Productivity slowdown in Austria between 1995 and 2019

Industry-level analysis using EU KLEMS data

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REPORTS 03/2023

March 2023

Abstract This report analyses productivity growth in Austria between 1995 and 2019 using aggregate and industry-level data. We combine two vintages of the EU KLEMS dataset, which provide information on output and productivity growth and growth components for up to 30 countries and 42 industries. We compare Austria's productivity growth with that of peer countries, focusing on developed European small open economies.

The analysis confirms the productivity slowdown for Austria, similar to many other developed countries. The productivity growth rates in the most recent part of the sample have not recovered to their pre-financial crisis values. The effect of changing industry composition on productivity growth in Austria was positive and relatively small throughout the sample period, while the decline in productivity growth within industries, both in manufacturing and service sector, was more important. The international comparison shows that the aggregate development in Austria was similar to that of the peer country groups, with higher productivity growth in the years before and during the financial crisis. However, the industry-level evidence shows some important differences for Austria.

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Research assistance: Anna Brunner. Helpful comments by Robert Stehrer are acknowledged.

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Summary

In this report, we analyze and discuss the productivity growth in Austria over the period from the mid-1990s using aggregate and industry-level data. We combine two vintages of the EU KLEMS data, the EUKLEMS & INTANProd data base published by Luiss–Lab of European Economics (Release 2021) and an older version of EU KLEMS published by the Vienna Institute for International Economic Studies (Release 2019). These datasets provide information on output and productivity growth and growth components for up to 42 industries consistent with the NACE Rev. 2 industry classification. We compare the productivity growth in Austria to selected countries and country groups, in particular to developed small open economies within the EU.

The analysis of the EU KLEMS data confirms earlier findings of declining productivity growth for Austria, as the growth rates in the most recent years have not recovered to the values before the global financial crisis of 2007–2008.

- Real aggregate value-added growth declined from the annual average of 2.4% in the first ten years of the sample (1996–2005) to 1.9% in the most recent five years (2015–2019). Average labor productivity growth declined from 1.8% to 0.6% and average total factor productivity growth declined from 0.7% to 0.4% for the same periods.
- The decline in labor productivity growth of -1.2 pp can be decomposed into the reduced contribution of total factor productivity (-0.3 pp), the contribution of labor input composition (-0.5 pp), and the reduced contribution of (tangible) capital (-0.4 pp).
- The international comparison shows that the development in Austria was similar to the reference country groups, with consistently higher productivity growth in the years around the financial crisis.
- The slowdown in productivity growth in Austria was not the result of structural changes, such as the declining importance of manufacturing. The effect of changing industry composition on productivity growth in Austria was positive and relatively small throughout the sample period, while the decline in productivity growth within the individual industries, both in manufacturing and service sector, was more important.

The analysis shows that the aggregate productivity slowdown in Austria can be attributed to a decline in productivity growth in many of the industries where productivity growth was high prior to the financial crisis. These include industries in both manufacturing (Repair and installation of machinery and equipment, other manufacturing; Manufacturing of basic metals and metal products; Manufacturing of rubber and plastic products; Manufacturing of pharmaceutical products; Manufacturing of textiles and wearing apparel; Manufacturing of computer, electronic and optical products) and services (Financial and insurance activities, Wholesale and retail trade, Air transport, etc.). This wide-spread decline in productivity growth was only partly offset by the increased productivity growth of some service industries, such as Telecommunications and Professional, scientific and technical activities.

International comparison shows some differences in the contributions of industries to the aggregate productivity growth. In line with the evidence for Austria, other countries also experienced a decline in labor productivity growth in both manufacturing and service industries. In contrast to Austria, the decline of productivity growth in the manufacturing sector was more concentrated in a single industry, Manufacturing of computer, electronic and optical products. In the service sector, the experience was more varied across countries, with Austria facing particularly large declines in the contributions from Financial and insurance activities and Construction.

1. Introduction

Productivity and productivity growth are central economic concepts that relate the value created by economic activity to scarce production inputs. In the long run, gains in productivity reflect technological progress, innovation, better allocation of resources and improvements of production processes. While increases in economic productivity do not necessarily translate one-to-one into increased welfare of all individuals, productivity is an important determinant of the overall welfare in society.[1] A large body of literature has documented a gradual decline of productivity growth since the 1960s and 1970s for EU countries, including Austria, see for example ECB (2021), Deutsche Bundesbank (2021). The productivity slowdown over the last three decades is particularly puzzling in the context of major technological changes and the ICT revolution.

In this report, we analyze and discuss productivity growth in Austria over the period since the mid-1990s, using aggregate and industry-level data. We compare Austria with other countries, focusing on developed European small open economies. We assess the role of structural change and decompose the decline in productivity growth into the contributions of individual industries.

Various measures of productivity are used by economists depending on data availability and purpose.[2] Probably the most commonly used productivity measures are labor productivity and total factor productivity. Labor productivity (LP) relates output, most often measured in terms of real value added or GDP, to labor inputs (measured in hours worked or persons employed) and provides information on the efficiency with which the labor input is used in the economy. In addition to being relatively easy to calculate and less data-intensive, labor productivity plays an important role in various economic mechanisms, such as in wage bargaining. In comparison, total factor productivity (TFP) attempts to capture the joint efficiency of all production factors, including labor, capital, and sometimes intermediate inputs such as materials and energy. Ideally, with perfect measurement of inputs and outputs, TFP should approximate technological progress in the economy. In reality, TFP is measured as a residual that captures technological progress along with various measurement and composition effects, such as factor utilization.[3] Total factor productivity and its long-run trend component are often used as diagnostic tools by policymakers, for example in monetary policy.

Although partially overshadowed by the recent economic downturns caused by the COVID-19 pandemics and the Russian attack on Ukraine, national and international organizations have recognized that the productivity slowdown is a major challenge for developed economies with significant implications for economic sustainability and well-being in the long run. OECD (2021) reports a widespread decline in labor productivity and TFP growth across OECD countries and economic sectors since 2000. In most OECD countries, manufacturing industries contributed more to the productivity slowdown than business services. However, in some countries, including Austria, the contribution of business services to the slowdown was more pronounced.[4] ECB (2021) combines the aggregate, industry and firm-level evidence from various EU countries and concludes that the slowdown in aggregate productivity is mainly explained by the ability of firms to increase their efficiency (within-firm productivity growth) and by the reallocation of resources across firms operating in the same industry. Structural changes in the relative importance of sectors over the past three decades have played a smaller role. This is in line with the existing international literature, see for example Sorbe et al. (2018), Kierzenkowski et al. (2018), Coyle and Mei (2022).

[1] For a discussion see for example Oulton (2022).

[2] For an overview see OECD (2001).

[3] See e. g. Basu et al. (2006) and Fernald (2012).

[4] Other countries in which the productivity slowdown was mainly driven by lower contributions from business services according to OECD (2021) include Greece, Luxembourg, Baltic countries, and the United Kingdom.

Several explanations of the productivity puzzle at the level of individual firms or industries suggest a changing nature of the technological progress. These include the lower importance of recent technological breakthroughs compared to the past innovations (Gordon, 2012; Bergeaud et al., 2016), their delayed adoption in the production process due to increasing complexity and need for organizational changes (Brynjolfsson and McAfee, 2011; Baily et al., 2013), and the slower diffusion of technology innovations from the most technologically advanced firms to the rest of the economy (Akcigit and Ates, 2021; Andrews et al., 2016; OECD, 2015). ECB (2021) analyses the firm-level evidence from six euro area countries and finds that the widening gap between frontier and laggard firms is particularly important in the services sector. Berlingieri et al. (2020) find slower convergence of laggard firms in highly digital- and skill-intensive industries, suggesting that barriers to technology and knowledge diffusion may play an increasingly important role for productivity growth in the future.

Another view that has received particular attention in this context is that the analysis of recent productivity developments may be hampered by increasing measurement issues. New forms of production inputs and outputs, driven in particular by digitalization, as well as the growing importance of knowledge-based intangible assets, have added new measurement challenges and exacerbated the existing ones. While improved accounting for intangible assets, such as computer software, research activities, and other intellectual property products, is important for explaining the determinants of measured productivity growth,[5] existing evidence does not support the idea that the productivity puzzle is simply a consequence of increasing mismeasurement of inputs and outputs (Syverson, 2017; Ahmad et al. 2017).

Focusing on the evidence for Austria, Peneder and Prettner (2021) analyze firm-level data on labor productivity and TFP for the period 2008-2018 and find substantial heterogeneity in measured productivity and productivity growth within and across industries. Weyerstrass et al. (2021) review the productivity growth in Austria between 1996 and 2017 in the context of international competitiveness, but do not report industry-level results for Austria. In this study, we use the industry-level dimension of the EU KLEMS data and analyze the industry contributions to aggregate productivity growth for the period from 1995 to 2019. We compare the evidence across countries. The analysis of the determinants of productivity growth at the industry and firm level is beyond the scope of this study.

2. Data and methodology

A number of national and international institutions report time series data for various measures of productivity and productivity growth. Despite the widespread use of the concept of total factor productivity, the series from different data sources differ considerably. Figure 1 shows the comparison of the two productivity measures from standard data sources, which are all based on National Accounts information but are subject to methodological differences.[6] While the labor productivity series appear to be consistent across data sources, TFP growth shows differences of up to 1 percentage points, with even larger differences during economic downturns.

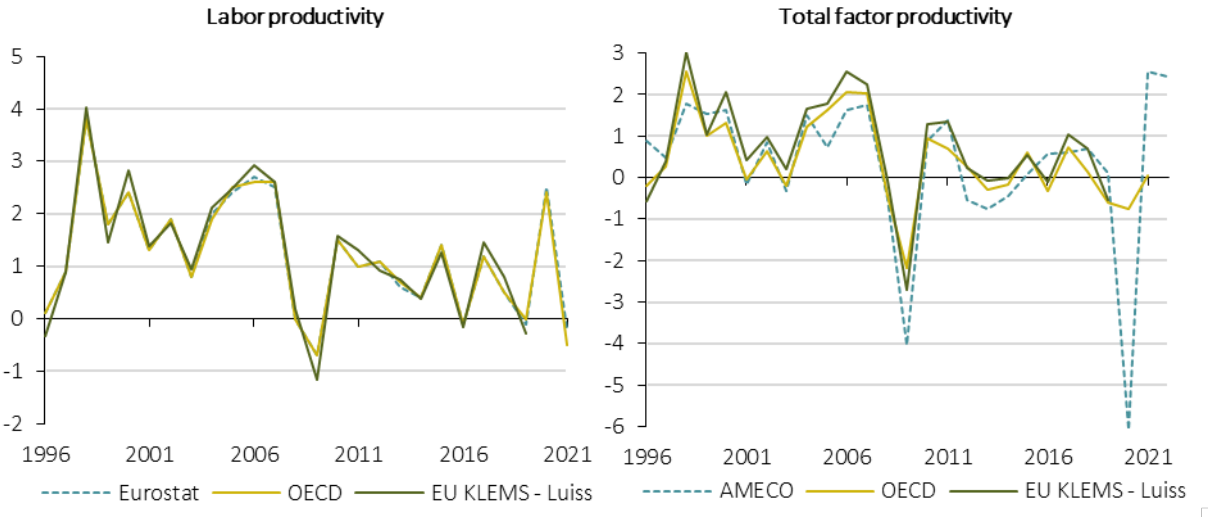
In this analysis, we work with the EU KLEMS data, which provide (1) a large number of productivity-related time series (2) disaggregated at the industry level, (3) a detailed and transparent description of the methodology, and (4) additional information in the analytical datasets. However, considering the discrepancies illustrated in Figure 1, the results of the analysis should be interpreted with caution and validated with additional sources whenever possible.

[5] For example, Adarov et al. (2022) show an important role of intangible ICT capital in driving labor productivity growth using the analytical version of the EU KLEMS data for 2000–2017.

[6] Compare EUKLEMS & INTANProd (2021), OECD Stats (2021), Havik et al. (2014).

Figure 1: **Growth rates of labor productivity and total factor productivity in Austria, comparison of time series from various data sources**

Growth rates in %



Sources: OECD (GDP per hour worked, constant prices; Multifactor productivity); AMECO (Total factor productivity: total economy); Eurostat (Real labor productivity per hour worked); EUKLEMS & INTANProd (Real value added per hour worked, TFP), own calculations. In line with the other data sources, we report the EUKLEMS TFP series including the effect of labor composition.

2.1 Data sources

In this analysis, we work with two different vintages of the EU KLEMS database. The primary data source is the most recent vintage of EUKLEMS & INTANProd (Release 2021) published by Luiss – Lab of European Economics (2021). Throughout this study, we refer to this dataset as the *Luiss data*. The dataset includes productivity and growth accounting information for 16 EU member states, the US, the UK, and Japan for the period 1995–2019. The data are provided for up to 42 industries consistent with the NACE Rev. 2 industry classification. However, the information is not complete with a number of missing industry-level series and incomplete aggregate growth accounting variables for some countries. Therefore, in some cases we supplement the Luiss data with the information from the older version of EU KLEMS (Release 2019) published by the Vienna Institute for International Economic Studies (wiiw, see Stehrer et al., 2019). Throughout this study, we refer to this dataset as the *wiiw data*. The dataset includes information for the 27 EU member states, UK, US, and Japan for the period 1995–2017. The industry-level information is provided at almost the same level of disaggregation as the Luiss data, with 40 detailed industries according to NACE Rev. 2, and the growth accounting dataset is nearly complete.

As we combine the data from the two sources in some cases, it is desirable to check their consistency. At the industry level and for total economy, the countries and variables included in both datasets are broadly consistent, with minor discrepancies towards the end of the sample due to data revisions. However, for some industry aggregates, such as market economy (MARKT), there are significant discrepancies between the data series. For this reason, we do not use the industry aggregates, but always calculate them using the bottom-up approach described in section 2.2. Finally, since the wiiw data end in 2017, averages across country groups are biased due to the missing observations in the last two years.

Both datasets provide two versions of the growth accounting variables, statistical and analytical. The aim of the analytical modules is to correctly account for additional investment in intangible capital, which is not fully accounted for in the National Accounts. In this analysis, we only use the statistical modules, which are based on National Accounts information and are therefore comparable with productivity estimates from other international institutions.

2.2 Growth accounting methodology

In this section, we briefly outline the basic principles of the growth accounting methodology following the EU KLEMS approach. More details on the methodology and data collection can be found in Stehrer et al. (2019), Jorgenson et al. (2005).

The growth accounting approach is based on the representation of production process in each industry by a production function that transforms industry-level capital services, labor input and intermediate inputs into industry output. Conditional on several standard assumptions,[7] changes in industry value added can be decomposed into contributions of capital, labor, and total factor productivity according to

$$\Delta \, ln \, VA_i \; = \; \bar{v}_i^K \Delta \, ln \, K_i + \; \bar{v}_i^L \Delta \, ln \, L_i + \Delta \, ln \, TFP_i, \tag{1}$$

where i denotes the industry, VA denotes real value added, L denotes labor input, K denotes industry capital stock, and TFP is the measured total factor productivity, identified as the residual. Parameters $\bar{v}_i^K$ and $\bar{v}_i^L$ are Divisia shares of capital and labour costs in value added,[8] and $\Delta \, ln \, x_t \; = \; ln \, x_t \; - \; ln \, x_{t-1}$ denotes the growth rate between periods t and $t-1$. The production inputs can be further broken down into categories. In our dataset, capital is differentiated into three asset types (intangible, tangible ICT, and tangible non-ICT capital). Labor input is differentiated according to educational attainment levels, age, and gender, where the groups differ in their average labor productivity.[9] The contribution of labor input can thus be decomposed into the contribution of labor volume (total working hours H) and labor composition (LC). The growth rate of industry labor productivity, computed as value added per hour worked, can be expressed as

$$\Delta \, ln \, VA_i - \Delta \, ln \, H_i \; = \; \bar{v}_i^K (\Delta \ln \mathrm{K}_i - \Delta \, ln \, H_i) + \; \bar{v}_i^L \Delta \ln \mathrm{LC}_i + \Delta \ln \mathrm{TFP}_i. \tag{2}$$

Following the approach of Coyle and Mei (2022), we use the Törnqvist aggregation in order to aggregate the industry-level series into aggregate quantities and to decompose the aggregate productivity growth into within-industry and reallocation components. We choose this decomposition approach as it is largely consistent with the dataset.[10] First, we use industry real gross value added (VA_i) to construct aggregate real gross value added (VA) through the weighted sum of log changes in industry gross value added:

$$\Delta \, ln \, VA = \sum_i \bar{\omega}_i \, \Delta \, ln \, VA_{i,} \tag{3}$$

[7] The growth accounting approach is based on several important assumptions: production function of translog form, competitive product and factor markets and constant returns to scale.

[8] Divisia shares satisfy $\bar{v}_i^K + \bar{v}_i^L = 1$. In the practical implementation, the Divisia shares are replaced by their discrete approximation, the Törnqvist shares: $\bar{\mathrm{v}}_i^X = 0.5(v_{i,t-1}^X + \; v_{i,t}^X)$, where $v_{i,t}^X$ is the nominal cost share of the production factor in value added in period t.

[9] The differences in labor productivity between demographic groups in KLEMS data are approximated using the wage information. This approach is based on the strong assumption that wage differentials reflect the actual quality of the labor force. However, wages depend on various factors, such as the institutional framework or discrimination (e.g., gender pay gap). For this reason, Stehrer et al. (2019) estimate composition based only on age-education structure (without gender dimension).

[10] A commonly used alternative is shift-share decomposition, which computes the contributions of industry LP growth using beginning-of-period real value-added shares. The main results of this paper hold when replicated using the (approximate) shift-share analysis.

where $\bar{\omega}_i$ is the average between periods t and $t-1$ of the share of nominal value added of the industry in the total nominal value added. Since aggregate total hours can be expressed as a simple sum of industry hours, we obtain the growth rate of aggregate labor productivity as

$$\Delta \ln \left(\frac{VA}{H}\right) = \Delta \ln VA - \Delta \ln H. \quad (4)$$

The growth rates of the aggregate labor productivity can then be decomposed into contributions of individual industries and the reallocation term R according to

$$\Delta \ln \frac{VA}{H} = \sum_i \bar{\omega}_i \Delta \ln \frac{VA_i}{H_i} + R, \quad (5)$$

with contribution of industry i given by $\bar{\omega}_i \Delta \ln \frac{VA_i}{H_i}$. Correspondingly, the aggregate growth rate of total factor productivity can be decomposed into industry components given by $\bar{\omega}_i \Delta \ln TFP_i$.

3. Aggregate productivity

In this section, we compare the aggregate labor productivity (LP) and aggregate total factor productivity (TFP) growth in Austria with other countries and country groups. Since the focus of the analysis is on medium- and long-term trends, we mostly discuss averages over defined subperiods and plot time series as their 5-year rolling averages[11], unless otherwise stated. We also focus on the periods before and after the financial crisis, which are less affected by the decline in measured productivity during the crisis. The analysis of the cyclical pattern of measured productivity, due to for example factor utilization and composition effects, is not the main focus of this study.

We report the results for two different aggregates: total economy (TOT), which relates closely to standard macroeconomic variables such as GDP and total hours worked, and market economy (MARKT), which focuses on production of market goods and services. The market economy excludes industries Public administration and defense, compulsory social security; Education; Human health and social work activities (O-Q); Real estate activities (L); Activities of households as employers (T), and Activities of extraterritorial organizations and bodies (U). Industries dominated by the public sector are often excluded from productivity analyses as the value of their output is typically measured based on the value of inputs. Real estate activities are excluded because their value added is distorted by the inclusion of imputed rents of owner-occupied dwellings. Owner-occupied dwellings are typically not considered productive capital and are produced without any labor input, thus artificially inflating the estimates of labor productivity in this sector.

In addition to the industries excluded from the MARKT aggregate, agriculture is sometimes excluded from similar analyses because productivity measures are distorted by, for example, the declining number of part-time farmers or weather conditions. Mining and quarrying industry is sometimes excluded because its importance in terms of natural resources varies widely across countries (EC 2021). In our analysis, we leave these two industries in the sample, and discuss their contribution in section 4.

[11] 5-year rolling average around year t is the simple mean of observations from year $t-2$ to $t+2$.

3.1 Aggregate productivity growth in Austria

Figure 2 plots the growth rates of aggregate value added, labor productivity and total factor productivity in Austria together with their 5-year rolling averages for total economy (TOT). The figure confirms earlier analyses reporting declining productivity growth as the growth rates in the latter part of the sample have not recovered to their levels before the financial crisis for all three variables. Value added growth declined from the annual average of 2.4% in the first ten years of the sample (1996–2005) to 1.9% in the most recent five years (2015–2019). Average labor productivity growth declined from 1.8% to 0.6% and average TFP growth declined from 0.7% to 0.4% for the same periods. Table 1 in Appendix reports the detailed results for Austria and selected countries and country groups. Further discussion and comparison of TFP and labor productivity series is provided in section 3.3.

Figure 3 shows that the same pattern holds for the market economy (MARKT), although the growth rates for the market economy are somewhat higher on average.[12] Between the initial period 1996–2005 and the most recent period 2015–2019, average value-added growth declined from 2.8% to 2.2%, labor productivity growth from 2.3% to 1.1%, and TFP growth from 1.1% to 0.8%. Importantly, the data show that the slowdown of productivity growth is comparable in market and total economy. Thus, the aggregate slowdown is not primarily driven by developments in real estate markets, public sector, or other non-market economy industries.

Figure 2: **Aggregate output and productivity growth in Austria, 1996–2019**

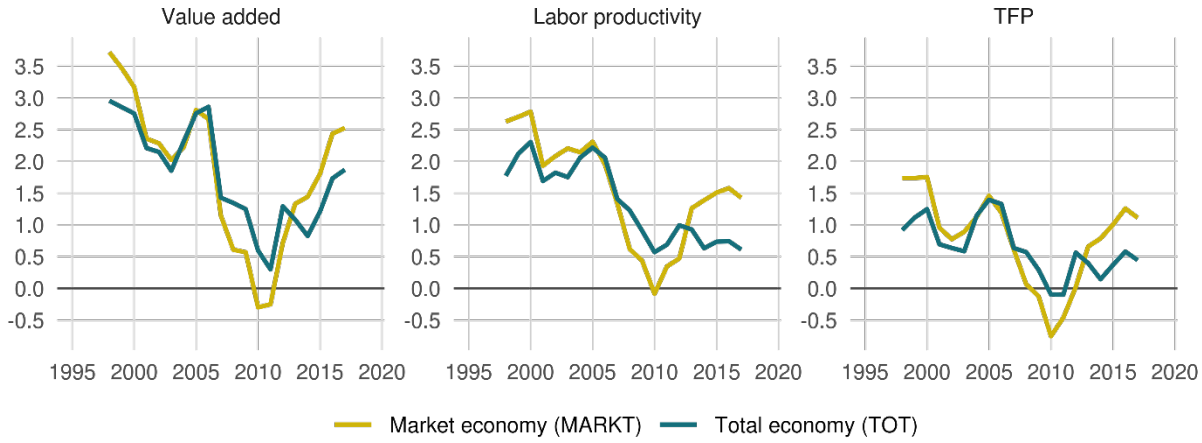
Growth rates in %

Source: EUKLEMS & INTANProd (Luiss), own calculations.

[12] See Table 2 in Appendix for detailed results for Austria and selected countries and country groups.

Figure 3: **Output and productivity growth in Austria, total and market economy, 1996-2019**

5-year rolling averages, rates in %



Source: EUKLEMS & INTANProd (Luiss), own calculations.

3.2 Comparison of productivity growth in Austria and selected countries

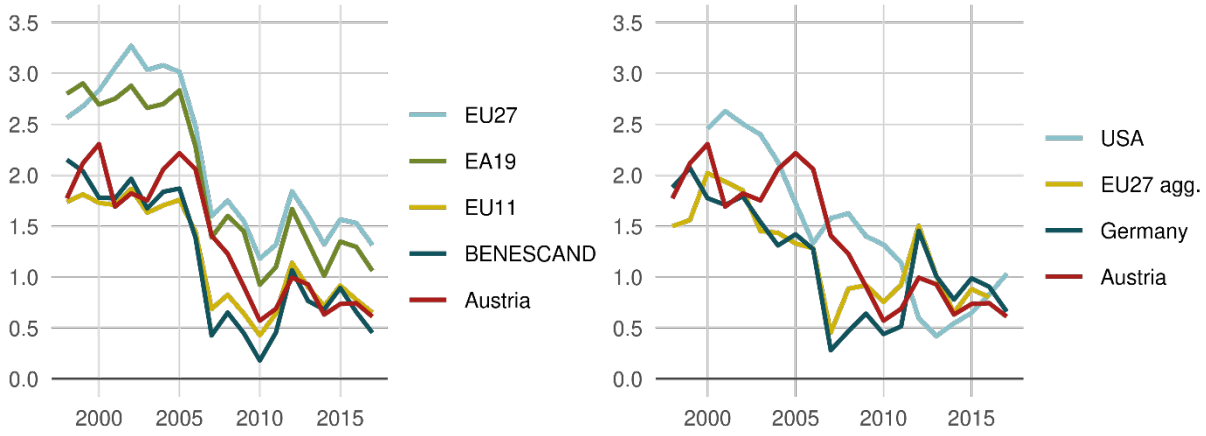
In this section, we compare productivity growth in Austria with selected countries and country groups. Besides the EU27 (2020) and Euro Area (EA19) country groups, we define two additional groups that are particularly relevant benchmarks for Austria. BENESCAND is a group of high-performing small open economies within the EU, consisting of Belgium, Denmark, Finland, the Netherlands, and Sweden. EU11 is a group of 11 countries, mostly old EU members, consisting of Austria, Belgium, the Czech Republic, Germany, Denmark, Spain, Finland, France, Italy, the Netherlands, and Sweden. The choice of countries in the EU11 group is driven by data availability – for these countries, EU KLEMS data are available from at least 1998. Since the most recent vintage of the EU KLEMS (Luiss data) does not include growth accounting information for all EU countries, we supplement the data with the additional information from the older vintage (wiiw data), which ends in 2017. Therefore, the international comparisons should be interpreted with caution, especially towards the end of the sample period. In the case of the EU27 group, this concerns 7 countries: Denmark, Greece, Ireland, Poland, Romania, Slovakia, and Slovenia. Moreover, we exclude Cyprus, Luxembourg, and Malta from the EU27 and EA19 due to data issues. Unless otherwise stated, we report simple averages across country groups and ignore missing values.

Figure 4 shows the comparisons for aggregate labor productivity growth. The left panel shows that the growth rates for Austria are similar to those of the EU11 and BENESCAND groups, although Austria performed better in the years around the financial crisis. The consistently higher growth for the EU27 and EA19 country averages can be attributed to the fast growth of the new member states. The right panel of the figure shows the comparison with the US, Germany, and the EU27 aggregate.[13] Again, the growth rates for Germany and the EU27 are comparable to Austria, except for the years around the financial crisis. The US economy, although starting from higher growth rates before the financial crisis (2.4% in 1998–2005), also experienced a sharp slowdown and only returned to an average annual growth of 1% in the most recent five years.

[13] Notice the difference between the EU27 average (simple average across countries) and the EU27 aggregate, which treats the EU27 (2020) countries as a geographic region, effectively weighting countries by their size. We use the EU27 aggregate data provided by the Luiss dataset.

Figure 4: **Aggregate labor productivity growth, Austria compared to selected countries and country groups, total economy, 1996–2019**

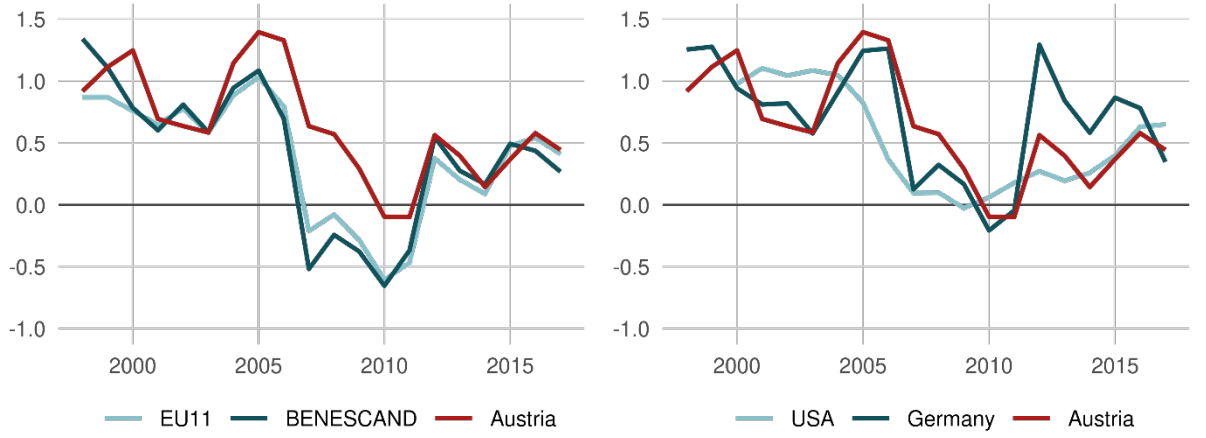
5-year rolling averages, rates in %



Source: EUKLEMS & INTANProd (Luiss), own calculations. — Country groups refer to simple averages across countries. In contrast to EU27 simple average (left panel), EU27 agg. (right panel) refers to aggregate EU27 (2020) geographic region (Luiss data). Data for DK, EL, IE, PL, RO, SI, SK supplemented from the wiiw dataset (available until 2017); Sweden data until 2017; ES, FR, HU, LT, LV until 2018; BG, EE, PT available from 2000 to 2018. Poland starting form 2001.

Figure 5: **Aggregate TFP growth, Austria compared to selected countries and country groups, total economy, 1996–2019**

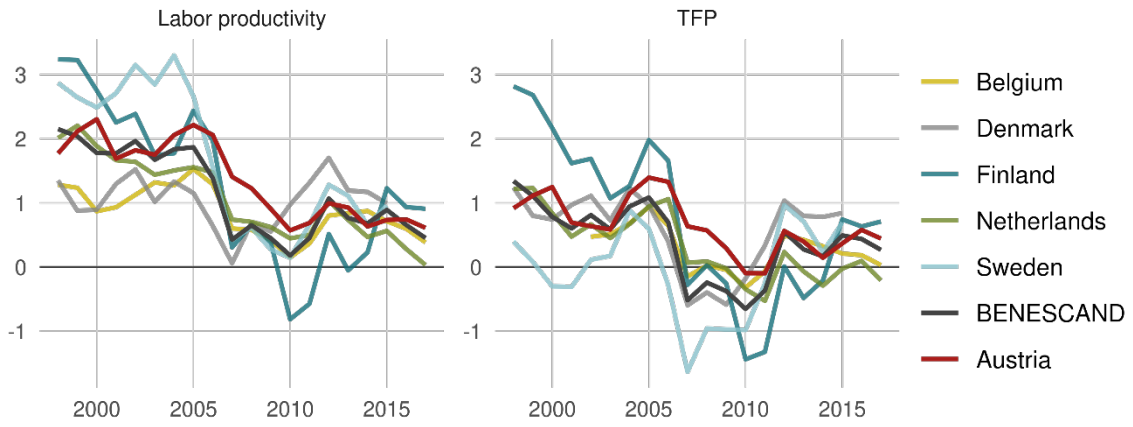
5-year rolling averages, rates in %



Source: EUKLEMS & INTANProd (Luiss), own calculations. — Country groups refer to simple averages across countries. Data for Denmark supplemented from the wiiw dataset (available until 2017); Sweden data until 2017; Spain, France until 2018; Belgium starting from 2000.

Figure 6: **Productivity growth in Austria and BENESCAND countries, total economy, 1996–2019**

5-year rolling averages, rates in %



Source: EUKLEMS & INTANProd (Luiss data), own calculations. — BENESCAND refers to simple average across countries. Data for Denmark supplemented from the wiiw dataset. Denmark and Sweden data until 2017, Belgium data (TFP growth) starting from 2000.

For aggregate total factor productivity, we are only able to compute the averages for the two smaller country groups due to data availability constraints. Growth rates for Austria are again similar to the BENESCAND and EU11 averages, with higher growth rates in the years around the financial crisis (Figure 5, left panel). Germany experienced faster TFP growth after the financial crisis but has returned to lower levels in the most recent five years. Interestingly, the TFP growth rates for the US economy according to the EU KLEMS dataset are comparable to Austria and other European countries throughout the whole sample period. Together with the evidence in Figure 4, this suggests that the higher labor productivity growth in the US economy before and during the financial crisis was driven by higher contributions of capital.

Finally, Figure 6 compares the productivity growth for the individual countries in the BENESCAND group. Although the average growth rates across BENESCAND countries are similar to those of Austria, there is a substantial heterogeneity within the group. At the beginning of the sample (1996–2000), Finland grew particularly fast with 3.2% (LP) and 2.8% (TFP) annually, but then experienced a sharp slowdown. Denmark and Belgium grew more slowly than Austria in the first ten years of the sample in terms of labor productivity (DK: 1.2%, BE: 1.3%) but caught up eventually. On the other hand, the Netherlands had growth rates close to the BENESCAND average in the first part of the sample and experienced growth rates close to zero in most recent five years (LP: 0.0%, TFP: -0.2%). For Sweden, the contrast between the high growth rates of labor productivity (2.9%) and low TFP growth rates (0.3%) in the first part of the sample is explained by the high contributions of capital and labor composition to labor productivity growth in the EU KLEMS dataset.

3.3 Components of aggregate output and productivity growth

In this section we discuss the decomposition of value-added growth following the EU KLEMS methodology, see section 2.2 for details. First, value-added growth can be decomposed into contributions of hours worked and labor productivity. Labor productivity contribution can be further decomposed into contributions of capital (intensity), labor composition, and total factor productivity. The labor composition term in the EU KLEMS data reflects changes in the educational attainment, age structure, and gender composition of the labor force. Although missing other important dimensions, it can be interpreted as a proxy measure for the average quality of the labor input. Capital is differentiated into three categories: tangible ICT assets, tangible non-ICT assets, and intangible assets. Tangible ICT assets include computer hardware and telecommunication equipment, while non-ICT assets include transport and machinery equipment, buildings, and other structures. Intangible assets include computer software and

databases, research activities, and other intellectual property products. Total factor productivity is measured as a residual.[14]

The top left panel of Figure 7 shows the value-added growth decomposition for Austria. The contribution of capital was relatively stable throughout the sample period. Intangible capital contributed about 0.2 pp on average. Tangible ICT capital contributed to growth in the 1990s and early 2000s by around 0.1 pp annually, but this effect has largely disappeared. The contribution of non-ICT tangible capital has declined from the 0.6 pp (1996–2005) due to low investment following the financial crisis but has partly recovered towards the end of the sample to 0.4 pp (2015–2019). Overall, the contribution of capital is still about 0.2 pp lower than at the beginning of the sample.

In general, the contribution of capital is similar for the other country groups in Figure 7, except for high contributions in the US in the early 2000s. In all cases, the contribution of capital in the most recent period is lower than in the initial part of the sample. Interestingly, the contribution of tangible ICT capital has declined in all country groups, while intangible assets kept contributing to output growth. This suggests that the digital transformation has to a large extent been a matter of knowledge-based assets and innovations, rather than an increase in the intensity of ICT-hardware investment.

Unsurprisingly, hours are strongly procyclical, with positive contributions in the recovery period after the financial crisis. While labor composition in Austria used to contribute positively in the 1990s and early 2000s (0.3 pp annually for 1996–2005), the estimated contribution turned negative in the most recent years, with -0.1 pp in the 2015–2019 period. While the contribution of labor composition to economic growth has declined to some extent for many countries in the sample, the change seems to be particularly important for Austria. The estimated effect of the demographic composition of the labor force on average productivity has decreased due to the ageing of the population and possibly due to other demographic changes, such as slower improvements in average educational attainment or the increasing participation rate of women. Further analysis of the labor composition and its impact on overall productivity growth is left for future work.

Finally, the contribution of measured TFP growth is identified as a residual that cannot be accounted for by the contributions of other factor inputs. As discussed in the previous section, TFP growth in Austria has slowed down by about 0.3 to 0.5 pp (depending on the periods considered), which is similar in magnitude to the reference country groups. For all countries, TFP shows a strongly cyclical pattern with low growth rates around the economic downturns. This confirms that in the medium run, together with technological progress, the residual captures various measurement and composition effects, such as factor utilization (e. g. labor hoarding and capital utilization), declining markups, and increasing returns to scale. However, technological progress is a substantial contributor to TFP and labor productivity improvements in the long run.

Overall, the difference in average growth of value added between the first ten years of the sample (1996–2005) and the most recent period (2015–2019) is 0.5 pp in the total economy. Compared to the mid-1990s, the contribution of TFP growth rate declined by 0.3 pp, the contribution of the labor composition declined by 0.5 pp, and the contribution of (tangible) capital declined by 0.2 pp. These declines were partly offset by the increased contribution of hours (+0.4 pp).

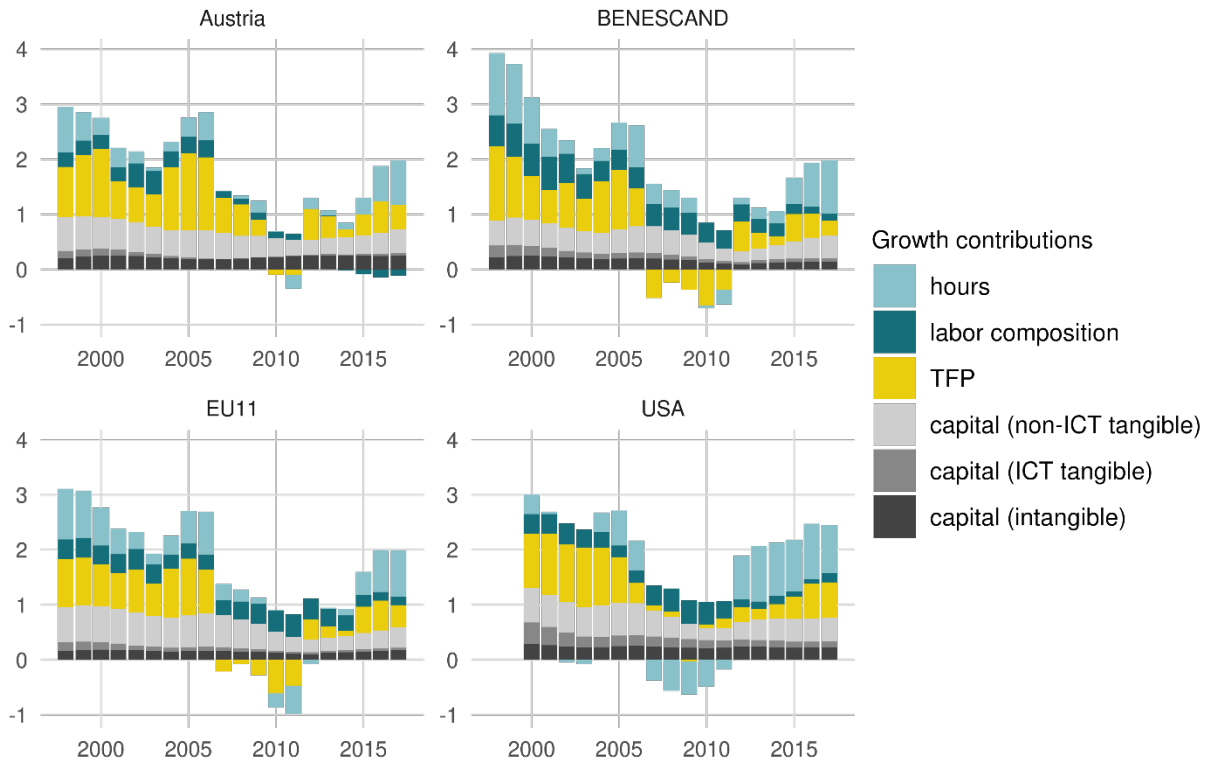
Expressing these values in terms of contributions to labor productivity growth (cf. equation 2), contribution of TFP growth rate declined by 0.3 pp, the contribution of labor composition declined by 0.5 pp, and the contribution of capital intensity declined by 0.4 pp. These numbers are broadly in line with the averages across the selected country groups, confirming that Austria's performance was similar to that of its peer countries.[15]

[14] Table 3 in the Appendix reports the detailed decomposition results for the selected country groups.

[15] Table 3b in the Appendix reports the detailed decomposition results for the selected country groups.

Figure 7: **Contributions to output growth, Austria, the USA, and selected country groups, 1996–2019**

5-year rolling averages, rates in %



Source: EUKLEMS & INTANProd (Luiss data), own calculations. — Country groups refer to simple averages across countries. Data for Denmark supplemented from the wiiw dataset (available until 2017); Sweden until 2017; Spain, France until 2018; Belgium starting from 2000.

4. Industry decomposition of productivity growth

We now turn to the analysis of productivity growth from the industry perspective. Aggregate productivity growth can be decomposed into the contributions of individual industries and changes in their composition following equation 5 in section 2.2. Structural change in the relative importance of economic sectors or industries, measured in terms of employment or output, affects the aggregate productivity growth because industries differ from each other with respect to their own productivity levels and productivity growth. Such differences reflect the intensity with which industries use skilled labor and capital in their production, the scope for product and process innovation, the absorption of external knowledge, the degree of product standardization, the scope for economies of scale, and the exposure to international competition through their participation in global value chains (OECD, 2021). Indeed, the share of manufacturing in Austria's value added has declined from more than 24% in the mid-1970s to less than 19% in 2019, and the share of agriculture, forestry, and fishing declined from roughly 5% to 1% over the same period.[16] However, most of these changes took place in the period up to the mid-1990s, prior to the start of our data sample.

4.1 Structural change and productivity growth in Austria

First, we assess the relative importance of changes in industry composition (reallocation) and the within-industry productivity changes for Austria. To gain some intuition about the overall role of the changing industry composition, we first compare the aggregate labor productivity growth in Austria to a counterfactual series, in which we keep the industry composition constant over time. The left panel of Figure 8

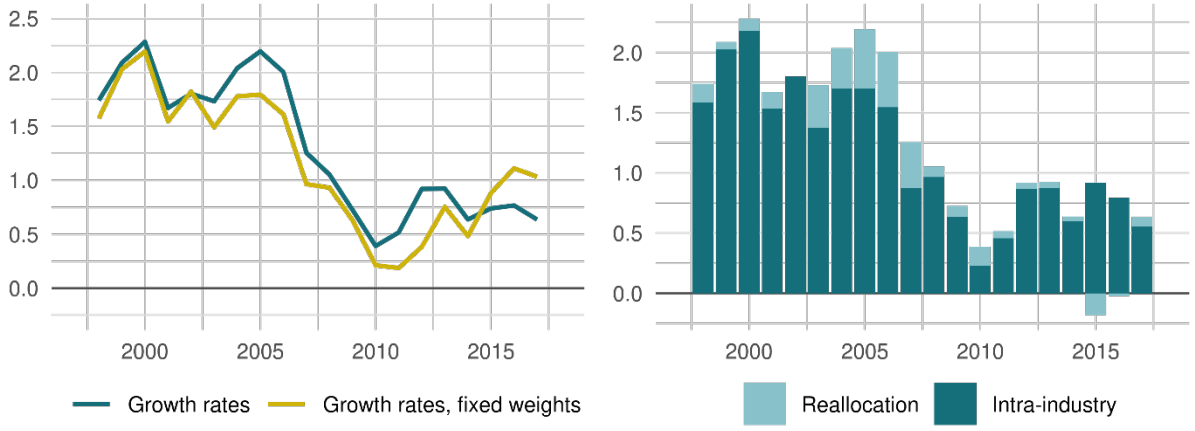
[16] See OECD (2023), "Value added by activity" (indicator), [08.02.2023].

shows that the structural change had a positive overall effect on the aggregate productivity growth: the LP growth is smaller in most periods when we fix the industry weights $\bar{\omega}_i$ at the average of the first five years in the sample (1995–1999). More specifically, we can use equation 5 to distinguish between the growth contribution of reallocation and within-industry changes in each year (right panel of Figure 8). On average, the reallocation term is positive and relatively small, confirming that the slowdown of productivity growth took place at the level of specific industries.

Most of the increase in the reallocation component in the period shortly before the financial crisis is explained by the development in the real estate industry, which steeply increased its nominal value-added share in this period. However, the measured productivity growth in this industry is mainly driven by the inclusion of imputed rents of owner-occupied dwellings and does not reflect improvements in the actual factor productivity. The remainder of the increase in the contribution of reallocation can likely be attributed to the increased business dynamism in the run-up to the financial crisis.

Figure 8: **Labor productivity growth in Austria, reallocation effect, 1996–2019**

5-year rolling averages, rates in %



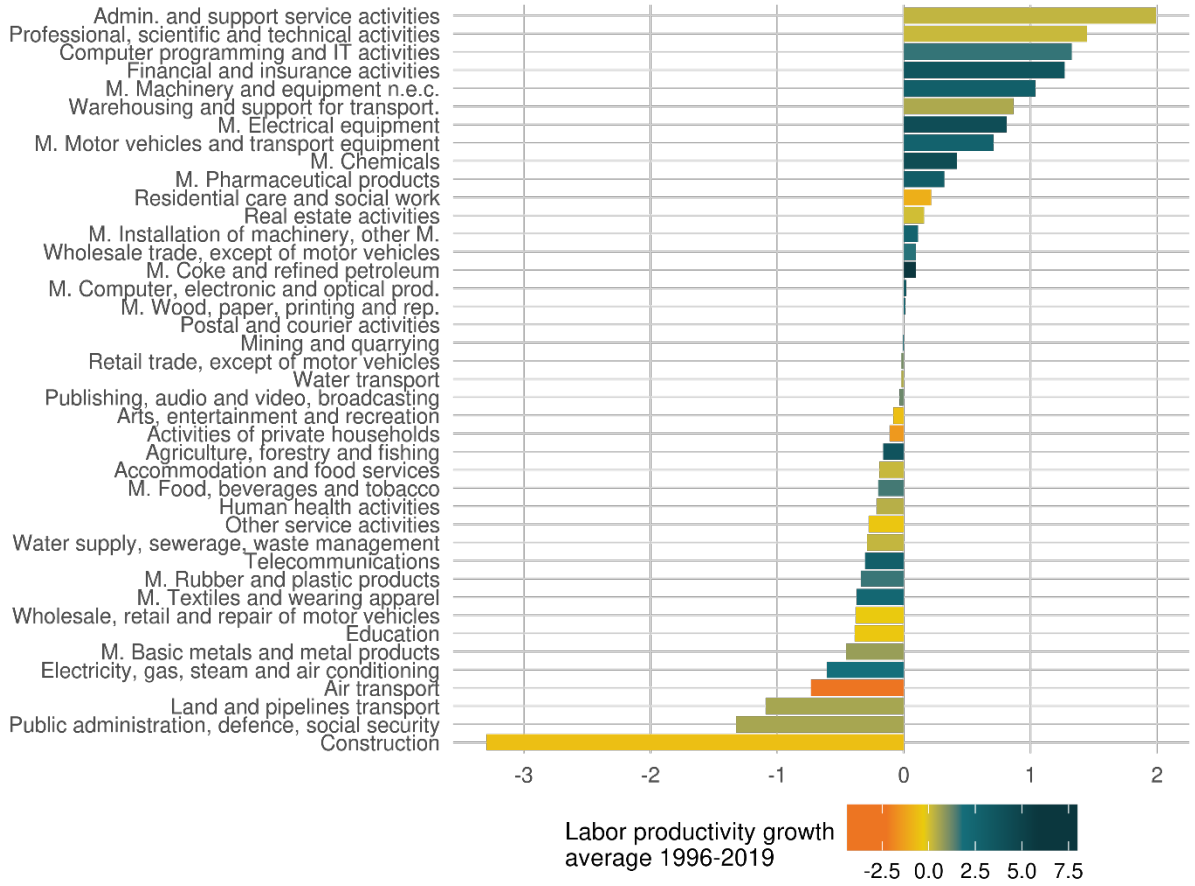
Source: EUKLEMS & INTANProd (Luiss data), own calculations. — Left panel: aggregate LP growth vs. counterfactual series with value-added weights in each year fixed at the average of the first five years in the sample (1995–1999). Right panel: decomposition of aggregate LP growth to the contribution of reallocation and within-industry changes in each year.

Figure 9 provides further information on the changes in industry composition. The figure plots the changes in real value-added shares for individual industries between the initial period (1995–1999) and the most recent 5-year period (2015–2019). First, the figure shows that the changes in value-added shares vary for individual industries within both manufacturing and service sectors. Industries that increased their share the most include service activities (Administrative and support service activities; Professional, scientific and technical activities; Computer programming and IT activities; Financial and insurance activities), but also manufacturing industries (Manufacturing of electrical equipment; Manufacturing of motor vehicles and transport equipment; Manufacturing of machinery and equipment n. e. c.). Overall, the share of manufacturing stayed roughly constant over the sample period. Several of the growing service industries are highly ICT-intensive (see OECD, 2019) and skill-intensive (see Peneder, 2007), which are particularly important with regard to the digital transformation.

The color-coding in Figure 9 provides additional information on the average labor productivity growth in each industry over the entire sample period. The (dark) blue shades highlight the industries with high average productivity growth rates above the total economy average of 1.3% annually. Yellow shades indicate average growth rates close to zero and orange shades indicate negative growth rates. The figure again shows that the industries with labor productivity growth rates above the aggregate LP growth (blue shades) are concentrated between the growing industries, confirming the positive effect of reallocation on aggregate productivity growth in Austria.

Figure 9: **Change in industry shares in real value added, Austria**

Difference between industry shares in 2015-2019 (average) and 1995-1999 (average) in percentage points



Source: EUKLEMS & INTANProd (Luiss data), own calculations. — Bar size: difference in real value-added share between 2015-2019 (average) and 1995-1999 (average) in pp. Bar color: average annual labor productivity growth rate in % over sample period (1995-2019). Reading example: Administrative and support service activities increased their share in real value added by 2.0 pp (bar size). The industry's average annual labor productivity growth (0.2%, bar color) was below the average of the total economy's growth (1.3%).

4.2 Industry contributions to aggregate productivity growth in Austria

We now analyse the contributions of individual industries to aggregate productivity growth.[17] Following equation (5) in section 2.2, the contribution of each industry to aggregate LP growth is $\bar{\omega}_i \Delta lp_i$. Since we are interested in explaining the productivity slowdown, we focus on changes in industry contributions between the beginning and the end of the sample. Figure 10 plots the change in industry contributions to labor productivity growth between the initial period (1996–2000) and the most recent period (2015–2019).

First, we see that for most of the industries, the change is negative, meaning that their contribution to aggregate LP growth has decreased over time. This is not surprising, considering that the contributions of individual industries sum up to the within-industry component of the aggregate LP growth, which has decreased as well (cf. Figure 8). Some exceptions are Telecommunications and Professional, scientific and technical activities, which might have benefited from the technological breakthroughs and market liberalization in the respective areas.[18]

[17] The detailed results for the industries together with their NACE Rev. 2 codes are provided in Table 5 and Table 6 in the Appendix.

[18] An additional important insight, not directly visible from Figure 10, is that at the level of individual industries, the change in the contribution to aggregate LP growth is largely driven by a decrease in industry labor productivity growth and not by the decrease in its weights, see Figure 15 in the Appendix.

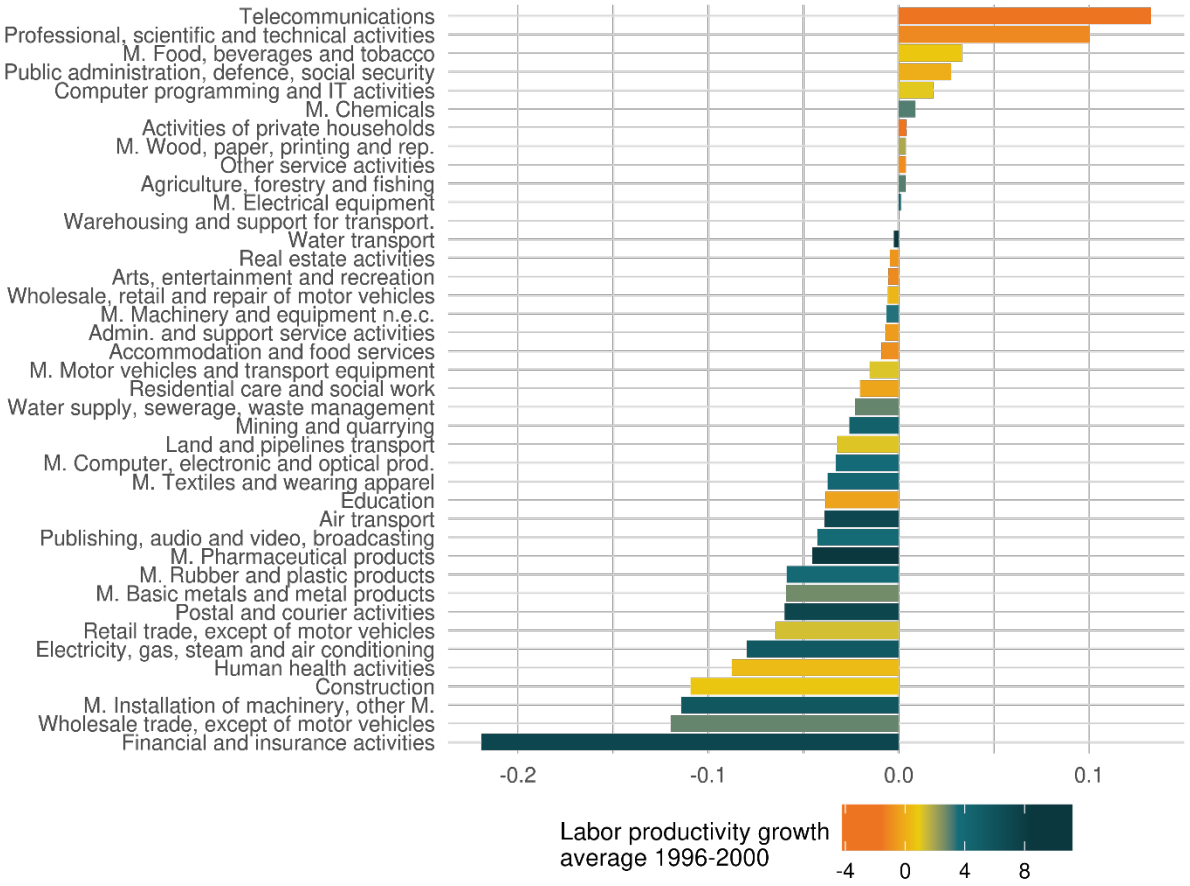
Second, the color-coding in Figure 10 again provides additional information on industry labor productivity growth. In contrast to the previous figure, the colors in Figure 10 reflect the average LP growth in the *initial* period 1996–2000. The (dark) blue shades indicate the industries with high average productivity growth rates over this period, above the total economy average of 1.8% annually. Yellow shades indicate positive growth rates below the total economy average and (dark) orange shades indicate negative growth rates. The color-coding shows that the industries for which the change in contribution to aggregate LP growth is most positive are the ones that started with particularly low initial LP growth rates (Telecommunications -4.4%; Professional, scientific and technical activities -1.1%; Manufacturing of food, beverages and tobacco 0.7%). On the other end, for many industries with high LP growth rates in the initial period, their contribution has decreased, as their LP growth rates became much lower in recent periods. This includes around half of the manufacturing industries, such as Repair and installation of machinery and equipment, other manufacturing (decline in annual LP growth from 5.6% to -1.7%); Manufacturing of basic metals and metal products (2.7% to 0.7%); Manufacturing of rubber and plastic products (4.0% to 1.6%); Manufacturing of pharmaceutical products (9.3% to 0.5%); Manufacturing of textiles and wearing apparel (4.0% to 0.2%); and Manufacturing of computer, electronic and optical products (3.9% to 2.3%), but also service sectors such as Financial and insurance activities (7.1% to 3.8%); Wholesale (2.8% to 1.1%); Air transport (5.4% to -9.1%), and some others.

Figure 11 replicates the same graph for industry contributions to total factor productivity growth and delivers similar results to the labor productivity case. For most of the industries that experienced high TFP growth rates in the initial period, the contribution to aggregate TFP growth decreased over time as a consequence of lower industry TFP growth. For some of the capital-intensive industries such as Real estate activities; Construction; and Water supply, sewerage, waste management, the change in contribution to aggregate TFP was less negative compared to labor productivity. This suggests that low growth rates in labor productivity in these industries are attributable to underinvestment rather than low TFP growth.

Summing up, we find that the decrease in labor productivity and TFP growth in Austria can be attributed to the decline in productivity growth in a big number of industries, many of which experienced high productivity growths in the 1990s and early 2000s. These include both manufacturing and service industries. The widespread decline was only to a small extent offset by increased productivity growth of some service industries.

Figure 10: **Change in contributions of individual industries to labor productivity growth, Austria**

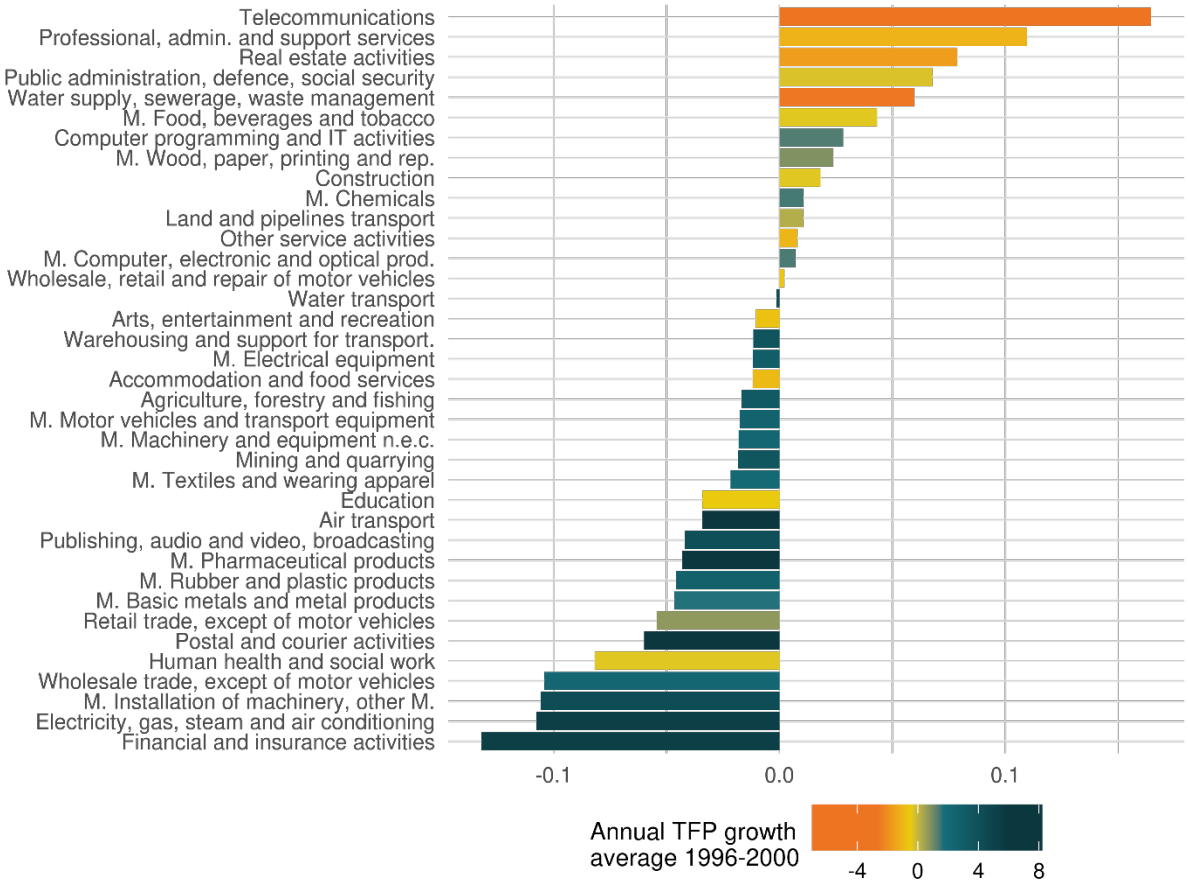
Differences between 2015–2019 (average) and 1996–2000 (average) in percentage points



Source: EUKLEMS & INTANProd (Luiss data), own calculations. — Bar size: difference in industry contribution to aggregate labor productivity growth between 2015-2019 (average) and 1996-2000 (average). Bar color: average annual labor productivity growth rate in the initial 5-year period (1996-2000). Manufacturing of coke and refined petroleum products (C19) excluded due to data issues. Reading example: Telecommunications increased their annual contribution to aggregate labor productivity growth by 0.13 pp. The industry's average annual labor productivity growth in the first five years of the sample (-4.4%) was below the average of the total economy's growth in the same period (1.8%).

Figure 11: **Change in contributions of individual industries to total factor productivity growth, Austria**

Differences between 2015–2019 (average) and 1996–2000 (average) in percentage points



Source: EUKLEMS & INTANProd (Luiss data), own calculations. — Bar size: difference in industry contribution to aggregate total factor productivity growth between 2015-2019 (average) and 1996-2000 (average). Bar color: average annual TFP growth rate in the initial 5-year period (1996-2000). Manufacturing of coke and refined petroleum products (C19) excluded due to data issues. Reading example: Financial and insurance activities decreased their annual contribution to aggregate TFP growth by -0.13 pp. The industry's average annual TFP growth in the first five years of the sample (+5.3%) was above the average of the total economy's growth in the given period.

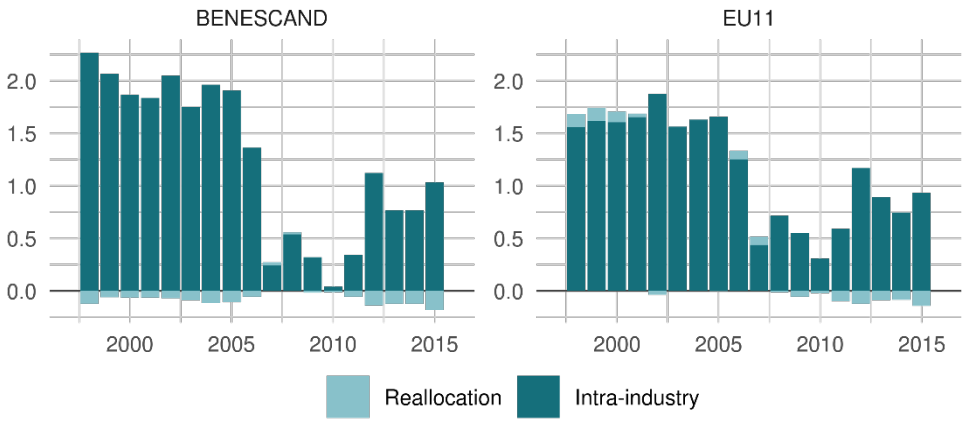
4.3 International comparison of industry contributions to aggregate productivity growth

Finally, we compare the industry-level evidence for Austria with the peer country groups. Due to numerous missing data series for specific countries and industries in the newest vintage of the EU KLEMS dataset, we conduct the analysis using the industry-level data from the wiiw dataset. Therefore, in this section the data series are shorter, and the most recent available 5-year period is 2013–2017. As a result, the industry-level results for Austria slightly differ from the results presented in the previous section.

Figure 12 shows the decomposition to reallocation and within-industry component for BENESCAND and EU11 country groups. The contribution of the reallocation term is again small compared to the within-industry component. However, in contrast to Austria (cf. Figure 8), the effect of reallocation is negative in case of BENESCAND countries and in EU11 countries after the financial crisis. Again, the real estate sector positively influences the reallocation component. When excluding the Real estate activities, the reallocation term for these country groups becomes even more negative, contributing up to -0.25% annually.

Figure 12: **Labor productivity growth in selected country groups, effect of reallocation**

5-year rolling averages, rates in %



Source: EUKLEMS (wiiw data), own calculations. — Country groups refer to simple averages across countries. Belgium data starting in 2000.

The negative reallocation term is likely related to the fact that a number of the peer countries (Finland, Sweden, Belgium, France, among others) experienced a decline in the share of manufacturing since the mid-1990s. In contrast, Austria's decline in the share of manufacturing took place mostly before the start of the sample period. Since then, the share of manufacturing in Austria has remained more or less stable and comparatively high. In a number of the peer countries, the relative importance of manufacturing was initially increased by dynamic and innovative manufacturing industries, such as Manufacturing of computers and communication products (Finland, Sweden) or Manufacturing of motor vehicles and transport equipment (Spain, France), which they eventually started to lose to international competitors. In Austria, the shares of these industries were relatively small and the loss of market shares less important.

Figure 13 and Figure 14 plot the change in industry contributions to aggregate productivity analogous to Figure 10. Figure 13 shows the results for the manufacturing industries. In line with the evidence for Austria, the contribution to growth declined for most manufacturing industries in BENESCAND and EU11 countries. However, the decline is much more concentrated in a single manufacturing industry, Manufacturing of computer, electronic and optical products, especially in the case of BENESCAND countries. The change in contribution of this single industry accounts for more than 0.4 pp decline in annual LP growth rate in BENESCAND countries, due to both slower average LP growth rate and decreasing share of the industry in aggregate value added.

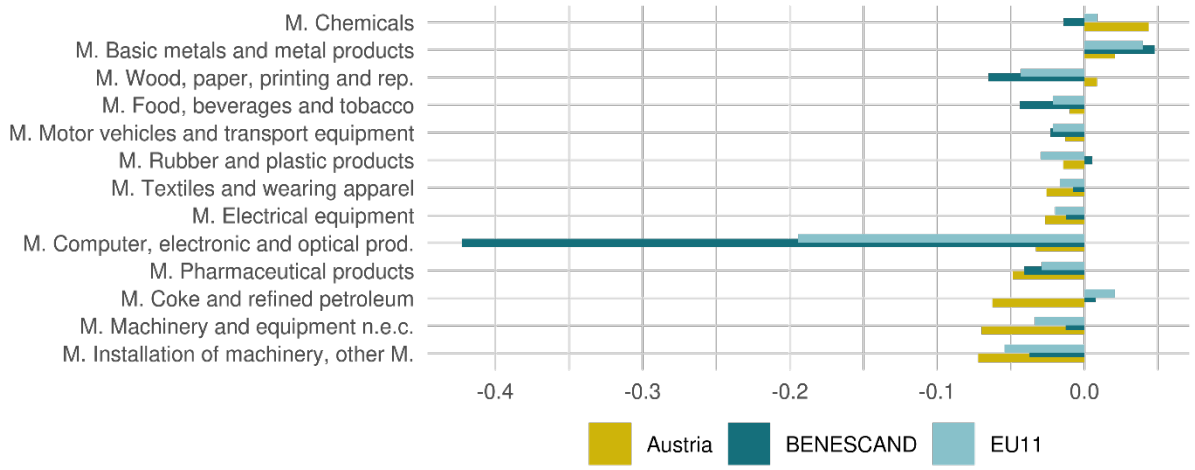
Figure 14 plots the results for non-manufacturing industries that are part of the market economy. For these industries, we find somewhat more variation across the country groups. The contribution of Financial and insurance services; Wholesale trade; Electricity, gas, steam and air conditioning strongly declined in all three geographic areas. The decline in the contribution of Financial and insurance services was particularly important in Austria, accounting for up to 0.3 pp decline in annual LP growth rate (0.2 pp for the Luiss data). The contribution of the large service sector that includes Professional, scientific and technical services together with the Administrative and support service activities has also strongly increased in all three cases. However, there are significant differences in the case of Construction; Telecommunications; and Computer programming and IT activities. Additionally, for BENESCAND and EU11 country groups the decline is stronger in Mining and quarrying sector and three transport industries (Water transport; Land and pipelines transport; Warehousing and support for transport activities).

To summarize, in line with the evidence for Austria, the decrease in labor productivity growth in the two country groups is present in both manufacturing and service industries. In contrast to Austria, in the manufacturing sector, the decline in productivity growth is to a large extent concentrated in the

Manufacturing of computer, electronic and optical products. In the service sector, the experience across countries is more differentiated, with Austria facing particularly high decline from Financial and insurance activities and Construction industries.

Figure 13: **Change in contributions of manufacturing industries to labor productivity growth, Austria compared to selected country groups**

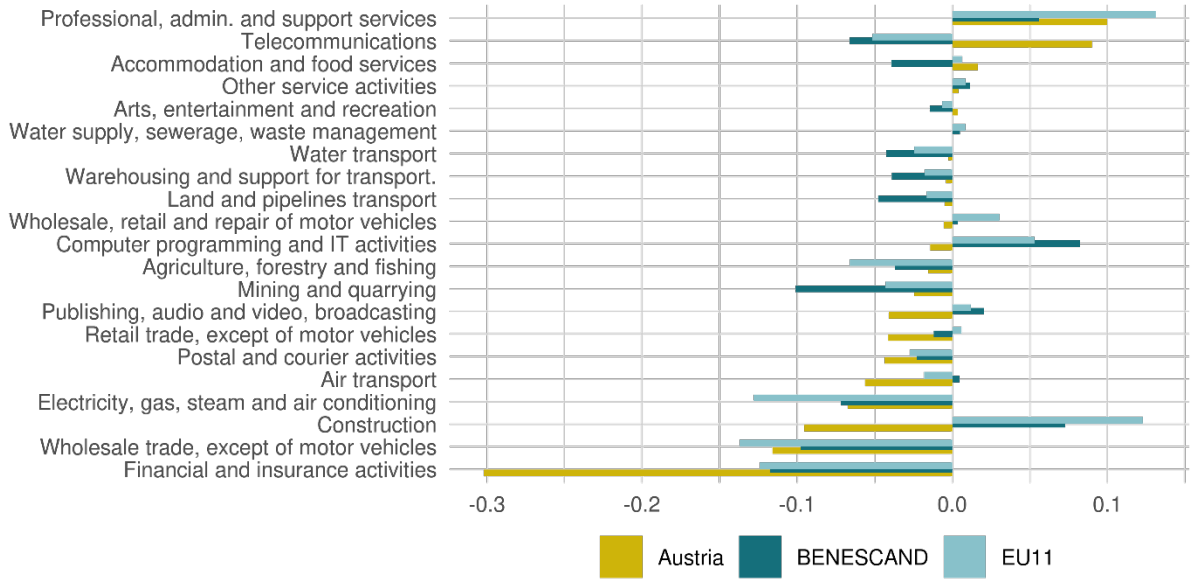
Differences between 2013–2017 (average) and 1996–2000 (average) in percentage points



Source: EUKLEMS (wiiw data), own calculations. — Country groups refer to simple averages across countries.

Figure 14: **Change in contributions of non-manufacturing industries to labor productivity growth, Austria compared to selected country groups**

Differences between 2013–2017 (average) and 1996–2000 (average) in percentage points



Source: EUKLEMS (wiiw data), own calculations. — Country groups refer to simple averages across countries.

5. Concluding remarks

The previous sections analyzed the productivity growth and its slowdown in Austria in the period from the mid-1990s using aggregate and industry-level data. We compare Austria with other countries and country groups, focusing on developed European small open economies. We find that, at the aggregate level, the development of productivity growth in Austria was similar to that of the peer countries.

However, the decompositions of aggregate productivity growth into production factors and into industry contributions reveal a number of interesting observations.

First, the decline in labor productivity and output growth can be attributed to both lower contribution of capital and of total factor productivity. Second, the recovery prior to the COVID-19 pandemics was largely driven by increases in hours worked and some TFP gains. Third, demographic changes in the composition of the labor force also affected productivity growth. According to the EUKLEMS data, the contribution of labor force composition in Austria to the measured output per hour has decreased over time and even became negative at the end of the sample. It is possible that this trend will continue in the future due to the ageing of the (working) population and other demographic factors. Specific forms of investment, such as labor-enhancing and supporting technologies, digitalization, and (re-)training of workers could mitigate the impact of the demographic changes on the economy.

Measured productivity in Austria grew relatively strongly in the years before and during the financial crisis, a period of high business dynamism and transformation of business models associated with the 2004 EU enlargement and the opening up of markets in the Central, Eastern and South-Eastern Europe (CESEE), but also with market liberalization and high private investment, for example in R&D. These developments were to some extent reflected in the changing economic composition - looking at the industry-level evidence, we find that structural changes had a moderate but positive overall effect on productivity growth in Austria.

The effect of structural change in the peer countries was also moderate, although mostly negative. The difference is likely related to the decreasing share of manufacturing sector in a number of the peer countries. In Austria, the decline in the share of manufacturing mainly took place before the mid-1990s and the share of manufacturing remained relatively high and more or less stable thereafter.

In line with the existing literature, we find that most of the productivity slowdown across countries can be attributed to productivity growth within individual industries. The aggregate productivity slowdown in Austria and in other countries can be attributed to a decline in productivity growth in many of the industries where productivity growth was high prior to the financial crisis. These include industries in both manufacturing and service sectors. However, some country-specific features stand out. While a number of European countries experienced (and subsequently lost) high productivity growth contributions from the Manufacturing of computers and communication products, this was not the case in Austria. On the other hand, in the initial part of the sample, Austria experienced particularly large contributions from some service sectors, notably the Financial and insurance services. While this sector remains an important contributor to productivity growth in Austria, it cannot match the high productivity growth rates before the financial crisis, following the restructuring of the banking environment in the 1990s and the expansion of market shares in the CESEE region.

The telecommunications industry in Austria went through a period of negative productivity growth in the late 1990s, but productivity growth has improved since then, likely related to market liberalization and the entry of new technologies. Similar factors may have benefited many of the activities included in the Professional, scientific and technical activities, such as legal, accounting, and business services, marketing, engineering, and R&D activities, which were transformed by the digitalization over the past twenty years. While both these sectors significantly increased their contributions to productivity growth in Austria, the contribution of Computer programming and IT activities stayed roughly the same, lagging behind the development in the reference country groups.

The negative change in the labor productivity contribution of the Austrian construction sector also appears somewhat puzzling. On the one hand, the share of the industry in aggregate value added declined after the financial crisis. Moreover, in recent years, the industry also experienced very low to negative productivity growth. The low labor productivity growth in the construction sector can be attributed both to the lower TFP growth, but even more to the lower contribution of capital. A similar pattern can be

observed in some other capital-intensive industries, such as water supply, sewerage and waste management.

Finally, it is important to mention some caveats of the analysis. The methodology used to calculate productivity growth and its components is based on standard but rather strong assumptions of competitive markets and constant returns to scale. Therefore, even in the medium and long run, the productivity measures may also be influenced by, e.g., changes in market concentration and changes in markups. Moreover, there are measurement issues connected to both measuring outputs and production inputs. Crucially, all measures of real productivity gains rely on correct price deflating of, e.g., nominal value-added and capital stock. However, price changes often reflect the improved quality of products, and accounting for quality improvements becomes increasingly difficult as products and services become more differentiated and short-lived. While this issue affects all industries, it is particularly important for intellectual property and knowledge-based services, such as Computer programming and IT services; Professional, scientific and technical activities; and Financial and insurance activities.

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Appendix

Table 1: **Aggregate output and productivity growth, total economy**

Average annual growth rates for selected periods

	Value added					Labor productivity					TFP				
	All years	First 5 years	First 10 years	Last 5 years	Last 5 –first 10 years	All years	First 5 years	First 10 years	Last 5 years	Last 5 –first 10 years	All years	First 5 years	First 10 years	Last 5 years	Last 5 –first 10 years
	1996–2019	1996–2000	1996–2005	2015–2019	Difference	1996–2019	1996–2000	1996–2005	2015–2019	Difference	1996–2019	1996–2000	1996–2005	2015–2019	Difference
	In %				In pp.	In %				In pp.	In %				In pp.
AT	**1.8**	**3.0**	**2.4**	**1.9**	**-0.5**	**1.3**	**1.8**	**1.8**	**0.6**	**-1.2**	**0.6**	**0.9**	**0.7**	**0.4**	**-0.3**
BE	1.8	2.6	2.3	1.7	-0.6	0.8	1.3	1.3	0.4	-0.9	0.2	0.5	0.5	0.0	-0.5
CZ	2.5	1.6	2.7	3.5	0.9	2.4	1.8	3.2	2.2	-1.0	0.7	-0.3	1.1	1.5	0.4
DE	1.4	2.0	1.4	1.6	0.2	1.1	1.9	1.7	0.7	-1.1	0.7	1.2	0.9	0.3	-0.6
DK	1.5	3.1	2.0	2.2	0.1	1.0	1.3	1.2	0.9	-0.3	0.6	1.2	1.0	1.0	0.0
ES	2.1	3.9	3.5	2.9	-0.6	0.6	0.0	0.0	0.3	0.3	-0.2	-0.3	-0.4	0.6	1.0
FI	2.0	5.1	3.7	1.8	-1.9	1.3	3.2	2.5	0.9	-1.6	0.8	2.8	1.9	0.7	-1.2
FR	1.6	2.9	2.3	1.5	-0.8	1.1	1.9	1.6	0.8	-0.9	0.6	1.3	1.1	0.2	-0.9
IT	0.6	2.0	1.4	1.0	-0.4	0.3	1.0	0.6	0.1	-0.5	-0.3	0.3	-0.1	0.1	0.2
NL	2.0	4.2	2.8	2.1	-0.7	1.0	2.0	1.7	0.0	-1.7	0.3	1.2	0.8	-0.2	-1.0
SE	2.5	3.7	3.1	2.9	-0.3	1.7	2.9	2.9	0.9	-1.9	0.0	0.4	0.3	0.8	0.5
US	2.2	4.3	3.0	2.5	-0.6	1.5	2.4	2.4	1.0	-1.4	0.6	1.2	1.1	0.6	-0.5
BENESCAND	2.0	3.7	2.8	2.0	-0.8	1.1	2.1	1.9	0.4	-1.5	0.4	1.3	1.0	0.3	-0.7
EU11	1.8	3.1	2.5	2.0	-0.5	1.1	1.7	1.7	0.6	-1.0	0.4	0.9	0.7	0.4	-0.3
EA19	2.4	3.9	3.6	2.4	-1.2	1.9	2.8	2.7	1.1	-1.7	-	-	-	-	-
EU27	2.5	3.5	3.5	2.6	-0.9	2.0	2.6	2.8	1.3	-1.5	-	-	-	-	-
EU27 agg.	1.5	2.3	1.9	2.1	0.2	1.2	1.5	1.5	0.9	-0.6	-	-	-	-	-

Source: EUKLEMS & INTANProd (Luiss), own calculations.

Notes: Country groups refer to simple averages across countries, missing observations are ignored. EU27 agg. refers to aggregate EU27 (2020) geographic region (Luiss data, available until 2018). Data for DK, EL, IE, PL, RO, SI, SK supplemented from the wiiw data set (available until 2017). Sweden data until 2017; Spain, Hungary, Latvia, Lithuania until 2018; France (LP & TFP growth) until 2018. Bulgaria, Estonia, Portugal from 2000 to 2018. US data starting from 1998, Belgium (TFP growth) starting from 2000, Poland (LP growth) form 2001.

Table 2: **Aggregate output and productivity growth, market economy**

Average annual growth rates for selected periods

	Value added					Labor productivity					TFP				
	All years	First 5 years	First 10 years	Last 5 years	Last 5 –first 10 years	All years	First 5 years	First 10 years	Last 5 years	Last 5 –first 10 years	All years	First 5 years	First 10 years	Last 5 years	Last 5 –first 10 years
	1996–2019	1996–2000	1996–2005	2015–2019	Difference	1996–2019	1996–2000	1996–2005	2015–2019	Difference	1996–2019	1996–2000	1996–2005	2015–2019	Difference
	In %				In pp.	In %				In pp.	In %				In pp.
AT	**2.0**	**3.5**	**2.8**	**2.2**	**-0.5**	**1.6**	**2.3**	**2.3**	**1.1**	**-1.2**	**0.8**	**1.3**	**1.1**	**0.8**	**-0.3**
BE	1.9	3.0	2.5	1.8	-0.8	1.0	1.7	1.8	0.5	-1.3	0.3	0.5	0.8	0.1	-0.8
CZ	2.9	1.9	3.1	4.2	1.1	2.8	2.1	3.6	3.1	-0.5	0.9	-0.7	1.1	2.3	1.2
DE	1.3	1.8	1.2	1.7	0.5	1.2	1.8	1.7	1.0	-0.7	0.7	1.1	0.8	0.5	-0.3
ES	1.9	4.4	3.5	3.5	-0.1	0.5	0.0	-0.2	0.6	0.8	-0.2	-0.2	-0.4	0.9	1.3
FI	2.4	6.2	4.5	2.1	-2.4	1.8	4.0	3.3	1.3	-2.0	1.6	3.9	3.1	1.3	-1.8
FR	1.8	3.8	2.8	1.8	-1.0	1.3	2.6	2.1	0.9	-1.2	0.4	1.7	1.1	0.1	-1.0
IT	0.7	2.4	1.7	1.7	0.0	0.4	1.6	0.8	0.4	-0.4	-0.3	0.4	-0.2	0.4	0.6
NL	2.1	5.1	3.1	2.4	-0.6	1.2	2.6	2.3	0.1	-2.1	0.6	1.8	1.4	0.1	-1.3
SE	3.2	5.1	4.3	3.4	-0.9	2.5	3.8	4.0	1.8	-2.1	1.0	1.5	1.6	1.5	-0.2
US	2.4	5.3	3.5	2.9	-0.6	2.0	3.5	3.3	1.5	-1.8	0.7	1.3	1.5	0.8	-0.8

Source: EUKLEMS & INTANProd (Luiss), own calculations.

Notes: Missing observations are ignored. Sweden data until 2017; Spain, Italy until 2018; France (LP & TFP growth) until 2018. US data starting from 1998, Belgium (TFP growth) starting from 2000.

Table 3: **Contributions of production factors to value added growth**

	All years	First 5 years	First 10 years	Last 5 years	Last 5 –first 10 years
	1996–2019	1996–2000	1996–2005	2015–2019	Difference
	Contributions to VA growth in pp.				
Austria					
Hours	0.4	0.8	0.4	0.8	0.4
Labor composition	0.1	0.3	0.3	-0.1	-0.5
Intangible capital	0.2	0.2	0.2	0.3	0.0
Tangible ICT capital	0.1	0.1	0.1	0.0	-0.1
Tangible non-ICT capital	0.5	0.6	0.6	0.4	-0.1
Total factor productivity	0.6	0.9	0.8	0.4	-0.3
Value added growth in %	1.9	3.0	2.4	1.9	-0.5
BENESCAND					
Hours	0.5	1.1	0.6	1.0	0.3
Labor composition	0.4	0.6	0.5	0.1	-0.4
Intangible capital	0.2	0.2	0.2	0.1	-0.1
Tangible ICT capital	0.1	0.2	0.2	0.1	-0.1
Tangible non-ICT capital	0.4	0.5	0.4	0.4	0.0
Total factor productivity	0.4	1.3	1.0	0.3	-0.7
Value added growth in %	2.0	3.8	2.8	2.0	-0.8
EU11					
Hours	0.4	0.9	0.6	0.8	0.3
Labor composition	0.3	0.4	0.4	0.2	-0.2
Intangible capital	0.2	0.2	0.2	0.2	0.0
Tangible ICT capital	0.1	0.2	0.1	0.0	-0.1
Tangible non-ICT capital	0.5	0.6	0.6	0.4	-0.2
Total factor productivity	0.4	0.9	0.7	0.4	-0.3
Value added growth in %	1.8	3.1	2.5	2.0	-0.5
United States					
Hours	0.4	1.2	0.4	0.9	0.5
Labor composition	0.3	0.3	0.3	0.2	-0.1
Intangible capital	0.2	0.3	0.3	0.2	0.0
Tangible ICT capital	0.2	0.5	0.3	0.1	-0.2
Tangible non-ICT capital	0.5	0.7	0.6	0.4	-0.2
Total factor productivity	0.6	1.2	1.1	0.7	-0.5
Value added growth in %	2.2	4.3	3.0	2.5	-0.6

Source: EUKLEMS & INTANProd (Luiss), own calculations.

Notes: Country groups refer to simple averages across countries, missing observations are ignored. Sweden data until 2017; Spain, Italy until 2018; France (LP & TFP growth) until 2018. US data starting from 1998, Belgium (TFP growth) starting from 2000.

Table 4: **Contributions of production factors to labor productivity growth**

	All years	First 5 years	First 10 years	Last 5 years	Last 5 –first 10 years
	1996–2019	1996–2000	1996–2005	2015–2019	Difference
	Contributions to LP growth in pp.				
Austria					
Labor compositionn	0.1	0.3	0.3	-0.1	-0.5
Intangible capital	0.2	0.2	0.2	0.2	0.0
Tangible ICT capital	0.0	0.1	0.1	0.0	-0.1
Tangible non-ICT capital	0.3	0.3	0.4	0.1	-0.3
Total factor productivity	0.6	0.9	0.8	0.4	-0.3
Labor productivity growth in %	1.3	1.8	1.8	0.6	-1.2
BENESCAND					
Labor composition	0.4	0.6	0.5	0.1	-0.4
Intangible capital	0.1	0.2	0.2	0.0	-0.1
Tangible ICT capital	0.1	0.2	0.1	0.0	-0.1
Tangible non-ICT capital	0.1	0.0	0.1	0.0	-0.2
Total factor productivity	0.4	1.3	1.0	0.3	-0.7
Labor productivity growth in %	1.1	2.2	1.9	0.5	-1.5
EU11					
Labor composition	0.3	0.4	0.4	0.2	-0.2
Intangible capital	0.1	0.1	0.1	0.1	0.0
Tangible ICT capital	0.1	0.1	0.1	0.0	-0.1
Tangible non-ICT capital	0.3	0.2	0.4	0.0	-0.4
Total factor productivity	0.4	0.9	0.7	0.4	-0.3
Labor productivity growth in %	1.1	1.7	1.7	0.6	-1.0
United States					
Labor composition	0.3	0.3	0.3	0.2	-0.1
Intangible capital	0.2	0.2	0.2	0.1	-0.1
Tangible ICT capital	0.2	0.5	0.3	0.1	-0.2
Tangible non-ICT capital	0.3	0.2	0.4	0.0	-0.4
Total factor productivity	0.6	1.2	1.1	0.7	-0.5
Labor productivity growth in %	1.5	2.4	2.4	1.0	-1.4

Source: EUKLEMS & INTANProd (Luiss), own calculations.

Notes: Country groups refer to simple averages across countries, missing observations are ignored. Sweden data until 2017; Spain, Italy until 2018; France (LP & TFP growth) until 2018. US data starting from 1998, Belgium (TFP growth) starting from 2000.

Table 5: **Industry labor productivity growth and contributions to aggregate labor productivity growth, Austria**

		Labor productivity growth					Contribution to aggregate				
		All years	First 10 years	First 5 years	Last 5 years	Last 5 –first 5 years	All years	First 10 years	First 5 years	Last 5 years	Last 5 –first 5 years
		1996–2019	1996–2005	1996–2000	2015–2019	Difference	1996–2019	1996–2005	1996–2000	2015–2019	Difference
Industry code	Industry	Average annual rates in %				In pp.	In pp., multiplied by 100				
A	Agriculture, forestry and fishing	3.7	2.5	2.9	5.1	2.2	5.9	5.1	6.3	6.7	0.4
B	Mining and quarrying	2.4	6.5	4.7	-2.6	-7.3	1.1	2.5	1.7	-0.9	-2.6
C10-C12	M. Food, beverages and tobacco	1.4	1.7	0.7	2.4	1.8	3.0	3.4	1.3	4.6	3.3
C13-C15	M. Textiles and wearing apparel	2.2	3.2	4.0	0.2	-3.8	1.6	2.6	3.9	0.2	-3.7
C16-C18	M. Wood, paper, printing and rep.	2.6	1.6	1.8	3.0	1.2	5.3	4.1	4.6	5.0	0.4
C19	M. Coke and refined petroleum	-	8.4	15.5	48.8	33.3	-	4.4	8.4	7.9	-0.5
C20	M. Chemicals	3.8	3.9	3.0	2.8	-0.2	3.4	3.2	2.3	3.1	0.9
C21	M. Pharmaceutical products	2.5	6.9	9.3	0.5	-8.8	1.7	4.1	5.0	0.5	-4.5
C22-C23	M. Rubber and plastic products	1.5	2.4	4.0	1.6	-2.4	3.1	5.1	8.5	2.6	-5.9
C24-C25	M. Basic metals and metal products	0.3	1.9	2.7	0.7	-1.9	2.2	6.2	8.3	2.4	-5.9
C26	M. Computer, electronic and optical prod.	3.5	4.0	3.9	2.3	-1.6	4.6	6.1	6.0	2.7	-3.3
C27	M. Electrical equipment	3.9	3.3	4.7	3.4	-1.3	5.6	4.0	5.4	5.5	0.1
C28	M. Machinery and equipment n.e.c.	2.7	3.5	3.3	2.3	-1.0	6.6	7.6	6.8	6.1	-0.7
C29-C30	M. Motor vehicles and transport equipment	2.5	3.8	1.0	0.2	-0.7	4.6	6.6	2.0	0.5	-1.5
C31-C33	M. Installation of machinery, other M.	2.4	4.3	5.6	-1.7	-7.3	4.2	7.0	9.1	-2.3	-11.4
D	Electricity, gas, steam and air conditioning	1.5	5.5	5.5	3.5	-2.0	4.5	14.4	14.5	6.5	-8.0
E	Water supply, sewerage, waste management	0.0	0.1	2.2	1.2	-1.0	0.3	0.8	3.6	1.3	-2.3
F	Construction	-0.6	1.4	0.7	-0.8	-1.5	-3.7	10.1	5.5	-5.4	-10.9
G45	Wholesale, retail and repair of motor vehicles	-0.5	-0.6	0.0	-0.3	-0.3	-0.5	-0.7	0.3	-0.3	-0.6
G46	Wholesale trade, except of motor vehicles	1.7	2.6	2.8	1.1	-1.7	11.1	17.1	18.6	6.7	-12.0
G47	Retail trade, except of motor vehicles	1.1	1.6	1.2	-0.1	-1.3	5.1	7.7	5.9	-0.6	-6.5
H49	Land and pipelines transport	0.5	0.6	1.1	0.3	-0.8	1.7	2.0	4.1	0.9	-3.2
H50	Water transport	-5.4	4.8	4.3	-7.7	-12.0	0.0	0.1	0.2	-0.1	-0.2
H51	Air transport	-8.0	-8.2	5.4	-9.1	-14.4	-1.0	-0.7	2.1	-1.8	-3.9
H52	Warehousing and support for transport.	-0.4	-4.1	2.6	1.2	-1.4	0.8	-4.8	2.6	2.6	0.0
H53	Postal and courier activities	3.9	7.1	6.9	-2.7	-9.6	2.6	4.7	4.8	-1.2	-6.0
I	Accommodation and food services	0.2	0.0	-0.9	-0.9	0.1	0.8	0.4	-3.5	-4.4	-0.9
J58-J60	Publishing, audio and video, broadcasting	1.0	3.4	3.7	-2.1	-5.8	0.9	2.6	2.8	-1.5	-4.3
J61	Telecommunications	2.5	2.9	-4.4	7.6	12.0	3.6	5.1	-6.4	6.8	13.2
J62-J63	Computer programming and IT activities	1.6	2.1	0.9	1.2	0.3	2.2	2.6	0.5	2.3	1.8

		Labor productivity growth					Contribution to aggregate				
		All years	First 10 years	First 5 years	Last 5 years	Last 5 –first 5 years	All years	First 10 years	First 5 years	Last 5 years	Last 5 –first 5 years
		1996–2019	1996–2005	1996–2000	2015–2019	Difference	1996–2019	1996–2005	1996–2000	2015–2019	Difference
Industry code	Industry	Average annual rates in %				In pp.	In pp., multiplied by 100				
K	Financial and insurance activities	3.6	4.8	7.1	3.8	-3.4	18.0	25.3	38.3	16.4	-21.9
L	Real estate activities	-0.1	-1.3	-0.9	-0.7	0.2	0.8	-9.9	-5.6	-6.0	-0.5
M	Professional, scientific and technical activities	0.1	-0.2	-1.1	1.1	2.2	1.2	-0.6	-4.2	5.8	10.0
N	Admin. and support service activities	0.2	0.6	-0.6	-0.5	0.1	0.9	2.4	-1.4	-2.0	-0.7
O	Public administration, defence, social security	0.6	0.3	0.0	0.5	0.5	3.0	1.6	-0.1	2.6	2.7
P	Education	-0.4	-0.8	-0.4	-1.1	-0.7	-2.2	-4.2	-2.1	-6.0	-3.9
Q86	Human health activities	0.4	0.6	0.3	-1.3	-1.7	1.7	3.2	1.8	-7.0	-8.7
Q87-Q88	Residential care and social work	-1.0	-1.7	-0.3	-1.4	-1.1	-1.3	-2.0	-0.3	-2.3	-2.0
R	Arts, entertainment and recreation	-0.7	-1.0	-1.2	-1.3	-0.1	-0.7	-1.0	-1.1	-1.6	-0.6
S	Other service activities	-0.5	0.0	-1.0	-0.8	0.2	-0.7	0.0	-1.5	-1.1	0.4
T	Activities of private households	-2.0	-3.7	-4.0	-2.6	1.4	-0.2	-0.4	-0.5	-0.1	0.4

Source: EUKLEMS & INTANProd (Luiss), own calculations.

Notes: Industry codes according to NACE Rev. 2 classification. Growth rates for the industry C19 – Manufacturing of coke and refined petroleum products are not defined for some periods due to negative reported value added. Excluding industry C19 does not significantly affect the results.

Table 6: **Industry TFP growth and contributions to aggregate labor productivity growth, Austria**

		TFP growth					Contribution to aggregate				
		All years	First 10 years	First 5 years	Last 5 years	Last 5 –first 5 years	All years	First 10 years	First 5 years	Last 5 years	Last 5 –first 5 years
		1996–2019	1996–2005	1996–2000	2015–2019	Difference	1996–2019	1996–2005	1996–2000	2015–2019	Difference
Industry code	Industry	Average annual rates in %				In pp.	In pp., multiplied by 100				
A	Agriculture, forestry and fishing	3.2	2.0	3.2	3.9	0.7	5.2	4.1	6.8	5.1	-1.7
B	Mining and quarrying	0.1	4.2	3.5	-1.8	-5.4	0.1	1.6	1.3	-0.5	-1.8
C10-C12	M. Food, beverages and tobacco	0.7	0.2	-0.5	1.7	2.1	1.6	0.5	-1.1	3.2	4.3
C13-C15	M. Textiles and wearing apparel	0.8	0.9	2.0	-1.0	-3.0	0.6	0.8	2.0	-0.2	-2.2
C16-C18	M. Wood, paper, printing and rep.	1.9	0.6	0.8	2.6	1.8	3.8	1.6	2.0	4.4	2.4
C19	M. Coke and refined petroleum	-	-	-	-	-	-	-	-	-	-
C20	M. Chemicals	1.9	1.8	1.3	1.8	0.5	1.9	1.5	1.1	2.2	1.1
C21	M. Pharmaceutical products	1.5	4.5	8.1	-0.1	-8.2	1.1	2.8	4.3	0.0	-4.3

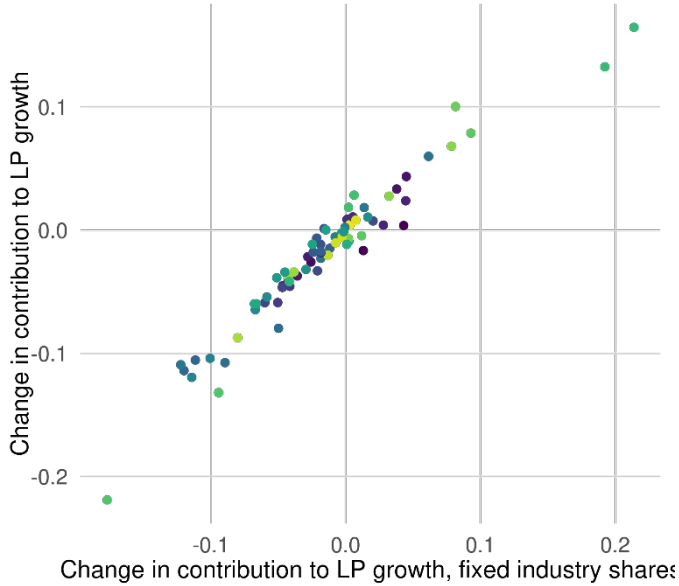
		TFP growth					Contribution to aggregate				
		All years	First 10 years	First 5 years	Last 5 years	Last 5 –first 5 years	All years	First 10 years	First 5 years	Last 5 years	Last 5 –first 5 years
		1996–2019	1996–2005	1996–2000	2015–2019	Difference	1996–2019	1996–2005	1996–2000	2015–2019	Difference
Industry code	Industry	Average annual rates in %				In pp.	In pp., multiplied by 100				
C22-C23	M. Rubber and plastic products	0.4	1.1	2.8	0.7	-2.0	1.2	2.3	5.8	1.2	-4.6
C24-C25	M. Basic metals and metal products	-0.7	0.7	1.6	0.1	-1.5	-0.8	2.3	5.1	0.4	-4.7
C26	M. Computer, electronic and optical prod.	1.0	1.8	1.4	2.5	1.1	1.5	2.8	2.1	2.9	0.7
C27	M. Electrical equipment	1.4	0.8	2.8	1.3	-1.5	2.1	1.2	3.4	2.2	-1.2
C28	M. Machinery and equipment n.e.c.	1.1	1.8	2.1	1.0	-1.1	2.9	3.9	4.6	2.8	-1.8
C29-C30	M. Motor vehicles and transport equipment	1.3	3.1	2.5	1.2	-1.3	2.5	5.0	3.8	2.0	-1.7
C31-C33	M. Installation of machinery, other M.	1.4	2.7	4.2	-2.6	-6.8	2.5	4.5	6.8	-3.8	-10.6
D	Electricity, gas, steam and air conditioning	0.7	5.0	5.3	1.8	-3.5	2.6	13.2	14.2	3.4	-10.8
E	Water supply, sewerage, waste management	-0.2	-2.1	-2.7	2.8	5.5	-0.2	-2.2	-3.0	3.0	6.0
F	Construction	-0.7	0.1	-0.4	-0.2	0.2	-4.4	0.8	-2.9	-1.1	1.8
G45	Wholesale, retail and repair of motor vehicles	-1.1	-1.6	-0.9	-0.8	0.1	-1.5	-2.3	-1.2	-1.0	0.2
G46	Wholesale trade, except of motor vehicles	1.2	2.1	2.3	0.8	-1.5	7.8	14.0	15.2	4.8	-10.4
G47	Retail trade, except of motor vehicles	0.5	1.0	0.6	-0.6	-1.2	2.7	4.8	3.1	-2.4	-5.4
H49	Land and pipelines transport	0.0	-0.7	0.2	0.7	0.4	-0.1	-2.5	0.9	1.9	1.0
H50	Water transport	-5.1	-0.3	-4.7	-6.4	-1.7	0.0	0.1	0.1	-0.1	-0.1
H51	Air transport	-7.1	-6.5	4.7	-7.8	-12.5	-0.8	-0.3	1.9	-1.5	-3.4
H52	Warehousing and support for transport.	0.3	-0.4	3.7	1.0	-2.6	0.6	-1.0	3.4	2.3	-1.2
H53	Postal and courier activities	3.1	6.3	6.3	-3.4	-9.7	2.1	4.2	4.5	-1.5	-6.0
I	Accommodation and food services	0.0	-0.1	-1.0	-1.0	0.0	0.1	-0.2	-3.7	-4.9	-1.2
J58-J60	Publishing, audio and video, broadcasting	0.1	2.0	4.0	-1.7	-5.7	0.2	1.5	2.9	-1.3	-4.2
J61	Telecommunications	0.7	-0.3	-7.2	6.1	13.3	1.0	0.1	-11.0	5.5	16.4
J62-J63	Computer programming and IT activities	1.5	1.7	1.3	1.9	0.7	2.1	2.0	0.9	3.7	2.8
K	Financial and insurance activities	3.0	3.3	5.3	3.6	-1.7	15.0	17.4	28.3	15.2	-13.2
L	Real estate activities	-0.6	-1.2	-1.7	-0.5	1.2	-4.7	-9.4	-13.1	-5.2	7.9
M-N	Professional, scientific and technical activities	-0.3	-1.1	-1.2	0.4	1.5	-1.3	-7.1	-7.3	3.7	11.0
O	Public administration, defence, social security	0.6	-0.1	-0.3	1.0	1.3	2.8	-0.7	-1.7	5.1	6.8
P	Education	-0.6	-1.2	-0.6	-1.2	-0.6	-3.4	-6.7	-3.2	-6.6	-3.4
Q	Human health activities	-0.2	0.0	-0.4	-1.5	-1.1	-1.5	0.3	-2.0	-10.2	-8.2
R	Arts, entertainment and recreation	-0.4	-0.8	-0.9	-1.5	-0.6	-0.4	-0.8	-0.8	-1.8	-1.0
S	Other service activities	-0.9	-0.4	-1.1	-0.6	0.4	-1.2	-0.6	-1.7	-0.9	0.8

Source: EUKLEMS & INTANProd (Luiss), own calculations.

Notes: Industry codes according to NACE Rev. 2 classification. Growth rates for the industry C19 – Manufacturing of coke and refined petroleum products are not defined due to negative reported value added (no TFP data available).

Figure 15: **Change in contributions of individual industries to aggregate labor productivity growth, comparison with fixed industry weights, Austria**

Differences between 2015–2019 (average) and 1996–2000 (average) in percentage points



Source: EUKLEMS & INTANProd (Luiss data), own calculations.

Notes: Y-axis: difference in industry contribution to aggregate labor productivity growth between 2015-2019 (average) and 1996-2000 (average). X-axis: difference in industry contribution to aggregate labor productivity growth between 2015-2019 (average) and 1996-2000 (average) keeping the industry shares fixed at initial 5-year period (1995-1999) average. Manufacturing of coke and refined petroleum products (C19) excluded due to data issues.