Europe Falling Behind:
Structural Transformation and Labor Productivity Growth Differences Between Europe and the U.S. *

Cesare Buiatti[†] Joao B. Duarte[‡] Luis Felipe Sáenz[§]

May 5, 2022

Abstract

We investigate the labor productivity growth gap in services between Europe and the U.S. through the lenses of a structural transformation theory that allows for an arbitrary number of sectors and long-run income and price effects. We disaggregate services into several subsectors comparable between the U.S. and Europe to account for differences within services. Our calibrated model can explain the observed sectoral labor reallocation in both regions and the aggregate labor productivity time paths. We use the model to perform numerical experiments in which the sectoral labor productivity in Europe grows counterfactually at the same rate as its American counterpart. In line with previous literature, we find that wholesale and retail trade, business, and financial services were the sectors behind most of the lack of catch-up and decline in aggregate labor productivity, accounting for two-thirds of the gap since 1995. In contrast to the literature, we show that the endogenous labor reallocation across sectors significantly amplifies the quantitative role of these sectors in explaining labor productivity growth differences.

JEL: E24, O41, O47;
Keywords: Structural Transformation, Service Sector, Labor Productivity.

*We thank Dan Bernhardt, Paco Buera, Vasco Carvalho, Gilbert Cette, Giancarlo Corsetti, Paloma Lopez-Garcia, Robert Lucas, Martí Mestieri, Stephen Parente, Cezar Santos, Marcelo Santos, Minchul Shin, Timothy Uy, Rui Zhao, and various participants at various seminar series for helpful suggestions and discussions. Joao Duarte acknowledges funding from Fundação para a Ciência e a Tecnologia (UID/ECO/00124/2013, UID/ECO/00124/2019 and Social Sciences DataLab, LISBOA-01-0145-FEDER-022209), POR Lisboa (LISBOA-01-0145-FEDER-007722, LISBOA-01-0145-FEDER-022209), POR Norte (LISBOA-01-0145-FEDER-022209) and CEECIND/03227/2018. First version: May 7th, 2018.

[†]T. Row Price. Email: buiatti2@illinois.edu.

[‡]Nova School of Business and Economics. Email: joao.duarte@novasbe.pt.

[§]University of South Carolina. Email: felipe.saenz@moore.sc.edu.

1 Introduction

Labor productivity in Europe has been falling behind the U.S. since 1995, reversing a previously observed convergence pattern between these two regions. Figure 1 illustrates how this catch-up process came to a halt and later even reversed for the majority of the European countries. Average annual labor productivity growth (measured as GDP per hour worked) in the U.S. accelerated from 1.4 percent in the 1970–1995 period to 2 percent from 1995 to 2009, while the European countries, on average, experienced a labor productivity growth slowdown between these two time periods from 2.8 percent to 1.4 percent. These data imply a labor productivity gap in growth rates between the U.S. and Europe of about 0.6% annually from 1995 to 2009. Hence, the falling behind pattern in Europe is a combination of the U.S. taking off together with a European slowdown.

During the same period (1970-2009), the U.S. and Europe underwent large-scale sectoral reallocations of labor in a process commonly known as structural transformation (Kuznets (1957); Herrendorf, Rogerson, and Valentinyi (2014)). With Europe and the U.S. at their later stages of structural transformation (the so-called post-industrial era), labor has reallocated further from agriculture and manufacturing toward services. As Duarte and Restuccia (2010) suggests, through the lenses of structural transformation, it is possible to conclude that the service sector is responsible for most cases of relative stagnation in aggregate productivity observed at later stages of development since almost no other country experienced the productivity gains in the service sector witnessed in the U.S.

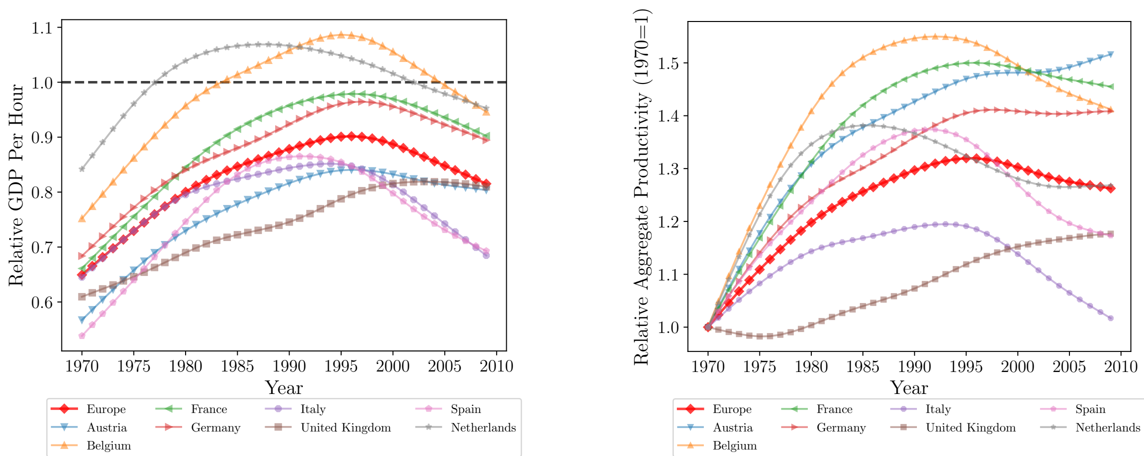
We argue that it is crucial to break down the service sector in order to understand the relative under-performance of Europe in aggregate labor productivity growth. Services constitute the predominant (and growing) sector for most advanced economies, and the lack of labor productivity gains in this sector is an increasing cause of concern for long-run economic growth. This paper investigates the labor productivity growth gap in services between Europe and the U.S. during the 1970–2009 period through the lenses of a structural transformation theory. This theory allows us to quantitatively explore how changes in labor allocations brought by changes in services subsectors' productivity can explain the relative slowdown of the European aggregate labor productivity.

Based on the World KLEMS database[1], we classify 13 comparable sectors across regions and document the relative aggregate and sectoral labor productivity growth and labor reallocation across these sectors between the U.S. and Europe. Our documentation reveals two important facts. First, the underlying differential sectoral labor productivity

[1] For details on the methodology behind the construction of the World KLEMS database see (O'Mahony & Timmer, 2009).

Figure 1: GDP per hour and aggregate productivity index relative to United States

(a) GDP per hour **(b)** Aggregate productivity index



Notes: Figure shows yearly labor aggregate labor productivity of selected European countries relative to the U.S. from 1970 to 2009. Panel (a) shows the time series of relative aggregate labor productivity in levels, measured by GDP per hour. Panel (b) shows the time series of relative aggregate labor productivity in growth rates.

growth rates alone cannot account for Europe falling behind the U.S. in aggregate labor productivity. A shit-share decomposition of the productivity gap indicates that half of the average annual labor productivity growth gap between Europe and the U.S. in the 1995–2009 period is explained by labor reallocation across sectors. In other words, compositional effects are crucial to understanding aggregate labor productivity dynamics of Europe vis-‘a-vis the U.S. Second, the labor reallocation towards different types of service activities is distinct.

Motivated by these facts, we develop a theoretical model of structural transformation that combines the CES non-homothetic preferences crafted by Comin, Lashkari, and Mestieri (2021) with production functions whose unique input is labor, as in Duarte and Restuccia (2010). We calibrate the model for several aggregations where we disaggregate services, maintaining the sectoral comparability between the U.S. and Europe. We use our model as a measuring device to account for the effect of sectoral productivity growth on aggregate productivity.

To map our theory to data, we provide a calibration algorithm derived from the general equilibrium equations for relative sectoral expenditures in our model to assign parameter values to the relative Engel curves and the price elasticity. This calibration strategy is minimal in the consumption of data as it only uses the first and last observations for the United States to pin down all the model's parameter values. The initial employment shares in agriculture, manufacturing and all the service sectors are matched perfectly by construction. We then feed in the time paths of labor productivity constructed with the observed labor productivity growth rates and the growth rates of an unobserved real consumption index implicitly defined in the preferences. We then establish three tests for our theory. First, we judge the model's capacity to explain the structural transformation in the United States, as only the first and last observations were used in these data for the parameterization. Second, we inquire whether the model can generate the U.S. aggregate labor productivity path through a weighted average of sectoral productivities using the employment shares, i.e., the structural transformation, as weights. Last, we address the capacity of our calibrated structure to account for the structural transformation and the aggregate productivity paths in Europe. Our model accounts well for all these dimensions.

Using a set of numerical experiments whereby the sectoral labor productivity in the U.S. is fed counterfactually to map the aggregate productivity in Europe, we can summarize the main findings of our analysis as follows: In line with previous literature on the subject of productivity gaps in services between the U.S. and Europe, we find that wholesale and retail trade, business, and financial services were the sectors behind most of the lack of catch-up and decline in aggregate labor productivity. When combined, these sectors account for two-thirds of the gap since 1995. Looking at each sector individually, we find that Europe's low labor productivity growth in wholesale and retail trade and business services can account for 40% and 30% of the gap, respectively.

We are not the first to address the productivity gap between the U.S. and Europe during the 1990s. Anchored on shift-share and growth accounting methods using industry-level data from KLEMS, a prominent explanation for the labor productivity gap emerged in the literature. Europe's aggregate labor productivity growth would have been much higher if labor productivity growth in the market service sectors—wholesale and retail trade, finance and business services—had been high as in the U.S. since 1995 (see e.g.van Ark, Inklaar, and McGuckin (2003), van Ark, O'Mahony, and Timmer (2008), and M. P. Timmer, Inklaar, O'Mahony, and Van Ark (2011)). These findings are in line with our main results. However, one limitation of the shift-share and growth accounting methods is that they assume fixed sectoral labor shares – i.e., fixed weights to compute weighted averages of productivity – when performing labor productivity growth counterfactuals. This limitation can be problematic in light of the literature on economic growth and structural transformation, which emphasizes the endogenous reallocation of labor as a function of changes in relative sectoral productivity. And this labor reallocation matters for aggregate productivity.

We show that, in contrast to shift-share analysis, the endogenous labor reallocation across sectors significantly amplifies the quantitative role of these sectors in explaining labor productivity growth differences. Specifically, we find that disregarding labor reallocation can lead to a 15% increase in the counterfactual labor productivity growth gap. We show that the structural transformation amplification mechanism is particularly acute in financial and business services. The reason is that the income effects are more substantial in these sectors. Our benchmark calibration shows that these sectors have the highest income elasticities. These relatively high income-elasticities imply that financial and business services see the demand for their products rise proportionally more when aggregate income increases, leading to higher employment shares in these sectors.

Related Literature. Our first contribution is to show that the sectoral productivity growth counterfactuals in the literature[2] using shift-share and growth accounting methods give biased estimates of aggregate labor productivity. As productivity changes, shifts in the sectors' employment shares occur endogenously due to substitution and income effects. Hence, labor productivity counterfactual exercises that disregard general equilibrium effects on labor shares give biased estimates. Our proposed model fully accounts for these general equilibrium effects. In our specific application, we find that these methods underestimate the effect of productivity gains in market services on aggregate productivity growth in Europe during the 1970–2009 period. We show that in the counterfactual exercises performed using our benchmark model, labor allocation across sectors' response to changes in the sectoral relative productivity is substantial. While we already find a sizable bias in our counterfactual exercises, we note that the bias can be more prominent for a higher counterfactual sectoral labor productivity rate because it leads to higher counterfactual aggregate income. The higher the counterfactual aggregate income, the stronger the labor reallocation movements will be and thus the size of the bias.

One added benefit of our approach to account for the labor productivity growth gap is that we can learn about the economic mechanisms behind sectoral labor reallocation. In our model, labor reallocation is driven by income and price (substitution) effects. Price effects result from differences across sectors in productivity growth rates, while income effects stem from combining heterogeneity in income elasticities of demand across sectors with income growth. We use our model to study the contribution of price and income effects to the labor reallocation in Europe relative to the U.S. from 1970 to 2009. We find the relative labor reallocation is driven mainly by income effects, especially since 1995. Hence, our second contribution is to show that the structural transformation

[2] See e.g. van Ark et al. (2003), van Ark et al. (2008), and M. P. Timmer et al. (2011).

in Europe relative to the U.S. has been driven mainly by relative income effects. Our results are in line with the findings in Comin et al. (2021) that show that income effects explain 80% of the structural change in agriculture, manufacturing and services for a more extensive set of countries.

Our third contribution is to document comparable disaggregated services' labor reallocation and labor productivity dynamics across Europe and the U.S. We classify services industries from the World KLEMS data – which uses International Standard Industry Classification (ISIC) Rev.3 at the two digits level – into eleven sectors that are comparable across an extensive set of European countries and the U.S. Thus, we extend the M. Timmer, de Vries, and De Vries (2015) database on productivity from 5 to 11 service industries for selected European countries and the U.S. Our documentation of labor reallocation within the service sector complements Buera and Kaboski (2012) explanation of the rise of the service sectors. We highlight that in addition to the marketization of home production, a significant increase in the labor share of services has also, in fact, been driven by business-to-business services.

Finally, more broadly, our paper contributes to the literature on structural transformation that dates back to the works of Kuznets (1957) who documented the sweeping changes across the different industries in the process of economic development. More recent contributions to structural change build upon the works of Kongsamut, Rebelo, and Xie (2001) and Ngai and Pissarides (2007) who emphasized the role of income and sector-biased productivity channels respectively as the drivers of structural transformation. Several attempts have been made to incorporate both mechanisms in a single framework, such as Buera and Kaboski (2009), Duarte and Restuccia (2010), Ferreira and Silva (2014), and Boppart (2014) among many others[3]. Our paper proposes a simplified version of the model proposed by Comin et al. (2021) to study productivity differences in the service sector with a highly disaggregated structural transformation model.

Section 2 documents the motivating facts. Section 3 describes the theoretical framework. Section 4 calibrates the baseline model. Section 5 evaluates the model's sectoral labor shares and aggregate productivity predictions against the data. Section 6 shows the counterfactual exercises. Section 7 concludes.

[3]For a detailed survey of the literature of structural change see Matsuyama (2008) and Herrendorf et al. (2014)

2 Motivating Facts

To understand why aggregate labor productivity growth has fallen in Europe relative to the U.S. since 1995, one needs to know, on the one hand, which activities had higher/lower relative productivity gains, and on the other hand, which sectors saw their relative importance increase/decrease. In this section, we use the World KLEMS database to document the relative aggregate and sectoral labor productivity growth and relative labor reallocation across sectors in Europe and the U.S. First, we document the sectoral labor productivity growth and composition changes in Europe relative to the U.S. from 1970 to 2009. Second, we decompose the aggregate labor productivity gap to document how much is driven by differences in relative sectoral labor productivity growth vs. differences in relative labor reallocation. Before diving into a detailed exposition, we provide a summary of the main stylized facts:

1. Sectoral labor productivity growth
   (a) Europe's labor productivity growth has outpaced that of the U.S. in agriculture, manufacturing and services from 1970 to 1995. However, from 1995 to 2009, while Europe has continued to experience higher productivity gains in agriculture and manufacturing, it has had lower gains in services than the U.S.
   (b) Within service activities, labor productivity growth gains in Europe relative to the U.S. have been concentrated in low-productivity-growth services such as personal, education, government, real estate, health and social services. At the same time, Europe has been falling behind the U.S. significantly in high-productivity-growth services such as wholesale and retail trade, financial, and business services.
   (c) While common to all individual European countries, these trends have been particularly acute for countries falling behind the U.S. the most in aggregate labor productivity since 1995.
2. Sectoral hours worked
   (a) From 1970 to 2009, working hours in services as a share of total hours have increased more in Europe than in the U.S., while in agriculture and manufacturing they have decreased by more.
   (b) Within service activities, sectoral hours worked as a share of total hours have increased by more than the U.S. in low and high productivity growth services,

especially in business, telecommunications, government, education, health, social and real estate services.

(c) As with labor productivity growth, the trends now in terms of sectoral relative allocation of hours worked have been particularly sharp for countries falling behind the U.S. the most in aggregate labor productivity since 1995.

3. Aggregate labor productivity gap

   (a) The aggregate average annual labor productivity growth gap between Europe and the U.S. in the 1995–2009 was 0.6%, half of which is explained by different sectoral labor productivity and the other half by labor reallocation across sectors.

   (b) The average annual labor productivity growth gap is smaller than the aggregate gap for services (0.38%), but is wider for market services (wholesale and retail trade, finance and business services, 0.99%).

   (c) Labor reallocation contributed to a smaller annual labor productivity growth gap in services and market services. The reason being that labor reallocated proportionally more to high-productivity growth service sectors in Europe than the U.S. Absent differential labor reallocation, Europe would have an annual labor productivity growth gap in market services of 1.6%.

The enumerated facts imply that: a) underlying differential sectoral labor productivity growth rates alone cannot account for Europe falling behind the U.S. in aggregate labor productivity. In other words, compositional effects are crucial to understanding aggregate labor productivity dynamics of Europe vis-à-vis the U.S.; and b) the services sector's breakdown reveals distinct dynamics among different types of service activities.

When combined, these implications motivate one to look at disaggregated services when performing a comparative analysis of labor productivity between Europe and the U.S.

2.1 Data

We use the World KLEMS[4] data on sectoral hours worked and value-added per hour to document both the process of labor reallocation and the labor productivity growth in Europe relative to the U.S. from 1970 to 2009. We combine data from a subset of

[4]For details on the methodology and data sources, see Jorgenson (2012).

European countries—Austria, Belgium, France, Germany, Italy, Netherlands, Spain, and United Kingdom—with U.S. data into a single dataset with comparable sectoral data.

We cannot merge the U.S. and EU data directly. The EUKLEMS has data on 34 industries according to the ISIC Rev. 4 (NACE Rev. 2) industry classification, while the U.S. KLEMS has data on 65 industries following the DJA65 industry classification. Hence, a uniform sectoral classification is needed to have comparable sectoral data. First, we classify a subset of these industries into agriculture and manufacturing in the same fashion as previous literature on structural change (i.e., Duarte and Restuccia (2010)). Second, we classify services industries into 11 sectors: the wholesale and retail trade, business services, financial intermediation, hotels and restaurants, transport and storage, post and telecommunication, real estate activities, public administration, education, health and social work, and community, social and personal activities. Table 1 provides a summary of the sectoral classification we use and how it maps into the ISIC, NAICS2017 and DJA65 industry classification. We end up with a total of 13 sectors. Before discussing the facts on the disaggregated services sector, one caveat is in order. Some of our classified services include non-market services, in which there are no market prices to aggregate outputs and no quality improvement measures ((O'Mahony & Timmer, 2009)). Also, the real estate sector output is mainly composed of imputed rents. Hence, labor productivity growth in government, education, health and social work, and real estate services should be interpreted carefully.

Table 1: Sectoral classification and KLEMS data correspondence

Abbreviated Name			Name	ISIC4 2-digit Codes	NAICS2017 2-digit Codes	DJA65 Industry
agr			Agriculture	1–3	11	1–2
man			Manufacturing	5–33, 35–39, 41–43	21, 22, 23, 31–33	3–26
ser		trd	Wholesale and retail trade	45–47	42, 44–45	27–28
ser	nps	trs	Transportation and storage	49–53	48–49	29–36
ser	nps	rst	Accommodation and food services	55–56	72	59–60
ser	nps	com	Communication	58–63	51	39–40
ser		fin	Financial intermediation	64–66	52	41–44
ser	nps	res	Real estate activities	68	53	45–46
ser		bss	Business services	69–75, 77–82	54–56	47–52
ser	nps	gov	Public administration and defence	84	92	62–65
ser	nps	edu	Education	85	61	53
ser	nps	hlt	Health and social work	86–88	62	54–56
ser	nps	per	Personal, community and other activities	90–99	71, 81	57–58, 61

Notes: Table shows the mapping between the ISIC, NAICS2017 and DJA65 industry classification and the sectoral classification used in this paper. In addition, it shows two aggregate classifications of services: nonperforming services nps and total services ser.

Next, we start by documenting labor productivity's growth rate, measured by real value-added per hour growth, in our sample of European countries vis-à-vis the U.S.

2.2 Sectoral Labor Productivity Growth

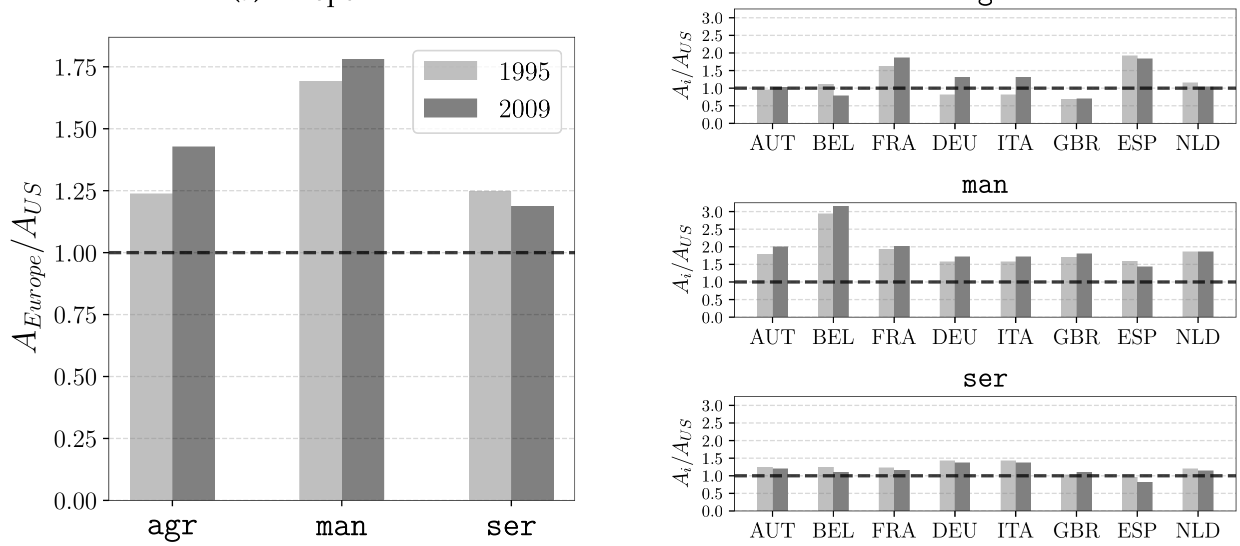
We start by documenting that labor productivity grew faster in Europe than in the U.S. in agriculture, manufacturing and services from 1970 to 2009. Figure 2a shows the cumulative productivity growth in Europe relative to the U.S. from 1970 to 1995 and 2009 for the three broad sectors. We can see that in all three sectors, labor productivity grew more than in the U.S., particularly in manufacturing, whereby productivity increased by approximately 75% more than in the U.S. However, from 1995 to 2009, while Europe continued to experience higher productivity gains in agriculture and manufacturing, it had lower gains in services than the U.S. Relative labor productivity gains in services fell from 25% in 1995 to 20% in 2009. If this lagging behind in services continues, all gains in relative terms from 1970 to 1995 may be lost. In Figure 2b we show the same relative cumulative change in labor productivity growth, now for each European country. We conclude that the labor productivity trends are broadly consistent across all individual countries, with a few exceptions. Namely, the services and agriculture labor productivity growth was lower in Spain and Great Britain than in the U.S.

The services sector is an aggregate of strikingly different types of service activities. In particular, service activities have experienced substantial rises in productivity growth, such as wholesale and retail trade, while others have experienced almost no change in productivity, such as personal services. Figure 3 shows that labor productivity growth gains in Europe relative to the U.S. have been concentrated in transportation and storage (`trs`), personal (`per`), government (`gov`),health and social (`hlt`), and real estate (`res`) activities. At the same time, Europe has been severely falling behind (-40%) the U.S. in wholesale and retail trade (`trd`) and financial services(`fin`) over the entire period, and in business services (`bss`) since 1995.

In Figure 4 we show the European cross-country labor productivity growth relative to the U.S. in each service sector. It shows that the labor productivity growth underperformance in wholesale and retail trade (`trd`) and financial services relative to the U.S. is common to all European countries in our sample. A critical difference between the two sectors is that while wholesale and retail trade has fallen further behind since 1995 in all countries, financial services have caught up with the U.S. since then in Austria, Belgium, Great Britain and Spain. Furthermore, it shows some interesting dynamics in business services (`bss`). First, there are significant differences in labor productivity growth across countries. While Belgium and Great Britain could keep up and even surpass the U.S., Spain and France severely lagged. Second, except for Great Britain, labor productivity growth in business services was lower than in the U.S. since 1995.

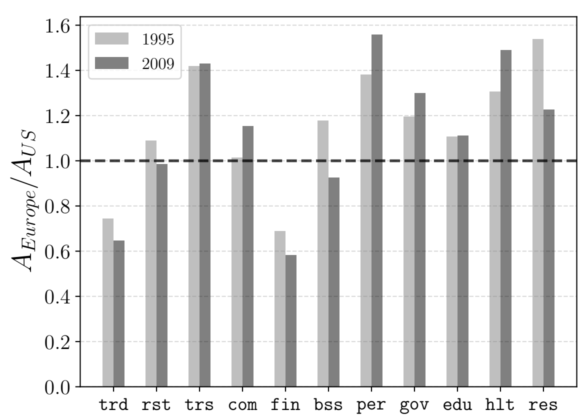
Figure 2: European labor productivity growth relative to the U.S. in agriculture, manufacturing and total services

(a) Europe **(b)** Individual european countries



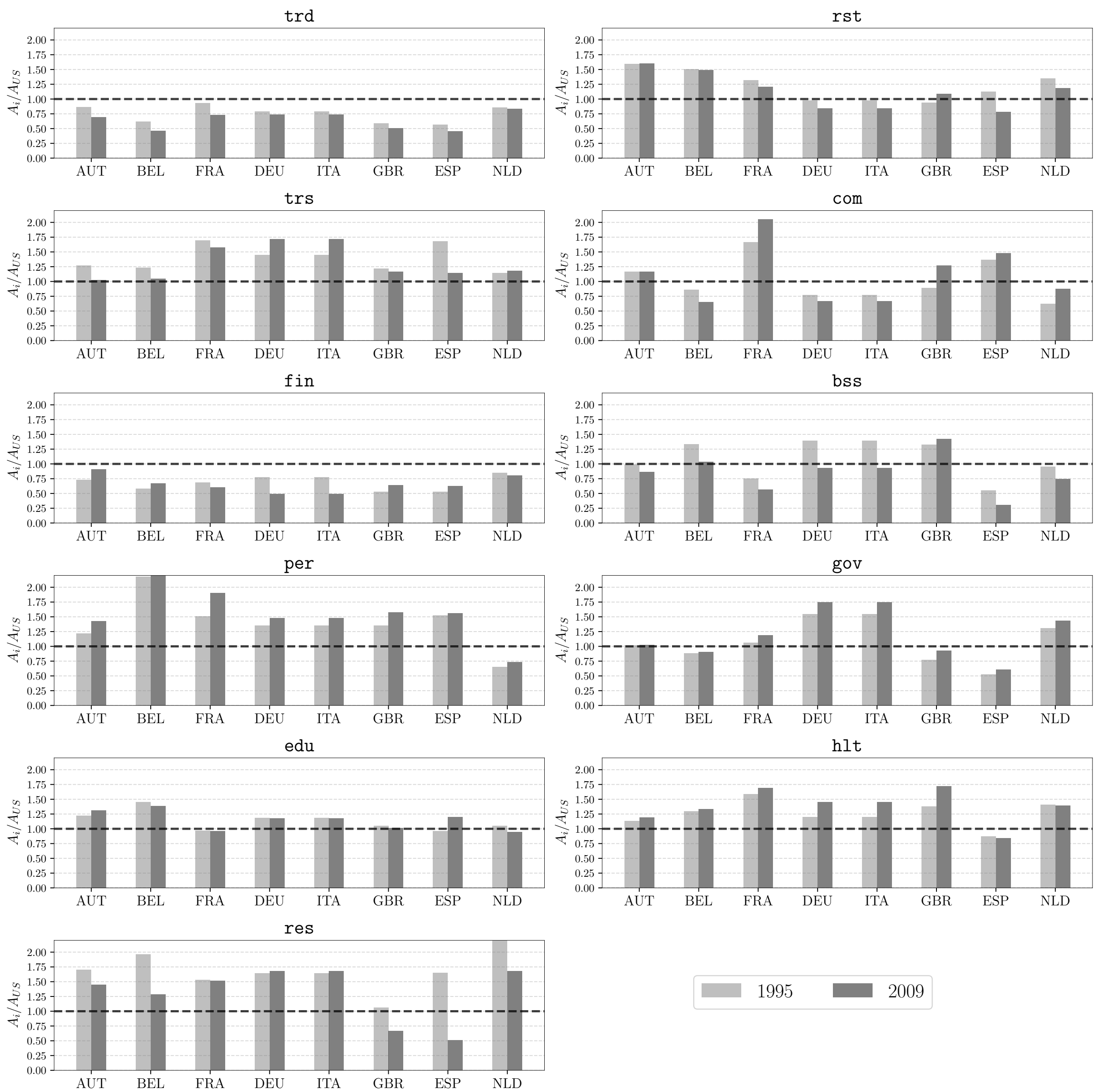
Notes: Figures show the sectoral cumulative productivity growth of Europe relative to the U.S. from 1970 to 1995 and 2009. The initial labor productivity level is normalized to 1 for all sectors in 1970. Thus, the focus is on showing how different the labor sectoral productivity growth were in Europe relative to the U.S. A value above (below) one means labor productivity grew more (less) in Europe than in the U.S. since 1970. Figure 2a shows the relative labor productivity growth of a weighted average of the European countries in our sample with weights given by the ratio of hours worked of each country to total hours worked. Figure 2b shows the relative labor productivity growth for each european country in our sample.

Figure 3: European labor productivity growth relative to the U.S. in each service sector



Notes: Figure shows the sectoral cumulative productivity growth of Europe relative to the U.S. from 1970 to 1995 and 2009 for each service sector. The service sectors classification can be found in Table 1.

Figure 4: European cross-country labor productivity growth relative to the U.S. in each service sector



Notes: Figure shows the sectoral cumulative productivity growth of each european country relative to the U.S. from 1970 to 1995 and 2009 for each service sector. The initial labor productivity level is normalized to 1 for all sectors in 1970. The service sectors classification can be found in Table 1.

2.3 Sectoral Hours Worked

In contrast to labor productivity, we do have da on hours worked initial levels in 1970. Table 2 presents the sectoral employment shares in Europe and U.S. in 1970. European countries and the U.S. we at very different stages of structural change in 1970. Europe had a share of hours worked in agriculture (12.9%) that was twice that of the U.S. (5.8%), a larger manufacturing sector and a much smaller service sector–approximately 20 percentage points lower. Furthermore, the sectoral employment shares differ quite substantially among European countries. In particular, Austria, Italy and Spain were still much further behind in structural transformation. Interestingly, within services, the sectoral employment shares in Europe were much more similar to the U.S., except for health and social, education, and business services. In the latter three sectors, the U.S. had twice the employment share.

Table 2: European and U.S. sectoral hours share of total hours (%) in 1970

	U.S.	EU	AUT	BEL	FRA	DEU	ITA	GBR	ESP	NLD
agr	5.8	12.9	22.9	5.3	16.8	7.8	22.7	3.5	26.3	6.9
man	29.6	40.6	33.3	42	35	46.1	37.9	45.4	34.5	35.7
ser	64.6	46.5	43.9	52.7	48.2	46.1	39.4	51.1	39.2	57.3
trd	14	13.5	11.8	16.6	12.8	13.4	13.7	13.6	12.9	16.8
trs	3.5	4.1	4.1	4.6	2.7	4.2	3.1	5.4	4.4	5.2
rst	3.9	3.1	5.6	3.1	3.3	2.2	3.6	3	3.8	2.5
com	2.9	1.6	1.6	2.2	1.8	2.1	1.2	1.6	0.9	1.3
fin	3.5	2	1.7	2.8	1.8	2.6	1	2.3	1.4	2.7
res	0.8	0.4	0.7	0.2	0.5	0.3	0.1	0.4	0.3	0.6
bss	6.3	3.9	2.6	4.2	4.6	3.6	1.7	6	1.6	5.9
gov	7.4	6.1	4.9	7.5	6.5	7.1	5.2	6.2	3.6	7.2
edu	6.7	3.2	3.7	4.9	2.8	3.2	2.5	4	2.1	4.1
hlt	11.5	4.5	3.6	2.7	6.9	3.6	3.4	5.2	2.3	6.5
per	4	4	3.4	3.9	4.4	3.8	3.9	3.3	5.9	4.8

Notes: Table shows the sectoral composition of each economy in terms of hours worked. The EU is computed as the weighted average of the European countries in our sample with weights given by the ratio of hours worked of each country to total hours worked. The service sectors classification can be found in Table 1.

We now turn our attention to labor reallocation in Europe relative to the U.S. from 1970 to 2009. Let L_{ik}^{t} denote hours work in sector k, country i and period t, and let $s_{ik}^{t} = \frac{L_{ik}^{t}}{\sum_k L_{ik}^{t}}$ denote sectoral employment shares in period t. We document how sectoral employment shares in Europe have changed relative to the U.S. from 1970 to 1995 and

2009. In other words, we compute

$$\frac{s^t_{Europe}/s^t_{US}}{s^{1970}_{Europe}/s^{1970}_{US}} \quad \text{for} \quad t = \{1995, 2009\}.$$

In Figure 5a we plot the relative European change in sectoral reallocation for agriculture, manufacturing and services. Agriculture and manufacturing shrunk in relative size at a higher pace in Europe than in the U.S., while services increased at a higher rate. When combined with the European high labor productivity in manufacturing and low productivity in services documented above, this fact largely explains the stagnation and decline in aggregate productivity. Moreover, in Figure 5b, we note that while individually European countries had different relative reallocation of labor in agriculture and manufacturing, they had similar reallocation of labor in services—particularly in Spain and Italy, the ones that have been falling behind the most. All in all, these figures showcase the relevance of compositional changes in explaining aggregate labor productivity trends.

Breaking down services, we show in Figure 6 that the service activities where labor has reallocated the most relative to the U.S. are telecommunications (`com`), business services (`bss`), government (`gov`), and real estate (`res`). We note that from 1995 to 2009, there was a significant reallocation of labor into business services and real estate in Europe relative to the U.S–incidentally, in the same period, Europe has been falling behind. Looking at the individual European countries, Figure 7 shows that labor reallocation to different service activities has been similar, except for Spain and Italy, which experienced a significantly more significant rise in the employment share in business services than other European countries.

2.4 Aggregate Productivity Growth

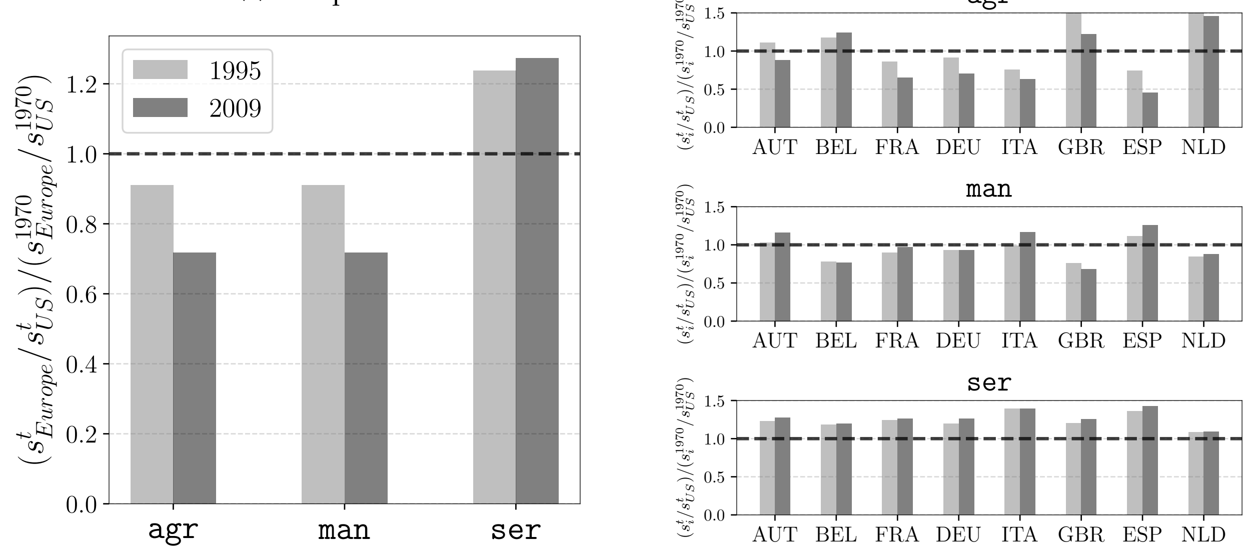
We now turn to how the aggregate labor productivity growth differed between Europe and the U.S. for the entire period, and from 1995 onwards. In Table 3 we show the average annual labor productivity growth in Europe and the U.S. and the associated gap. Furthermore, we also present the results of decomposing the productivity gap using a shift-share analysis. The decomposition allows us to compute how much of the gap comes from differences in relative sectoral productivity differences vs. how much comes from relative sectoral labor allocation differences.

The average annual labor productivity growth gap between Europe and the U.S. in the 1995–2009 was 0.6%, with half of the gap being explained by differences in sectoral

Figure 5: European sectoral composition change relative to the U.S. in hours worked in agriculture, manufacturing and total services

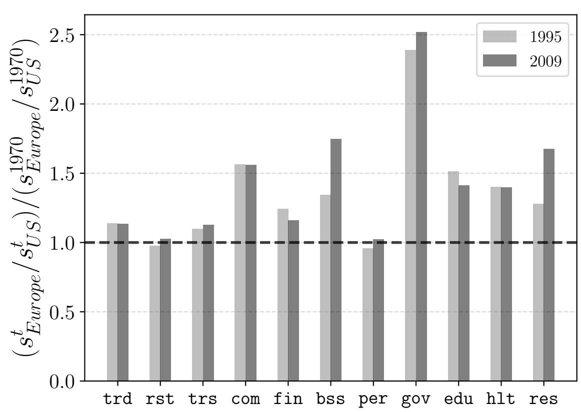
(a) Europe

(b) Individual European countries



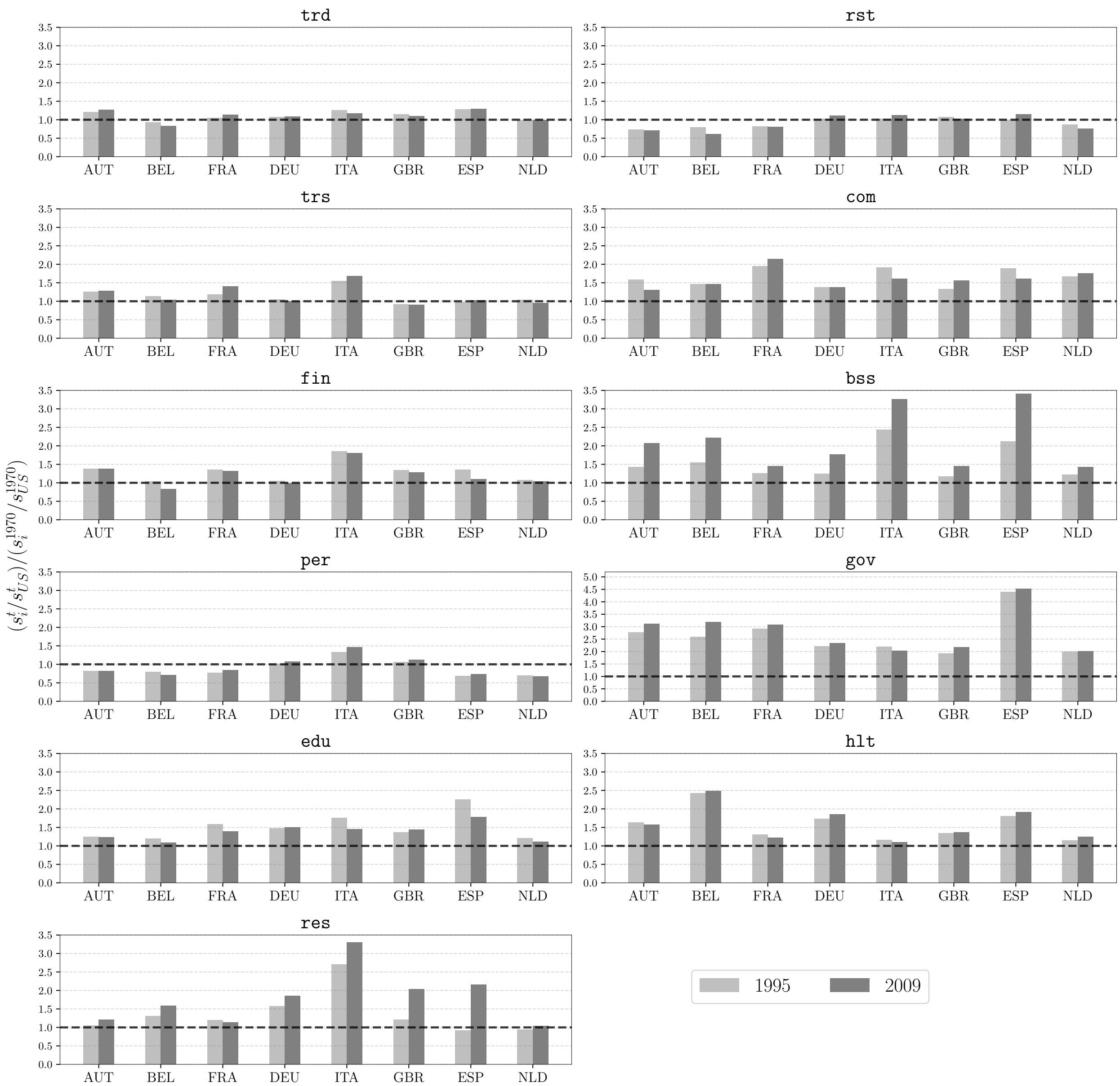
Notes: Figures show the cumulative change in sectoral share of hours worked in Europe relative to the U.S. from 1970 to 1995 and 2009. A value above one means that specific sector share of employment has grown more in Europe than in the U.S. since 1970. Conversely, a value below one means that specific sectors share of total hours has grown less in Europe than in the U.S. Figure 5a shows the relative structural change of a weighted average of the European countries in our sample with weights given by the ratio of hours worked of each country to total hours worked. Figure 5b shows the relative structural change for each european country in our sample.

Figure 6: European sectoral composition change relative to the U.S. in hours worked in each service sector



Notes: Figure shows the cumulative change in sectoral share of hours worked in Europe relative to the U.S. from 1970 to 1995 and 2009 for each service sector. The service sectors classification can be found in Table 1.

Figure 7: European sectoral composition change relative to the U.S. in hours worked in each service sector



Notes: Figure shows the cumulative change in sectoral share of hours worked in European countries relative to the U.S. from 1970 to 1995 and 2009 in each service sector. The service sectors classification can be found in Table 1.

labor productivity and the other half by labor reallocation across sectors. The average annual labor productivity growth gap, while smaller than the aggregate gap for services (0.38%), is wider for market services (wholesale and retail trade, finance and business services, 0.99%). Labor reallocation contributed to a smaller annual labor productivity growth gap in services and market services. The reason is that labor reallocated proportionally more to high-productivity growth service sectors in Europe than the U.S. Absent differential labor reallocation, Europe would have an annual labor productivity growth gap in market services of 1.6%.

Table 3: Aggregate productivity growth differences between U.S. and Europe (average annual per cent change)

				Gap Decomposition	
		Growth	Gap	Sectoral productivity	Sectoral labor reallocation
1970–2009 period					
`all`	U.S. Europe	1.68 1.97	-0.28	-0.53	0.24
`ser`	U.S. Europe	2.22 2.62	-0.39	0.30	-0.69
`trd` + `fin` + `bss`	U.S. Europe	3.48 2.84	0.64	1.24	-0.61
1995–2009 period					
`all`	U.S. Europe	1.92 1.33	0.59	0.30	0.29
`ser`	U.S. Europe	2.37 1.99	0.38	0.66	-0.29
`trd` + `fin` + `bss`	U.S. Europe	3.18 2.19	0.99	1.60	-0.62

Notes: Table shows, in the first column, the average labor productivity annual growth rate for different sectoral aggregates for the U.S. and Europe for the 1970–2009 and 1995–2009 periods. The aggregate `all` comprises all sectors in the economy, `ser` all services, and `trd` + `fin` + `bss` all progressive services. The second column shows the productivity growth gap between the U.S. and Europe. If positive, it means Europe is, on average, growing less than the U.S. each year. Finally, the third and fourth columns show the gap decomposition using a shift-share analysis. The decomposition allow us to compute how much of the gap comes from differences in relative sectoral productivity differences vs how much comes from relative sectoral labor allocation differences. For details on the decomposition, see the online appendix.

All in all, the stylized facts make clear that there have been significant patterns of sectoral employment shares in tandem with considerable and common differences in sectoral labor productivity growth paths between Europe and the U.S. from 1970 to 2009. Structural transformation theories show that these trends are intertwined with economic development as labor shares respond to productivity changes via supply (price effects) and demand channels (income effects). Hence, to fully understand why Europe is falling behind the U.S. in average labor productivity growth through sectoral labor productivity and employment shares, one needs a structural model that captures the endogenous response of labor shares to sectoral labor productivity changes.

3 A Model of Structural Transformation

This section presents a model of structural transformation for an economy with an arbitrary number of sectors where the reallocation of labor is a function of income and price effects. The model borrows the production technology from Duarte and Restuccia (2010) and the preferences from Comin et al. (2021) to account for the structural transformation via Engel curves and heterogeneous sectoral labor productivity growth rates. The economy is closed to international trade, and there is no capital. Hence, there is no motive for savings and investment. The equilibrium allocations of our model define the structural transformation as a sequence of static choices that get updated each period with the arrival of exogenous labor productivity.

3.1 Environment

An infinitely lived stand-in household of measure L supplies labor inelastically. There are I sectors, and each sector produces output using labor as the only production input. In addition, labor can move freely across sectors.

3.1.1 Preferences

The household has preferences over its consumption stream over time, but since we are not dealing with an inter-temporal choice in our model (*i.e.* there are no savings), there is no need to formalize the structure of preferences toward the inter-temporal substitution of consumption. We abstract from time subscript when defining intra-temporal allocations, but we will use time subscripts later in the exposition of the calibration. The preferences for consumption are defined implicitly through the constraint

$$\sum_{i=1}^{I} (\Omega_i \tilde{C}^{\epsilon_i})^{\frac{1}{\sigma}} c_i^{\frac{\sigma-1}{\sigma}} = 1, \tag{1}$$

where $\tilde{C}$ is an unobservable aggregate consumption index, c_i is the consumption from output produced in sector $i \in I$, σ is the price elasticity of substitution, ϵ_i is the income elasticity for good i (i.e. the Engel curve), and $\Omega_i > 0$ are constant weights for each good i, where $\sum_{i\in I}\Omega_i = 1$. There are two main reasons for using this particular non-homothetic CES preference structure: First, it is trivial to extend the model for any arbitrary number of sectors, which is not a feature of other types of preferences such as Boppart (2014), Herrendorf, Rogerson, and Valentinyi (2013), and Duarte and Restuccia (2010), among many others. Second, these preferences give rise to heterogeneous sectoral log-linear Engel curves that are consistent with the empirical evidence (Aguiar and Bils (2015); Comin et al. (2021)), and this is critical for the rise of services, the object of inquiry in this paper.

3.1.2 Technology

There are I different goods corresponding to the number of sectors in each period. There is a continuum of homogeneous competitive firms in each sector $i \in I$ that use production technology linear in labor described by

$$y_i = A_i l_i, \quad i \in I, \tag{2}$$

where y_i represents the output produced by a representative firm of sector i, A_i stands for the labor productivity of the firm, and l_i is the labor input demanded by firm i, measured in labor hours. The firm in this model economy hires labor at the prevailing wage W, which is the same for each sector i since labor is perfectly mobile.

3.1.3 Endowments

The households are endowed each period with L hours of labor that are supplied inelastically in competitive labor markets.[5]

3.2 Household's Problem

Given prices for each good, the household problem is to minimize its budget subject to constraint (1), namely

$$\min_{c_i} p_i c_i \quad \text{subject to} \quad \sum_{i=1}^{I} (\Omega_i \tilde{C}^{\epsilon_i})^{\frac{1}{\sigma}} c_i^{\frac{\sigma-1}{\sigma}} = 1. \tag{3}$$

Assume interior solution. The FONCs yield the following Hicksian demand

[5]We allow for L to change over time in the empirical counterpart of the model according to the evolution of the observed total number of hours supplied.

$$c_i = \Omega_i \left(\frac{p_i}{E}\right)^{-\sigma} \tilde{C}^{\epsilon_i}, \tag{4}$$

where the output demand of sector i is defined in terms of observables E (total nominal expenditure) and p_i, and the unobservable real consumption index aggregator $\tilde{C}$. Defining the expenditure shares as $\omega_i = \frac{p_i c_i}{E}$, where $E = \sum_{i=1}^{I} p_i c_i$, and using equation (4) to solve for ω_i yields

$$\omega_i = \Omega_i \left(\frac{p_i}{E}\right)^{1-\sigma} \tilde{C}^{\epsilon_i}. \tag{5}$$

Equation 5 defines the sectoral expenditure shares in terms of parameters, sectoral prices p_i , total household nominal expenditure E and the unobservable real consumption index $\tilde{C}$. The parameters ϵ_i and σ describe the income and price mechanisms of the structural transformation: Whereas ϵ_i measures the sensitivity for changes in the expenditure share of goods produced in sector i with respect to changes in real consumption index, namely the Engel curve for sector i, σ reflects the sensitivity of the expenditure shares to changes in prices. For the empirically relevant case of $\sigma < 1$, when goods are gross complements, a drop in p_i causes a less than proportional increase in demand for this good, thus reducing the nominal expenditure share for sector i.

3.3 Firm's problem

The firm's problem is a static maximization of profits through labor demand given competitive prices. Formally,

$$\max_{l_i} \{p_i A_i l_i - W l_i\} \qquad \forall i \in I. \tag{6}$$

Assume interior solution. The FONCs yield

$$p_i = \frac{W}{A_i}. \tag{7}$$

Equation 7 shows that increases in sectoral labor productivity reduce the price of a good produced in sector i, whereas increases in wages have a positive impact on prices. However, notice that wages do not change the relative prices in the economy since there are no restrictions on labor mobility in our model economy. Thus, it is only through heterogeneous growth in labor productivity across sectors that one changes relative prices.

3.4 Market Clearing Conditions

In every period, the demand of each consumption good or service is supplied by each sector, namely

$$y_i = c_i \quad \forall i \in I. \tag{8}$$

Labor markets also clear: The total demand for labor, the sum of all sectoral labor demand, must be equal to the labor endowment in every period, that is

$$L = \sum_{i=1}^{I} l_i. \tag{9}$$

We now have all the elements in place to formally define the equilibrium concept of our model economy of the structural transformation.

3.5 Equilibrium

Definition 1. *A Competitive Equilibrium is a collection of prices $\{p_i, W\}$, household allocations $\{c_i\}$ and firm's allocations $\{l_i\}$, such that for each sector i:*

(α) Given prices, c_i^* solve the household's problem defined in (3)*;*

(β) Given prices, l_i^* solve the firm's problem defined in (6)*;*

(γ) Market clearing conditions defined in (8) *and* (9) *hold.*

Combining equations (5), (7), the market clearing conditions (8) and (9), and the definition of ω_i one gets the following expression for the sectoral labor demand

$$l_i = \left(\frac{E}{W}\right)^{\sigma} \Omega_i \tilde{C}^{\epsilon_i} A_i^{\sigma-1}. \tag{10}$$

From the market-clearing conditions, the total labor demand comes from adding equation (10) across sectors, which yields

$$L = \left(\frac{E}{W}\right)^{\sigma} \sum_{j=1}^{I} \Omega_j \tilde{C}^{\epsilon_j} A_j^{\sigma-1}. \tag{11}$$

Equation 10 illustrates the two main drivers of the structural transformation in our model. First, the parameter ϵ_i defines the Engel curve for sector i, and shows how this non-homotheticity affects the labor demand for each sector, linking it directly to the sector's elasticity relative to the unobserved real consumption index. Second, the parameter

σ shows the relation between the price elasticity of substitution and labor demand. For the empirically relevant case of $\sigma < 1$ — where all goods are gross complements—- the price effect illustrates the so-called Baumol's cost disease in which labor is continuously allocated toward less productive sectors in the long run.

Taking the ratio of equations (10) and (11) one gets the following expression that defines the structural transformation in the economy in terms of parameters, observables, and the unobservable real consumption index

$$\frac{l_i}{L} = \frac{\Omega_i \tilde{C}^{\epsilon_i} A_i^{\sigma-1}}{\sum_{j=1}^{I} \Omega_j \tilde{C}^{\epsilon_j} A_j^{\sigma-1}}. \tag{12}$$

The sectoral employment shares defined in equation (12) are affected by both income and price effects: as the real consumption index rises in our model economy, the employment share of sector i will rise if the income elasticity of demand of good i is relatively higher and will fall otherwise. On the other hand, as labor productivity grows, the employment share of sector i will diminish relative to other sectors with slower labor productivity growth rates if the economy exhibits the so-called Baumol's costs disease.

Equation (12) is not sufficient to define the labor allocations across sectors in terms of the time series for $\{A_i\}$ and parameter values for ϵ_i and σ for every sector i due to the unobservable aggregate real consumption index $\tilde{C}$. In order to derive a system of demand equations in terms of parameters and observables, the next section presents our calibration strategy where we exploit the implicit Marshallian demand system and then use these parameters to compute an unobservable real consumption index consistent with our theory to later feed in the sectoral labor productivity time paths in equation (12) to compute the main predictions of the model.

4 Calibration

Our calibration strategy proceeds in four steps. First, we derive a system of Marshallian demand equations relative to manufacturing in terms of observables. Then, we use the initial and final observations of the process of structural transformation in the U.S. for the period 1970–2009 to jointly calibrate the parameters that define the preferences. Third, we use these parameter values to compute an unobserved real consumption index consistent with the theory. Last, we feed in time paths for labor productivity and the unobservable aggregate consumption index in the equation that defines the structural transformation for each sector (equation (12)) to generate predictions for the evolution of the employment shares across sectors.

4.1 Marshallian Demand System

The expenditure shares in equation (5) are defined in terms of preferences, observables and the unobservable real consumption index aggregator $\tilde{C}$. In order to define a demand system in terms of parameters and observables, consider the equation (5) for manufacturing, i.e. $i = m$ and solve for $\tilde{C}$. This yields

$$\tilde{C} = \frac{\omega_m}{\Omega_m} \left(\frac{E}{p_m} \right)^{1-\sigma} \tag{13}$$

Taking the ratio of the expenditures shares for sector $i \neq m$ relative to m, plugging in (13) and using market clearing conditions one gets a system of sectoral labor demand relative to manufacturing in terms of preferences and observables. After taking logs on both sides, one gets

$$\begin{aligned} \log\left(\frac{l_i}{l_m}\right) = \log\left(\frac{\Omega_i}{\Omega_m}\right) + (1-\sigma)\log\left(\frac{p_i}{p_m}\right) + (1-\sigma)(\epsilon_i - 1)\log\left(\frac{E}{p_m}\right) \\ + (\epsilon_i - 1)\log\left(\frac{\omega_m}{\Omega_m}\right). \end{aligned} \tag{14}$$

With the system of Marshallian demands at hand, the first step of the parameterization is to normalize the initial productivity levels $A_{i,t=1970} = 1$ and the initial level of the real consumption index $\tilde{C}_{t=1970} = 1$. As $\tilde{C}$ is an object of the preferences, we are free to determine its level. With this normalization, and using the fact that $\sum_{i \in I} \Omega_i = 1$, one gets parameter values for each Ω_i from equation (12) simply as $\Omega_i = \frac{l_{i,t=1970}}{L_{t=1970}}$, i.e. the initial employment shares. Then, we employ an algorithm that minimizes the squared distance between the left and the right hand side of equation (14) for the last period (2009) across all sectors to calibrate σ and $\epsilon_{i \in I}$.[6]

4.2 Computation of the Unobserved Real Consumption Index

Albeit unobserved, we can compute a time path for $\tilde{C}_t$ that is consistent with the theory. There are I equations in the model that one can use to compute the evolution of $\tilde{C}_t$. First, one can use the real consumption index for base good m, expressed in equation (13). In addition, one can solve for the expenditure share in sector i relative to manufacturing. This yields $I - 1$ equations, one for each $i \neq m$, namely

[6] Appendix A describes in detail our calibration algorithm.

$$\tilde{C}_t = \left[\frac{\Omega_m}{\Omega_i}\frac{l_{it}}{l_{mt}}\left(\frac{p_{it}}{p_{mt}}\right)^{\sigma-1}\right]^{\frac{1}{\epsilon_i - 1}}, \quad i \neq m, \quad i \in I. \tag{15}$$

We use (15) for each $i \neq I$ to compute $I-1$ paths for $\tilde{C}_t$, and then take the weighted average across sectors using the non-manufacturing employment shares as weights. Although we could also compute the weighted average for all I sectors, including equation (13), we chose not to use this approximation since we already use (13) to obtain the Marshallian demand system in order to obtain parameter values for the preferences,in particular Engel curves relative to manufacturing.[7]

To complete the calibration, the last step is to feed in $\tilde{C}_t$ and the observed paths for $\{A_{i,t}\}$ in equation (12). Doing so enables us to compute both the model's prediction for the evolution of the employment shares across sectors and the model's aggregate productivity, in order to compare these two set of results to the data.[8]

4.3 Parameterization

We calibrate three versions of the model in order to compare results as we disaggregate the service sector in our model economy. The first version of the model, **Model (1)** hereafter, includes the three broad sectors traditionally studied in the literature of structural transformation: agriculture (`agr`), manufacturing (`man`) and services (`ser`). The second version of the model, **Model (2)** hereafter, opens services into non-progressive services as a whole, and each progressive sector individually. These are: finance (`fin`), business services (`bss`) and whole sale/retail trade (`trd`). Recall that we follow Baumol (1967) in labeling as "non-progressive" the sectors with modest or absent labor productivity growth. Last, we present version of the model, **Model (3)** hereafter, where we include all the sectors that are comparable between the U.S. and Europe. These are all the sectors discussed in the motivating facts above.

Table 4 presents the parameter values for each model calibration. Columns (1), (2) and (3) report the parameterization for Models (1), (2), and (3) respectively. For each model, our calibration delivers values for σ below the unit, consistent with the Baumol mechanism for the structural transformation where labor is displaced toward less pro-

[7] Nevertheless, the quantitative predictions of the model are virtually the same if one includes (13) in the computation of the weighted average to construct $\tilde{C}_t$.

[8] Following Duarte and Restuccia (2010), we map from sectoral to aggregate productivity by adding each sector's labor productivity with the employment share of each sector as weight, namely $A_t = \sum_{i \in I} \frac{l_{i,t}}{L_t} A_{i,t}$.

Table 4: Parameterization. The model is calibrated to the U.S. for the period 1970–2009.

Parameter	Objective/Target	Model (1)	(2)	(3)
σ	Price elasticity of substitution.	0.72	0.89	0.89
$\epsilon_{\texttt{agr}}$	Engel curve for agriculture.	0.88	0.64	0.63
$\epsilon_{\texttt{man}}$	Engel curve for manufacturing (normalization.)	1	1	1
$\epsilon_{\texttt{ser}}$	Engel curve for services.	1.17		
$\epsilon_{\texttt{nps}}$	Engel curve for non-progressive services.		1.45	
$\epsilon_{\texttt{trd}}$	Engel curve for whole sale and retail trade.		1.32	1.33
$\epsilon_{\texttt{bss}}$	Engel curve for business services.		1.88	1.90
$\epsilon_{\texttt{fin}}$	Engel curve for financial services.		1.50	1.51
$\epsilon_{\texttt{rst}}$	Engel curve for accommodation and food services.			1.72
$\epsilon_{\texttt{trs}}$	Engel curve for transportation and storage.			1.33
$\epsilon_{\texttt{com}}$	Engel curve for communication.			0.94
$\epsilon_{\texttt{res}}$	Engel curve for real estate activities.			1.70
$\epsilon_{\texttt{hlt}}$	Engel curve for health and social work.			1.63
$\epsilon_{\texttt{edu}}$	Engel curve for education.			1.46
$\epsilon_{\texttt{gov}}$	Engel curve for public administration and defense.			0.73
$\epsilon_{\texttt{per}}$	Engel curve for personal, community and other activities.			1.72
$\Omega_{\texttt{agr}}$	Initial emp. share in agriculture.	0.06	0.06	0.06
$\Omega_{\texttt{man}}$	Initial emp. share in manufacturing	0.30	0.30	0.30
$\Omega_{\texttt{ser}}$	Initial emp. share in services.	0.65		
$\Omega_{\texttt{nps}}$	Initial emp. share in non-progressive services.		0.41	
$\Omega_{\texttt{trd}}$	Initial emp. share in whole sale and retail trade.		0.14	0.14
$\Omega_{\texttt{bss}}$	Initial emp. share in business services.		0.06	0.06
$\Omega_{\texttt{fin}}$	Initial emp. share in financial services.		0.03	0.03
$\Omega_{\texttt{rst}}$	Initial emp. share in accommodation and food services.			0.04
$\Omega_{\texttt{trs}}$	Initial emp. share in transportation and storage.			0.03
$\Omega_{\texttt{com}}$	Initial emp. share in communication.			0.03
$\Omega_{\texttt{res}}$	Initial emp. share in real estate activities.			0.01
$\Omega_{\texttt{hlt}}$	Initial emp. share in health and social work.			0.11
$\Omega_{\texttt{edu}}$	Initial emp. share in education.			0.07
$\Omega_{\texttt{gov}}$	Initial emp. share in public administration and defense.			0.07
$\Omega_{\texttt{per}}$	Initial emp. share in personal, community and other activities.			0.04

Notes: Table shows the calibrated parameters for models (1), (2) and (3).

ductive sectors.[9] Our findings support a stronger Baumol effect for the model with only three sectors than when opening the service sectors, but importantly, the effects are similar when considering non-progressive sectors as a bundle vs. each sector individually.[10] Moreover, our algorithm delivers parameter values that rank $\epsilon_{\texttt{agr}} < \epsilon_{\texttt{man}} = 1 < \epsilon_{\texttt{ser}}$,

[9]Although our calibration algorithm is restricted to deliver values for $\sigma < 1$, parameter values below the unit and similar to the ones reported in Table 4 are obtained if one lifts this parametric restriction in our calibration algorithm.

[10]Duernecker, Herrendorf, and Valentinyi (2019) calibrate a model for the U.S. using nested non-homothetic preferences to account for the structural transformation across goods and services, as well as within services. This approach allows for substitution within services while keeping the goods and services as gross complements, and they do find evidence supporting complementary between goods and services and substitution within services. This can be reconciled with our finding of a stronger price effect for Model (1), as it only takes into account the three broad sectors of the structural transformation. For Model (2) and (3), we hold a single elasticity of substitution that considers the output all sectors as gross complements, regardless of the number of sectors within services, and we found these complementary to be weaker. However, as we will show next, this simpler framework is capable of explaining the salient features of the structural transformation beyond agriculture, manufacturing and services.

and relative Engel curves for sectors within services above one with the exception of $\epsilon_{\texttt{com}}$ and $\epsilon_{\texttt{gov}}$, which are below the unit. For the rest of the sectors , we found stronger income effects than for services as a whole. Importantly for our results, the stronger income effects are found in business services. Overall, our calibration delivers parameter values consistent with the literature of structural transformation for the three broad sectors,[11] and strong income effect within services with the notable exceptions government services and the sector of communication.

The next section presents calibration results of the U.S. and Europe structural transformation and the aggregate productivity.

5 Model Evaluation

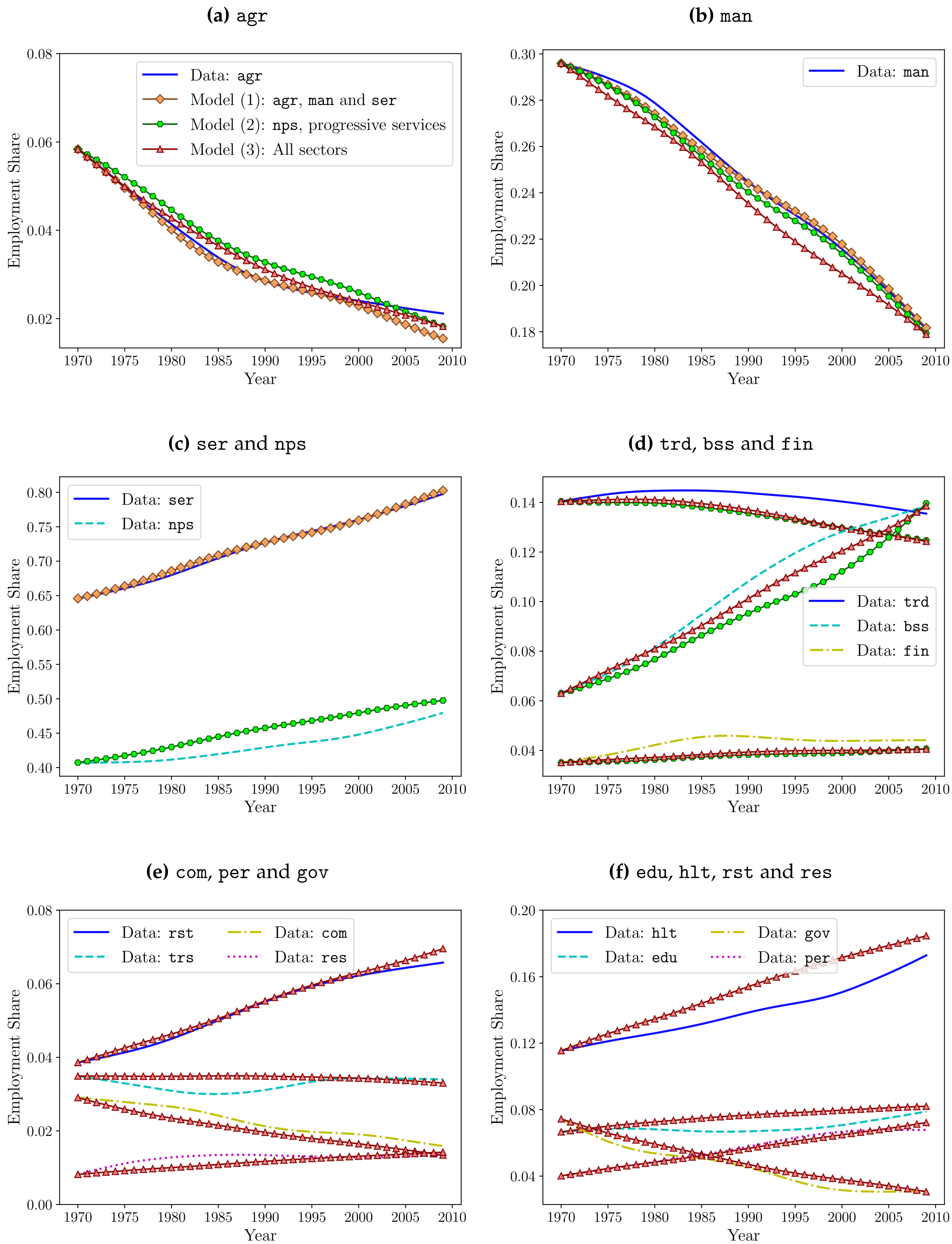
In this section, we test our theory by evaluating the model's sectoral labor shares and aggregate productivity predictions against the data. First, we evaluate the models' predictions for the structural transformation in the U.S . Second, we evaluate the models' predictions for the structural transformation in each European country. Last but not least, we compare the models' predictions for aggregate productivity growth in both regions and the associated gap with the data. With the structural transformation predictions for both regions in hand and evaluated against the data, we use the model to study how much of the change in labor shares in Europe relative to the U.S. comes from relative price effects vs. income effects.

5.1 Structural Transformation in the U.S.

Figure 8 presents the model predictions for the evolution of U.S. employment shares *vis-à-vis* the observed time paths. Panel 8a illustrates that the model does a good job predicting the movement of labor out of agriculture since 1970 in the U.S. and the quantitative differences among our three model predictions are negligible. Panel 8b shows that all models are capable of generating the deindustrialization pattern observed since 1970, where the employment share fell from about 30 percent down to 13 percent. The model with the tree traditional sectors and non-progressive and progressive sectors follows the pattern slightly closer than the model with all sectors, but all model predictions generate patterns consistent with the data.

[11] Similar to the case for the parametric restriction for $\sigma < 1$ in our calibration algorithm, we still obtain values below the unit in our calibration algorithm if we lifts the restriction for $\epsilon_{\texttt{agr}} < 1$. These values are 0.80 for Model (1), 0.88 for Model (2) and 0.87 for Model (3).

Figure 8: Structural transformation in the U.S. 1970–2009. Model predictions vs. data.



Notes: Figure compares the employment shares observed in the U.S. from 1970 to 2009 vis-à-vis the ones predicted by our three models.

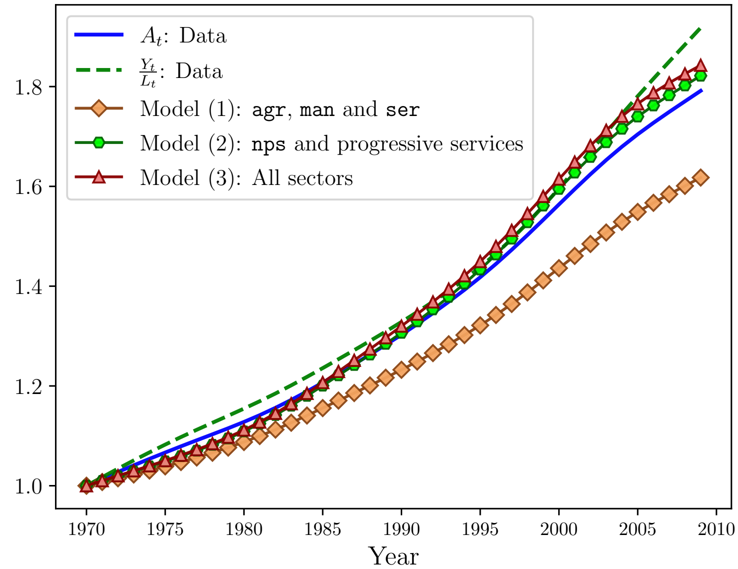
Panel 8c shows predictions for the employment share in services as a whole [Model (1)] and the entire bundle of non-progressive services [Model (2)]. Both models generate the observed rise in employment in services and the non-progressive subset, although the latter prediction is slightly above the data throughout the calibration period. Panel 8d illustrates the predictions for the progressive sectors, namely wholesale and retail trade, business services, and finance. Models (2) and (3) generate predictions for these services that are almost equivalent, except for the rise in business services, where Model (3) follows the pattern slightly closer. Both models predict a decline in whole sale and retail trade of about one percentage point stronger than the data, and flat evolution for the employment share of financial services slightly below the data, as the models miss a minor rise in the financial employment share (of about one percentage point) between 1970 and 1985.

Last, Panels 8e and 8f show that the individual predictions for all non-progressive sectors produced by Model (3) do follow the observed employment shares in these services between 1970 and 2009. The non-progressive sector that displays more discrepancies between our model and the data is health services, with a slight overprediction of about two percentage points during the 90s. However, our model closes part of that gap afterward, delivering a final prediction of around 18 percent in 2009, in contrast to the 17 percent employment share observed in the data. Overall, although Figure 8 does not constitute a test of the theory directly – as part of these data was used in the parameterization of the model – it is reassuring that our calibration does match the evolution of the employment shares when we open the model economy in order to consider sectors within services in line with the observed structural transformation in the U.S.

Figure 9 compares the model's predictions for the aggregate productivity to the data. As mentioned before, with exogenous paths for each $\{A_{i \in I}\}_{t=1970}^{2009}$, we can use our model predictions for the structural transformation to generate a prediction for the aggregate productivity. We compare our model predictions against two indexes constructed with measures of aggregate labor productivity from World KLEMS and the GDP per hour measures from the OECD. We use A_t to refer to the aggregate productivity data from World KLEMS, and $\frac{Y_t}{L_t}$ to refer to the GDP per hour measure. Both labels are equivalent to the aggregate labor productivity in our theoretical counterpart, as $A_t = \frac{Y_t}{L_t}$.

As we did not use the data on aggregate productivity in the calibration, Figure 9 constitutes a quantitative test of the theory. Between 1970 and 2009, aggregate labor productivity in the U.S. multiplied by 1.8 and 1.9 depending on whether the source is World KLEMS or the GDP per hour measures of the OECD, respectively. The average growth rate was 1.7 and 1.5 percent, respectively. Our predictions show that whereas Model (1)

Figure 9: Aggregate Labor Productivity in the U.S. for the period 1970–2009: Model vs. data.



Notes: We compare our predictions for aggregate productivity against two indexes: A_t computed with the growth rate of labor productivity from World KLEMS, and $\frac{Y_t}{L_t}$, computed with the growth rate of GDP per hour from the OECD .

with only three sectors falls short in generating the observed rise in labor productivity, Models (2) and (3) succeed in generating aggregate productivity paths that are in line with the data: For the last period, the aggregate labor productivity predicted by Model (1) is 90 percent (84 percent) of the observed growth in A_t $\left(\frac{Y_t}{L_t}\right)$. In contrast, Models (2) and (3) generate 102 percent (95 percent) and 103 percent (96 percent) the observed growth in A_t $\left(\frac{Y_t}{L_t}\right)$, which suggests that opening the service sector pays dividends in order to understand the evolution of aggregate labor productivity. Figure 9 suggests that our quantitative exercise helps us understand the evolution of the aggregate labor productivity through the lenses of structural transformation with deeper disaggregations for services.

5.2 Structural Transformation in Europe

With the calibrated structure of the model, we can now evaluate the model's capacity to explain both the structural transformation and the evolution of aggregate productivity in Europe. Unlike Duarte and Restuccia (2010), we continue with the normalization of the initial productivity levels in Europe instead of using the model to recover initial productivity levels, letting each $\Omega_{i\in I}$ to be a country-specific parameter to account for the initial employment shares.[12] We aim to address the model's capacity to deliver time paths for the structural transformation and the aggregate productivity in the European countries. As we do not use this data in the calibration, this exercise constitutes an additional quantitative test of the theory.

To address whether our model helps to explain the structural transformation in Europe, Figure 10 plots a scatter between each observed sectoral employment share in 2009 and our model prediction for the same period for each model calibration. It also plots a solid line representing the 45-degree line starting at the origin of the y and x-axis. The closer the pair between the observed labor share (y-axis) and our model's prediction (x-axis) to the 45-degree line, the more accurate our model is in capturing the process of structural transformation. Except for Spain, Model (1) explains well the European patterns of the structural transformation in agriculture, manufacturing and services.[13]

Looking at the sectors within services, Figure 10 shows that the model produces predictions close to the 45-degree line with some important exceptions: For whole and retail trade in Belgium, the model over-predicts the final employment share by about five percentage points; for accommodation and food services (`rst`), the model also over-predicts the employment shares, in particular for the case of Austria. Personal services (`per`) are over-predicted everywhere, especially in Spain. Notably, the model predicts an employment share of about 2 percent in each country for government services (`gov`), which is counterfactual, especially in France and Belgium. Overall, Figure 10 illustrates that the model successfully generates sectoral employment shares roughly consistent with the data, despite the notable exceptions.

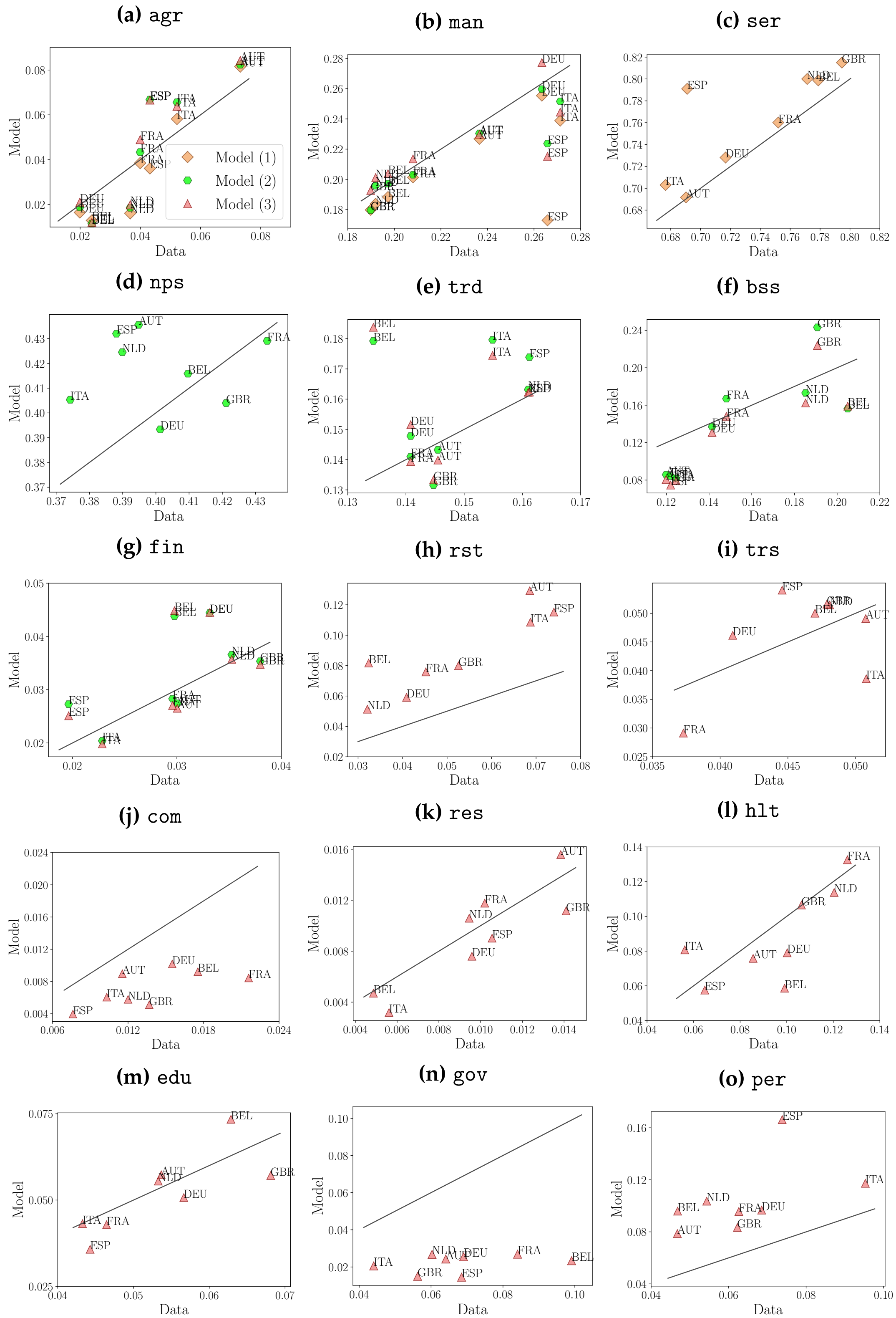
5.3 Relative Aggregate Labor Productivity

With predictions for the structural transformation in each sector, we can now address whether our model can address the convergence in aggregate productivity that Europe witnessed between 1970 and 1990 and the posterior divergence afterward. We do this by comparing the relative aggregate productivity observed between the U.S. and Europe *vis-à-vis* the relative aggregate productivity predicted by our model economy. Figure 11

[12] When opening the model to account for sectors within services in Europe while recovering their initial productivity levels relative to the U.S. we found implausible results, as some sectors within services are tiny. For instance, in 1970, communication (`com`) services had an employment share in the U.S. of about 3 percent, while the Spaniard employment share was below one percent. To account for this initial difference, the model requires implausibly large labor productivity for communication services in Spain to account for an initial smaller sector in a poorer country.

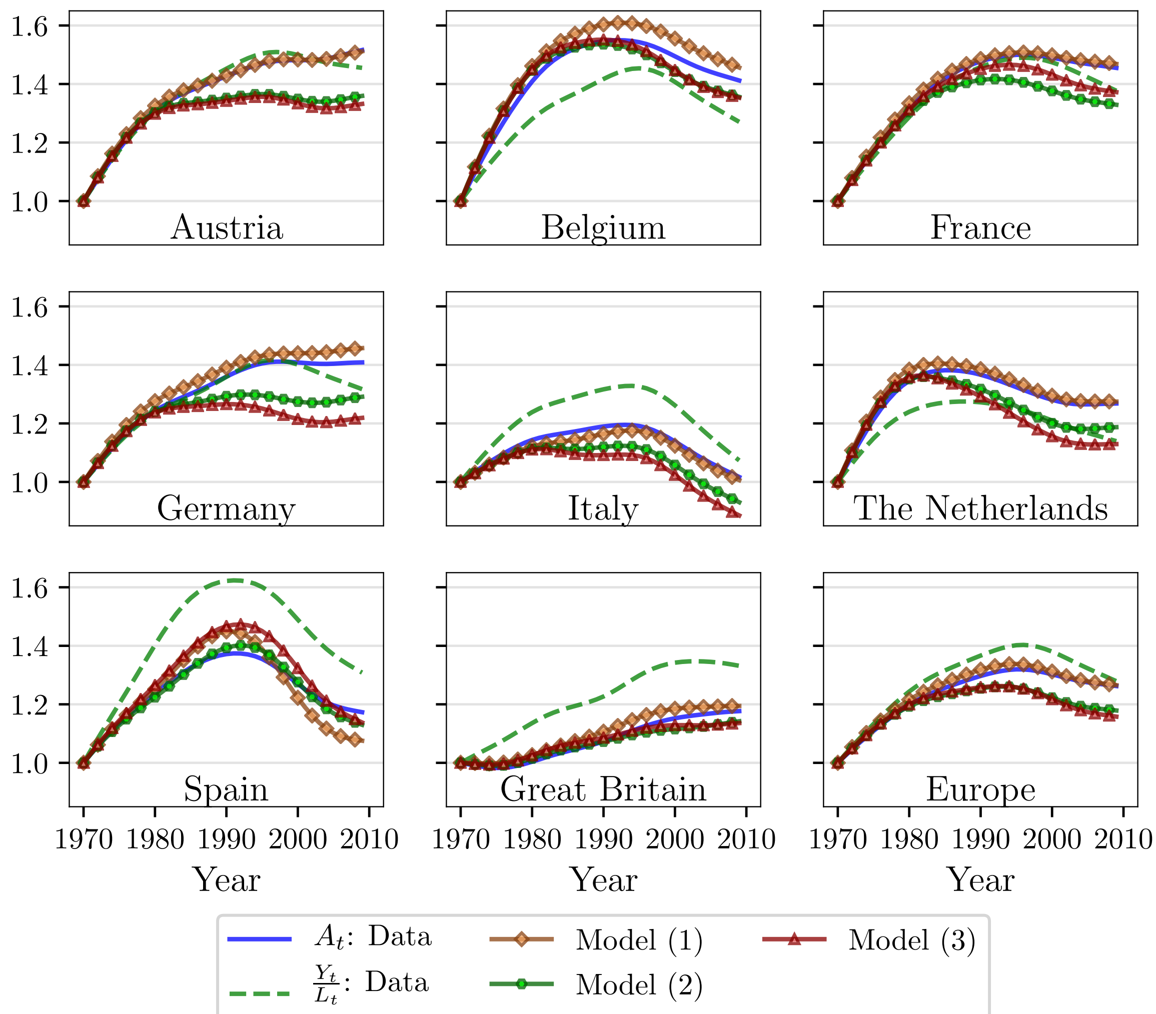
[13] For Spain, Model (1) generates a substantial over-prediction of the employment share in the manufacturing sector of about eight percentage points that is compensated by an under-prediction in services. However, the predictions of Models (2) and (3) improve in this regard.

Figure 10: Structural transformation in Europe. Model predictions vs. data for the last period (2009).



Notes: Figure compares the employment shares observed in the European countries in 2009 vis-à-vis the ones predicted by our three models.

Figure 11: Aggregate labor productivity in Europe relative to the U.S. 1970–2009. Model predictions vs. data



Notes: Figure compares the relative aggregate productivity observed between the U.S. and Europe vis-à-vis the relative aggregate productivity predicted by our model economy. We use A_t to refer to the aggregate productivity data from World KLEMS, and Y_t/L_t to refer to the GDP per hour measure from the OECD .

presents this comparison. These data are the same ones used previously to produce Figure 1 in the introduction. The only difference here is that instead of taking the ratios of GDP per hour directly from the data presented in Panel 1a, we use the growth rates of these data to construct the index for $\frac{Y_t}{L_t}$ relative to the U.S. normalizing the first period to 1, to be able to compare its evolution directly to the output of the model.

Figure 11 shows that the predictions of the model economy do follow the evolution of the relative aggregate labor productivity. In particular, our model does generate the period of catch-up prior to 1990 and the subsequent divergence. For Austria, Model (1) follows the data closely, while Models (2) and (3) show a deceleration that starts early. For Belgium, Model (1) over-predict both data sources, whereas Models (2) and (3) generate a prediction that falls between $\frac{Y_t}{L_t}$ and A_t. For France, model (1) follows closer A_t whereas Models (2) and (3) are more in line with $\frac{Y_t}{L_t}$, although both time paths are relatively close. For Germany, Model (1) does a good job generating the time path for A_t, and it is closer to $\frac{Y_t}{L_t}$ up to the mid-90s, whereas Models (2) and (3) are not following the hump pattern as close as Model (1) but ended the time-period closer to $\frac{Y_t}{L_t}$ than Model (1), especially Model (2). For Italy, the hump produced by $\frac{Y_t}{L_t}$ is more pronounced and elusive to our model, while Model (1) generates a pattern following close A_t, while Models (2) and (3) generate a more substantial divergence. For the Netherlands, Model (1) follows closely A_t while Models (2) and (3) follow closer $\frac{Y_t}{L_t}$, although they generate a more decisive catch up than observed during the 1970s, more in line with A_t. For Spain, similar to the case of Italy, the gap between $\frac{Y_t}{L_t}$ and A_t is substantial, although the pattern is similar, showing strong convergence prior to 1990 and substantial divergence afterward. Our model predictions follow close A_t, generating the strong hump observed in both data sources. Similarly, For Great Britain, the convergence measured by $\frac{Y_t}{L_t}$ is more emphatic than A_t, and our model predictions do follow closely the latter. Notice that Great Britain's convergence suffers a deceleration during the mid-90s, but there is no divergence in our sample period. Last, taking Europe as a whole[14] one observes that each of our models generates the process of convergence prior to 1990 and posterior divergence, where Model (1) delivers predictions closer to the data.

Figure 11 does not suggest that one model is dominant in terms of its prediction capacity because of our two distinct but complementary data sources for aggregate productivity. We showed in Figure 9 that Model (1) falls short in explaining the labor productivity growth observed during the sample period in the United States —which is the denominator in Figure 11—and Figure B.1 in the Appendix shows that if one plots the prediction of the Index itself in Europe rather than the relative evolution to the U.S. one observes that Model (1) is not superior to Models (2) and (3), especially for the case of Spain. This disparity should not be taken as criticism of Model (1). It delivers valuable insights with a more straightforward framework. Nevertheless, we highlight that increasing the number of sectors sharpens the aggregate predictions while accounting explicitly for sectors within services. Therefore, we select Model (3) as our benchmark model that we will use to study the model mechanisms and perform counterfactual exercises.

We now turn to the most important evaluation of our model. The one in which

[14]The aggregate productivity in Europe is computed as the average of the eight European countries aggregate productivity, weighted by their national GDP.

we compare the average annual labor productivity growth gap predicted by the model with the data. Table 5 presents our benchmark model's average gap predictions together with the observed gap in the data for the 70–09 and 95–09 periods and for three different aggregates: all sectors (`all`), service sectors only (`ser`), and market services only (`trd` + `fin` + `bss`). Furthermore, we present the results from a shit-share analysis that decomposes the gap in each period and sectoral aggregate to assess the contribution of sectoral productivity vs. labor reallocation. We conclude that the model's prediction is close to the observed gap across all periods and aggregates.

Table 5: Aggregate productivity growth differences between U.S. and Europe: Model vs. Data (average annual per cent change)

	Growth Rate Gap		Gap Decomposition			
			Sectoral productivity		Sectoral labor reallocation	
	Data	Model (3)	Data	Model (3)	Data	Model (3)
1970–2009 period						
`all`	-0.28	-0.30	-0.52	-0.53	0.24	0.24
`ser`	-0.39	-0.34	0.30	0.34	-0.69	-0.68
`trd` + `fin` + `bss`	0.64	0.48	1.24	1.23	-0.61	-0.75
1995–2009 period						
`all`	0.59	0.59	0.30	0.29	0.29	0.30
`ser`	0.38	0.31	0.66	0.77	-0.29	-0.45
`trd` + `fin` + `bss`	0.99	1.04	1.60	1.57	-0.62	-0.53

Notes: Table shows the average annual labor productivity annual growth rate difference between Europe and the U.S. for different sectoral aggregates for the 1970–2009 and 1995–2009 periods in the data and in model (3). The aggregate `all` comprises all sectors in the economy, `ser` all services, and `trd` + `fin` + `bss` all progressive services. Finally, the last four columns show the gap decomposition using a shift-share analysis. The decomposition allow us to compute how much of the gap comes from differences in relative sectoral productivity differences vs how much comes from relative sectoral labor allocation differences. For details on the decomposition, see the online appendix.

In summary, we judged the model's performance in three dimensions quantitatively: i) The U.S. structural transformation, ii) the European structural transformation, and iii) the aggregate labor productivity in Europe relative to the U.S. Our exercises show that our theoretical framework is successful in accounting the participation of employment in agriculture, manufacturing, and several services in the U.S. and Europe, and it also accounts for the aggregate differences in output per hour worked between these two regions, and for each country individually. These results are reassuring that our theoretical framework is quantitatively valid.

The model mechanisms working through price and income effects explain the data well. Hence, before we move on to the counterfactual experiments we study their relative importance in explaining the structural change across the two regions.

Contribution of Relative Price and Income Effects With the structural transformation predictions for both regions in hand, we use the model to study how much of the change in labor shares in Europe relative to the U.S. comes from relative price effects vs. income effects. We use equation 14 to perform the decomposition of relative change in labor shares from 1970 and 1995 to 2009. In a given year t the relative labor shares between the two regions is given by:

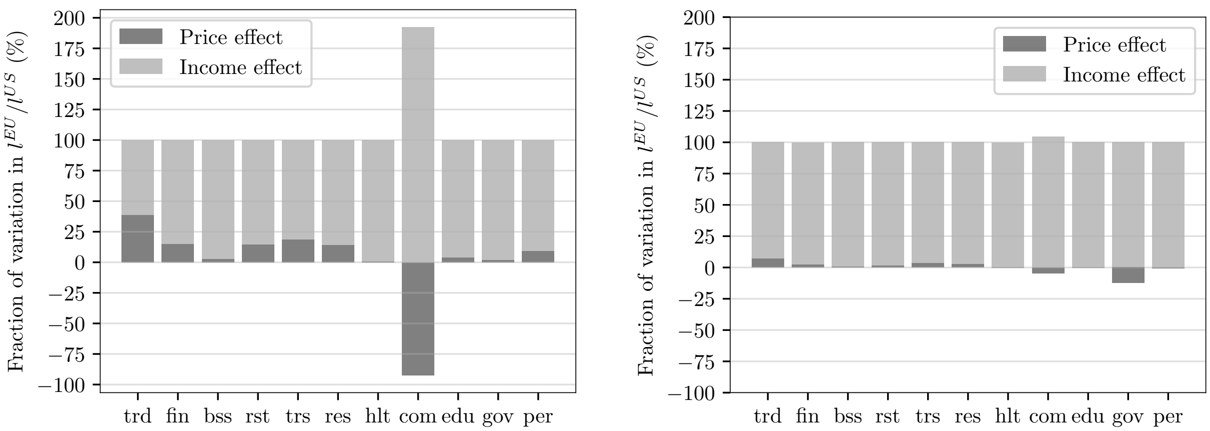
$$\begin{aligned}
\log\left(\frac{l_i}{l_m}\right)^{EU} - \log\left(\frac{l_i}{l_m}\right)^{US} = & \log\left(\frac{\Omega_i}{\Omega_m}\right)^{EU} - \log\left(\frac{\Omega_i}{\Omega_m}\right)^{US} + \\
& \underbrace{(1-\sigma)\left(\log\left(\frac{p_i}{p_m}\right)^{EU} - \log\left(\frac{p_i}{p_m}\right)^{US}\right)}_{\text{Relative Price Effect}} + \\
& \underbrace{(1-\sigma)(\epsilon_i - 1)\left(\log\left(\frac{E}{p_m}\right)^{EU} - \log\left(\frac{E}{p_m}\right)^{US}\right)}_{\text{Relative Income Effect}} + \\
& \underbrace{(\epsilon_i - 1)\left(\log\left(\frac{\omega_m}{\Omega_m}\right)^{EU} - \log\left(\frac{\omega_m}{\Omega_m}\right)^{US}\right)}_{\text{Relative Income Effect}}.
\end{aligned} \tag{16}$$

Equation 16 shows that in our model labor reallocation is driven by income and price (substitution) effects. Price effects result from differences across sectors in productivity growth rates, while income effects stem from combining heterogeneity in income elasticities of demand across sectors with income growth. We then use equation 16 to compare the relative change in labor shares of the two regions between 1970 and 2009, and between 1995 and 2009.

We present the contribution of relative price and income effects in Figure 12. We conclude that relative labor reallocation is mostly driven by income effects, especially since 1995. Nevertheless, in Figure 12a, which shows the relative contribution of price and income effects for the 1970–2009 period, we see that price effects were still substantial in wholesale and retail trade (`trd`) and in communication (`com`). Looking at Figure 12b, we see that from 1995 onward, all the action in relative structural change is explained by relative income effects. When combining these two Figures, we conclude that the price effects were more important from 1970 to 1995.

Figure 12: Contribution of Relative Price and Income Effects

(a) 1970–2009 period **(b)** 1995–2009 period



6 Counterfactual Experiments

After illustrating the theory's quantitative success, we use our parameterized model economy to perform a set of counterfactual experiments to understand each sector's role in aggregate productivity. We aim to identify which sectors are primarily responsible for the slowdown in Europe after the rapid convergence witnessed until the 1990s. Our disaggregation allows quantifying what would have happened to the European aggregate productivity if one specific sector had witnessed a counterfactual U.S. labor productivity growth. Through our numerical experiments, we find that differences in the productivity growth rates in market services—wholesale and retail trade, financial and business services—are critical to addressing the divergence that Europe experienced after 1995. In contrast, differences in other sectors, albeit significant on their own, do not have much quantitative significance in aggregate productivity differences.

6.1 Europe keeping pace with the U.S. since 1970

Our first counterfactual experiment asks what would have happened with the aggregate labor productivity in Europe had it experienced the observed sectoral productivity growth in the U.S. from 1970 to 2009. We ask this question for each sector individually through the lenses of our benchmark model. More specifically, we use our model to predict the structural transformation in Europe when one feeds a counterfactual sectoral productivity growth, and then use these counterfactual employment shares as weights to

Table 6: Counterfactual aggregate labor productivity if Europe had grown in each sector like the U.S. since 1970. (average annual per cent change difference relative to the U.S.)

	AUT	BEL	FRA	DEU	ITA	NLD	ESP	GBR	EUR	
Benchmark model: Gap relative to U.S.										
	-0.73	-0.78	-0.81	-0.51	0.31	-0.31	-0.33	-0.33	-0.30	
Counterfactual: Gap relative to U.S.										CF - Model (%)
agr	-0.73	-0.81	-0.61	-0.49	0.3	-0.33	0.03	-0.35	-0.24	20.0
man	-0.28	0.07	-0.39	-0.1	0.5	0.07	-0.18	-0.01	0.04	113.3
trd	-0.89	-1.13	-0.96	-0.68	-0.19	-0.44	-0.7	-0.6	-0.57	-90.0
fin	-0.75	-0.85	-0.88	-0.61	0.19	-0.36	-0.42	-0.39	-0.4	-33.3
bss	-0.76	-0.79	-0.95	-0.55	0.14	-0.42	-0.46	-0.14	-0.36	-20.0
trd + fin + bss	-0.91	-1.17	-1.1	-0.78	-0.37	-0.55	-0.82	-0.46	-0.64	-113.3
rst	-0.65	-0.75	-0.82	-0.54	0.21	-0.32	-0.41	-0.33	-0.34	-13.3
trs	-0.74	-0.79	-0.81	-0.45	0.26	-0.31	-0.36	-0.32	-0.31	-3.3
com	-0.73	-0.82	-0.77	-0.56	0.24	-0.34	-0.36	-0.33	-0.33	-10.0
res	-0.73	-0.8	-0.84	-0.52	0.26	-0.33	-0.38	-0.34	-0.34	-13.3
hlt	-0.73	-0.78	-0.76	-0.49	0.31	-0.29	-0.39	-0.25	-0.29	3.3
edu	-0.72	-0.77	-0.84	-0.52	0.27	-0.34	-0.37	-0.34	-0.33	-10.0
gov	-0.74	-0.8	-0.83	-0.49	0.26	-0.31	-0.39	-0.34	-0.33	-10.0
per	-0.71	-0.64	-0.75	-0.47	0.2	-0.37	-0.26	-0.28	-0.29	3.3

Notes: Table shows the results from the counterfactual numerical experiment where each European country grows at the pace of U.S. labor productivity in the indicated sector, for the period 1970–2009. Percentage change of the 2009 aggregate labor productivity level. Benchmark prediction vs. counterfactual.

compute the effect on the aggregate labor productivity growth gap with all the observed productivity paths, except for the counterfactual sector in question. Then, we compare these outcomes with our benchmark predictions for the average annual aggregate productivity growth gap.

Table 6 illustrates our findings. The first pattern we observe is that European countries would have had a more significant gap with respect to the U.S had they witnessed the American productivity growth in agriculture and manufacturing. We already know from the motivating facts presented in section 2 that the European countries did experience faster growth in agriculture and manufacturing. Notably, the more substantial decline would have happened if the European economies had had the American manufacturing productivity growth, in line with the notion of unconditional convergence in manufacturing supported by Rodrik (2013) and results in Duarte and Restuccia (2010).

Except for Great Britain in business services, every European country would have had a sizable improvement in its aggregate productivity growth had their progressive sectors grown at the American pace, thus contributing to closing the gap or making it more negative, especially in the case of wholesale and retail trade. For Europe as a whole, the average aggregate productivity growth gap would fall by 90% only by keeping the pace in trd. Hence, over the entire period, Europe would have converged at almost twice the speed in labor productivity if it had experienced the same labor productivity growth in wholesale and retail trade as in the U.S. The counterfactual also shows that the effect for financial and business services is substantial (33.3 % and 20% respectively), but it is a small fraction of the effect of whole sale and retail trade, which is valid for all countries. As Lewis (2005, p. 34) puts it, ”In the United States, wholesalers [. . .] began to consolidate their warehouses and improve the productivity of the operations in those warehouses. This change was the largest single contribution to the productivity acceleration in the U.S. economy in the late 1990s [. . .] not the efforts of Microsoft and Silicon Valley”.

Remarkably, among non-progressive services, Europe stands out with a positive contribution from productivity only in health and personal services. If these sectors grew with the counterfactual American productivity, the effects for Europe as a whole would be of rising the gap by 3.3%. These results are surprising in light of the motivating facts in section 2. We show that Europe had higher sectoral productivity growth than the U.S. not only in health and personal services but also in transportation, government, education, communication and real estate services. Despite these facts, our results show that if Europe had grown at the U.S. pace in each of the latter sectors, Europe would have converged faster with the U.S. In other words, if Europe had enjoyed lower labor productivity growth in non-progressive sectors, it would have converged more in aggregate labor productivity with the U.S. The latter is the result of general equilibrium effects affecting labor reallocation. These results showcase the importance of considering endogenous labor movements when performing sectoral counterfactual exercises.

6.2 Europe keeping pace with the U.S. since 1995

Our second counterfactual experiment asks what would have happened if Europe had continued with the U.S. labor productivity growth rates after 1995, when the convergence process came to a halt. We follow the same set of exercises from the previous section, with the only difference that the U.S. sectoral labor productivity growth rates that are counterfactually fed start in 1995 rather than in 1970.

Table 7 shows our findings for the falling behind period. We find that the market services play a key in accounting for the labor productivity growth gap. When combined, these sectors account for two-thirds of the gap since 1995. Looking at each market service sector individually, we find that Europe’s low labor productivity growth in wholesale and retail trade and business services can account for 40% and 30% of the gap, respectively. Hence, we see that business services gain a more prominent role in

Table 7: Counterfactual aggregate labor productivity if Europe had grown in each sector like the U.S. since 1995. (average annual per cent change difference relative to the U.S.)

	AUT	BEL	FRA	DEU	ITA	NLD	ESP	GBR	EUR	
Benchmark model: Gap relative to U.S.										
	0.13	0.86	0.49	0.16	1.53	0.51	1.77	-0.11	0.59	
Counterfactual: Gap relative to U.S.										CF - Model (%)
agr	0.2	0.79	0.6	0.31	1.35	0.43	1.59	-0.11	0.58	-1.7
man	0.36	1.06	0.55	0.35	1.02	0.5	1.57	0	0.57	-3.4
trd	-0.1	0.58	0.22	0.06	1	0.46	1.53	-0.23	0.35	-40.7
fin	0.17	0.89	0.44	-0.03	1.48	0.46	1.76	-0.06	0.51	-13.6
bss	0.07	0.62	0.33	-0.2	1.41	0.27	1.64	0	0.41	-30.5
trd + fin + bss	-0.1	0.4	0.07	-0.4	0.92	0.25	1.48	-0.07	0.2	-66.1
rst	0.12	0.84	0.44	0.09	1.42	0.44	1.58	-0.07	0.51	-13.6
trs	0.05	0.79	0.44	0.19	1.44	0.48	1.53	-0.14	0.51	-13.6
com	0.11	0.8	0.52	0.09	1.52	0.51	1.74	-0.06	0.55	-6.8
res	0.1	0.84	0.46	0.12	1.49	0.45	1.7	-0.13	0.53	-10.2
hlt	0.13	0.85	0.5	0.17	1.51	0.46	1.72	0	0.58	-1.7
edu	0.13	0.83	0.46	0.12	1.5	0.45	1.76	-0.12	0.54	-8.5
gov	0.12	0.85	0.48	0.14	1.51	0.49	1.74	-0.1	0.55	-6.8
per	0.16	0.93	0.57	0.16	1.47	0.5	1.74	-0.05	0.58	-1.7

Notes: Table shows the results from the counterfactual numerical experiment where each European country grows at the pace of U.S. labor productivity in the indicated sector, for the 1995–2009 period. Benchmark prediction vs. counterfactual.

aggregate productivity during the falling behind period, almost at the level of wholesale and retail trade.

Also noteworthy is that, in this counterfactual exercise, all sectors contribute to decreasing the labor productivity gap. One indeed expects a positive contribution to shortening the gap from sectors with labor productivity growing faster in the U.S. than in Europe, such as the case in market services. However, the result is puzzling for sectors that had higher labor productivity growth rates in Europe than in the U.S. For instance, during this period, Europe enjoyed faster labor productivity growth in transportation, health and personal services. Nonetheless, by way of general equilibrium effects that change the economy's sectoral composition, lower productivity growth in these sectors would have led to higher aggregate labor productivity growth in Europe. These results also highlight the importance of using our proposed general equilibrium framework to conduct counterfactual exercises.

To make the point that ignoring the general equilibrium amplification forces can lead to a sizable bias in aggregate labor productivity in counterfactual exercises, we show in the following subsection the quantitative role of structural transformation in our two counterfactual exercises.

Table 8: Counterfactual aggregate productivity growth differences between U.S. and Europe (average annual per cent change difference relative to the U.S.)

	Gap		
	Model CF (1)	Model CF Fixed Labor Shares (2)	% Difference (2)-(1)
1970–2009 period			
`trd`	-0.57	-0.56	-1.8
`fin`	-0.40	-0.36	-10.0
`bss`	-0.36	-0.33	-8.3
`trd` + `fin` + `bss`	-0.64	-0.64	0.0
1995–2009 period			
`trd`	0.35	0.38	8.6
`fin`	0.51	0.57	11.8
`bss`	0.41	0.46	12.2
`trd` + `fin` + `bss`	0.20	0.23	15.0

Notes: Table shows the counterfactual average labor productivity annual growth rate gap between the U.S. and Europe for the 1970–2009 and 1995–2009 periods. The first column shows the first counterfactual exercise of the benchmark model. The second column shows the first counterfactual exercise shutting down the endogenous labor reallocation mechanism in the model. The last column shows the percentage difference between columns 1 and 2.

6.3 The Role of Structural Transformation in Counterfactual Gaps

In our previous counterfactual exercises, as productivity changes, shifts in the sectors' employment shares occur endogenously due to substitution and income effects. This section shows what the sectoral productivity growth counterfactuals would look like if we had shut down the endogenous labor reallocation in our previous counterfactual exercises. Shutting down the labor reallocation in our counterfactual exercises essentially replicates what would be the counterfactual gaps predicted by shift-share and growth accounting methods.

Table 8 shows the predicted counterfactual gaps when fixing sectoral labor shares in both time periods. We conclude that in the counterfactual exercises performed using our benchmark model, labor allocation across sectors' response to changes in the sectoral relative productivity is substantial, particularly in financial and business services. Hence, one underestimates the effect of productivity gains in market services on aggregate productivity growth in Europe when one disregards structural transformation—approximately in 12% for financial and business services during the 1995–2009 period. Structural transformation provides a significant amplification force boosting aggregate labor productivity. Consequently, labor productivity counterfactual exercises that disregard general equilibrium effects on labor shares give biased estimates.

While we already find a sizable bias in our counterfactual exercises, we note that the bias can be more prominent for a higher counterfactual sectoral labor productivity rate because it leads to higher counterfactual aggregate income. The higher the counterfactual aggregate income, the stronger the labor reallocation movements will be and thus the size of the bias.

7 Conclusion

We propose a model of structural transformation in order to quantitatively study the labor productivity differences between Europe and the U.S . We use the model to perform counterfactual exercises in which Europe grows at the same rate as the U.S. in each sector. In line with previous literature, we find that wholesale and retail trade, business, and financial services were the sectors behind most of the lack of catch-up and decline in labor productivity, accounting for two-thirds of the gap since 1995. In contrast to the literature, we show that the endogenous labor reallocation across sectors significantly amplifies the quantitative role of these sectors in explaining labor productivity growth differences. Wholesale and retail trade has always employed a large share of labor, while business services have experienced an astonishing increase in their employment share throughout our analysis, especially in Europe. Our findings and the rising importance of market services in the economy reinforce that policies aiming at fostering aggregate labor productivity growth in European economies should focus on wholesale and retail trade, financial and business services.

The literature has pointed out some main challenges that need to be addressed in Europe to promote labor productivity growth in these sectors. One frequent challenge are the different regulations of the product, capital, and labor markets in the U.S. and in Europe (see e.g. McKinsey Global Institute (2002), Lewis (2005), Crafts (2006), Nicoletti and Scarpetta (2003) and Cette, Lopez, and Mairesse (2016)). Another challenge to close the productivity growth gap in these sectors had been identified in differences in ICT diffusion in Europe relative to the U.S. (see e.g. van Ark et al. (2003), Inklaar, Timmer, and van Ark (2008), M. P. Timmer et al. (2011), and Bloom, Sadun, and Van Reenen (2012)). Our paper shows that addressing these challenges yields a significant payoff in closing the European countries' aggregate labor productivity gap with the U.S. because of general equilibrium amplification effects that allocate more labor towards high-productivity-growth market services.

References

Aguiar, M., & Bils, M. (2015). Has Consumption Inequality Mirrored Income Inequality? *American Economic Review*, *105*(9), 2725–2756.

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

Bloom, N., Sadun, R., & Van Reenen, J. (2012). Americans Do IT Better: US Multinationals and the Productivity Miracle. *American Economic Review*, *102*(1), 167–201.

Boppart, T. (2014). Structural Change and the Kaldor Facts in a Growth Model with Relative Price Effects and Non-Gorman Preferences. *Econometrica*, *82*(6), 2167–2196.

Buera, F. J., & Kaboski, J. P. (2009). Can Traditional Theories of Structural Change Fit the Data? *Journal of the European Economic Association*, *7*(2-3), 469–477.

Buera, F. J., & Kaboski, J. P. (2012). The rise of the Service Economy. *American Economic Review*, *102*(6), 2540-2569.

Cette, G., Lopez, J., & Mairesse, J. (2016). Market Regulations, Prices, and Productivity. *American Economic Review*, *106*(5), 104—108.

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

Crafts, N. (2006). Regulation and Productivity Performance. *Oxford Review of Economic Policy*, *22*(2), 186–202.

Duarte, M., & Restuccia, D. (2010). The Role of the Structural Transformation in Aggregate Productivity. *Quarterly Journal of Economics*, *125*(1), 129–173.

Duernecker, G., Herrendorf, B., & Valentinyi, A. (2019). Structural Change within the Service Sector and the Future of Cost Disease. *Unpublished Manuscript*.

Ferreira, P. C., & Silva, L. F. d. (2014). Structural Transformation and Productivity in Latin America. *Economics Working Papers, EPGE, Getulio Vargas Foundation*.

Herrendorf, B., Rogerson, R., & Valentinyi, A. (2013). Two Perspectives on Preferences and Structural Transformation. *American Economic Review*, *103*(7), 2752–2789.

Herrendorf, B., Rogerson, R., & Valentinyi, A. (2014). Growth and Structural Transformation. In *Handbook of Economic Growth* (Vol. 2, p. 855-941). Elsevier.

Inklaar, R., Timmer, M. P., & van Ark, B. (2008). Market services productivity across europe and the us. *Economic Policy*, *23*(53), 140–194.

Jorgenson, D. W. (2012, Fall). The World KLEMS Initiative. *International Productivity Monitor*, *24*, 5-19.

Kongsamut, P., Rebelo, S., & Xie, D. (2001). Beyond Balanced Growth. *The Review of Economic Studies*, *68*(4), 869–882.

Kuznets, S. (1957). Quantitative Aspects of the Economic Growth of Nations: Ii. Industrial Distribution of National Product and Labor Force. *Economic Development and Cultural Change*, 1–111.

Lewis, W. W. (2005). *The Power of Productivity: Wealth, Poverty, and the Threat to Global Stability*. University of Chicago Press.

Matsuyama, K. (2008). Structural Change. In S. N. Durlauf & L. E. Blume (Eds.), *The New Palgrave Dictionary of Economics* (Vol. 2). New York: Palgrave Macmillan.

McKinsey Global Institute. (2002). *Reaching higher productivity growth in france and germany— retail trade sector.* Washington, DC.

Ngai, L. R., & Pissarides, C. A. (2007). Structural Change in a Multisector Model of Growth. *The American Economic Review*, 429–443.

Nicoletti, G., & Scarpetta, S. (2003). Regulation, Productivity and Growth: OECD Evidence. *Economic Policy*, *18*(36), 9—72.

O'Mahony, M., & Timmer, M. P. (2009). Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database. *The Economic Journal*, *119*(538), F374–F403.

Rodrik, D. (2013). Unconditional Convergence in Manufacturing. *The Quarterly Journal of Economics*, *128*(1), 165–204.

Timmer, M., de Vries, G. J., & De Vries, K. (2015). Patterns of structural change in developing countries. In *Routledge handbook of industry and development* (pp. 79–97). Routledge.

Timmer, M. P., Inklaar, R., O'Mahony, M., & Van Ark, B. (2011). Productivity and economic growth in europe: A comparative industry perspective. *International Productivity Monitor*(21), 3.

van Ark, B., Inklaar, R., & McGuckin, R. H. (2003). Ict and productivity in europe and the united states where do the differences come from? *CESifo Economic Studies*, *49*(3), 295–318.

van Ark, B., O'Mahony, M., & Timmer, M. P. (2008). The Productivity Gap between Europe and the United States: Trends and Causes. *Journal of Economic Perspectives*, *22*(1), 25–44.

Appendix

A Calibration Algorithm

With parameter values for each $\Omega_{i\in I}$ obtained using the initial sectorial employment shares, we use the relative sectoral labor demands for the last period of the U.S. data (2009) using equation (14), namely

$$\log\left(\frac{l_{i,t=2009}}{l_{m,t=2009}}\right) = \log\left(\frac{\Omega_i}{\Omega_m}\right) + (1-\sigma)\log\left(\frac{p_{i,t=2009}}{p_{m,t=2009}}\right) + (1-\sigma)(\epsilon_i - 1)\log\left(\frac{E_{t=2009}}{p_{m,t=2009}}\right) + (\epsilon_i - 1)\log\left(\frac{\omega_{m,t=2009}}{\Omega_m}\right). \tag{A.1}$$

From World KLEMs, one can obtain data to construct sectoral labor demand relative to manufacturing, $\frac{l_{i,t=2009}}{l_{m,t=2009}}$, sectoral prices relative to manufacturing, $\frac{p_{i,t=2009}}{p_{m,t=2009}}$, total nominal expenditures relative to manufacturing prices, $\frac{E_{t=2009}}{p_{m,t=2009}}$, and the manufacturing expenditure share, $\omega_{m,t=2009}$. With these data, we employ the following algorithm to obtain parameter values for σ and each ϵ_i:[15]

1. Select from a discrete grid an arbitrary income elasticity for agriculture .
2. Obtain a value for σ that minimizes the squared residual using equation A.1 for agriculture relative to manufacturing.
3. Conditional of the value for σ obtained in step 2, obtain values for rest of income elasticities $\epsilon_{i\in I, i\neq\{a,m\}}$ minimizing the squared residuals from equation A.1 in each sector relative to manufacturing, storing all the squared residuals.
4. Sum the squared residuals obtained in each sector.
5. Iterate the process with alternative values for ϵ_a and find the tuple $\{\sigma, \epsilon_{i\in I, i\neq m}\}$ that minimize the sum of squared residuals across sectors.

[15] We impose the following parametric restrictions: $\epsilon_a < \epsilon_m = 1$, $\sigma < 1$. These restrictions keep the parametric space empirically relevant in the literature.

B Model Predictions for Aggregate Productivity in Europe

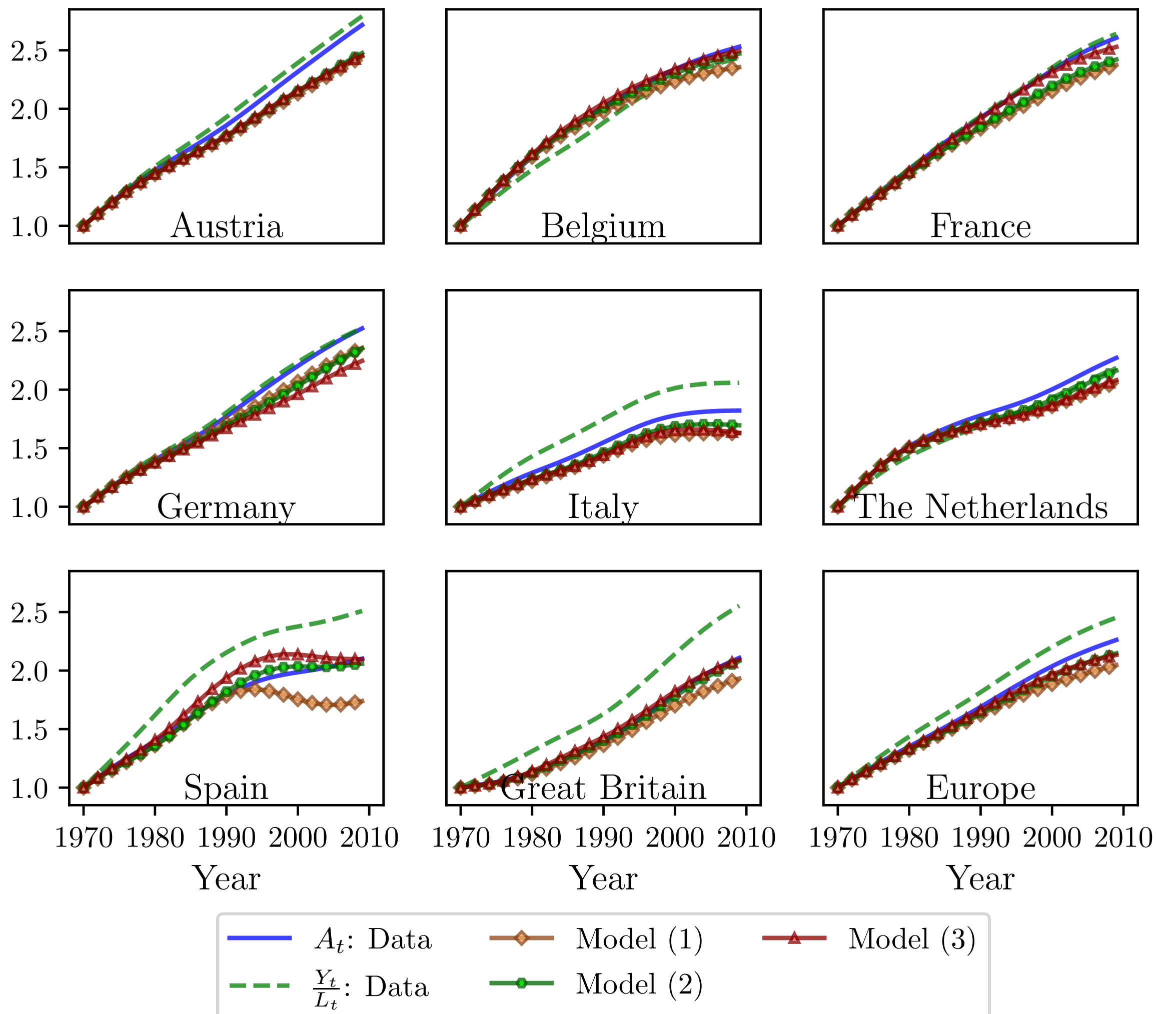


Figure B.1: Aggregate labor productivity in Europe. 1970–2009. Model predictions vs. data