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Structural change and productivity growth in the European Union: Past, present and future

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Structural change and productivity growth in the European Union: Past, present and future

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No 09/2021

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The **JRC Working Papers on Territorial Modelling and Analysis** are published under the supervision of Simone Salotti and Andrea Conte of JRC Seville, European Commission. This series mainly addresses the economic analysis related to the regional and territorial policies carried out in the European Union. The Working Papers of the series are mainly targeted to policy analysts and to the academic community and are to be considered as early-stage scientific papers containing relevant policy implications. They are meant to communicate to a broad audience preliminary research findings and to generate a debate and attract feedback for further improvements.

Executive Summary

The concern about low productivity performance ranks high on the EU political agenda for job creation and growth. The Annual Sustainable Growth Strategy 2020 identified productivity gains as one of the four dimensions of EU economic policy that should guide structural reforms, investment and responsible fiscal policies in the years to come. The main reason why stagnant total factor productivity (TFP) and labour productivity growth are a source of concern is, primarily, the fact that they are considered to be the most important determinants of economic growth and welfare, respectively. Poor productivity performance is indeed widely regarded as the main culprit of the European economic growth slowdown since the mid-1990s.

The aim of this paper is to shed light on the current debate surrounding the productivity growth slowdown by focusing on structural change and its link with productivity performance at different time horizons. In particular, we analyse their past, present, and likely future relationship. Our main results are the following:

- 1) The *tertiarization* process of EU economies has had a non-negligible negative impact on long-term aggregate productivity growth across all EU economies, although the size of this impact is larger for older relative to newer Member States.
- 2) We estimate the existing labour productivity gap between the EU and the US is bound to further widen in future, on the back of greater value added shares of more stagnant services in the EU compared to the US, and lower productivity growth rates in the former with respect to the latter.
- 3) Base on a general equilibrium model calibrated to EU data, we show that EU countries are predicted to experience a severe productivity slowdown in the medium term due to unfavourable sectoral reallocations. These sectoral shifts are the result of both supply and demand-side forces, with the former being a more dominant factor.
- 4) The growth slowdown predicted for newer EU Member States these countries is even larger than that for older ones. This is because, although productivity growth in the service sector is still higher in these countries than in the rest of the EU, they are predicted to experience a more profound process of structural transformation, leading to a larger expansion of the sluggish service sectors.
- 5) From a policy standpoint, these results imply policy efforts should primarily be directed to accelerating productivity growth in the most stagnant market service sectors. Promising avenues include fostering investment in intangible capital and digital technologies in the lowest performing service sectors in terms of productivity growth. Importantly, our results do not call for policy interventions aimed at reversing the observed sectoral shifts, as these may be welfare-diminishing. These interventions would only be advisable in case there is well grounded evidence of major market failures at play giving rise to an inefficient allocation of resources across industries.

Structural Change and Productivity Growth in the European Union: Past, Present and Future

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Abstract

The aim of this paper is to investigate the interplay between structural change, interpreted as the secular process of sectoral transformation, and labour productivity growth in the EU in several new dimensions. First, based on the latest data, we document the size of the negative effect that structural change has exerted onto productivity growth over long time horizons. We provide a comparative analysis of these and present-day trends with respect to the US. Second, we develop a general equilibrium model calibrated to match these empirical observations to analyse the potential impact that projected structural change may have on future productivity growth. This model generates structural change through both price and income effects. Our main results indicate that, other things equal, this phenomenon is bound to have a greater dent on productivity growth in the future than it has had in the past. This is the case for both newer and older EU Member States, albeit with important nuances. Our findings suggest that policies should focus on the promotion of productivity-enhancing technological innovation, as well as on the furtherance of greater levels of competition, especially in the most sluggish service sectors.

Keywords: Structural change, Productivity growth, Baumol's cost disease, Service sector, European Union

JEL classification: O41; O47; O52.

1 Introduction

The productivity growth slowdown is currently one of the most pressing economic challenges faced by advanced economies. EU Member States, and, in particular, EU14 countries have experienced a significant deceleration, for at least the last twenty years, in both labour productivity and total factor productivity growth (Bauer et al., 2020). This phenomenon has exacerbated over the last decade¹; aggregate labour productivity growth was already quite low before the 2008-2009 crisis and has been even lower in the aftermath, until 2019, reaching an average of around 1 per cent per year in the EU27 and 0.8 per cent in the EU14.²

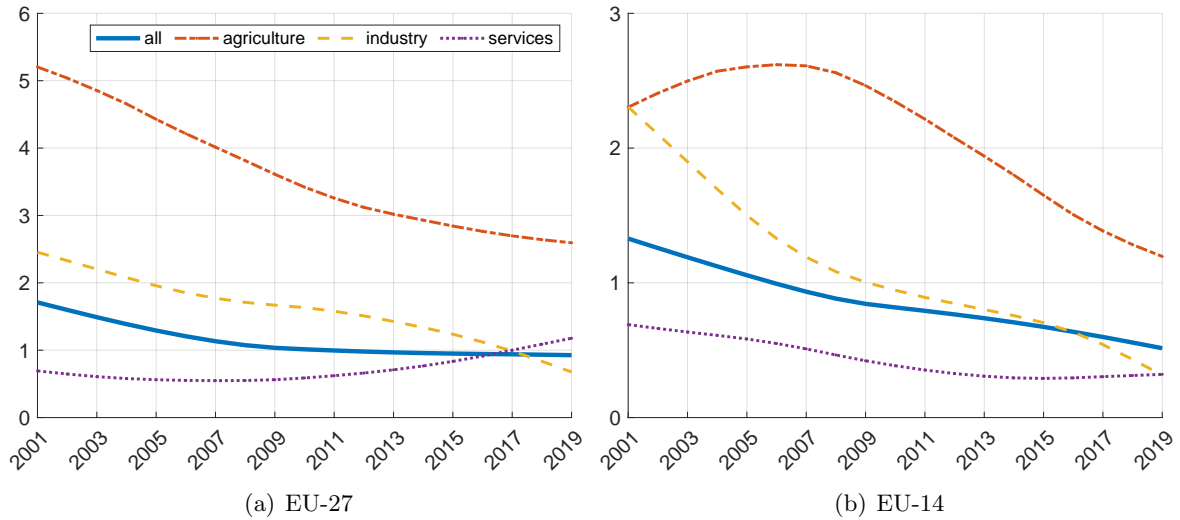


Figure 1: Annual labour productivity growth in the EU27 and EU14 (HP-filtered). Note: data for EU27 sourced directly from EUROSTAT. The sectoral growth rates for EU14 are a weighted average of the growth rates in each EU14 Member State. The weights are the nominal value added shares of each country-industry pair in the EU14 total.

The concern about low productivity performance ranks high on the EU political agenda for job creation and growth. The Annual Sustainable Growth Strategy 2020 (European Commission, 2019) identified productivity gains as one of the four pillars of EU economic policy that should guide structural reforms, investment and responsible fiscal policies in the years to come.

The main reason why stagnant total factor productivity (TFP) and labour productivity growth are a source of concern is, primarily, the fact that they are considered to be the most important determinants of economic growth and welfare, respectively.³ Poor productivity performance is indeed widely regarded as the main culprit of the European economic growth slowdown since

¹See Fernald and Inklaar (2020) for a discussion on the potential impact of the Great Recession on trend productivity growth in the EU.

²EU14 countries include Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, and Sweden.

³Labour productivity is a directly observable measure, whereas TFP is an object that is calculated as a residual from growth accounting techniques.

the mid-1990s (van Ark et al., 2008; Timmer et al., 2010; Mas and Stehrer, 2012).

This sluggish productivity growth is often referred to as the productivity puzzle as there is no certainty about the real causes behind it. Some of the most salient potential explanations that have been set forth in the context of advanced economies include: i) the detrimental role played by structural change (Duernecker et al. (2017), Bauer et al. (2020)), ii) the slow rate of diffusion of technology and innovation (Andrews et al. (2015), Borunsky et al. (2020)), iii) decreasing business dynamism (Fernandez-Villaverde and Ohanian (2018), Bauer et al. (2020)), iv) diminishing returns to R&D and innovation (Gordon, 2016), v) tepid investment in Information and Communication Technologies (ICTs) and intangible assets (Van Ark and Jaeger (2017), Niebel et al. (2017), Atkinson (2018), Adarov and Stehrer (2019)), vi) mismeasurement (Byrne et al. (2016), Syverson (2017), Brynjolfsson et al. (2019)), and vii) regulatory barriers (Arnold et al. (2008), Igna et al. (2019)). The current consensus is, however, that none of these factors alone can explain the productivity puzzle in full (Bauer et al., 2020).

The aim of this paper is to shed light on the current debate surrounding the productivity puzzle by focusing on one of these drivers, namely, structural change. In particular, we analyse in detail the impact this phenomenon has had in driving productivity growth in the last decades across the different EU economies, while examining in-depth the disparities observed among the latter. As we document, the *servicification* or *tertiarization* process of EU economies is a central element in explaining the dismal path followed by trend productivity growth in EU countries. This process refers to the increasing economic weight of the services sector, which represents a major drag to overall productivity growth. In addition, we contribute to the literature on the EU-US gap in aggregate productivity by decomposing this gap into expected future differences in sectoral composition and differences in sectoral productivity growth rates. Finally, we develop a general equilibrium model capable of replicating the observed pattern of structural change to shed light on the potential role it may have as a driver of future productivity growth in EU Member States. This constitutes, to our knowledge, the first attempt at investigating this issue under the lenses of a macroeconomic model that can accommodate structural change as observed in the data in the EU context.

2 Related literature

2.1 Structural change and productivity growth

This paper belongs to a growing body of empirical and theoretical literature that attempts to disentangle the interrelationship between structural change and the observed stagnation in secular productivity growth. A brief overview of the studies closest to ours in nature, including on the EU-US productivity gap, is offered hereunder.

From an empirical standpoint, the focus has mainly been on quantifying the impact that the slow, but steady, process of structural transformation across sectors has had on labour productivity growth over relatively long time periods.⁴ In order to gauge this impact, this literature often relies on decomposition methods such as OP and BHC-FHK (Murao, 2017), with the latter being the one most widely used.^{5,6} Despite the different approaches and, importantly, time periods covered, these studies generally find that stagnation in within-sector productivity growth accounts for the lion share of the economy-wide productivity growth slowdown.⁷ However, when considering relatively long periods of time, and focusing on the computation of counterfactual productivity growth rates, which assume no changes in the industrial composition of economies over time, it follows that structural change on its own has had a non-negligible impact in terms of foregone productivity growth. Hence, structural change constitutes an important drag to the expansion of welfare levels from a long-run perspective (Duernecker et al. (2017) and Bauer et al. (2020)).

The research we conduct in this paper is closest in nature to the literature surrounding the so-called Baumol’s cost disease. The significance of this phenomenon has been studied for both the US (Nordhaus, 2008) and the EU (Hartwig, 2011). Both of these authors provide econometric evidence in favour of the main hypotheses stemming from Baumol’s (1967) original theory, namely, that the continuous rise in the nominal value added share, employment and prices of service sub-sectors with relatively (i.e., stagnant) flat productivity profiles substantially weighs on overall productivity growth.⁸ These findings have been further corroborated for specific EU Member States and with more recent data in studies such as Bauer et al. (2020).⁹

More specifically, our contribution pertains to the literature aimed at modelling the impact of structural change through the lenses of general equilibrium models. These models are designed to replicate the most important empirical regularities on structural transformation and labour productivity growth over long periods of time in order to serve as useful tools in the exploration of the macroeconomic effects of this phenomenon going forward.

⁴The definition of structural transformation or change used throughout the paper corresponds simply to the secular shift over time in the economy’s sectoral composition. For the vast majority of advanced economies, this shift is characterized by an increasing share in the economy of the services sector at the detriment of the other two main aggregate sectors, namely agriculture and manufacturing. This process is also informally referred to as the servicification or tertiarization of the economy.

⁵These productivity growth decomposition approaches were originally employed for aggregating firm-level data and can be equivalently applied to sector-level data.

⁶The OP decomposes labour productivity growth into, first, a component that captures the shift in mean productivity across industries over time and, second, a covariance term that captures the co-movement between changes in sectoral productivity levels and value added shares over time. The BHC-FHK decomposition breaks labour productivity growth down into the contributions of the within, between, and the cross-/dynamic efficiency components.

⁷Examples include Bauer et al. (2020), IMF (2019), European Commission (2020a), Buiatti et al. (2018), Duernecker et al. (2017), Dabla-Norris et al. (2015).

⁸With nuances, a statistically significant presence of Baumol’s effects is confirmed in both cases.

⁹The latter, as well as Duernecker et al. (2017) for the case of the US, also rely on the computation of counterfactual growth rates to document the detrimental effect of structural change on productivity growth. An important degree of variation across Member States is observed in terms of the size of the effect.

One recent such model, featuring non-homothetic preferences and neoclassical production functions, is developed in Comin et al. (2021). The authors estimate the demand system derived from the model using household-level data from the United States and India to capture the broad patterns of sectoral reallocation observed among advanced, *miracle*, and developing economies. Their main finding is that income effects (i.e., demand-side factors) are stronger than price effects (i.e., supply-side factors) in driving the observed within-country evolution of sectoral reallocation.

Focusing on replicating the share of workers and output observed in the service sub-sectors with the fastest productivity growth in the US, Genna et al. (2020) propose a model where productivity is an endogenous outcome and output is produced with two intermediate, substitutable capital goods. Their main conclusion is that the growth path followed by countries is dependent on initial conditions, and thus countries with the same fundamentals but lower initial wealth are characterized by lower wealth in the long-run in their model economy.

Duarte (2020) investigates cross-country variation in consumption patterns of manufacturing goods, relative prices and productivity. Specifically, using disaggregated expenditure and consumption data, and employing a simple development accounting model, she finds large differences in productivity across countries for manufacturing categories and sub-sectors, although these are smaller than differences between manufacturing and services and considerably smaller than differences across individual manufacturing categories within countries. The very detailed taxonomy of developments in the manufacturing sector is the main contribution of this paper, departing from the more intense attention the services sector has attracted in the recent literature.

Delving into the theoretical underpinnings of existing models, Herrendorf et al. (2020) discuss in-depth the issue of structural change in both investment and consumption goods. First, using US data, they document the lack of empirical support behind the widely used assumption that the share of goods value added has always been much higher in investment expenditure than in consumption expenditure. Second, they construct a general equilibrium model that departs from the conventional assumptions behind existing models of structural transformation to reach a number of novel theoretical findings that challenge the conventional wisdom. This paper proposes thus a more suitable modelling framework for studying structural transformation not only in final consumption goods, but also in investment.

Another important theoretical issue surrounding this literature is the reconciliation of the observed productivity growth slowdown, partly a result of structural change, with Kaldor's stylized growth facts. Duernecker et al. (2020) provide one possible approach to reconcile these empirical observations by developing a two-sector growth model in which productivity growth slows down over time and real GDP is measured with the Fisher index used to construct the US's NIPA.

Regarding research contributions on the interrelationship between structural change and productivity growth in relatively new Member States, the literature is still scant. In a growth accounting exercise paralleling EU KLEMS, Levenko (2019) examine the growth experiences of eleven Central and Eastern EU countries before, during, and after the Great Recession. They find that growth in TFP was the main contributor to output growth in Slovenia, Hungary and Slovakia before the crisis, while capital deepening was more important in the Czech Republic, Croatia and Poland. During the global financial crisis, the contributions of TFP and investment differed markedly across countries, whereas after the crisis the contribution of TFP growth has been negligible in all the countries in the sample.

Kuusk et al. (2017) assess the importance of structural change as a driver of aggregate productivity growth for ten Central and Eastern EU countries over the years 2001–2012. They document that labour productivity growth within sectors plays a more dominant role for aggregate productivity growth, while reallocation of labour between sectors is less important. This holds despite the years analysed covering boom, crisis, and recovery periods.

All in all, to date, an all-encompassing, model-based analysis of the potential effects of structural change on productivity growth in these countries has not yet been developed. Our analysis fills this gap by providing new results for these Member States.

2.2 The EU-US productivity gap

Next we summarise the main results from the literature that investigates the sources of the productivity gap that has arisen over time between the EU and the US.

It was around the middle of the 1990s when labour productivity levels in Europe started falling behind those of the United States (U.S.). At that time, the U.S. experienced a productivity growth revival, while Europe missed out on the opportunities offered by the information and communications technology (ICT) revolution. As a result, a significant labour productivity gap opened up between the US and the EU; by 2005, value added per hour worked in the EU had dropped to only 70 per cent of the U.S. level. In addition, it was the widening gap in business services that started to account for most of the aggregate labour productivity growth gap between the US and the EU (Bauer et al., 2020).

A boost in investment in ICT capital, alongside robust improvement of labour skills, contributed substantially to labour productivity growth in market services during the late 90s and early 2000s in both the US and the EU (Inklaar et al., 2008). However, Europe did not experience as substantial a boost in productivity growth as the US did. Some studies concur that a few service sectors were at the centre of the divergent aggregate labour and total factor productivity

performance (Inklaar et al., 2007; 2008; Timmer et al., 2010). Buiatti et al. (2018) identify wholesale and retail trade and business services, and to a lesser extent financial services, as the sectors driving most of the aggregate labour and TFP gap.

The latter use a structural model to provide an account of the relative levels of sectoral labour productivity between the EU and the US, while estimating the contributions stemming from ICT capital and TFP. Their findings indicate that European countries are generally more productive than the U.S. in information and communication, education, real estate, and health services. At the same time, EU countries are on average less productive in wholesale and retail trade and business services, with sectoral labour productivity levels approximately 20 per cent below the U.S.'s. They also show that weaker physical capital investment has played an important role in explaining the productivity level gaps between the EU and the U.S..

Although close in nature, there are a number of important differences between this paper and ours. First, they use a smaller sample of countries (9 versus 28) and a shorter time period (1970-2009 versus 1970-2017). Second, they focus on exploring the sectoral origins of the productivity gap with respect to the U.S., while we make predictions about future structural change and productivity growth for both the EU and the US. Third, at a conceptual level, these authors use thirteen sectors but restrict the elasticity of substitution to be the same across goods, whereas we do not impose such restriction.¹⁰

A recent study by Gordon and Sayed (2019) digs deeper into the origins of the slowdown in labour productivity growth, drawing from the EU KLEMS 2017 release. They compare the case of the U.S. with that of Western European economies, going back to the 1950s. When comparing the early post-World War II period to the most recent decade, these authors conclude that there has been a substantial productivity growth slowdown, due to the slower pace of technological change, affecting both blocks of economies. According to these authors, the timing was slightly different, but the same industries have been affected both in the US and Europe.

In particular, they illustrate the performance of a group of ten EU economies¹¹ that have been catching up with US technology in different stages. During 1950-1972, rapid European growth reflected the adoption of the inventions that had propelled productivity growth in the U.S. during the first half of the 20th century. The following period of 1972-1995 was instead characterised by the imitation of U.S. technology during the period previous twenty years.¹²

¹⁰Buiatti et al.'s assumption is rather strong; there are no reasons *a priori* to believe that the elasticity of substitution between, for instance, agriculture and education is the same as that between agriculture and manufacturing. In fact, when conducting a counterfactual exercise where we restrict these elasticities to be the same, the model fit deteriorates substantially.

¹¹The countries included in their analysis are: Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, and the U.K.

¹²This is supported by the observation that the difference in EU productivity growth achieved in the period 1972-95 in relation to that in the period 2005-2015 (-1.68 percentage points) exactly matched the slowdown in U.S. productivity growth during the period 2005-2015 relative to its 1950-72 average growth rate.

Furthermore, they find a strong EU-US correlation across industries in the dynamics of what they call “early-to-late” change.¹³ This study also finds a dominant role for commodities in driving the slowdown in both the US and EU. This is mainly explained by a “further to fall” effect given the high labour productivity growth rates achieved by the commodities sectors in earlier decades (1950-72 for the US and 1972-95 for the EU-10).

Sen (2020) presents a very similar model, in terms of structure, to the one developed in this paper. It also addresses similar types of questions. The focus is however on the US and on productivity convergence between other developed countries and developing economies toward the former country’s productivity levels. He shows that differences in the growth rates of business service sectors in the US relative to those of other developed countries can explain the bulk of the increase in the productivity gap between the former and the latter, which was initiated in the second half of the 1990s. In line with Duernecker et al. (2017), he demonstrates that structural change within the services sector is also a major driver of productivity differences between the US and other developed countries. In contrast with our approach, he uses only three sectors (namely, goods, stagnant and progressive services). We show that this three-sector representation is insufficient to capture reallocation dynamics within services that are key to making reliable predictions about future structural change and its impact on productivity growth.

In brief, while the EU had been successful in catching up with labour productivity growth rates in the US in the boom post-War periods, it failed to do so after the mid-1990s, despite a similar adoption speed of ICTs. There was some stimulus to productivity growth from the ICT-intensive industries in the EU at the turn of the last century and the beginning of this one, but this was not large enough to offset the decline in growth experienced by the non-ICT industries, particularly after 2005.

Our paper adds a new perspective to this literature by analysing differences in the expected future impact of structural change on labour productivity growth between the EU and the US. Our results indicate that the impact that transformation has had on productivity growth in the past is bound to continue in the future in the EU, contrary to the US. The main predicted culprit is the productivity gap in services, especially those services which are predicted to experience the largest expansion. This implies that the gap with respect to the US in terms of aggregate productivity levels is anticipated to widen further, and thus that the key to closing this gap is to foster productivity growth in the EU’s service sectors.

2.3 Structural change and the COVID-19 crisis

Although the main focus of the present paper is on the long-term link between productivity growth and structural change, the current crisis is bound to have a non-negligible bearing on

¹³The “early-to-late” slowdown refers to the change in U.S. productivity growth from 1950-72 to 2005-15 and to the change in EU-10 productivity growth from 1972-95 to 2005-15.

long-term economic performance. Chiefly hinging on the direction and success of policy action, the current crisis might arguably accelerate the secular slowdown in productivity growth or lead to shifts in the sectoral composition of the economy and/or rises in technological progress within industries that deliver enhanced prospects for productivity growth in the medium-to-long term. As an example of the former negative aspects, recent firm-level research shows that allocative efficiency, as measured by the covariance between firm size and productivity in each sector, has declined (Compnet, 2020). In this sense, the crisis represents an opportunity to improve on this allocation by gearing resources towards the sectors with higher productivity. Regarding the possible positive effects of the crisis, in the particular case of the EU, to the extent that the *NextGeneration* funds are successful in their goal of achieving a swift green and digital transition, the productivity growth performance of relatively slacking industries might improve. This could be the case, for instance, if certain lagging sectors within services adopt digital technologies (e.g., wholesale and retail sector) that can significantly boost their production efficiency.

Our paper’s contributions to the existing literature are manifold. First, building on Duernecker et al. (2017) and Bauer et al. (2020), we empirically document in detail the size of both the productivity growth slowdown and the structural change phenomenon for 25 EU Member States. Second, we examine by how much structural change has dragged on productivity growth across Member States in the past. We also inspect, via the computation of counterfactual growth rates, which degree of sectoral breakdown is needed to properly capture the process of structural transformation and its impact onto long-term productivity growth. Third, this paper constitutes the first attempt, to our knowledge, at quantifying the potential impact of structural change onto future productivity growth in EU economies in the framework of a model calibrated to EU data. Fourth, we contribute to the literature on the EU-US productivity growth gap by establishing how much of this gap is due to differences in sectoral composition as opposed to differences in sectoral productivity growth rates. One of the main findings following from this analysis is that Baumol’s disease constitutes a more prevalent phenomenon in EU economies than in the US.

The rest of the paper is structured as follows. Section 3 provides an overview of the data used and the empirical regularities observed, including the impact of structural change on past productivity growth. Section 4 presents the general equilibrium model used for the impact simulations. Section 5 provides details of the quantitative analysis and discusses the main conclusions. Section 6 features a number of robustness analyses to support our results. Finally, section 7 contains concluding remarks, including main policy messages stemming from our analysis.

3 Data and stylized facts

Data description

The data that we use in the empirical and in the theoretical, model-based analysis are taken from two waves of the EU-KLEMS database: the November 2009 release (updated March 2011) and the 2019 release. The 2009 release covers the period 1970-2007 while the latter covers the period 1995-2017. Structural change is a long-run phenomenon; hence, it is essential that our data cover a sufficiently long time period so that we can analyse the patterns of sectoral reallocation in a meaningful way. In order to maximize the time coverage, we link the two waves. The 2009 release is based on the ISIC Revision 3 industry classification, while the 2019 release uses the ISIC Revision 4 classification. In order to connect the two datasets, we use the correspondence tables of the Statistics Division of the United Nations Department of Economic and Social Affairs.¹⁴ The quality of the combined dataset depends on the degree of overlap between the two industry classifications. In our analysis, the finest-grain level of industry classification used is relatively broad, namely the two-digit level. Hence, quite naturally the amount of overlap between the two industry classifications at this level of disaggregation is very large. In order to avoid major shifts in the series in the year when the two datasets are connected (1995), we calculate the values for the different time series in the period 1970-1995 by extrapolating the time series of the 2019 release using the growth rates of the corresponding variables from the 2009 release.

Our sample includes the following set of 28 countries (acronym in brackets): Austria (AT), Belgium (BE), Bulgaria (BG), Cyprus (CY), Czechia (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (EL), Hungary (HU), Ireland (IE), Italy (IT), Japan (JP), Latvia (LV), Lithuania (LT), Luxembourg (LU), Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Slovakia (SK), Slovenia (SI), Spain (ES), Sweden (SE), United Kingdom (UK), USA (US).¹⁵ The coverage of these variables in our combined dataset is from 1970-2017 for the older Member States, and from 1995-2017 for the newer Member States.^{16,17}

Facts for 3 broad sectors

As a first step, we analyse the patterns of structural change and productivity growth across the countries in our sample. We start by disaggregating the economy into the three broad sectors:

¹⁴The correspondence tables are freely available at <https://unstats.un.org/unsd/classifications/Econ>.

¹⁵The sample includes all countries belonging to the European Union, except Croatia and Malta, for which the data coverage is insufficient for our purposes. Japan, the U.K. and the U.S. are included for comparative analysis purposes.

¹⁶Older Member States: countries that were members of the EU before May 2004 (excluding the UK), namely, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, and Sweden. Newer Member States: countries that joined the EU in May 2004 or later, namely, Bulgaria, Croatia, Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia.

¹⁷Table 10 in the appendix reports detailed data availability for all countries and all variables in our combined dataset.

agriculture, industry and services.¹⁸ In Panels (a) and (b) of Figure 2 we show for each country the sectoral shares of nominal value added and employment in the year 2017. A number of important observations emerge from this figure. First, agriculture is a very small sector with a share in total value added of less than 5% on average across countries. Interestingly, this pattern applies to all countries in the sample, including the new EU-member states. Nevertheless, we can observe significant variation in terms of the agricultural employment share across countries, with some countries exhibiting employment shares larger than 10%. This indicates the existence of large cross-country differences in agricultural productivity.

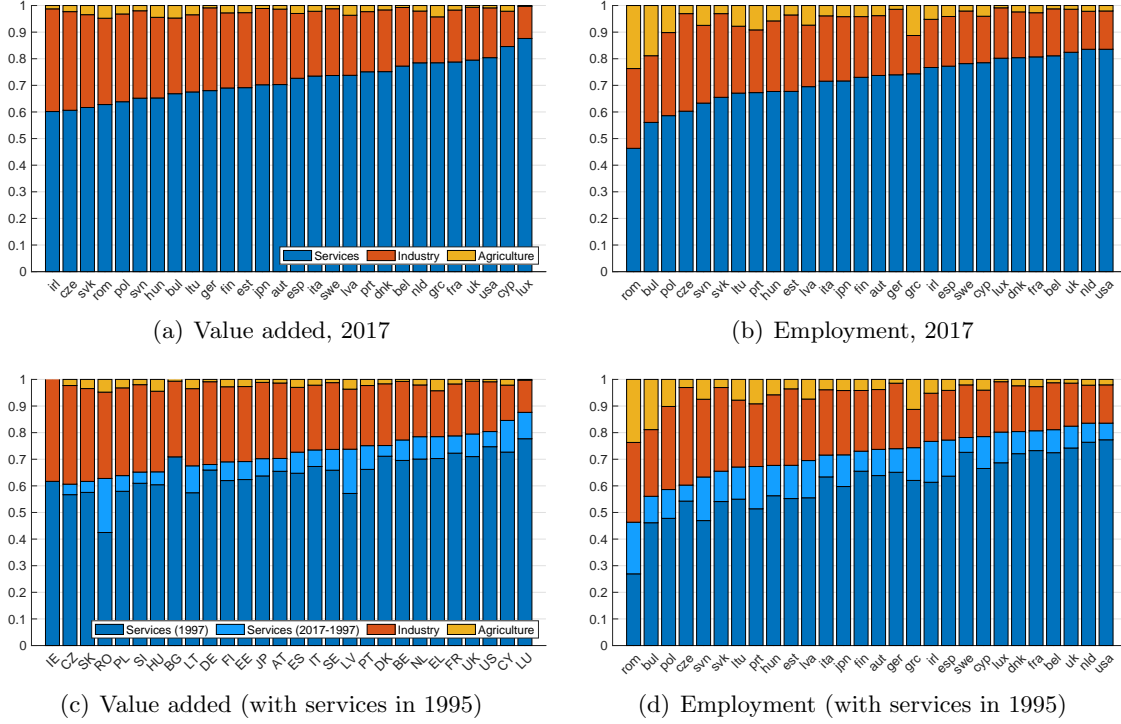


Figure 2: Sectoral shares of value added and employment.

A second important observation emerging from Figure 2 is that there is a substantial amount of variation across countries in the size of the service sector. The size measured as the sector's share in total value added ranges from about 60% in Ireland, Czechia and Slovakia to more than 80% in the U.S., Cyprus and Luxembourg. Since the agriculture sector is small in all countries, the large variation in the size of services is mirrored by a large variation in the size of the industry sector; countries with a large service sector have a small industry sector and vice versa. As is well known, in a growing economy the service sector expands at the expense of the other two sectors. To illustrate how much the service sector has expanded in our sample of countries, we show in Panels (c) and (d) of Figure 2 the difference between the 1995 and the 2017 levels of the service share. This difference is indicated by the light-blue bars. For all the

¹⁸Agriculture consists of: agriculture, hunting, forestry and fishing; industry consists of: mining, quarrying, manufacturing, utilities, and construction; services consists of: wholesale and retail trade, accommodation, food services, transportation, storage, information and communication, finance, real estate, professional activities, scientific and technical activities, administrative and support activities, public administration, education, health and social work activities, and other community, social or personal services.

countries in our sample, we can observe a sizable expansion of the service sector of up to 20 percentage points in terms of value added and employment shares. For several countries we can go back further in time and calculate the change in the sectoral shares since 1970. In Table 1 we report this change for the value added and employment shares. As can be seen, the rise in the service sector is not a feature of the 1990s and 2000s but a long-run phenomenon that has been ongoing for most of the post-war period.

In Table 1 we also report the growth rates of sectoral labour productivity. We measure labour productivity as real value added per hour worked and in the table we report the average annual growth rate.¹⁹ Reassuringly, the usual patterns in sectoral productivity growth rates observed in the literature also apply to the countries in our sample. That is, productivity growth in the service sector is lower than that in the agriculture sector which in turn is generally higher than that in the industry sector.²⁰

The previous two observations that the service sector features low productivity growth and has expanded in size over time jointly imply that the infamous Baumol's cost disease applies to essentially all the countries under consideration. Put differently, the reallocation of value added and labour towards the sectors with the lowest productivity growth means that structural change has had a negative impact on past aggregate labour productivity growth. We will investigate this aspect further below.

Table 1 also addresses the difference between the U.S. and Europe in terms of sectoral composition and productivity growth. First, it is important to notice that the EU is generally very heterogenous. Some countries exhibit a sectoral composition that is similar to that in the US - this applies, for example, to France, the Netherlands and the UK - while others differ substantially, mostly due to larger industry sectors. This applies most notably to Austria, Finland, Ireland and Germany. However, a common feature of essentially all EU countries is the larger expansion of the service sector in the post-war period and a corresponding larger decline of the goods-producing sectors than in the US. This pattern is not surprising. After WWII, Europe was generally poorer than the U.S. and thus had relatively larger agriculture and industry sectors. Then, during the post-war period European countries experienced a rapid catching-up process which led to a fast expansion of the service sector and a gradual narrowing of the gap to the U.S.. The convergence of Europe is also reflected in the larger sectoral productivity growth rates. However, as is well known, productivity growth in many EU countries has substantially slowed down in recent years and has fallen short of U.S.'s productivity growth at both the sectoral and the aggregate levels. We will address this issue in greater detail further below.

¹⁹We compute the real value added of each broad sector by applying a Törnqvist aggregation of the real value added of the respective subsectors.

²⁰The exceptions to this rule are Luxembourg and Cyprus. This is in turn due to the very specific industry composition of these countries, specialized in service sectors with relatively higher growth profiles.

	Value added						Employment						Productivity		
	Share in 2017			Δ 1970-2017			Share in 2017			Δ 1970-2017			Δ 1970-2017		
	agr	ind	srv	agr	ind	srv	agr	ind	srv	agr	ind	srv	agr	ind	srv
AT	1	28	70	-6	-13	20	4	22	74	-14	-14	28	4.1	2.8	1.5
BE	1	22	77	-3	-21	24	1	18	81	-3	-25	28	3.6	3.7	1.2
DK	2	23	75	-4	-8	12	2	17	80	-8	-18	26	5.8	2.3	1.3
ES	3	24	73	-6	-18	24	4	19	77	-21	-17	38	5.5	2.3	0.7
FI	3	28	69	-8	-11	20	4	23	73	-17	-10	27	4.3	3.3	1.3
FR	2	20	79	-5	-16	21	3	17	81	-11	-18	29	4.5	2.8	1.5
DE	1	31	68	-2	-17	19	1	25	74	-6	-23	28	3.9	2.5	1.8
EL	4	17	78	-6	-16	21	11	14	74	-28	-9	37	2.5	1.3	0.5
IE	1	39	60	-11	8	3	5	18	77	-20	-10	30	2.6	5.5	1.8
IT	2	24	73	-7	-14	21	4	25	72	-16	-13	29	3.5	2.0	0.5
JP	1	29	70	-4	-14	18	4	24	72	-15	-12	27	2.3	3.1	1.9
LU	0	12	88	-3	-39	42	1	19	80	-9	-25	34	1.4	0.5	2.6
NL	2	19	78	-4	-16	20	2	14	84	-3	-20	23	3.7	2.7	1.5
PT	2	23	75	-12	-1	13	9	24	67	-17	-12	29	3.5	2.5	1.8
SE	1	25	74	-5	-9	15	2	20	78	-5	-17	22	2.5	2.8	1.1
UK	1	20	79	-2	-22	24	1	16	82	-1	-25	27	2.6	2.2	1.2
US	1	19	80	-1	-12	13	2	14	84	-2	-12	14	3.0	2.1	1.1
EU6	1	25	73	-4	-16	20	2	21	76	-9	-19	28	3.9	2.5	1.4
EU14	2	25	73	-5	-15	20	3	21	76	-11	-18	29	4.0	2.5	1.3
	Share in 2017			Δ 1995-2017			Share in 2017			Δ 1995-2017			Δ 1995-2017		
	agr	ind	srv	agr	ind	srv	agr	ind	srv	agr	ind	srv	agr	ind	srv
BG	5	28	67	-5	9	-4	19	25	56	-3	-7	10	-0.6	-1.7	1.3
CY	2	13	85	-3	-9	12	4	17	79	-4	-8	12	-0.6	1.1	1.3
CZ	2	37	61	-2	-2	4	3	37	60	-2	-4	6	2.4	3.6	1.6
EE	3	28	69	-3	-4	7	4	29	68	-8	-5	12	8.2	5.7	3.2
HU	4	30	65	-4	-1	5	6	27	68	-7	-4	11	5.2	2.8	1.6
LT	3	29	68	-8	-3	10	8	25	67	-11	-1	12	4.3	5.0	3.4
LV	4	23	74	-6	-11	17	7	23	70	-11	-3	14	7.5	4.0	3.6
PL	3	33	64	-3	-3	6	10	31	59	-9	-1	11	2.9	4.3	2.4
RO	5	32	63	-14	-6	20	24	30	46	-19	-1	19	4.8	4.3	2.5
SK	3	35	62	-2	-2	4	3	31	66	-7	-5	11	8.7	5.6	1.7
SI	2	33	65	-2	-2	4	7	29	63	-7	-10	16	4.5	3.7	1.1
EUnew	4	32	64	-5	-3	8	12	30	58	-9	-3	12	3.7	3.7	2.1

agr: agriculture, **ind:** industry, **srv:** services. **Productivity:** Average annual growth rate of constant price value added per hour worked. **EU6:** Belgium, France, Germany, Italy, Luxembourg, Netherlands; **EU14:** EU6 + Austria, Denmark, Finland, Greece, Ireland, Portugal, Spain, Sweden; **EUnew:** Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovak Republic, Slovenia. Employment-weights are used to compute cross-country averages. **Source:** EU-KLEMS.

Table 1: Sectoral value added, employment and productivity growth.

Disaggregating the service sector

The service sector in a given country is generally extremely heterogenous in terms of value added and employment dynamics, and productivity growth. For example, some service sub-sectors stagnate in terms of size, whereas others expand rapidly. Likewise, there are service sectors that exhibit high productivity growth, while others have zero or even negative productivity growth. Given the large size of total services and the heterogeneity within services it is advisable not to lump all services into one broad sector but to disaggregate it and consider service sub-sectors separately. As we will see, this heterogeneity implies that the sectoral composition and future developments in terms of the allocation of resources within services play a

key role in driving aggregate productivity growth.²¹

We choose to disaggregate services into the two-digit sub-sectors.²² This classification scheme is sufficiently fine-grained so as to capture the large degree of heterogeneity within services while remaining still tractable for modelling purposes. Table 2 characterizes the nine service sectors in terms of size and productivity growth. A few remarks are in order. First, the size distribution of sectors (as measured by the sector's share in total value added) is remarkably similar across countries. In all countries – with the exception of Luxembourg – business services are by far the largest sub-sector, followed by trade, health and finance. Interestingly, we observe that not all sub-sectors have increased in size. In fact, several sub-sectors, such as trade and transportation, have declined. At the same time, other sectors within services have expanded rapidly. This applies particularly to business services, finance and health. Together, these three sectors account for almost the entire increase in the value added share of services. This pattern is remarkably uniform across countries.

²¹Similarly, we could also consider to disaggregate the industry sector. We do not do that because, first, the industry sector is relatively small in most countries and has been shrinking over time. Hence, the dynamics of aggregate productivity growth depend to an increasingly smaller degree on the industry sector. Second, the sub-sectors within the industry sector are comparably homogenous in terms of productivity growth. Hence, no further insights would be gained by disaggregating this sector.

²²These include the following sub-sectors: (1) wholesale and retail trade, (2) accommodation and food services, (3) transport, storage and communication, (4) financial intermediation, (5) business services, (6) public administration, (7) education, (8) health, and (9) social and personal services.

	Value added									Productivity growth								
	Share in 2017									Δ 1970-2017								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AT	12	5	9	4	20	5	5	7	3	-4	2	0	1	15	1	1	4	1
BE	12	2	10	6	23	8	7	7	2	0	1	2	-1	15	0	2	4	1
DK	13	2	10	6	20	5	6	10	3	-4	0	0	1	10	-1	1	4	1
ES	12	7	9	4	19	6	6	6	3	2	3	2	2	12	-0	3	1	0
FI	9	2	11	3	22	6	5	9	3	-1	0	2	1	11	0	1	3	1
FR	10	3	10	4	27	8	5	9	3	-1	1	0	0	11	2	2	5	1
DE	10	2	9	4	22	6	4	8	4	-1	0	1	0	12	-1	1	4	1
EL	11	7	10	4	22	10	6	4	4	-4	3	2	0	8	6	3	2	1
IE	8	2	13	7	18	3	3	5	1	-5	0	-2	4	7	-3	-0	2	0
IT	12	4	9	5	24	7	4	6	3	-0	1	2	1	13	0	1	3	0
JP	14	3	10	4	19	5	4	7	3	1	-2	2	0	11	1	1	4	1
LU	11	2	8	28	20	6	4	6	2	-1	-1	1	23	17	-0	0	3	0
NL	14	2	10	7	22	7	5	9	2	1	0	1	3	12	-1	-1	4	0
PT	14	6	8	5	20	7	6	6	2	0	4	3	1	-9	4	3	4	1
SE	11	2	12	4	20	5	6	11	3	0	0	-0	0	10	-1	1	3	1
UK	10	3	11	7	26	5	6	8	4	-1	1	0	3	15	-2	1	4	2
US	12	3	11	8	23	12	1	8	3	-2	1	1	3	9	-3	0	3	1
EU6	11	2	9	5	23	7	5	8	3	-0	1	1	1	12	0	1	4	1
EU14	11	3	10	4	22	7	5	8	3	-0	1	1	1	11	0	1	4	1
	Share in 2017									Δ 1995-2017								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
BG	14	2	12	7	16	6	4	4	2	8	1	5	-0	-20	-1	1	2	1
CY	11	7	12	11	20	9	7	4	3	-2	-1	-1	6	7	-0	2	1	-0
CZ	11	2	11	4	15	6	4	5	2	1	-1	1	1	3	-1	0	1	-0
EE	12	2	13	4	20	7	5	4	2	0	1	1	1	9	-3	-2	1	-0
HU	10	2	11	4	18	8	5	4	3	1	-1	1	-1	5	0	-0	0	-0
LT	18	2	16	2	14	6	4	4	2	2	0	7	0	3	-2	-1	1	0
LV	15	2	15	4	20	8	5	3	3	6	1	-3	1	11	1	-1	-0	1
PL	17	1	11	4	13	6	5	4	2	-1	0	2	2	3	-1	-1	1	0
RO	11	2	13	3	17	6	4	4	3	4	-0	5	-4	7	3	2	3	1
SK	12	1	11	3	16	7	4	4	3	-1	-0	1	-3	5	0	0	0	2
SI	12	2	11	4	18	6	5	5	3	0	0	3	-2	3	0	-0	0	-0
EUnew	14	2	12	4	15	6	4	4	3	1	-0	3	-0	3	-0	0	1	0

(1): Wholesale and retail trade; (2): Accommodation and food services; (3): Transport, storage and communication; (4): Financial intermediation; (5): Business services; (6): Public administration; (7): Education; (8): Health; (9): Social and personal services. **Productivity growth:** Average annual growth rate of constant price value added per hour worked. **EU6:** Belgium, France, Germany, Italy, Luxembourg, Netherlands; **EU14:** EU6 + Austria, Denmark, Finland, Greece, Ireland, Portugal, Spain, Sweden; **EUnew:** Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovak Republic, Slovenia. Employment-weights are used to compute cross-country averages. **Source:** EU-KLEMS.

Table 2: Services: Value added shares and productivity growth.

Baumol's cost disease across countries

Table 2 also reveals that these sub-sectors differ significantly in terms of their productivity performance. While some sectors - such as trade, transportation and finance -, have exhibited high productivity growth, even comparable to that of the manufacturing sector, other sectors - such as food, business services, education and health -have tended to stagnate. Interestingly, there exists a somewhat inverse relationship between the change in the size of a sector and its productivity growth. That is, the sectors with relatively low productivity growth have experienced an increase in their size (e.g., business services, health) whereas the sectors with relatively fast productivity growth have stagnated or even declined in size (e.g., trade, transportation, finance). This observation suggests that Baumol's cost disease is at play in the majority of EU countries,

exerting a negative effect on aggregate productivity growth. To further investigate this issue and to assess the impact of structural change on aggregate labour productivity growth, we compare, for each country, the actual and counterfactual productivity growth rates, where the latter that are computed by holding the sectoral shares of value added and hours worked constant at their 1970 levels. By proceeding this way, we isolate the true effect of structural change over time, as aggregate productivity growth is the result of the weighted sum of the sectoral level productivity growth rates, where the weights are fixed at the 1970 values of each sector's value added and hours share.²³

Table 3 reports the actual and the so-calculated counterfactual, economy-wide productivity growth rates. Not surprisingly, for almost all countries, counterfactual productivity growth is higher, implying that structural change has caused aggregate, long-term productivity growth to be lower.²⁴ Generally, this negative effect is sizeable, in the range of -0.1 to -0.8 percentage points. For example, for Spain, the 1970-2017 average annual aggregate productivity growth rate would have been 0.8 percentage points higher if the sectoral composition had not changed over time. At a first glance, a difference of 0.8 percentage points may seem rather small. However, the cumulative effect over time leads to a large effect on productivity in levels, and thus on income per capita, in the long run. Hence, this figure is non-negligible in terms of foregone welfare (Bauer et al. (2020)). Importantly, the large effect of Baumol's cost disease on aggregate growth does not depend on what measure of productivity we use.²⁵

²³Unless otherwise noted, we define labour productivity as real value added per hour worked throughout all the analyses.

²⁴This finding is in line with the results obtained by Duernecker et al. (2017) for the U.S. and by Bauer et al. (2020) for the EU.

²⁵As can be observed from Table 11 in the appendix, the results are very similar when productivity is measured in terms of TFP, value added per worker, or value added per efficiency hour.

	Aggregate productivity growth					
	Average, 1970-2017			Growth slowdown		
	actual	no SC	Δ	actual		no SC
				70-85	02-17	02-17
AT	2.3	2.8	-0.5	3.6	1.1	1.7
BE	2.1	2.5	-0.4	3.9	0.7	1.3
DK	1.9	2.3	-0.4	2.9	1.0	1.8
ES	1.8	2.6	-0.8	3.7	1.0	1.3
FI	2.4	3.1	-0.7	3.3	0.9	1.7
FR	2.2	2.8	-0.6	3.8	0.7	1.0
DE	2.1	2.4	-0.3	3.1	0.9	1.4
EL	1.3	1.7	-0.4	2.7	0.0	-0.2
IE	3.3	3.0	0.3	3.6	3.8	2.7
IT	1.5	2.0	-0.5	2.5	0.2	0.3
JP	2.5	2.8	-0.3	3.8	0.9	1.3
LU	2.0	1.3	0.7	3.4	-0.0	0.7
NL	1.9	2.2	-0.3	3.6	0.9	1.4
PT	2.4	2.5	-0.1	3.2	0.9	1.9
SE	1.7	1.9	-0.2	1.6	1.2	1.2
UK	1.6	1.9	-0.3	1.7	0.7	0.9
US	1.4	1.6	-0.2	1.1	1.2	1.4
EU6	2.0	2.4	-0.4	3.2	0.7	1.0
EU14	2.0	2.4	-0.4	3.2	0.8	1.1
	Average, 1995-2017			actual		no SC
	actual	no SC	Δ	95-06	06-17	06-17
BG	1.2	0.2	1.0	-0.2	2.7	4.4
CY	1.5	1.4	0.1	2.5	0.5	0.4
CZ	2.4	2.2	0.2	3.5	1.3	1.3
EE	4.3	4.4	-0.1	6.6	2.1	2.4
HU	2.3	2.6	-0.3	4.0	0.6	0.8
LT	4.2	3.8	0.4	5.7	2.7	3.0
LV	4.5	4.5	0.0	6.7	2.2	2.8
PL	3.4	3.3	0.1	3.9	2.8	2.8
RO	4.2	4.4	-0.2	4.5	4.0	4.6
SK	3.5	3.8	-0.3	4.6	2.4	2.6
SI	2.7	3.1	-0.4	4.3	1.2	1.1
EUnew	3.2	3.1	0.0	3.9	2.5	2.9
actual: Data outcome. no SC: Sectoral composition of value added and hours worked fixed at 1970-level. Δ : Difference between <i>actual</i> and <i>no SC</i> .						

Table 3: Actual and counterfactual productivity growth (annual, percentage).

In order to offer more perspective into the size of the issue, and to check that the results obtained are not an artifact of the choice of 1970 as the base year, we undertake a similar exercise in which we compute average annual labour productivity growth in the two periods 1970-1985 and 2002-2017, and then proceed to calculate the counterfactual average productivity growth rates in the second period using the average sectoral composition that prevailed in the first period. The impact of so-calculated structural change is shown in the columns under *Growth slowdown* in Table 3. Several remarks are worth underlining. First and foremost, almost all European countries in our sample have experienced a dramatic slowdown of aggregate growth between 1970-1985 and 2002-2017. Clearly, part of this slowdown comes naturally as many countries are still in a period of transition during which aggregate growth slows down due to economic convergence. That is, decreasing returns to scale in development phases characterized by the *ex-*

tensive margin Another reason for the observed growth slowdown is related to the exhaustion of some of the most relevant *engines* of growth. According to modern theories of economic growth, this phenomenon is due to the erosion of the drivers of long-run growth in the more advanced economies such as decreasing returns to research and innovation, and possibly slower rates of technology diffusion. However, another reason is structural change. As explained above, the ongoing reallocation of resources towards services leads to a decline in aggregate productivity growth. Thus, part of the observed slowdown in aggregate productivity is due to this reallocation. This follows from the observation in 3 that, for most countries, the counterfactual growth slowdown is less severe than the actual one. Moreover, it is important to notice that these counterfactual growth rates are close to or even higher than actual aggregate productivity growth in the US. In other words, a substantial part of the recent dismal productivity performance in the EU relative to the US is due to the more rapid expansion of the service sector in the EU which, in addition, exhibits lower productivity growth on average than in the U.S.

To sum up, we find that since the 1970s structural change in the EU has led to a sizable shift in the sectoral composition of economies towards services and has thereby exerted a substantial negative impact on long-term aggregate productivity growth in most countries. Moreover, this effect has been more pronounced in the EU than in the U.S., especially in recent years. In the next sections, we aim to explore the impact that structural change may have on future aggregate productivity growth in the EU. To this end, we set up and calibrate a multi-sector growth model and use it to build scenarios - separately for each country - for the future potential paths that sectoral reallocations and aggregate labour productivity growth may follow. In this sense, it is paramount that the model can accurately replicate the historical patterns of productivity growth and structural change described in this section. Only then can this framework be a suitable tool for producing credible simulations of future scenarios. Our model builds on the canonical model of structural change as described, for example, in Herrendorf et al. (2014), and Comin et al. (2020). However, since the baseline model in this family of models is typically applied to study a three-sector representation of the aggregate economy, we extend it so that our model can deal with a richer set of eleven different one-digit sectors. As we show below, this is needed in order to more properly capture the true impact of structural change.

4 Model

We start by describing the building blocks of the model economy. Time is discrete and indexed by $t = 0, 1, \dots, \infty$. Preferences of the representative consumer are given by

$$\sum_{i=1}^N \alpha_i^{\frac{1}{\sigma_i}} \left(\frac{C_{it}}{C_t^{\epsilon_i}} \right)^{\frac{\sigma_i - 1}{\sigma_i}} = 1 \quad (1)$$

where N is the number of different consumption varieties (or sectors) available in the economy.^{26,27} C_i is the quantity consumed of variety i and $\alpha_i \geq 0$ is the utility weight of variety i . C_t is a consumption index given by the flow of utility derived from the consumption of C_i . Parameters $\sigma_i, \sigma_j \geq 0$ for $i \neq j$ govern the elasticity of substitution between varieties i and j . The preferences in (1) belong to the class of implicitly additive utility functions that were originally proposed by Hanoch (1975) and Sato (1975). An important feature of these preferences is that they are non-homothetic and, thus, they allow for income effects. Moreover, these income effects can be non-linear, meaning that the composition of consumer's consumption expenditures need not linearly vary with income. In other words, the Engel curves associated with consumer's demand have non-constant slopes. The sign and strength of the income effect for variety i is governed by parameter ϵ_i . Notice that (1) nests the standard homothetic CES-utility function. To see this, set $\epsilon_i = 1$, and $\sigma_i = \sigma_j$, for all $i \neq j = 1, 2, \dots, N$, to obtain:

$$C_t = \left(\sum_{i=1}^N \alpha_i^{\frac{1}{\sigma}} C_{it}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

To ensure global monotonicity and quasi-concavity of preferences, we require the following restrictions on σ_i and ϵ_i (see Hanoch, 1971): (i) $\alpha_i, \epsilon_i > 0$, (ii) $\sigma_i > 0$, (iii) $(\sigma_i - 1)/\sigma_i$ has the same sign for all i , which is achieved when $\sigma_i > 1$ or $\sigma_i \in [0, 1]$. As usual, the consumer's optimization problem can be formulated as a utility-maximization problem or as an expenditure minimization problem. Here, we choose the latter for ease of exposition. The consumer chooses the consumption level of each variety, C_i , to minimize total expenditures subject to the constraint in (1).

$$\min_{\{C_{it}\}_{i=1}^N} \sum_{i=1}^N p_{it} C_{it} + \lambda_t \left[1 - \sum_{i=1}^N \alpha_i^{\frac{1}{\sigma_i}} \left(\frac{C_{it}}{C_t^{\epsilon_i}} \right)^{\frac{\sigma_i-1}{\sigma_i}} \right]$$

where p_i is the price of variety i and λ is the Lagrange multiplier. The first-order necessary conditions with respect to varieties i and j are given by:

$$\begin{aligned} C_{it} : \quad p_{it} - \lambda_t \alpha_i^{\frac{1}{\sigma_i}} \left(\frac{\sigma_i-1}{\sigma_i} \right) C_{it}^{-\frac{1}{\sigma_i}} C_t^{-\epsilon_i \frac{\sigma_i-1}{\sigma_i}} &= 0 \\ C_{jt} : \quad p_{jt} - \lambda_t \alpha_j^{\frac{1}{\sigma_j}} \left(\frac{\sigma_j-1}{\sigma_j} \right) C_{jt}^{-\frac{1}{\sigma_j}} C_t^{-\epsilon_j \frac{\sigma_j-1}{\sigma_j}} &= 0 \end{aligned}$$

We multiply both expressions by C_i and C_j , respectively and divide the first by the second expression to obtain the relative demand function of the consumer:

$$\frac{p_{it} C_{it}}{p_{jt} C_{jt}} = \left(\frac{\sigma_i - 1}{\sigma_j - 1} \right) \left(\frac{\sigma_j}{\sigma_i} \right) \alpha_i^{\frac{1}{\sigma_i}} \alpha_j^{-\frac{1}{\sigma_j}} C_{it}^{\frac{\sigma_i-1}{\sigma_i}} C_{jt}^{\frac{1-\sigma_j}{\sigma_j}} C_t^{\epsilon_i \frac{1-\sigma_i}{\sigma_i} - \epsilon_j \frac{1-\sigma_j}{\sigma_j}} \quad (2)$$

It is important to understand the role played by C_t in shaping the income effect between varieties i and j . For concreteness, suppose that $\sigma_i = \sigma_j$. If $\epsilon_i > \epsilon_j$, then an increase in aggregate income

²⁶Without loss of generality, we set the utility index equal to 1 for simplicity

²⁷Later, in the quantitative analysis, we set $N = 11$.

leads - via the associated rise in C_t - to a shift in relative nominal consumption expenditures towards variety i .

Each variety i is produced by a representative firm. The production technology of the firm is $Y_{it} = A_{it}L_{it}$, where Y_i is total output of variety i , A_{it} is the level of technology, and L_{it} is labour input. Importantly, A_{it} is exogenous and allowed to differ across sectors. The firm's profit maximization problem is given by:

$$\max_{L_{it}} p_{it}A_{it}L_{it} - \tau_{it}w_tL_{it}$$

where w_t is the wage per unit of labour, and $\tau_{it} \geq 1$ captures a sector-specific *wedge*.²⁸ The introduction of this wedge, τ_{it} , is needed for the model to match the observed differences in sectoral nominal labour productivity levels. The first-order necessary condition for variety i is

$$p_{it}A_{it} - \tau_{it}w_t = 0 \quad (3)$$

Consider the first-order conditions for i and j and divide one by the other to obtain:

$$\frac{p_{it}A_{it}}{p_{jt}A_{jt}} = \frac{\tau_{it}}{\tau_{jt}} \quad \Rightarrow \quad \frac{p_{it}}{p_{jt}} = \frac{\tau_{it}}{\tau_{jt}} \frac{A_{jt}}{A_{it}} \quad (4)$$

The relative wedge τ_{it}/τ_{jt} drives a gap between the relative price and the relative productivities between two given sectors. A simple rearrangement of this expression gives

$$\frac{p_{it}A_{it}L_{it}}{p_{jt}A_{jt}L_{jt}} = \frac{\tau_{it}}{\tau_{jt}} \frac{L_{it}}{L_{jt}} \quad \Rightarrow \quad \frac{p_{it}Y_{it}}{p_{jt}Y_{jt}} = \frac{\tau_{it}}{\tau_{jt}} \frac{L_{it}}{L_{jt}} \quad \Rightarrow \quad \frac{p_{it}Y_{it}/L_{it}}{p_{jt}Y_{jt}/L_{jt}} = \frac{\tau_{it}}{\tau_{jt}} \quad (5)$$

The latter implies that whenever $\frac{\tau_{it}}{\tau_{jt}} \neq 1$, the nominal value added share, $\frac{p_{it}Y_{it}}{p_{jt}Y_{jt}}$, is not equal to the labour share, $\frac{L_{it}}{L_{jt}}$, and thus that the ratio of nominal labour productivities is not equalized across sectors. In the standard model of structural change, we have that $\tau_i = \tau_j = 1$ and, thus, $p_{it}Y_{it} = p_{jt}Y_{jt}$. However, this relationship does not generally hold in the data as shown, for example, in Duernecker (2020). For our purposes, it is important that the model is able to capture this deviation of conventional theories of structural change from empirical observations in order for the model to provide as good a representation of the data as possible. This is a necessary condition to ensure the reliability of the model's simulation of future productivity growth paths.

Labour market clearing and goods market clearing requires that

$$\sum_{i=1}^N L_{it} = L \quad C_{it} = Y_{it} \quad \text{for } i = 1, 2, \dots, N$$

Revenues from sectoral wedges/taxes are rebated to the consumer in a lump-sum fashion and

²⁸This wedge might capture anything that drives gaps between relative prices and productivities across sectors, ranging from market distortions and regulation to taxes and other factors

are given by T_t ²⁹

$$T_t = \sum_{i=1}^N (\tau_{it} - 1) w_t L_{it}$$

Lastly, we define the competitive equilibrium of the model economy as follows:

Definition: A competitive equilibrium consists of sequences of allocations $\{Y_{it}, C_{it}, L_{it}\}_{i=1}^N$ and prices $\{p_{it}, w_t\}_{i=1}^N$ such that,

- (given prices) the allocation is consistent with the solution to the consumer's optimization problem – represented by the relative demand functions in (2)
- (given prices) the allocation is consistent with the firms' profit maximization problem – represented by the first-order condition in (3)
- all markets clear

Before presenting the quantitative analysis it is worth highlighting the main forces at work in the model. Of particular interest are the drivers of structural change, which govern the sectoral reallocation of resources. There are two main drivers of structural change: the income effect and the price effect.³⁰ We have discussed the income effect already above in the context of the consumer's demand function. To reiterate, the income effect is caused by the non-homotheticity property of the consumer's preferences, which implies that the income elasticity of demand is not only different across varieties, but also changes with total income. As a result, in a growing economy the composition of consumption expenditures changes over time and it shifts towards those varieties that are characterized by an income elasticity larger than unity. In our model economy, sectoral consumption expenditures are identical to sectoral value added - due to the absence of intermediate inputs and investment - and, thus, the income effect implies that the sectoral composition of value added changes over time as the economy grows. The second driver of structural transformation is represented by the so-called price effect (or substitution effect). Equation (4) establishes an inverse relationship between the relative price of two goods p_i/p_j and their relative sectoral productivities A_j/A_i . As a consequence, uneven growth of total factor productivity across sectors leads to variations in relative prices. More concretely, if productivity grows faster in sector j than in sector i , ($\Delta A_j > \Delta A_i$), then p_i/p_j increases. The change in relative prices induces the consumer to adjust her consumption bundle - as implied by the relative demand function in (2). To the extent that the two goods bear some degree of gross substitution, then the consumer will shift expenditure away from the relatively more expensive good towards the relatively cheaper good. This reallocation of consumption is thus another force behind the changes in the structural composition of the economy.

²⁹It is straightforward to show that market clearing implies that the household's budget constraint holds with equality. Total income of the household is equal to $w_t L_t + T_t = \sum_{i=1}^N w_t L_{it} + \sum_{i=1}^N (\tau_{it} - 1) w_t L_{it} = \sum_{i=1}^N \tau_{it} w_t L_{it} = \sum_{i=1}^N p_{it} A_{it} L_{it} = \sum_{i=1}^N p_{it} Y_{it} = \sum_{i=1}^N p_{it} C_{it}$. The latter term is equal to consumer's total expenditure.

³⁰The income effect is generally referred to in the literature as the Engel (or demand-side) effect whereas the price effect can be assimilated to the Baumol (or supply-side) effect (see, e.g., Iscan (2010)).

As part of the ensuing analysis we quantify the contribution of the income effect and the price effect, respectively, to the observed sectoral reallocation of value added and labour input. The details of this analysis are presented in Appendix E. We find that the price effect tends to be the dominant channel behind the changes in the sectoral composition. However, we also show that a version of the model where the income effect is absent, thus only featuring the price effect as a driver of structural change, yields a significantly poorer fit to the data.

5 Quantitative analysis

Calibration

In this section we present the calibration of the model. It is important to mention that we calibrate the set of parameters for each country separately. This approach guarantees that the calibrated model fits the historical pattern of structural change for each country in the best possible way. As a robustness check, we apply an alternative calibration approach in Section 6 where we pool all countries together and calibrate one set of model parameters to fit all country/year observations at the same time.

For each country, we calibrate the preference parameters $\{\alpha_i, \sigma_i, \epsilon_i\}_{i=1}^N$, and the paths of sector-specific productivity and wedges: $\left\{ \left\{ \tau_{it}, A_{it} \right\}_{i=1}^N \right\}_{t=1}^T$. We explain the calibration of each of these in turn.³¹

Sector-specific wedges: To compute the equilibrium of the model economy, it suffices to know the relative distortion, $\frac{\tau_{it}}{\tau_{jt}}$, between any two sectors, and not the absolute level of the distortion τ_{it} . Thus, we can set $\tau_{it} = 1$ for a given sector. We call this sector the "reference sector" and denote it by \underline{i} . To calibrate τ_{it} for $i \neq \underline{i}$, we use expression (5) that relates the ratio of sectoral wedges to the ratio of nominal labour productivity levels:

$$\frac{p_{it}Y_{it}/L_{it}}{p_{\underline{i}t}Y_{\underline{i}t}/L_{\underline{i}t}} = \frac{\tau_{it}}{\tau_{\underline{i}t}} = \tau_{it}$$

Using the available sectoral data on $\frac{p_{it}Y_{it}/L_{it}}{p_{\underline{i}t}Y_{\underline{i}t}/L_{\underline{i}t}}$, we can back out the time series for τ_{it} for $i \neq \underline{i} = 1, \dots, N$

Sector-specific productivity levels: We set $A_{\underline{i}1} = 1$ and normalize $p_{i1} = 1$ for all i . Then we set $\{A_{\underline{i}t}\}_{t=2}^T$ to match the observed growth rate of real labour productivity in the reference sector. After that, we obtain $\{A_{it}\}_{t=1}^T$ for $i \neq \underline{i}$ by matching the observed relative prices in the data according to

$$\frac{p_{it}}{p_{\underline{i}t}} = \tau_{it} \frac{A_{\underline{i}t}}{A_{it}} \quad \text{for } i = 1, \dots, N \quad t = 1, \dots, T \quad (6)$$

This calibration procedure ensures that the model can match the relative prices, the sectoral

³¹All the data used in the calibration are taken from EU-KLEMS, as explained above in Section 3.

real and nominal labour productivity growth rates, and the differences in sectoral productivity levels, as observed in the data.

Parameters: To calibrate the utility weights, α_i , we need to impose the restriction that $\sum_{i=1}^N \alpha_i = 1$. The relative demand function in (2) demonstrates that the values of ϵ_i are not separately identified. Thus, we require a restriction on (at least) one value of ϵ_i . As a restriction, we choose to normalize $\epsilon_{\underline{i}} = 1$. We calibrate the remaining $3N - 2$ parameters, $(\alpha_i, \sigma_i, \epsilon_i)$ by targeting the nominal value added ratios given by

$$\frac{p_{it}C_{it}}{p_{\underline{i}t}C_{\underline{i}t}} = \left(\frac{\sigma_i - 1}{\sigma_{\underline{i}} - 1} \right) \left(\frac{\sigma_{\underline{i}}}{\sigma_i} \right) \alpha_i^{\frac{1}{\sigma_i}} \alpha_{\underline{i}}^{-\frac{1}{\sigma_{\underline{i}}}} C_{it}^{\frac{\sigma_i - 1}{\sigma_i}} C_{\underline{i}t}^{\frac{1 - \sigma_{\underline{i}}}{\sigma_{\underline{i}}}} C_t^{\epsilon_i \frac{1 - \sigma_i}{\sigma_i} - \epsilon_{\underline{i}} \frac{1 - \sigma_{\underline{i}}}{\sigma_{\underline{i}}}} \quad (7)$$

for all $i \neq \underline{i}$ and in all years. For example, when $N = 11$ and $T = 48$ (1970-2017), we use $(N - 1) \times T = 480$ observations on relative nominal value added to calibrate $3N - 2 = 29$ parameters. Importantly, only the values on the left-hand side of (7) are taken from the data, whereas the values of $(C_{it}, C_{\underline{i}t}, C_t)$ on the right-hand side follow from the equilibrium conditions.

Calibration results

In the baseline case, we disaggregate the economy into eleven different sectors, including two goods-producing sectors and nine service-producing sectors.³² We choose a relatively fine disaggregation of the service sector because, as shown above, the service sector is large - and becoming larger over time - and it is very heterogenous in terms of productivity growth across its constituent sub-sectors. Therefore, the future path of aggregate productivity critically depends on how structural transformation affects not only sectoral reallocations between the three broad sectors (agriculture, industry, and services), but, more importantly, the sub-sectoral reallocations within services. If, for example, the stagnant service sub-sectors grow larger over time at the expense of the more dynamic sectors, then this will have a negative effect on aggregate productivity growth. Our disaggregation of services into nine sub-sectors is a good compromise between duly capturing important heterogeneity in terms of productivity performance and keeping the model parsimonious.³³ Moreover, a key advantage of our industry disaggregation compared to others in the literature is that it is comparable across countries since it is based on time-fixed characteristics (i.e., industry classification) and not time variable ones (e.g., skill intensity). While the former is the same across countries, the latter may differ and it, thus, may give rise to a different industry classification scheme across countries.

In what follows, we report a number of statistics for each country to illustrate the empirical fit

³²The goods-producing sectors are "Agriculture" and "Industry". The service-producing sectors are "Wholesale and retail trade", "Accommodation and food services", "Transport, storage and communication", "Financial intermediation", "Business services", "Public administration", "Education", "Health", and "Social and personal services".

³³In the robustness analysis section below, we provide a detailed numerical exercise to justify the choice of eleven versus three sector.

of the calibrated model.³⁴ First, we show the model fit with respect to the value added shares that we used as data targets in the calibration. In Figure 3 we compare for each country and each of the eleven sectors the value added shares observed in the data with the value added shares implied by the calibrated model. The values we report in the figure are for the year 2017. Generally, the points are located very closely to the 45-degree line, indicating an extremely good fit of the calibrated model. We did not cherry-pick the 2017-observations to compare the actual and the predicted values. The good fit of the model is a general feature and it extends also to other years.³⁵ The very good empirical fit of the calibrated model extends also to the sectoral labour shares as can be seen in Figure 6 in the appendix.

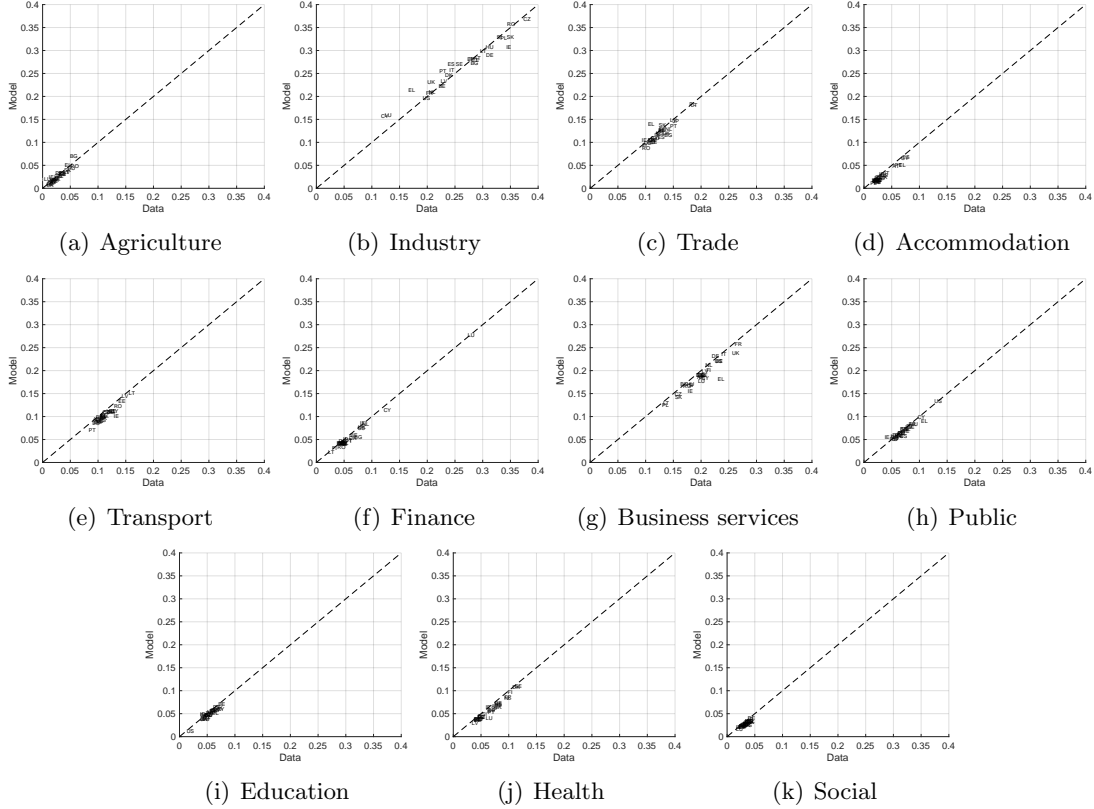


Figure 3: Shares of sectoral nominal value added in 2017, data and model.

A good fit of the model with respect to the observed value added and labour shares are key for the model to match the observed time series of aggregate labour productivity growth. This is because aggregate productivity growth is computed as a weighted average of the sectoral productivity growth rates, where the weights depend on the nominal value added share and the labour share of each sector. Thus, if the model could not replicate the observed sectoral composition of labour and value added, then it would not be able to reproduce the observed series of aggregate productivity growth. In Figure 4 we compare the actual and the predicted values of

³⁴For conciseness, we relegate the results for the calibrated parameters to the appendix

³⁵In the appendix, we show the model-implied time series of the value added shares for each country and each sector and compare them to the actual data.

the average annual growth rate of aggregate labour productivity for each country. Reassuringly, the points in the figure are clustered closely around the 45-degree line, which indicates a very good empirical fit of the model. In addition, we depict in Figures 11 and 12 in the Appendix the model-implied and the actually observed time paths of labour productivity growth for every country in the sample. As we can observe from these figures the model matches well not only average productivity growth but, for most countries, it is able to track the evolution of productivity growth over time. From these observations, we conclude that the calibrated model is able to accurately replicate the historical trends of structural change and productivity growth for the countries in our sample. This provides fundamental evidence in favour of this modeling framework as a suitable tool to make credible predictions about the future paths of structural change and productivity growth.

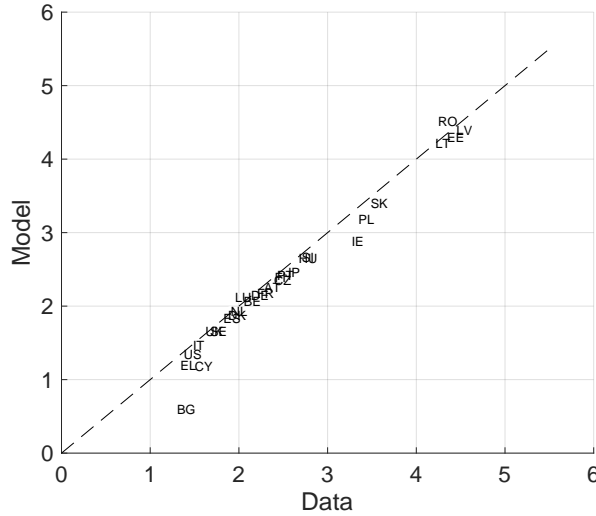


Figure 4: Aggregate productivity growth, average 1970-2017, percentage.

Simulation results

In this section, we use the calibrated model to simulate possible future paths of structural change and aggregate productivity growth for each country. To produce these forecasts, we need to make assumptions about how the exogenous objects in the model, namely sectoral productivity growth rates A_{it} and sectoral wedges τ_{it} , evolve going forward. Once these inputs are specified, the model then determines the implied paths of the endogenous sectoral composition and other aggregate variables such as consumption of each good. We consider different scenarios for the future paths of sectoral productivity growth rates and wedges. In the first scenario, we set the future path for the growth rate of A_{it} equal to the average growth rate observed during the last 20 years. Similarly, the paths followed by the sectoral wedges are set equal to the mean value of τ_{it} during the last 20 years.³⁶

³⁶We opt for the average value for the wedges since they do not exhibit a clear trend. Besides, for the quantitative analysis, it does not matter whether one uses the past mean value or the growth rate.

Using the inputs as specified, we simulate the model forward for a period of ten years. In Table 4 we report the outcomes for economy-wide and sectoral productivity growth and sectoral composition. As can be seen from the column labelled Δ , the model predicts a slowdown of aggregate productivity growth for all countries in the sample. The magnitude of the predicted slowdown ranges from moderate values of less than -0.1 percentage points for the Netherlands, the UK and the U.S., to substantial reductions in aggregate growth of -0.5 percentage points and more. Two main observations emerge. First, the growth slowdown predicted for European countries exceeds by far that of the U.S. This is in turn due to two main reasons. One, structural change is already more advanced in the U.S., which is reflected in its larger service sector. Therefore, there is less room in the U.S. for further reallocation from the fast-growing goods producing sectors (columns *agr*, *ind*) to the slow-growing service sectors (*srv*). Second, and more importantly, productivity growth in European service sectors is below the U.S. service sectors'. Putting these observations together, it follows that the slowdown in the EU is more pronounced because of two reinforcing effects; EU countries are predicted to reallocate more resources than the U.S. to service sectors, which are in turn predicted to exhibit lower productivity growth. A similar reasoning can be applied to the second important observation that the growth slowdown predicted for the relatively newer EU Member States is even larger than that for relatively older Member States. Even though productivity growth in the service sector is still higher in these countries than in the rest of the EU, these countries are predicted to experience a more profound degree of structural change, leading to a larger expansion of the sluggish service sectors.

Importantly, as can be observed from the columns labelled (1)-(9) in Table 4, the model predicts a fundamental change in the composition of the service sector. In particular, it predicts a substantial expansion of the sectors with low or even negative productivity growth (e.g., business services, education and health) and a corresponding decline of the sectors with fast productivity growth (e.g., trade, transportation). This pattern is an exact confirmation of Baumol's cost disease, which the model predicts to continue to represent a substantial drag to European productivity growth.

	Productivity growth			Productivity growth (first row). Change in value added share (second row)											
	Past	Pred.	Δ	agr	ind	srv	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AT	1.42	1.16	-0.26	3.8 -0.3	1.9 -2.6	0.7 2.9	1.4 -0.5	0.7 -0.0	1.3 -0.1	3.5 -0.5	-0.4 3.4	0.7 -0.1	-0.2 0.2	0.3 0.4	-0.1 0.1
BE	0.78	0.57	-0.21	1.1 -0.1	2.1 -3.0	0.2 3.0	1.3 -0.7	-0.1 0.1	1.9 -0.3	2.4 -0.3	-0.9 3.3	0.6 -0.2	-0.5 0.3	-1.1 0.8	0.4 0.1
DK	1.01	0.85	-0.16	3.9 -0.3	1.4 -1.9	0.6 2.2	1.8 -0.8	-2.5 0.1	2.6 -0.4	2.1 -0.1	-1.2 3.2	-0.0 0.0	0.9 -0.1	0.6 0.2	-0.7 0.1
ES	0.69	0.52	-0.18	2.7 -0.6	1.3 -2.7	0.1 3.2	1.0 -0.8	-2.1 1.4	1.3 -0.6	2.5 -0.4	-1.1 3.8	1.0 -0.4	0.0 0.2	-0.3 0.2	0.0 -0.1
FI	1.33	0.94	-0.38	3.9 -0.6	2.3 -3.7	0.3 4.3	2.6 -0.8	-0.1 -0.0	2.3 -0.5	1.0 -0.0	-1.2 4.6	0.4 -0.1	0.1 0.0	-1.5 1.0	-0.8 0.1
FR	1.07	0.91	-0.15	2.8 -0.3	1.6 -2.1	0.6 2.4	1.2 -0.3	-0.3 0.0	2.2 -0.4	1.6 -0.2	-0.4 3.2	1.4 -0.3	-0.7 0.2	0.5 0.2	0.7 -0.0
DE	1.19	0.97	-0.22	1.9 -0.2	2.1 -4.3	0.6 4.5	2.4 -0.9	-0.3 0.0	2.6 -0.5	-0.4 0.1	-1.1 6.0	1.6 -0.5	-1.0 0.2	0.7 0.1	-0.1 0.1
EL	0.53	-0.07	-0.59	1.8 -0.8	1.3 -2.3	-0.7 3.1	-2.3 2.4	0.3 -0.1	2.7 -0.6	0.5 -0.1	-1.1 1.5	0.3 -0.2	0.1 -0.1	-2.8 0.3	-0.6 0.0
IE	3.57	2.73	-0.84	0.4 0.1	6.6 -3.1	1.6 3.0	-0.2 1.1	0.4 0.1	4.9 -1.3	4.2 1.1	2.1 0.0	-1.2 0.5	-0.2 0.4	1.1 1.0	2.8 0.1
IT	0.30	0.15	-0.15	1.4 -0.3	0.5 -1.7	-0.1 2.0	0.7 -0.8	-1.0 -0.0	1.4 -0.7	1.3 -0.4	-2.0 4.7	1.0 -0.5	0.1 -0.2	-0.8 0.1	-0.3 -0.1
JP	1.28	1.04	-0.23	1.9 -0.2	2.0 -3.2	0.6 3.4	1.4 -0.0	-0.6 0.2	1.5 0.1	1.9 -0.0	-0.1 2.2	0.9 -0.0	0.4 0.1	-1.5 0.9	0.6 0.0
LU	0.28	-0.14	-0.42	-0.0 -0.0	-0.1 -0.0	-0.2 0.1	1.4 -1.1	-3.3 0.0	1.3 -0.3	0.5 -1.6	-1.9 3.3	0.9 -0.2	-1.0 0.0	-1.3 0.0	-0.5 -0.0
NL	1.14	1.12	-0.02	2.0 -0.2	1.9 -2.6	1.0 2.8	2.4 -0.5	-1.1 0.0	2.7 -0.3	2.6 -0.5	-0.0 4.0	1.5 -0.5	-0.6 0.3	0.4 0.3	-0.9 0.0
PT	0.93	0.53	-0.40	3.0 -0.5	1.5 -2.5	-0.1 3.0	1.1 -0.1	-0.6 0.4	0.6 0.2	3.3 -0.0	-1.6 0.8	0.1 0.4	-0.4 0.6	-0.9 0.7	0.3 0.1
SE	1.54	1.36	-0.18	1.8 -0.2	2.2 -1.5	1.1 1.8	3.1 -0.5	-0.1 0.0	3.3 -0.5	3.5 -0.5	0.2 2.2	0.4 -0.2	-0.3 0.1	-0.7 0.9	0.9 0.0
UK	1.23	1.18	-0.06	1.8 -0.1	1.2 -1.7	1.2 1.8	1.5 -0.4	0.4 -0.0	2.5 -0.2	2.9 -0.6	0.6 2.8	0.6 -0.3	-1.3 0.4	1.2 0.0	0.1 0.1
US	1.55	1.49	-0.06	2.8 -0.0	2.2 -2.1	1.3 2.1	2.2 -0.4	0.0 0.1	4.1 -0.6	2.0 0.1	1.0 2.0	0.2 0.1	-0.3 0.0	0.7 0.5	-0.2 0.1
EU6	0.94	0.77	-0.17	2.0 -0.2	1.6 -3.0	0.5 3.2	1.7 -0.7	-0.5 0.0	2.2 -0.5	0.9 -0.2	-1.0 4.7	1.4 -0.4	-0.6 0.1	0.2 0.2	0.0 0.0
EU14	1.44	1.08	-0.35	2.4 -0.3	2.4 -2.6	0.6 2.9	1.3 -0.2	-0.4 0.1	2.4 -0.5	2.2 -0.0	-0.4 2.7	0.5 -0.0	-0.4 0.2	-0.2 0.6	0.5 0.1
				agr	ind	srv	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
BG	3.00	2.50	-0.49	0.1 -0.2	4.7 -3.6	2.0 3.8	3.3 -0.6	4.8 -0.1	4.0 -0.9	3.8 -0.2	-3.5 6.4	2.9 -0.3	4.5 -0.3	4.1 -0.2	4.2 -0.2
CY	1.52	1.14	-0.38	-0.2 -0.1	1.1 -1.5	1.2 1.5	3.4 -1.4	-0.9 -0.0	2.8 -0.8	2.5 -1.0	-1.0 5.1	0.9 -0.2	-0.3 0.1	0.1 -0.1	-0.2 -0.1
CZ	2.52	2.34	-0.18	3.0 -0.4	3.7 -1.6	1.5 2.0	5.8 -0.4	-4.1 0.2	1.3 0.2	4.0 0.2	0.8 1.2	1.0 -0.3	0.2 0.3	-1.1 0.5	-1.7 0.2
EE	3.93	3.55	-0.38	7.7 -0.9	5.3 -3.1	2.7 4.0	4.0 -0.6	1.7 0.2	4.1 -0.7	4.3 0.6	1.7 4.1	0.6 0.1	0.8 -0.1	0.5 0.3	0.0 0.2
HU	2.15	1.60	-0.55	5.4 -1.1	2.7 -2.1	0.8 3.2	2.5 -0.4	-0.2 0.0	3.3 -0.6	3.3 -0.2	-1.9 4.3	-0.8 0.3	0.9 -0.1	1.0 -0.1	1.3 -0.1
LT	4.08	3.58	-0.50	4.5 -1.0	4.9 -2.6	2.8 3.6	4.8 -1.3	0.5 0.1	3.5 1.3	1.5 0.2	0.5 4.2	1.6 -0.5	1.9 -0.4	2.7 -0.1	-0.8 0.3
LV	4.48	2.48	-1.99	9.3 -1.5	3.4 -3.4	1.7 4.9	5.9 -3.5	1.8 -0.0	1.9 -2.2	4.8 -0.3	-4.2 13.2	2.6 -1.1	3.2 -0.9	3.6 -0.3	1.3 -0.0
PL	3.30	2.99	-0.30	3.3 -0.5	4.0 -1.4	2.2 1.9	3.0 -1.1	2.2 0.1	3.8 -0.3	4.9 0.3	0.3 2.3	0.6 0.0	0.1 0.2	3.1 0.3	1.2 0.2
RO	4.79	4.05	-0.75	5.4 -1.7	4.9 -5.5	2.6 7.2	6.9 -0.4	1.0 0.1	5.0 0.4	3.0 -0.0	2.3 3.3	-3.6 1.4	1.6 0.5	-1.5 1.5	0.3 0.5
SK	3.19	2.61	-0.57	8.2 -0.7	5.7 -3.4	0.9 4.0	1.0 0.8	-0.9 0.1	1.0 0.3	-0.4 0.4	0.3 1.6	2.6 0.1	2.7 0.1	0.3 0.3	0.8 0.2
SI	2.27	1.74	-0.53	3.5 -0.5	3.1 -3.1	0.8 3.6	2.7 -0.6	-0.9 0.2	2.8 0.5	3.1 -0.2	-1.3 2.6	1.5 0.1	-0.7 0.4	-0.0 0.3	-0.6 0.2
EUnew	3.38	2.90	-0.47	4.1 -0.8	4.1 -2.7	2.0 3.5	4.1 -0.7	0.9 0.1	3.5 -0.1	3.7 0.1	0.1 3.2	0.1 0.2	1.1 0.2	1.3 0.5	0.8 0.2

Past: Annual aggregate productivity growth, 1997-2017 average. **Pred.:** Predicted aggregate productivity growth, 2017-2027 average. Δ : Difference between *Forecast* and past *Data*. **agr:** agriculture, **ind:** industry, **srv:** services. (1): Wholesale and retail trade; (2): Accommodation and food services; (3): Transport, storage and communication; (4): Financial intermediation; (5): Business services; (6): Public administration; (7): Education; (8): Health; (9): Social and personal services.

Table 4: 10-year forecasts of sectoral composition and productivity growth.

The model's predictions crucially depend on the underlying assumptions about future sectoral productivity growth rates and sectoral wedges. In the previous example, we chose the last twenty years as the reference period from which we computed the obtained the exogenous productivity growth rates and wedges going forward. To rule out the possibility that our results may be driven by this specific assumption, we run the following robustness checks. We chose a whole sequence of reference periods starting at the previous five years before the sample's endpoint year (2017) and increasing this horizon until twenty years prior (i.e., 1997). For each of these reference years, we compute the average productivity growth rates and wedges and use these as inputs to re-simulate the model forward and calculate the implied change in aggregate productivity growth. As a result, we obtain, for each country, a whole set of predicted future changes in productivity, where each element corresponds to a given reference period from the past. In Table 5, we report the average, over the different reference periods, of the predicted changes in aggregate productivity growth (column *avg*) as well as the minimum and the maximum predicted changes (*min,max*) and the predicted changes for the 5-year, 10-year, 15-year, and 20-year past reference periods. The results in the table confirm the previous findings that European countries are predicted to experience a pronounced productivity growth slowdown, irrespective of the calibration period chosen, but with important differences in the intensity of the drop in growth rates.

	avg	min	max	5yrs	10yrs	15yrs	20yrs
AT	-0.15	-0.27	-0.06	-0.07	-0.06	-0.17	-0.26
BE	-0.10	-0.21	-0.03	-0.08	-0.03	-0.11	-0.21
DK	-0.08	-0.16	-0.00	-0.15	-0.01	-0.08	-0.16
ES	0.00	-0.18	0.17	0.09	0.05	-0.05	-0.18
FI	-0.20	-0.38	-0.01	-0.17	-0.03	-0.26	-0.38
FR	-0.05	-0.15	0.02	-0.03	0.02	-0.05	-0.15
DE	-0.14	-0.25	-0.02	-0.08	-0.05	-0.16	-0.22
EL	-0.76	-0.97	-0.12	-0.12	-0.79	-0.76	-0.59
IE	-0.68	-1.20	-0.35	-1.20	-0.51	-0.48	-0.84
IT	-0.01	-0.15	0.09	0.09	0.01	-0.03	-0.15
JP	-0.17	-0.29	-0.01	-0.07	-0.06	-0.27	-0.23
LU	-0.22	-0.42	0.07	-0.05	-0.29	-0.34	-0.42
NL	0.10	-0.02	0.21	0.15	0.18	0.04	-0.02
PT	-0.17	-0.40	0.12	0.07	-0.09	-0.31	-0.40
SE	-0.18	-0.26	-0.12	-0.23	-0.12	-0.16	-0.18
UK	-0.03	-0.07	0.06	-0.06	-0.01	-0.01	-0.06
US	-0.05	-0.13	0.02	-0.11	0.02	-0.03	-0.06
EU6	-0.07	-0.18	0.03	-0.01	-0.00	-0.09	-0.17
EU14	-0.21	-0.42	-0.03	-0.23	-0.12	-0.22	-0.35
BG	-0.50	-0.80	0.07	0.07	-0.08	-0.76	-0.49
CY	-0.50	-0.69	-0.18	-0.18	-0.62	-0.54	-0.38
CZ	-0.12	-0.18	-0.03	-0.10	-0.04	-0.14	-0.18
EE	-0.27	-0.44	-0.15	-0.21	-0.42	-0.22	-0.38
HU	-0.45	-0.55	-0.25	-0.50	-0.50	-0.51	-0.55
LT	-0.50	-0.76	-0.24	-0.34	-0.41	-0.65	-0.50
LV	-1.24	-2.15	0.10	0.10	-1.78	-1.73	-1.99
PL	-0.32	-0.46	-0.22	-0.22	-0.28	-0.40	-0.30
RO	-0.77	-1.75	-0.15	-1.75	-0.23	-0.74	-0.75
SK	-0.43	-0.57	-0.32	-0.40	-0.32	-0.47	-0.57
SI	-0.20	-0.53	0.12	0.06	-0.07	-0.32	-0.53
EUnew	-0.44	-0.77	-0.15	-0.51	-0.28	-0.51	-0.47

avg: average over reference periods: 5, 6, ..., 20 years; **min** (**max**): minimum (maximum) predicted change; **5-, 10-, 15-, 20-year:** prediction for specific reference periods.

Table 5: Predicted differences in the aggregate productivity growth rates between the 2017-2027 and the 1997-2017 averages for different reference periods for the calibration of relative sectoral productivity growth rates and wedges.

As is well known, most European countries experienced rapid labour productivity growth in the post-war period and until the 1990s some of the most advanced countries managed to catch up with the US's level of productivity. However, in the 1990s European growth started to stall whereas productivity growth in the U.S. accelerated. As a result, a substantial productivity gap emerged for most European countries. To illustrate this gap, Table 6 reports the 2017-level of aggregate labour productivity for the countries in our sample together with the percentage difference with respect to the U.S.. For most EU countries, the level of economy-wide productivity is well below the U.S.'s. This includes the largest countries, such as France and Germany, which

exhibit a 5% gap, and Italy and Spain, with large gaps of around 25%. The column labelled 2027 in Table 6 shows the predicted productivity difference with respect to the U.S. for the year 2027 as implied by our forecasts. Not surprisingly, for most countries the gap increases. For example, for France and Germany the gap widens from 5% in 2017 to 10%, for the UK it increases from 7% to 10% and for Italy and Spain it increases from 24% and 25% to more than 30% in both cases.

To summarize, in our quantitative analysis we have established that Europe is predicted to experience a severe productivity slowdown during the next decade. The slowdown predicted for the U.S. is comparably smaller. Thus, our finding implies a further widening of the existing U.S.-EU productivity gap.

	2017		2027
	Level	Gap	
AT	68.1	0.97	0.94
BE	71.5	1.02	0.93
DK	72.2	1.03	0.97
ES	52.4	0.75	0.68
FI	62.3	0.89	0.84
FR	66.9	0.95	0.90
DE	66.3	0.95	0.90
EL	33.5	0.48	0.41
IE	95.0	1.35	1.53
IT	53.4	0.76	0.67
JP	45.7	0.65	0.62
LU	96.5	1.38	1.17
NL	68.1	0.97	0.94
PT	39.1	0.56	0.51
SE	68.4	0.98	0.96
UK	58.1	0.83	0.80
US	70.1	1.00	1.00
EU6	64.2	0.92	0.86
EU14	68.4	0.97	0.95
BG	24.4	0.35	0.38
CY	-	-	-
CZ	40.6	0.58	0.63
EE	37.1	0.53	0.65
HU	35.3	0.50	0.51
LT	40.4	0.58	0.71
LV	35.1	0.50	0.55
PL	37.3	0.53	0.62
RO	31.2	0.45	0.57
SK	42.0	0.60	0.67
SI	44.0	0.63	0.64
EUnew	35.7	0.51	0.59
Level: 2017-level of GDP per hour worked, PPP-adjusted, in constant 2010-USD-prices.			
Gap: Relative to U.S.-level.			

Table 6: Absolute and relative productivity levels across countries.

6 Robustness analysis

The goal of this section is to assess the robustness of our main findings to various modifications including the model setup, the data and the calibration strategy.

11 sectors vs 3 sectors

In the baseline case, we disaggregate the total economy into eleven sectors, including two goods-producing sectors (agriculture and industry) and nine service-producing sectors, at the one-digit level. The finer disaggregation of the service sector is motivated by the empirical observation that this sector is very heterogeneous in terms of value added and labour productivity growth. Thus, any reallocation within services has a potentially large effect on the dynamics of labour productivity within the service sector as a whole, and thus, in turn, on economy-wide productivity growth. Such dynamics can only be properly captured with a detailed representation of the service sector. Typically, a fine sector representation is not the rule but rather the exception in the literature on structural transformation. The common approach is to split the aggregate economy into the three broad sectors: agriculture, industry and services. In this section we assess whether our sector representation yields significantly different results than a coarser one. To this end, we adopt the standard three-sector representation and repeat the entire quantitative analysis, with a new model calibration and forecast simulations for each country. The fourth data column in Table 7 reports the simulation results. For comparison, the table also shows in the first three rows the baseline results. Quite remarkably, but as expected, the three-sector split generates a growth slowdown that is substantially less severe than the one obtained with the eleven-sector split.

This difference is due to two main reasons. First, when services are treated as one broad sector then, by construction, future TFP growth in the service sector equals its past growth during the reference period. By contrast, when the service sector is split into sub-sectors, productivity growth in total services is affected by within-sector reallocation. As shown above, reallocation within services leads to an expansion of the sub-sectors with lower productivity growth. As a result, productivity growth of total services is lower under the eleven-sector split than under the three-sector split. Second, lower productivity growth in services implies a larger productivity differential with respect to agriculture and industry. Therefore, under the eleven-sector split, there is a greater degree of structural transformation from the two goods-producing sectors towards services. Thus, both effects imply that under the eleven-sector split the service sector has lower productivity growth and expands more rapidly than under the three-sector split. As a consequence, the predicted decline in aggregate productivity growth going forward is more pronounced.

	Productivity growth						
	Past	Baseline Pred.	Δ	three-Sectors Δ	Market sectors only Past	Pred. Δ	
AT	1.42	1.16	-0.26	-0.11	1.80	1.59	-0.21
BE	0.78	0.57	-0.21	-0.08	1.20	1.06	-0.14
DK	1.01	0.85	-0.16	-0.01	1.33	1.20	-0.13
ES	0.69	0.52	-0.18	-0.05	0.71	0.59	-0.12
FI	1.33	0.94	-0.38	-0.18	2.06	1.80	-0.26
FR	1.07	0.91	-0.15	-0.07	1.32	1.17	-0.15
DE	1.19	0.97	-0.22	-0.10	1.48	1.19	-0.29
EL	0.53	-0.07	-0.59	-0.01	0.16	-0.11	-0.27
IE	3.57	2.73	-0.84	-0.45	4.57	4.08	-0.49
IT	0.30	0.15	-0.15	-0.07	0.38	0.22	-0.16
JP	1.28	1.04	-0.23	-0.15	1.65	1.59	-0.06
LU	0.28	-0.14	-0.42	-0.29	0.45	0.32	-0.14
NL	1.14	1.12	-0.02	-0.03	1.48	1.45	-0.04
PT	0.93	0.53	-0.40	-0.25	1.40	1.11	-0.29
SE	1.54	1.36	-0.18	-0.02	2.37	2.32	-0.05
UK	1.23	1.18	-0.06	-0.01	1.56	1.71	0.15
US	1.55	1.49	-0.06	-0.03	2.09	2.06	-0.03
EU6	0.94	0.77	-0.17	-0.08	1.19	0.99	-0.20
EU14	1.44	1.08	-0.35	-0.18	1.94	1.70	-0.24
BG	3.00	2.50	-0.49	-0.28	3.07	2.61	-0.46
CY	1.52	1.14	-0.38	-0.19	1.73	1.50	-0.23
CZ	2.52	2.34	-0.18	-0.09	3.23	3.22	-0.01
EE	3.93	3.55	-0.38	-0.25	4.90	4.57	-0.34
HU	2.15	1.60	-0.55	-0.20	2.65	2.18	-0.47
LT	4.08	3.58	-0.50	-0.27	4.77	4.41	-0.36
LV	4.48	2.48	-1.99	-0.76	4.88	2.82	-2.06
PL	3.30	2.99	-0.30	-0.34	4.02	3.80	-0.23
RO	4.79	4.05	-0.75	-0.62	5.88	5.81	-0.08
SK	3.19	2.61	-0.57	-0.20	3.63	3.37	-0.26
SI	2.27	1.74	-0.53	-0.39	2.93	2.56	-0.38
EUnew	3.38	2.90	-0.47	-0.34	4.07	3.81	-0.26
Past: Annual aggregate productivity growth, 1997-2017 average. Pred.: Predicted aggregate productivity growth, 2017-2027 average. Δ : Difference between <i>Forecast</i> and <i>Data</i> . Baseline: Results for eleven-sector split, three-Sectors: Results for 3-sector split.							

Table 7: Past and predicted aggregate productivity growth for different sector splits.

Market services only

An often-raised concern relates to the possible mis-measurement of non-market services. This type of services includes public administration, health and social services, and education. The issue of potential mis-measurement arises because the output of non-market services is typically not traded and in some cases not even well defined. As a result of this discrepancy, statistical agencies usually resort to an input-based approach to impute the value added of non-market services. Another complication arises because in the absence of market exchange, value added prices are often unobserved and have to be proxied.^{37,38}

As a result of these complications, one may be skeptical about the quality of the data on sectoral value added, prices and productivity in public services. In most countries in our sample non-market services are a large and growing sector with an employment share of 20% and more. Therefore, the mis-measurement concern is to a serious issue, and may cast doubt on the robustness of our baseline results. To address this concern, we exclude non-market services altogether from the analysis and repeat the quantitative exercise for only market sectors only. The last three columns in Table 7 report the results for past and future aggregate productivity growth. Average growth during the reference period - which, as before, corresponds to the last 20 years - is higher than in the baseline case because the excluded non-market services typically have lower productivity growth (see Table 2). However, our model still predicts a substantial growth slowdown to occur also in the business economy, as can be seen in the last column. The

³⁷Done, for example, by using hedonic pricing methods.

³⁸In addition, non-market services are often heavily regulated; hence, the prices, if they exist, may not reflect the market value of output.

magnitude of the slowdown is lower than in the baseline scenario, although there are substantial differences across countries.³⁹ The reason for this finding is straightforward; namely, non-market services are characterized by lower productivity growth and are predicted to increase in size in the forecast horizon.

Measure of labour productivity

In the baseline scenario, we define labour productivity as real value added per hour worked. However, the related literature employs different measures owing to different reasons. As a consequence, we test the robustness of our results to the definition of labour productivity used. As alternatives, we consider productivity measured as (constant-price) value added (i) per worker, (ii) per efficiency hour, and (iii) TFP.⁴⁰ For each of these measures, we repeat the quantitative analysis and report the results for aggregate productivity growth in Table 8. For comparison, we also include the baseline results. It can be seen that the level of aggregate productivity growth differs across the different measures but, most importantly, in all cases the model predicts a substantial growth slowdown. In fact, in relative terms, the magnitude of this slowdown is similar across the different measures. We conclude from this exercise that our baseline results are quite robust to alternative ways of measuring productivity.⁴¹

Alternative calibration approach

In the baseline analysis, we calibrate the model parameters for each country separately. The main advantage of this procedure is that we obtain a calibrated model that best fits the historical paths of structural transformation for each specific country. However, as a result of this procedure, country-specific preferences - described by the parameters $(\alpha_i, \sigma_i, \epsilon_i)$ - capture all the residual variation across countries in the evolution of sectoral value added that is not accounted for by country-specific prices and sectoral productivity growth rates. This may include country-specific factors such as different regulatory frameworks, institutional settings, taxes and norms. This is somewhat undesirable because preferences are usually considered a time and location invariant entity. This in turn stems from the difficulty to empirically validate potential cross-country differences in preferences due to the lack of suitable data. We address this issue next by proposing an alternative calibration strategy. In short, we calibrate only one set of model parameters to jointly fit all country-year observations of the sectoral value added shares. As a first step, we regress the observed sectoral value added shares on a full set of country-fixed effects and use the residuals as our data targets in the calibration. This procedure removes all time-invariant variation across countries in the level of sectoral value added shares that may

³⁹For example, in countries such as Ireland and Luxembourg, non-market services are expected to be a major drag to productivity growth in the future, since excluding them yields a much smaller negative impact of structural change on aggregate productivity growth.

⁴⁰Efficiency hours are computed as the weighted sum of raw hours where relative wages are used as weights. As a result, the hours of high-wage workers enter with a higher weight than the hours of low-wage workers.

⁴¹Data on quality-adjusted hours worked or TFP are not available for several of the countries in our sample. Thus, to maximize the country coverage we chose to use value added per hour as our baseline measure of productivity. The per-worker measure would have allowed for a large coverage. However, this measure is rather coarse, as, by construction, it disregards changes in the intensive margin of labour input.

	Productivity growth											
	per hour			per worker			per efficiency hour			TFP		
	Past	Pred.	Δ	Past	Pred.	Δ	Past	Pred.	Δ	Past	Pred.	Δ
AT	1.42	1.16	-0.26	0.84	0.62	-0.23	1.47	1.28	-0.18	0.67	0.61	-0.06
BE	0.78	0.57	-0.21	0.68	0.47	-0.21	0.42	0.22	-0.20	0.23	0.15	-0.08
DK	1.01	0.85	-0.16	0.92	0.83	-0.10	0.71	0.50	-0.21	0.47	0.41	-0.06
ES	0.69	0.52	-0.18	0.52	0.34	-0.18	0.59	0.42	-0.17			
FI	1.33	0.94	-0.38	0.93	0.53	-0.40	1.29	0.95	-0.34	0.89	0.69	-0.20
FR	1.07	0.91	-0.15	0.84	0.72	-0.12	0.72	0.58	-0.13	0.45	0.43	-0.03
DE	1.19	0.97	-0.22	0.70	0.51	-0.19	1.08	0.90	-0.18	0.72	0.62	-0.10
EL	0.53	-0.07	-0.59	0.38	-0.22	-0.60						
IE	3.57	2.73	-0.84	3.08	2.11	-0.97						
IT	0.30	0.15	-0.15	-0.07	-0.23	-0.16	0.12	-0.00	-0.12	-0.36	-0.39	-0.03
JP	1.28	1.04	-0.23	0.82	0.56	-0.26	0.79	0.56	-0.23	0.14	0.12	-0.03
LU	0.28	-0.14	-0.42	-0.02	-0.39	-0.36						
NL	1.14	1.12	-0.02	0.98	1.06	0.07	0.92	0.90	-0.02	0.67	0.58	-0.09
PT	0.93	0.53	-0.40	0.90	0.49	-0.41						
SE	1.54	1.36	-0.18	1.39	1.24	-0.15	0.10	-0.25	-0.35	-0.17	-0.38	-0.21
UK	1.23	1.18	-0.06	1.07	1.09	0.02	1.07	0.98	-0.09	0.60	0.59	-0.01
US	1.55	1.49	-0.06	1.40	1.38	-0.02	1.33	1.26	-0.07	0.63	0.57	-0.06
EU6	0.94	0.77	-0.17	0.59	0.44	-0.15	0.74	0.60	-0.14	0.39	0.33	-0.06
EU14	1.44	1.08	-0.35	1.16	0.80	-0.36	0.87	0.69	-0.18	0.39	0.32	-0.07
BG	3.00	2.50	-0.49	2.81	2.21	-0.59						
CY	1.52	1.14	-0.38	1.17	0.80	-0.36						
CZ	2.52	2.34	-0.18	2.32	2.14	-0.18	2.20	1.98	-0.22	0.94	0.85	-0.08
EE	3.93	3.55	-0.38	3.48	2.92	-0.56						
HU	2.15	1.60	-0.55	1.82	1.41	-0.41						
LT	4.08	3.58	-0.50	4.39	3.80	-0.59						
LV	4.48	2.48	-1.99	4.06	3.33	-0.73						
PL	3.30	2.99	-0.30	3.21	2.76	-0.45						
RO	4.79	4.05	-0.75	4.61	3.99	-0.63						
SK	3.19	2.61	-0.57	2.86	2.36	-0.50	3.37	2.94	-0.43	1.37	1.40	0.02
SI	2.27	1.74	-0.53	1.99	1.52	-0.47						
EUnew	3.38	2.90	-0.47	3.21	2.73	-0.48						

Past: Annual aggregate productivity growth, 1997-2017 average. **Pred.:** Predicted aggregate productivity growth, 2017-2027 average. Δ : Difference between *Forecast* and *Data*.

Table 8: Past and predicted aggregate productivity growth for different productivity measures.

stem from differences in regulation, institutions, or preferences. By de-meaning the data we do not target the level of sectoral value added shares in the calibration as in the baseline Case, but rather the evolution of the sectoral shares over time.

We pool the observations of all twenty-eight countries in our sample and calibrate the model parameters. Table 16 in the appendix reports the values of the parameters. To illustrate the empirical fit of the model we compare in Figure 5 the data and the model outcome for the average annual growth rate of aggregate productivity. Since we jointly calibrate one model to all countries, the empirical fit of the calibrated model for each individual country is not as good as in the baseline case. Nevertheless, for most countries the model can match the data reasonably well. Next, we perform the forward simulation for each country and report the results for past and future aggregate productivity growth in Columns (1)-(3) of Table 9. The most important observation is that, for our sample of countries, the alternative calibration implies a growth slowdown that is both qualitatively and quantitatively similar to that obtained in the baseline calibration.

An important step in the alternative calibration approach is the removal of country-fixed effects in order to control for country heterogeneity that is not accounted for by the model. Despite this step, the countries in our sample are still quite diverse in terms of unobserved and time-varying characteristics. As a result of this heterogeneity, the calibrated model can match each

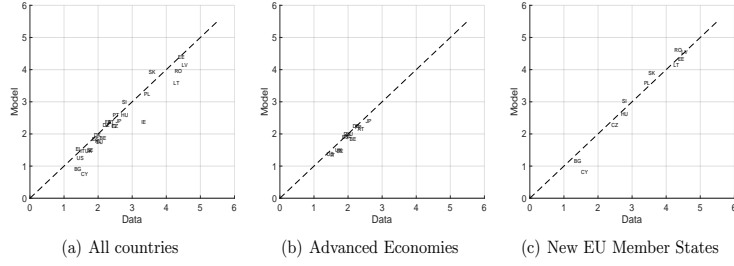


Figure 5: Average aggregate productivity growth for alternative calibration: Data and model. New Member States: EU-6 + AT, DK, ES, JP, SE, UK, US.

country only to a certain degree. To mitigate this issue, we split the sample of countries into two (relatively) homogenous groups and repeat the analysis for both groups separately. The first group consists of the newer EU Member States, while the second group consists of older Member States and Japan and the US.⁴² From Panels (b)-(c) in Figure 5 we can observe that the empirical fit of the model for both groups markedly improves with respect to the case where all countries are pooled together. Lastly, we perform the forward simulation and, as we can see from Table 9 the results are qualitatively but also quantitatively similar to the findings of the baseline case.

	Past	Predicted change in aggregate productivity growth, 2017-2027			
		Baseline	All	Advanced	New
AT	1.42	-0.26	-0.09	-0.15	
BE	0.78	-0.21	-0.03	-0.09	
DK	1.01	-0.16	-0.22	-0.17	
ES	0.69	-0.18	-0.09	-0.07	
FI	1.33	-0.38	-0.32		
FR	1.07	-0.15	-0.13	-0.13	
DE	1.19	-0.22	-0.14	-0.20	
EL	0.53	-0.59	-0.38		
IE	3.57	-0.84	-1.05		
IT	0.30	-0.15	-0.15	-0.17	
JP	1.28	-0.23	-0.09	-0.18	
LU	0.28	-0.42	-0.45	-0.42	
NL	1.14	-0.02	-0.01	0.03	
PT	0.93	-0.40	-0.36		
SE	1.54	-0.18	-0.20	-0.23	
UK	1.23	-0.06	-0.09	-0.05	
US	1.55	-0.06	-0.07	-0.02	
EU6	0.94	-0.17	-0.13	-0.15	
EU14	1.44	-0.35	-0.35	-0.13	
BG	3.00	-0.49	-0.68		-0.52
CY	1.52	-0.38	-0.50		-0.54
CZ	2.52	-0.18	-0.37		-0.20
EE	3.93	-0.38	-0.66		-0.44
HU	2.15	-0.55	-0.54		-0.51
LT	4.08	-0.50	-0.69		-0.50
LV	4.48	-1.99	-1.92		-1.91
PL	3.30	-0.30	-0.20		-0.01
RO	4.79	-0.75	-1.26		-0.81
SK	3.19	-0.57	-0.80		-0.54
SI	2.27	-0.53	-0.39		-0.27
EUnew	3.38	-0.47	-0.59		-0.37

Past: Annual aggregate productivity growth, 1997-2017 average. **All:** all 28 countries; **Advanced:** AT, BE, DK, ES, FR, DE, IT, JP, LU, NL, SE, UK, US; **New EU Member States:** BG, CY, CZ, EE, HU, LT, LV, PL, RO, SK, SI.

Table 9: Past and predicted change in average aggregate productivity growth for alternative calibration.

⁴²Notice that we do not include Finland, Greece, Ireland and Portugal in the second group because these countries are characterized by markedly different historical paths of structural transformation (due to structural breaks, economic depressions and extended periods of high aggregate volatility)

7 Conclusions

In this paper, we shed new light into the issue of structural change and productivity growth in the EU along several dimensions. As a starting point, after documenting the observed productivity growth slowdown in the EU, we provide an overview of the hypotheses that have been put forward in the related literature to explain this stagnation. There is widespread consensus that none of the drivers that have been explored to date can on their own explain the observed decline in labour productivity growth.

As a next step, we argue that structural change has played a non-negligible role as a driver of productivity growth in the case of the EU. In particular, we examine the issue from a historical point of view and document the impact that this phenomenon has had on long-term productivity growth across the different EU economies. The main observation is that the secular process of sectoral transformation, characterized by the increasing economic weight of the tertiary sector, has had a negative impact on long-term aggregate productivity growth across all EU economies. The size of this impact is however larger for older relative to newer Member States.

In addition, we review the literature on the EU-US productivity gap and provide a discussion of its current and potential future status. It is a well-known fact that during the post-war period, EU countries experienced a rapid catching up process with respect to the US, based on higher growth rates across most sectors. This narrowing of the gap was also accompanied by a fast expansion of the service sector. However, productivity growth in many EU Member States has slowed down substantially in recent years and has fallen short of U.S. productivity growth at both the sectoral and aggregate levels. We estimate that this gap is bound to further widen in future, due to our prediction of greater value added shares of more stagnant services in the EU compared to the US, and lower productivity growth rates in the former with respect to the latter. This is tantamount to saying that Baumol's cost disease is expected to be a more prevalent phenomenon in the EU than in the US.

We also show that a simple three-sector breakdown of the economy does not suffice to properly capture the dynamic interplay between structural change and economy-wide productivity growth. This is simply because the service sector exhibits a great deal of variation in terms of productivity growth, and hence any analysis of the impact of the *tertiarization* process needs to take into account this heterogeneity within services. We show that reallocation within services leads to a greater expansion of the sub-sectors with lower productivity growth, and thus that aggregate productivity growth is always lower under a more fine-grained sectoral split than under the three-sector split. We thus conclude that the negative effect of structural change is underestimated under the latter.

Our most salient contribution to the literature is the development of a general equilibrium model capable of replicating the pattern of structural change observed in the data, which is then em-

ployed as a framework to investigate the potential impact of predicted structural change onto future productivity growth in EU countries. The main finding stemming from our quantitative analysis is that the EU is predicted to experience a severe productivity slowdown during the next decade due to unfavourable sectoral reallocations. These sectoral shifts are the result of both supply and demand-side forces, with the former being a more dominant factor.

Importantly, our paper also represents the first attempt at quantifying the impact of structural change on future productivity growth in newer Member States. Our findings indicate that the growth slowdown predicted for these countries is even larger than that for older ones. This is because, although productivity growth in the service sector is still higher in these countries than in the rest of the EU, they are predicted to experience a more profound process of structural transformation, leading to a larger expansion of the service sectors.

Furthermore, we provide a robustness analysis and show that we show that a one-digit level disaggregation of services is important to not underestimate the true effect of structural change onto productivity growth. We also observe that the results generally hold - with nuances - when non-market services are excluded from the analysis. Additionally, we also confirm that the pattern of lasting damage of structural change onto productivity growth holds for different past reference periods used in the projection of TFP. The results are also robust to the different definitions of labour productivity growth oftentimes used in the literature, and they are also qualitatively equivalent to alternative calibrations of the model's deep parameters.

A number of policy implications can be derived from our analysis. Although structural change is bound to continue exerting a negative impact on the already dismal productivity performance in the EU into the future, the conclusions in this paper should not necessarily be interpreted as a call for interventions into this process aimed at reversing these trends. This is because it is a well-established result of welfare economics that market equilibrium allocations, as long as they are not distorted by important market failures, are also welfare-maximising. Thus, any policies directed at reconfiguring these market allocations could lead to potentially large inefficiencies, understood in terms of welfare losses.⁴³ Showing that there exist strong allocative inefficiencies could call for the implementation of policies that partially correct for the structural composition of economies by, for instance, improving the regulatory framework of certain industries and removing barriers to firm entry-exit and firm growth. We leave the exploration of the latter issues for future work.

It follows from our results that policy efforts should primarily be focused on accelerating productivity growth in the most stagnant market service sectors. Although these sectors have traditionally been regarded as exhibiting an intrinsically narrower scope for technological progress, current technologies, such as digital, and certain assets, such as intangible assets, have a number of characteristics that could lead to productivity gains even in these sectors. In this respect,

⁴³It is beyond the scope of this paper to show to what extent there are market failures at play.

the mobilisation of large amounts of funds in the context of *NextGeneration EU*, funnelled primarily toward the digital and green transitions, represent a unique opportunity for improving productivity performance in these sectors.

Concerning potential avenues of future research, the most natural and promising extension of the analysiss presented in this paper is the incorporation of endogenous economic growth, through endogenous innovation activities, to the modelling framework. This would allow having a better grasping of the development of total factor productivity going forward, using the model as a simulation tool for the examination of the impact of different policies, including innovation policies, such as R&D credits and subsidies, and regulation.

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Appendix

A Data availability

Value added			labour			
	nominal	real	employment	hours	efficiency hours	TFP
AT	1970-2017	1970-2017	1970-2017	1970-2017	1980-2017	1980-2017
BE	1970-2017	1970-2017	1970-2017	1970-2017	1980-2017	1980-2017
DK	1970-2017	1970-2017	1970-2017	1970-2017	1980-2017	1980-2017
ES	1970-2017	1970-2017	1970-2017	1970-2017	1980-2017	1980-2016
FI	1970-2017	1970-2017	1970-2017	1970-2017	1970-2017	1970-2017
FR	1970-2017	1970-2017	1970-2017	1970-2017	1980-2017	1980-2017
DE	1970-2017	1970-2017	1970-2017	1970-2017	1970-2017	1991-2017
EL	1970-2017	1970-2017	1970-2017	1970-2017	-	-
IE	1970-2017	1970-2017	1970-2017	1970-2017	-	-
IT	1970-2017	1970-2017	1970-2017	1970-2017	1970-2017	1970-2017
JP	1973-2015	1973-2015	1970-2015	1970-2015	1973-2015	1973-2015
LU	1970-2017	1970-2017	1970-2017	1970-2017	-	-
NL	1970-2017	1970-2017	1970-2017	1970-2017	1979-2017	1979-2017
PT	1970-2017	1970-2017	1970-2017	1970-2017	-	-
SE	1970-2017	1970-2017	1970-2017	1970-2017	1981-2017	1993-2016
UK	1970-2016	1970-2016	1970-2017	1970-2017	1970-2016	1970-2016
US	1977-2017	1977-2017	1977-2017	1977-2017	1977-2017	1977-2017
BG	1995-2017	1995-2017	1995-2017	1995-2017	-	-
CY	1995-2017	1995-2017	1995-2017	1995-2017	-	-
CZ	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017
EE	1995-2017	1995-2017	1995-2017	1995-2017	-	-
HU	1991-2017	1991-2017	1992-2017	1992-2017	-	-
LT	1995-2017	1995-2017	1995-2017	1995-2017	-	-
LV	1995-2017	1995-2017	1995-2017	1995-2017	-	-
PL	1995-2017	1995-2017	1995-2017	1995-2017	-	-
RO	1995-2017	1995-2017	1995-2017	1995-2017	-	-
SK	1995-2017	1995-2017	1995-2017	1995-2017	1995-2017	2000-2017
SI	1995-2017	1995-2017	1995-2017	1995-2017	-	-

Table 10: Data availability in EU-KLEMS.

B Counterfactual exercise with different productivity measures

	Productivity growth											
	per hour			per worker			per efficiency hour			TFP		
	actual	no SC	Δ	actual	no SC	Δ	actual	no SC	Δ	actual	no SC	Δ
AT	2.3	2.8	-0.5	1.7	2.1	-0.4	1.4	1.6	-0.2	0.8	1.0	-0.2
BE	2.1	2.5	-0.4	1.6	2.1	-0.5	1.0	1.7	-0.7	0.3	0.7	-0.4
DK	1.9	2.3	-0.4	1.3	1.8	-0.5	1.1	1.5	-0.4	0.6	0.9	-0.3
ES	1.8	2.6	-0.8	1.5	2.3	-0.8	0.8	1.3	-0.5	-	-	
FI	2.4	3.1	-0.7	2.0	2.5	-0.5	1.6	2.0	-0.4	0.9	1.1	-0.2
FR	2.2	2.8	-0.6	1.6	2.1	-0.5	1.1	1.4	-0.3	0.7	1.0	-0.3
DE	2.1	2.4	-0.3	1.4	1.7	-0.3	2.0	2.2	-0.2	0.8	1.1	-0.3
EL	1.3	1.7	-0.4	1.3	1.7	-0.4				-	-	
IE	3.3	3.0	0.3	3.0	2.9	0.1				-	-	
IT	1.5	2.0	-0.5	1.3	1.8	-0.5	1.1	1.3	-0.2	0.3	0.5	-0.2
JP	2.5	2.8	-0.3	2.0	2.3	-0.3	1.7	1.8	-0.1	0.6	0.8	-0.2
LU	2.0	1.3	0.7	1.8	1.7	0.1				-	-	
NL	1.9	2.2	-0.3	1.3	1.6	-0.3	0.9	1.2	-0.3	0.6	0.9	-0.3
PT	2.4	2.5	-0.1	2.3	2.3	0.0				-	-	
SE	1.7	1.9	-0.2	1.7	2.0	-0.3	0.8	1.2	-0.4	-0.1	0.1	-0.2
UK	1.6	1.9	-0.3	1.4	1.7	-0.3	1.3	1.6	-0.3	0.4	0.6	-0.2
US	1.4	1.6	-0.2	1.2	1.5	-0.3	1.2	1.4	-0.2	0.4	0.5	-0.1
EU6	2.0	2.4	-0.4				1.4	1.7	-0.3			
EU14	2.0	2.4	-0.4				1.3	1.6	-0.3			
BG	1.2	0.2	1.0	1.1	0.1	1.0				-	-	
CY	1.5	1.4	0.1	1.2	1.1	0.1				-	-	
CZ	2.4	2.2	0.2	2.2	2.0	0.2	2.0	1.9	0.1	0.6	0.5	0.1
EE	4.3	4.4	-0.1	4.0	4.2	-0.2				-	-	
HU	2.3	2.6	-0.3	2.6	3.0	-0.4				-	-	
LT	4.2	3.8	0.4	4.5	4.2	0.3				-	-	
LV	4.5	4.5	0.0	4.1	4.0	0.1				-	-	
PL	3.4	3.3	0.1	3.3	3.3	0.0				-	-	
RO	4.2	4.4	-0.2	4.2	4.3	-0.1				-	-	
SK	3.5	3.8	-0.3	3.1	3.4	-0.3	3.6	3.9	-0.3	1.5	1.8	-0.3
SI	2.7	3.1	-0.4	2.3	2.6	-0.3				-	-	
EUnew	3.2	3.1	0.0									

Table 11: Actual and counterfactual productivity growth with different productivity measures.

C Calibrated parameters and wedges

	AT	BE	DK	ES	FI	FR	DE	EL	IE	IT	JP	LU	NL	PT	SE	UK	US
α_1	0.05	0.02	0.04	0.06	0.07	0.04	0.02	0.06	0.10	0.06	0.03	0.04	0.04	0.07	0.05	0.02	0.04
α_2	0.39	0.31	0.24	0.34	0.22	0.28	0.35	0.22	0.37	0.29	0.29	0.21	0.31	0.92	0.43	0.31	0.21
α_3	0.15	0.12	0.13	0.11	0.16	0.10	0.10	0.10	0.09	0.09	0.18	0.08	0.15	0.12	0.12	0.10	0.18
α_4	0.04	0.06	0.06	0.03	0.07	0.05	0.05	0.08	0.06	0.05	0.02	0.05	0.07	0.04	0.04	0.05	0.06
α_5	0.09	0.11	0.13	0.06	0.13	0.16	0.13	0.28	0.11	0.09	0.13	0.47	0.14	0.09	0.12	0.19	0.16
α_6	0.04	0.12	0.11	0.14	0.03	0.05	0.09	0.06	0.03	0.07	0.07	0.13	0.02	0.06	0.02	0.02	0.04
α_7	0.05	0.05	0.07	0.03	0.07	0.11	0.05	0.09	0.16	0.06	0.13	0.07	0.03	0.91	0.06	0.05	0.13
α_8	0.04	0.06	0.06	0.11	0.08	0.07	0.08	0.04	0.05	0.10	0.04	0.15	0.08	0.09	0.05	0.06	0.13
α_9	0.05	0.07	0.06	0.02	0.08	0.08	0.07	0.04	0.06	0.10	0.03	0.05	0.06	0.09	0.05	0.10	0.05
α_{10}	0.05	0.05	0.07	0.03	0.06	0.04	0.03	0.07	0.04	0.03	0.05	0.07	0.04	0.07	0.06	0.03	0.05
α_{11}	0.05	0.04	0.06	0.08	0.04	0.04	0.05	0.08	0.06	0.09	0.03	0.04	0.07	0.02	0.03	0.10	0.06
σ_1	0.13	0.18	0.20	0.18	0.09	0.20	0.20	0.07	0.11	0.15	0.12	0.84	0.24	0.38	0.12	0.12	0.79
σ_2	0.34	0.12	0.32	0.24	0.07	0.25	0.12	0.06	0.69	0.21	0.08	0.07	0.06	0.06	0.72	0.05	0.27
σ_3	0.35	0.40	0.44	0.48	0.64	0.45	0.48	0.37	0.35	0.30	0.62	0.32	0.64	0.54	0.72	0.43	0.61
σ_4	0.45	0.83	0.87	0.16	0.85	0.77	0.81	0.74	0.89	0.72	0.26	0.90	0.84	0.40	0.88	0.69	0.77
σ_5	0.37	0.61	0.73	0.32	0.66	0.68	0.66	0.81	0.53	0.61	0.71	0.92	0.71	0.56	0.69	0.69	0.67
σ_6	0.37	0.67	0.78	0.77	0.54	0.59	0.70	0.70	0.57	0.64	0.67	0.17	0.28	0.87	0.29	0.21	0.38
σ_7	0.41	0.45	0.29	0.05	0.09	0.13	0.15	0.16	0.74	0.07	0.71	0.11	0.15	0.98	0.46	0.24	0.27
σ_8	0.19	0.15	0.36	0.61	0.61	0.51	0.48	0.39	0.63	0.68	0.48	0.87	0.36	0.50	0.14	0.13	0.51
σ_9	0.31	0.44	0.62	0.08	0.68	0.69	0.65	0.63	0.75	0.75	0.55	0.75	0.29	0.40	0.56	0.66	0.87
σ_{10}	0.50	0.60	0.54	0.09	0.45	0.49	0.50	0.77	0.69	0.50	0.70	0.79	0.40	0.41	0.34	0.37	0.52
σ_{11}	0.72	0.77	0.77	0.71	0.72	0.72	0.68	0.81	0.89	0.82	0.54	0.86	0.82	0.32	0.72	0.79	0.74
ϵ_1	0.58	0.81	2.09	1.91	0.23	1.05	0.73	0.26	0.24	0.66	0.24	1.73	1.62	0.44	0.41	0.51	2.25
ϵ_2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
ϵ_3	1.65	0.21	2.07	2.19	0.44	2.89	2.33	1.22	0.38	1.69	0.81	1.57	3.47	1.45	2.87	1.86	2.09
ϵ_4	1.29	1.90	2.24	0.71	0.79	1.96	2.20	2.84	2.17	2.21	0.27	2.51	2.02	1.62	2.56	0.73	2.30
ϵ_5	2.43	1.81	4.69	3.82	1.37	4.28	4.01	4.27	0.58	4.22	1.08	0.85	4.27	2.47	3.43	3.86	3.14
ϵ_6	2.91	0.52	4.15	2.92	1.00	2.36	1.74	3.52	2.60	1.34	1.19	4.89	4.17	1.81	2.57	4.62	3.35
ϵ_7	4.50	3.76	3.02	4.97	1.12	3.09	4.44	4.50	0.78	3.02	3.33	3.33	4.77	0.43	3.64	4.96	3.18
ϵ_8	1.05	0.58	0.56	1.13	0.34	2.23	1.15	3.20	0.26	1.28	0.50	2.83	0.87	2.35	0.22	0.20	0.41
ϵ_9	0.78	0.32	2.27	2.91	0.64	2.56	1.59	3.48	0.97	2.07	0.65	2.07	0.30	2.17	0.85	1.20	2.41
ϵ_{10}	2.73	2.50	3.39	1.95	0.59	3.80	4.19	3.45	1.98	3.02	2.51	1.69	2.86	2.29	0.89	3.02	3.10
ϵ_{11}	2.29	2.47	2.93	0.82	1.25	2.96	2.69	2.78	2.30	1.86	0.52	2.28	1.79	1.79	2.93	1.96	2.02

Table 12: Calibrated parameter values.

	BG	CY	CZ	EE	HU	LT	LV	PL	RO	SK	SI
α_1	0.10	0.11	0.02	0.07	0.05	0.08	0.06	0.03	0.13	0.04	0.03
α_2	0.23	0.16	0.42	0.21	0.43	0.33	0.34	0.36	0.25	0.41	0.32
α_3	0.06	0.13	0.07	0.16	0.11	0.11	0.07	0.15	0.12	0.12	0.08
α_4	0.05	0.12	0.08	0.06	0.02	0.05	0.04	0.05	0.03	0.05	0.06
α_5	0.07	0.25	0.06	0.09	0.11	0.15	0.13	0.06	0.17	0.10	0.11
α_6	0.10	0.05	0.04	0.08	0.05	0.03	0.05	0.08	0.04	0.06	0.05
α_7	0.31	0.08	0.08	0.09	0.07	0.07	0.08	0.07	0.08	0.11	0.17
α_8	0.11	0.06	0.04	0.07	0.07	0.07	0.06	0.07	0.05	0.07	0.06
α_9	0.08	0.04	0.07	0.05	0.03	0.05	0.05	0.05	0.03	0.05	0.06
α_{10}	0.07	0.07	0.06	0.06	0.03	0.03	0.07	0.04	0.05	0.06	0.04
α_{11}	0.05	0.08	0.06	0.07	0.04	0.03	0.06	0.05	0.06	0.05	0.03
σ_1	0.09	0.87	0.20	0.44	0.29	0.06	0.15	0.30	0.06	0.60	0.15
σ_2	0.69	0.08	0.73	0.19	0.76	0.49	0.51	0.58	0.10	0.71	0.48
σ_3	0.44	0.58	0.57	0.49	0.75	0.16	0.15	0.39	0.58	0.60	0.36
σ_4	0.85	0.76	0.91	0.79	0.23	0.81	0.75	0.88	0.53	0.88	0.82
σ_5	0.49	0.78	0.42	0.19	0.73	0.63	0.08	0.24	0.67	0.69	0.69
σ_6	0.75	0.08	0.77	0.72	0.76	0.64	0.62	0.77	0.14	0.82	0.53
σ_7	0.13	0.08	0.51	0.12	0.51	0.22	0.44	0.19	0.39	0.64	0.63
σ_8	0.79	0.41	0.28	0.11	0.66	0.28	0.37	0.54	0.62	0.69	0.56
σ_9	0.81	0.47	0.83	0.28	0.36	0.18	0.43	0.56	0.50	0.79	0.57
σ_{10}	0.83	0.77	0.82	0.62	0.58	0.51	0.70	0.64	0.77	0.82	0.51
σ_{11}	0.84	0.79	0.89	0.70	0.75	0.53	0.71	0.80	0.74	0.82	0.61
ϵ_1	0.24	2.19	0.36	0.27	0.59	0.12	1.22	0.20	0.27	1.82	0.43
ϵ_2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
ϵ_3	1.81	2.81	2.76	0.79	2.56	1.25	3.83	0.69	1.44	1.29	1.88
ϵ_4	2.87	1.74	1.25	1.47	0.47	1.01	2.55	2.35	0.45	2.57	1.83
ϵ_5	1.92	3.25	0.88	0.93	3.25	1.77	2.31	1.18	1.27	0.94	3.86
ϵ_6	2.82	4.53	3.17	2.03	3.39	1.05	4.65	2.61	1.00	2.45	2.09
ϵ_7	0.20	4.56	1.32	1.01	3.69	1.17	4.88	0.77	1.48	1.68	1.96
ϵ_8	2.10	3.08	0.29	0.29	1.60	0.30	1.18	0.27	0.24	1.78	1.75
ϵ_9	2.67	2.50	1.85	0.19	1.46	0.36	0.77	0.28	1.01	2.45	0.63
ϵ_{10}	2.94	1.92	2.43	0.64	1.50	0.75	0.91	1.67	2.63	2.40	1.11
ϵ_{11}	2.45	1.47	1.74	0.47	0.76	0.50	1.87	1.42	0.98	2.70	0.75

Table 13: Calibrated parameter values, cont'd.

	agr	ind	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AT	0.16	1.00	0.69	0.53	0.86	1.23	1.21	0.66	0.82	0.61	0.58
BE	0.35	1.00	0.78	0.46	1.00	1.68	0.98	0.65	0.93	0.59	0.51
DK	0.45	1.00	0.71	0.48	0.96	1.60	1.41	0.85	0.73	0.57	0.70
ES	0.54	1.00	0.60	0.94	1.17	2.13	1.43	0.81	1.04	0.90	0.64
FI	0.33	1.00	0.66	0.38	0.85	1.35	1.49	0.69	0.78	0.55	0.56
FR	0.36	1.00	0.74	0.56	1.11	1.29	1.57	0.88	0.92	0.65	0.64
DE	0.38	1.00	0.66	0.35	1.05	1.28	1.67	0.85	0.81	0.57	0.75
EL	0.33	1.00	0.57	0.65	1.31	1.94	2.52	1.02	1.21	1.08	0.68
IE	0.15	1.00	0.52	0.29	0.97	1.48	1.17	0.58	0.67	0.52	0.41
IT	0.41	1.00	0.76	0.67	1.31	1.97	2.07	1.43	1.12	0.97	0.72
JP	0.28	1.00	0.79	0.57	1.07	2.11	2.09	1.40	1.15	0.70	0.68
LU	0.98	1.00	1.25	0.75	1.58	3.71	2.12	1.60	1.44	1.19	0.94
NL	0.56	1.00	0.73	0.42	0.94	2.05	0.96	1.02	0.82	0.59	0.49
PT	0.32	1.00	1.03	0.86	1.88	4.59	1.85	1.55	1.24	0.95	0.70
SE	0.43	1.00	0.70	0.45	1.03	1.82	1.38	0.74	0.52	0.57	0.54
UK	0.40	1.00	0.70	0.49	1.06	1.71	1.53	0.88	0.90	0.67	0.70
US	0.41	1.00	0.76	0.40	1.51	1.47	1.32	0.74	0.53	0.59	0.57
BG	0.43	1.00	0.79	0.57	1.51	3.95	2.90	0.91	0.82	0.75	0.84
CY	0.40	1.00	0.77	0.75	1.87	2.40	2.92	1.44	1.71	1.12	1.00
CZ	0.66	1.00	0.76	0.60	1.33	2.29	1.55	1.16	0.79	0.71	0.77
EE	0.73	1.00	1.02	0.57	1.38	2.98	2.70	1.07	0.67	0.66	0.67
HU	0.52	1.00	0.70	0.57	1.19	1.82	2.17	1.12	0.77	0.64	0.69
LT	0.36	1.00	0.94	0.60	1.50	1.72	1.83	1.06	0.54	0.45	0.61
LV	0.43	1.00	0.88	0.59	1.84	2.40	4.07	1.23	0.66	0.58	1.00
PL	0.22	1.00	1.20	0.55	1.17	1.82	2.03	0.91	0.80	0.68	0.78
RO	0.25	1.00	0.69	1.07	1.58	2.47	3.13	1.18	0.89	0.70	0.91
SK	0.85	1.00	0.77	0.41	1.19	1.87	1.41	1.03	0.47	0.57	0.98
SI	0.20	1.00	0.95	0.66	1.23	1.89	1.48	1.17	0.90	0.88	0.87

Table 14: 1997-2017 average values of τ_i .

D Model fit

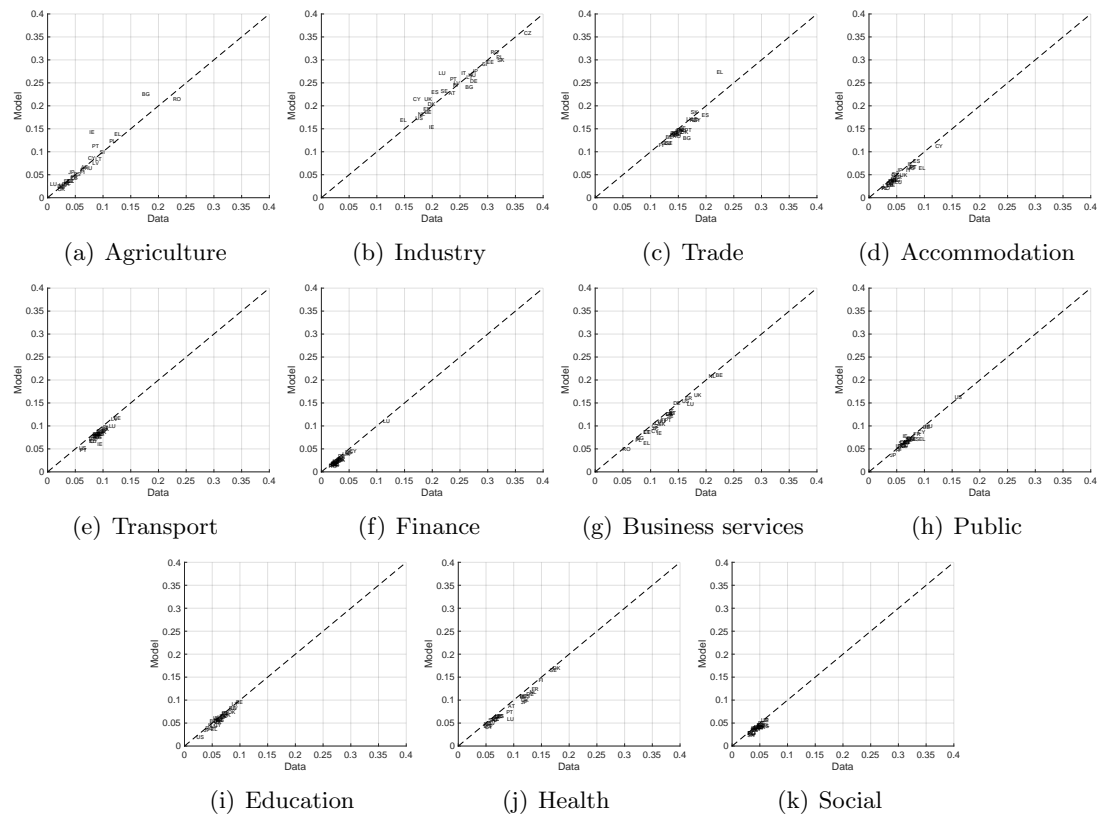


Figure 6: Sectoral shares of hours worked in 2017, Data and model.

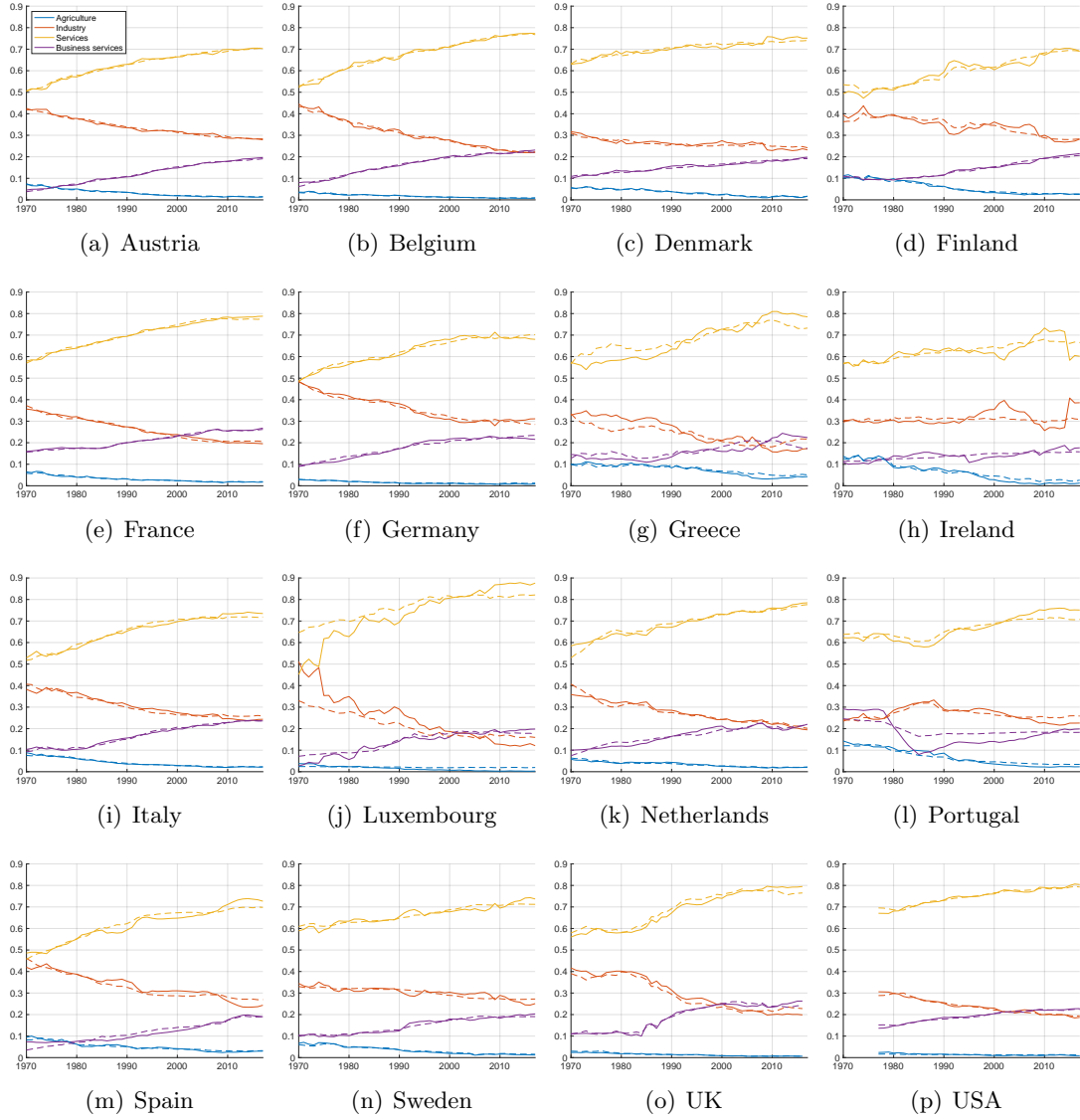


Figure 7: Sectoral shares of value added, Data (solid line) and model (broken line).

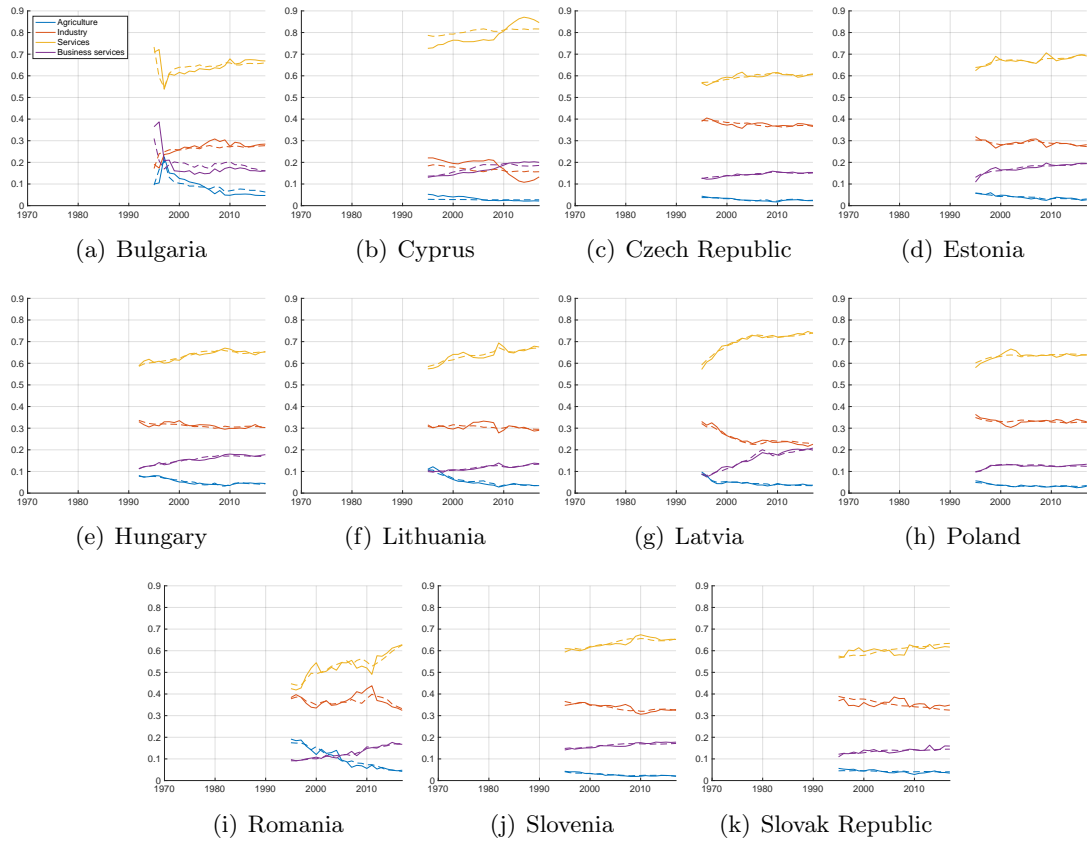


Figure 8: Sectoral shares of value added, Data (solid line) and model (broken line).

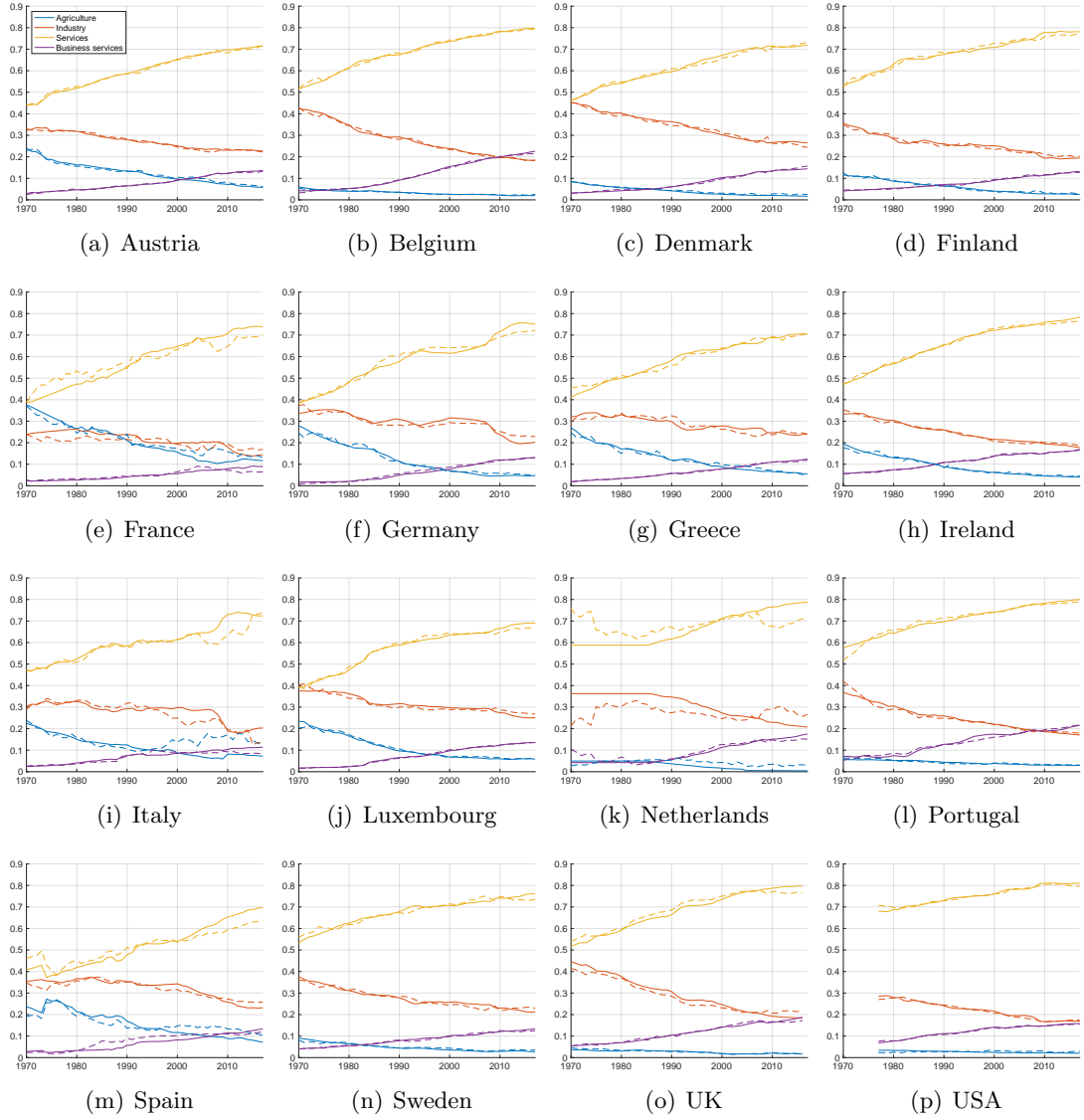


Figure 9: Sectoral shares of hours worked, Data (solid line) and model (broken line).

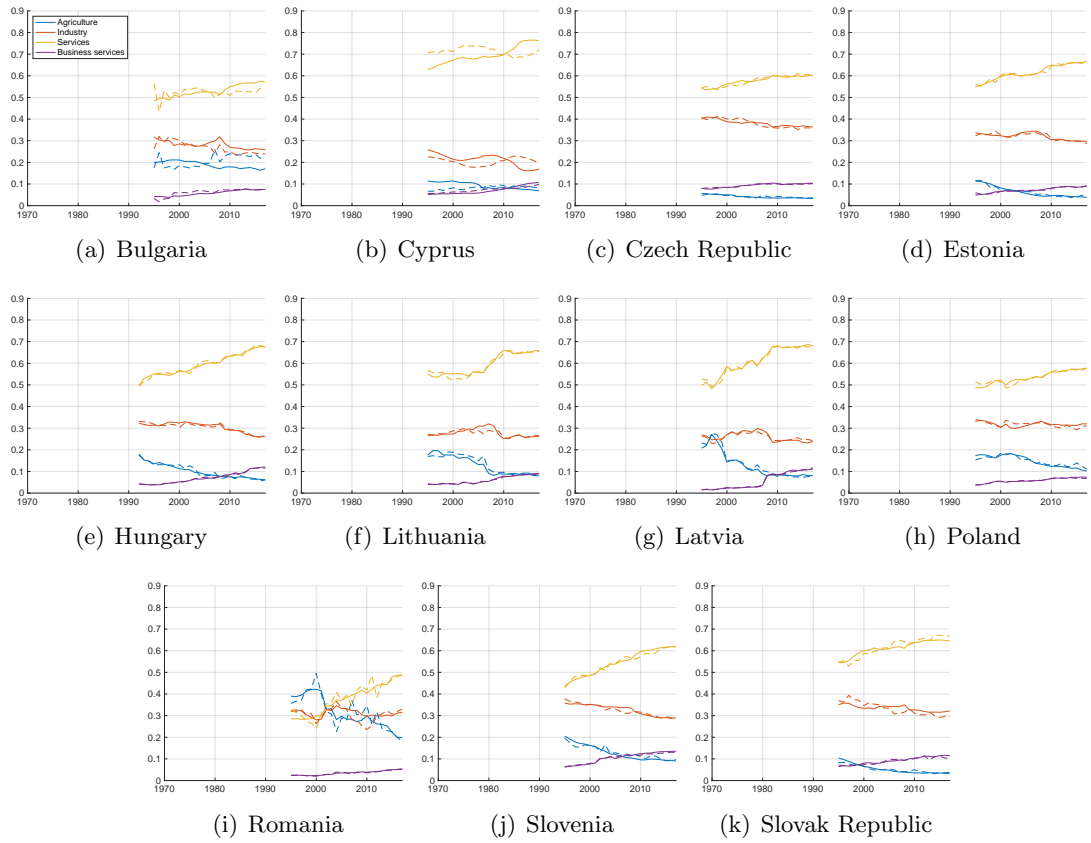


Figure 10: Sectoral shares of hours worked, Data (solid line) and model (broken line).

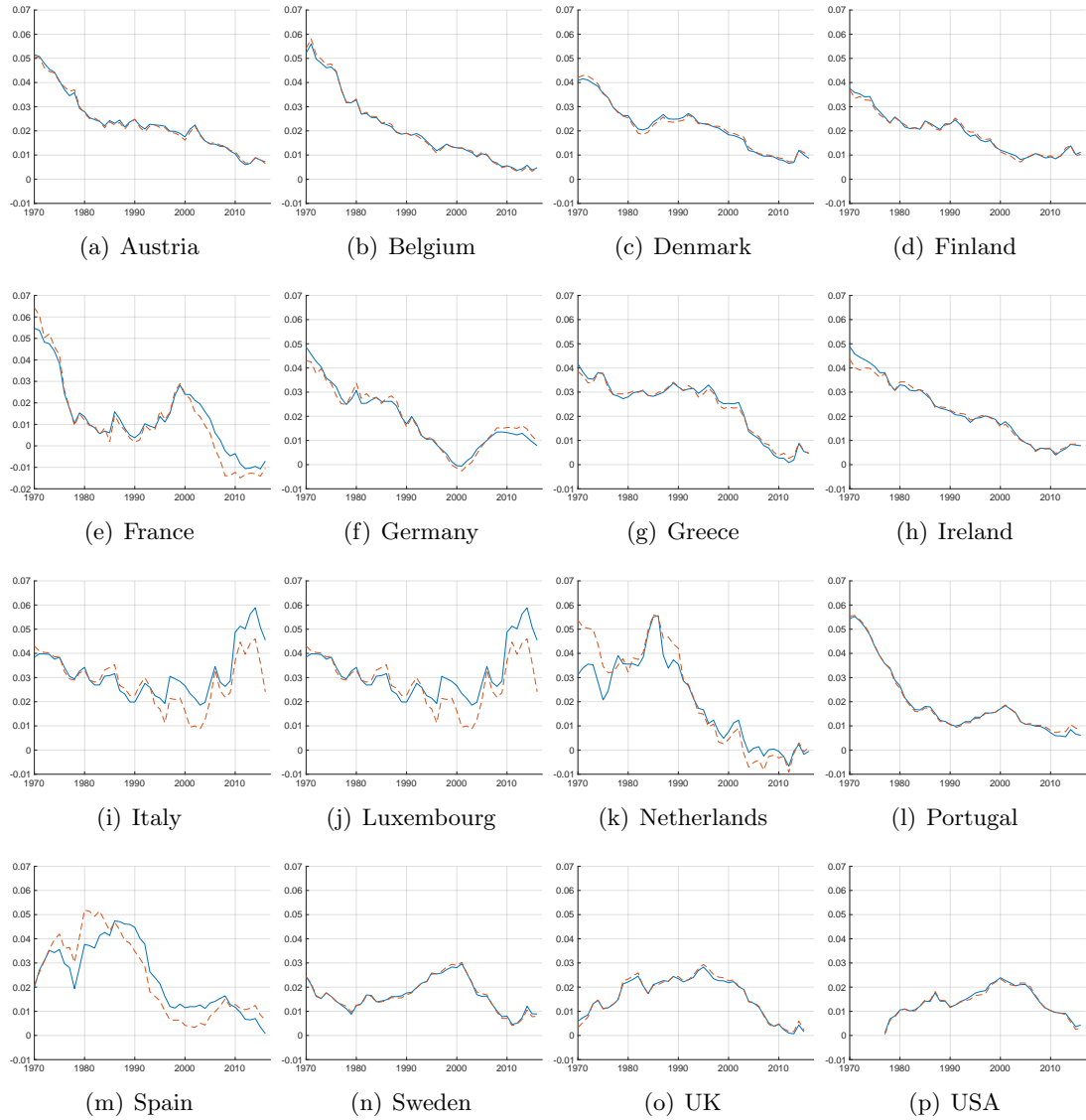


Figure 11: Aggregate labour Productivity Growth, 10yrs moving average, Data (solid line) and model (broken line).

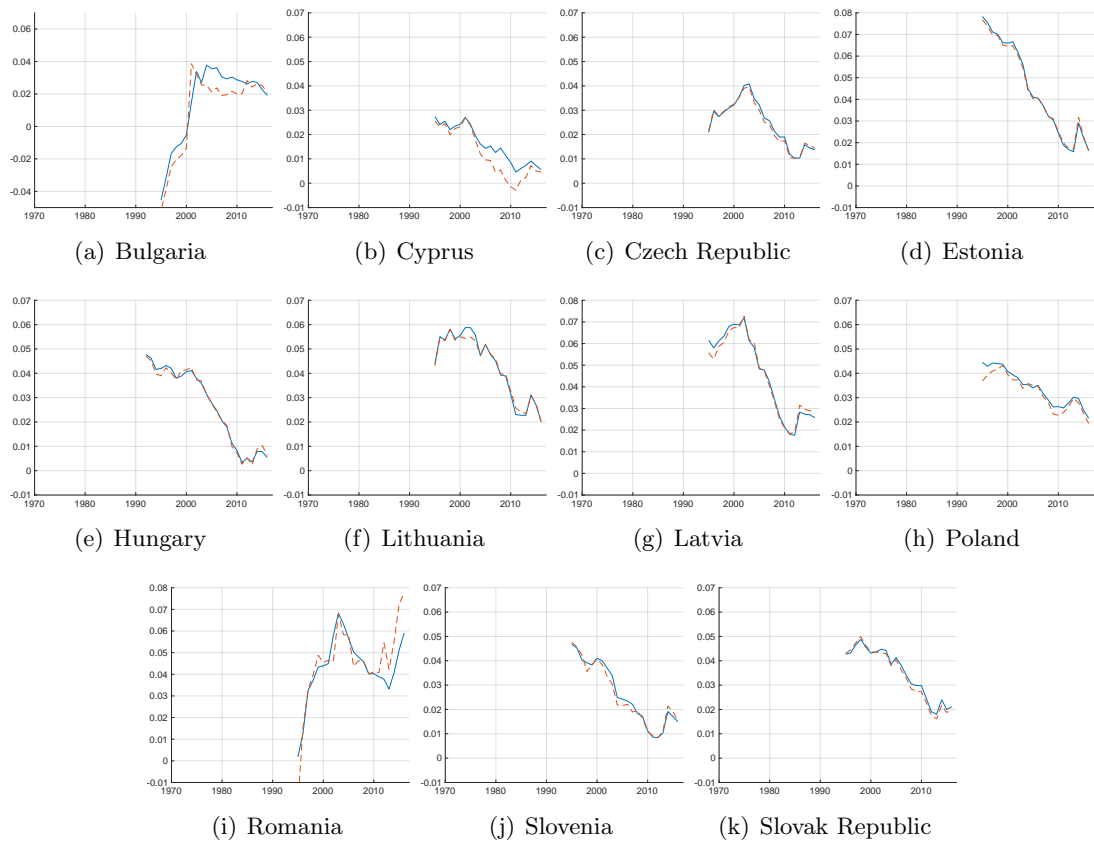


Figure 12: Aggregate labour Productivity Growth, 10yrs moving average, Data (solid line) and model (broken line).

E The importance of price and income effects

As mentioned above in Section 4, structural change in the model is driven by two factors: the income effect and the price effect. In this section, we gauge the relative importance of the two forces for explaining the changes in the sectoral composition of value added and labour. We do so by running an OLS-regression of the value added share of each sector on a set of regressor variables. As regressors we include country fixed effects and the model-implied sectoral prices p_{it} and the consumption index C_t . We include fixed effects to control for country-specific factors that affect the sectoral composition but that are not part of the model. To measure the importance of the income and the price effect, we compare the r^2 of the regression where we include only the sectoral prices, or only the consumption index, or both variables together. Table 15 reports the r^2 of the different specifications when the value added share (labour share) is used as dependent variable.⁴⁴ According to the results in the table, the price effects tends to be the dominant determinant of the sectoral composition. The r^2 of the regression that includes only prices is very close to the r^2 of the specification where all regressors are included. In contrast, when only the consumption index is included, the implied r^2 is well below that of the full model.

	agr	ind	Services								
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel (a): Value added share as dependent variable											
FE+prices	88	67	24	52	36	42	79	41	62	79	64
FE+consumption index	66	21	3	11	19	23	35	0	13	53	39
All regressors	90	69	24	53	36	47	79	45	65	79	64
Panel (b): labour share as dependent variable											
FE+prices	83	79	46	68	21	63	87	40	67	76	82
FE+consumption index	57	37	2	45	14	28	62	15	33	56	57
All regressors	85	79	50	69	28	64	88	41	67	77	84
agr: agriculture; ind: industry; (1): Wholesale and retail trade; (2): Accommodation and food services; (3): Transport, storage and communication; (4): Financial intermediation; (5): Business services; (6): Public administration; (7): Education; (8): Health; (9): Social and personal services											

Table 15: Importance of income and price effect.

The seemingly dominant role of the price effect raises the question whether a model without income effects would be an equally suitable framework. To address this question, we turn off the income effects in our model by setting $\epsilon_i = 1$ and $\sigma_i = \sigma_j$, for $i = 1, 2, \dots, 11$ and then re-do the quantitative analysis. The upper panels in Figure 13 depict the results. For comparison, the lower panels show the results of the baseline analysis. Panel (a) compares the model outcome and the data for average aggregate productivity growth. Clearly, due to the parameter restriction, the model is substantially less flexible to match the data. As a result, the model fit of aggregate

⁴⁴The dependent variable as well as the independent variables are expressed in logs.

productivity growth is significantly worse than in the baseline case. For all the countries in the our sample, the model under-predicts actual productivity growth. The reason is that in the absence of income effects the model misses a significant part of the observed rise (drop) in the share of services (industry). This pattern can be observed in the remaining panels in Figure 13 which depict for the three largest EU-countries, Germany, France and Italy, the time series of sectoral value added for agriculture (blue), industry (red), total services (yellow) and business services (purple). The data (model) is represented by the solid (broken) line. In the baseline analysis the model can account very well for the observed change in the sectoral composition. However, the model without income effects cannot match the large rise in services and the corresponding decline in the industry sector and, at the same time, it predicts a larger (smaller) than observed initial level of services (industry). As a consequence, the predicted aggregate productivity growth falls short of the actual one.

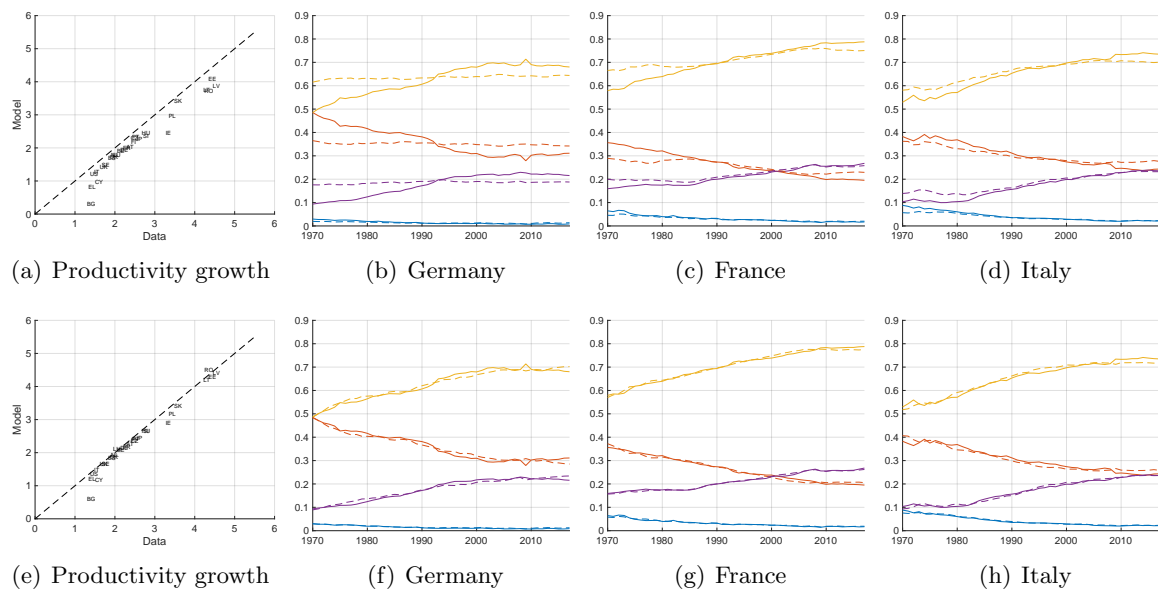


Figure 13: Upper panels: model w/o income effects; lower panels: baseline model; panels (a), (e): average aggregate productivity growth; other panels: sectoral shares of value added; blue line: agriculture, red: industry, yellow: total services, purple: business services; data: solid line, model: broken line.

F Alternative calibration approach

	All	Advanced	New
α_1	0.09	0.07	0.06
α_2	0.18	0.20	0.21
α_3	0.02	0.06	0.15
α_4	0.02	0.02	0.05
α_5	0.31	0.02	0.20
α_6	0.01	0.48	0.03
α_7	0.10	0.09	0.08
α_8	0.27	0.05	0.07
α_9	0.01	0.01	0.05
α_{10}	0.01	0.01	0.07
α_{11}	0.01	0.02	0.05
<hr/>			
σ_1	0.54	0.62	0.22
σ_2	0.40	0.05	0.73
σ_3	0.42	0.65	0.75
σ_4	0.60	0.98	0.79
σ_5	0.86	0.63	0.71
σ_6	0.46	0.89	0.55
σ_7	0.29	0.64	0.16
σ_8	0.80	0.55	0.72
σ_9	0.20	0.76	0.53
σ_{10}	0.42	0.46	0.74
σ_{11}	0.70	0.82	0.77
<hr/>			
ϵ_1	0.87	0.87	0.40
ϵ_2	1.00	1.00	1.00
ϵ_3	1.71	1.09	3.20
ϵ_4	2.43	2.79	1.74
ϵ_5	4.85	4.93	2.43
ϵ_6	4.83	2.50	3.34
ϵ_7	3.18	4.95	2.23
ϵ_8	1.42	0.38	0.76
ϵ_9	2.45	3.84	0.91
ϵ_{10}	4.77	4.37	1.50
ϵ_{11}	4.20	4.51	1.53
<hr/>			
Columns differ in terms of samples of pooled countries. All: all 28 countries; Advanced: aut, bel, dnk, esp, fra, ger, ita, jpn, lux, nld, swe, uk, usa; New: bul, cyp, cze, est, hun, ltu, lva, pol, rom, svk, svn.			
<hr/>			

Table 16: Alternative calibration - parameter values.



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