EKONOMISTA | **ARTYKUŁY**

online first
DOI: 10.52335/ekon/199763

Dariusz Kotlewski
The Department of Economic Geography, SGH Warsaw School of Economics, Poland,
https://orcid.org/0000-0003-1059-7114, dariusz.kotlewski@gmail.com

The Vitality of ICT Hardware Equipment Industry in the Light of Productivity Accounting

Żywotność przemysłu wytwarzającego sprzęt elektroniczny i komunikacyjny (ICT) w świetle rachunku produktywności

Abstract

This paper assesses whether Information and Communications Technology (ICT) equipment manufacturing is a standardised, or even declining, industry, or whether it is still in a phase of innovative expansion. The analysis uses the results of calculations performed on growth accounting data. In particular, data from the latest KLEMS productivity accounting online platforms were used. Based on the reasoning presented in the article, a proper comparison of the compound gross value added (GVA) growth rates, and the compound multifactor productivity (MFP) contributions to them, warrants the conclusion that, at least for the countries analysed, the ICT industry remains vibrant.

Keywords: Productivity, Decomposition, GVA, MFP, KLEMS.

JEL: E22, E23, 047

Streszczenie

Celem artykuł jest przybliżenie odpowiedzi na pytanie czy przemysł wytwarzający sprzęt elektroniczny i komunikacyjny (ICT) można zaliczyć do produkcji wystandaryzowanej lub nawet schyłkowej, czy też przemysł ten nadal jest w fazie innowacyjnej ekspansji. W analizie posłużono się wynikami obliczeń bazujących na danych z obszaru rachunkowości wzrostu gospodarczego. W szczególności wykorzystano dane z najnowszych platform internetowych rachunku produktywności KLEMS. Na podstawie rozumowania zaprezentowanego w artykule, odpowiednie porównanie skumulowanych przyrostów wartości dodanej brutto (WDB) oraz skumulowanych wkładów rezydualnej produktywności (multifactor productivity – MFP) do tych przyrostów pozwala wyciągnąć wniosek, że przynajmniej dla grupy krajów uwzględnionej w analizie przemysł wytwarzający sprzęt ICT jest ciągle przemysłem bardzo żywotnym.

Słowa kluczowe: produktywność, dekompozycja, WDB, MFP, KLEMS.

JEL: E22, E23, 047

1. Introduction

Industry, particularly heavy industry, in contrast to 19th-century expectations (which remained optimistic well into the 20th century), has come to be associated with obsolescence. There is a fairly widely accepted view that this is a logical consequence of the well-known three-sector theory in economics. According to this theory, the transition from an economy dominated by agriculture (primary sector)[1] to an economy dominated by industry (secondary sector), an equally inevitable transition from an economy dominated by industry to an economy dominated by services (tertiary sector). Observation has shown that this view has been largely borne out—thanks to processes such as automation and robotisation that followed mechanisation, the labour force freed up by the industrial sector has been employed in other activities, mainly in the services sector, and the declining share of industrial activity in GDP has been offset by the increasing share of service activity.

This raises the question as to whether this process has gone too far. Much of it can be attributed, not to the three-sector-theory related processes, but to the relocation of some economic activities from developed economies to developing ones. If this last process is saturated, then the developed economies might reindustrialise to some degree. At the same time, the developing economies (at least the successful ones) have already been making (and some have completed) the transition to a services-dominated economy and have even started to compete with the developed economies in this area. Therefore, if the process of deindustrialisation is partly due to temporary relocations that are, or soon will be, coming to an end, at the global scale then perhaps the developed economies should partly reindustrialise and the successful, but still developing, economies should maintain their industrial, and especially their manufacturing, sectors to some extent.[2]

However, it should be kept in mind that any reindustrialisation (or industrialisation in the case of previously unindustrialised countries) should not be merely a return to traditional industrial activities. Newly developed industrial activities should be aimed at furthering modernisation or even launching futuristic innovations that will yield tomorrow's bread-and-butter applications. The extreme position is that, only nanotechnology, biotechnology and information technology are worth investing in, as everything else has been rendered obsolete. Be that as it may, this paper focuses solely on ICT issues.

The ICT industry is not a newcomer; It has been developed for decades. The economy is already impregnated with ICT products, including ICT hardware. This industry might be experiencing something similar to those now outdated heavy industries, (and many other strands of manufacturing) during the course

[1] The primary sector is often taken to include hunting and mining.

[2] As far as a narrower (but still very representative for industry as a whole) category of manufacturing is considered, this issue has been widely discussed in (Kotlewski, 2023). In the mentioned reference it was found, despite the limitations of the study due to data availability, that reindustrialisation (or exactly speaking a return to manufacturing) seems advisable, and is at least economically sound, and should therefore be embraced.

of the 20th century. Moreover, at least some parts of the ICT industry, including hardware manufacturing, is presently being relocated. The issue of whether digital equipment (hardware) manufacturing is still economically sustainable, whether it properly belongs to the future economic leaders, therefore naturally arises. Any consideration of this issue would move this discussion forward.

The present author contends that such an assessment can be made with the use of KLEMS productivity accounting.[3] This because this accounting is not only applied at the aggregate level, but also at the sectoral (industry) level. The only analytical issue is whether appropriate KLEMS data are available at sectoral and division levels of the NACE or ISIC classifications.[4] An affirmative answer would mean that this methodology could be employed to study and compare the relative competitiveness and sustainability of different industries in terms of their value-added capture capability. Industries with high value-added capture capabilities achieve greater sustainable profitability. In particular, those industries in which value-added capture capabilities are growing rapidly achieve greater and growing sustainable long-run profitability. These value-added capture capabilities and their growth rates should be measured against the inputs of production factors and their growth rates (the basic production factors are labour and capital, but they may be refined). Therefore, they (i.e. the factors) can be understood as having high productivity (i.e. as having high *total factor productivity* [TFP] or its KLEMS variant, *multifactor productivity* [MFP]) levels, and particularly its dynamics, as measured in the framework of KLEMS growth accounting methodology. That is because these industries absorb capital resources from the market, which spills over onto their long-run growth. The KLEMS growth accounting methodology, when applied at the industry level, makes it possible to assess whether this is the case for the ICT hardware equipment industry, and consequently, whether there is scope to increase its economic share. The analysis can be performed on a number of countries for which KLEMS accounting is regularly performed.

The analysis based on KLEMS methodology can be used, despite the limited number of countries for which KLEMS datasets are available. Not only can the intensiveness of deindustrialisation be observed, but its economic soundness or advisability can be assessed. The same analysis can be performed on ICT hardware equipment manufacturing, as the contribution of MFP to economic growth by industry is also observable through KLEMS lenses. If a given sector of the economy is shrinking, i.e. if its growth rate is lower than that of the aggregate

[3] KLEMS is an acronym for: K – capital, L – Labour, E – Energy, M – Materials, and S – Services. KLEMS productivity accounting (or KLEMS growth accounting) is the most systematically performed growth accounting methodology based on the decomposition concept devised initially by Robert Solow (see Section 2 of this paper). However, the number of countries for which growth decomposition is truly performed remains limited.

[4] NACE stands for *Nomenclature statistique des Activités économiques dans la Communauté Européenne*. NACE rev. 2 is the current version of this European Union classification and will be referred to in this paper as NACE 2 or simply NACE. From the standpoint of growth accounting (here implemented) NACE is equivalent to ISIC (i.e. NACE 2 is the equivalent of ISIC 4 and NACE 1 is the equivalent of ISIC 3).

economy, while at the same time the contribution of MFP to its growth rate is higher in percentage points than that for the aggregate economy, then this shrinking needs to be reversed. This follows because economic activities whose MFP contributions (as measured by percentage points) to their sectoral gross-value-added growth rates are greater than those for the aggregate economy, should be promoted. The successful economies are those which increase their proportion of sectors with high GVA growth rates, particularly when these value-added increases are due to high MFP contributions, as this makes this evolution economically sustainable.

Whether the ICT hardware equipment industry is worth promoting, or whether it is becoming averagely mature, or even obsolete, can also be assessed. The present study answers the following question: *Is ICT hardware equipment manufacturing still an economically sustainable industry when assessed using KLEMS productivity accounting?* While this analysis can also be carried out using other decomposition methodologies with residual TFP extraction, the comparable KLEMS data are the most readily available for a number of countries. The present study determines this issue for the 15 countries and country aggregates for which it was possible to obtain appropriate data from the most recent KLEMS release[5]. It is structured as follows: Section 2 reviews the literature; Section 3 presents the methodology; Section 4 compiles the data; Section 5 presents and discusses the results; and Section 6 contains the conclusion(s).

2. Literature review

There is a wealth of literature on the role of ICT technology in the economy. For example, a recently published and authoritative work on economic growth by Fernández-Portillo, Almodóvar-González & Hernández-Mogollón (2020) states that '*Most of the scientific literature recognizes a positive impact of Information and Communication Technologies on economic growth. In contrast, different investigations suggest that this impact is limited or even null, that is, there are mixed results*'. It further asserts that ICT drives the economic growth of **developed** European economies. This alone warrants further research on the issue. A previously published research paper by García-Muñiz & Vicente (2014) claims that ICT are general purpose technologies, that their pervasiveness drives knowledge flows, and that they are catalysts of innovation, and as such, have a positive impact on economic growth. The positive impact of ICT on manufacturing is confirmed by Li, Chen & Miao (2022). According to these authors, although many previous studies have failed to reach a consistent conclusion, there was a positive correlation between ICT and the TFP of manufacturing firms in China in 2010-2019. The positive spillover effects in the Korean economy are demonstrated by Hwang & Shin (2017). Earlier works are even more optimistic about the impact of ICT on economic growth. For example, many of the works cited in Vu (2011) contend that ICT has a positive impact on economic growth. A profound analysis on the generally positive impact

[5] At the time when this paper was drafted.

of ICT on economic growth in India can be found in Maiti, Castellacci & Melchior (eds) (2020).

As informative as this literature is, it does not precisely cover what is being analysed in the present study, viz the narrower topic of ICT-producing industries,[6] particularly hardware manufacturing. The reasons for this are provided in this section. Pilat & Lee (2001, p. 4) point towards this difference in focus in their attempt to explain the role of ICT in the rapid economic growth of the USA vis-à-vis the rest of the OECD during the final decade of the 20th century, stating '[…] *ICT-producing industries have made significant contributions to labour productivity growth in several OECD countries, including Finland, Japan, Sweden and the United States. The relative importance of the ICT-producing sector in different countries, and its growth over time, might thus be one cause for the large difference in growth performance that have been observed in several OECD countries in recent years*'. What remains to be demonstrated is whether this still holds true—or at least did so until recently, as the present author is constrained by the currency of the most recent publications. The same source states that '[…] *telecommunications, financial services, insurance and business services, are among the key users of ICT, but productivity growth in these sectors has often been sluggish* […] *there is also a view that ICT has not yet had any real impact on MFP in some services sectors*'. This is *prima facie* contradictory, but it may be that other broader ICT sectors, on which ICT-producing industries rely, have exhibited greater value-added capture capability in the value chains. This is applicable to many NACE codes related to trade and services.[7] The problem is that the available data coverage is only partial, and usually insufficient to perform a comprehensive growth accounting for them.[8] Extending the present study to additionally cover ICT-using industries would require a book-length work that would not even be comprehensive because of the lack of data.

Because of the impracticability of conducting a fully comprehensive study on the role of ICT, the present study is restricted to determining whether the ICT hardware manufacturing industry has been more productive than the manufacturing sector (NACE code C) and the aggregate economy (NACE code Tot) during the most recent period for which comprehensive data have been available, and consequently, whether it is advisable to increase its share in the economy. One work seems to be highly relevant to the present analysis—Vu & Amann (2024) basically adopt the same approach, i.e. growth accounting methodology using EUKLEMS

[6] And this distinction seems to be ignored in Vu (2011) mentioned above.

[7] E.g.: trade: 4651 – Wholesale of computers, computer peripheral equipment, and software; 4652 – Wholesale of electronic and telecommunication equipment; services: 582 – Software publishing, 6110 – Wired telecommunications activities, 6120 – Wireless telecommunications activities, 6201 – Computer programming activities, 6311 – Data processing, hosting, and related activities, etc.

[8] The available distinction in KLEMS data is: J – Information and communication; J58–J60 – Publishing, motion picture, video, television programme production; sound recording, programming and broadcasting activities; J61 – Telecommunications; J62–J63 – Computer programming, consultancy, and information services. The available body of data concerns rather the broadly understood information related activities than pure ICT related activities, although some of them belong to both categories.

2019 release's data. The literature review of this work cites many other works relevant to the present study, but the work itself is the most recent and appropriate for comparisons. Its results are compared with those of the present study, although the latter are based on a more recent EUKLEMS data release. Significantly, Ghodsi et al. (2021, p. 11) state that '*...comparably less attention has been paid, and less in-depth analysis provided, regarding the supply side of ICT products and services and ICT production*.' This statement alone justifies the present study. This work makes a clear distinction (p. 21) between ICT manufacturing industries (NACE code C26), ICT trade industries (belonging to NACE code G46 category), and ICT services industries (mostly belonging to the NACE code J section). It further confirms that there has been more real value-added growth in ICT-producing industries than in ICT-using industries (p. 26). However, here no growth accounting decomposition is performed within the framework of a similar methodology. For this reason, the present study uses the work cited previously (i.e. Vu & Amann, 2024) as the most relevant one for making comparisons.

3. Methodology

The methodology used in this paper is very similar to that presented in many KLEMS related papers, however, in order to preserve the paper's integrity it will be recalled bellow with the necessary adjustments to the present paper requirements.

Economic growth was first decomposed into the contributions of the two basic factors of production by Solow (1957). This was a specific development of his economic growth theory (Solow, 1956). The application of this theory in regularly conducted productivity accounts was associated with the introduction of Leontief (1966) concepts in statistics. Due to the complexity of its numerous calculations, its implementation had to await the advent of the computer era. The present version of economic growth accounting in the form of KLEMS productivity accounting was mainly formulated by Jorgenson and associates (Jorgenson & Griliches, 1967; Jorgenson, Gollop & Fraumeni, 1987; Jorgenson, Ho & Stiroh, 2005).[9] This methodology is basically consistent with the OECD (2001) methodology. These are the two most common economic growth accounting methodologies that use the index method. Moreover, their use is strongly recommended by Diewert (1976, 1978, 1992, 2004 and 2005),[10] a leading expert on productivity and price indices. Solow's decomposition is therefore the starting point:

$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \alpha \frac{\Delta K}{K} + \beta \frac{\Delta L}{L} \tag{1}$$

[9] See also: Jorgenson (1963 and 1989). The basic KLEMS methodology is summarized in: Timmer et al. (2007); and O'Mahony & Timmer (2009).

[10] There is also the econometric method developed by, e.g.: Ackerberg, Caves & Frazer (2015); Levinsohn & Petrin (2003); and Olley & Pakes (1996). This is often considered to be more appropriate for decompositions at the individual firm level.

where: Y is gross domestic product (GDP); L is labour, measured as physical counted hours (later, strictly defined as hours worked); and K is capital-stock value. The weights α and β are elasticities. These can be specified as shares of factor remunerations in total income, which theoretically presuppose perfect competition and constant returns to scale in the economy. It is these assumptions that warrant the use of the formula $\beta = 1 - \alpha$ in (1). A is total factor productivity (TFP). Its contribution, $\Delta A/A$, is calculated residually by subtracting the other values in (1). It is termed as *Solow's residual*. In this way, there is no direct need to establish the value of A, which is an abstract category whose interpretation was (and somehow still is) an issue. Solow interpreted it as technological progress. Currently, it is usually interpreted as the technological or organizational progress disembodied in labour or capital (with an uncertainty introduced later to which we shall refer later on in this paper).

However, following Jorgenson and associates (supra), the Törnqvist quantity index should be used for aggregation of GVA growth rates of individual products:

$$\Delta ln V_{jt} = \sum\nolimits_i \overline{v}^{V}_{ijt} \Delta \ln V_{ijt} \tag{2}$$

where: V_{jt} is the GVA for industry j over a usually yearly period t, V_{ijt} are the GVA levels for individual products i of industry j over period t; and $\overline{v}^{V}_{ijt}$ are individual product i shares in V_{jt}, calculated as the averages of periods t and t-1. The growth rates of individual products are therefore weighted by their (intertemporal in the Törnqvist procedure) pre-aggregation shares, and relative growth rates are expressed logarithmically. Similar indices are used for aggregating production factor growth rates at the product i level. Therefore, whenever a Solow decomposition is conducted at the industry level, formula (1) is replaced in the KLEMS framework by its trans-log approximation:

$$\Delta ln V_{jt} = \Delta ln A^{V}_{jt} + \overline{\alpha_{jt}} \Delta ln K_{jt} + \overline{\beta_{jt}} \Delta ln L_{jt} \tag{3}$$

which is consistent with the Törnqvist procedure. It has been established that the average shares between two time periods t and t-1 should be used, according to the formula $\overline{\alpha}_t = \left(\alpha_t + \alpha_{t-1}\right)/2$ and similarly for $\overline{\beta}_t$. Subscript j, present in (2) and (3), has been omitted here for simplicity. By definition, these shares are shares in the GVA $-V_{jt}$, and the left-hand side of (3) is the growth in GVA, not GDP (for the consistency of the accounts). Formula (3) should be used independently for each year and each industry (as represented by e.g. NACE sections and divisions). Thanks to its trans-log shape, formula (3) is strictly conformable with the original Cobb-Douglas production function.[11]

Formula (3) can be developed by introducing an additional variable, representing intermediate inputs (II), to the original production function. In the theory developed after Solow, it was finally established that only the decomposition of gross output (GO) growth (with an additional factor-alike contribution of II)

[11] However, when growth rates are high (>> 10%), the logarithmic values deviate from the classic relative growths present in Formula (1).

enables the contribution of technological or organizational progress, disembodied in labour or capital, to growth to be calculated exactly (which is the uncertainty mentioned above). This gross-output MFP contribution is different than the value-added MFP contribution, but in an ideal situation they should be related by the ratio between GO and GVA (which would mean that they are equivalent in their essence although not equal in value). Otherwise, Formula (3) only enables an approximate assessment of this contribution of technological or organizational progress. It may be inconsistent (i.e. not related by a known ratio) because of the phenomenon of substitution between the production factors and II. For this reason, the contribution of *A* in Formula (3) is currently considered to be the industry capacity to capture the value and participate in the income (OECD, 2001, p. 23). But this understanding of the residual productivity contribution to growth is even more appropriate to the present study, because of the rationale presented in the introduction.

There are issues associated with the use of GO growth decomposition. Data insufficiency compels most countries performing KLEMS to only carry out GVA growth decomposition according to Formula (3). Fortunately, GVA growth decomposition remains the backbone of KLEMS, and provides the most essential information about the economy. Therefore, despite its limitations, it remains the basis of most analyses that use this accounting methodology. Performing GVA growth decomposition as in Formula (3) instead of GO growth decomposition also facilitates international comparisons, as the differences (possibly huge) in the vertical integration of firms, which can impact II, are no longer an issue. This is further justification for selecting KLEMS data with GVA growth decomposition.

It is important to note that in KLEMS accounting, different definitions of production factor contributions are used—instead of contributions of factor stocks (resources), as in Solow's decomposition, the notions of contributions of factor services are used in Formula (3). This is because the Törnqvist quantity index is used to aggregate factor values. For this reason, the productivity term is MFP, which can be considered as a 'modernisation' of TFP. The present study is therefore based on MFP productivity.

Some values have been calculated especially for the present study. Preference has been given to compound calculations that give greater weight to later-years economic growth rates. They are therefore not equivalent to arithmetic means. Chaining was used according to the formulae:

$$\begin{aligned} \Delta lnV_{(1,n)} &= \prod_{t=1}^{n}\left(1+\Delta lnV_t\right)-1 \\ \Delta lnA^V_{(1,n)} &= \prod_{t=1}^{n}\left(1+\Delta lnA^V_t\right)-1 \end{aligned} \qquad (4)$$

where: V is for GVA in discrete time periods t or the entire time span $(1, n)$; and A^V is value-added MFP in discrete time periods t or the entire time span $(1, n)$.

4. Data Compilation

Useful results are only obtainable for countries for which appropriate growth decomposition data in NACE Rev. 2 system are published, including data on GVA growth and the MFP contribution to this growth for the aggregate economy (NACE *total economy*), the manufacturing sector (NACE section C – *manufacturing*), and the ICT hardware equipment industry (NACE division C26 – *manufacture of computer, electronic and optical products*). The 2023 EU KLEMS release,[12] i.e. the most recently available, contains 14 such countries or country aggregates. These include the UK, presently outside the EU, the USA, and Japan, for which countries there are consistent data. They include also the EU19 aggregate of 19 countries that were in the euro area at the time of the EU KLEMS 2023 release. The other countries from this release, included in the present study, are Austria, Belgium, Czechia, Germany, Greece, Finland, France, Italy, the Netherlands, and Sweden. Data for Poland are taken from the Statistics Poland website.[13] They contain GVA growth decomposition data, which are not available in the EU KLEMS release. The methodology used to compute them is, however, very similar.

The mentioned EU KLEMS release data release includes every country in the EU. However, the most important methodological component of KLEMS productivity accounting, viz. the GVA growth decomposition into the contributions of production factors and MFP, is not available for all of them. Moreover, the time series are quite short for some of them. The analysis therefore begins in 2009 in order to maximise the number of countries for which sufficient data are available. Moreover, as the aim is to examine ongoing trends, there is no need to delve into the remote past. The World KLEMS site[14] additionally contains data for Argentina, India, South Korea, China and Canada,[15] but these cannot be easily used in the present analysis, because they are either methodologically inconsistent or incomplete, and their time series are often too short.

Appendix Tables A1 and A2 contain the data used. As stated at the beginning of this section, these data concern the total economy, NACE section C, and NACE division C26. For Poland, the aggregate of NACE divisions C26–27 is applied as an approximation[16] instead of NACE division C26. The values contained in the Tables are yearly values and compound values for sub-periods 2009–2014, 2015–2020, and the entire period 2009–2020. For the EU19 aggregate and Italy, the appropriate data on this EU KLEMS release are available only until 2019, and for Japan only until 2018. The relevant compound values therefore cover slightly shorter periods. The compound

---

[12] Luiss Lab of European Economics (2023), EUKLEMS & INTANProd – Release 2023, https://euklems-intanprod-llee.luiss.it/

[13] https://stat.gov.pl/en/experimental-statistics/klems-economic-productivity-accounts/

[14] https://www.worldklems.net/

[15] The other two main world platforms are LA KLEMS (*Latin America KLEMS*) and Asia KLEMS. The data for the vast majority of these countries are very basic, and do not include growth accounting with a decomposition.

[16] NACE division C26 – *manufacture of computer, electronic and optical products* together with NACE division C27 – *manufacture of electrical equipment*.

values calculated using Formulae (4) make it possible to conduct an analysis that provides a rational response to the question posed in the introduction.

5. Empirical Findings

The essential results of the study are compiled in Table 1 below. These are the compound GVA growth rates and compound MFP contributions for 2009–2014 and 2015–2020, and have been taken from Tables A1 and A2 in the Appendix.[17] Additional columns under the heading RI have been added in order to provide for a qualitative interpretation of the results in the left-hand side neighbouring cells. Each cell in these additional columns has been populated with one of three symbols, as follows:

I. For each row labelled 'Tot' under the heading 'NACE aggregation', '-' in column labelled RI signifies a negative compound value, and '+' a positive compound value. The former implies an economic contraction, understood as a GVA decrease (in column group I – "Compound GVA growth") or a negative MFP contribution to GVA growth (in column group II – "Compound MFP contribution") over the period in question. Conversely, the latter implies an economic expansion or a positive MFP contribution over the period in question.

II. For each row labelled 'C' under the heading 'NACE aggregation', '-' signifies either a negative compound value or a positive compound value that is less than the value immediately above it in the 'Tot' row, and '+' signifies a positive compound value and greater than the value immediately above it in the 'Tot' row. The former implies either deindustrialisation, understood as a decreasing share of manufacturing (NACE section C) in the aggregate economy (column group I) or a MFP contribution to GVA growth (column group II) in manufacturing that is either negative or lower than that for the aggregate economy over the period in question. Conversely, the latter implies either reindustrialisation[18] or a MFP contribution to GVA growth in manufacturing that is greater than that for the aggregate economy over the period in question. This latter case indicates that, according to the rationale presented in the introduction, reindustrialisation is economically sound (and possibly advisable).

III. For each row labelled 'C26' under the heading 'NACE aggregation': '-' signifies a negative compound value or a positive compound value that is less than the one in the 'Tot' row above it (i.e. for the same country); and '+' signifies a positive compound value that is greater than the one in the 'Tot' row above it but less than the one in the 'C' row immediately above it; and the

[17] Compound results for the entire period 2009–2020 have been omitted here, as they do not provide any additional information – they are, however, not contradictory to the results presented in Table 1.

[18] Or just industrialisation in countries that never were industrialised before.

symbol '++' signifies a positive compound value that is greater than both those in the 'Tot' and 'C' rows above it. The first case indicates a decrease in ICT hardware product (belonging to NACE division C26)[19] manufacturing value as a proportion of aggregate GVA (column group I) or an MFP contribution to this industry GVA growth that is either negative or less than that for the aggregate economy (column group II) over the period in question. The second case indicates an increase in ICT hardware product manufacturing value as a proportion of aggregate GVA or an MFP contribution to this industry GVA growth that is greater than that for the aggregate economy, thereby indicating that, according to the rationale presented in the introduction, expanding the manufacture of ICT hardware products is economically sound (or even advisable). The third case indicates that expanding the manufacture of ICT hardware products is not only sound, but more advisable than reindustrialisation (understood as manufacturing, i.e. NACE section C, increase, which can be often sound in its own right, but not necessarily).

[19] For Poland, the group of division C26–27 is used as an approximation, due to data availability.

Table 1.

Essential results of the study

		I Compound GVA growth				II Compound MFP contribution			
Country or country aggregate	NACE aggregation	2009–2014		2015–2020		2009–2014		2015–2020	
		Value	RI	Value	RI	Value	RI	Value	RI
Austria	Tot	2,03	+	2,12	+	-0,43	-	1,05	+
	C	1,37	-	7,47	+	-0,42	-	2,22	+
	C26	17,54	++	22,06	++	26,96	++	2,04	+
Belgium	Tot	5,69	+	3,11	+	0,49	+	-1,45	-
	C	-1,22	-	2,05	-	10,08	+	2,93	+
	C26	-36,40	-	3,59	++	14,32	++	11,50	++
Czechia	Tot	0,99	+	13,48	+	-6,78	-	6,10	+
	C	4,21	+	13,72	+	-1,75	-	8,37	+
	C26	32,41	++	48,21	++	4,72	++	24,70	++
Germany	Tot	4,56	+	3,92	+	1,10	+	0,64	+
	C	2,56	-	-0,84	-	2,32	+	-3,55	-
	C26	17,31	++	24,08	++	21,99	++	17,90	++
Greece	Tot	-24,52	-	-6,12	-	-18,34	-	0,53	+
	C	-40,04	-	17,33	+	-22,98	-	21,96	+
	C26	-30,69	-	17,80	++	-15,09	-	33,88	++
Finland	Tot	-7,46	-	6,50	+	-6,99	-	1,65	+
	C	-30,77	-	8,33	+	-15,47	-	14,45	+
	C26	-79,12	-	-3,12	-	-69,71	-	44,05	++
France	Tot	3,54	+	-0,86	-	-1,33	-	-3,09	-
	C	1,23	-	-6,95	-	6,88	+	-5,13	-
	C26	36,67	++	4,94	++	60,44	++	1,62	++
Italy	Tot	-7,25	-	-3,96	-	-4,31	-	-0,21	-
	C	-16,43	-	-5,42	-	-4,10	-	-1,96	-
	C26	-23,25	-	0,40	++	-17,30	-	-1,76	-
The Netherlands	Tot	0,79	+	6,69	+	-1,53	-	-4,55	-
	C	-2,30	-	11,03	+	1,50	+	5,17	+
	C26	4,77	++	-2,62	-	18,20	++	-26,10	-
Poland	Tot	18,52	+	19,98	+	-0,60	-	7,87	+
	C	31,28	+	17,64	-	19,63	+	4,79	-
	C26-27	76,46	++	43,89	++	56,49	++	23,91	++
Sweden	Tot	7,87	+	10,38	+	-0,18	-	0,77	+
	C	-17,90	-	3,97	-	-1,98	-	0,74	-
	C26	-48,42	-	-8,52	-	-2,53	-	9,27	++
UK	Tot	5,59	+	-1,73	-	-1,96	-	-1,30	-
	C	-0,63	-	-2,90	-	6,39	+	3,22	+
	C26	17,23	++	-13,89	-	26,59	++	-1,19	-
euro area (EU19)	Tot	0,00	-	0,08	+	-0,17	-	1,22	+
	C	-0,02	-	0,09	+	0,08	+	0,64	-
	C26	0,03	++	-0,59	-	0,47	++	0,15	-
USA	Tot	6,99	+	12,07	+	1,26	+	3,43	+
	C	-1,31	-	7,83	-	-1,74	-	2,21	-
	C26	31,65	++	34,72	++	38,70	++	28,17	++
Japan	Tot	1,09	+	3,46	+	2,35	+	0,56	+
	C	-4,44	-	6,82	+	7,07	+	2,22	+
	C26	6,86	++	2,51	-	33,62	++	1,24	+

Note: the following NACE Rev. 2 aggregations are in the table: Tot – total economy, section C – manufacturing, division C26 – manufacture of computer, electronic and optical products, group of divisions C26–27 – the mentioned C26 division together with C27 – manufacture of electrical equipment.

Source: own elaboration based on EU KLEMS 2023 release[20] and Statistics Poland sites.

[20] Luiss Lab of European Economics (2023), EUKLEMS & INTANProd – Release 2023, https://euklems-intanprod-llee.luiss.it/

Following the rationale laid out in the introduction, together with Rules I, II and III mentioned above, the results presented in Table 1 can be analysed for each individual country:

- For Austria, developing the ICT equipment industry was particularly advisable (++) in the first period (2009–2014) and remained sound (+) in the second period (2015-2020), as illustrated by the values for NACE aggregation C26 in the column group II (Compound MFP contribution). The compound GVA growth rates in both these periods, as illustrated by the values for NACE aggregation C26 in the column group I (Compound GVA growth), were much higher (++) than for both manufacturing (NACE aggregation C) and the aggregate economy (NACE aggregation Tot). This economic behaviour is consistent with the advice given in the first sentence of this paragraph.
- For Belgium, developing the ICT equipment industry was very sound (++) in both periods, as illustrated by the values for NACE aggregation C26 in the column group II. Following the adopted rationale, the economic behaviour was sound in the second period, when the compound GVA growth rate was higher than for both the manufacturing sector and the aggregate economy, but not in the first period.
- For Czechia, developing the ICT equipment industry was very sound (++) in both periods, and the economic behaviour was conformable with that advice (following the same kind of analysis employed for the countries above).
- For Germany, developing the ICT equipment industry was very sound (++) in both periods, and the economic behaviour was conformable with that advice.
- For Greece, developing the ICT equipment industry was particularly sound (++) in the second period, and the economic behaviour was conformable with that advice. In the first period, the economy was heavily impacted by the Greek government-debt crisis. This strongly impacted these results. The severity of this crisis became much milder in the second period, however, at least as far as the issue at hand is considered.
- For Finland, developing the ICT equipment industry was very sound (++) in the second period, but the economic behaviour was not conformable (-) with that advice (negative compound GVA growth for the C26 aggregation). A similarity can be observed here with Sweden.
- For France, developing the ICT equipment industry was sound (++) in both periods, and the economic behaviour was conformable with that advice.
- For Italy, developing the ICT equipment industry was not sound (-) in either period. These results indicate a generally adverse economic state; one in which many industrial sectors were struggling (although within this milieu, the ICT equipment industry might not have been performing all that poorly, particularly in the second period).
- For the Netherlands, developing the ICT equipment industry was particularly sound in the first period (++) but not in the second (-), and the economic behaviour was conformable with that advice – a similarity can be observed here with the UK.

- For Poland, developing the ICT equipment industry was clearly sound (++) in both periods, and the economic behaviour was conformable with that advice. However, it must be kept in mind that electrical equipment (NACE division C27) is included in the aggregation for this country (C26–27 was used instead of C26). Therefore, this result may be skewed by the high expansion of electrical equipment production.[21]
- For Sweden, developing the ICT equipment industry was particularly sound (++) in the second period, but the economic behaviour was not conformable (-) with that advice (negative compound GVA growth for the C26 aggregation) – a similarity can be observed here with Finland.
- For the UK, developing the ICT equipment industry was particularly sound (++) in the first period, but not in the second (-), and the economic behaviour was conformable with that advice – a similarity can be observed here with the Netherlands.
- For the EU19 aggregate, developing the ICT equipment industry was particularly sound in the first period (++), but not in the second (-), and the economic behaviour was conformable with that advice – a similarity can be observed here with the UK and the Netherlands.
- For the USA, developing the ICT equipment industry was very sound (++) in both periods, and the economic behaviour was conformable with that advice.
- For Japan, developing the ICT equipment industry was very sound in the first period (++) and remained justified (+) in the second period, and the economic behaviour was conformable with that advice in the first period (++), but not in the second (-).

This outcome, based on the 2023 EU KLEMS release,[22] presented in Table 1, indicates that increasing the proportion of ITC hardware equipment manufacturing (understood as the C26 division of the NACE Rev. 2 classification) in GVA would have been sound in 2009–2014 for 11 of the 15 countries and country aggregates considered in the study. The result was similar, but not identical, for 11 of the 15 countries and country aggregates in 2015–2020. There were only 3 (for Finland, Sweden, and Japan) out of 22 situations (as stated above: 11 in the first period and 11, but not exactly the same, in the second period), that did not act on the soundness of increasing the proportion of ICT hardware manufacturing in GVA.

These results support the hypothesis that ICT hardware equipment manufacturing is not only an economically sustainable industry (as established through KLEMS

[21] In Hagemejer et al. (2021) there is a statement (roughly interpreted to English) that *In the economic growth in Poland compared to EU countries, investment in ICT capital were relatively low. The low digitalization rates of the Polish economy indicate that investments in ICT could be an important source of growth in the future.* While the author of the present paper agrees with this statement, it is nevertheless not fully relevant to the issue at hand, since it is mostly about ICT-using industries (that may additionally, and even predominantly, import equipment), whereas the present paper is concerned with ICT-producing industries. These may be in their infancy in Poland, but they are growing.

[22] Although many analyses can be performed using the same kind of data and a similar method, this inference must be restricted to the issue at hand.

productivity accounting) but is still in its heyday. It is certainly not a shrinking, obsolete activity. The countries examined here, however, vary in size, and are not very numerous. Given that several major economies are missing in the analysis (suffice it to mention China, India, Brazil, and Indonesia), this general outcome can only be considered as plausible. The countries analyses here are nevertheless quite representative of the OECD.

These results can be compared with those of Vu & Amann (2024). As stated above, their work is the most relevant to the present study and it is almost as recent. It is conformable with the present study in that it finds (Vu & Amann, 2024, p. 7) GVA growth in 9 of the 13 economies analysed. Their paper states that *Leading the pack is Czechia… followed by the US…* which is conformable with the observations in the present paper for the period 2009–2014, which is subsumed by their period 2000–2015. Similar conformability, but in a negative sense, can be observed for Italy and Finland. Some differences can be easily attributed to the different time series and the slightly different country coverage analysed by Vu & Amann, but there are many more similarities, as a comparison of Vu & Amann (2024, p. 8, Table 4A) and Table 1 of the present paper reveals.

Neither Vu & Amann's paper (2024) nor the present study are fully comprehensive because of data availability and coverage, but their joint representativeness is greater. The present paper study, however, contains a more specific policy recommendation based on the rationale presented in the introduction.

6. Conclusion

Given the state of the available statistical data, the analysis using KLEMS productivity accounting of whether the ICT hardware equipment manufacturing industry is expanding (as an increasing proportion of GVA) can be conducted only as an assessment. The analysis performed in the present study, however, is quite representative for the OECD and the results are unequivocal – it is rational to infer that it is highly probable that the situation is similar for many other countries, and consequently for the world economy. The work of Vu & Amann (2024), in conjunction with the present study, increases the representativeness of the results, because its coverage is somehow different.

ICT hardware equipment manufacturing is not only an economically sustainable industry, but it is still in its heyday. It is certainly not a shrinking, obsolete activity. In a situation where the worldwide increase in productivity is decelerating,[23]

[23] This can be a source of secular stagnation. The issue is the feasibility of a continuous exponential growth on a finite planet (Jackson, 2019). Increased inequality and the rise of political populism, together with historical congruence between declining productivity growth and resource bottlenecks are cited as causes. Demographic reasons (Cerrellati, Sunde & Zimmermann, 2017), and unfavourable technological developments (Cova, Notarpietro, Pagano & Pisani, 2021) are additional factors. Too many other explanations are being advanced to be cited here. Unbalanced growth between technologically dynamic and stagnant sectors (Storm, 2018) are a consideration, although not exactly in the manner contended by this author.

any means that can help reverse, or at least contain this negative trend, should be employed. Embracing ICT hardware equipment manufacturing is one such means; one that should be accepted as beneficial for the economies of several countries. It should, however, be kept in mind that more data are welcome to extend and confirm these results. A Computable General Equilibrium exercise may be possible once such data become available. If so, more precise conclusions will be able to be drawn.

References

Ackerberg, D., Caves, K., & Frazer, G. (2015). Identification Properties of Recent Production Function Estimators. *Econometrica*, *83*(6), 2411–2451. https://doi.org/10.3982/ECTA13408

Cerrellati, M., Sunde, U., & Zimmermann, K. F. (2017). Demographic Dynamics and Long-Run Development: Insights for the Secular Stagnation Debate. *Journal of Population Economics*, *30*, 401–432. https://doi.org/10.1007/s00148-016-0626-8

Cova, P., Notarpietro, A., Pagano, P., & Pisani, M. (2021). Secular Stagnation, R&D, Public Investment, and Monetary Policy: A Global-model Perspective. *Macroeconomic Dynamics*, *25*(5), 1267–1287. https://doi.org/10.1017/S136510051900066X

Diewert, W. E. (1976). Exact and Superlative Index Numbers. *Journal of Econometrics*, *4*(2), 115–145. https://doi.org/10.1016/0304-4076(76)90009-9

Diewert, W. E. (1978). Superlative Index Numbers and Consistency in Aggregation. *Econometrica*, *46*(4), 883–900. https://doi.org/10.2307/1909755

Diewert, W. E. (1992). The Measurement of Productivity. *Bulletin of Economic Research*, *44*(3), 163–198. https://doi.org/10.1111/j.1467-8586.1992.tb00542.x

Diewert, W. E. (2004). Basic Index Number Theory. In *Consumer Price Index Manual: Theory and Practice.* Chapter 15. International Monetary Fund.

Diewert, W. E. (2005). Issues in the Measurement of Capital Services, Depreciation, Asset Price Changes and Interest Rates. In C. Corrado, J. Haltinger, D. Sichel (eds), *Measuring Capital in the New Economy*, 479–542, University of Chicago Press. https://doi.org/10.7208/chicago/9780226116174.003.0013

Fernández-Portillo, A., Almodóvar-González, M., & Hernández-Mogollón, R. (2020). Impact of ICT Development on Economic Growth. A Study of OECD European Union Countries. *Technology in Society*, *63*, Article 101420. https://doi.org/10.1016/j.techsoc.2020.101420

García-Muñiz, A. S., & Vicente, M. R. (2014). ICT Technologies in Europe: A Study of Technological Diffusion and Economic Growth Under Network Theory. *Telecommunication Policy*, *38*(4), 360–370. https://doi.org/10.1016/j.telpol.2013.12.003

Ghodsi, M., Adarov, A., Exadaktylos, D., Stehrer, R., & Stöllinger, R. (2021). Production and Trade of ICT from an EU Perspective. *Research Report*, *456*. https://wiiw.ac.at/production-and-trade-of-ict-from-an-eu-perspective-p-5974.html

Hagemejer, J., Poniatowski, G., Pechcińska, A., Turgut, M. B., & Śmietanka, A. (2021). *Inwestycje i ich determinanty a wzrost gospodarczy Polski w długim okresie*. CASE Reports 505.

Hwang, W-S., & Shin, J. (2017). ICT-Specific Technological Change and Economic Growth in Korea. *Telecommunication Policy*, *41*(4), 282–294. https://doi.org/10.1016/j.telpol.2016.12.006

Jacson, T. (2019). The Post-growth Challenge: Secular Stagnation, Inequality and the Limits to Growth. *Ecological Economics*, *156*, 236–246. https://doi.org/10.1016/j.ecolecon.2018.10.010

Jorgenson, D. W. (1963). Capital Theory and Investment Behavior. *The American Economic Review*, *53*(2), 247–259. http://www.jstor.org/stable/1823868

Jorgenson, D. W. (1989). Productivity and Economic Growth. In R. E. Berndt, & E. J. Triplett (eds), *Fifty Years of Economic Measurement: The Jubilee of the Conference on Research in Income and Wealth* (pp. 19–118). University of Chicago Press.

Jorgenson, D. W., Gollop, F. M., & Fraumeni, B. M. (1987). *Productivity and US Economic Growth*. Harvard University Press. https://doi.org/10.2307/2233624

Jorgenson, D. W., & Griliches, Z. (1967). The Explanation of Productivity Change. *The Review of Economic Studies*, *34*(3), 249–283. https://doi.org/10.2307/2296675

Jorgenson, D. W., Ho, M. S., & Stiroh, K. J. (2005). *Information Technology and the American Growth Resurgence*. MIT Press.

Kotlewski, D. (2023). The Soundness of Returning to Manufacturing Through the Lens of Productivity Accounting. *Ekonomista*, *3*, 253–274. https://doi.org/10.52335/ekon/171520

Leontief, W. (1966). *Input-Output Economics*. Oxford University Press 1986. https://doi.org/10.2307/2229313

Levinsohn, J., & Petrin, A. (2003). Estimating Production Functions Using Inputs to Control for Unobservables. *Review of Economic Studies*, *70*, 317–341. https://doi.org/10.1111/1467-937X.00246

Li, D., Chen, Y., & Miao, J. (2022). Does ICT Create a new Driving Force for Manufacturing? – Evidence from Chinese Manufacturing Firms. *Telecommunication Policy*, *46*, Article 102229. https://doi.org/10.1016/j.telpol.2021.102229

O'Mahony, M., & Timmer, M. (2009). Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database. *The Economic Journal*, *119*, F374–F403. https://doi.org/10.1111/j.1468-0297.2009.02280.x

OECD (2001). *Measuring Productivity, OECD Manual, Measurement of Aggregate and Industry-Level Productivity Growth*.

Olley, G. S., & Pakes, A. (1996). The Dynamics of Productivity in the Telecommunications Equipment Industry. *Econometrica*, *64*(6), 1263–1297. https://doi.org/10.2307/2171831

Pilat, D., & Lee, F. (2001). Productivity Growth in ICT-producing and ICT-using Industries: A Source of Growth Differentials in the OECD? *OECD Science, Technology and Industry Working Papers*, *4*. https://doi.org/10.1787/774576300121

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, *70*(1), 65–94. https://doi.org/10.2307/1884513

Solow, R. M. (1957). Technical Change and the Aggregate Production Function. *Review of Economics and Statistics*, *39*(3), 312–320. https://doi.org/10.2307/1926047

Storm, S. (2017). The New Normal: Demand, Secular Stagnation, and the Vanishing Middle Class. *International Journal of Political Economy*, *46*(4), 169–210. https://doi.org/10.1080/08911916.2017.1407742

Timmer, M., van Moergastel, T., Stuivenwold, E., Ypma, G., O'Mahony, M., & Kangasniemi, M. (2007). *EU KLEMS Growth and Productivity Accounts. Version 1.0. Part I. Methodology*. EU KLEMS Consortium. https://doi.org/10.1111/j.1468-0297.2009.02280.x

Vu, K. (2011). ICT as a Source of Economic Growth in the Information Age: Empirical Evidence from the 1996–2005 Period. *Telecommunication Policy*, *35*(4), 357–372. https://doi.org/10.1016/j.telpol.2011.02.008

Vu, K., & Amann, J. (2024). An Analysis of ICT Hardware Manufacturing in Industrialized Economies: Growth Patterns, Productivity Performance, and Driving Forces. *Telecommunication Policy*, *48*(1), Article 102675. https://doi.org/10.1016/j.telpol.2023.102675

Appendix

Table A1.
Yearly and compound GVA growth rates at total economy (TOT), manufacturing section (C), and manufacturing of computer, electronic and optical products division (C26) levels for countries and country aggregates included in the study[a]

			GVA yearly growth rates												GVA compound growth rates		
		NACE code	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2009–2014	2015–2020	2009–2020
1	Austria	TOT	-0,04281	0,018978	0,032125	0,005276	0,001428	0,006795	0,008416	0,019336	0,022893	0,025855	0,014605	-0,06687	2,03	2,12	4,20
		C	-0,1593	0,078065	0,069808	0,020186	0,002602	0,02212	0,008503	0,042643	0,031743	0,043634	0,009645	-0,05991	1,37	7,47	8,94
		C26	-0,07665	0,020355	0,170215	0,012487	0,069279	-0,01522	-0,04714	0,123797	0,031066	0,138314	0,053976	-0,0785	17,54	22,06	43,48
2	Belgium	TOT	-0,02042	0,028434	0,019651	0,007854	0,004118	0,01668	0,021986	0,009375	0,015509	0,018117	0,022207	-0,05426	5,69	3,11	8,97
		C	-0,09117	0,059172	0,001291	-0,01585	0,010305	0,030692	0,026918	-0,01658	0,01523	-0,00123	0,035448	-0,03757	-1,22	2,05	0,80
		C26	-0,52751	0,085739	0,097351	0,108023	-0,04582	0,068511	-0,03621	0,130142	0,046371	-0,06354	0,066722	-0,09015	-36,40	3,59	-34,12
3	Czechia	TOT	-0,05424	0,029583	0,01741	-0,00842	-0,00016	0,028181	0,047087	0,024676	0,050701	0,033521	0,029625	-0,05408	0,99	13,48	14,60
		C	-0,13312	0,110176	0,104852	-0,04113	-0,01264	0,03513	0,073096	0,044718	0,083104	0,018689	0,045766	-0,12088	4,21	13,72	18,50
		C26	-0,14149	0,351874	0,109656	0,054396	-0,0708	0,049369	0,080568	0,065605	0,164148	0,132193	-0,05989	0,038808	32,41	48,21	96,25
4	Germany	TOT	-0,0642	0,042711	0,03799	0,005221	0,004602	0,022277	0,012009	0,022289	0,027536	0,009369	0,008276	-0,03948	4,56	3,92	8,66
		C	-0,2145	0,174718	0,080029	-0,01813	-0,00063	0,048771	0,010758	0,038342	0,035518	0,008999	-0,01272	-0,08409	2,56	-0,84	1,70
		C26	-0,21609	0,177586	0,173647	0,011088	0,012459	0,057678	0,087557	0,053105	0,008864	0,074756	0,02651	-0,02666	17,31	24,08	45,55
5	Greece	TOT	-0,03441	-0,05854	-0,09612	-0,0602	-0,0209	-0,0017	0,000729	-0,00833	0,017294	0,012618	0,01326	-0,09367	-24,52	-6,12	-29,14
		C	-0,0445	-0,14339	-0,13536	-0,08947	-0,09036	0,022966	0,018194	-0,04117	0,044476	0,055832	0,016263	0,072355	-40,04	17,33	-29,65
		C26	-0,24617	0,265485	-0,32208	0,181468	-0,14386	0,059485	0,025988	0,080081	0,057636	0,117733	-0,03326	-0,06979	-30,69	17,80	-18,35
6	Finland	TOT	-0,09017	0,031833	0,018908	-0,01921	-0,01059	-0,00308	0,003961	0,02575	0,035557	0,007351	0,014641	-0,02297	-7,46	6,50	-1,45
		C	-0,26414	0,073146	0,000501	-0,1231	0,008188	-0,00891	0,003671	0,047868	0,071697	-0,04398	0,031063	-0,02496	-30,77	8,33	-25,01
		C26	-0,3553	0,018938	-0,23664	-0,71635	0,389894	0,056232	-0,08112	0,092449	0,052368	-0,30976	0,095416	0,212915	-79,12	-3,12	-79,77
7	France	TOT	-0,0266	0,017266	0,02214	0,005632	0,006174	0,011055	0,008989	0,009635	0,021523	0,018669	0,018744	-0,08199	3,54	-0,86	2,65
		C	-0,06015	0,023333	0,039626	-0,00246	-0,00114	0,016037	0,006656	0,008535	0,02214	0,016471	0,020425	-0,13554	1,23	-6,95	-5,81
		C26	-0,06847	0,198937	0,037171	0,046812	0,08516	0,038631	0,000539	0,023638	0,033825	0,039371	0,095867	-0,12983	36,67	4,94	43,43
8	Italy	TOT	-0,056	0,018105	0,007268	-0,02711	-0,01574	0,000536	0,008667	0,013489	0,015908	0,009292	0,004879	-0,08819	-7,25	-3,96	-10,92
		C	-0,20429	0,090044	0,015989	-0,0408	-0,01347	0,002223	0,025088	0,029302	0,034164	0,017091	-0,00445	-0,14396	-16,43	-5,42	-20,95
		C26	-0,14901	0,074789	-0,03691	-0,03628	-0,07571	-0,02189	0,028836	-0,05673	0,021043	0,013074	0,011047	-0,01079	-23,25	0,40	-22,95

			GVA yearly growth rates												GVA compound growth rates		
		NACE code	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2009–2014	2015–2020	2009–2020
9	Netherlands	TOT	-0,03359	0,014989	0,018539	-0,00797	0,002631	0,014284	0,016901	0,019473	0,028886	0,022933	0,019981	-0,04138	0,79	6,69	7,53
		C	-0,10623	0,04229	0,044256	-0,00942	-0,00939	0,023519	0,007118	0,021292	0,059058	0,038946	0,004012	-0,02286	-2,30	11,03	8,48
		C26	-0,11786	-0,03141	0,061711	0,021397	0,067689	0,059014	-0,10298	-0,01124	0,049186	0,085702	0,003304	-0,03928	4,77	-2,62	2,03
10	Sweden	TOT	-0,04852	0,058878	0,035809	-0,00512	0,011632	0,027002	0,04264	0,016509	0,02736	0,01985	0,020561	-0,02602	7,87	10,38	19,06
		C	-0,26397	0,195517	0,056639	-0,07424	-0,03521	-0,01142	0,054162	0,004611	0,036917	0,023414	-0,01848	-0,05747	-17,90	3,97	-14,65
		C26	-0,29768	-0,16404	-0,18763	0,235624	-0,03033	-0,09733	-0,0615	-0,03406	0,054985	0,062414	-0,01178	-0,08891	-48,42	-8,52	-52,81
11	UK	TOT	-0,04606	0,025615	0,011315	0,016763	0,01711	0,031908	0,021605	0,022511	0,024783	0,016021	0,017108	-0,11172	5,59	-1,73	3,76
		C	-0,09346	0,014894	-0,01224	0,02283	0,037392	0,030528	0,007414	-0,00611	0,012084	0,042057	0,011728	-0,09117	-0,63	-2,90	-3,51
		C26	0,052711	-0,00448	0,044001	0,011552	0,06336	-0,00389	-0,14509	0,105857	0,03401	0,017105	-0,01262	-0,12285	17,23	-13,89	0,95
12	EU19	TOT	-0,00054	0,00028	0,000235	-5E-05	2,17E-06	0,00011	0,000152	0,000183	0,000252	0,000153	0,000105		0,00	0,08	0,09
		C	-0,00173	0,001045	0,0005	-0,00027	-3,5E-05	0,000257	0,000198	0,000283	0,000388	0,000102	-9,6E-05		-0,02	0,09	0,06
		C26	-0,00197	0,001258	0,000805	-0,0004	0,000324	0,000286	0,000297	0,000377	0,000311	0,000376	-0,00721		0,03	-0,59	-0,56
13	US	TOT	-0,02632	0,023389	0,013771	0,021122	0,014508	0,02239	0,026278	0,016786	0,021484	0,027743	0,023471	-0,00041	6,99	12,07	19,91
		C	-0,10606	0,056714	0,002906	-0,00447	0,02815	0,017707	0,012819	-0,00255	0,030134	0,042801	0,016465	-0,02246	-1,31	7,83	6,41
		C26	0,019996	0,127783	0,024351	0,03674	0,027384	0,0489	0,078328	0,032156	0,049587	0,097256	0,017134	0,033319	31,65	34,72	77,36
14	Japan	TOT	-0,06004	0,039309	-0,00179	0,016227	0,016158	0,003826	0,014372	-0,00428	0,018713	0,005485			1,09	3,46	4,58
		C	-0,18366	0,153872	-0,02795	0,033902	-0,01392	0,023705	0,040832	-0,01568	0,029086	0,013207			-4,44	6,82	2,08
		C26	-0,14439	0,222809	0,029712	-0,02227	-0,03585	0,05219	0,057216	-0,02541	-0,01524	0,010258			6,86	2,51	9,54
15	Poland	TOT	0,03071	0,03706	0,04624	0,01368	0,01193	0,03312	0,03997	0,03063	0,04573	0,05165	0,0451	-0,02609	18,52	19,98	42,19
		C	0,0179	0,0805	0,07578	0,02597	0,00162	0,07971	0,07522	0,04818	0,0209	0,06434	0,03838	-0,07488	31,28	17,64	54,44
		C26-27	0,02895	0,38913	0,0616	0,03896	-0,0163	0,13783	0,00789	0,04296	-0,00495	0,2056	0,06735	0,06902	76,46	43,89	153,90

Note: Data are in NACE Rev. 2 system. EU19 is the aggregate of the 19 EU member states that were in the Euro Zone at the time of the EU KLEMS 2023 release. Blank cells indicate a lack of data.[a] Polish data are for division aggregate C26–27, and not division C26.
Source: own elaboration based on EU KLEMS 2023 release[24], and Statistics Poland site.

[24] Luiss Lab of European Economics (2023), EUKLEMS & INTANProd – Release 2023, https://euklems-intanprod-llee.luiss.it/

Table A2.

Yearly and compound MFP contributions at total economy (TOT), manufacturing section (C), and manufacturing of computer, electronic and optical products division (C26) levels for countries and country aggregates included in the study[a]

			MFP yearly contributions												MFP compound contributions		
		NACE code	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2009-2014	2015-2020	2009-2020
1	Austria	TOT	-0,03218	0,012479	0,012972	0,000867	-0,00163	0,003869	0,004129	0,001606	0,009752	0,006585	-0,00256	-0,0089	-0,43	1,05	0,62
		C	-0,12749	0,07174	0,053646	0,002752	-0,00451	0,012509	-0,00113	0,02914	0,014683	0,018368	-0,00961	-0,02838	-0,42	2,22	1,79
		C26	-0,03234	0,117603	0,166128	-0,01989	0,056334	-0,02763	-0,05811	0,095044	-0,00595	0,078832	0,000404	-0,07782	26,96	2,04	29,56
2	Belgium	TOT	-0,01793	0,015531	-0,00154	0,000393	0,000941	0,007853	0,011985	-0,00666	-0,00481	-0,00068	0,00322	-0,01739	0,49	-1,45	-0,96
		C	-0,02654	0,064327	-0,00761	-0,00381	0,024579	0,048945	0,02801	-0,01653	0,004365	-0,00881	0,027323	-0,00456	10,08	2,93	13,30
		C26	-0,2507	0,123126	0,088841	0,141191	-0,00467	0,098393	-0,01611	0,102473	0,035723	-0,02415	0,061909	-0,04231	14,32	11,50	27,46
3	Czechia	TOT	-0,05818	0,012974	0,001283	-0,0147	-0,01978	0,010372	0,030669	-0,00459	0,029989	0,008472	0,013533	-0,01764	-6,78	6,10	-1,09
		C	-0,08335	0,104873	0,073436	-0,05611	-0,05606	0,014336	0,040197	0,010522	0,066595	-0,00906	0,040996	-0,06301	-1,75	8,37	6,47
		C26	-0,09986	0,344966	0,078056	-0,02929	-0,19007	0,020529	-0,00019	-0,02161	0,097055	0,100012	-0,01372	0,071083	4,72	24,70	30,59
4	Germany	TOT	-0,05264	0,025038	0,022864	-4,3E-05	0,002203	0,015662	0,000218	0,010764	0,01511	-0,00247	-0,00126	-0,01564	1,10	0,64	1,75
		C	-0,15672	0,15533	0,051109	-0,02432	-0,00767	0,032024	-0,00081	0,032749	0,023861	-0,00684	-0,02451	-0,05775	2,32	-3,55	-1,31
		C26	-0,1353	0,163848	0,137353	0,007746	0,011455	0,045576	0,063263	0,044892	0,005209	0,055629	0,011584	-0,01136	21,99	17,90	43,82
5	Greece	TOT	-0,03603	-0,03845	-0,06959	-0,04229	-0,0158	0,004592	0,030429	-0,0288	0,019823	-0,01679	0,018651	-0,0165	-18,34	0,53	-17,91
		C	-0,02161	-0,0504	-0,09615	-0,05072	-0,05082	0,017973	0,076861	-0,06862	0,066464	0,023854	0,001607	0,111892	-22,98	21,96	-6,06
		C26	-0,13084	0,16352	-0,30461	0,326766	-0,094	0,004403	0,068198	0,006294	0,146569	0,199537	-0,0598	-0,03681	-15,09	33,88	13,67
6	Finland	TOT	-0,0706	0,026933	0,006354	-0,02288	-0,00553	-0,00347	0,002247	0,019959	0,024715	-0,01322	-0,0002	-0,01641	-6,99	1,65	-5,46
		C	-0,19354	0,092858	-0,00153	-0,10923	0,054784	0,022391	0,024635	0,064783	0,073561	-0,04444	0,035081	-0,01203	-15,47	14,45	-3,25
		C26	-0,3258	0,0328	-0,20004	-0,6887	0,535056	0,137887	-0,00959	0,167042	0,14482	-0,24921	0,14538	0,265947	-69,71	44,05	-56,37
7	France	TOT	-0,02486	0,005832	0,007601	-0,0047	0,000498	0,002623	-0,00319	-0,00322	0,014436	-0,00115	-0,00032	-0,03709	-1,33	-3,09	-4,38
		C	-0,0192	0,04435	0,032367	-0,00952	0,007278	0,013094	0,005496	0,003462	0,029517	0,000727	-0,00792	-0,08007	6,88	-5,13	1,40
		C26	0,032517	0,209849	0,077957	0,063704	0,091321	0,026388	-0,01828	0,020729	0,038438	0,005161	0,083787	-0,10358	60,44	1,62	63,04
8	Italy	TOT	-0,04038	0,01516	0,001524	-0,01487	-0,00342	-0,00104	0,002413	0,001946	0,005406	-0,00113	0,001962	-0,01256	-4,31	-0,21	-4,51
		C	-0,13019	0,096196	0,009001	-0,01043	0,001712	0,005643	0,020978	0,011398	0,018742	0,000463	-0,0106	-0,05852	-4,10	-1,96	-5,98
		C26	-0,11037	0,063145	-0,05818	-0,01356	-0,07123	0,013408	0,036954	-0,05109	-0,0063	-0,00528	0,01003		-17,30	-1,76	-18,75
9	Netherlands	TOT	-0,03105	0,019112	0,006852	-0,00885	-0,00652	0,005802	-0,00349	-0,00233	0,004673	-0,00054	-0,00891	-0,03528	-1,53	-4,55	-6,01
		C	-0,08142	0,049487	0,042674	-0,00435	-0,00377	0,018032	0,007927	0,014676	0,048647	0,019088	-0,02616	-0,01184	1,50	5,17	6,75
		C26	-0,08059	-0,00982	0,098464	0,046795	0,07541	0,049994	-0,15478	-0,0539	0,012417	0,019517	-0,04966	-0,05787	18,20	-26,10	-12,65

			MFP yearly contributions												MFP compound contributions		
		NACE code	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2009-2014	2015-2020	2009-2020
10	Sweden	TOT	-0,04764	0,037987	0,013737	-0,01554	0,000969	0,010831	0,024838	-0,01014	0,007151	-0,0027	0,009272	-0,02008	-0,18	0,77	0,59
		C	-0,17115	0,223861	0,07715	-0,06387	-0,02865	-0,01348	0,049216	-0,00728	0,014237	0,015865	-0,02222	-0,03992	-1,98	0,74	-1,25
		C26	-0,14509	-0,02379	0,136902	0,191392	-0,04949	-0,09285	0,121227	-0,0077	0,079714	0,020366	-0,03174	-0,07934	-2,53	9,27	6,51
11	UK	TOT	-0,04102	0,021467	-0,00413	-0,00254	0,000193	0,007346	0,009526	0,000391	0,011807	0,003094	0,000824	-0,03788	-1,96	-1,30	-3,24
		C	-0,0371	0,025345	-0,01073	0,016945	0,038143	0,031801	-7,6E-05	-0,01028	0,001472	0,027313	0,012215	0,001574	6,39	3,22	9,82
		C26	0,137807	0,026753	0,013758	0,010003	0,049984	0,007887	-0,06484	0,122335	0,033056	0,012874	-0,0436	-0,05926	26,59	-1,19	25,08
12	EU19	TOT	-0,00062	-0,00034	-0,00023	-0,00028	-0,00022	-6,9E-05	-0,00028	-0,0003	-0,00013	0,001698	0,011222		-0,17	1,22	1,04
		C	-0,00076	0,001105	0,000359	-0,00021	2,87E-05	0,000258	3,53E-05	-4,8E-05	0,000213	0,000963	0,005191		0,08	0,64	0,71
		C26	0,000341	0,001769	0,00139	-0,00021	0,000601	0,000791	0,000574	0,000366	5,47E-05	0,003245	-0,00272		0,47	0,15	0,62
13	US	TOT	-0,00107	0,016553	-0,00518	0,002119	-0,00298	0,003206	0,006939	-0,00296	0,006967	0,006735	0,005335	0,010824	1,26	3,43	4,73
		C	-0,04423	0,052689	-0,01113	-0,02901	0,010829	0,006168	0,001805	-0,01722	0,018195	0,022885	0,006014	-0,00917	-1,74	2,21	0,43
		C26	0,077461	0,132837	0,018179	0,026583	0,034773	0,050603	0,074675	0,028	0,034539	0,094028	0,018805	0,006083	38,70	28,17	77,76
14	Japan	TOT	-0,03688	0,030601	0,000407	0,007423	0,023641	-0,00046	0,006424	-0,01179	0,001671	0,009406			2,35	0,56	2,93
		C	-0,09884	0,139192	-0,02022	0,028448	0,012264	0,022483	0,035462	-0,02481	0,014903	-0,00253			7,07	2,22	9,45
		C26	-0,06096	0,228732	0,038916	0,034856	0,004381	0,07241	0,05905	-0,01947	-0,01735	-0,00788			33,62	1,24	35,27
15	Poland	TOT	0,00699	0,0154	0,00829	-0,01054	-0,01642	-0,00931	0,01467	0,01005	0,0275	0,03684	0,02727	-0,0383	-0,60	7,87	7,22
		C	0,02014	0,07425	0,03912	0,02482	-0,01885	0,04475	0,05167	0,00456	-0,01621	0,0416	0,02809	-0,05847	19,63	4,79	25,36
		C26-27	0,03288	0,37058	0,01779	0,00255	-0,01414	0,0989	0,00695	-0,01704	-0,02292	0,2081	0,02412	0,03555	56,49	23,91	93,91

Note: Data are in NACE Rev. 2 system. EU19 is the aggregate of the 19 EU member states that were in the Euro Zone at the time of the EU KLEMS 2023 release. Blank cells indicate a lack of data.[a] Polish data are for division aggregate C26–27, and not division C26.

Source: own elaboration based on EU KLEMS 2023 release, and Statistics Poland site.