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LuxKLEMS: Productivity trends and drivers in Luxembourg

Auteurs :
Golnaz Amjadi, Charles-Henri DiMaria, Xi Chen.[1]

Résumé / Abstract

FR
Depuis plus d'une décennie, l'initiative LuxKLEMS, menée par le STATEC, fournit des mesures robustes de la productivité pour le Luxembourg. Ce rapport présente les résultats de la dernière mise à jour couvrant la période 1995–2023, basée sur les Comptes nationaux publiés en février 2025. L'analyse présente les tendances et les sources de la productivité totale des facteurs (PTF), mesurée comme le ratio de la production brute aux facteurs de production — capital, travail et consommations intermédiaires — et décomposée en efficience et progrès technique. L'examen des grands agrégats met en évidence des évolutions contrastées : les services ont enregistré une croissance faible de la PTF depuis le début des années 2000, principalement en raison d'un changement technologique négatif. Étant donné le poids dominant de ces activités dans la production nationale, cela explique une grande partie du ralentissement global de la productivité du pays. À l'inverse, le secteur manufacturier a maintenu une croissance positive de la PTF, soutenue par des avancées technologiques. Les données à un niveau plus fin, par section d'activité, montrent que la plupart des sections des services ont connu un recul technique, entraînant des tendances négatives de la PTF à long terme. En revanche, les industries extractives (B), les industries manufacturières (C) et la production et distribution d'énergie (D) ont enregistré une croissance positive et soutenue de la PTF sur la période 1996–2023, principalement grâce au progrès technique. Le rapport compare également la productivité entre industries selon leur intensité en capital TIC. Alors qu'une intensité en TIC plus élevée était associée à de plus forts gains de productivité avant la Grande Récession, ce lien s'est fortement affaibli durant la période post-crise.

EN
For over a decade, the LuxKLEMS initiative, led by STATEC, has provided robust productivity measures for Luxembourg. The LuxKLEMS report documents the evolution of Total Factor Productivity (TFP) in Luxembourg from 1995 to 2023, using National Accounts data released in February 2025. TFP is measured as the ratio of gross output to inputs—capital, labour, and intermediate consumption—and decomposed into efficiency change and technical change. A focus on broad aggregates highlights contrasting developments: Luxembourg's service industries have experienced weak TFP growth since the early 2000s, largely due to negative technological change. Given their dominant role in national output, this explains much of the country's overall productivity slowdown. In contrast, manufacturing has maintained positive TFP growth, supported by technological advances. Data at more detailed section-level shows that most service sections experienced technical regress, resulting in negative long-run TFP trends. In contrast, mining and quarrying (B), manufacturing (C), and energy supply (D) achieved sustained positive TFP growth over 1996–2023, mainly due to technical progress. The report also analyses productivity trends through the lens of ICT capital intensity, classifying industries as low, medium, or high-ICT. Before the 2008 financial crisis, high-ICT industries exhibited strong TFP growth. After the crisis, however, this link weakened significantly.

1 STATEC Research.

The authors gratefully acknowledge the support of STATEC, the National Statistical Office of Luxembourg. Views and opinions expressed in this article are those of the authors and do not reflect those of STATEC and funding partners. This work was produced using statistical data from STATEC reprocessed for research purposes. Thanks are due to Serge Allegrezza and the Conseil National de la Productivité, STATEC seminar attendees and colleagues at STATEC Research and the Ministry of the Economy, DG Compétitivité, for their comments.

LuxKLEMS: Productivity trends and drivers in Luxembourg

Golnaz Amjadi, Charles-Henri DiMaria, Xi Chen.[1]

For over a decade, the LuxKLEMS initiative, led by STATEC, has provided robust productivity measures for Luxembourg. The LuxKLEMS report documents the evolution of Total Factor Productivity (TFP) in Luxembourg from 1995 to 2023, using National Accounts data released in February 2025. TFP is measured as the ratio of gross output to inputs—capital, labour, and intermediate consumption—and decomposed into efficiency change and technical change. A focus on broad aggregates highlights contrasting developments: Luxembourg's service industries have experienced weak TFP growth since the early 2000s, largely due to negative technological change. Given their dominant role in national output, this explains much of the country's overall productivity slowdown. In contrast, manufacturing has maintained positive TFP growth, supported by technological advances. Data at more detailed section-level shows that most service sections experienced technical regress, resulting in negative long-run TFP trends. In contrast, mining and quarrying (B), manufacturing (C), and energy supply (D) achieved sustained positive TFP growth over 1996–2023, mainly due to technical progress. The report also analyses productivity trends through the lens of ICT capital intensity, classifying industries as low, medium, or high-ICT. Before the 2008 financial crisis, high-ICT industries exhibited strong TFP growth. After the crisis, however, this link weakened significantly.

1. Introduction

The LuxKLEMS initiative, led by the National Institute of Statistics and Economic Studies of Luxembourg (STATEC), has been providing productivity figures for the country for over a decade (e.g. DiMaria and Ciccone, 2008; Peroni, 2012; Amjadi et al., 2020; Amjadi et al., 2024). This report presents selected indicators of productivity for Luxembourg from the latest LuxKLEMS update. The indicators cover the period from 1995 to 2023 and are compiled from the National Accounts data released in February 2025. What follows describes the evolution of Total Factor Productivity (TFP) for Luxembourg's economic activities and examines sources of that evolution, that is, changes in efficiency and technical progress. It also presents the comparative productivity performance of industries characterised by different intensities of information and communication technologies (ICT) capital.

[1] STATEC Research.

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TFP "reflects the overall efficiency with which [...] inputs are combined in the production process" (OECD) and is often compiled using ratios of output to a combination of inputs.[2] Specifically, in LuxKLEMS, TFP is defined as the ratio of gross output to a combination of inputs[3], consisting of capital, labour, and intermediate consumption, which includes energy, materials, and services.[4] The growth in TFP is decomposed into the sum of efficiency change and technical change, which capture, respectively, improvements in the use of inputs and advances in production technology and input quality (Kumbhakar et al., 2015).

This report also presents the comparative productivity performance of industries characterised by different intensities of information and communication technology (ICT) capital. Empirical studies conducted at the firm and industry level show that higher investment in ICT is associated to higher productivity (Oliner & Sichel, 2000; Brynjolfsson & Hitt, 2003). As a general-purpose technology, ICT enhances efficiency in production processes when complemented by appropriate skills and organisational structures (Bresnahan & Trajtenberg, 1995). ICT adoption enhances industries' performance by automating routine tasks and increasing productivity of workers engaged in non-routine tasks (Autor et al., 2003), while generating economy-wide spillovers (Romer, 1990). Given this evidence, we explore whether Luxembourg's industries with higher ICT capital[5] intensity tend to exhibit stronger TFP growth. ICT capital refers to the stock of information and communication technology assets used in production (OECD, 2009). These assets include computers, communication equipment, databases, and software (European Commission, 2020).

The intensity of ICT capital is measured as the share of ICT capital in an industry's total capital stock, capturing the degree to which economic activities rely on those technologies. Based on this measure, industries are classified according to their ICT capital share into low, medium, and high-ICT-intensity groups. This classification allows us to examine whether Luxembourg's industries with higher ICT capital intensity tend to exhibit stronger TFP growth.

The findings show that Luxembourg's service industries have experienced weak TFP growth since the early 2000s, which explains the aggregate modest TFP performance of the country. The data indicate that negative technical change is a source of the slowdown in TFP growth, as efficiency gains are offset by technical regress[6]. In contrast, TFP growth has been positive in manufacturing, where technological advances have sustained productivity performances. The analysis of TFP trend by ICT capital intensity shows that, prior to the Great Recession,

[2] https://www.oecd.org/en/data/indicators/multifactor-productivity.html

[3] On productivity definitions one can see the OECD manual Measuring Productivity (2001).

[4] Note that studies on productivity often use value added to measure output. Value added equals gross output minus intermediate consumption. So, those studies focus on the use of the two remaining inputs, labour and capital. The LuxKLEMS methodology departs from those frameworks by including energy, materials, and services (EMS) in the inputs set, in addition to capital and labour. This requires using gross output, instead of value added, as a measure of production. This allows us to consider the role of intermediate consumption in production. For a comparison of value added or gross output-based productivity measures, see Cobbold (2003).

[5] ICT capital refers to the stock of information and communication technology assets used in production (OECD, 2009). These assets include computers, communication equipment, databases, and software (European Commission, 2020).

[6] Technical regress refers to the loss or deterioration of existing technologies, which is a counterintuitive outcome and often difficult to interpret. On this, one can see Amjadi et al. (2020), where authors discuss an explanation based on demand and capacity utilization rates, and references therein.

higher ICT capital intensity is associated with stronger productivity performances. However, in the post-recession period, greater ICT capital intensity is no longer linked to higher productivity growth. A section-level analysis further shows that only a few sections—mining and quarrying (B), manufacturing (C), and energy supply (D)—featured positive average TFP growth over the period, with gains primarily driven by technical progress.

The rest of this report is organised as follows. Section 2 presents the LuxKLEMS framework. Section 3 examines trends in TFP and its main drivers for the total economy and for two major aggregates: service and manufacturing industries. Section 4 introduces the concept of ICT capital and analyses the evolution of TFP and its drivers across industry groups classified according to their ICT capital intensity. Section 5 reviews the period averages of annual growth rates of TFP, efficiency change, and technical change across 18 economic sections. Section 6 concludes.

2. The LuxKLEMS framework

LuxKLEMS provides productivity indicators compiled from STATEC's National Accounts. National Accounts are a comprehensive system of accounts and balance sheets, which provide a framework to describe Luxembourg's economy. They align with the European System of Accounts (ESA 2010) and the Statistical classification of economic activities in the European Community (NACE Rev. 2) in terms of definitions and accounting rules.

LuxKLEMS provides productivity indicators at the industry level. The framework describes the Luxembourg economy as composed by 30 groups of economic activities (industries). This report focuses on presenting results for the total economy and two broad aggregates of industries, referred to as "manufacturing" and "services". These economic activities use production factors including capital, labour, energy, raw materials, and services to produce outputs that are either goods or services. The aggregate "Manufacturing" consists of agriculture, mining, manufacturing, utilities and construction. "Services" consists of business services, financial activities, and non-market services. These industries cover all economic activities in Luxembourg according to NACE Rev. 2 at the two-digit level. Table 1 provides a detailed breakdown of these industries and their respective period-average shares in total output.

Studies on productivity often use value added to measure output. Value added equals gross output minus intermediate consumption. So, those studies focus on the use of the two remaining inputs, labour (L) and capital (K). The LuxKLEMS methodology departs from those frameworks by including energy, materials, and services (EMS) in the inputs set, in addition to capital and labour. This requires using gross output, instead of value added, as a measure of production. This allows us to consider the role of intermediate consumption in production. Thus, throughout this LuxKLEMS report, TFP is measured on a gross-output basis, and defined as the ratio of output to all inputs considered, that is *capital, labour, and intermediate consumption* (i.e. energy, materials, and services), rather than on a value-added basis. For a comparison of value added or gross output-based productivity measures, see Cobbold (2003).

TFP captures the overall ability of an economy to transform all inputs into output, i.e. goods and services. TFP growth can be decomposed in the sum of efficiency gains and technical progress. Efficiency gains are improvements in the utilisation of inputs, while technical change captures improvements in production technology and input quality (Kumbhakar et al., 2015).

To compile productivity indicators, LuxKLEMS framework adopts Data Envelopment Analysis (DEA), a frontier approach originally developed by Charnes et al. in 1978.[7] This framework allows for a decomposition of TFP growth into the separate components of technical change and efficiency change (see e.g. DiMaria and Ciccone, 2007). Technical changes refer to advancements in technology that enable a given set of resources to produce more output than was previously possible. Efficiency changes refer to the degree to which an industry enhances its capacity to produce the highest possible level of output with the available resources and the current technology.

One marking feature of LuxKLEMS framework is that it provides productivity indicators at the industry level. Indicators for services, manufacturing, or other industry groupings, as well as the total economy, are compiled using a bottom-up approach, by aggregating industry-level productivity indicators with weights that reflect each industry's contribution to its respective sector's total output. In practice, aggregate TFP measures for each year are derived based on industry-level Malmquist TFP growth rates aggregated using production values as weights (Zelenyuk, 2006). Box 1 provides more details on the aggregation approach.

[7] We use DEA primarily for its advantages in measuring productivity across industries with diverse input mixes, for the robustness of indicators to revisions, and because it allows us to produce indicators when the availability of observations is limited. DEA, unlike parametric methods, does not assume any functional form on the production frontier (which, broadly speaking, represents production possibilities according to the overall technological level), except for assumptions on returns to scale. Using DEA also minimizes the impact of data revisions on the previously produced indicators based on previous data vintages.

Table 1. Period average share in total gross output by manufacturing and services industries in Luxembourg (1995–2023)

Industry	Name	Average annual share in total gross output (%)
Manufacturing, Agriculture, Utilities, and construction (NACE Rev. 2 sections: A,B,C,D,E, and F)		
	Agriculture	0.31
	Forestry	0.01
	Mining and Quarrying	0.07
	Food, Textiles, Paper & wood, Petroleum	2.48
	Chemical and pharmaceuticals	0.25
	Other manufacturing	6.62
	Electricity and gas	0.82
	Water supply	0.08
	Waste management	0.35
	Construction	4.31
Business services, financial activities, and non-market services (NACE Rev. 2 sections: G,H,I,K,L,M,N,O,P,Q,R,S)		
	Wholesale and retail trade	6.65
	Transport and postal activities	3.37
	Accommodation and food services	1.33
	Publishing activities	0.94
	Telecommunications and IT services	4.99
	Financial service activities	33.53
	Insurance, reinsurance & pension funding	1.99
	Activities auxiliary to financial services& insurances	13.75
	Real estate activities	3.35
	Services to business and R&D	5.62
	Rental, leasing, Employment, Travel agency, Others	1.92
	Public administration	2.56
	Education	1.61
	Health services	1.48
	Social work activities	0.85
	Arts and entertainment activities	0.20
	Sport activities	0.15
	Activities of membership organizations	0.20
	Repair of computers and personal & household goods	0.02
	Other personal services	0.19

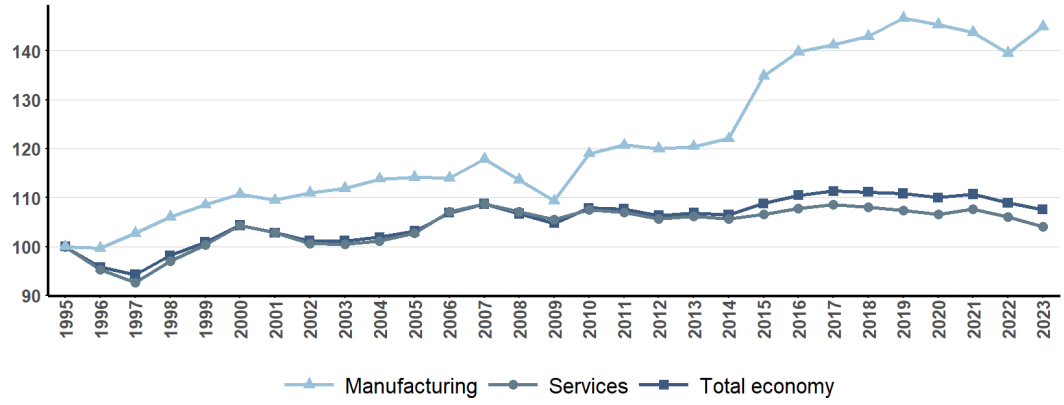
Note: Shares in the table are expressed as percentages (two decimal digits).

3. Trends of TFP, efficiency and technical change

Total Factor Productivity (TFP) is a key indicator of economic performance, defined by Farrell (1957) as the ratio of output to inputs. TFP measures the overall ability of economic entities to transform inputs into output (i.e. goods and services). TFP growth measures the part of output growth that cannot be attributed to changes in input volumes (OECD, 2023). This growth is mainly driven by technical progress and/or efficiency gains.

This section provides an overview of TFP trends in Luxembourg's total economy and its two major aggregates, namely the service and manufacturing industries. Figure 1 presents the evolution of TFP for the total economy and main aggregates from 1995 to 2023. The total economy's trend of TFP is flat, which largely reflects TFP patterns in services. This contrasts with the increasing trend of TFP in manufacturing, which also reveals the severe impact of the recession of 2008–2009.

Figure 1. Trend of TFP (1995–2023)
Index (1995=100)

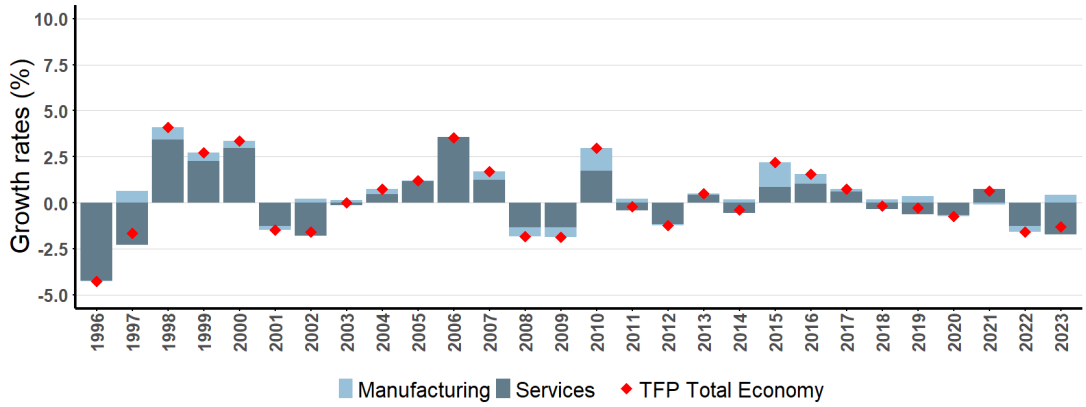


Note: Figures show trends of TFP for the total economy, services and manufacturing industries (1995=100).
Sources: Authors' calculations from STATEC data.

Figure 2 displays annual TFP growth rates for Luxembourg's total economy, highlighting the weighted contributions from services and manufacturing.[8] The data show that TFP growth in the total economy is mainly driven by the service sector. TFP growth has been weak and volatile, sometimes negative, especially since the recession. The last decade also shows a general slowdown in productivity growth across countries.[9] In 2023, TFP growth rate remains negative. This underscores the persistent weakness in total economy TFP growth, which is predominantly attributable to the service sector's performance.

[8] Detailed figures for this chart can be found in Tables A1-A3 in Appendix.
[9] The slowdown in productivity growth is not unique to Luxembourg. Belgium shows comparable trends after the financial crisis (Biatour and Kegels, 2021).

Figure 2. TFP growth (1996–2023)



Note: TFP's annual growth rate (diamonds) and weighted contributions from services TFP growth (dark blue) and manufacturing (pale blues). Weights reflect manufacturing and service shares in total output. Sources: Authors' calculations from STATEC data.

In LuxKLEMS, TFP changes are compiled using the Malmquist index (Caves et al. 1982), which captures productivity change as the geometric mean of efficiency change and technical change (Färe et al., 1994). Efficiency change measures how well inputs are used to produce output by comparing an entity's output to the maximum feasible output attainable with the same input levels in a given period. Efficiency gains therefore reflect changes in this distance over time.[10] Technical change measures shifts in the production frontier by capturing differences in the maximum attainable output between consecutive periods for given input levels. Broadly, technical change reflects improvements in production technology and input quality (Färe et al., 1994; Kumbhakar et al., 2015). For each aggregate, TFP growth rates are presented together with the contributions of efficiency and technical change. Decomposing TFP into these two components provides insights into the sources of productivity growth.

[10] This can be achieved through refined management practices, improved worker training (Wang et al., 2016; Ali et al., 2012), and measures that optimise operations and resource allocation.

Box 1: Compilation of aggregate TFP.

Following Zelenyuk's (2006) approach, in LuxKLEMS, we first compile productivity indicators at the industry level, then we aggregate them into broader categories such as manufacturing, services, and the total economy. The approach involves aggregating TFP Malmquist Indices as a weighted geometric mean of individual industries, according to the formula:

$$TFP = \left(\frac{\prod_{i=1}^{N} D_t^i(y_{t+1}^i, x_{t+1}^i)^{s_{t+1}^i} \prod_{i=1}^{N} D_{t+1}^i(y_{t+1}^i, x_{t+1}^i)^{s_{t+1}^i}}{\prod_{i=1}^{N} D_t^i(y_t^i, x_t^i)^{s_t^i} \prod_{i=1}^{N} D_{t+1}^i(y_t^i, x_t^i)^{s_t^i}} \right)^{0.5} = \prod_{i=1}^{N} TFP^i \quad (1)$$

With:

$$TFP^i = \left(\frac{D_t^i(y_{t+1}^i, x_{t+1}^i)^{s_{t+1}^i} D_{t+1}^i(y_{t+1}^i, x_{t+1}^i)^{s_{t+1}^i}}{D_t^i(y_t^i, x_t^i)^{s_t^i} D_{t+1}^i(y_t^i, x_t^i)^{s_t^i}} \right)^{0.5}$$

In this formula, *t* represents a specific year, *i* denotes industries, and *D* distance functions. Distances measure the difference between an industry's actual performance (given its input bundle *x* and output *y*) and the best possible performance considering the available technology. For example, $D_t^i(y_t^i, x_t^i)$ measures an industry's performance in year *t* relative to the best performance achieved by other industries in the same year, taking into account the inputs used. Similarly, $D_{t+1}^i(y_{t+1}^i, x_{t+1}^i)$ evaluates the industry *i*'s performance in year *t+1*, taking into account its inputs used, relative to best performing industries in year *t+1*, and so forth. The *s* denotes the weights assigned to industries' distance functions. The choice of weight is important as it significantly affects the evolution of aggregate values. To assign weights, we compute TFP Malmquist Indices using different weights and compare them with Eurostat data. Our findings indicate that the optimal weights are based on each industry's output share in the total output of its respective sector. This means that, when computing aggregates for manufacturing and services, different weights are applied. Taking the logarithm of both sides of Equation (1) gives the aggregated Malmquist TFP growth rate as:

$$ln(TFP) = ln\left(\prod_{i=1}^{N} TFP^i\right) = \sum_{i=1}^{N} ln\left(TFP^i\right) \quad (2)$$

Equation (2) implies that the aggregated TFP growth equals the sum of TFP growth rates of all individual industries.

Figure 3 depicts yearly growth rates of TFP (red diamonds), and the contributions to growth from, respectively, technical changes (dark blue bars) and efficiency changes (pale blue bars). This is shown for the total economy (upper panel), for services (middle panel) and manufacturing (lower panel).

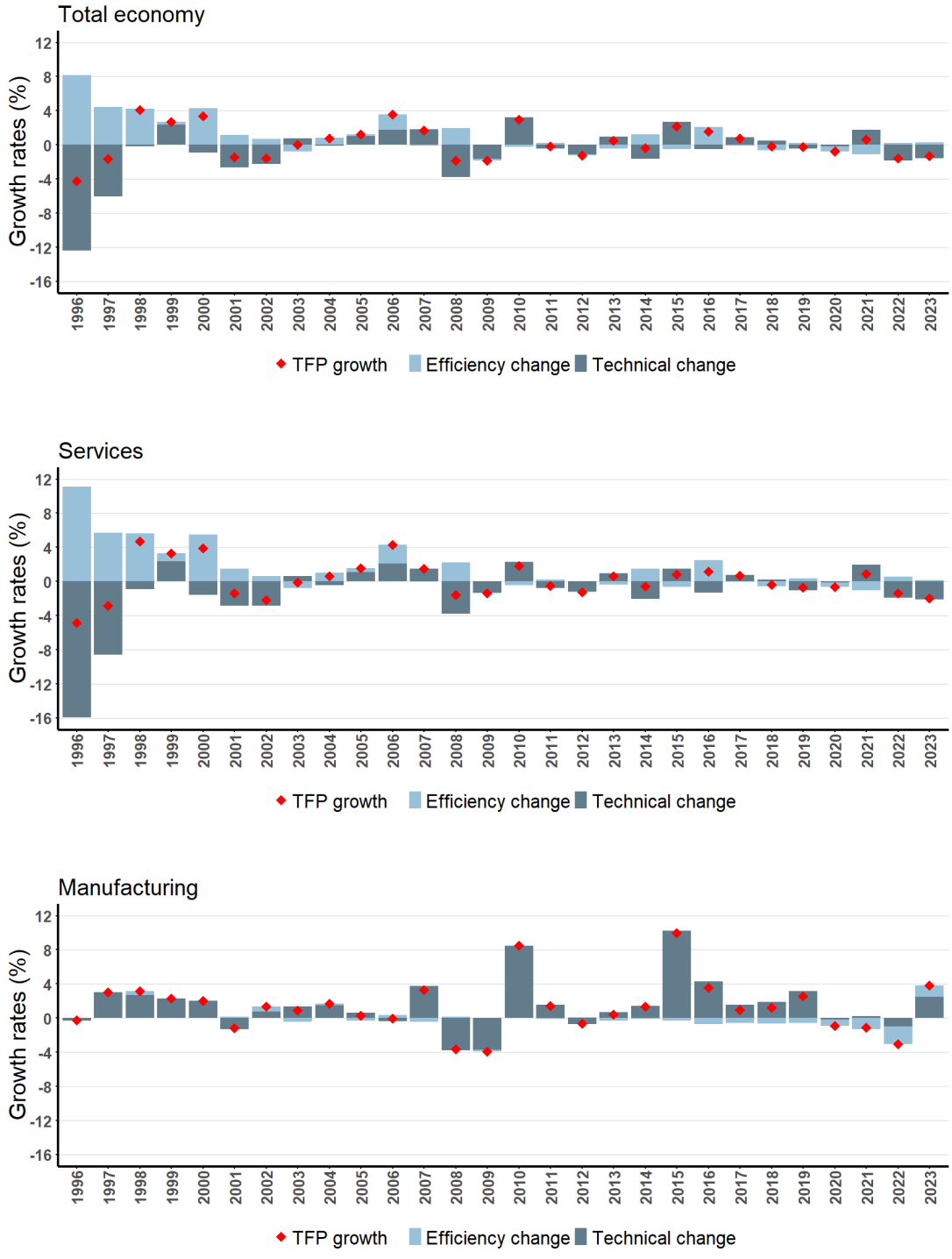
The chart shows a slowdown in TFP growth since 2001. Since then, TFP has fluctuated around zero. The slowdown in TFP since the early 2000s is a global issue. Despite significant research efforts, there is no consensus on its cause (Goldin et al., 2024). We also observe that negative TFP growth rates were mainly driven by technical regress (that is, negative technical change) throughout the period. As noted above, this trend reflects the evolution of TFP in service industries. In those industries, negative technical change offset gains in efficiency over the period. Manufacturing has generally featured positive, albeit more volatile, TFP growth. Notable declines in the productivity of manufacturing industries occurred during major economic disruptions, such as the burst of the IT bubble (2001) and the global recession

(2008–2009). TFP growth patterns in manufacturing were mainly driven by technical change. For the years 2020–2022, we observe efficiency losses, which contributed to negative TFP growth. This confirms the findings in OECD (2025) that TFP growth either stagnated or even turned negative in other OECD countries in 2023 and was particularly pronounced in Luxembourg.

Note that this year's report introduces revised data for the years 2020–2022, and preliminary data for 2023. Thus, figures remain provisional and are subject to revision as more data become available. The revised data for the years 2021–2022 shows weaker productivity performances than previously estimated for all three main aggregates. This suggests that productivity challenges for Luxembourg are more severe than previously recognized. In 2023, TFP growth turned negative in the total economy and services, while manufacturing recorded positive growth.

Revisions also affect the assessment of efficiency and technical change. In the total economy and services, efficiency change was overestimated in 2020–2021 and underestimated in 2022, while technical change was underestimated in 2020–2021 and overestimated in 2022. In manufacturing, efficiency change was consistently overestimated between 2020 and 2022, while technical change was underestimated in 2020 and 2022 but slightly overestimated in 2021. In 2023, technical change turned negative in the total economy and services, with efficiency change remaining close to zero, whereas both measures were positive in manufacturing.

Figure 3. TFP growth, efficiency and technical change (1996–2023)



Note: Diamonds and bars represent annual growth rate (in %) of, respectively, TFP (diamond) and its drivers: efficiency change (pale blue bar) and technical change (dark blue bar). Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Values for year T refer to the growth rate between years T and T-1. Sources: Authors' calculations from STATEC data.

4. Trends of TFP, efficiency and technical change by ICT capital intensity

This section introduces the concept of information and communication (ICT) capital and examines the evolution of TFP, efficiency, and technical change across industry groups classified according to their ICT capital intensity. ICT capital refers to the stock of information and communication technology assets used in production (OECD, 2009). These assets include computers, communication equipment, databases, and software (European Commission, 2020). In this report, we focus specifically on ICT capital, which overlaps only partially with the concept of intangible capital. ICT capital comprises both tangible assets, such as computers and communication equipment, and intangible assets, such as databases and software. While the two concepts overlap, they are not equivalent. By contrast, intangible capital encompasses a broader range of knowledge-based assets, including research and development, patents, design, financial products, branding, and organisational capital (Corrado et al., 2022).

We classify industries into three categories based on their ICT capital intensity (the share of ICT capital in total capital stock). Industries with a share of ICT capital in total capital below the 1% threshold are classified as low intensity (denoted as LICT), those between 1% and 10% are classified as medium intensity (MICT), and those above 10% as high intensity (HICT). This classification broadly aligns with the ICT taxonomy proposed by the OECD (Calvino et al., 2018). We use this classification to compile and compare the evolution of TFP by (group of) ICT intensity.

Table 2 presents the classification of Luxembourg's industries by ICT capital intensity, showing the ICT capital share in total capital and the share of total output in aggregate output, both expresses as averages, based on STATEC National Accounts data. LICT industries account for about 6% of Luxembourg's total output, while MICT and HICT industries account for, respectively, 31% and 63% of total output. These figures indicate that HICT industries in Luxembourg occupy a large share of overall output. Agriculture and forestry are examples of low ICT-intensity industries. In the medium-intensity group, we find electricity and gas, transport, and postal activities. All HICT industries belong to the services, with telecommunications ranking highest, showing an average ICT capital share of about 38%.

Table 2. Period average ICT capital intensity by industries in Luxembourg (1995-2023)

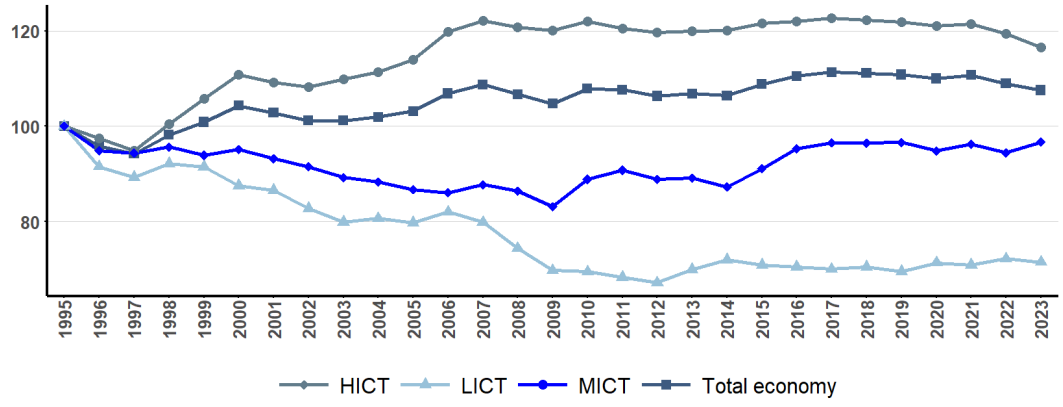
Industry	Name	ICT class	Average ICT share in total capital (%)	Average annual share in total gross output (%)
Manufacturing, Agriculture, Utilities, and construction (NACE Rev. 2 sections: A,B,C,D,E, and F)				
	Agriculture	Low	0.00	0.31
	Forestry	Low	0.66	0.01
	Mining and Quarrying	Low	0.49	0.07
	Food, Textiles, Paper&wood, Petroleum	Medium	1.42	2.48
	Chemical and pharmaceuticals	Low	0.26	0.25
	Other manufacturing	Medium	1.42	6.62
	Electricity and gas	Medium	1.96	0.82
	Water supply	Low	0.35	0.08
	Waste management	Low	0.16	0.35
	Construction	Medium	4.89	4.31
Business services, financial activities, and non-market services (NACE Rev. 2 sections: G,H,I, K,L,M,N,O,P,Q,R, S)				
	Wholesale and retail trade	Medium	4.31	6.65
	Transport and postal activities	Medium	3.83	3.37
	Accommodation and food services	Medium	3.55	1.33
	Publishing activities	High	27.96	0.94
	Telecommunications and IT services	High	38.05	4.99
	Financial service activities	High	16.16	33.53
	Insurance, reinsurance&pension funding	High	19.11	1.99
	Activities auxiliary to financial services& insurances	High	20.69	13.75
	Real estate activities	Medium	3.08	3.35
	Services to business and R&D	High	16.56	5.62
	Rental, leasing, Employment, Travel agency, Others	High	10.12	1.92
	Public administration	Low	0.92	2.56
	Education	Low	0.42	1.61
	Health services	Medium	1.73	1.48
	Social work activities	Medium	2.46	0.85
	Arts and entertainment activities	Low	0.96	0.20
	Sport activities	Low	0.34	0.15
	Activities of membership organizations	Medium	2.11	0.20
	Repair of computers and personal & household goods	Medium	1.17	0.02
	Other personal services	Medium	2.56	0.19

Note: Shares in the table are expressed as percentages (two decimal digits). Industries with high ICT intensity are also more likely to be early adopters of Artificial Intelligence (Calvino et al., 2023).

This section presents trends and growth rates of TFP across industry groups classified by their ICT capital and decomposes TFP growth into efficiency change and technical change. By doing so, it evaluates whether industries with different levels of ICT capital intensity exhibit distinct patterns of TFP growth. It also identifies whether technical change or efficiency change is the main driver of productivity growth.

Figure 4 presents TFP trends across the groups of industries and for the total economy. The data reveal two distinct phases in the evolution of TFP for these groups. Before the financial crisis of 2008–2009, HICT industries recorded positive TFP growth, while productivity in MICT and LICT declined, suggesting that greater ICT investment was associated with stronger productivity performance. After the crisis, however, TFP growth in HICT industries stagnated, MICT industries achieved only modest gains, and LICT featured persistently low productivity growth. Overall, this suggests that higher ICT intensity no longer ensured productivity growth.

Figure 4. TFP trend by ICT capital intensity (1995–2023)
Index (1995=100)



Note: TFP is defined as the ratio of gross output to a combination of inputs (capital, labour, and intermediate consumption). Figures show trends of TFP by ICT capital intensity classes (1995=100). LICT, MICT, and HICT, respectively, denote low, medium, and high ICT capital intensive classes. Sources: Authors' calculations from STATEC data.

Figure 5 depicts the decomposition of TFP growth into the contribution of efficiency and technical changes.[11] The analysis focuses on MICT and HICT industries, which represent about 94% of Luxembourg's output.

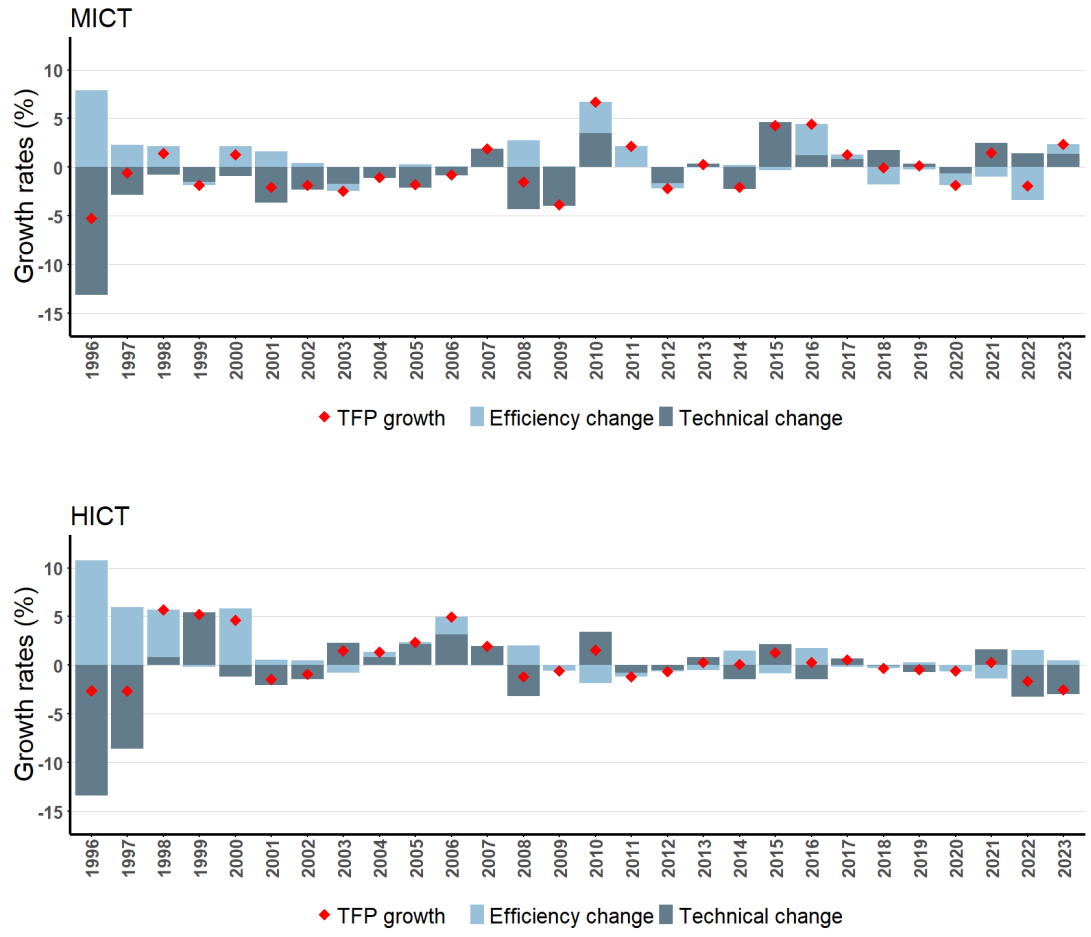
The results show that in HICT industries, TFP growth before 2008 was mainly driven by technical change, while efficiency gains were limited. The post-crisis stagnation in HICT industries resulted from efficiency and technical changes evolving in opposite directions, offsetting each other and constraining overall productivity growth. In MICT industries, TFP declined before 2007 and during the 2008–2009 recession due to negative technical change. In more recent years, however, technical change has shown moderate progress, contributing more positively to TFP dynamics. Before the crisis, efficiency change was unable to counterbalance the declining TFP trend, as efficiency changes were either negative or relatively small compared to the impact of technical regress. After the crisis, TFP growth and its components show no clear or consistent pattern. Box 2 further disaggregates the

[11] Detailed figures for this chart can be found in Tables A4-A6 in Appendix.

respective contributions of financial activities and other activities within HICT industries to TFP growth.

In summary, before the financial crisis, HICT capital intensive industries exhibited positive TFP growth, whereas MICT industries recorded a decline in TFP. This pattern suggests that greater ICT capital intensity is associated with stronger TFP growth. In the post-crisis period, however, TFP growth in HICT industries stagnated, while MICT industries experienced modest gains. This suggests that higher ICT capital intensity does not necessarily translate into higher TFP growth. The decomposition of TFP growth into efficiency and technical changes indicates that stagnation within HICT industries results from these two factors evolving in opposite directions and with comparable magnitudes, thereby offsetting each other and constraining overall productivity growth.

Figure 5. TFP growth by ICT capital intensity (1996–2023)

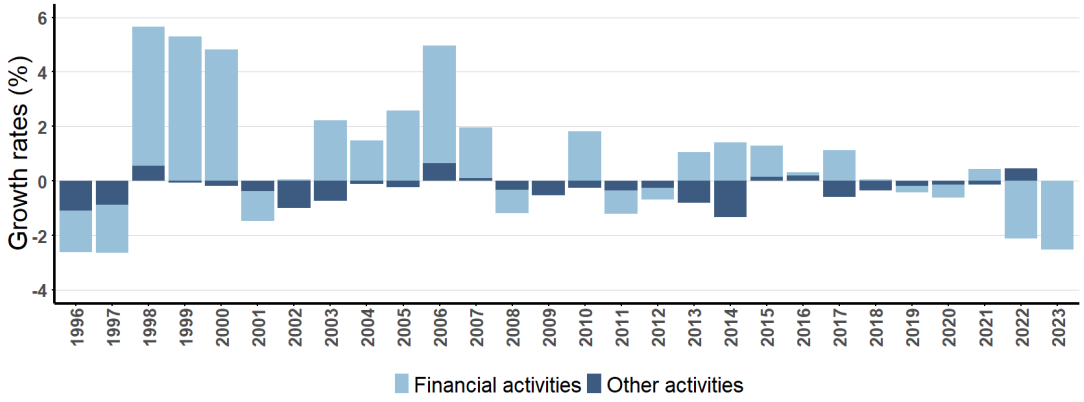


Note: Diamonds and bars represent annual growth rate (in %) of, respectively, TFP (diamond) and its drivers: efficiency change (pale blue bar) and technical change (dark blue bar) by ICT capital intensity classes: MICT, and HICT, respectively, present medium and high ICT capital intensive classes. TFP is defined as the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Values for year T refer to the growth rate between years T and T-1. Sources: Authors' calculations from STATEC data.

Box 2: Financial activities: Driver of productivity in High-ICT Industries

A key advantage of the LuxKLEMS framework is that it does not limit productivity analysis to broad aggregates but allows a closer examination of the contribution of individual industries to group-level Malmquist TFP growth. We make use of this feature by focusing on the high ICT intensity class, which plays a dominant role in Luxembourg's economy and includes several strategically important sectors. Within this group, the financial industries stand out: they account for a substantial share of output and are highly sensitive to international economic cycles. By isolating their contribution, we can better understand the extent to which Luxembourg's productivity trends are shaped by developments in finance.

Figure 6. TFP Growth Decomposition in High-ICT Industries



Note: Bars represent annual growth rate (in %) of (Malmquist) TFP for financial activities and other activities within the high ICT capital intensive class (HICT). TFP is defined as the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Values for year T refer to the growth rate between years T and T-1. Sources: Authors' calculations from STATEC data.

Figure 6 shows that TFP growth in the high ICT intensity group is largely driven—both positively and negatively—by changes in financial industries' productivity. Before 2007, periods of negative growth occurred during the Asian financial crisis of 1997 and the Dot-com bubble of 2000–2002, each followed by a rebound. However, the global financial crisis of 2007–2008 marked a turning point: since then, financial industries have not regained the strong and sustained TFP growth observed before the crisis.

A plausible explanation lies in the way output is measured for financial intermediaries. The CNP 2020–2021 report (2021) highlighted the difficulty of producing reliable productivity indicators for banks. In this sector, output is typically defined as the sum of fees, commissions, dividends, and Financial Intermediation Services Indirectly Measured (FISIM). FISIM represents the margin between interest on loans and deposits with the non-financial sector and the refinancing costs from other financial intermediaries. This measure excludes interest on bonds and derivatives as well as realized capital gains. Chiappini et al. (2024) have recently pointed to several drawbacks of this methodology and proposed alternative approaches to better capture the output of financial intermediaries.

5. Average TFP, efficiency, and technical change by Section

This section presents the average annual TFP growth for the period 1995–2023 across 18 economic sections, in line with the European System of Accounts (2010) framework. In ESA 2010, "sections" refer to the highest-level industry grouping defined in the Statistical Classification of Economic Activities in the European Community, Rev. 2 (NACE Rev. 2), which is the standard EU industry classification system. These sections cover broad areas of economic activity, listed in Table 3. This chapter also presents statistics for the main drivers of TFP changes — namely, efficiency changes and technical changes — within each section. Table 3 reports the NACE Rev. 2 sections, along with their corresponding division ranges and descriptions.

Table 3. Economic sections based on the A21 classification of economic activities

NACE Rev. 2 section	NACE Rev. 2 division	Description
A	01-03	Agriculture, forestry and fishing
B	05-09	Mining and quarrying
C	10-33	Manufacturing
D	35	Electricity, gas, steam and air conditioning supply
E	36-39	Water supply; sewerage, waste management and remediation activities
F	41-43	Construction
G	45-47	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	49-53	Transportation and storage
I	55-56	Accommodation and food service activities
J	58-63	Information and communication
K	64-66	Financial and insurance activities
L	68	Real estate activities
M-N	69-82	Professional, scientific and technical activities, Administrative and support service activities
O	84	Public administration and defense; compulsory social security
P	85	Education
Q	86-88	Human health and social work activities
R	90-93	Arts, entertainment and recreation
S	94-96	Other service activities

Note: *Sections M and N are merged in this report due to statistical disclosure agreement. Sources: European system of accounts ESA 2010.*

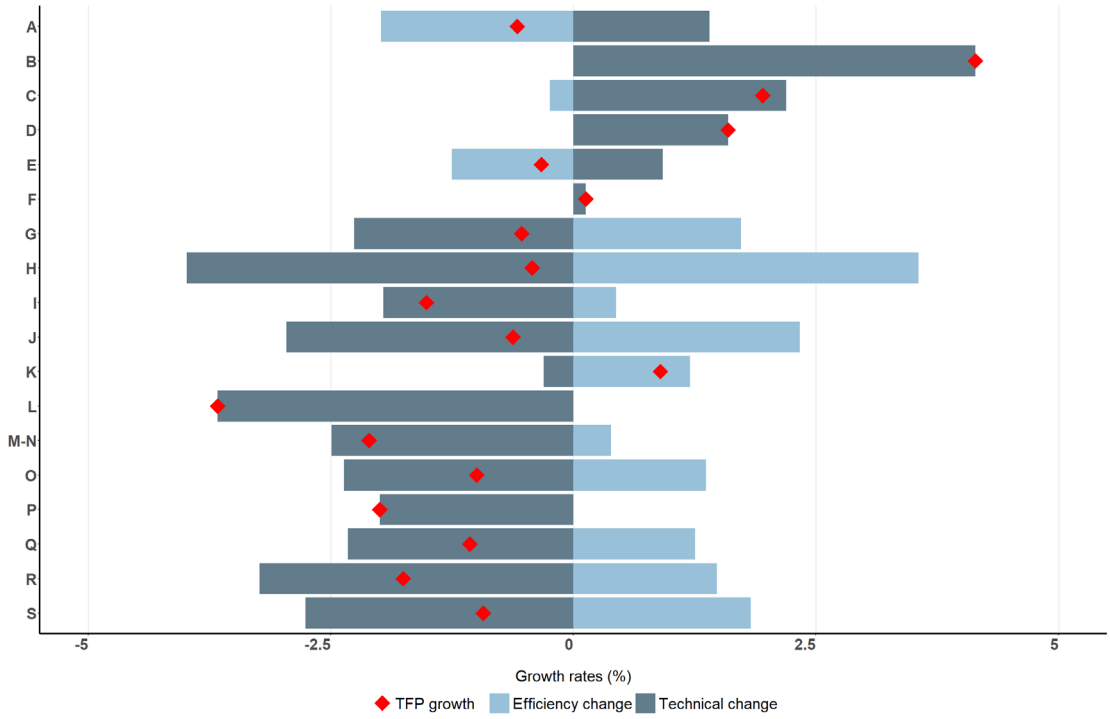
Table 4 and Figure 7 present the average annual growth rates of TFP and its main drivers across the 18 economic sections of the Luxembourg's economy for the period 1995–2023. The results show that TFP growth was weak in most sections. Only mining and quarrying (B), manufacturing (C), and energy supply (D), featured TFP gains driven by technical progress. The remaining activities, primarily service industries, exhibited declining TFP, with negative average growth rates. Real estate activities (L) recorded the lowest average annual TFP growth due to technical regress. Technical and efficiency changes tended to move in opposite directions.

Table 4. Growth rates of TFP and drivers (1996–2023)

NACE Rev. 2 section	TFP growth	Efficiency change	Technical change
A	-0.58	-1.98	1.40
B	4.14	0.00	4.14
C	1.95	-0.24	2.19
D	1.60	0.00	1.60
E	-0.33	-1.25	0.92
F	0.13	0.00	0.13
G	-0.53	1.73	-2.26
H	-0.43	3.56	-3.98
I	-1.51	0.44	-1.96
J	-0.62	2.33	-2.96
K	0.90	1.20	-0.31
L	-3.66	0.00	-3.66
M-N	-2.10	0.39	-2.49
O	-0.99	1.37	-2.36
P	-2.00	0.00	-2.00
Q	-1.07	1.26	-2.32
R	-1.75	1.48	-3.23
S	-0.93	1.83	-2.76

Note: Figures are average yearly growth rates (in %) at section level. or each section, detailed information on the NACE Rev. 2 section code, division range, and description is provided in Table 3. TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Figure 7. Growth rates of TFP and drivers by NACE Rev. 2 section (1996–2023)



Note: Diamonds and bars represent the average yearly growth rate (in %) of, respectively, TFP (diamond) and its drivers: efficiency change (pale blue bar), technical change (grey bar) across sections. TFP is defined as the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

When examining the sources of TFP growth, the results reveal that technical change and efficiency change often move in opposite directions. Efficiency change generally shows positive or zero average annual growth, with a few exceptions—specifically in sections A (Agriculture, forestry, and fishing), C (Manufacturing), and E (Water supply, sewerage, waste management, and remediation activities). The highest efficiency growth is recorded in section H (Transportation and storage), at 3.56%. In contrast, technical change is predominantly negative across the majority of sections, except for sections A to F, where some evidence of positive technical progress appears.

In summary, the analysis shows that sections covering manufacturing industries, i.e. sections A to F, generally featured positive TFP growth, with gains primarily driven by technical progress. In contrast, sections covering service industries, i.e. sections G to S, predominantly exhibited negative TFP growth, mainly driven by technical regress. Technical regress refers to the loss or deterioration of existing technologies, which is a counterintuitive outcome and often difficult to interpret. On this, one can see Amjadi et al. (2020), where authors discuss an explanation based on demand and capacity utilization rates, and references therein.

6. Concluding remarks

This report presents the evolution of total factor productivity (TFP) and its drivers —efficiency change and technical change— in Luxembourg from 1995 to 2023. These indicators are compiled using the latest available data from Luxembourg's National Accounts, released in February 2025.

TFP is measured as the ratio of gross output to a combination of capital, labour, and intermediate consumption. Its growth reflects improvements in productive efficiency and technical change. Efficiency change captures the improvement in the use of inputs, while technical change reflects advances in technology and/or input quality.

For a summary view of productivity dynamics in Luxembourg, this report presents indicators for the total economy and two major industry groups: manufacturing and services. The analysis shows that Luxembourg's service industries have experienced weak TFP growth since the early 2000s, which explains the aggregate modest TFP performance of the country. The data indicate that negative technical change is a source of the slowdown in TFP growth, as efficiency gains are offset by technical regress. In contrast, TFP growth has been positive in manufacturing, where technological advances have sustained productivity performances. At a more detailed level, the analysis shows that mining and quarrying (B), manufacturing (C), and energy supply (D) featured positive TFP growth, with gains primarily driven by technical progress.

This report also compares productivity performance across industries characterised by different levels of information and communication technologies (ICT) capital intensity. Industries are classified into three categories based on the share of gross ICT capital stock (in volume) in total gross capital stock. This classification supports an assessment of whether Luxembourg's industries with higher ICT capital intensity tend to exhibit stronger TFP growth. The analysis by ICT capital intensity revealed two distinct phases in TFP trends over the period 1995–2023. Prior to the Great Recession, HICT industries achieved positive TFP growth, while

MICT industries experienced declines, suggesting that a higher ICT capital intensity was associated with stronger productivity performances. However, in the post-recession period, TFP growth in HICT industries stagnated, and MICT industries showed only modest gains, suggesting that higher ICT capital intensity is no longer linked to higher productivity growth. The decomposition analysis reveals that this stagnation in HICT industries resulted from efficiency and technical changes evolving in opposite directions, offsetting each other and constraining overall productivity growth.

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Appendix

A1. Decomposition of productivity indicators.

In this report, productivity analysis focuses on **total factor productivity (TFP)** and its two main drivers: technical change and efficiency change. Within a production framework, gross output Q_t is generated using inputs such as capital (K), labour (L), and intermediate consumption (M). Assuming a Cobb–Douglas production technology, this can be expressed as:

$$Q_t = A_t K_t^{\alpha} E_t^{\beta} L_t^{1-\alpha-\beta}, \alpha + \beta < 1 \quad (1)$$

where t denotes time (year), Q gross output, A a technology parameter. Capital (K), labour (L), and energy (E) are the inputs to production. Equation (1) suggests that with constant inputs, a rise in output corresponds to an increase in the technology parameter (A), known as total factor productivity (TFP). To distinguish between technological progress and changes in the use of available technology, we follow a stochastic frontier framework (Aigner et al., 1977), in which:

$$Q_t = \underbrace{A_t K_t^{\alpha} E_t^{\beta} L_t^{1-\alpha-\beta}}_{Production\ frontier} \times \underbrace{exp(Ef_t)}_{Efficiency\ term} \quad (2)$$

The first component of this equation represents the technological frontier, which gives the highest achievable output given inputs use and technology. If A_t rises due to technical advancements, this frontier shifts upward, enabling economies to produce more output from the same inputs use, or to maintain output levels with fewer inputs. Yet, not every economic entity optimally performs; some might not obtain their maximum potential output for their given inputs. Such entities, not fully using available technology, are termed inefficient and fall below this frontier, which explains the introduction of the efficiency term. Dividing both sides of equation (2) by hour worked and then taking the log first difference (i.e. dln gives allows us to derive an equation for productivity growth:

$$\underbrace{dln\left(\frac{Q_t}{L_t}\right)}_{Labour\ productivity\ growth} = \underbrace{dln(A_t)}_{Technical\ change} + \overbrace{(Ef_{t+1} - Ef_t)}^{Efficiency\ change} + \underbrace{\alpha \times dln\left(\frac{K_t}{L_t}\right) + \beta \times dln\left(\frac{E_t}{L_t}\right)}_{Input\ deepening} \quad (3)$$

Equation (3) shows that labour productivity growth (based on gross output per hour work) can be decomposed into technical change, efficiency change and input deepening.

A2. Impact of ICT on productivity growth

Information and Communication Technologies (ICT) have profoundly transformed society over the past quarter-century, driving both qualitative and quantitative changes in economic activity (Biagi, 2013). ICT is widely regarded as a General-Purpose Technology (GPT) – a type of innovation that fundamentally reshapes economies and requires complementary changes to unlock its full potential (Bresnahan and Trajtenberg, 1995). GPTs like ICT have several defining features:

- Pervasiveness: they spread across almost all sectors of the economy, becoming widely used in diverse industries.
- Improvement potential: they tend to rapidly evolve and improve over time, increasing in performance and decreasing in cost.
- Innovation complementarities: they enable and necessitate new innovations (in products, processes, and organizations) to maximize their impact.
- Inducement of innovation: by their nature, GPTs induce additional technological and organizational advancements throughout the economy.

In the case of ICT, these characteristics mean that its influence is not confined to the technology sector alone. Initially, ICT adoption can boost productivity within ICT-producing industries (for example, companies manufacturing hardware or developing software). Over time, as ICT tools diffuse, they act as an enabler of product, process, and organizational innovation in ICT-using sectors across the economy (David and Wright, 2003).

Productivity Gains Attributed to ICT

Researchers have tried to quantify how much ICT capital contributes to productivity growth. A common method is growth accounting, which breaks down economic growth into contributions from various inputs (labour, tangible capital, human capital, and ICT capital) and technological progress. This approach asks: how much of the increase in output per worker can be credited to the growth of ICT capital, above and beyond other factors?

Early findings were mixed: In a seminal study, Oliner et al. (1994) found that before 1992, ICT made only a minor contribution to labour productivity growth in the United States.

Late 1990s rapid rise: Between 1995 and 2000, the combination of rapid productivity gains in the ICT-producing sector and heavy investments in ICT equipment by businesses led to a significant acceleration in productivity growth. Estimates suggest that during this period ICT capital deepening (more computers, software, etc. per worker) plus efficiency gains in producing ICT accounted for up to two-thirds of U.S. labour productivity growth (Oliner and Sichel, 2000; Oliner and Sichel, 2002). Jorgenson et al. (2002) reached similar conclusions.

Post-2000 slowdown: After the early 2000s, however, ICT's measured contribution to productivity growth appeared to decline. Jorgenson et al. (2008) noted a drop in the contribution of ICT investment to growth after 2000. Gordon (2012) expressed skepticism about whether ICT would continue to drive long-term productivity gains. While Gordon acknowledged that ICT had powered the U.S. productivity resurgence from about 1995 to 2004, he argued this impact was fading by the mid-2000s.

Europe vs. United States: Van Ark et al. (2008) found that productivity gap between European Union and the U.S. in the late 1990s and early 2000s was partly due to slower growth of ICT capital per worker in Europe.

Beyond Growth Accounting: Searching for Causality

Growth accounting provides useful measures but has a limitation that it does not prove that ICT caused the productivity growth.

To address questions of causality, economists have turned to econometric analyses (statistical regression studies). These studies attempt to isolate the effect of ICT on productivity by controlling for other factors. However, the results from such studies have been mixed and inconclusive. Key findings from the literature include:

Negative or no impact in some analyses: O'Mahony and Vecchi (2005) found a negative relationship between ICT investment and productivity growth. Similarly, McMorrow et al. (2010) concluded there was likely no measurable link between ICT and productivity growth in their analysis. These results suggest that simply spending on computers and software does not guarantee productivity improvements.

Positive impact in others: Other studies do find a positive link between ICT and growth under certain conditions. Venturini (2009) reported a positive link between ICT and productivity for the United States, but no significant relationship for most European countries. Biagi (2005) found a positive association between ICT investment and productivity growth in both European countries and the U.S.

Mixed evidence at industry level: When zooming in to the industry level, evidence still varies. Basu and Fernald (2007) identified a positive correlation between ICT and productivity. In contrast, Inklaar et al. (2005) found a negative correlation. The divergent findings across studies underscore that the impact of ICT may depend on context, measurement, and complementary factors.

Why would some studies fail to find a positive effect, or even find a negative relationship? Part of the answer may lie in what else is happening alongside ICT investment.

The Importance of Complementary Investments and Conditions

One explanation for the weak or negative findings in some country-level studies is that ICT capital still represents a relatively small share of total capital in many economies. As Biagi (2013) argues, if ICT makes up only a small fraction of an economy's capital stock, then even substantial improvements in ICT might be hard to detect in aggregate productivity statistics. Its effects may be masked by productivity gains from non-ICT capital deepening.

Another crucial insight is that ICT does not generate productivity gains in isolation. The technology often requires significant complementary investments and changes within firms and industries to have an effect. Brynjolfsson and Hitt (1995) were early to emphasize that along with buying hardware and software, companies need to invest in organizational changes, process innovations, and human capital (skills and training) to fully leverage ICT.

There is also the factor of spillover effects. ICT adoption by one firm can benefit other firms (for instance, through network effects or learning from each other), meaning the full returns to ICT might not show up entirely within the investing firm's productivity measures. Van Leeuwen and van der Wiel (2003) suggest that if studies do not control for these spillovers and network externalities within industries, they might underestimate ICT's true impact. For example, if one company's use of a new ICT platform forces its suppliers and customers to also adopt more efficient digital processes, the productivity gains may spread across the industry, not just in the original company.

Because of these issues, recent research often looks at micro-level data (firm-level) to get a clearer picture. Firm-level studies can match ICT investments with outcomes while accounting for differences in management, skills, and innovation practices among firms. These studies have generally been more optimistic about ICT's benefits:

Van Ark et al. (2002) found evidence of positive ICT spillovers at the firm level in the U.S. – firms appeared to benefit not only from their own ICT investments but also from the overall ICT usage in their industry. Interestingly, they did not find similar spillover benefits in European firms.

An example of complementary investment is organizational change. Studies like Barrett et al. (2006) highlight that without reorganizing business processes or management structures, simply introducing new technology may not improve productivity. For instance, a government office that installs new computers and software will only see gains if it also updates its procedures and trains staff to use these tools effectively.

Conclusion: ICT's Role in Productivity – U.S. vs Europe

In summary, ICT played a major role in boosting U.S. productivity in the late 1990s and early 2000s, particularly in ICT-producing and ICT-intensive sectors. Its impact has since declined. In Europe, the evidence is less conclusive.

Table A1. Total economy: TFP growth and drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-4.27	8.14	-12.41
1997	-1.64	4.42	-6.06
1998	4.09	4.26	-0.17
1999	2.71	0.32	2.39
2000	3.34	4.27	-0.92
2001	-1.46	1.16	-2.62
2002	-1.59	0.68	-2.26
2003	-0.01	-0.77	0.77
2004	0.73	0.85	-0.12
2005	1.19	0.19	1.00
2006	3.55	1.79	1.76
2007	1.71	-0.08	1.80
2008	-1.85	1.95	-3.80
2009	-1.88	-0.21	-1.66
2010	2.96	-0.24	3.20
2011	-0.21	0.21	-0.43
2012	-1.24	-0.13	-1.11
2013	0.49	-0.45	0.94
2014	-0.38	1.23	-1.62
2015	2.19	-0.52	2.71
2016	1.54	2.08	-0.54
2017	0.73	-0.13	0.86
2018	-0.16	-0.63	0.47
2019	-0.27	0.20	-0.47
2020	-0.75	-0.58	-0.16
2021	0.63	-1.11	1.75
2022	-1.60	0.22	-1.82
2023	-1.29	0.30	-1.59
Average	0.26	0.98	-0.72

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Sources: Authors' calculations from STATEC data.

Table A2. Services: TFP growth and drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-4.83	11.08	-15.91
1997	-2.85	5.72	-8.57
1998	4.69	5.63	-0.94
1999	3.28	0.92	2.36
2000	3.91	5.50	-1.59
2001	-1.36	1.52	-2.88
2002	-2.21	0.65	-2.85
2003	-0.12	-0.77	0.65
2004	0.60	1.02	-0.42
2005	1.56	0.48	1.07
2006	4.26	2.15	2.12
2007	1.46	-0.02	1.49
2008	-1.56	2.24	-3.80
2009	-1.41	-0.09	-1.32
2010	1.84	-0.46	2.30
2011	-0.53	0.23	-0.76
2012	-1.26	-0.09	-1.17
2013	0.59	-0.39	0.98
2014	-0.59	1.48	-2.07
2015	0.85	-0.66	1.51
2016	1.16	2.50	-1.33
2017	0.68	-0.06	0.74
2018	-0.38	-0.61	0.23
2019	-0.72	0.33	-1.05
2020	-0.65	-0.52	-0.14
2021	0.89	-1.08	1.96
2022	-1.40	0.53	-1.93
2023	-1.97	0.16	-2.13
Average	0.14	1.34	-1.19

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Sources: Authors' calculations from STATEC data.

Table A3. Manufacturing: TFP growth and drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-0.28	0.05	-0.33
1997	3.01	0.01	3.00
1998	3.13	0.41	2.72
1999	2.31	0.00	2.31
2000	2.02	0.00	2.03
2001	-1.17	0.16	-1.33
2002	1.36	0.63	0.73
2003	0.88	-0.48	1.36
2004	1.66	0.19	1.48
2005	0.27	-0.32	0.59
2006	-0.06	0.34	-0.39
2007	3.32	-0.43	3.75
2008	-3.65	0.12	-3.78
2009	-3.91	-0.17	-3.74
2010	8.48	0.03	8.45
2011	1.45	-0.10	1.54
2012	-0.62	0.11	-0.74
2013	0.40	-0.32	0.72
2014	1.33	-0.10	1.43
2015	9.97	-0.30	10.27
2016	3.59	-0.72	4.31
2017	0.99	-0.58	1.56
2018	1.24	-0.68	1.92
2019	2.58	-0.56	3.14
2020	-0.89	-0.71	-0.17
2021	-1.10	-1.31	0.21
2022	-3.02	-2.01	-1.01
2023	3.82	1.32	2.50
Average	1.33	-0.19	1.52

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Sources: Authors' calculations from STATEC data.

Table A4. Low-ICT: TFP growth and drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-8.83	-5.43	-3.40
1997	-2.45	4.48	-6.93
1998	3.16	7.34	-4.18
1999	-0.78	1.96	-2.74
2000	-4.40	-4.70	0.29
2001	-1.05	1.75	-2.81
2002	-4.54	5.64	-10.18
2003	-3.51	-2.70	-0.81
2004	0.96	5.20	-4.23
2005	-1.15	-5.81	4.66
2006	2.82	5.29	-2.47
2007	-2.69	-1.49	-1.20
2008	-7.06	1.71	-8.78
2009	-6.44	2.85	-9.29
2010	-0.39	1.78	-2.17
2011	-1.68	-2.30	0.62
2012	-1.68	3.33	-5.02
2013	4.09	-2.61	6.69
2014	2.79	2.66	0.13
2015	-1.46	0.80	-2.26
2016	-0.64	-1.58	0.93
2017	-0.60	-4.13	3.53
2018	0.61	0.96	-0.34
2019	-1.27	0.55	-1.83
2020	2.54	1.74	0.80
2021	-0.65	-0.14	-0.51
2022	1.80	-0.99	2.80
2023	-0.95	-5.43	4.48
Average	-8.83	-5.43	-3.40

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Sources: Authors' calculations from STATEC data.

Table A5. Medium-ICT: TFP growth and drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-5.24	7.89	-13.13
1997	-0.56	2.26	-2.82
1998	1.40	2.17	-0.78
1999	-1.85	-0.36	-1.49
2000	1.28	2.19	-0.90
2001	-2.03	1.65	-3.67
2002	-1.86	0.45	-2.31
2003	-2.48	-0.74	-1.74
2004	-1.06	0.04	-1.10
2005	-1.80	0.31	-2.12
2006	-0.76	0.10	-0.86
2007	1.89	0.00	1.90
2008	-1.53	2.76	-4.29
2009	-3.86	0.10	-3.96
2010	6.69	3.17	3.52
2011	2.13	2.11	0.02
2012	-2.17	-0.53	-1.64
2013	0.28	-0.07	0.35
2014	-2.06	0.20	-2.25
2015	4.30	-0.32	4.63
2016	4.46	3.24	1.22
2017	1.32	0.50	0.82
2018	-0.06	-1.80	1.74
2019	0.13	-0.22	0.35
2020	-1.88	-1.22	-0.66
2021	1.48	-0.99	2.47
2022	-1.91	-3.35	1.44
2023	2.38	1.02	1.35
Average	-5.24	7.89	-13.13

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Sources: Authors' calculations from STATEC data.

Table A6. High-ICT: TFP growth and drivers (1996–2023)

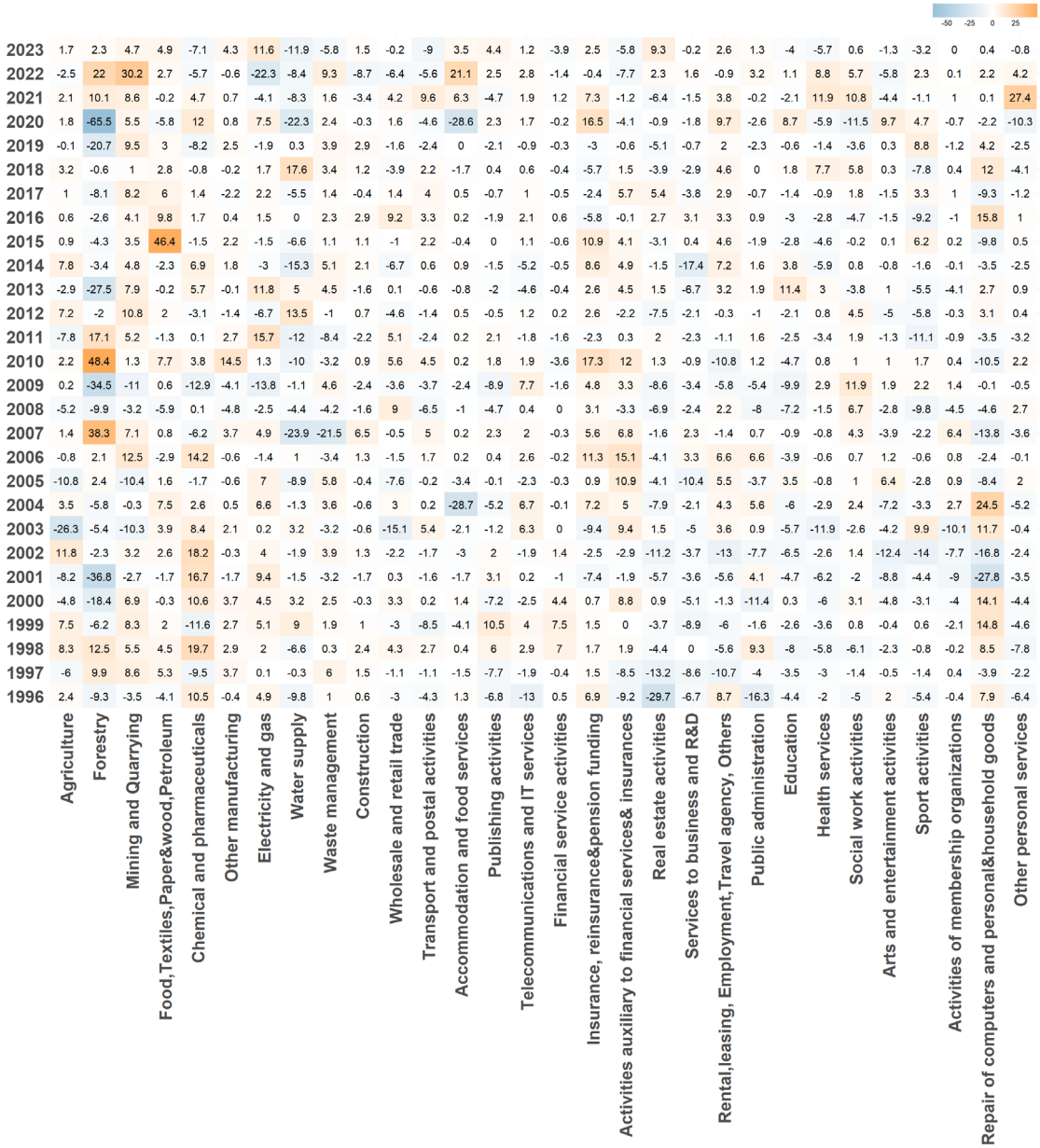
Year	TFP	Efficiency change	Technical change
1996	-2.62	10.80	-13.42
1997	-2.63	5.96	-8.59
1998	5.66	4.83	0.84
1999	5.25	-0.20	5.44
2000	4.63	5.84	-1.20
2001	-1.46	0.57	-2.03
2002	-0.94	0.50	-1.43
2003	1.49	-0.77	2.26
2004	1.37	0.58	0.79
2005	2.35	0.21	2.14
2006	4.95	1.77	3.19
2007	1.96	-0.03	1.98
2008	-1.18	1.99	-3.18
2009	-0.55	-0.55	0.00
2010	1.56	-1.88	3.44
2011	-1.21	-0.45	-0.76
2012	-0.67	-0.16	-0.51
2013	0.27	-0.53	0.80
2014	0.08	1.51	-1.43
2015	1.28	-0.85	2.14
2016	0.31	1.78	-1.47
2017	0.54	-0.17	0.71
2018	-0.29	-0.26	-0.03
2019	-0.42	0.30	-0.72
2020	-0.60	-0.61	0.01
2021	0.29	-1.35	1.64
2022	-1.64	1.58	-3.22
2023	-2.51	0.49	-2.99
Average	-2.62	10.80	-13.42

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Sources: Authors' calculations from STATEC data.

A3. Industry-level statistics over time

In this part of the Appendix, we present summary statistics for total factor productivity (TFP) and its drivers—efficiency change and technical change—for 30 individual industries in Luxembourg over the period 1995 to 2023. Two complementary formats are used: heatmaps and tables. The heatmaps provide a visual representation of the statistics, allowing for quick identification of patterns, trends, and divergences across industries in an accessible and intuitive way. Figures A1-A3 display heatmaps for the different productivity indicators, followed by 30 detailed tables, each corresponding to one of the industries analysed.

Figure A1. Total factor productivity growth by industry and year (1996–2023)

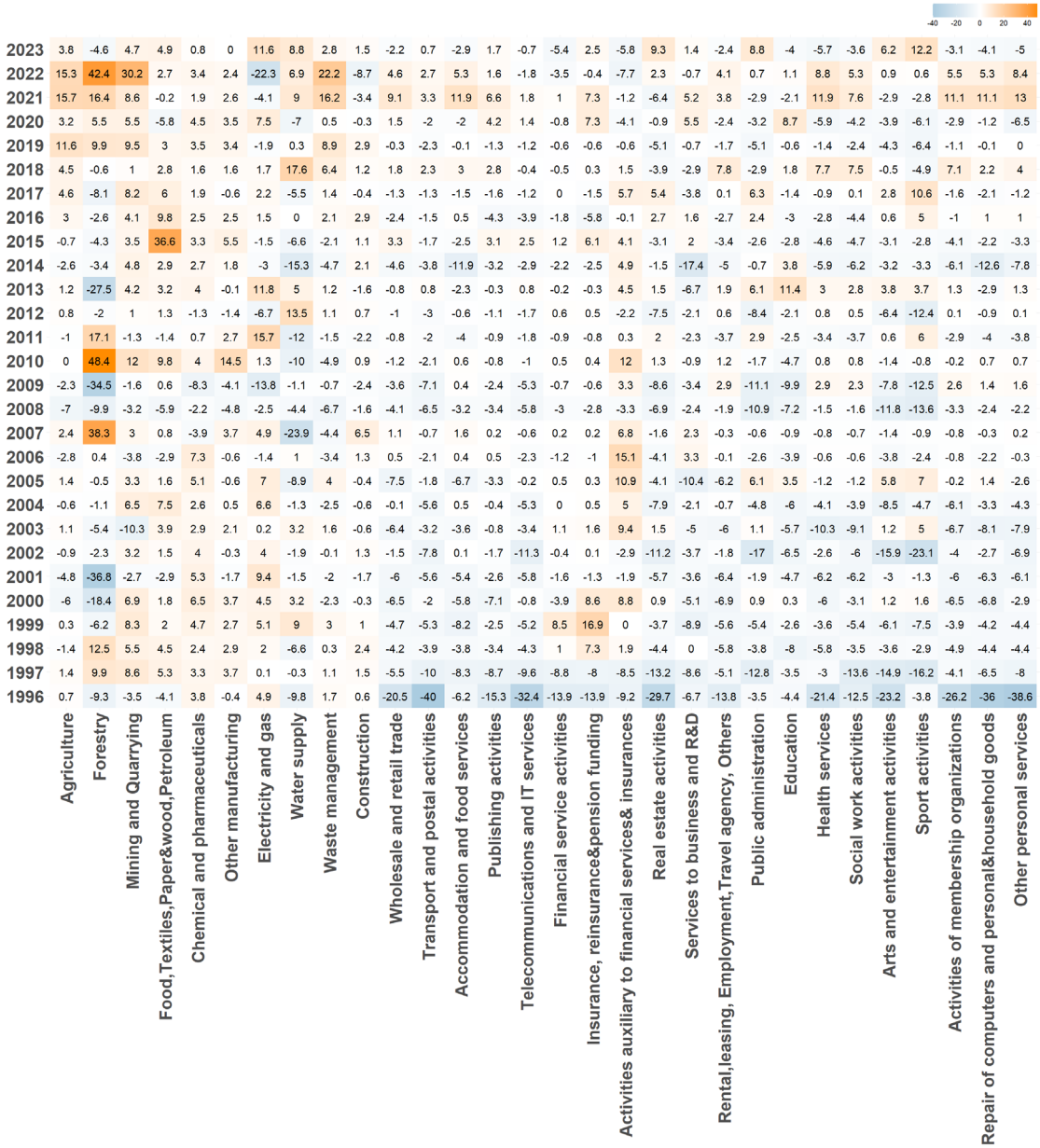


Note: This heatmap illustrates the annual growth rates (%) of TFP by industry. TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption Blue represents a decline (negative growth rates), while orange denotes an increase (positive growth rates). The intensity of the colour corresponds to the extent of growth or decline. Sources: Authors' calculations from STATEC data.

Figure A2. Efficiency change by industry and year (1996–2023)

Note: This heatmap illustrates the annual percentage change in efficiency by industry. Efficiency change indicates improvement of input use during production. Blue represents a decline (negative growth rates), while orange denotes an increase (positive growth rates). The intensity of the colour corresponds to the extent of growth or decline. Sources: Authors' calculations from STATEC data.

Figure A3. Technical change by industry and year (1996–2023)



Note: This heatmap illustrates the annual percentage change in technical progress by industry. Technical change captures improvements in production technology and input quality. Blue represents a decline (negative growth rates), while orange denotes an increase (positive growth rates). The intensity of the colour corresponds to the extent of growth or decline. Sources: Authors' calculations from STATEC data.

Table A7. Agriculture
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	2.37	1.66	0.71
1997	-6.03	-7.41	1.38
1998	8.26	9.70	-1.45
1999	7.54	7.27	0.28
2000	-4.81	1.21	-6.02
2001	-8.21	-3.41	-4.79
2002	11.82	12.71	-0.89
2003	-26.30	-27.42	1.12
2004	3.45	4.03	-0.58
2005	-10.85	-12.21	1.36
2006	-0.84	1.97	-2.81
2007	1.45	-0.99	2.44
2008	-5.17	1.87	-7.04
2009	0.21	2.48	-2.26
2010	2.24	2.25	-0.01
2011	-7.83	-6.79	-1.04
2012	7.16	6.32	0.84
2013	-2.92	-4.09	1.17
2014	7.79	10.38	-2.60
2015	0.89	1.59	-0.70
2016	0.59	-2.37	2.96
2017	1.04	-3.53	4.57
2018	3.18	-1.27	4.46
2019	-0.10	-11.65	11.55
2020	1.76	-1.40	3.17
2021	2.13	-13.55	15.68
2022	-2.48	-17.76	15.28
2023	1.69	-2.15	3.84

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A8. Forestry
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-9.30	0.00	-9.30
1997	9.89	0.00	9.89
1998	12.55	0.00	12.55
1999	-6.25	0.00	-6.25
2000	-18.39	0.00	-18.39
2001	-36.82	0.00	-36.82
2002	-2.32	0.00	-2.32
2003	-5.36	0.00	-5.36
2004	-5.80	-4.66	-1.14
2005	2.44	2.95	-0.51
2006	2.14	1.72	0.42
2007	38.29	0.00	38.29
2008	-9.92	0.00	-9.92
2009	-34.49	0.00	-34.49
2010	48.42	0.00	48.42
2011	17.07	0.00	17.07
2012	-2.01	0.00	-2.01
2013	-27.51	0.00	-27.51
2014	-3.41	0.00	-3.41
2015	-4.32	0.00	-4.32
2016	-2.57	0.00	-2.57
2017	-8.15	0.00	-8.15
2018	-0.55	0.00	-0.55
2019	-20.70	-30.55	9.86
2020	-65.50	-71.02	5.52
2021	10.10	-6.26	16.36
2022	21.95	-20.49	42.44
2023	2.30	6.95	-4.65

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A9. Mining and Quarrying
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-3.50	0.00	-3.50
1997	8.61	0.00	8.61
1998	5.47	0.00	5.47
1999	8.29	0.00	8.29
2000	6.87	0.00	6.87
2001	-2.72	0.00	-2.72
2002	3.17	0.00	3.17
2003	-10.33	0.00	-10.33
2004	-0.31	-6.77	6.46
2005	-10.36	-13.68	3.32
2006	12.53	16.37	-3.84
2007	7.11	4.08	3.03
2008	-3.20	0.00	-3.20
2009	-10.96	-9.35	-1.61
2010	1.34	-10.68	12.03
2011	5.19	6.54	-1.35
2012	10.82	9.80	1.01
2013	7.92	3.68	4.23
2014	4.77	0.00	4.77
2015	3.55	0.00	3.55
2016	4.08	0.00	4.08
2017	8.16	0.00	8.16
2018	1.04	0.00	1.04
2019	9.47	0.00	9.47
2020	5.46	0.00	5.46
2021	8.63	0.00	8.63
2022	30.22	0.00	30.22
2023	4.69	0.00	4.69

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A10. Manufacture of food products, textiles, paper and wood products, and petroleum products Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-4.10	0.00	-4.10
1997	5.32	0.00	5.32
1998	4.49	0.00	4.49
1999	2.00	0.00	2.00
2000	-0.32	-2.16	1.84
2001	-1.74	1.12	-2.86
2002	2.58	1.04	1.54
2003	3.93	0.00	3.93
2004	7.49	0.00	7.49
2005	1.60	0.00	1.60
2006	-2.90	0.00	-2.90
2007	0.77	0.00	0.77
2008	-5.88	0.00	-5.88
2009	0.60	0.00	0.60
2010	7.73	-2.02	9.76
2011	-1.35	0.10	-1.45
2012	2.03	0.77	1.26
2013	-0.23	-3.45	3.22
2014	-2.33	-5.19	2.87
2015	46.39	9.80	36.60
2016	9.75	0.00	9.75
2017	5.97	0.00	5.97
2018	2.84	0.00	2.84
2019	3.02	0.00	3.02
2020	-5.77	0.00	-5.77
2021	-0.18	0.00	-0.18
2022	2.71	0.00	2.71
2023	4.89	0.00	4.89

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A11. Manufacture of chemical and pharmaceuticals products
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	10.54	6.78	3.76
1997	-9.51	-12.80	3.29
1998	19.74	17.33	2.40
1999	-11.57	-16.27	4.70
2000	10.55	4.09	6.46
2001	16.72	11.46	5.26
2002	18.17	14.14	4.03
2003	8.39	5.53	2.86
2004	2.60	0.00	2.60
2005	-1.75	-6.89	5.14
2006	14.18	6.89	7.29
2007	-6.23	-2.30	-3.92
2008	0.10	2.30	-2.20
2009	-12.90	-4.57	-8.33
2010	3.78	-0.18	3.95
2011	0.09	-0.60	0.69
2012	-3.14	-1.89	-1.25
2013	5.72	1.68	4.04
2014	6.95	4.23	2.71
2015	-1.55	-4.90	3.35
2016	1.70	-0.79	2.49
2017	1.45	-0.49	1.94
2018	-0.75	-2.35	1.59
2019	-8.21	-11.70	3.49
2020	12.03	7.55	4.48
2021	4.74	2.82	1.92
2022	-5.68	-9.08	3.39
2023	-7.14	-7.92	0.77

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A12. Other manufacturing industries
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-0.43	0.00	-0.43
1997	3.65	0.00	3.65
1998	2.92	0.00	2.92
1999	2.74	0.00	2.74
2000	3.67	0.00	3.67
2001	-1.75	0.00	-1.75
2002	-0.26	0.00	-0.26
2003	2.11	0.00	2.11
2004	0.54	0.00	0.54
2005	-0.60	0.00	-0.60
2006	-0.64	0.00	-0.64
2007	3.66	0.00	3.66
2008	-4.78	0.00	-4.78
2009	-4.13	0.00	-4.13
2010	14.46	0.00	14.46
2011	2.74	0.00	2.74
2012	-1.43	0.00	-1.43
2013	-0.12	0.00	-0.12
2014	1.82	0.00	1.82
2015	2.19	-3.31	5.50
2016	0.35	-2.17	2.52
2017	-2.23	-1.67	-0.56
2018	-0.18	-1.75	1.58
2019	2.45	-0.91	3.37
2020	0.81	-2.74	3.55
2021	0.66	-1.97	2.62
2022	-0.63	-3.07	2.44
2023	4.30	4.32	-0.02

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A13. Electricity and gas
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	4.86	0.00	4.86
1997	0.08	0.00	0.08
1998	2.04	0.00	2.04
1999	5.07	0.00	5.07
2000	4.47	0.00	4.47
2001	9.41	0.00	9.41
2002	4.00	0.00	4.00
2003	0.24	0.00	0.24
2004	6.60	0.00	6.60
2005	7.05	0.00	7.05
2006	-1.44	0.00	-1.44
2007	4.95	0.00	4.95
2008	-2.54	0.00	-2.54
2009	-13.77	0.00	-13.77
2010	1.26	0.00	1.26
2011	15.69	0.00	15.69
2012	-6.72	0.00	-6.72
2013	11.82	0.00	11.82
2014	-3.04	0.00	-3.04
2015	-1.48	0.00	-1.48
2016	1.46	0.00	1.46
2017	2.21	0.00	2.21
2018	1.66	0.00	1.66
2019	-1.85	0.00	-1.85
2020	7.47	0.00	7.47
2021	-4.06	0.00	-4.06
2022	-22.31	0.00	-22.31
2023	11.59	0.00	11.59

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A14. Water supply
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-9.76	0.00	-9.76
1997	-0.27	0.00	-0.27
1998	-6.58	0.00	-6.58
1999	8.98	0.00	8.98
2000	3.16	0.00	3.16
2001	-1.46	0.00	-1.46
2002	-1.93	0.00	-1.93
2003	3.24	0.00	3.24
2004	-1.33	0.00	-1.33
2005	-8.93	0.00	-8.93
2006	0.97	0.00	0.97
2007	-23.88	0.00	-23.88
2008	-4.42	0.00	-4.42
2009	-1.07	0.00	-1.07
2010	-9.98	0.00	-9.98
2011	-12.00	0.00	-12.00
2012	13.49	0.00	13.49
2013	5.01	0.00	5.01
2014	-15.35	0.00	-15.35
2015	-6.60	0.00	-6.60
2016	0.04	0.00	0.04
2017	-5.46	0.00	-5.46
2018	17.57	0.00	17.57
2019	0.34	0.00	0.34
2020	-22.33	-15.34	-6.99
2021	-8.30	-17.35	9.05
2022	-8.43	-15.36	6.93
2023	-11.91	-20.70	8.79

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A15. Waste management
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	0.99	-0.69	1.67
1997	5.99	4.86	1.13
1998	0.25	0.00	0.25
1999	1.95	-1.04	2.99
2000	2.51	4.78	-2.27
2001	-3.16	-1.15	-2.01
2002	3.94	4.01	-0.07
2003	-3.15	-4.79	1.64
2004	3.59	6.11	-2.52
2005	5.84	1.79	4.05
2006	-3.40	0.00	-3.40
2007	-21.54	-17.18	-4.37
2008	-4.18	2.53	-6.70
2009	4.56	5.29	-0.73
2010	-3.23	1.70	-4.93
2011	-8.37	-6.86	-1.52
2012	-0.98	-2.07	1.09
2013	4.47	3.29	1.18
2014	5.13	9.86	-4.73
2015	1.14	3.28	-2.14
2016	2.25	0.17	2.08
2017	1.36	0.00	1.36
2018	3.40	-3.02	6.41
2019	3.86	-5.07	8.92
2020	2.35	1.90	0.45
2021	1.58	-14.59	16.17
2022	9.26	-12.95	22.21
2023	-5.83	-8.61	2.79

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A16. Construction
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	0.58	0.00	0.58
1997	1.49	0.00	1.49
1998	2.44	0.00	2.44
1999	1.01	0.00	1.01
2000	-0.28	0.00	-0.28
2001	-1.72	0.00	-1.72
2002	1.33	0.00	1.33
2003	-0.61	0.00	-0.61
2004	-0.65	0.00	-0.65
2005	-0.41	0.00	-0.41
2006	1.33	0.00	1.33
2007	6.50	0.00	6.50
2008	-1.61	0.00	-1.61
2009	-2.42	0.00	-2.42
2010	0.89	0.00	0.89
2011	-2.21	0.00	-2.21
2012	0.73	0.00	0.73
2013	-1.58	0.00	-1.58
2014	2.13	0.00	2.13
2015	1.05	0.00	1.05
2016	2.90	0.00	2.90
2017	-0.45	0.00	-0.45
2018	1.19	0.00	1.19
2019	2.88	0.00	2.88
2020	-0.33	0.00	-0.33
2021	-3.36	0.00	-3.36
2022	-8.71	0.00	-8.71
2023	1.52	0.00	1.52

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A17. Wholesale and retail trade
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-3.04	17.45	-20.49
1997	-1.12	4.34	-5.46
1998	4.32	8.49	-4.17
1999	-2.97	1.78	-4.75
2000	3.27	9.74	-6.47
2001	0.26	6.22	-5.95
2002	-2.23	-0.69	-1.54
2003	-15.08	-8.64	-6.44
2004	3.03	3.10	-0.07
2005	-7.64	-0.14	-7.50
2006	-1.53	-2.02	0.49
2007	-0.47	-1.53	1.06
2008	8.99	13.11	-4.12
2009	-3.60	-0.05	-3.55
2010	5.57	6.76	-1.19
2011	5.10	5.95	-0.85
2012	-4.62	-3.59	-1.03
2013	0.10	0.90	-0.80
2014	-6.67	-2.11	-4.56
2015	-0.95	-4.21	3.25
2016	9.21	11.59	-2.38
2017	1.41	2.73	-1.32
2018	-3.94	-5.78	1.84
2019	-1.55	-1.29	-0.26
2020	1.60	0.12	1.47
2021	4.24	-4.87	9.10
2022	-6.40	-10.96	4.56
2023	-0.19	1.97	-2.16

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A18. Transport and postal activities
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-4.33	35.69	-40.01
1997	-1.06	8.90	-9.96
1998	2.73	6.65	-3.92
1999	-8.48	-3.17	-5.31
2000	0.23	2.19	-1.96
2001	-1.57	4.07	-5.64
2002	-1.74	6.03	-7.77
2003	5.38	8.55	-3.17
2004	0.24	5.84	-5.60
2005	-0.16	1.64	-1.79
2006	1.66	3.77	-2.12
2007	5.03	5.76	-0.73
2008	-6.54	-0.03	-6.51
2009	-3.73	3.37	-7.09
2010	4.50	6.62	-2.12
2011	-2.42	-0.39	-2.03
2012	-1.42	1.62	-3.04
2013	-0.59	-1.41	0.83
2014	0.59	4.40	-3.82
2015	2.21	3.90	-1.69
2016	3.31	4.78	-1.48
2017	4.00	5.33	-1.33
2018	2.21	-0.08	2.29
2019	-2.41	-0.13	-2.28
2020	-4.60	-2.62	-1.97
2021	9.62	6.31	3.31
2022	-5.61	-8.27	2.67
2023	-8.96	-9.66	0.71

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A19. **Accommodation and food service activities**
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	1.32	7.51	-6.20
1997	-1.47	6.79	-8.26
1998	0.44	4.20	-3.76
1999	-4.09	4.07	-8.16
2000	1.38	7.18	-5.80
2001	-1.69	3.72	-5.40
2002	-3.02	-3.07	0.06
2003	-2.07	1.51	-3.59
2004	-28.70	-29.20	0.50
2005	-3.42	3.23	-6.65
2006	0.22	-0.20	0.42
2007	0.17	-1.47	1.64
2008	-0.98	2.25	-3.23
2009	-2.42	-2.79	0.37
2010	0.22	-0.38	0.60
2011	0.16	4.18	-4.02
2012	0.45	1.08	-0.63
2013	-0.79	1.51	-2.30
2014	0.94	12.87	-11.93
2015	-0.40	2.13	-2.52
2016	0.24	-0.22	0.46
2017	0.46	1.99	-1.53
2018	-1.70	-4.66	2.96
2019	-0.02	0.10	-0.12
2020	-28.60	-26.59	-2.01
2021	6.34	-5.52	11.86
2022	21.12	15.80	5.32
2023	3.54	6.39	-2.85

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A20. Publishing activities
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-6.83	8.44	-15.27
1997	-7.70	1.02	-8.72
1998	6.00	9.37	-3.37
1999	10.53	13.05	-2.52
2000	-7.17	-0.05	-7.12
2001	3.06	5.69	-2.62
2002	2.04	3.75	-1.71
2003	-1.17	-0.35	-0.82
2004	-5.20	-4.79	-0.41
2005	-0.13	3.13	-3.25
2006	0.37	-0.10	0.48
2007	2.31	2.11	0.19
2008	-4.68	-1.24	-3.44
2009	-8.89	-6.47	-2.41
2010	1.84	2.59	-0.75
2011	2.13	3.06	-0.93
2012	-0.47	0.60	-1.07
2013	-2.05	-1.74	-0.30
2014	-1.47	1.77	-3.24
2015	0.04	-3.03	3.07
2016	-1.91	2.35	-4.27
2017	-0.71	0.90	-1.61
2018	0.41	-2.36	2.76
2019	-2.05	-0.75	-1.30
2020	2.30	-1.91	4.21
2021	-4.68	-11.25	6.56
2022	2.48	0.84	1.64
2023	4.39	2.68	1.71

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A21. Telecommunications and IT services
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-12.97	19.45	-32.42
1997	-1.86	7.77	-9.63
1998	2.89	7.16	-4.27
1999	3.96	9.14	-5.18
2000	-2.45	-1.63	-0.83
2001	0.19	5.95	-5.76
2002	-1.91	9.39	-11.30
2003	6.26	9.63	-3.37
2004	6.74	12.05	-5.30
2005	-2.32	-2.08	-0.24
2006	2.56	4.91	-2.34
2007	1.99	2.56	-0.58
2008	0.40	6.19	-5.78
2009	7.66	12.93	-5.27
2010	1.89	2.92	-1.03
2011	-1.78	-0.01	-1.77
2012	1.23	2.95	-1.72
2013	-4.61	-5.39	0.78
2014	-5.24	-2.37	-2.88
2015	1.10	-1.40	2.50
2016	2.10	6.05	-3.94
2017	0.96	2.18	-1.22
2018	0.57	0.94	-0.37
2019	-0.88	0.30	-1.18
2020	1.65	0.25	1.40
2021	1.88	0.12	1.76
2022	2.84	4.62	-1.78
2023	1.22	1.92	-0.70

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A22. Financial service activities
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	0.52	14.45	-13.93
1997	-0.40	8.36	-8.77
1998	7.04	6.04	1.00
1999	7.53	-0.92	8.45
2000	4.37	8.22	-3.85
2001	-1.00	0.63	-1.63
2002	1.42	1.85	-0.42
2003	0.02	-1.10	1.12
2004	-0.10	-0.07	-0.03
2005	-0.29	-0.75	0.45
2006	-0.16	1.01	-1.16
2007	-0.32	-0.49	0.16
2008	0.03	3.01	-2.98
2009	-1.63	-0.97	-0.66
2010	-3.59	-4.07	0.47
2011	-1.65	-0.79	-0.85
2012	0.21	-0.39	0.60
2013	-0.39	-0.24	-0.15
2014	-0.55	1.62	-2.16
2015	-0.65	-1.85	1.20
2016	0.58	2.37	-1.80
2017	-0.45	-0.46	0.00
2018	-0.39	0.11	-0.50
2019	-0.29	0.29	-0.58
2020	-0.18	0.61	-0.79
2021	1.19	0.21	0.98
2022	-1.41	2.10	-3.51
2023	-3.91	1.47	-5.38

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A23. Insurance, reinsurance and pension funding
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	6.90	20.78	-13.88
1997	1.53	9.57	-8.03
1998	1.73	-5.59	7.33
1999	1.54	-15.39	16.93
2000	0.72	-7.91	8.63
2001	-7.37	-6.03	-1.34
2002	-2.52	-2.64	0.12
2003	-9.42	-11.04	1.62
2004	7.23	6.68	0.55
2005	0.87	0.55	0.32
2006	11.27	12.24	-0.97
2007	5.61	5.42	0.19
2008	3.06	5.84	-2.78
2009	4.77	5.41	-0.64
2010	17.31	16.93	0.38
2011	-2.26	-1.45	-0.80
2012	2.58	2.11	0.47
2013	2.62	2.91	-0.29
2014	8.56	11.02	-2.46
2015	10.94	4.82	6.12
2016	-5.82	0.00	-5.82
2017	-2.37	-0.86	-1.51
2018	-5.68	-5.97	0.29
2019	-3.02	-2.39	-0.63
2020	16.55	9.21	7.33
2021	7.32	0.00	7.32
2022	-0.42	0.00	-0.42
2023	2.48	0.00	2.48

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A24. Activities auxiliary to financial services and insurance activities
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-9.16	0.00	-9.16
1997	-8.53	0.00	-8.53
1998	1.91	0.00	1.91
1999	0.00	0.00	0.00
2000	8.79	0.00	8.79
2001	-1.87	0.00	-1.87
2002	-2.88	0.00	-2.88
2003	9.42	0.00	9.42
2004	4.96	0.00	4.96
2005	10.85	0.00	10.85
2006	15.12	0.00	15.12
2007	6.83	0.00	6.83
2008	-3.28	0.00	-3.28
2009	3.35	0.00	3.35
2010	12.00	0.00	12.00
2011	0.32	0.00	0.32
2012	-2.22	0.00	-2.22
2013	4.51	0.00	4.51
2014	4.94	0.00	4.94
2015	4.11	0.00	4.11
2016	-0.15	0.00	-0.15
2017	5.66	0.00	5.66
2018	1.55	0.00	1.55
2019	-0.56	0.00	-0.56
2020	-4.05	0.00	-4.05
2021	-1.25	0.00	-1.25
2022	-7.74	0.00	-7.74
2023	-5.81	0.00	-5.81

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A25. Real estate activities
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-29.74	0.00	-29.74
1997	-13.15	0.00	-13.15
1998	-4.41	0.00	-4.41
1999	-3.74	0.00	-3.74
2000	0.87	0.00	0.87
2001	-5.73	0.00	-5.73
2002	-11.18	0.00	-11.18
2003	1.45	0.00	1.45
2004	-7.88	0.00	-7.88
2005	-4.08	0.00	-4.08
2006	-4.07	0.00	-4.07
2007	-1.63	0.00	-1.63
2008	-6.89	0.00	-6.89
2009	-8.64	0.00	-8.64
2010	1.31	0.00	1.31
2011	2.00	0.00	2.00
2012	-7.47	0.00	-7.47
2013	1.54	0.00	1.54
2014	-1.47	0.00	-1.47
2015	-3.10	0.00	-3.10
2016	2.69	0.00	2.69
2017	5.44	0.00	5.44
2018	-3.94	0.00	-3.94
2019	-5.13	0.00	-5.13
2020	-0.85	0.00	-0.85
2021	-6.40	0.00	-6.40
2022	2.25	0.00	2.25
2023	9.32	0.00	9.32

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A26. Services to business and research and development
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-6.68	0.00	-6.68
1997	-8.58	0.00	-8.58
1998	-0.02	0.00	-0.02
1999	-8.94	0.00	-8.94
2000	-5.05	0.00	-5.05
2001	-3.61	0.00	-3.61
2002	-3.70	0.00	-3.70
2003	-4.98	0.00	-4.98
2004	-2.06	0.00	-2.06
2005	-10.45	0.00	-10.45
2006	3.26	0.00	3.26
2007	2.29	0.00	2.29
2008	-2.43	0.00	-2.43
2009	-3.42	0.00	-3.42
2010	-0.86	0.00	-0.86
2011	-2.32	0.00	-2.32
2012	-2.15	0.00	-2.15
2013	-6.67	0.00	-6.67
2014	-17.35	0.00	-17.35
2015	0.42	-1.53	1.95
2016	3.09	1.53	1.56
2017	-3.75	0.00	-3.75
2018	-2.86	0.00	-2.86
2019	-0.68	0.00	-0.68
2020	-1.79	-7.26	5.47
2021	-1.54	-6.72	5.18
2022	1.58	2.31	-0.72
2023	-0.19	-1.62	1.43

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A27. Rental and leasing activities, Employment activities, Travel agency and other business support activities, Other professional activities
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	8.70	22.54	-13.83
1997	-10.68	-5.63	-5.06
1998	-5.63	0.20	-5.83
1999	-5.95	-0.38	-5.57
2000	-1.26	5.63	-6.89
2001	-5.59	0.76	-6.35
2002	-12.96	-11.15	-1.81
2003	3.59	9.56	-5.97
2004	4.26	4.93	-0.67
2005	5.45	11.63	-6.18
2006	6.61	6.71	-0.11
2007	-1.42	-1.12	-0.31
2008	2.19	4.10	-1.91
2009	-5.77	-8.69	2.92
2010	-10.82	-12.00	1.19
2011	-1.11	2.56	-3.67
2012	-0.30	-0.92	0.62
2013	3.18	1.26	1.92
2014	7.24	12.21	-4.97
2015	4.61	8.00	-3.39
2016	3.30	5.97	-2.66
2017	2.86	2.73	0.13
2018	4.57	-3.23	7.80
2019	2.02	3.73	-1.72
2020	9.74	12.10	-2.36
2021	3.82	0.00	3.82
2022	-0.91	-5.02	4.12
2023	2.62	5.02	-2.41

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A28. Public administration
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-16.33	-12.81	-3.52
1997	-4.04	8.71	-12.75
1998	9.34	13.12	-3.77
1999	-1.60	3.81	-5.41
2000	-11.43	-12.35	0.92
2001	4.14	6.07	-1.93
2002	-7.66	9.32	-16.97
2003	0.90	-0.23	1.13
2004	5.56	10.32	-4.76
2005	-3.69	-9.82	6.14
2006	6.63	9.25	-2.61
2007	0.69	1.27	-0.58
2008	-7.99	2.87	-10.87
2009	-5.37	5.70	-11.07
2010	1.15	2.84	-1.69
2011	1.62	-1.31	2.94
2012	-0.98	7.38	-8.36
2013	1.95	-4.13	6.08
2014	1.65	2.30	-0.66
2015	-1.92	0.64	-2.56
2016	0.89	-1.53	2.42
2017	-0.75	-7.07	6.33
2018	-0.02	2.92	-2.93
2019	-2.33	2.75	-5.08
2020	-2.63	0.55	-3.18
2021	-0.16	2.73	-2.89
2022	3.18	2.50	0.68
2023	1.34	-7.45	8.79

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A29. Education
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-4.35	0.00	-4.35
1997	-3.55	0.00	-3.55
1998	-7.98	0.00	-7.98
1999	-2.64	0.00	-2.64
2000	0.26	0.00	0.26
2001	-4.70	0.00	-4.70
2002	-6.48	0.00	-6.48
2003	-5.74	0.00	-5.74
2004	-6.02	0.00	-6.02
2005	3.47	0.00	3.47
2006	-3.88	0.00	-3.88
2007	-0.85	0.00	-0.85
2008	-7.17	0.00	-7.17
2009	-9.93	0.00	-9.93
2010	-4.69	0.00	-4.69
2011	-2.48	0.00	-2.48
2012	-2.11	0.00	-2.11
2013	11.35	0.00	11.35
2014	3.77	0.00	3.77
2015	-2.84	0.00	-2.84
2016	-2.96	0.00	-2.96
2017	-1.37	0.00	-1.37
2018	1.82	0.00	1.82
2019	-0.62	0.00	-0.62
2020	8.72	0.00	8.72
2021	-2.05	0.00	-2.05
2022	1.13	0.00	1.13
2023	-3.99	0.00	-3.99

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A30. Health services
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-2.01	19.37	-21.38
1997	-2.95	0.00	-2.95
1998	-5.80	0.00	-5.80
1999	-3.58	0.00	-3.58
2000	-5.99	0.00	-5.99
2001	-6.18	0.00	-6.18
2002	-2.61	0.00	-2.61
2003	-11.93	-1.61	-10.32
2004	-2.90	1.24	-4.14
2005	-0.85	0.37	-1.21
2006	-0.64	0.00	-0.64
2007	-0.77	0.00	-0.77
2008	-1.46	0.00	-1.46
2009	2.90	0.00	2.90
2010	0.81	0.00	0.81
2011	-3.39	0.00	-3.39
2012	0.77	0.00	0.77
2013	3.03	0.00	3.03
2014	-5.91	0.00	-5.91
2015	-4.58	0.00	-4.58
2016	-2.81	0.00	-2.81
2017	-0.92	0.00	-0.92
2018	7.71	0.00	7.71
2019	-1.39	0.00	-1.39
2020	-5.91	0.00	-5.91
2021	11.88	0.00	11.88
2022	8.83	0.00	8.83
2023	-5.73	0.00	-5.73

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A31. Social work activities
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-5.02	7.48	-12.49
1997	-1.44	12.20	-13.64
1998	-6.06	-2.54	-3.53
1999	0.80	6.17	-5.37
2000	3.13	6.18	-3.05
2001	-2.02	4.20	-6.21
2002	1.36	7.32	-5.96
2003	-2.64	6.51	-9.14
2004	2.40	6.34	-3.94
2005	0.95	2.14	-1.18
2006	0.70	1.34	-0.64
2007	4.30	5.02	-0.72
2008	6.72	8.34	-1.62
2009	11.86	9.52	2.34
2010	1.05	0.27	0.77
2011	1.93	5.64	-3.71
2012	4.49	3.95	0.54
2013	-3.79	-6.64	2.85
2014	0.79	7.03	-6.24
2015	-0.24	4.47	-4.71
2016	-4.67	-0.28	-4.39
2017	1.81	1.70	0.11
2018	5.76	-1.72	7.47
2019	-3.58	-1.20	-2.38
2020	-11.54	-7.31	-4.23
2021	10.85	3.27	7.58
2022	5.67	0.33	5.34
2023	0.56	4.13	-3.57

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A32. Arts and entertainment activities
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	2.05	25.21	-23.16
1997	-0.46	14.41	-14.88
1998	-2.29	1.28	-3.57
1999	-0.44	5.69	-6.13
2000	-4.78	-6.00	1.22
2001	-8.84	-5.86	-2.98
2002	-12.39	3.55	-15.94
2003	-4.19	-5.38	1.18
2004	-7.20	1.25	-8.45
2005	6.39	0.61	5.77
2006	1.15	4.96	-3.81
2007	-3.87	-2.47	-1.40
2008	-2.82	8.99	-11.81
2009	1.85	9.61	-7.76
2010	1.04	2.45	-1.41
2011	-1.30	-1.93	0.63
2012	-5.03	1.34	-6.36
2013	1.04	-2.77	3.81
2014	-0.83	2.36	-3.19
2015	0.14	3.22	-3.08
2016	-1.50	-2.11	0.61
2017	-1.49	-4.31	2.82
2018	0.27	0.78	-0.51
2019	0.27	4.55	-4.28
2020	9.69	13.57	-3.87
2021	-4.39	-1.52	-2.87
2022	-5.76	-6.66	0.90
2023	-1.27	-7.45	6.18

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A33. Sport activities
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-5.37	-1.54	-3.83
1997	-1.39	14.85	-16.24
1998	-0.82	2.06	-2.88
1999	0.61	8.08	-7.48
2000	-3.11	-4.67	1.56
2001	-4.42	-3.16	-1.26
2002	-14.04	9.08	-23.12
2003	9.90	4.85	5.04
2004	-3.26	1.42	-4.68
2005	-2.84	-9.85	7.01
2006	-0.64	1.78	-2.42
2007	-2.23	-1.36	-0.87
2008	-9.78	3.79	-13.57
2009	2.23	14.77	-12.54
2010	1.66	2.50	-0.85
2011	-11.10	-17.11	6.01
2012	-5.82	6.62	-12.43
2013	-5.53	-9.24	3.71
2014	-1.58	1.74	-3.32
2015	6.15	8.99	-2.84
2016	-9.18	-14.18	5.00
2017	3.35	-7.30	10.65
2018	-7.80	-2.89	-4.91
2019	8.81	15.24	-6.43
2020	4.72	10.83	-6.11
2021	-1.09	1.68	-2.77
2022	2.34	1.78	0.57
2023	-3.16	-15.38	12.22

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A34. Activities of membership organizations
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-0.40	25.77	-26.17
1997	0.38	4.43	-4.06
1998	-0.20	4.70	-4.90
1999	-2.11	1.79	-3.89
2000	-3.99	2.55	-6.54
2001	-9.02	-3.00	-6.02
2002	-7.71	-3.72	-3.98
2003	-10.13	-3.45	-6.68
2004	2.66	8.73	-6.07
2005	0.95	1.11	-0.16
2006	0.79	1.58	-0.79
2007	6.40	7.25	-0.85
2008	-4.51	-1.19	-3.33
2009	1.43	-1.19	2.62
2010	0.39	0.56	-0.17
2011	-0.95	1.99	-2.94
2012	-0.33	-0.45	0.12
2013	-4.09	-5.34	1.26
2014	-0.06	6.07	-6.12
2015	0.18	4.24	-4.06
2016	-1.00	-0.04	-0.96
2017	1.02	2.58	-1.56
2018	0.39	-6.71	7.11
2019	-1.25	-0.12	-1.13
2020	-0.70	2.21	-2.91
2021	1.04	-10.09	11.13
2022	0.14	-5.34	5.48
2023	0.03	3.16	-3.12

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A35. Repair of computers and personal and household goods
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	7.92	43.91	-35.99
1997	-3.92	2.58	-6.50
1998	8.47	12.83	-4.36
1999	14.80	19.02	-4.23
2000	14.10	20.89	-6.79
2001	-27.80	-21.49	-6.31
2002	-16.79	-14.06	-2.73
2003	11.69	19.81	-8.12
2004	24.52	27.78	-3.26
2005	-8.41	-9.76	1.35
2006	-2.44	-0.27	-2.17
2007	-13.80	-13.46	-0.34
2008	-4.63	-2.22	-2.41
2009	-0.14	-1.55	1.41
2010	-10.47	-11.15	0.68
2011	-3.50	0.50	-4.00
2012	3.09	3.96	-0.86
2013	2.72	5.65	-2.93
2014	-3.45	9.12	-12.57
2015	-9.80	-7.56	-2.25
2016	15.80	14.85	0.95
2017	-9.35	-7.26	-2.09
2018	11.97	9.78	2.20
2019	4.23	4.35	-0.11
2020	-2.17	-1.02	-1.15
2021	0.09	-11.01	11.10
2022	2.16	-3.19	5.35
2023	0.39	4.48	-4.09

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.

Table A36. Other personal service activities
Growth rates of productivity indicators and their drivers (1996–2023)

Year	TFP	Efficiency change	Technical change
1996	-6.42	32.17	-38.59
1997	-2.18	5.82	-8.00
1998	-7.80	-3.40	-4.40
1999	-4.62	-0.24	-4.39
2000	-4.43	-1.54	-2.88
2001	-3.53	2.61	-6.14
2002	-2.37	4.56	-6.94
2003	-0.36	7.56	-7.92
2004	-5.23	-0.92	-4.31
2005	2.00	4.57	-2.56
2006	-0.06	0.22	-0.28
2007	-3.62	-3.84	0.22
2008	2.74	4.97	-2.23
2009	-0.52	-2.16	1.63
2010	2.19	1.47	0.72
2011	-3.15	0.65	-3.80
2012	0.37	0.23	0.14
2013	0.91	-0.36	1.27
2014	-2.51	5.26	-7.78
2015	0.51	3.81	-3.30
2016	1.03	0.00	1.03
2017	-1.15	0.00	-1.15
2018	-4.10	-8.12	4.02
2019	-2.46	-2.51	0.05
2020	-10.30	-3.76	-6.54
2021	27.42	14.39	13.03
2022	4.18	-4.21	8.39
2023	-0.75	4.21	-4.96

Note: Figures are annual growth rates (in %). Values for year T refer to the growth rate between years T and T-1. TFP is the ratio of TFP is the ratio of gross output to a combination of inputs: capital, labour, and intermediate consumption. Efficiency change indicates improvement of input use during production. Technical change captures improvements in production technology and input quality. Sources: Authors' calculations from STATEC data.