CESifo WORKING PAPERS

9323
2021

September 2021

Structural Change and Productivity Growth in Europe – Past, Present and Future

Georg Duernecker, Miguel Sanchez-Martinez

CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editor: Clemens Fuest
https://www.cesifo.org/en/wp
An electronic version of the paper may be downloaded
· from the SSRN website: www.SSRN.com
· from the RePEc website: www.RePEc.org
· from the CESifo website: https://www.cesifo.org/en/wp

CESifo *Working Paper No. 9323*

Structural Change and Productivity Growth in Europe – Past, Present and Future

Abstract

This paper studies the effect of structural change on the historical path of aggregate labor productivity growth for a large sample of European countries, and it builds a quantitative multi-sector growth model to analyze the potential impact that structural change may have on future productivity growth. We document that the observed reallocation of economic activity since the 1970s towards the service sector has exerted a strongly negative effect on aggregate productivity growth in most European countries. Moreover, we perform a quantitative analysis to show that the expected path of structural change might continue to have a sizable dent on future productivity growth in Europe. By contrast, the impact in the U.S. is expected to rapidly diminish. We show that this differential result can be explained by the large expansion, in Europe, of certain service sub-sectors characterized by stagnant productivity.

JEL-Codes: O410, O470, O520.

Keywords: structural change, productivity growth, Baumol's cost disease, service sector, European Union.

Georg Duernecker
Goethe-University Frankfurt / Germany
duernecker@em.uni-frankfurt.de

Miguel Sanchez-Martinez
European Commission / Brussels / Belgium
Miguel.Sanchez-Martinez@ec.europa.eu

August 19, 2021
We thank Berthold Herrendorf for helpful comments and suggestions. Duernecker acknowledges financial support from the European Commission (DG JRC, Unit B.7) under contract number CT-EX2020D401490-101. All errors are our own.

1 Introduction

The slowdown of aggregate productivity growth is currently one of the most pressing economic challenges faced by many advanced economies. The United States (U.S.), as well as the Member States of the European Union (EU), and, in particular, EU14 countries have experienced a significant deceleration during the last decades in both labor productivity and total factor productivity (TFP) growth.[1] Low rates of TFP and labor productivity growth are a source of concern because these factors are considered to be key determinants of economic growth and future standards of living. As a consequence, much research has been recently devoted to the exploration of the causes behind sluggish aggregate productivity growth. Some of the most salient potential explanations that have been set forth include diminishing returns to R&D and innovation (Gordon (2016)), decreasing business dynamism (Fernandez-Villaverde and Ohanian (2018)), tepid investment in ICT and intangible assets (van Ark and Jaeger (2017), Niebel et al. (2017)), mismeasurement (Byrne et al. (2016), Syverson (2017)), the slow rate of diffusion of technology and innovation (Andrews et al. (2015)), and regulatory barriers (Arnold et al. (2008)).

While most of the existing work emphasizes the role played by the slowdown of the traditional engines of growth, a recent strand in the literature stresses the importance of changes in the sectoral composition of economies as an important factor behind the observed deceleration in aggregate productivity growth.[2] According to this explanation, the so-called process of structural change represents a major drag to overall productivity growth because it leads to a reallocation of economic activity from sectors with high rates of productivity growth – such as agriculture and industry – towards the service sector which is characterized by comparably low rates of productivity growth.[3] While the quantitative importance of this mechanism is well documented for the U.S. (see Nordhaus (2008) and Duernecker et al. (2017)), there is only scant work investigating the effects of structural change on aggregate productivity growth in Europe.[4]

The aims of this paper are, first, to fill this gap by documenting in detail the effect of structural change on past and present productivity growth in the EU and, second, build a model of structural change able to inform about the likely paths of these sectoral shifts and productivity growth going forward. In particular, we use data from EU-KLEMS covering the period from 1970-2017 to show that the secular rise of the service sector is a central element in explaining the dismal productivity performance of EU countries over relatively long historical periods. To undertake this analysis, we first show the importance of breaking down the service sector into its constituent first-digit sub-sectors in order to properly account for the impact of structural change on productivity growth. Based on this sector classification, we then document the rel-

[1]Duernecker et al. (2017) and Bauer et al. (2020) document the magnitude of the growth slowdown in the U.S. and in Europe, respectively.

[2]The engines of economic growth typically include technological progress and the accumulation of factors of production, such as physical, human and intangible capital.

[3]This phenomenon is a manifestation of the *Cost Disease* which was first emphasized in the work by Baumol (1967).

[4]A noteable exception is Bauer et al. (2020) who document this issue in the EU context.

atively large degree of heterogeneity among service sub-sectors in terms of their productivity performance over time. Crucially, we find that reallocation within services towards sectors with stagnant productivity plays a key role in capturing the slowdown in aggregate productivity growth. According to our results, the observed changes in the sectoral composition of EU14 countries can account for a reduction in average annual productivity growth of about 0.4 percentage points. This is a substantial reduction considering that aggregate productivity grew, on average, by 2% per year during this period. Among the countries in our sample, the effect of structural change is very diverse and it ranges from relatively small effects in the order of magnitude of -0.1 percentage points (e.g., Portugal and Sweden) to sizable values of up to -0.8 percentage points (e.g., Spain).

In the second part, we develop a multi-sector general equilibrium model capable of replicating the observed historical pattern of structural change. We calibrate the model and perform a quantitative analysis to shed light on the potential role structural change may play as a driver of future productivity growth in EU Member States. Importantly, we find that structural change is expected to continue to have a strongly negative effect on European productivity growth. According to our quantitative results, the simulated shifts in the different economies' sectoral compositions during the next 10 years are projected to lead to a sizable slowdown of average annual productivity growth in the EU14, of about 0.35 percentage points. In other words, the effect of structural change on future productivity growth is expected to be almost identical to its effect during the last decades. We also find substantial heterogeneity among EU member states; the predicted reduction in productivity growth ranges from 0.15 percentage points for France and Italy to 0.84 percentage points for Ireland.[5] The intuition for the sizable future effect of structural change is straightforward. First, productivity growth in the European service sector is generally very low and equal to 0.6% per year for the EU14; thus, it is substantially below productivity growth in agriculture (2.4%) and industry (2.4%). Therefore, any shift in economic activity towards services is predicted to have a large negative effect on aggregate growth. Second, the sector-composition within services is predicted to shift strongly towards the service sectors with stagnant productivity. As a result, the rise in the stagnant service sectors in Europe, which happens at the expense of the *progressive* service sectors implies a substantial drag on aggregate productivity growth. As a consequence of this, aggregate productivity growth in Europe is predicted to fall behind that of the U.S, since such detrimental sectoral shifts are not predicted for the latter. Thus, the existing EU-US gap in productivity levels is predicted to widen even further during the next decade.

The research we conduct in this paper is closest in nature to the literature surrounding the so-called *Baumol's cost disease*. Within this literature several papers are related to ours. Our paper takes inspiration from Duernecker et al. (2017) (henceforth, DHV), who study the effect

[5] In fact, it is somewhat misleading to focus on the absolute instead of the relative reduction in the growth rate. For example, Italy's average growth rate is equal to 0.30% per year. Thus, a reduction by 0.15 percentage points amounts to a decline by 50%.

of structural change on past and future aggregate productivity growth in the U.S. Similarly to us, these authors find a quantitatively sizable effect of shifts in sectoral composition on the past evolution of aggregate productivity growth. Likewise, they disaggregate the service sector and find that shifts within services play an important role for the overall effect of structural change on productivity growth. While similar in spirit and goals, there are several important differences between their paper and ours. First, their study focuses exclusively on the U.S., whereas our analysis is conducted for a large sample of countries including 28 European countries, as well as the U.S. and Japan. Even though we use a different data source and time horizon, we can reproduce the main result in DHV that structural change is predicted to have a negligible effect on future aggregate productivity growth in the U.S.. However, as mentioned above, our analysis reveals that this pattern does not generally extend to other industrialized countries. Instead, the finding for the U.S. stands in stark contrast to our main prediction for most European countries that structural change will continue to have a strongly negative effect on future productivity growth. The reasons for this are twofold. First, productivity in services is expected to grow at a substantially lower rate in Europe than in the U.S., while remaining largely similar for agriculture and industry. As a result, a further rise in services weighs more strongly on aggregate productivity in Europe than in the U.S. Second, as shown by DHV, the composition of services in the U.S. is predicted to remain stable over time. That is, neither the sub-sectors with high productivity growth (progressive sectors), nor those with low productivity growth (stagnant sectors) are foreseen to gain in relative size. This is different in Europe, where we find that the stagnant sectors are bound to attain higher economic shares in the future, thereby weighing on future productivity growth.

Yet another difference between the two papers concerns the disaggregation of the service sector. While DHV split total services into two sub-sectors, namely progressive and stagnant services, we consider nine sub-sectors at the one-digit level. Such a fine grained classification of services allows for a more accurate depiction of structural change within services. But more importantly, the key advantage of our sectoral disaggregation is its comparability across countries. The one-digit classification of sectors can be applied in the same way to all countries, whereas the split between progressive and stagnant services may imply a different classification scheme across countries. Lastly, to meaningfully incorporate a large number of sectors in the model we adopt a more flexible preference structure than DHV, which can be deemed preferable in that it does not require to impose restrictions on the elasticity of substitution across goods.

Another related contribution is that by Buiatti et al. (2017), who use a calibrated multi-sector model of structural change to study the anatomy of the EU-U.S. productivity gap. In line with us, they identify the business services sector, together with trade and finance, as one of the main culprits for the differential productivity performance between the U.S. and European countries. Compared to our work, they study a smaller set of countries (9 instead of 30) and use a shorter time-period (1970-2009, instead of 1970-2017). However, more importantly, the main focus of their analysis is on the exploration of the sectoral origins of the aggregate productivity gap with respect to the U.S., whereas we delve into how structural change is predicted to affect the future path of productivity growth in both blocks of economies, and how this in turn will affect the gap with respect to the US. They also approach their analysis by disaggregating services, albeit they restrict the elasticity of substitution to be the same across goods. This is a strong assumption as it implies that the elasticity of substitution between, for instance, agriculture and education is the same as that between agriculture and manufacturing. In fact, we perform a counterfactual exercise in which we restrict the elasticities to be identical and find that the empirical fit of the calibrated model deteriorates substantially.[6] These results strongly suggest that allowing the elasticity of substitution to vary across sectors is essential for capturing the observed sectoral shifts.

Also closely related to our analysis is the work by Sen (2020) who uses a multi-sector growth model to evaluate the effects of structural change on past and future productivity growth in Europe and the U.S. Unlike us, he finds a strongly diminishing effect of this phenomenon on the future path of aggregate productivity not only for the U.S. but also for European countries. This is in stark contrast to our result that structural change in Europe will continue to weigh down on productivity growth going forward. The reasons behind these opposite findings might be linked to the different approach in terms of the disaggregation of the service sector. While he distinguishes between two services sectors, we consider nine service sectors. Our finer disaggregation allows for a more accurate depiction of the reallocation within services which, as we show, is a key determinant for how structural change affects future productivity. Moreover, our preference specification is less restrictive than that his as we do not assume the elasticity of substitution between goods and each type of services to be equivalent.

Our analysis provides important insights for economic policy. Most importantly, we identify structural change as one of the main culprits of the secular stagnation of productivity growth in European countries. Furthermore, structural change is also predicted to exert a sizable negative effect on future growth. Nevertheless, these results should not be interpreted as evidence in favor of policy interventions that reverse the course of structural change (e.g. by providing incentives to bring economic activity back to high-growth sectors such as agriculture and industry). These would not represent an efficient way of reviving EU productivity growth insofar as the model's equilibrium allocation is also socially optimal. Thus, any policy measure aimed at forcing a shift in the natural path of the economies' sectoral composition would be welfare-decreasing. Instead, our findings suggest that in order to promote aggregate growth it may be fruitful to implement policies aimed at stimulating productivity growth in the sluggish European service sector. Such policies would help limit the negative effects of structural change, due to an ever rising service sector, on aggregate productivity growth. We leave an in-depth analysis of such types of policies for future work, as it requires a framework with endogenous sectoral productivity.

The rest of the paper is structured as follows. Section 2 presents the data and documents main

[6] The results of this counterfactual exercise are not included in the paper but are available upon request.

empirical regularities. Section 3 presents the multi-sector general equilibrium model. Section 4 provides details of the quantitative analysis and simulations and discusses the main results. Section 5 features a number of robustness checks and Section 6 concludes. An appendix at the end contains additional, supporting material.

2 Data and stylized facts

Data description

The data that we use in the empirical and in the theoretical model-based analysis is taken from the EU-KLEMS database and consists of two waves: the November 2009-Release (updated March 2011) and the 2019-Release. The 2009-release covers the period from 1970-2007 while the latter covers 1995-2017. Structural change is a long-run phenomenon; hence, it is essential that our data covers 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 data releases, whose industry classification differs. The 2009-release is based on the ISIC Revision 3 industry classification while the 2019-release uses the ISIC Revision 4 classification. To connect the two datasets, we use the correspondence tables of the Statistics Division of the United Nation's Department of Economic and Social Affairs[7]. Clearly, the quality of the combined dataset depends on the degree of overlap between the two industry classifications. In our analysis below, use an industry classification that is based on a relatively broad disaggregation of sectors, namely, at the one-digit level. Hence, quite naturally the amount of overlap between the two industry classification at this level of disaggregation is very large. When building the combined dataset, we extrapolate 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).[8] The coverage of these variables in our combined dataset is from 1970-2017 for most countries, and from 1995-2017 for the newer Member States.[9]

Facts for 3 broad sectors

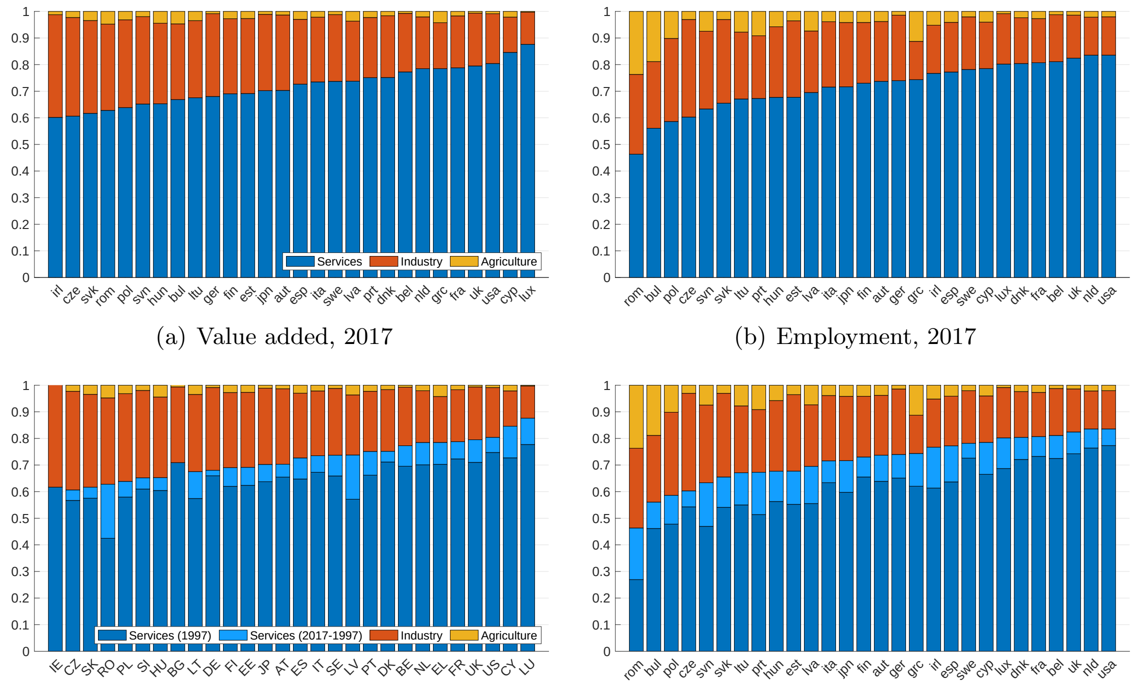
As a first step, we analyse the patterns of structural change and productivity growth across the countries in our sample. We start by disaggregating the economy into the three broad sectors:

[7]The correspondence tables are freely available at `https://unstats.un.org/unsd/classifications/Econ`.

[8]The sample includes all countries belonging to the European Union, except for Croatia and Malta. The data coverage for both countries is insufficient for our purpose.

[9]Table 10 in the appendix reports the data availability for all countries and all variables in our combined dataset.

agriculture, industry and services[10]. In Panels (a) and (b) of Figure 1 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.



(a) Value added, 2017

(b) Employment, 2017

(c) Value added (with services in 1995)

(d) Employment (with services in 1995)

Figure 1: Sectoral shares of value added and employment

A second important observation emerging from Figure 1 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% for Ireland, Czechia and Slovakia to more than 80% for 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 1 the difference between the 1995-level and the 2017-level of the service share. This difference is indicated by the light-blue bars. For all

[10] Agriculture 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 communication, finance, real estate, professional, scientific and technical activities, administrative and support activities, public administration, education, health and social work activities, other community, social or personal services.

the countries in our sample, we can observe a sizable expansion of the service sector of up to 20 percentage point in terms of the value added share and the employment share. 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 share and the employment share. 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 labor productivity. We measure labor productivity as real value added per hour worked and in the table we report the average annual growth rate.[11] 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.[12]

The previous two observations that the service sector has low productivity growth but expands in size 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 labor towards the sectors with the lowest productivity growth means that structural change has had a negative impact on past aggregate labor productivity growth. We will investigate this aspect further below.

As a final remark concerning Table 1 we address the difference between the U.S. and Europe in terms of the sectoral composition and productivity growth. First, it is important to notice that Europe 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 European 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 went through a rapid catching-up process which has led to a fast expansion of the service sector and a gradual narrowing of the gap to the U.S. The catching-up of Europe is also reflected by the larger sectoral productivity growth rates. However, as is well known, productivity growth in many European countries has slowed down substantially in recent years and has fallen short of U.S.-productivity growth at the sectoral and the aggregate level. We will address this issue in greater detail further below.

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

[12] The 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 "rather heterogeneous 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 fruitful not to lump all services into one broad sector but to disaggregate it and to consider the 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.[13]

We choose to disaggregate services into the following one-digit 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. This classification scheme is sufficiently fine-grained so as to capture the large degree of heterogeneity within services while remaining still tractable. 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 is by far the largest sub-sector, followed by trade, health and finance. Interestingly, the strong expansion of total services is not reflected at the level of the sub-sectors. In fact, several of the sub-sectors have declined. This applies for example to trade and transportation. 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. Again, this pattern is remarkably uniform across countries.

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 had high productivity growth, even comparable to that of the industry sector, other sectors - such as food, business services, education and health - have tended to stagnate. Interestingly, there exists somewhat of an inverse relationship between the change in the size of a sector and its productivity growth. That is, the sectors with low productivity growth have experienced an increase in their size (e.g. business services, health) whereas the sectors with fast productivity growth have stagnated or even declined in size (trade, transportation, finance). This observation suggests that Baumol's cost disease is at play in the majority of EU countries, which exerts a negative effect on aggregate productivity growth. To further investigate this issue and to assess the impact of structural change on aggregate labor productivity growth, we compare for each country the actual aggregate productivity growth with the counterfactual productivity growth that is computed by holding the sectoral shares of value added and hours worked constant at their 1970-levels. By proceeding this way, 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. Here we define labor productivity as real value added per hour worked.

[13] Similarly, 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 depends to a lesser and lesser extent 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.

	Value added																		Productivity growth								
	Share in 2017									Δ 1970-2017									Δ 1970-2017								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(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	2.2	0.9	2.7	2.8	0.1	1.0	0.5	0.2	-0.1
BE	12	2	10	6	23	8	7	7	2	0	1	2	-1	15	0	2	4	1	1.4	0.8	2.5	1.8	0.3	0.9	0.8	-0.3	1.9
DK	13	2	10	6	20	5	6	10	3	-4	0	0	1	10	-1	1	4	1	2.5	-0.8	2.6	2.6	-0.2	0.3	0.8	0.6	0.4
ES	12	7	9	4	19	6	6	6	3	2	3	2	2	12	-0	3	1	0	1.1	-0.7	3.1	1.7	-1.5	-0.1	0.3	-0.6	-0.2
FI	9	2	11	3	22	6	5	9	3	-1	0	2	1	11	0	1	3	1	2.8	0.6	2.8	3.6	-0.8	0.4	0.3	-0.7	0.3
FR	10	3	10	4	27	8	5	9	3	-1	1	0	0	11	2	2	5	1	2.6	-0.3	3.5	1.4	0.4	1.4	0.3	0.5	0.4
DE	10	2	9	4	22	6	4	8	4	-1	0	1	0	12	-1	1	4	1	2.4	-0.5	3.4	1.2	0.5	2.5	0.2	0.8	0.6
EL	11	7	10	4	22	10	6	4	4	-4	3	2	0	8	6	3	2	1	-1.1	-0.3	3.8	0.8	0.1	0.2	-0.3	-1.2	-0.6
IE	8	2	13	7	18	3	3	5	1	-5	0	-2	4	7	-3	-0	2	0	1.8	-0.5	3.8	2.3	-0.9	-0.3	1.4	2.4	2.1
IT	12	4	9	5	24	7	4	6	3	-0	1	2	1	13	0	1	3	0	1.4	-0.8	2.0	-0.1	-2.3	0.6	0.2	0.1	0.3
JP	14	3	10	4	19	5	4	7	3	1	-2	2	0	11	1	1	4	1	3.3	-0.8	2.2	3.4	0.0	1.9	1.4	-0.1	0.7
LU	11	2	8	28	20	6	4	6	2	-1	-1	1	23	17	-0	0	3	0	2.2	-0.4	3.6	4.6	2.1	2.1	1.3	2.0	0.0
NL	14	2	10	7	22	7	5	9	2	1	0	1	3	12	-1	-1	4	0	2.6	0.1	2.5	2.7	0.5	2.1	0.2	0.7	-1.4
PT	14	6	8	5	20	7	6	6	2	0	4	3	1	-9	4	3	4	1	1.8	1.8	3.4	4.4	-0.7	2.5	2.6	1.9	0.4
SE	11	2	12	4	20	5	6	11	3	0	0	-0	0	10	-1	1	3	1	2.4	-0.1	2.9	1.7	-0.5	0.3	-0.1	-0.3	0.5
UK	10	3	11	7	26	5	6	8	4	-1	1	0	3	15	-2	1	4	2	1.4	-0.2	3.0	1.6	0.4	0.3	-0.3	1.0	0.8
US	12	3	11	8	23	12	1	8	3	-2	1	1	3	9	-3	0	3	1	2.5	0.1	3.2	1.5	-0.1	0.2	-0.3	-0.3	0.5
EU6	11	2	9	5	23	7	5	8	3	-0	1	1	1	12	0	1	4	1	2.2	-0.4	3.0	1.1	-0.1	1.7	0.2	0.5	0.4
EU14	11	3	10	4	22	7	5	8	3	-0	1	1	1	11	0	1	4	1	2.0	-0.3	3.0	1.4	-0.3	1.3	0.3	0.4	0.3
	Share in 2017									Δ 1995-2017									Δ 1995-2017								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(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	0.7	1.5	2.0	4.1	-2.8	-0.8	1.9	1.2	1.5
CY	11	7	12	11	20	9	7	4	3	-2	-1	-1	6	7	-0	2	1	-0	3.0	-0.7	2.6	2.8	-0.8	0.7	-0.4	0.1	0.2
CZ	11	2	11	4	15	6	4	5	2	1	-1	1	1	3	-1	0	1	-0	5.8	-3.3	1.5	3.9	0.4	0.8	0.1	-1.2	-2.4
EE	12	2	13	4	20	7	5	4	2	0	1	1	1	9	-3	-2	1	-0	4.5	3.2	4.5	5.7	2.9	-0.5	0.8	0.6	0.2
HU	10	2	11	4	18	8	5	4	3	1	-1	1	-1	5	0	-0	0	-0	2.3	-0.1	3.8	3.0	-1.9	-0.4	1.6	1.4	1.4
LT	18	2	16	2	14	6	4	4	2	2	0	7	0	3	-2	-1	1	0	4.9	2.1	3.5	1.7	1.1	2.4	2.4	3.5	0.3
LV	15	2	15	4	20	8	5	3	3	6	1	-3	1	11	1	-1	-0	1	5.8	2.8	2.9	4.3	-3.2	2.3	2.7	3.6	2.8
PL	17	1	11	4	13	6	5	4	2	-1	0	2	2	3	-1	-1	1	0	3.2	2.5	3.8	5.3	-0.2	0.8	0.1	3.0	0.7
RO	11	2	13	3	17	6	4	4	3	4	-0	5	-4	7	3	2	3	1	6.2	1.3	5.1	2.0	1.7	-2.6	1.6	-1.5	1.4
SK	12	1	11	3	16	7	4	4	3	-1	-0	1	-3	5	0	0	0	2	1.3	-0.4	1.2	-3.6	1.1	3.4	4.3	1.4	3.4
SI	12	2	11	4	18	6	5	5	3	0	0	3	-2	3	0	-0	0	-0	3.0	0.0	2.9	3.0	-1.1	1.4	-0.6	-0.0	-0.2
EUnew	14	2	12	4	15	6	4	4	3	1	-0	3	-0	3	-0	0	1	0	3.8	1.0	3.5	3.5	-0.1	0.1	1.0	1.2	0.7

(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

Table 3 reports the actual and the counterfactual aggregate productivity growth rates. Not surprisingly, for almost all countries counterfactual aggregate productivity growth is higher which implies that structural change has had a negative impact on aggregate productivity growth.[14] Generally, this negative effect is sizable and is in the range of -0.2 to -0.5 percentage points. For example, for France the 1970-2017 average annual aggregate productivity growth would have been 0.5 percentage points higher if the sectoral composition had not changed over time. Over time such a difference in productivity growth accumulates and leads to a large effect on the productivity level, and thus on income per capita. Hence, this figure is substantial in

[14] This finding is in line with the results one obtained by Duernecker et al. (2017) for the U.S. and by Bauer et al. (2020) for Europe.

terms of foregone welfare (see 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.[15]

	Aggregate productivity growth					
	Average, 1970-2017			Growth slowdown		
				actual		no SC
	actual	no SC	Δ	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 *actual* and *no SC*.

Table 3: Actual and counterfactual productivity growth, annual, in %,

The pronounced slowdown in aggregate labor productivity growth in many industrialized countries over long periods of time is a well documented fact (see the literature discussed in the Introduction). Thus, a natural question in this context is to what extent structural change can account for this slowdown. To investigate this question, we first compute the average annual productivity growth for the two 25-year periods 1970-1985 and 2002-2017 and then we calculate the counterfactual average productivity growth in the second period using the sectoral composition that prevailed in the first period. The results are in the columns labelled *Growth slowdown* in Table 3. First and foremost, almost all European countries in our sample

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

have experienced a dramatic slowdown of aggregate growth between 1970-1985 and 2002-2017. Clearly, part of this slowdown comes naturally as many of the countries have been, and some still are, in a period of transition during which aggregate growth naturally slows down due to convergence. Another reason for a growth slowdown is - figuratively speaking - related to the engine of growth losing steam. This phenomenon is due to the erosion of the drivers of long-run growth such as decreasing marginal returns to the accumulation of factors, decreasing returns to research and innovation, and possibly slower rates of technology diffusion. However, another reason - unrelated to the previously mentioned ones - is due to 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 of aggregate productivity is due to this reallocation. We quantify the contribution of structural change to the slowdown by holding the sectoral composition of value added and labor constant at the 1970-1985-average and compute the counterfactual 2002-2017 average aggregate productivity growth using these fixed sectoral weights. As we can see from Table 3 for most of the countries the counterfactual growth slowdown is less severe than the actual one. Moreover, it is important to notice that the counterfactual 2002-2017 average growth rates for most European countries 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 Europe (relative to the US) is due to the more rapid expansion of the service sector in Europe which, on average, has lower productivity growth, than that in the U.S.

To sum up, we find that since the 1970s structural change in Europe has led to a sizable shift in the sectoral composition towards services and has thereby exerted a substantial negative impact on aggregate productivity growth in most countries. Moreover, this effect has been more pronounced in Europe than in the U.S., especially in recent years. As a consequence, structural change has been a major contributor to the long-term productivity developments. In the next step, we aim to explore the impact of structural change on future aggregate productivity growth in Europe. To this end, we set up and calibrate a multi-sector growth model and use it to build scenarios for each country separately of future potential paths of sectoral composition and aggregate labor productivity growth. For our purpose it is paramount that the model can accurately replicate the historical patterns of productivity growth and structural change just described in this section. Only then can this framework be a suitable tool for producing credible simulations. Our model builds on the canonical model of structural change as described, for example, in Herrendorf et al. (2014), or in Comin et al. (2021). However, since the basic model is typically applied to study a 3-sector representation of the aggregate economy, we extend it so that our model can deal with a richer set of 11 different one-digit sectors, needed to more accurately capture the impact of structural change.

3 Model

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

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

N is the number of different consumption varieties (or sectors) available in the economy.[16] C_i is the quantity consumed of variety i and $\alpha_i \geq$ is the utility weight of variety i. C_t is a consumption index given by the flow utility derived from the consumption of C_i. The 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. That is, the composition of consumer's consumption expenditures changes with income in a non-linear way. 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 the 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 $i \neq j = 1, 2, ..., N$, 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 the 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, which is achieved when $\sigma_i > 1$, or $\sigma_i \in [0, 1]$, for all i. As usual, the consumer's optimization problem can be formulated as a utility-maximization problem or as expenditure minimization problem. Here, we choose the latter for ease of exposition. The consumer chooses the consumption of each variety, C_i, to minimize total expenditures subject to the constraint in (1).

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

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:

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

[16]Later, in the quantitative analysis, we set $N = 11$.

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:

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

It is important to understand the role played by C 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 leads - via the associated rise in C - 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 the labor 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 labor, and $\tau_{it} \geq 1$ captures a sector-specific wedge (capturing distortions, regulation, taxes, et cetera). We introduce the tax τ_{it} so that the model is able to match the observed differences in sectoral nominal labor productivity levels. The first-order necessary condition for variety i is

$$p_{it}A_{it} - \tau_{it}w_t = 0 \tag{3}$$

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

$$\frac{p_{it}A_{it}}{p_{jt}A_{jt}} = \frac{\tau_{it}}{\tau_{jt}} \qquad \Rightarrow \qquad \frac{p_{it}}{p_{jt}} = \frac{\tau_{it}}{\tau_{jt}}\frac{A_{jt}}{A_{it}} \tag{4}$$

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

$$\frac{p_{it}A_{it}L_{it}}{p_{jt}A_{jt}L_{jt}} = \frac{\tau_{it}}{\tau_{jt}}\frac{L_{it}}{L_{jt}} \qquad \Rightarrow \qquad \frac{p_{it}Y_{it}}{p_{jt}Y_{jt}} = \frac{\tau_{it}}{\tau_{jt}}\frac{L_{it}}{L_{jt}} \qquad \Rightarrow \qquad \frac{p_{it}Y_{it}/L_{it}}{p_{jt}Y_{jt}/L_{jt}} = \frac{\tau_{it}}{\tau_{jt}} \tag{5}$$

This expression implies that whenever $\frac{\tau_{it}}{\tau_{jt}} \neq 1$, the value added share $\frac{p_{it}Y_{it}}{p_{jt}Y_{jt}}$ is not equal to the labor share $\frac{L_{it}}{L_{jt}}$ (second expression), and the ratio of nominal labor productivities is not equalized across sectors (third expression). In the standard model of structural change $\tau_i = \tau_j = 1$ and, thus, $p_{it}Y_{it} = p_{jt}Y_{jt}$. However, this relationship does not generally hold in the data as shown by Duernecker (2020). For our purposes, it is important that the model is able to capture this deviation of theory from empirics in order for the model to provide as good a representation of the data as possible. This is a key necessity to ensure the reliability of the model's simulation of future productivity growth paths.

Labor market clearing and goods market clearing requires that

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

Revenues from sectoral taxes are rebated to the consumer in a lump-sum fashion and are given by T_t[17]

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

Lastly, we define the competitive equilibrium of the model economy.

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 worthwhile to highlight the main forces at work in the model. Of particular interest are the driving forces of structural change that govern the sectoral reallocation of resources. There are two main drivers of structural change: the income effect and the price effect.[18] 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 different across varieties and varies 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 the relative sectoral productivities A_j/A_i. As a consequence, uneven growth of total factor productivity across sectors leads to a change in the relative price. More concretely, if for

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

[18] The income effect is generally referred to in the literature as the Engel effect whereas the price effect can can be assimilated to the Baumol effect (see, e.g., Iscan (2010)).

example, productivity grows faster in sector j than in sector i, ($\Delta A_j > \Delta A_i$), then p_i/p_j increases; that is, good i becomes more expensive relative to good j. The change in relative prices induces the consumer to adjust the consumption bundle - as implied by the relative demand function in (2). For example, if the two goods are gross substitutes, then the consumer shifts expenditures away from the relatively more expensive good towards the relatively cheaper good. This reallocation of consumption is thus another force behind the change in the composition of sectoral value added.

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 the labor input. The details of this analysis are presented in Appendix E. We find that the price effect tends to be the dominant force behind the changes in the sectoral composition. However, we also show that a version of the model without income effects and only with the price effect as a driver of structural change would yield a significantly poorer fit of the data.

4 Quantitative analysis

Calibration

In this section we present the calibration of the model. Importantly, 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 5 where we pool all countries 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 productivities and taxes: $\left\{\{\tau_{it}, A_{it}\}_{i=1}^N\right\}_{t=1}^T$. We explain the calibration of each of these in turn.[19]

Sector-specific taxes: 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 labor productivities:

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

Using 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 $i \neq \underline{i} = 1, ..., N$

[19] All the data used in the calibration are taken from EU-KLEMS, as explained above in Section 2.

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

$$\frac{p_{it}}{p_{\underline{i}t}} = \tau_{it}\frac{A_{\underline{i}t}}{A_{it}} \qquad \text{for } i = 1, ..., N \quad t = 1, ..., T \tag{6}$$

This calibration procedure ensures that the model can match the observed relative prices, the sectoral real and nominal labor productivity growth rates, and the differences in the sectoral productivity levels.

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

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

for all $i \neq \underline{i}$ and in all years. For example, when $N = 11$ sectors and $T = 48$ years (1970-2017), we use $(N - 1) \times T = 480$ observations on relative 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 are all computed from the equilibrium of the model.

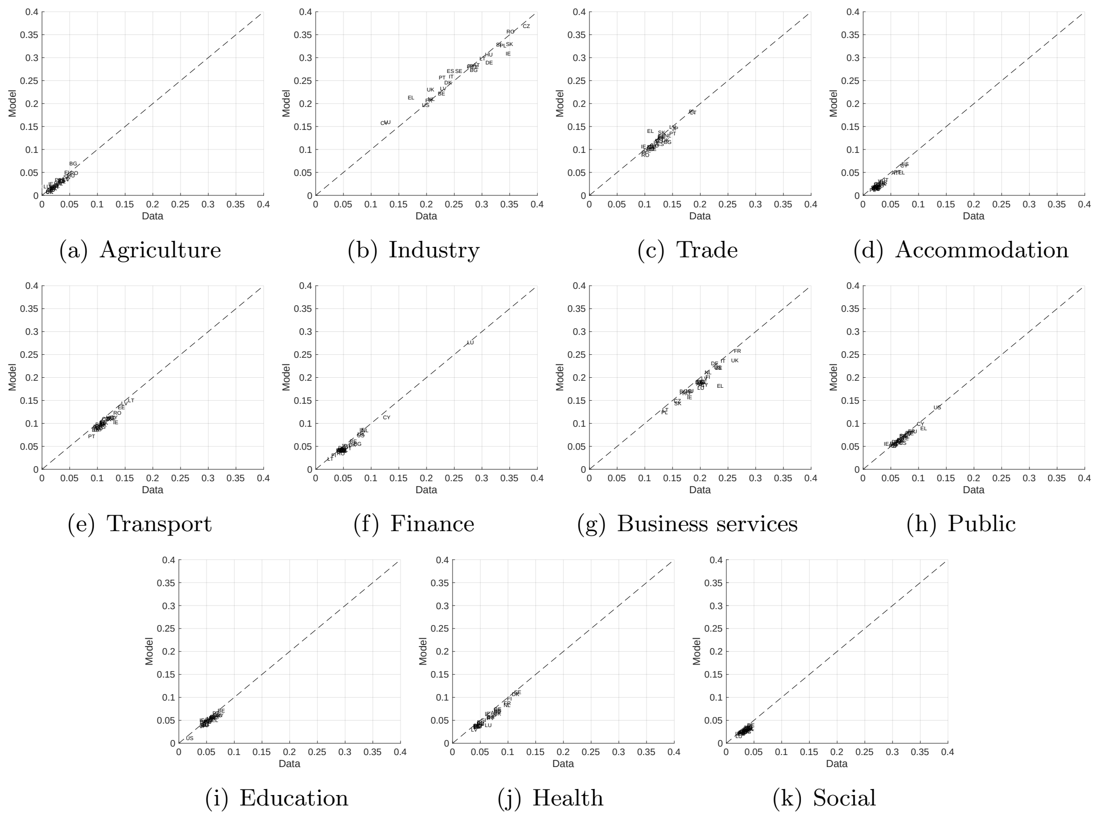
Results

In the baseline case, we disaggregate the economy into 11 different sectors which include two goods-producing sectors and nine service-producing sectors.[20] We choose a relatively fine disaggregation of the service sector because as we have shown above, the service sector is large, and is becoming larger over time, and it is very heterogenous in terms of productivity growth across the service-sub-sectors. Therefore, the future path of aggregate productivity depends fundamentally 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 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. Moreover, a key advantage of our industry disaggregation

[20]The 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", "Social and personal services".

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 classification scheme across countries.

In what follows, we report a number of statistics for each country to illustrate the empirical fit of the calibrated model. For conciseness we relegate the results for the calibrated parameters to the appendix. First, we show the model fit with respect to the value added shares that we used as data targets in the calibration. In Figure 2 we compare for each country and each of the 11 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 which indicates 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.[21] The very good empirical fit of the calibrated model extends also to the sectoral labor shares as can be seen in Figure 5 in the appendix.



(a) Agriculture (b) Industry (c) Trade (d) Accommodation

(e) Transport (f) Finance (g) Business services (h) Public

(i) Education (j) Health (k) Social

Figure 2: Shares of sectoral value added, in 2017, data and model

Clearly, a good fit of the model with respect to the observed value added shares and the labor

[21] In 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 data outcome.

shares are key for the model to match the observed time series of aggregate labor 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 value added share and the labor share of the sector. Thus, if the model could not replicate the observed sectoral composition of labor and value added, then it would not be able to reproduce the observed series of aggregate productivity growth. In Figure 3 we compare the actual and the predicted values of the average annual growth rate of aggregate labor 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 10 and 11 in the Appendix the model-implied and the observed time paths of labor productivity growth for every country in the sample. As we can observe from these figures the model matches well not only the average productivity growth but, for most countries, it is able to capture 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. Thus, this modeling framework is a suitable tool to make predictions about the future paths of structural change and growth.

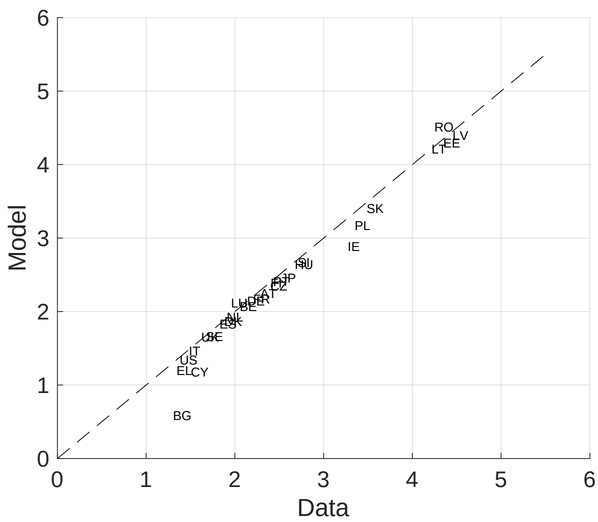


Figure 3: Aggregate productivity growth, average 1970-2017, in %

Simulations

In this section, we use the calibrated model to simulate the future paths of structural change and aggregate productivity for each country. To produce these forecasts we are required to make assumptions about how the sectoral productivity A_{it} and the sectoral wedges τ_{it} evolve in the future. Once we have specified these (exogenous) inputs, the model determines the implied paths of the (endogenous) sectoral composition and the aggregate variables. Given that we do not know the future paths of sectoral productivities and wedges, we consider different scenarios for these. For the first scenario, we set the paths of sectoral productivity such that the growth rate of A_{it} is equal to its average growth rate during the last 20 years, whereas the paths of the sectoral wedges are set equal to the mean value of τ_{it} during the last 20 years. We opt for the average values since the wedges 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 10 years. In Table 4 we report the outcomes for aggregate and sectoral productivity growth and the sectoral value added 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 by a larger service sector in the U.S. 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 sector (*srv*. Second, more importantly, productivity growth in European service sectors is below that in the U.S. service sectors. Putting these observations together, the slowdown in Europe is more pronounced because of two reinforcing effects: Europe is predicted to reallocate more resources than the U.S. to service sectors that are in turn predicted to exhibit lower productivity growth in Europe. A similar reasoning can be applied to the second important observation that the growth slowdown predicted for the newer EU Member States is even larger than that of older Member States. Even though productivity growth in the service sector is higher in these countries than in the rest of Europe, these countries are predicted to experience a more profound degree of structural change, leading to a larger expansion of the service sector.

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 (such as business services, education and health) and a corresponding decline of the sectors with fast productivity growth (trade, transportation). This pattern is an exact confirmation of Baumol's cost disease, which the model predicts to represent a substantial drag on European productivity growth in the future.

Clearly, the predictions of the model depend crucially on the underlying assumptions about future sectoral productivity growth and sectoral wedges. In the previous example, we chose the last 20 years as a reference period from which we computed the productivities and wedges. 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 5 years, 6 years, 7 years .... until 20 years. For each of these reference years, we compute average productivity growth and wedges and use these as inputs to simulate the model forward and to compute the implied change in aggregate productivity growth. As a result of

	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	1.9	0.7	1.4	0.7	1.3	3.5	-0.4	0.7	-0.2	0.3	-0.1
				-0.3	-2.6	2.9	-0.5	-0.0	-0.1	-0.5	3.4	-0.1	0.2	0.4	0.1
BE	0.78	0.57	-0.21	1.1	2.1	0.2	1.3	-0.1	1.9	2.4	-0.9	0.6	-0.5	-1.1	0.4
				-0.1	-3.0	3.0	-0.7	0.1	-0.3	-0.3	3.3	-0.2	0.3	0.8	0.1
DK	1.01	0.85	-0.16	3.9	1.4	0.6	1.8	-2.5	2.6	2.1	-1.2	-0.0	0.9	0.6	-0.7
				-0.3	-1.9	2.2	-0.8	0.1	-0.4	-0.1	3.2	0.0	-0.1	0.2	0.1
ES	0.69	0.52	-0.18	2.7	1.3	0.1	1.0	-2.1	1.3	2.5	-1.1	1.0	0.0	-0.3	0.0
				-0.6	-2.7	3.2	-0.8	1.4	-0.6	-0.4	3.8	-0.4	0.2	0.2	-0.1
FI	1.33	0.94	-0.38	3.9	2.3	0.3	2.6	-0.1	2.3	1.0	-1.2	0.4	0.1	-1.5	-0.8
				-0.6	-3.7	4.3	-0.8	-0.0	-0.5	-0.0	4.6	-0.1	0.0	1.0	0.1
FR	1.07	0.91	-0.15	2.8	1.6	0.6	1.2	-0.3	2.2	1.6	-0.4	1.4	-0.7	0.5	0.7
				-0.3	-2.1	2.4	-0.3	0.0	-0.4	-0.2	3.2	-0.3	0.2	0.2	-0.0
DE	1.19	0.97	-0.22	1.9	2.1	0.6	2.4	-0.3	2.6	-0.4	-1.1	1.6	-1.0	0.7	-0.1
				-0.2	-4.3	4.5	-0.9	0.0	-0.5	0.1	6.0	-0.5	0.2	0.1	0.1
EL	0.53	-0.07	-0.59	1.8	1.3	-0.7	-2.3	0.3	2.7	0.5	-1.1	0.3	0.1	-2.8	-0.6
				-0.8	-2.3	3.1	2.4	-0.1	-0.6	-0.1	1.5	-0.2	-0.1	0.3	0.0
IE	3.57	2.73	-0.84	0.4	6.6	1.6	-0.2	0.4	4.9	4.2	2.1	-1.2	-0.2	1.1	2.8
				0.1	-3.1	3.0	1.1	0.1	-1.3	1.1	0.0	0.5	0.4	1.0	0.1
IT	0.30	0.15	-0.15	1.4	0.5	-0.1	0.7	-1.0	1.4	1.3	-2.0	1.0	0.1	-0.8	-0.3
				-0.3	-1.7	2.0	-0.8	-0.0	-0.7	-0.4	4.7	-0.5	-0.2	0.1	-0.1
JP	1.28	1.04	-0.23	1.9	2.0	0.6	1.4	-0.6	1.5	1.9	-0.1	0.9	0.4	-1.5	0.6
				-0.2	-3.2	3.4	-0.0	0.2	0.1	-0.0	2.2	-0.0	0.1	0.9	0.0
LU	0.28	-0.14	-0.42	-0.0	-0.1	-0.2	1.4	-3.3	1.3	0.5	-1.9	0.9	-1.0	-1.3	-0.5
				-0.0	-0.0	0.1	-1.1	0.0	-0.3	-1.6	3.3	-0.2	0.0	0.0	-0.0
NL	1.14	1.12	-0.02	2.0	1.9	1.0	2.4	-1.1	2.7	2.6	-0.0	1.5	-0.6	0.4	-0.9
				-0.2	-2.6	2.8	-0.5	0.0	-0.3	-0.5	4.0	-0.5	0.3	0.3	0.0
PT	0.93	0.53	-0.40	3.0	1.5	-0.1	1.1	-0.6	0.6	3.3	-1.6	0.1	-0.4	-0.9	0.3
				-0.5	-2.5	3.0	-0.1	0.4	0.2	-0.0	0.8	0.4	0.6	0.7	0.1
SE	1.54	1.36	-0.18	1.8	2.2	1.1	3.1	-0.1	3.3	3.5	0.2	0.4	-0.3	-0.7	0.9
				-0.2	-1.5	1.8	-0.5	0.0	-0.5	-0.5	2.2	-0.2	0.1	0.9	0.0
UK	1.23	1.18	-0.06	1.8	1.2	1.2	1.5	0.4	2.5	2.9	0.6	0.6	-1.3	1.2	0.1
				-0.1	-1.7	1.8	-0.4	-0.0	-0.2	-0.6	2.8	-0.3	0.4	0.0	0.1
US	1.55	1.49	-0.06	2.8	2.2	1.3	2.2	0.0	4.1	2.0	1.0	0.2	-0.3	0.7	-0.2
				-0.0	-2.1	2.1	-0.4	0.1	-0.6	0.1	2.0	0.1	0.0	0.5	0.1
EU6	0.94	0.77	-0.17	2.0	1.6	0.5	1.7	-0.5	2.2	0.9	-1.0	1.4	-0.6	0.2	0.0
				-0.2	-3.0	3.2	-0.7	0.0	-0.5	-0.2	4.7	-0.4	0.1	0.2	0.0
EU14	1.44	1.08	-0.35	2.4	2.4	0.6	1.3	-0.4	2.4	2.2	-0.4	0.5	-0.4	-0.2	0.5
				-0.3	-2.6	2.9	-0.2	0.1	-0.5	-0.0	2.7	-0.0	0.2	0.6	0.1

				agr	ind	srv	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
BG	3.00	2.50	-0.49	0.1	4.7	2.0	3.3	4.8	4.0	3.8	-3.5	2.9	4.5	4.1	4.2
				-0.2	-3.6	3.8	-0.6	-0.1	-0.9	-0.2	6.4	-0.3	-0.3	-0.2	-0.2
CY	1.52	1.14	-0.38	-0.2	1.1	1.2	3.4	-0.9	2.8	2.5	-1.0	0.9	-0.3	0.1	-0.2
				-0.1	-1.5	1.5	-1.4	-0.0	-0.8	-1.0	5.1	-0.2	0.1	-0.1	-0.1
CZ	2.52	2.34	-0.18	3.0	3.7	1.5	5.8	-4.1	1.3	4.0	0.8	1.0	0.2	-1.1	-1.7
				-0.4	-1.6	2.0	-0.4	0.2	0.2	0.2	1.2	-0.3	0.3	0.5	0.2
EE	3.93	3.55	-0.38	7.7	5.3	2.7	4.0	1.7	4.1	4.3	1.7	0.6	0.8	0.5	0.0
				-0.9	-3.1	4.0	-0.6	0.2	-0.7	0.6	4.1	0.1	-0.1	0.3	0.2
HU	2.15	1.60	-0.55	5.4	2.7	0.8	2.5	-0.2	3.3	3.3	-1.9	-0.8	0.9	1.0	1.3
				-1.1	-2.1	3.2	-0.4	0.0	-0.6	-0.2	4.3	0.3	-0.1	-0.1	-0.1
LT	4.08	3.58	-0.50	4.5	4.9	2.8	4.8	0.5	3.5	1.5	0.5	1.6	1.9	2.7	-0.8
				-1.0	-2.6	3.6	-1.3	0.1	1.3	0.2	4.2	-0.5	-0.4	-0.1	0.3
LV	4.48	2.48	-1.99	9.3	3.4	1.7	5.9	1.8	1.9	4.8	-4.2	2.6	3.2	3.6	1.3
				-1.5	-3.4	4.9	-3.5	-0.0	-2.2	-0.3	13.2	-1.1	-0.9	-0.3	-0.0
PL	3.30	2.99	-0.30	3.3	4.0	2.2	3.0	2.2	3.8	4.9	0.3	0.6	0.1	3.1	1.2
				-0.5	-1.4	1.9	-1.1	0.1	-0.3	0.3	2.3	0.0	0.2	0.3	0.2
RO	4.79	4.05	-0.75	5.4	4.9	2.6	6.9	1.0	5.0	3.0	2.3	-3.6	1.6	-1.5	0.3
				-1.7	-5.5	7.2	-0.4	0.1	0.4	-0.0	3.3	1.4	0.5	1.5	0.5
SK	3.19	2.61	-0.57	8.2	5.7	0.9	1.0	-0.9	1.0	-0.4	0.3	2.6	2.7	0.3	0.8
				-0.7	-3.4	4.0	0.8	0.1	0.3	0.4	1.6	0.1	0.1	0.3	0.2
SI	2.27	1.74	-0.53	3.5	3.1	0.8	2.7	-0.9	2.8	3.1	-1.3	1.5	-0.7	-0.0	-0.6
				-0.5	-3.1	3.6	-0.6	0.2	0.5	-0.2	2.6	0.1	0.4	0.3	0.2
EUnew	3.38	2.90	-0.47	4.1	4.1	2.0	4.1	0.9	3.5	3.7	0.1	0.1	1.1	1.3	0.8
				-0.8	-2.7	3.5	-0.7	0.1	-0.1	0.1	3.2	0.2	0.2	0.5	0.2

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

this procedure, we obtain, for each country, a whole set of predicted productivity changes, where each element corresponds to a given reference period. In Table 5, we report the average over the different reference periods of the predicted change in aggregate productivity growth (column "avg") as well as the minimum and the maximum predicted change ("min", "max") and the predicted changes for the 5-year, 10-year, 15-year, and 20-year reference period. 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 change in aggregate productivity growth for different reference periods

As is well known, most European countries have experienced rapid labor productivity growth in the post-war period and until the 1990s some of the richest 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 productivity for the countries in our sample together with the implied percentage difference to the U.S. For most countries, the level of aggregate productivity is well below the U.S. level. This includes for example the largest countries, such as France and Germany with a 5% gap, the UK with a gap of 17%, and Italy and Spain with large gaps of around 25%.

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.-Europe productivity gap. The column labeled 2027 in Table 6 shows the predicted productivity difference 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.

5 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 11 sectors, including two goods-producing sectors (agriculture and industry) and nine service-producing sectors. The fine disaggregation of the service sector is motivated by the empirical observation that the service sector is very heterogeneous in terms of value added growth and labor productivity growth. Thus, any reallocation within services has a potentially large effect on the dynamics of labor productivity within the service sector as a whole, and thus in turn on economy-wide productivity growth. Such dynamics can only be properly depicted 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 3-sector representation and repeat the entire quantitative analysis including the model calibration and the forecast simulation 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, the 3-sector split predicts

	2017 Level	2017 Gap	2027 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. Source: OECD.

Table 6: Absolute and relative productivity levels across countries

a growth slowdown that is substantially less severe than the one predicted by the 11-sector split.

This striking difference is due to two main reasons. First, when services are treated as one broad sector then, by construction, future productivity growth in the service sector is constant and equal to the past growth during the reference period. Instead when the service sector is split into sub-sectors, then productivity growth of total services is affected by the within-sector reallocation. As we have shown above, reallocation within services leads to an expansion of the sub-sectors with low productivity growth. As a result, productivity growth of total services is lower under the 11-sector split than under the 3-sector split. Second, lower productivity growth in services implies a larger productivity differential with respect to agriculture and industry. Therefore, under the 11-sector split, there is more structural transformation from the two goods-producing sectors towards services. In sum, both effects imply that under the 11-sector split the service sector has lower productivity growth and expands more rapidly than under the 3-sector split. As a consequence, the predicted decline in aggregate productivity growth is more pronounced.

	Productivity growth						
	Baseline			3-Sectors	Market sectors only		
	Past	Pred.	Δ	Δ	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 *Forecast* and *Data*. **Baseline**: Results for 11-sector split, **3-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, for example, 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 many cases it is 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; which is done, for example, by hedonic pricing methods. Moreover, non-market services are often heavily regulated; hence, the prices, if they exist, may not reflect the market value of output.

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 be taken seriously as it casts doubts 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 the 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, importantly, our model predicts a substantial growth slowdown to occur also in the market sector as can be seen in the last column. The magnitude of the slowdown is somewhat lower than in the baseline scenario, although there are substantial differences across countries.[22]. The reason is straightforward: Non-market services are characterized by lower productivity growth and are predicted to increase in size. This implied negative effect on future productivity growth is absent in the analysis of the market sector.

Measure of labor productivity

In the baseline scenario, we define labor 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 labor productivity used. As alternatives we consider productivity computed as (constant-price) value added (i) per worker and (ii) per efficiency hour, and (iii) TFP.[23] For each of these measures, we repeat the quantitative analysis and report the results for aggregate productivity growth in Table 8. For comparison, we include also the baseline results. Clearly, the level of aggregate productivity growth differs

[22] For example, in countries such as Ireland and Luxembourg, non-market services are expected to be a major drag to productivity growth going forward, since they yield a much smaller negative impact of structural change on aggregate productivity growth.

[23] Efficiency hours are computed as 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 wages of low-wage workers.

across the measures but most importantly, in all the 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 very robust to alternative ways of measuring productivity.[24]

	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*.

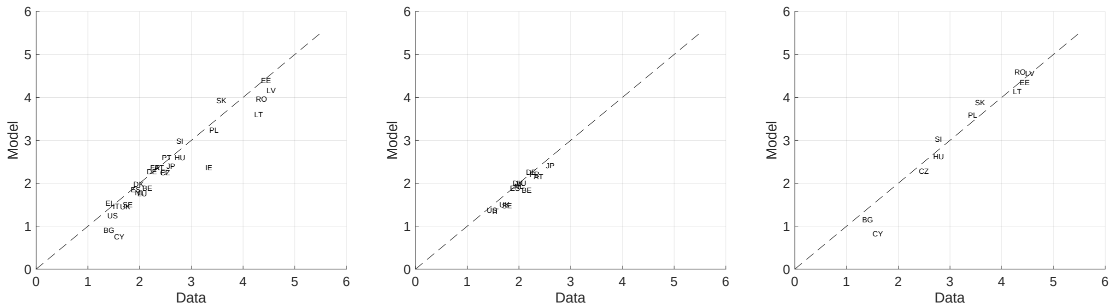
Table 8: Past and predicted aggregate productivity growth for different productivity measures

[24] The data on quality-adjusted hours worked or TFP are not available for several countries in our sample. Thus, to maximize the country coverage we chose to use value added per hour as our baseline measure of productivity. Also 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 the labor input.

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 in each 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 productivities. 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 practice stems from the difficulty to empirically validate potential cross-country differences in preferences due to the lack of suitable data. In this section, we address this issue 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. Importantly, in the first step of this approach we regress the empirical 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 stem from differences in regulation, institutions, or preferences. Thus, by de-meaning the data, we do not target the level of sectoral value added shares in the calibration as in the baseline analysis but the evolution of the sectoral shares over time.

We pool the observations of all 28 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 4 the data and the model outcome for the average annual growth of aggregate productivity. Clearly, as we calibrate one model to all countries jointly, 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 qualitatively and also quantitatively similar to that obtained in the baseline analysis.
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 country only to a rather satisfactory 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. Notice that, we have not included 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



(a) All countries (b) Rich countries (c) New EU-Member States

Figure 4: Average aggregate productivity growth for alternative calibration: Data and model. Rich countries: EU-6 + AT, DK, ES, JP, SE, UK, US

and extended periods of high aggregate volatility). By and large the two groups of countries have similar levels of income per capita. From Panels (b)-(c) in Figure 4 we can observe that the empirical fit of the model for both groups markedly improves with respect to the pooling case. 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 analysis.

6 Conclusion

In this paper, we provide a number of new contributions to the literature on the link between structural change and productivity growth. As a first step, we show that structural change has been an important driver of the secular, dismal productivity performance in EU countries. As a key contribution to the related literature, we also argue and demonstrate 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. In particular, we show that the sub-services within the aggregate service sector exhibit a great deal of variation in terms of productivity growth. This is important as we document that reallocation dynamics within services have led in the past and are prone to lead in the future to an expansion of sub-sectors exhibiting lower productivity growth. This implies that the resulting growth rate for aggregate productivity is lower under the fine-grained sectoral split that we use than under the three-sector split widely used in the literature, which tends to underestimate the size of the negative effect of structural change.

Moreover, we develop a multi-sector general equilibrium model capable of replicating the pattern of structural change observed in the data so as to employ it as a suitable framework to provide scenarios of change and productivity growth going forward. The main finding stemming from this analysis is that the EU is predicted to experience a severe productivity growth slowdown during the next decade due to unfavorable sectoral reallocations. These sectoral shifts are the result of both supply and demand-side forces, with the former being a more dominant factor. In addition, the slowdown predicted for the U.S. is comparably smaller, owing to our prediction

	Past	Predicted change in aggregate productivity growth			
		Baseline	All	Rich	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; **Rich**: AT, BE, DK, ES, FR, DE, IT, JP, LU, NL, SE, UK, US; **New**: BG, CY, CZ, EE, HU, LT, LV, PL, RO, SK, SI.

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

that the EU's structural transformation will lean more toward stagnant services than in the U.S., and that these sectors will in turn exhibit lower productivity growth in the former.

Furthermore, our paper also constitutes the first examination of the impact of structural change on future productivity growth in newer EU Member States. Our findings indicate that the growth slowdown predicted for these countries is even larger than that for older Member States. This is because although productivity growth in the service sector is presently higher in these countries than in the rest of the EU, these economies are predicted to experience a more profound degree of structural change, leading to a larger expansion of the service sector.

Concerning the robustness of our analysis, we show that a one-digit level disaggregation of services is paramount in order not to underestimate the true effect of structural change onto productivity growth. We also confirm that the results hold even when non-market services are excluded from the analysis and that the results are robust to the different definitions of labor productivity growth oftentimes used in the literature.

A number of policy implications follow from our analysis. First, although structural change is bound to continue exerting a negative impact on the already dismal productivity performance of European countries, the results in this paper should not be interpreted as a call for policy interventions aimed at reversing this naturally occurring economic process. It is a well-established fact from welfare economics that market equilibrium allocations, as long as they are not subject to important market failures, are also welfare-maximizing. Thus, any policies directed at distorting these market allocations could lead to net welfare losses. What instead follows from our analysis is that policy efforts should primarily be focused on accelerating productivity growth in the most stagnant service sectors. Although these sectors have traditionally been regarded as exhibiting an intrinsically narrower scope for technological progress, investment in critical factors such as intangible assets and digital technologies could potentially render production processes more efficient even in these sectors.

Finally, concerning potential avenues for future research, the most natural and promising extension of the analyses presented in this paper is the incorporation of endogenous economic growth to the modeling framework. This would permit to gain a better grasping of the development of sectoral productivity growth going forward, and to the model as a simulation tool for the examination of the impact of different policies, including innovation policies such as R&D taxes and subsidies.

References

Andrews, D., C. Criscuolo, and P. N. Gal (2015). Frontier Firms, Technology Diffusion and Public Policy: Micro Evidence from OECD Countries. OECD Productivity Working Papers 2, OECD Publishing.

Arnold, J. M., G. Nicoletti, and S. Scarpetta (2008). Regulation, Allocative Efficiency and Productivity in OECD Countries: Industry and Firm-Level Evidence. OECD Economics Department Working Papers 616, OECD Publishing.

Bauer, P., I. Fedotenkov, A. Genty, I. Hallak, P. Harasztosi, D. Martnez Turgano, D. Nguyen, N. Preziosi, A. Rincon-Aznar, and M. Sanchez Martinez (2020). Productivity in Europe: Trends and drivers in a service-based economy. JRC Working Papers JRC119785, Joint Research Centre (Seville site).

Baumol, W. J. (1967). Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis. *The American Economic Review 57*(3), 415–426.

Buiatti, C., J. Duarte, and F. Saenz (2017). Why is Europe falling behind? Structural transformation and services' productivity differences between Europe and the US. *Cambridge-INET Working Paper Series* (2017/04).

Byrne, D. M., J. G. Fernald, and M. B. Reinsdorf (2016). Does the United States Have a Productivity Slowdown or a Measurement Problem? *Brookings Papers on Economic Activity*, 109–157.

Comin, D., D. Lashkari, and M. Mestieri (2021). Structural Change With Long-Run Income and Price Effects. *Econometrica 89*(1), 311–374.

Duernecker, G. (2020). The Dichotomy between Relative Prices and Sectoral Labor Productivities. Working paper, Goethe-University Frankfurt.

Duernecker, G., B. Herrendorf, and A. Valentinyi (2017). Structural change within the service sector and the future of Baumol's disease. CEPR Discussion Paper No. DP12467, Center for Economic Policy Research.

Fernandez-Villaverde, J. and L. Ohanian (2018). The Lack of European Productivity Growth: Causes and Lessons for the U.S. PIER Working Paper Archive 18-024, Penn Institute for Economic Research, Department of Economics, University of Pennsylvania.

Gordon, R. J. (2016). *The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War* (REV - Revised ed.). Princeton University Press.

Hanoch, G. (1975). Production and Demand Models with Direct or Indirect Implicit Additivity. *Econometrica 43*, 395–419.

Herrendorf, B., R. Rogerson, and Á. Valentinyi (2014). Growth and Structural Transformation. In P. Aghion and S. N. Durlauf (Eds.), *Handbook of Economic Growth*, Volume 2, pp. 855–941. Elsevier.

Iscan, T. (2010). How Much Can Engel's Law and Baumol's Disease Explain the Rise of Service Employment in the United States? *The B.E. Journal of Macroeconomics 10*(1).

Niebel, T., M. O'Mahony, and M. Saam (2017). The contribution of intangible assets to sectoral productivity growth in the EU. *Review of Income and Wealth 63*, S49–S67.

Nordhaus, W. D. (2008). Baumol's Diseases: A Macroeconomic Perspective. *The B.E. Journal of Macroeconomics 8*(1).

Sato, R. (1975). The Most General Class of CES Functions. *Econometrica 43*, 999–1003.

Sen, A. (2020). Structural change within the services sector, Baumol's cost disease, and cross-country productivity differences. MPRA Paper 99614, University Library of Munich, Germany.

Syverson, C. (2017). Challenges to Mismeasurement Explanations for the US Productivity Slowdown. *Journal of Economic Perspectives 31*(2), 165–86.

van Ark, B. and K. Jaeger (2017). Recent Trends in Europe's Output and Productivity Growth Performance at the Sector Level, 2002-2015. *International Productivity Monitor 33*, 8–23.

Appendix

A Data availability

	Value added		Labor			
	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 taxes

	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

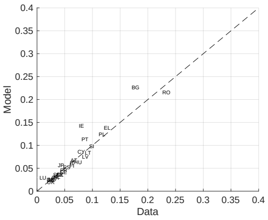
	BG	CY	CZ	EE	HU	LT	LV	PL	RO	SK	SI
α_1	0.10	0.11	0.02	0.07	0.05	0.08	0.06	0.03	0.13	0.04	0.03
α_2	0.23	0.16	0.42	0.21	0.43	0.33	0.34	0.36	0.25	0.41	0.32
α_3	0.06	0.13	0.07	0.16	0.11	0.11	0.07	0.15	0.12	0.12	0.08
α_4	0.05	0.12	0.08	0.06	0.02	0.05	0.04	0.05	0.03	0.05	0.06
α_5	0.07	0.25	0.06	0.09	0.11	0.15	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

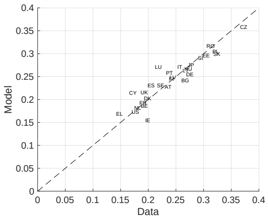
	agr	ind	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AT	0.16	1.00	0.69	0.53	0.86	1.23	1.21	0.66	0.82	0.61	0.58
BE	0.35	1.00	0.78	0.46	1.00	1.68	0.98	0.65	0.93	0.59	0.51
DK	0.45	1.00	0.71	0.48	0.96	1.60	1.41	0.85	0.73	0.57	0.70
ES	0.54	1.00	0.60	0.94	1.17	2.13	1.43	0.81	1.04	0.90	0.64
FI	0.33	1.00	0.66	0.38	0.85	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

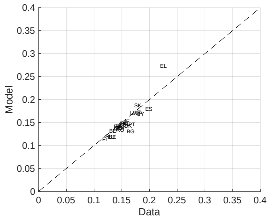
D Model fit



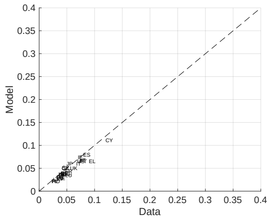
(a) Agriculture



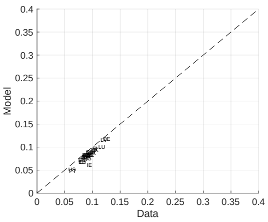
(b) Industry



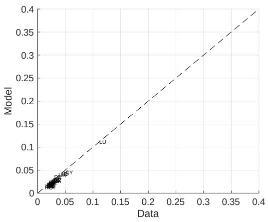
(c) Trade



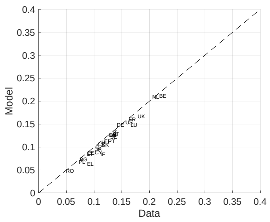
(d) Accommodation



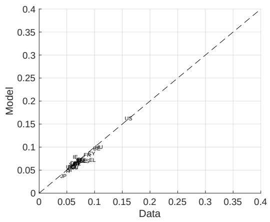
(e) Transport



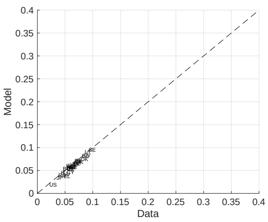
(f) Finance



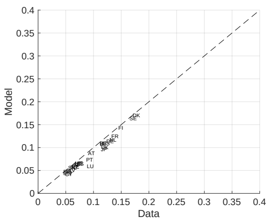
(g) Business services



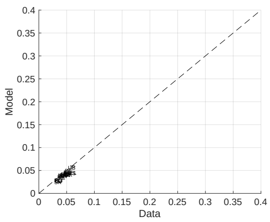
(h) Public



(i) Education

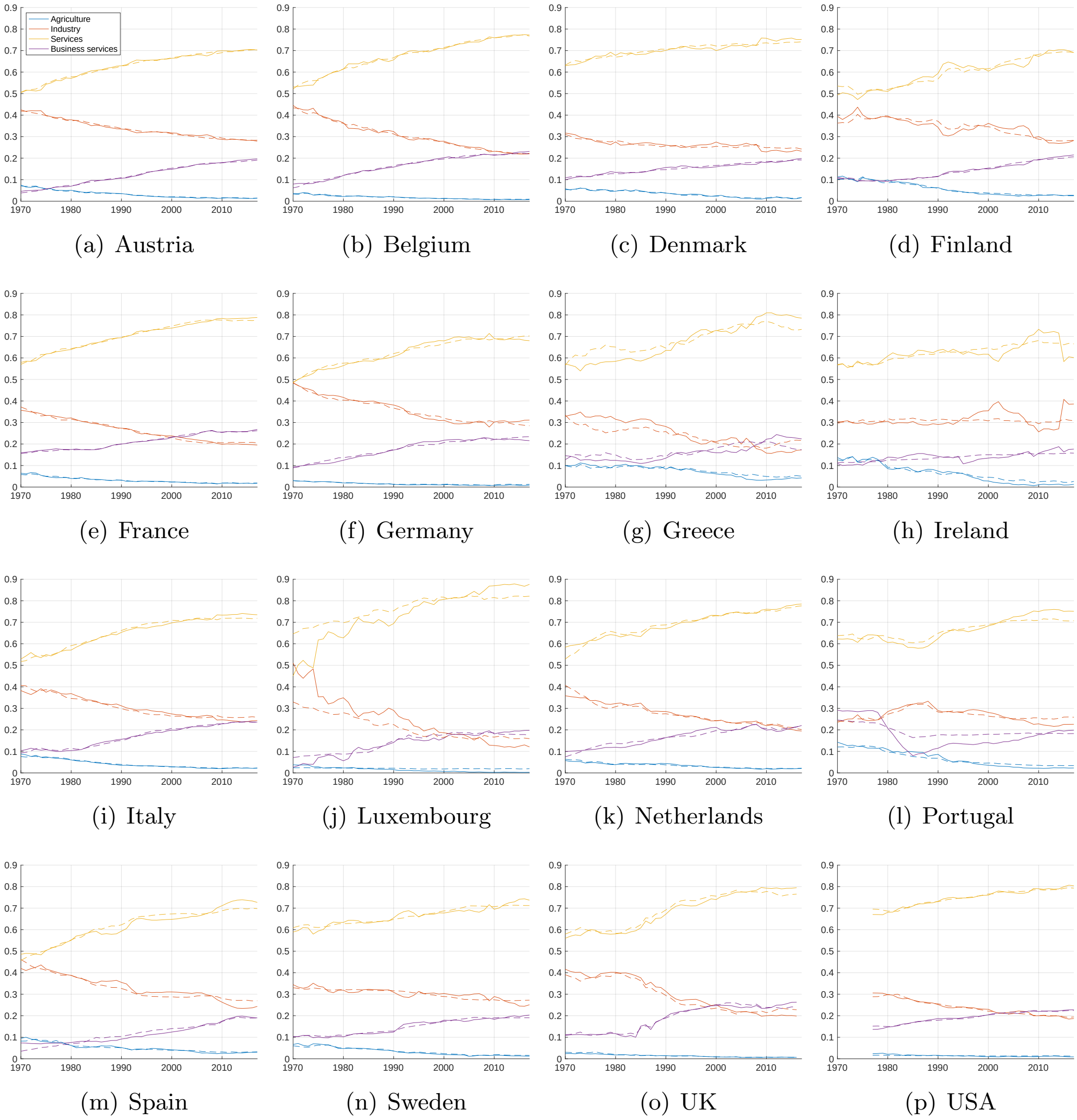


(j) Health



(k) Social

Figure 5: Sectoral shares of hours worked in 2017, Data and model



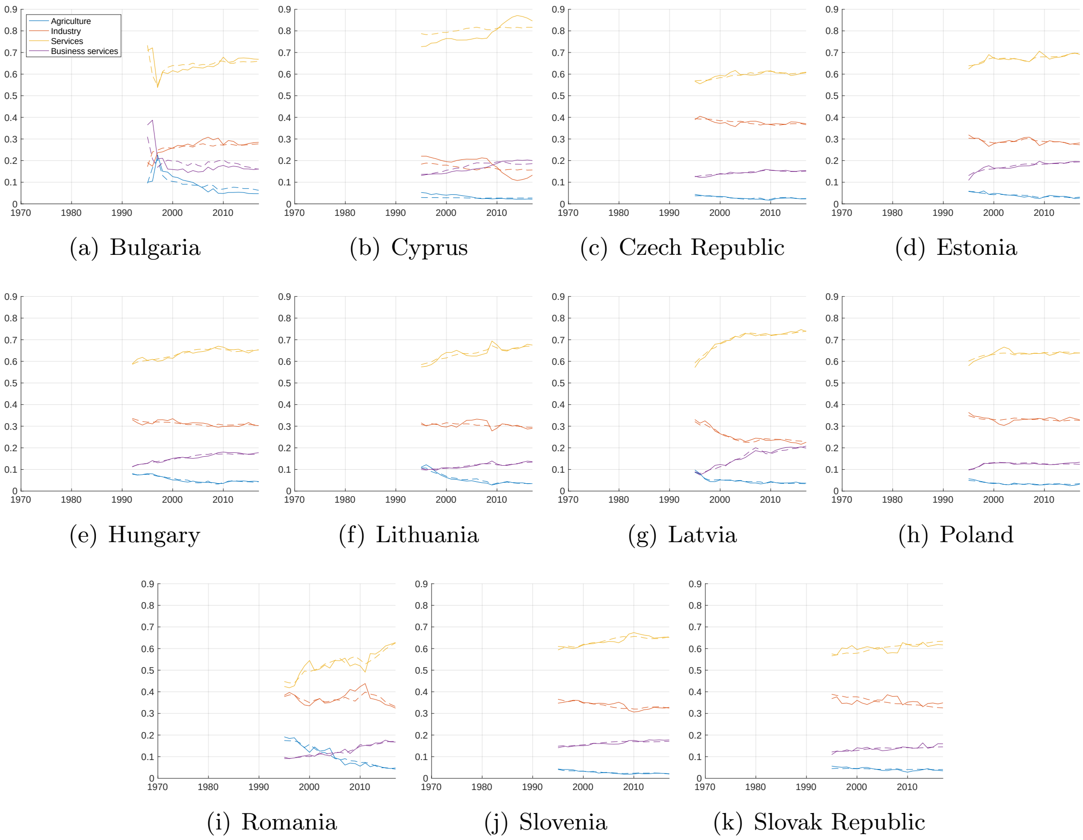
(a) Austria (b) Belgium (c) Denmark (d) Finland

(e) France (f) Germany (g) Greece (h) Ireland

(i) Italy (j) Luxembourg (k) Netherlands (l) Portugal

(m) Spain (n) Sweden (o) UK (p) USA

Figure 6: Sectoral shares of value added, Data (solid line) and model (broken line)

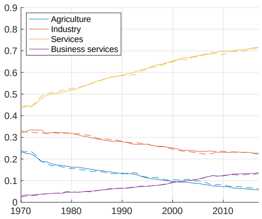


(a) Bulgaria (b) Cyprus (c) Czech Republic (d) Estonia

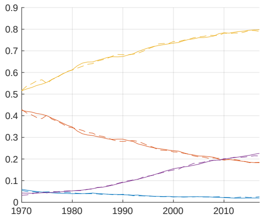
(e) Hungary (f) Lithuania (g) Latvia (h) Poland

(i) Romania (j) Slovenia (k) Slovak Republic

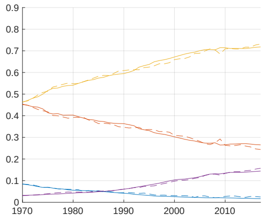
Figure 7: Sectoral shares of value added, Data (solid line) and model (broken line)



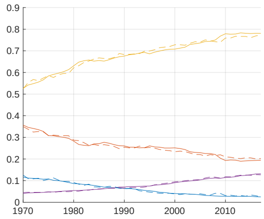
(a) Austria



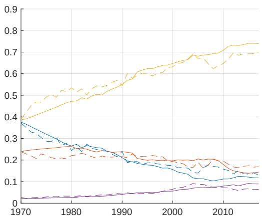
(b) Belgium



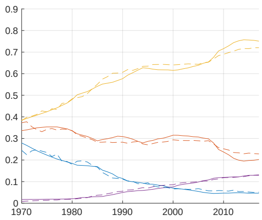
(c) Denmark



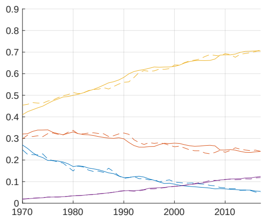
(d) Finland



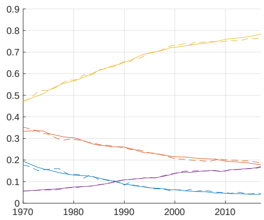
(e) France



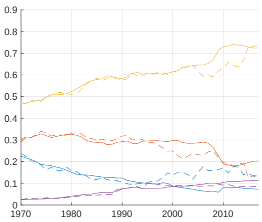
(f) Germany



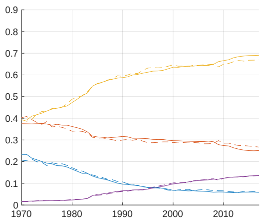
(g) Greece



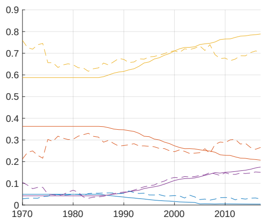
(h) Ireland



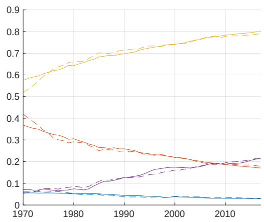
(i) Italy



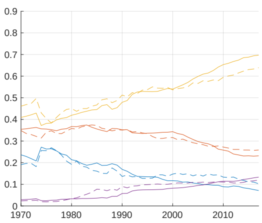
(j) Luxembourg



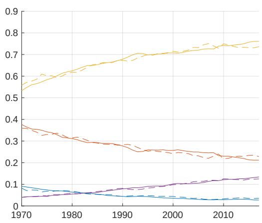
(k) Netherlands



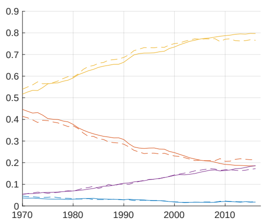
(l) Portugal



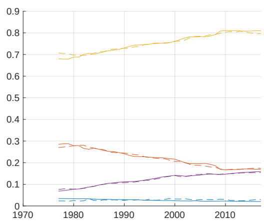
(m) Spain



(n) Sweden

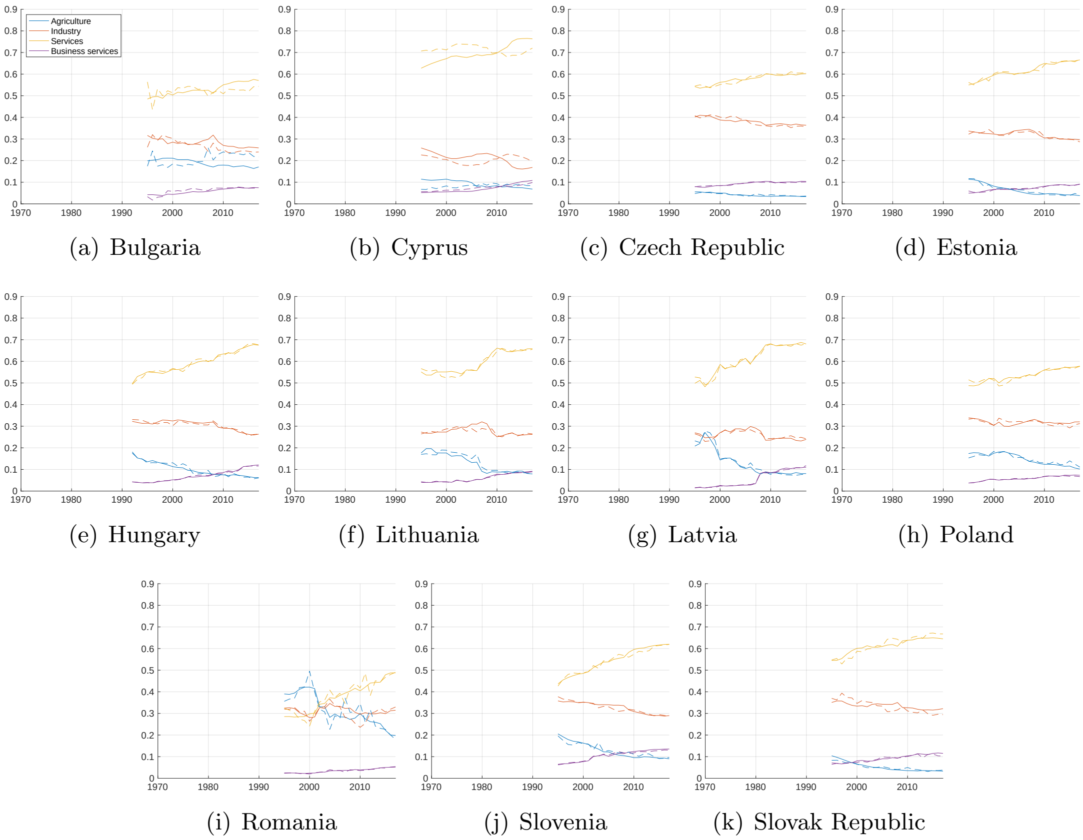


(o) UK



(p) USA

Figure 8: Sectoral shares of hours worked, Data (solid line) and model (broken line)

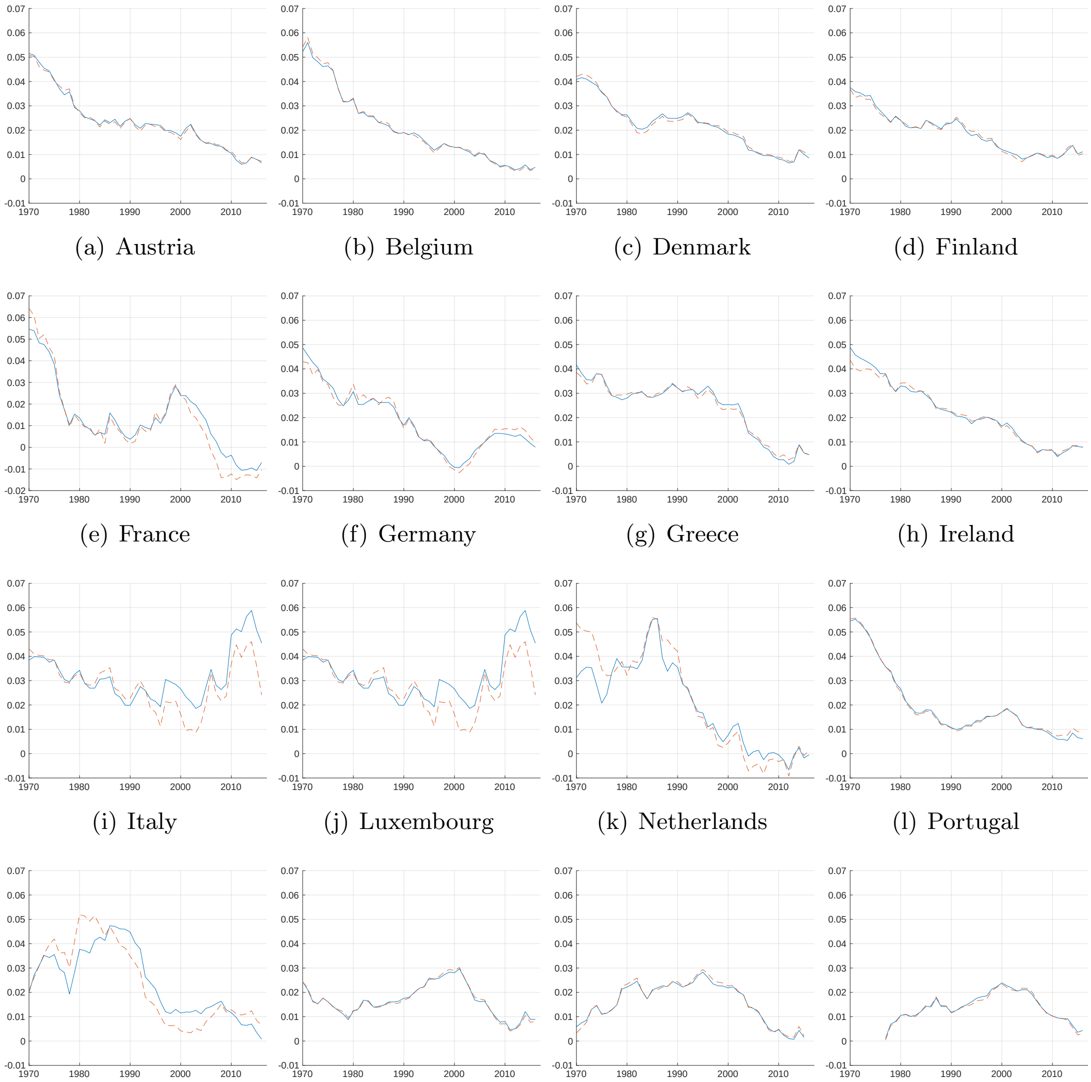


(a) Bulgaria (b) Cyprus (c) Czech Republic (d) Estonia

(e) Hungary (f) Lithuania (g) Latvia (h) Poland

(i) Romania (j) Slovenia (k) Slovak Republic

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



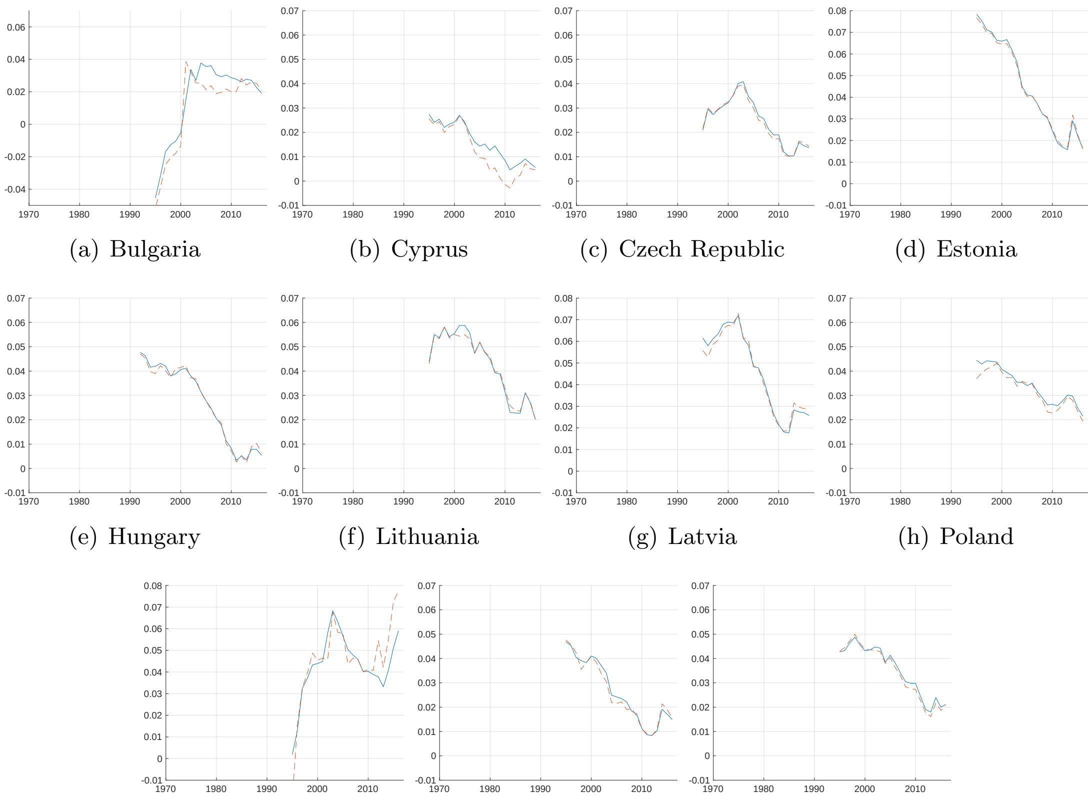
(a) Austria (b) Belgium (c) Denmark (d) Finland

(e) France (f) Germany (g) Greece (h) Ireland

(i) Italy (j) Luxembourg (k) Netherlands (l) Portugal

(m) Spain (n) Sweden (o) UK (p) USA

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



(a) Bulgaria (b) Cyprus (c) Czech Republic (d) Estonia

(e) Hungary (f) Lithuania (g) Latvia (h) Poland

(i) Romania (j) Slovenia (k) Slovak Republic

Figure 11: Aggregate Labor 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 3, 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 labor. 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 (labor share) is used as dependent variable.[25] 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.

			Services								
	agr	ind	(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): Labor 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

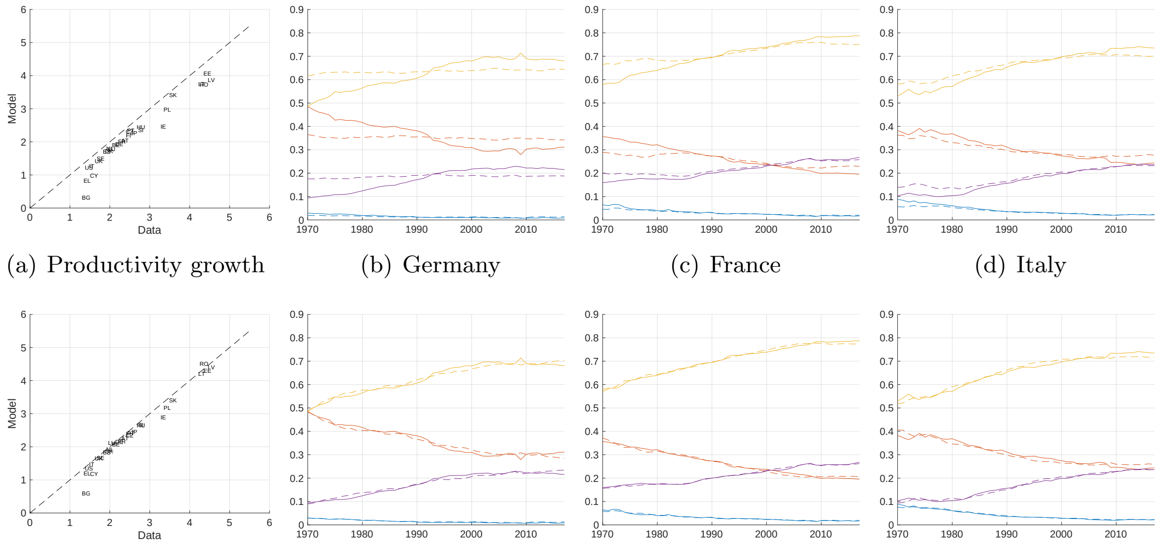
agr: agriculture; ind: industry; (1): Wholesale and retail trade; (2): Accommodation and food services; (3): Transport, storage and communication; (4): Financial intermediation; (5): Business services; (6): Public administration; (7): Education; (8): Health; (9): Social and personal services

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 $i = 1, 2, ..., 11$ and then re-do the quantitative analysis. The upper panels in Figure 12 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

[25] The 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 12 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.



(a) Productivity growth (b) Germany (c) France (d) Italy

(e) Productivity growth (f) Germany (g) France (h) Italy

Figure 12: 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	Rich	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
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
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

Columns differ in terms of samples of pooled countries. All: all 28 countries; Rich: 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.

Table 16: Alternative calibration - parameter values