are negatively related to labour productivity and TFP growth in all countries. The estimation of the contribution of each individual sector to the average annual total output, labour productivity, and employment growth shows a stronger relative contribution of output growth in knowledge-intensive services, industry, and construction than in other service sectors (although in absolute terms, this sector contributed the most owing to its high share in total output). The growth of labour productivity in the industry was the most significant for overall productivity growth, whereas the service sector generated the most employment growth.

Applying panel OLS (fixed effects) and simple OLS regression to unbalanced panel data, we estimate the contribution of growth in investment in R&D and tertiary educated employment for all sectors, but also for the industry, knowledge-intensive services, and other service sectors. The estimated results show that growth in R&D investment has the highest impact on output growth in the knowledge-intensive service sectors. Tertiary employment growth has positive and balanced effects on growth in all the sectors. The results from the estimated production functions show that the average non-R&D component of TFP growth was 1.65% for all sectors. While it is higher in industry (1.81%), it is lower in knowledge-intensive services (1.56%) and other services (0.6%). The estimated results are in line with the results estimated by applying the growth accounting method but also with the results presented by Foster-McGregor and Verspagen

(2017), who showed lower TFP growth in the service sector than in manufacturing. Although TFP growth in knowledge-intensive services is lower in relation to the industry, it is still significantly higher than that in other services.

To summarise, research has shown that although knowledge-intensive services are the fastest growing sector, with significant contributions to output and employment growth, industry is still the most relevant sector for long-term growth because it has the highest TFP growth and labour productivity growth. This gives medium-income countries positive future perspectives, as their industry's share in output has increased. However, TFP and labour productivity growth rates are higher in the knowledge-intensive sector than in other service sectors, meaning that the growing knowledge-services sector may partially overcome the negative effects of other services on long-term output growth. If the structure of the service sector continues to change toward expansion of the knowledge-intensive sector, the negative effects of overall service sector expansion may diminish.

As R&D investments are a significant factor in output growth in knowledge-intensive services, economies in which the service sectors are strategic should increase their R&D activities. Bacovic et al. (2021, p. 8) showed that R&D activities are strongly positively associated with tertiary educational attainment in STEM programs. In addition, the dynamics of STEM graduates have been positively associated with the quality of education in Europe, which has stagnated over the past few decades. This leads to the conclusion that education is also an important determinant of the future output structure and long-term economic growth.

The structural approach contributes to the existing literature in the analysis of the service sector and its impact on long-term output growth and productivity, showing different paths in knowledge-intensive and other service sectors.

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