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Structural Change within the Services Sector, Baumol's Cost Disease, and Cross-Country Productivity Differences*

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Abstract

I analyze structural change within the services sector and its implications for Baumol's cost disease and cross-country productivity differences. My results show that Baumol's cost disease becomes less relevant over development: It generates minor declines on aggregate productivity growth rate and accounts for a small share of the productivity growth slowdown. I argue that the existence of services sub-sectors with high-productivity growth rates, *progressive services*, and their substitutability with other sectors in the economy rationalize these facts. A model consistent with these stylized facts predict that Baumol's cost disease would depress aggregate productivity growth rate less in the future for developed countries. I later analyze cross-country productivity differences. The results in Duarte and Restuccia (2010) hide discrepancies between different services sub-sectors: Although developed countries have caught-up the US in the low-productivity growth services sub-sectors, *stagnant services*, the opposite conclusions emerge for the progressive/business services. I conclude that the substitutability between progressive/business and stagnant services sectors contribute to increasing aggregate productivity differences between the US and other developed countries. To put differently, structural change facts that limit Baumol's cost disease also advance cross-country productivity differences.

JEL Classification: O41, O47, O57, E01
Keywords: structural change, services, Baumol's cost disease, aggregate productivity.

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1 Introduction

In 1967 William Baumol observed that the services had the lowest productivity growth rate among broad sectors of the economy. Because of its low productivity growth, the relative price of the services sector had been rising, so had been its share in total economy. Because of this structural change toward the services sector aggregate productivity would resemble more and more the productivity in the services. But Baumol's prediction was bleak: Since productivity in fact did not grow in the services sector, aggregate productivity growth rate would decline, and eventually settle to zero. After the publication of his paper more than fifty years ago, the gloomy vision of William Baumol still troubles the economists. Some even wonder whether recent productivity growth slowdown in developed countries marks the fulfillment of his predictions. Baumol (1967) is not the only work that links economic growth to structural change. More recently, Duarte and Restuccia (2010) point that for productivity growth in the services developed countries perform inferiorly with respect to the US, and the rise of this sector explains why aggregate productivity differences between the US and other countries have increased recently. Both these works mark the significance of the services sector for understanding aggregate productivity.

Yet the services sector, in terms of productivity growth, consists of highly heterogenous sub-units: Low productivity growth services sub-sectors, such as hotels and restaurants, coexist with high productivity growth ones, such as wholesale and retail trade. It would not be wrong to argue that for developed countries characterized by a high share of the services today (as far as 2019 is concerned, 80% of total economy for the US and the UK; for other developed countries the number is similar) it is the structural change between these diverse subgroups within the services but not that among agriculture, industry and services that shapes aggregate productivity. Although the literature has long recognized the heterogenous makeup of the services (Jorgenson and Timmer (2011), Duarte and Restuccia (2019), Buera et al. (2019), Duernecker, Herrendorf and Valentinyi (2019), Barany and Siegel (2019) among others), it is difficult to say that commonly-applied and -accepted structural change facts exist for this sector. Comparative studies of structural change that specifically target the services are also scarce. This research aims to fill these gaps in the literature. I approach the heterogeneity in the services from a productivity-growth perspective: I identify common high- and low-productivity growth services sectors across countries and analyze structural change facts based on them. My analysis

reveals that the heterogeneity and structural change within the services sector have dramatic consequences for cross-country productivity differences and aggregate productivity growth.

For each country I identify the services sub-sectors with high-productivity growth as the ones that display a productivity growth rate greater than the aggregate services, and the services sub-sectors with low-productivity growth as the ones that display a productivity growth rate lower than aggregate. To distinguish common high-productivity growth services sub-sectors across countries I restrict my attention to services sub-sectors that satisfy above-average productivity growth criteria for the largest number of countries. Four services sub-sectors (wholesale and retail trade; transport and storage, post and telecommunications; financial intermediation) turn out to satisfy this criteria: Each one belongs to the high-productivity growth group for at least 80% of the countries in my sample, and for 75% of them these four services sectors rank among the five highest productivity growth services sectors. Borrowing the terminology in Baumol et al. (1985), I name the high-productivity growth services sectors as *progressive* and low-productivity growth services sectors as *stagnant*.

I later analyze structural change within the services sector through the lens of these new services categories. For most countries the share of progressive services sectors remains remarkably stable around $25 - 33\%$ of the aggregate economy. Indeed, panel-data evidence suggests that the share of progressive services within total services will show a U-shaped pattern over development. Both facts imply that a non-trivial lower bound exists for the share of progressive services within total services - this result would constitute my principal argument against Baumol's cost disease.

I quantify the effects of Baumol's cost disease on productivity growth. For the period between 1970 and 2015, Baumol's cost disease decreases the aggregate productivity growth on average 0.4 percentage points and accounts for 20% of the productivity growth slowdown. These numbers hide considerable contrasts among developed countries - however, what emerges from this accounting exercise is that Baumol's cost disease becomes less relevant over development. More specifically, it reduces productivity growth rate less and accounts for a small share of the productivity growth slowdown.

To assess the future effects of Baumol's cost disease I construct a multi-sector general equilibrium model with structural change. In the model I distinguish progressive and stagnant services sectors, and to be consistent with the stylized facts I document I represent the household pref-

erences with a nested nonhomothetic-CES utility specification consisting of two layers. In the outer layer the consumer allocates between progressive services and the rest of the economy; in the inner layer a separate allocation problem exists between goods and stagnant services. The elasticities of substitution that govern allocation problems differ between the outer and inner layers; the parameters that govern the income effects also differ across sectors. A key feature of the model is the persistent income effects needed to simulate long-term aggregate productivity growth rates. For each country my calibration results confirm that the progressive services are substitutes with other sectors in the economy.

I next simulate the model under certain scenarios. The model predicts that Baumol's cost disease would depress aggregate productivity growth less than it did in the past for almost every country. For a typical country the predicted productivity growth slowdown for the next 60 years is usually half of that observed from 1970-1995 to 1995-2015. My results remain robust across different datasets and modelling assumptions.

I later turn my attention to cross-country productivity differences. The results in Duarte and Restuccia (2010) mask considerable contrasts within the services sector: Although the US exhibits a greater productivity growth rate than other developed countries in the progressive/business services sector, many of them surpass the US in the stagnant services. The progressive/business services sector accounts for aggregate productivity growth revivals observed in most developed countries during the 1990's. In addition to this, the rise of the productivity growth in this services sub-group coincides with its increasing share within total services. These facts motivate that the progressive/business and the stagnant services could be substitutes, and considering the productivity growth differences between the US and other countries across these services sub-groups, structural change within the services sector might also contribute to cross-country differences.

To examine the sectoral sources of cross-country productivity differences and the role of structural change in shaping them, I consider a simplified version of the model I use in the first part of the paper. The calibrated relative productivity levels display distinct patterns across two services groups. Developed countries overtake the US in the stagnant services sector; regarding the catch-up, their behavior is closer to goods than aggregate services. It is indeed the progressive/business services sector that prompts the declines in aggregate relative productivity: For a typical country in the end year of my study, 2007, the relative productivity in this services

sub-sector is usually half of that in the stagnant services. In the counterfactuals where countries showed a productivity growth rate in the progressive/business services so that their relative productivity levels were equalized between two services sub-sectors at the end year of the study, I observe that all declines in the aggregate relative productivity are overturned.

To situate these results in a context, one should consider what Baumol's cost disease implies for cross-country productivity differences. If productivity growth in the US -the frontier country- had been converging to zero because of structural change, and since other countries would follow the US with a lag, productivity differences between the US and other countries would decline over time. In the limit Baumol's cost disease implies *absolute convergence*, where all countries would share the same productivity level. Under the light of this result, the declines in aggregate relative productivity that started universally in the 1990's pose a puzzle. I explain this puzzle by showing that it is not the complementarity but substitutability that characterizes structural change within the services. The declines in aggregate relative productivity are not temporary, but pointing a rather permanent phenomenon.

The substitutability between the progressive/business and stagnant services sectors indeed point a more fundamental distinction: Although stagnant services sub-sectors are almost exclusively related to final consumption, the output of progressive/business services sub-sectors is predominantly used as intermediate and investment. We could consider the substitutability between these two sub-sectors as the evidence that the part of the services sector more related to the production becomes more seminal over time. This in part might explain why a Baumol's cost disease perspective is not adequate for understanding structural change within the services, since the analysis of Baumol exclusively focuses upon consumption and overlooks that intermediate/investment demand could also affect structural change.

In a nutshell, my research shows that the heterogeneity matters for the services. I argue that the substitutability between high- and low-productivity growth services sectors commonly holds across countries and the lesser effects of Baumols cost disease on future productivity growth is not a fact limited to the US only. My results show, contrary to popular opinion, not only productivity growth performance of the US in certain services sub-sectors but also structural change within the services drive productivity differences between the US and other developed countries. Any approach based on only productivity-growth would struggle to explain why the reversals in aggregate relative productivity persist despite the lackluster productivity growth

performance of the US after 2007.

This paper consists of two different parts. The first part relates to Baumol's cost disease, and the second part to cross-country productivity differences. The next section discusses the relevant literature. The third section presents the facts on structural change within the services sector, Baumol's cost disease, and aggregate/sectoral productivity comparisons among countries. The fourth and fifth sections are devoted to the modeling of Baumol's cost disease and its quantitative analysis. The sixth section introduces a structural change model for cross-country productivity differences; the seventh section consists of the calibration of this model and the counterfactual results. The last section concludes.

2 Relevant Literature

This paper is most related to the literature that associates the changes in aggregate productivity to structural change: Duernecker, Herrendorf, and Valentinyi (2019); Duarte and Restuccia (2010, 2019); and Buiatti, Duarte, and Saenz (2018) are the closest works to this research. By distinguishing high- and low-productivity growth services sectors, Duernecker, Herrendorf, and Valentinyi (2019) study the future effects of Baumol's cost disease for aggregate productivity growth in the US. They argue that the substitutability between high- and low-productivity growth services sectors would limit productivity growth-slowdown in the US. I extend their work by showing that the substitutability within the services sector is a common property of structural change in developed countries, and this fact would restrain Baumol's cost disease for them as well in the future. I also show that the structural change facts in the services sector that limit productivity growth slowdown in the US also account for increasing aggregate productivity differences between him and other developed countries. I therefore link Duernecker, Herrendorf and Valentinyi (2019) to Duarte and Restuccia (2010).

I extend Duarte and Restuccia (2010) by considering the services sector at a more disaggregated level. Their companion paper to this work, Duarte and Restuccia (2019), also analyzes the services sector at a more disaggregated level by differentiating modern and traditional services sectors. Although it looks natural to associate modern and traditional services with progressive/business and stagnant services, the classification of the services sub-sectors in Duarte and Restuccia (2019) refers to the final consumption categories. Since the services sub-sectors I analyze in this work relate to value-added, it is not clear how to link them. For some services

sub-sectors considered in this study -for example, business services or wholesale and retail trade- no close counterparts in the final consumption exist. The relative price of a final consumption product does not always reflect productivity differences across sectors and countries.[1]

The closest work to my paper is Buatti, Duarte, and Saenz (2018). They also extend Duarte and Restuccia (2010) by considering the services sector at a more disaggregated level. I confirm their main result that business services and wholesale and retail trade are the two services sub-sectors that contrbiute most the aggregate productivity differences between the US and West European countries. Differently from them, this work also analyzes Baumol's cost disease and structural change within the services sector. For the cross-country productivity differences part, my study covers more countries and comes as close as to 2015, while theirs end in 2007. As we shall see, the revised dataset that becomes available with the recent releases of WORLD KLEMS implies smaller differences between the US and other developed countries in progressive and business services sub-sectors than what the previous datasets suggest. I therefore conclude that the revised data endorses more the view that structural change within the services sector drives cross-country productivity differences.

My work is also related to the literature that goes beyond the classical trichotomy among agriculture, industry and services and notices large productivity-growth differences among services sub-sectors: Baumol et al. (1985) and Jorgenson and Timmer (2011) are two prominent examples of this literature. Nordhaus (2008), Hartwig (2011), and Imbs (2017) test the implications of Baumol's cost disease for developed countries. Despite our common goal of quantifying Baumol's cost disease, my study differs from them methodologically.

3 Facts

This section presents the facts on the categorization of services sub-sectors, structural change with respect to these categories, Baumol's cost disease and productivity differences across countries at the aggregate and sectoral levels.

[1] Their original paper Duarte and Restuccia (2010) puts this fact plainly.

Table 1: List of Services Sub-Sectors according to the ISIC Rev. 3.1.

ISIC Code	Name of Services Sub-Sector
G	Wholesale and Retail Trade
H	Hotels and Restaurants
60t63	Transport and Storage
64	Post and Telecommunications
J	Financial Intermediation
70	Real Estate Activities
71t74	Renting of Machinery and Equipment and Other Business Activities
L	Public Administration and National Defense; Compulsory Social Security
M	Education
N	Health and Social Work
O	Other Community, Social, and Personal Services

Source: WORLD KLEMS

3.1 Classification of Services Sub-Sectors

This sub-section discusses the classification of services sub-sectors with respect to productivity growth. For a detailed discussion about data description and sources I refer the reader to the Appendix A.

Table 1 displays the list of two-digits service sub-sectors, compatible with the ISIC Rev. 3.1. classification system, considered in this study.[2] For each country I calculate labor productivity growth rate between 1970 and 2007 for the aggregate services. Since the data for real variables in the KLEMS database are not additive, I construct a Tornqvist index for aggregating labor productivity growth rates of different service sub-sectors based on the following formula:

[2]Throughout the text I refer to "Renting of Machinery and Equipment and Other Business Activities" as "Business Services", and "Public Administration and National Defense; Compulsory Social Security" as "Public Administration"

$$\Delta \ln LP_{st} = \left[\frac{S_{i,t} + S_{i,t-1}}{2}\right] \Delta \ln LP_{i,t} + \left[\frac{S_{i,t} + S_{i,t-1}}{2} - \frac{H_{i,t} + H_{i,t-1}}{2}\right] \Delta \ln HEMP_{i,t} \qquad (1)$$

where $\Delta \ln LP_{st} \equiv \ln LP_{st} - \ln LP_{s,t-1}$ is the change in labor productivity in the aggregate services from $t-1$ to t, $S_{i,t} \equiv \frac{VA_{i,t}}{\sum VA_{i,t}}$ is the share of the services sub-sector i in the aggregate services nominal value added, $H_{i,t} \equiv \frac{HEMP_{i,t}}{\sum HEMP_{i,t}}$ is the share of the services sub-sector i in total number of hours worked in the aggregate services, $\Delta \ln LP_{i,t} \equiv \ln LP_{i,t} - \ln LP_{i,t-1}$ is the change in labor productivity for the services sub-sector i from $t-1$ to t and $\Delta \ln HEMP_{i,t} \equiv \ln HEMP_{i,t} - \ln HEMP_{i,t-1}$ is the change in the number of hours worked for the services sub-sector i. s stands for the aggregate services. The second term in the equation refers to the increases in labor productivity because of the movement of labor from the sectors with low-nominal-productivity to the ones with high-nominal-productivity. Labor productivity growth is measured according to the following formula.

$$\ln LP_{i,t} = \ln RVA_{i,t} - \ln HEMP_{i,t} \qquad (2)$$

where RVA_{it} is the real value added and $HEMP_{i,t}$ is labor input in sub-sector i. In the WORLD KLEMS, the real value added is the nominal value added at constant prices and approximates changes in the quantity. The labor input is measured as the number of hours worked by people engaged.

In this study I abstract from the changes in labor quality and opt for a raw measure of labor input. This choice reflects a necessity: For most countries long-term data measuring labor quality changes does not exist at the sectoral level we consider. Although accounting for the labor quality is preferable, it is not an innocuous assumption in such a cross-country study. As we shall see, developed countries have actually caught up the US in the stagnant services sector that consists of mostly skill-intensive sub-sectors. If improvements in labor quality stand behind this result, incorporating them would lead to different conclusions. I nevertheless believe that the part played by the labor quality for the productivity catch-ups should be addressed in future studies, as long as one can overcome data constraints.

Table 2 presents the average labor productivity growth rates for the services sub-sectors and the aggregate services for all countries in my sample; and Table 3 shows whether a services

sub-sector displays a productivity growth rate greater than the aggregate services for a particular country. Tables $2-3$ confirm the heterogeneous makeup of the services sector from a productivity-growth perspective: The services sub-sectors with almost zero-productivity growth, such as Hotels and Restaurants, co-exist with the services sub-sectors with very high productivity growth rates, such as Post and Telecommunications. These results reinforce the observations of Jorgenson and Timmer (2011) and Baumol et al. (1985) concerning the productivity-growth heterogeneity within the services. Table 2 also shows considerable productivity growth differences across countries that cannot be simply accounted for by development levels.

Table 3 presents a clear picture about high- and low-productivity growth services sub-sectors: Wholesale and Retail Trade; Transport and Storage; Telecommunications and Postage; and Financial Intermediation stand out from the rest in terms of productivity growth performance. These services sub-sectors display a productivity growth rate greater than the aggregate services for at least 81% of the countries in my sample. For 71% of the countries they also rank among the five services sub-sectors with highest productivity growth rate. In any country the services sub-sectors different from these four ones could also display above average productivity growth (perhaps related to transition dynamics, since our time coverage is short and the sample consists of countries at different stages of development). To address this concern, I define high-productivity growth services sub-sectors as the ones that satisfy the criteria of the above-average productivity growth for the largest number of countries. The four services sub-sectors I identify are clearly the only ones that pass this test; in some countries -such as Australia, Austria, Korea, Spain, Sweden- they are the only services sub-sectors that display above-average productivity growth.[3] Borrowing the terminology of Baumol et al. (1985) I name these four services sub-sectors *progressive services* and the remaining services sub-sectors *stagnant services*. Table 4 summarizes this categorization. In the remainder of the text I use these names to refer to high- and low-productivity services sub-sectors.

[3]It is interesting to compare these four with the services sub-sector that comes closest to them, Public Administration. This services sub-sector displays an above-average productivity growth for only less than 30% of the countries in my sample.

Table 2: Labor Productivity Growth Rates for Services Sub-Sectors (1970-2007)

Country	Wholesale and Retail Trade	Hotels and Restaurants	Transport and Storage	Post and Tele-communications	Financial Intermediation	Real Estate Activities	Business Services	Public Administration	Education	Health and Social Work	Other Services	Aggregate Services
Australia	1.68	0.29	2.03	5.41	1.60	0.21	-0.53	0.46	-0.24	0.48	0.53	**0.98**
Austria	2.48	1.15	2.32	5.73	1.83	0.80	0.53	0.93	0.67	0.26	-0.29	**1.52**
Belgium	1.32	1.01	2.12	4.19	2.25	0.91	1.81	0.90	1.16	0.16	2.11	**1.51**
Canada	2.51	-0.30	1.76	3.47	2.07	1.53	0.93	1.06	0.69	0.57	0.56	**1.21**
Denmark	2.59	-0.61	1.61	5.03	3.59	-1.13	1.55	0.52	0.55	0.50	0.48	**1.35**
Finland	3.02	0.82	2.18	6.77	4.16	1.49	-0.50	0.30	0.30	-0.59	0.57	**1.55**
France	2.94	-0.15	3.12	6.67	1.83	2.05	0.60	1.57	0.33	0.47	0.56	**1.79**
Germany	2.38	-0.24	3.34	4.88	2.02	1.21	1.03	2.68	0.56	1.08	0.57	**2.13**
Greece	0.40	-0.12	5.04	4.87	2.30	-1.68	0.30	-0.06	-0.93	-0.06	0.60	**0.95**
Ireland	3.35	0.17	0.99	5.12	1.10	-1.82	-1.18	0.17	1.41	2.12	1.65	**1.78**
Italy	1.48	-0.95	1.84	4.23	-0.18	-1.08	-2.31	0.93	0.25	0.80	-0.06	**0.67**
Japan	3.76	1.48	1.41	6.51	3.66	0.20	1.44	2.96	0.97	0.78	0.63	**2.23**
Korea	2.93	2.69	4.51	11.36	8.43	-5.17	0.36	-1.18	-0.43	2.59	2.05	**2.84**
Luxembourg	2.67	0.56	3.99	6.69	6.02	3.35	4.01	2.00	2.09	3.28	-0.48	**3.42**
Netherlands	2.93	0.58	2.24	5.33	2.75	1.36	0.83	2.15	0.31	0.61	-0.98	**1.73**
Norway	4.98	-1.10	2.70	6.83	1.36	-3.34	1.10	1.41	0.71	0.52	0.68	**2.11**
Portugal	1.68	2.40	3.70	8.11	6.48	4.22	-0.88	3.33	3.76	3.23	0.50	**2.71**
Spain	1.14	-0.06	2.98	5.33	2.23	-1.15	-0.61	-0.22	0.58	-0.66	-0.42	**0.78**
Sweden	2.44	-0.02	1.94	5.07	1.27	-0.20	-0.37	0.28	0.09	0.02	0.33	**1.03**
UK	1.83	-0.04	2.80	5.82	1.67	-1.32	2.49	0.05	-0.14	1.05	0.72	**1.37**
USA	3.79	0.23	2.47	5.08	3.19	0.00	1.46	2.01	0.08	-0.01	-0.20	**1.66**
Max	4.98	2.69	5.04	11.36	8.43	4.22	4.01	3.33	3.76	3.28	2.11	**3.42**
Min	0.40	-1.10	0.99	3.47	-0.18	-5.17	-2.31	-1.18	-0.93	-0.66	-0.98	**0.67**
Mean	2.49	0.37	2.62	5.83	2.84	0.02	0.57	1.06	0.61	0.82	0.48	**1.68**
Median	2.51	0.17	2.32	5.33	2.23	0.20	0.60	0.93	0.55	0.52	0.56	**1.55**

Source: WORLD KLEMS, OECD STAN and my calculations

Table 3: Services Sub-Sectors with High-Productivity Growth (1970-2007)

Country	Wholesale and Retail Trade	Hotels and Restaurants	Transport and Storage	Post and Tele-communications	Financial Intermediation	Real Estate Activities	Business Services	Public Administration	Education	Health and Social Work	Other Services
Australia	■		■	■	■						
Austria	■		■	■	■						
Belgium			■	■	■		■				■
Canada	■		■	■	■	■					
Denmark	■		■	■	■		■				
Finland	■		■	■	■						
France	■		■	■	■	■					
Germany	■		■	■				■			
Greece			■	■	■					■	
Ireland	■			■							
Italy	■		■	■				■		■	
Japan	■			■	■			■			
Korea	■		■	■	■						
Luxembourg			■	■	■		■			■	
Netherlands	■		■	■	■			■			
Norway	■		■	■							
Portugal			■	■	■	■		■	■	■	
Spain	■		■	■	■						
Sweden	■		■	■	■						
UK	■		■	■	■		■				
USA	■		■	■	■			■			
Total	17	**0**	**19**	**21**	**17**	**3**	**4**	**6**	**1**	**4**	**1**
Percentage	**80.95%**	**0.00%**	**90.48%**	**100%**	**80.95%**	**14.29%**	**19.05%**	**28.57%**	**4.76%**	**19.05%**	**4.76%**

Source: WORLD KLEMS, OECD STAN and my calculations. Black square indicates whether a services sub-sector displays a productivity growth rate greater than that of the average services within a country.

One fundamental distinction between the progressive and stagnant services is the differences in their final uses. While progressive services predominantly relate to the production side of the economy -they provide intermediate and capital to other sectors-, stagnant services almost exclusively bear upon the consumption side. For a typical stagnant services sub-sector, more than 90% of its output serves to final consumption. Business Services, and to a certain extent Real Estate, differs from the rest of stagnant services in the sense that its output is used predominately as intermediate and capital. This point may seem trivial, but differences in output use implicates different results for aggregate productivity growth: Oulton (2001) shows that, as long as they display non-negative productivity growth, the rise of services sub-sectors that are used as intermediate would *actually* increase aggregate productivity growth rate. The Business Services sub-sector has an increasing share and relative price; however, the rise of this service category does not reflect the complementarity among consumption goods, but rather a choice between producing in-house (value added) and outsourcing (intermediate goods). Although throughout the text I maintain the assumption that the different services sub-sectors only produce different types of consumption goods, with respect to their implications for productivity growth I feel the difference between Business Services and other stagnant services sub-sectors should be stressed. As we shall see, structural change facts for the services sector look encouraging for the Oulton's argument.

How does my categorization of progressive and stagnant services sectors compare with other splits used in the literature? I previously argue that because of the value-added approach I opt for in this study, it is difficult to associate the modern/traditional services split favored by Duarte and Restuccia (2019) with my categorization of the services sectors. Duernecker, Herrendorf, and Valentinyi (2019) consider the progressive and stagnant services for the US. Although they analyze the services sub-sectors at a more disaggregated level, matching their services sub-sectors to more aggregate ones considered in this paper shows that their definition of progressive/stagnant services sectors largely overlaps with mine. The only departure is the Business Services: although this sub-sector belongs to the progressive services sector for the US, it is hardly the case for other developed countries. As I argue previously, in terms of the final output use the Business Services are closer to the progressive services, and the rise of this sub-sector suggests different results for productivity growth. Under the light of this evidence, treating this services sub-sector with other progressive services sub-sector is a natural

Table 4: Categorization of Services Sub-Sectors

	ISIC Rev. 3.1
Progressive Services	Wholesale and Retail Trade
	Transport and Storage
	Post and Telecommunications
	Financial Intermediation
Stagnant Services	Hotels and Restaurants
	Real Estate Activities
	Renting of Machinery and Equipment and Other Business Activities
	Public Administration and National Defense; Compulsory Social Security
	Education
	Health and Social Work
	Other Community, Social, and Personal Services

starting point for comparative analysis of productivity. I therefore consider the split between the progressive/business services sector and the remaining stagnant services sub-sectors in the second part of the paper where I study productivity differences between the US and other countries.

Appendix B provides additional robustness checks for the categorization of services sub-sectors.

3.2 Structural Change within the Services Sector

My objective in this sub-section is to provide new structural change facts for developed countries characterized by a high share of the services sector today. In other words, I want to extend the findings on structural change among broad sectors of the economy (agriculture, industry, and services) by Herrendorf, Rogerson, and Valentinyi (2014), Kuznets (1971), and Maddison (1980) to the services. In this regard, my motivation takes after Jorgenson and Timmer (2011). To avoid repetition and maintain a certain format in reporting the results, I document individual structural change facts only for the US. Appendix C also reports the results for 15 OECD countries for which I have longer data series. I report the results only for nominal value added.[4]

Table 5: Productivity Growth Rates: US, 1947-2007

Aggregate	Goods	Services	Progressive Services	Stagnant Services
1.93	2.86	1.35	3.12	0.33

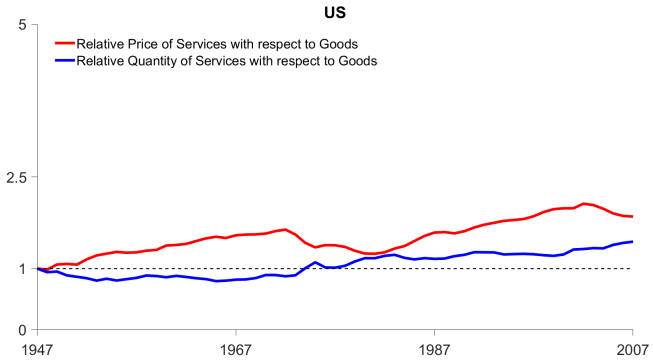
Source: WORLD KLEMS and my calculations.

For a typical country the progressive services sector exhibits a productivity growth rate comparable to the goods sector, sometimes even greater: Between 1970 and 2007 the median ratio of the average productivity growth rate in the progressive services to that in the goods is 0.89 in my sample. Likewise, the productivity growth rate in the progressive services sector is on average 2.29 percentage points greater than that in the stagnant services sector. Table 5 presents productivity growth rates of sectoral aggregates for the US between 1947 and 2007. In addition, Figure 1 demonstrates the behavior of relative prices and quantities across sectors for the US

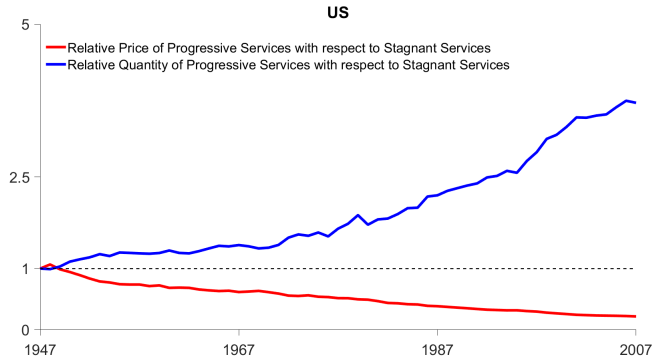
[4]To properly aggregate productivity I have to account for both nominal value added and hours worked shares. Since structural change facts for the services sector do not vary much with respect to these two measures, I decide to concentrate on nominal value added.

in the post-WWII period. While the relative quantity of the progressive services with respect to the stagnant services sector increases over time, its relative price decreases monotonically. In terms of relative prices the progressive services and the goods sectors usually exhibit close patterns; for the US, the relative price of the progressive services with respect to the goods sector decreases since 1969. It is worth noting that the increase in the relative quantity of the aggregate services with respect to the goods is mostly driven by the progressive services, and it is the stagnant services that drive the relative price of total services against goods.

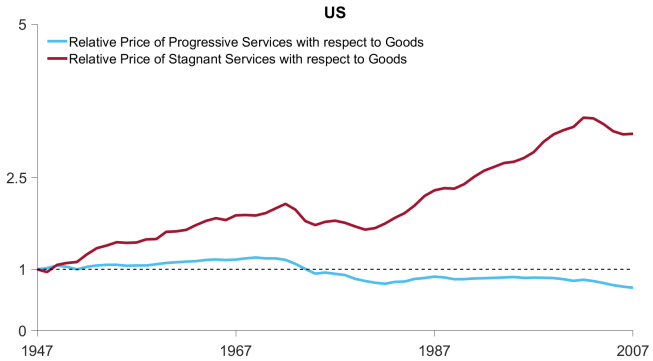
Figure 1: Relative Prices and Quantities: US



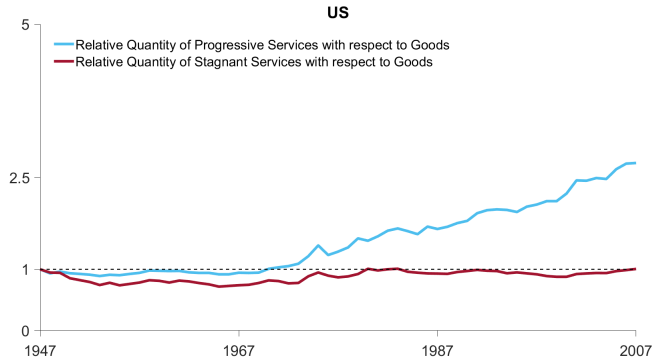
a. Goods vs. Services



b. Progressive Services vs. Stagnant Services



c. Services Subsectors vs. Goods: Relative Prices



d. Services Subsectors vs. Goods: Relative Quantitites

Notes: The data source is the WORLD KLEMS. The quantity refers to the real value added. All observations are normalized to 1 in the initial year, 1947.

To analyze structural change within the services over development, I estimate the following equation for the share of progressive services within the aggregate services:

$$Share_{Pro} = \beta_{fe} + \beta_1 logGDP_{i,t} + \beta_2 (logGDP)^2_{i,t} + \beta_3 (logGDP)^3_{i,t} + \epsilon_{it}$$

where $Share_{Pro}$ denotes the share of progressive services within total services, $logGDP_{i,t}$ the log of GDP per capita in 2017 US dollars, and β_{fe} country fixed effects. Table 6 shows the results of this estimation; Figure 2 the predicted share net of country fixed effects.

Table 6: Share of Progressive Services within Total Services

	β_1	β_2	β_3	β_1	β_2	β_3
$logGDP$	.0385***	.1133***	.6414***	−.0357***	−.8371***	10.1117***
$(logGDP)^2$	-	−.0072***	−.1110***	-	.0396***	−1.0608***
$(logGDP)^3$	-	-	.0051***	-	-	.0367***
Country Fixed Effects	Yes	Yes	Yes	No	No	No
Number of observations	1,254	1,254	1,254	1,254	1,254	1,254
R^2	0.9792	0.9857	0.9875	0.1006	0.1904	0.2768

Notes: *** indicates statistical significance at 1% confidence level.

From Figure 2 we observe that the share of progressive services within total services displays a U-shaped pattern over development. Although panel structure of data allows us to derive this regularity, surprisingly we do not observe it in the country-level time series data. For example in the US, as shown in Figure 4.*a*, the share of progressive services remains remarkably stable around $25 - 33\%$ of the aggregate value added in the post-WWII period. Since the share of the rest of the services sector increases in the same period, this fact implies a declining share for the progressive services within total services. This fact holds true for most of other developed countries as well. For some countries we can only talk about an *L-shaped* pattern for the share of progressive services within total services: It first declines and remains constant afterwards.

How can we reconcile panel and time-series evidence? As we shall see, transition dynamics concerning structural change within the services are very slow: Even a country as developed as the US may not display a U-shaped pattern we hope to see. Reassuringly, when we project

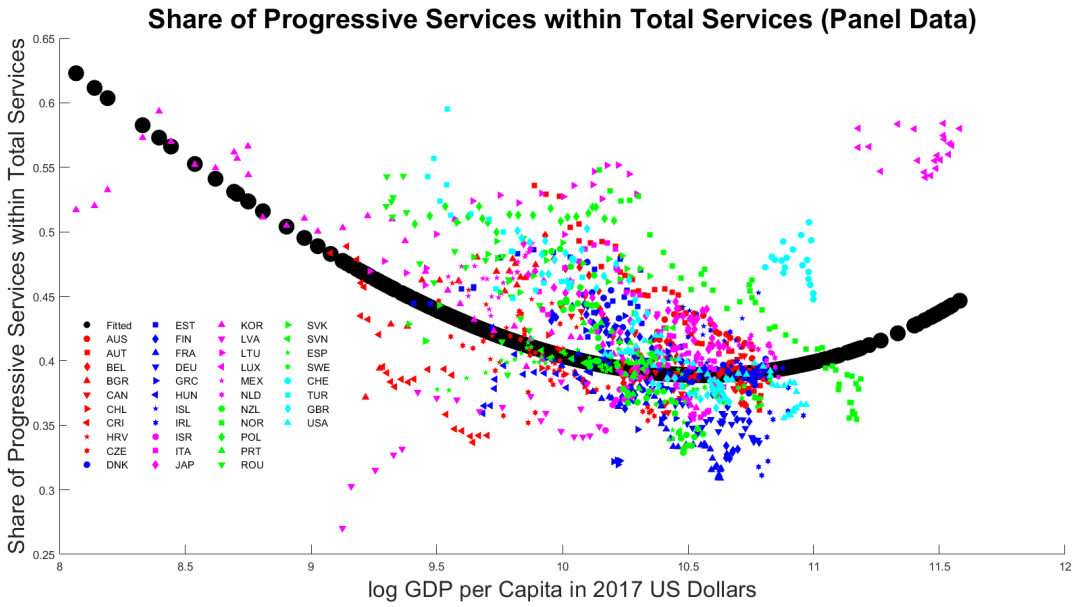


Figure 2: Share of Progressive Services within Total Services for Panel Data

Notes: GDP per capita values in 2017 US Dollars are obtained from the Total Economy Database. The data sources for sectoral shares are various releases of the WORLD KLEMS and OECD STAN. The black dots show the fitted values net of country fixed effects for the equation estimated in the third column of Table 6. The share refers to the nominal value added. Appendix B provides a list of country codes used in the figure.

structural change within the services it would be possible to observe the U-shaped pattern for individual countries as well.

I also consider the share of the progressive/business services, since this services sub-group constitutes high-productivity growth services sub-sectors in the US and this distinction would be useful in the analysis for cross-country productivity differences. More formally, I estimate the following equation:

$$Share_{Pro/Business} = \beta_{fe} + \beta_1 logGDP_{i,t} + \beta_2 (logGDP)^2_{i,t} + \beta_3 (logGDP)^3_{i,t} + \epsilon_{it}$$

where $Share_{Pro/Business}$ now denotes the share of progressive/business services within total services. Table 7 shows the results of this estimation; Figure 3 the predicted share net of country fixed effects.

From Figure 3 we observe that the share of progressive/business services within total services shows a shallow U-shaped pattern over development. Unlike the share of progressive services, we can see this regularity for the country-level data as well: Figure 4.*b* shows it clearly for the

Table 7: Share of Progressive/Business Services within Total Services

	β_1	β_2	β_3	β_1	β_2	β_3
$logGDP$	.0488***	.1077***	.4302***	−.0086***	−.4836***	8.8508***
$(logGDP)^2$	-	−.0057***	−.0691***	-	.0235***	−.9146***
$(logGDP)^3$	-	-	.0031***	-	-	.0313***
Country Fixed Effects	Yes	Yes	Yes	No	No	No
Number of observations	1,254	1,254	1,254	1,254	1,254	1,254
R^2	0.9866	0.9892	0.9897	0.0051	0.0328	0.0880

Notes: *** indicates statistical significance at 1% confidence level.

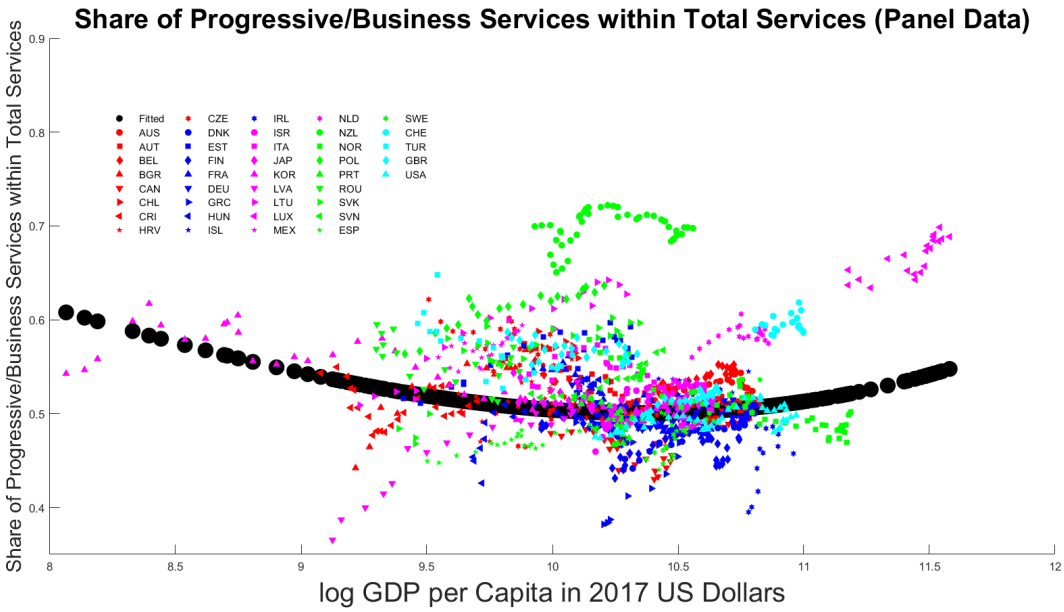


Figure 3: Share of Progressive/Business Services within Total Services for Panel Data

Notes: GDP per capita values in 2017 US Dollars are obtained from the Total Economy Database. The data sources for sectoral shares are various releases of the WORLD KLEMS and OECD STAN. The black dots show the fitted values net of country fixed effects for the equation estimated in the third column of Table 7. The share refers to the nominal value added. Appendix B provides a list of country codes used in the figure.

US. Even if it does not display a U-shaped pattern in other countries, it remains mostly stable, which is mostly consistent with the shallow U-shaped pattern we observe in the panel data.

We can summarize structural change facts for the services sector in three items (Figure 4

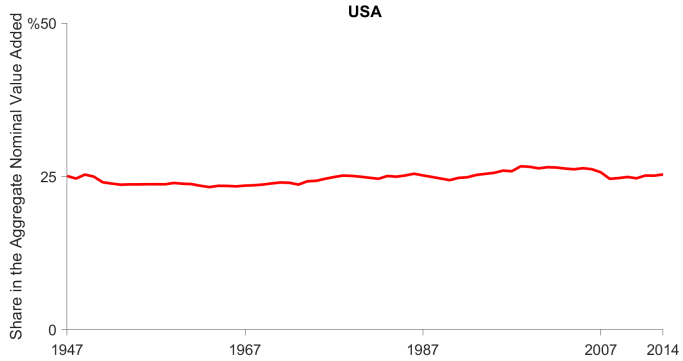
illustrates these structural change facts for the US economy in the post-WWII period. Appendix C provides figures for other developed countries.):

1. The share of the progressive services sector in aggregate value added is remarkably stable around $25 - 33\%$ of the aggregate value added. For some countries its share in total services first declines and remains constant afterwards (*L-shaped*). The panel data implies a U-shaped pattern for the share of progressive services within total services.

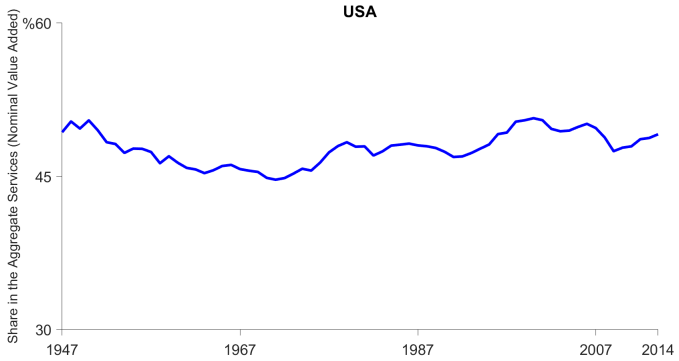
2. The share of the progressive/business services sector displays a shallow U-shaped pattern within total services.

3. The share of stagnant services excluding business services and real estate levels off around the $25 - 30\%$ of aggregate value added. The later rise of the services is mostly accounted for by the services sub-sectors (business services and real estate activities) that produce intermediate and capital goods.

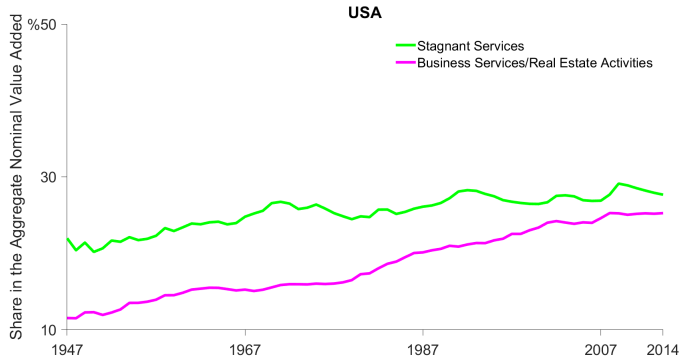
Figure 4: Structural Change within the Services: US



a. Progressive Services



b. Progressive/Business Services



c. Stagnant Services vs. Business Services and Real Estate Activities

Notes: The data source is the WORLD KLEMS. The figure (a) refers to the share of progressive services sector in the aggregate economy. The figure (b) refers to the share of the progressive/business services sector within the aggregate services. The figure (c) refers to the shares of stagnant services sector excluding business services and real estate and that of the business services and real estate in the aggregate economy. All shares are expressed in terms of nominal value added.

What do these results imply for aggregate productivity growth? While the aggregate share of the goods sector decreases 0.21 percentage points in the US between 1947 and 2007, the near-stable share of the progressive services, with their greater productivity growth rate than the goods sector, deserves attention. Even a simple back-of-envelope analysis would reveal that Baumol's prediction of zero productivity growth would not happen in the presence of progressive services, since it would ultimately bound the rise of stagnant services. Actually, my results would later reveal that the near-stable share of the progressive services signifies a more fundamental substitutability result between this sector and the rest of economy, consistent with the U-shaped pattern suggested by panel-data evidence. Fact 1, therefore, establishes my principal argument against Baumol's cost disease.[5]

Fact 2 motivated Duernecker, Herrendorf, and Valentinyi (2019) to conclude that the future effects of Baumol's cost disease would be limited in the US. My results show that this structural change fact could be extended to any developed country. The progressive/business services sector almost entirely accounts for the productivity growth revival that lasted between the mid-1990's until 2007 in the US. As we shall see, this services group explains productivity growth revivals during the same period for other countries as well. Productivity growth differences between the US and other countries in the progressive/business services largely justify aggregate productivity differences between them: Fact 2 constitutes the role played by structural change in shaping these differences.

When Baumol (1967) refers to the services sub-sectors with zero-productivity growth he specifically mentions the services sub-sectors that make up most of the stagnant services. Fact 3, however, shows that the share of this services group does not rise indefinitely: What propelled the later rise of the services is the services sub-sectors that produce intermediate and capital goods. As Oulton (2001) argues, such a rise signifies different results for productivity growth. The ascent of business services and real estate activities in aggregate value added suggests that the forces not considered by Baumol (1967), investment and intermediate demand, exert considerable impacts on structural change.

[5]Mine is not the first study that shows the near-constant share of the progressive services sector. Baumol et al. (1985) argue that the share of high-productivity growth service sub-sectors remains stable in aggregate value added. Jorgenson and Timmer (2011) note that for developed countries the distribution services that make up most of the progressive services sector displays a constant share in aggregate value added. I show this fact for a longer time period and a larger set of countries. I should add that the reduced-form approach used in these papers prevent them to fully appreciate the significance of their result.

It is usually of no interest to document the behavior of individual services sub-sectors. I reserve an exception for the Public Administration, since it is the only two-digits services sub-sector whose share exhibits a hump-shaped pattern within total services. At its highest point it ranks the second largest services sub-sector after the Wholesale and Retail Trade, and these facts remain remarkably robust across countries. Does increasing intermediate use in this sub-sector rationalize its hump-shaped pattern? Analyzing this question and other implications of these facts should be better left for future research: Recent work by Moro and Rachedi (2018) advance in some of them.

3.3 Baumol's Cost Disease in Advanced Countries

This sub-section evidences how much Baumol's cost disease impacted aggregate productivity growth in developed countries since 1970. Before reporting the results, I stress that the period I consider, from 1970 to 2007, does not offer the most ideal conditions for analyzing Baumol's cost disease. One productivity growth slowdown in the beginning (and a second one after 2007), and a productivity-growth revival starting in the mid-1990's largely characterize the journey of productivity in developed countries during this period. Some countries in my sample (for example, Korea) also manifest strong transition dynamics. Nevertheless, having a sample of countries with different development levels and productivity growth trajectories provides a wider perspective for analyzing Baumol's cost disease and enriches our analysis. It is comforting that my results change little when the Great Stagnation period is also taken into account.

I use the methodology of Nordhaus (2008) to quantify Baumol's cost disease. For each country I fix the nominal value added and hours worked shares of each industry at their average values between 1970 and 1971, and calculate the counterfactual productivity growth rate based on these shares. The purpose of this accounting exercise is to answer the following question: What would aggregate productivity growth be if there were no structural change in the economy (i.e., sectoral shares remained unchanged)? More formally,

$$\Delta \ln LP_{counterfactual} = \left[\frac{S_{i,1971} + S_{i,1970}}{2}\right] \Delta \ln LP_{i,t} + \left[\frac{S_{i,1971} + S_{i,1970}}{2} - \frac{H_{i,1971} + H_{i,1970}}{2}\right] \Delta \ln HEMP_{i,t} \tag{3}$$

In aggregating labor productivity growth I concentrate upon 16 industries: five of these (Agriculture, Mining, Total Manufacturing, Utilities, Construction) constitute the goods sector,

while the remaining ones are the service sub-sectors mentioned before. Some works (Nordhaus (2008) and Sun and Samaniego (2016)) show that structural change within the manufacturing sector favors the industries with higher productivity growth. Although considering manufacturing at a more disaggregated level would do justice to this fact, because of the prominence I give to the services sector in this research, I do not do it. Table 8 presents the results for the counterfactuals.

Table 8 reveals that Baumol's cost disease decreases productivity growth rate on average 0.30 percentage points between 1970 and 2007. This number, however, veils considerable differences across countries. For countries with high productivity growth rates in the goods sector but very low ones in the services (for example, Spain and Italy), Baumol's cost disease exerts greater impact. For countries characterized by strong transition dynamics (Korea, Finland), it again reduces productivity growth more. Surprisingly, for the two richest countries in my sample, Luxembourg and Norway, structural change impacts productivity growth positively. When these two countries along with Portugal are removed from the sample, the decrease in productivity growth rate on average becomes 0.41 percentage points.

Another way of seeing the effects of Baumol's cost disease is to check how much it accounts for the productivity growth slowdown between different periods. To do this exercise, for each country I compare the actual productivity growth difference between 1970-1990 and 1990-2007 with the counterfactual one. If the data points a greater difference between these two periods, I conclude that productivity growth slowdown is rationalized by Baumol's cost disease. Table 9 summarizes the results. On average Baumol's cost disease explains approximately 1/3 of the productivity growth slowdown (without Greece, it is 24%). Interestingly, it accounts for the productivity growth slowdowns most strongly for the countries characterized by transition dynamics (Korea, Finland, Norway, and Austria). If one considers the median instead of the mean, Baumol's cost disease rationalizes only 16.86% of the productivity growth-slowdown. Although still a considerable number, it does not represent the whole picture.

I repeat these exercises for countries where I have longer data series and extend the results to 2015. Despite the fact that the sample now includes the Great Stagnantion, the results for Baumol's cost disease change slightly: It lessens productivity growth on average 0.40 percentage points and explains on average only the 23.76% of the productivity growth slowdown. I refer to the reader Appendix D for the country-level details of these results.

Table 8: Counterfactual Aggregate Labor Productivity Growth Rates (1970-2007)

Country	Data	Counterfactual	Difference
Australia	1.76	1.92	-0.17
Austria	2.50	2.98	-0.48
Belgium	2.43	2.86	-0.43
Canada	1.64	1.76	-0.12
Denmark	1.93	2.19	-0.26
Finland	2.96	3.58	-0.62
France	2.65	3.16	-0.51
Germany	2.53	2.75	-0.22
Greece	2.00	2.61	-0.61
Ireland	3.34	3.72	-0.38
Italy	1.81	2.40	-0.59
Japan	2.83	3.14	-0.31
Korea	5.18	5.70	-0.52
Luxembourg	2.49	1.74	0.75
Netherlands	2.20	2.45	-0.25
Norway	3.25	2.85	0.40
Portugal	3.22	3.07	0.16
Spain	2.11	2.83	-0.73
Sweden	1.91	2.22	-0.31
UK	1.71	2.34	-0.63
USA	1.72	2.00	-0.28
Max	5.18	5.70	0.75
Min	1.64	1.74	-0.73
Median	2.43	2.75	-0.31
Average	2.48	2.77	-0.29

Source: WORLD KLEMS, OECD STAN and my calculations. The results are for the data compatible with the ISIC Rev.3.1.

Table 9: Baumol's Cost Disease and Productivity Growth Slowdown

	Productivity Growth							
	Data			**Counterfactual**			**Baumol's Effect**	**Baumol's Effect** (in percentage)
	1970-1990	1990-2007	Difference	1970-1990	1990-2007	Difference		
Australia	1.65	1.88	0.23	1.81	2.06	0.26	-0.02	
Austria	3.01	1.90	-1.11	3.25	2.66	-0.59	-0.53	47.27
Belgium	3.41	1.28	-2.13	3.69	1.88	-1.81	-0.32	15.21
Canada	1.62	1.68	0.06	1.69	1.84	0.15	-0.09	
Denmark	2.64	1.10	-1.54	2.81	1.46	-1.35	-0.19	12.62
Finland	3.34	2.50	-0.84	3.75	3.37	-0.38	-0.46	54.50
France	3.43	1.73	-1.70	3.80	2.41	-1.39	-0.32	18.51
Germany	3.00	1.98	-1.03	3.08	2.37	-0.71	-0.32	31.31
Greece	2.17	1.80	-0.37	2.54	2.69	0.15	-0.52	
Ireland	3.80	2.80	-1.00	4.08	3.29	-0.78	-0.22	21.99
Italy	2.48	1.02	-1.46	3.01	1.67	-1.34	-0.12	8.40
Japan	3.62	2.05	-1.57	3.91	2.38	-1.53	-0.04	2.60
Korea	5.96	4.26	-1.70	6.08	5.25	-0.83	-0.88	51.49
Luxembourg	3.67	1.10	-2.57	2.75	0.55	-2.20	-0.37	14.37
Netherlands	3.01	1.26	-1.75	3.19	1.59	-1.60	-0.16	8.94
Norway	3.96	2.42	-1.54	3.03	2.64	-0.39	-1.15	74.45
Portugal	4.07	2.17	-1.89	3.89	2.03	-1.86	-0.03	1.75
Spain	2.99	1.07	-1.91	3.63	1.89	-1.74	-0.17	9.10
Sweden	1.53	2.35	0.82	1.80	2.72	0.91	-0.09	
UK	1.35	2.12	0.77	1.93	2.81	0.88	-0.10	
USA	1.55	1.92	0.37	1.75	2.29	0.54	-0.17	
Max	5.96	4.26	0.82	6.08	5.25	0.91	-0.02	139.70
Min	1.35	1.02	-2.57	1.69	0.55	-2.20	-1.15	1.75
Median	3.01	1.90	-1.46	3.08	2.37	-0.78	-0.19	16.86
Average	2.96	1.92	-1.04	3.12	2.37	-0.74	-0.30	32.01

Notes: The sources are WORLD KLEMS, OECD STAN and my calculations. The results are expressed for data compatible with the ISIC Rev.3.1. Baumol's Effect is calculated as the difference between actual productivity growth rates difference between 1990-1970 and 2007-1990 and the counterfactual one for same periods. If the counterfactual productivity growth rates did not show much difference across time-periods but the actual ones did, we conclude that Baumol's cost disease accounts for productivity-growth differences across time. The effect of Baumol's cost disease in percentage terms is only expressed for countries where there was a productivity growth slowdown from 1990-1970 to 2007-1990.

From all these accounting exercises, it looks safe to conclude that Baumol's cost disease becomes less relevant over development: It accounts for a small share of the productivity growth slowdown and does not depress aggregate productivity growth much. For the most-developed countries in my sample, structural change actually enhances productivity growth. Besides, Baumol's cost disease rationalizes the productivity growth slowdowns largely for the countries

characterized by strong transition dynamics. How can we explain these results? First, the fact that services sector constitutes a considerable share of aggregate economy in developed countries today makes standard structural change from goods to services less relevant in shaping aggregate productivity. Second, not all services sub-sectors display low-productivity growth and these progressive services sub-sectors arrest the stagnant services to seize the whole economy. Third, the services sub-sectors that produce intermediate and capital goods become more seminal within total services, making Baumol's cost disease less compatible with structural change in developed countries. As we shall see, structural change within the services sector differs starkly from the one between the goods and services sectors. To hint the results to come, it would suffice to say that while the complementarily singularizes the structural change from the goods to the services sector, the structural change within the services behaves under the leverage of the substitutability. This result would rationalize why Baumol's cost disease becomes less relevant over time, and would depress the aggregate productivity less in the future.

Which sector splits capture Baumol's cost disease best? To find the best sector-split for analyzing Baumol's cost disease, I aggregate 16 industries under some categories and, instead of 16 industries I fix nominal and hours worked shares of these sectoral categories at their initial and end-year values (that is, 1970-1971 and 2006-2007) while sectoral productivity growth rates remain as in the data. If the difference between the counterfactual productivity growth rates based on these categories approximates well the difference between the counterfactual productivity growth rate based on 16 industries, then I conclude that the sector split in question can account well for Baumol's cost disease. I consider the splits between goods/services, 5 goods sub-sectors/services, goods/11 services sub-sectors, goods/progressive and stagnant services, goods/progressive plus business and stagnant services. Table 10 summarizes the results of these exercises.

The most striking result emerging from Table 10 is that structural change between the goods and services sectors is no relevant in any country for analyzing Baumol's cost disease. For the countries characterized by structural change out of the agriculture and strong transition dynamics (Korea, Greece, Spain), the split between the goods sub-sectors and services does a good job at capturing Baumol's cost disease. Overall, the split between goods and the services sub-sectors performs the best. This result strongly supports the argument that structural change within the services to a greater extent determines aggregate productivity in developed countries today

Table 10: Sector Splits for Baumol's Cost Disease

	Goods vs. Services	Goods vs. 11 Services Sub-sectors	5 Goods Sub-sectors vs. Services	Goods vs. Progressive and Stagnant Services	Goods vs. Progressive/Business and Stagnant Services
Australia	0.24	0.01	0.22	0.03	0.18
Austria	0.26	0.06	0.20	0.11	0.21
Belgium	0.09	0.05	0.14	0.03	0.08
Canada	0.20	0.13	0.06	0.18	0.24
Denmark	0.08	0.25	0.17	0.31	0.16
Finland	0.34	0.11	0.23	0.14	0.34
France	0.34	0.13	0.21	0.19	0.30
Germany	0.18	0.01	0.20	0.09	0.17
Greece	0.44	0.30	0.14	0.38	0.40
Ireland	0.42	0.36	0.06	0.33	0.42
Italy	0.60	0.27	0.33	0.51	0.58
Japan	0.42	0.08	0.34	0.17	0.36
Korea	0.22	0.20	0.02	0.50	0.36
Luxembourg	0.88	0.04	0.92	0.89	1.02
Netherlands	0.17	0.05	0.13	0.06	0.22
Norway	1.73	2.18	0.45	2.10	1.87
Portugal	0.41	0.03	0.39	0.50	0.42
Spain	0.82	0.68	0.14	0.68	0.82
Sweden	0.16	0.05	0.20	0.00	0.14
UK	0.37	0.37	0.00	0.21	0.36
USA	0.44	0.23	0.21	0.32	0.55

Notes: The data sources are the WORLD KLEMS, OECD STAN and my calculations. The results are for the data compatible with the ISIC Rev.3.1 and they cover between 1970 and 2007. I calculate two counterfactual aggregate productivity growth rates: First, by fixing the nominal value added and hours worked shares of 16 industries at their initial values (1970 and 1971); second, by fixing same shares of same 16 industries at their end values (2006 and 2007). The difference between these two counterfactual productivity growth rates is considered as an alternative measure of Baumol's cost disease in Nordhaus (2008). I apply the same procedure to the sectoral aggregates considered in table. For example, in the sectoral split between the goods and 11 services sub-sectors (third column) I consider the shares of the goods and 11 services sub-sectors at their initial and end values, and keep productivity growth rates of in total 12 sub-sectors as in the data. This exercise differs from the previous one in the sense while the disaggregation level for the services sector remains the same, the goods sector is now more aggregated. My purpose in doing it is to see the relevancy of structural change within the services for Baumol's cost disease. I then calculate the difference between these two counterfactual productivity growth rates. If this difference is close to the one obtained by considering all 16 industries, then I conclude that the sectoral split captures well Baumol's cost disease. The numbers in table represent the absolute value of the difference between these two differences. The lower the numbers in the table the better the related sectoral split captures Baumol's cost disease.

and reinforces the main message of Jorgenson and Timmer (2011, P.26): *the classical trichotomy among agriculture, manufacturing, and services has lost most of its relevance.* Despite the fact that my sample consists of countries at different stages of development, the split between progressive and stagnant services sectors approximates well the structural change within the services

sector. The split between progressive/business and stagnant services sectors, however, does not show the same success. These results establish that to analyze Baumol's cost disease I can concentrate upon progressive and stagnant services sectors to approximate structural change within the services sector. Consistent with this result, in the modelling part I disaggregate the services sector between progressive and stagnant services.

3.4 Cross-Country Productivity Differences

This sub-section reports aggregate and sectoral productivity patterns for developed countries. One might consider cross-country productivity differences and Baumol's cost disease as two independent research questions. However, as we shall see, aggregate productivity differences between the US and other developed countries originate from the same structural change forces that limit Baumol's cost disease.

After a protracted catch-up starting with the end of the Second World War, developed countries have been falling behind the US in terms of aggregate productivity. Especially for the West European countries this fact is well documented (Inklaar, Timmer, and van Ark (2008), Duarte and Restuccia (2010), Buiatti, Duarte, and Saenz (2018) among others). I would like to contribute some additional facts to what has been already reported in this literature; these facts I believe point that more fundamental forces of the economy shape productivity differences between the US and other developed countries. Figure 5 shows aggregate relative productivity levels for some selected countries.

1. These declines in relative aggregate productivity are not limited to the West European countries. They happen globally, in countries as diverse as Canada, Australia, Japan, Israel, and New Zealand.

2. The declines in relative aggregate productivity start at the same time (around 1995 and 1996) for almost all countries. For countries already in a declining trend (for example, Canada and Switzerland), the fall accelerates after the mid-1990's.

3. Despite the lackluster productivity growth performance of the US since 2007, developed countries do not revert back to their course of catching-up. Ireland, Australia, and Iceland stand out as notable and only exceptions.

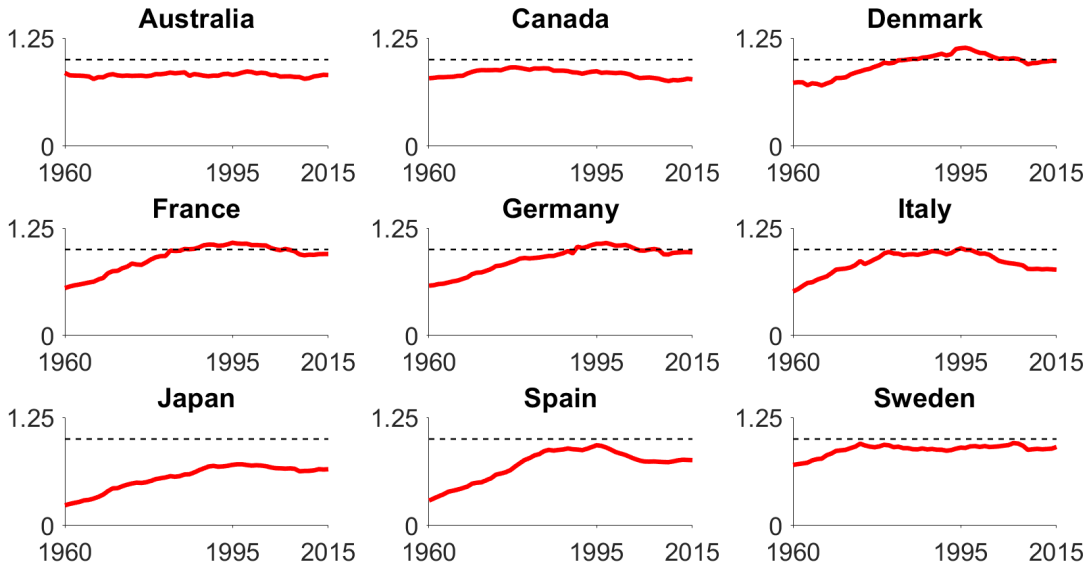


Figure 5: Relative Aggregate Productivity: Selected Countries

Notes: The data source is the Total Economy Database. The figures show the aggregate relative productivity with respect to the US in each country. The dashed black horizontal line shows the value of 1.00.

Duarte and Restuccia (2010) already show that the services sector accounts for all these declines in aggregate productivity. Yet approaching this result through the lens of the progressive/business and stagnant services classification yields new insights. Between 1970 and 1995 all countries in my sample displayed a greater aggregate productivity growth rate than the US. They retained the same performance in the stagnant services sector, but not much in the progressive/business services (Figure 6). Between 1995 and 2007, the differences between these two services groups became more stark. In only one country, Korea, productivity in the progressive/business services sector grew greater than that in the US between 1995 and 2007; yet many countries outstripped the US in the stagnant services in the same period (Figure 7).[6] The declines in aggregate productivity befell after 1995 despite the fact that many countries surpassed the US in the stagnant services sector.

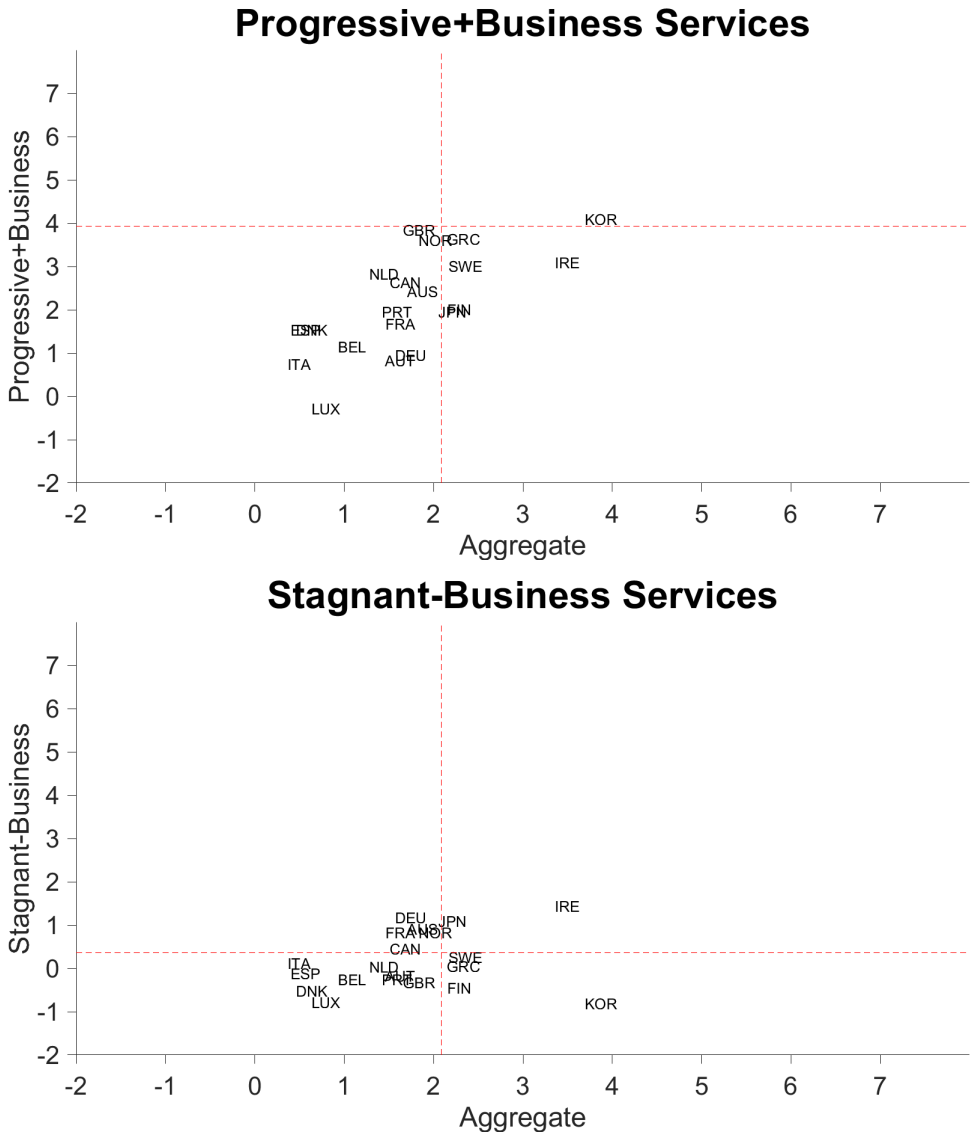
As can be seen from Table 11 the US is not the only country that revived productivity growth. The aggregate productivity growth rate increased in six other countries (Australia,

[6]Besides that, between 1995 and 2007 productivity in the progressive/business services sector grew 4.20 percentage points greater in the US than it did in the worst-performing country, but the productivity growth difference between the US and the worst-performing country was just 1.17 percentage points in the stagnant services.

Figure 6: Productivity Growth within the Services Sector, 1970-1995

Notes: The data sources are the WORLD KLEMS and OECD STAN. The dashed vertical line represents the aggregate productivity growth rate in the US. The dashed horizontal line represents the sectoral productivity growth rate in the US.

Figure 7: Productivity Growth within the Services Sector, 1995-2007



Notes: The data sources are the WORLD KLEMS and OECD STAN. The dashed vertical line represents the aggregate productivity growth rate in the US. The dashed horizontal line represents the sectoral productivity growth rate in the US.

Canada, Ireland, Greece, Sweden, UK) as well between 1995 and 2007. The US is also not the only country that revived the productivity growth in the services: Norway and the six countries that reanimated the aggregate productivity growth experienced a productivity growth resurgence in the services sector. The productivity growth revivals in the services sector largely resulted from these countries' superior performances in the progressive/business services: Productivity growth increased in this services sub-group for the Netherlands and all these seven countries that reanimated aggregate productivity. It should be emphasized that all services sub-sectors that make up the progressive/business services contribute to these productivity growth revivals. As I note in Section 3.2, the relative productivity of the progressive/business services sector with respect to the stagnant services increases monotonically and its share displays a shallow U-shaped pattern within total services. Between 1995 and 2007, its share within the services at least remained stable for most countries despite surge in its productivity growth rate.

Table 11: Sectoral Productivity Growth Differences across Time

	Productivity Growth											
	Progressive/Business Services			Stagnant Services			Services			Aggregate		
	1970-1995	1995-2007	Difference	1970-1995	1995-2007	Difference	1970-1995	1995-2007	Difference	1970-1995	1995-2007	Difference
Australia	1.72	2.43	0.71	0.30	0.92	0.62	1.06	1.68	0.62	1.70	1.88	0.18
Austria	2.81	0.83	-1.99	1.18	-0.16	-1.35	2.10	0.31	-1.79	2.92	1.62	-1.30
Belgium	1.91	1.15	-0.76	1.88	-0.24 -	2.13	1.97	0.55	-1.41	3.08	1.09	-1.99
Canada	1.93	2.64	0.71	0.41	0.45	0.04	1.10	1.43	0.33	1.62	1.69	0.06
Denmark	2.97	1.55	-1.42	0.65	-0.51	-1.16	1.81	0.40	-1.40	2.55	0.63	-1.92
Finland	2.97	2.01	-0.95	0.98	-0.45	-1.43	1.94	0.74	-1.20	3.28	2.29	-0.99
France	3.03	1.68	-1.35	1.30	0.84	-0.46	2.08	1.18	-0.90	3.13	1.63	-1.50
Germany	3.10	0.95	-2.14	2.11	1.18	-0.92	2.58	1.18	-1.40	2.91	1.74	-1.16
Greece	0.99	3.65	2.66	0.00	0.06	0.06	0.59	1.70	1.10	1.84	2.33	0.49
Ireland	2.22	3.09	0.88	1.01	1.45	0.44	1.44	2.49	1.04	3.26	3.50	0.24
Italy	0.94	0.74	-0.20	0.57	0.12	-0.45	0.81	0.36	-0.45	2.44	0.49	-1.94
Japan	3.82	1.96	-1.85	1.18	1.09	-0.08	2.59	1.58	-1.01	3.17	2.21	-0.96
Korea	4.49	4.10	-0.39	1.17	-0.80	-1.97	3.38	1.73	-1.65	5.81	3.88	-1.93
Luxembourg	4.75	-0.28	-5.03	3.81	-0.78	-4.60	4.86	0.44	-4.42	3.31	0.79	-2.51
Netherlands	2.30	2.83	0.53	1.53	0.05	-1.48	1.86	1.45	-0.41	2.57	1.45	-1.12
Norway	3.38	3.61	0.23	0.64	0.84	0.20	2.07	2.21	0.14	3.85	2.02	-1.83
Portugal	3.47	1.97	-1.51	3.17	-0.25	-3.41	3.53	0.85	-2.68	3.94	1.59	-2.35
Spain	1.87	1.54	-0.33	-0.13	-0.11	0.02	0.88	0.58	-0.30	2.85	0.57	-2.28
Sweden	1.46	3.01	1.56	0.20	0.27	0.07	0.78	1.53	0.75	1.70	2.35	0.66
UK	1.76	3.85	2.09	0.38	-0.32	-0.71	1.14	1.83	0.69	1.64	1.84	0.20
US	2.75	3.93	1.18	0.52	0.37	-0.16	1.49	2.03	0.54	1.54	2.09	0.55
Max	4.75	4.1	2.66	3.81	1.45	0.62	4.86	2.49	1.1	5.81	3.88	0.66
Min	0.94	-0.28	-5.03	-0.13	-0.8	-4.6	0.59	0.31	-4.42	1.54	0.49	-2.51
Median	2.75	2.01	-0.33	0.98	0.06	-0.46	1.86	1.43	-0.45	2.91	1.74	-1.16
Average	2.60	2.25	-0.35	1.09	0.19	-0.90	1.91	1.25	-0.66	2.81	1.79	-1.02

Source: WORLD KLEMS, OECD STAN and my calculations. The results are for the data compatible with the ISIC Rev.3.1.

These facts pose some challenges to the most popular explanation of productivity differences between the US and other developed countries. According to this explanation (which can be found in Inklaar et al. (2008)) the US surpassed other countries because of advances in the information and communications (IC) technologies. It is the market services sector, which largely overlaps with my progressive/business services categorization, that benefitted most from the ICT revolution and drove aggregate productivity differences between the US and other developed countries. As I show, the US was not the only country that experienced a productivity growth resurgence in that period, yet relative productivity with respect to the US deteriorated in these countries as well. If the US rekindled productivity growth more strongly than other countries between 1995 and 2007, then it is puzzling that these countries have not reverted to their relative productivity levels after 2007 - when the US has performed very poorly in terms of productivity growth. I also show that for the stagnant services sector that accounts for half of the services, productivity growth in many countries exceeded that in the US between 1995 and 2007. As we shall see, a structural change perspective missing in the literature could shed light on some of the puzzles stated here.

The remainder of this paper is devoted to the modeling and quantitative analyses of Baumol's cost disease and cross-country productivity differences. The models would help me to uncover the roles played by the heterogeneity and structural change within the services sector in shaping aggregate productivity.

4 Model for Baumol's Cost Disease

In modelling household preferences, I separate the progressive services sector from other broad sectors of the economy, and allow a different allocation problem for the composite of the goods and stagnant services sectors. This choice is consistent with the structural change facts I document where the progressive services sector has a decreasing relative price with respect to both goods and stagnant services sectors, and its share in aggregate economy has been increasing. In Appendix E I consider an alternative specification where I separate the goods sector from the services and consider the allocation problem within the services sector independently. Although the substitutability of the progressive services sector with rest of the economy would eventually imply that this services sub-sector is also a substitute with the stagnant services, the transition dynamics are overall very slow - as noted by Duernecker, Herrendorf, and Valentinyi (2019).

The slow transition dynamics imply that for some countries considered in this study we may not be able to derive a substitutability result for structural change within the services sector. Because of this fact I consider both specifications, but report the results in the main body of the text for more general one only.

4.1 Demand Side

The household preferences are represented by the non-homothetic CES preferences introduced by Comin, Mestieri, and Lashkari (2018). The problem of the representative household consists of two layers. In the outer layer, he chooses between the progressive services (p) and the composite of the goods (g) and stagnant services (s) sectors. In the inner layer a different allocation problem between the goods and stagnant services exists. He inelastically supplies labor and receives a wage w_t every period. I abstract from the intertemporal choice; therefore, the model is static. The outer layer of the problem is:

$$\min_{C_{pt},C_{rt}} P_{pt}C_{pt} + P_{rt}C_{rt} \quad \text{s.t.} \quad (\alpha_p^{\frac{1}{\sigma_c}} C_{pt}^{\frac{\sigma_c-1}{\sigma_c}} + \alpha_r^{\frac{1}{\sigma_c}} C_{rt}^{\frac{\sigma_c-1}{\sigma_c}})^{\frac{\sigma_c}{\sigma_c-1}} \geq C_t$$

The composite of the goods and stagnant services sector is denoted as r. C_{pt} and C_{rt} denote the consumption quantities of the progressive services and composite good, C_t represents the aggregate quantity index of consumption. $\alpha_p \geq 0$ and $\alpha_r \geq 0$ are the weights. $\sigma_c \geq 0$ represents the elasticity of substitution between the progressive services and the composite of the goods and stagnant services.

The first-order conditions of this optimization problem yield the following results:

$$\frac{P_{rt}C_{rt}}{P_{pt}C_{pt}} = \frac{\alpha_r}{\alpha_p}\left[\frac{P_{rt}}{P_{pt}}\right]^{1-\sigma_c}$$

$$P_t = (\alpha_p P_{pt}^{1-\sigma_c} + \alpha_r P_{rt}^{1-\sigma_c})^{\frac{1}{1-\sigma_c}}$$

where P_t represents the aggregate price index.

In the inner layer of the problem the representative household chooses allocations between the goods g and stagnant services s:

$$\min_{C_{gt},C_{st}} P_{gt}C_{gt} + P_{st}C_{st} \quad \text{s.t.} \quad (\alpha_g^{\frac{1}{\sigma_r}} C_t^{\frac{\epsilon_g-1}{\sigma_r}} C_{gt}^{\frac{\sigma_r-1}{\sigma_r}} + \alpha_s^{\frac{1}{\sigma_r}} C_t^{\frac{\epsilon_s-1}{\sigma_r}} C_{st}^{\frac{\sigma_r-1}{\sigma_r}})^{\frac{\sigma_r}{\sigma_r-1}} \geq C_{rt}$$

C_{gt} and C_{st} denote the consumption quantities of the goods and stagnant services. $\alpha_g \geq 0$ and $\alpha_s \geq 0$ are the weights in the utility index. $\sigma_r \geq 0$ represents the elasticity of substitution between the goods and stagnant services sectors. $\epsilon_g > 0$ and $\epsilon_s > 0$ govern persistent income effects. In the case of $\epsilon_g = \epsilon_s = 1$, the utility function reduces to the CES.

The first-order conditions of the inner-layer optimization problem yield the following results:

$$\frac{P_{st}C_{st}}{P_{gt}C_{gt}} = \frac{\alpha_s}{\alpha_g}\left[\frac{P_{st}}{P_{gt}}\right]^{1-\sigma_r} C_t^{\epsilon_s-\epsilon_g}$$

$$P_{rt} = (\alpha_g C_t^{\epsilon_g-1} P_{gt}^{1-\sigma_r} + \alpha_s C_t^{\epsilon_s-1} P_{st}^{1-\sigma_r})^{\frac{1}{1-\sigma_r}}$$

where P_t represents the price index for the composite good of the goods and stagnant services sectors.

In the allocation problem between the progressive services and composite good, $\sigma_c > 1$ implies that the progressive services sector and the rest of the economy are the substitutes. Since the relative price of the progressive services sector decreases with respect to both the goods and stagnant services, in such a case the direction of structural change would be toward the progressive services. For the allocation problem between the goods and stagnant services, $\sigma_r < 1$ implies that goods and stagnant services are the complements, and is consistent with the increasing (decreasing) share of the stagnant services (goods) in the aggregate economy. The parameters that govern persistent income effects ϵ_g, ϵ_s could reinforce or work against the price effects; the assumption that the stagnant services sector is a luxury with respect to the goods ($\epsilon_s > \epsilon_g$) conforms to the intuition.[7] In such a case income effects would attenuate price effects.

4.2 Supply Side

The goods, progressive services, and stagnant services sectors constitute the aggregate economy. Each sub-sector is characterized by linear production functions. Labor, measured in hours

[7]The literature show that the services is a luxury with respect to the goods (agriculture plus industry) (Herrendorf, Rogerson, and Valentinyi (2013), Boppart (2014), and Comin, Mestieri, and Lashkari (2018)), but it does not mean that the stagnant services is also luxury against the goods

worked, is the only input used in the production. In the data the marginal product of labor may not be equalized across the sectors (i.e., nominal labor productivity differs across sectors). This puts a wedge between nominal value added and hours worked shares of a sector. Since in aggregating productivity I should also account for the hours worked share of a sector, I introduce wedges to capture this fact.

The problem of the firm is:

$$\max_{L_{it}} P_{it}Y_{it} - w_t(1+\tau_{it})L_{it} \quad \text{where} \quad Y_{it} = A_{it}L_{it}, \quad i = g, p, s$$

τ_{it} represents the wedge for sector i at time t. A_{it} denotes the labor productivity for sector i at time t. The first-order conditions of the firm's problem give out the following result:

$$\frac{P_{it}}{P_{gt}} = \frac{(1+\tau_{it})A_{gt}}{(1+\tau_{gt})A_{it}}, \quad i = p, s$$

By using the production functions, this result becomes

$$\frac{P_{it}C_{it}/L_{it}}{P_{gt}C_{gt}/L_{gt}} = \frac{(1+\tau_{it})}{(1+\tau_{gt})}, \quad i = p, s$$

This expression would help me to derive hours worked shares from the nominal value added shares.

4.3 Market Equilibrium

The market clearing conditions are stated as follows:

$$Y_{it} = C_{it}, \quad i = g, p, s$$

$$1 = L_{gt} + L_{pt} + L_{st}$$

5 Quantitative Analysis for Baumol's Cost Disease

5.1 Calibration

To make precise predictions about the future of productivity growth, my model should match closely the aggregate productivity in each country. To achieve this objective I calibrate the country-specific model parameters. For each country I take sectoral productivity indexes $\{A_{gt}, A_{pt}, A_{st}\}$ and the price index for the goods sector $\{P_{gt}\}$ from the data (so, the goods sector becomes a numeraire). I derive the wedges as the ratio of nominal value added shares to hours worked shares for each sector and normalize the wedge in the goods sector. That is,

$$\frac{VA_{it}/L_{it}}{VA_{gt}/L_{gt}} = (1+\tau_{it}), \quad i = p, s$$

I obtain the prices $\{P_{pt}, P_{st}\}$ from the first-order conditions of the firm's problem:

$$P_{it} = (1+\tau_{it})\frac{w_t}{A_{it}}, \quad i = p, s$$

$$w_t = P_{gt}A_{gt}$$

For the remaining parameters $\{\alpha_p, \alpha_r, \alpha_g, \alpha_s, \sigma_c, \sigma_r, \epsilon_g, \epsilon_s\}$, I target relative nominal value added shares of the progressive and stagnant services sectors with respect to the goods, $\frac{VA_{pt}}{VA_{gt}}$ and $\frac{VA_{st}}{VA_{gt}}$, by minimizing the sum of squared differences between data and model. More specifically, the solution of the model implies the following relative nominal value added shares for $\frac{VA_{pt}}{VA_{gt}}$ (the one for $\frac{VA_{st}}{VA_{gt}}$ is similar):

$$\begin{aligned}\frac{VA_{pt}}{VA_{gt}} &= \frac{P_{pt}C_{pt}}{P_{gt}C_{gt}} = \frac{P_{pt}C_{pt}}{P_{st}C_{st}}\frac{P_{st}C_{st}}{P_{gt}C_{gt}} \\ &= \frac{\alpha_p {P_{pt}}^{1-\sigma_c}}{\alpha_r {P_{rt}}^{1-\sigma_c} + \alpha_p {P_{pt}}^{1-\sigma_c}}\frac{\alpha_s}{\alpha_g}\left[\frac{P_{st}}{P_{gt}}\right]^{1-\sigma_r} C_t^{\epsilon_s-\epsilon_g}\end{aligned}$$

where

$$P_{rt} = (\alpha_g C_t^{\epsilon_g - 1} P_{gt}^{1-\sigma_r} + \alpha_s C_t^{\epsilon_s - 1} P_{st}^{1-\sigma_r})^{\frac{1}{1-\sigma_r}}$$

$$C_t = (\alpha_p^{\frac{1}{\sigma_c}} C_{pt}^{\frac{\sigma_c - 1}{\sigma_c}} + \alpha_r^{\frac{1}{\sigma_c}} C_{rt}^{\frac{\sigma_c - 1}{\sigma_c}})^{\frac{\sigma_c}{\sigma_c - 1}}$$

and

$$C_{rt} = (\alpha_g^{\frac{1}{\sigma_r}} C_t^{\frac{\epsilon_g - 1}{\sigma_r}} C_{gt}^{\frac{\sigma_r - 1}{\sigma_r}} + \alpha_s^{\frac{1}{\sigma_r}} C_t^{\frac{\epsilon_s - 1}{\sigma_r}} C_{st}^{\frac{\sigma_r - 1}{\sigma_r}})^{\frac{\sigma_r}{\sigma_r - 1}}$$

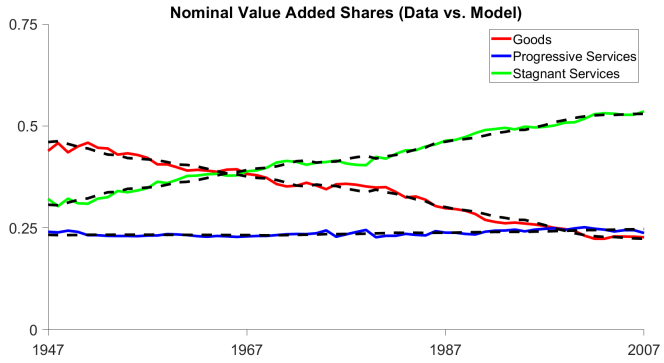
The model-implied values for P_{rt}, C_{rt}, C_t and their close counterparts in the data differ from each other. To solve this issue, I get $P_{gt}, P_{st}, C_{pt}, C_{gt}, C_{st}$ from the data and substitute them into the equations above. The solution-algorithm would start from some initial values of the unknown parameters, and these would give some values for P_{rt}, C_{rt}, C_t. Since the objective of the algorithm is to match as closely as possible the relative nominal value added shares, the initial values for the unknown parameters would get updated until we converge to a solution. While we converge to a solution, the algorithm would produce model-consistent values for P_{rt}, C_{rt}, C_t. Since it cannot be identified separately, I normalize $\epsilon_g = 1$ so that it would satisfy the regularity conditions. I also normalize $\alpha_p = 1 - \alpha_r$ and $\alpha_g = 1 - \alpha_s$.

Table 12 shows the calibration results for the US. The parameters yield desired outcomes: The progressive services sector and the rest of the economy (the goods and stagnant services sectors) are the substitutes ($\sigma_c > 1$); the goods and stagnant services sectors are the complements ($\sigma_r < 1$); the stagnant services sector is a luxury with respect to the goods ($\epsilon_s - \epsilon_g > 0$). It is reassuring that the model fits well to the sectoral shares and tracks closely the aggregate labor productivity for the US (Figure 8).

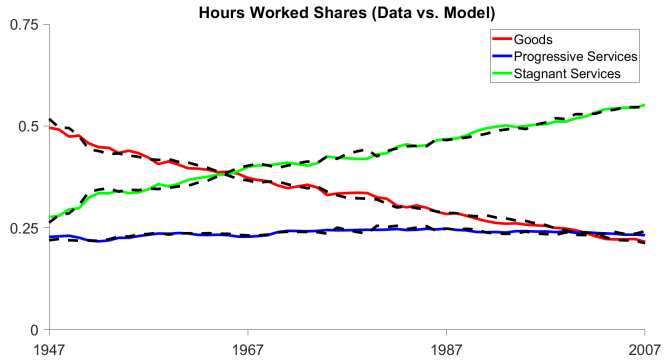
Table 12: Calibration: US, 1947-2007

α_g	α_s	α_p	α_r	σ_c	σ_r	$\epsilon_s - \epsilon_g$
0.76	0.24	0.23	0.77	1.03	0.66	1.39

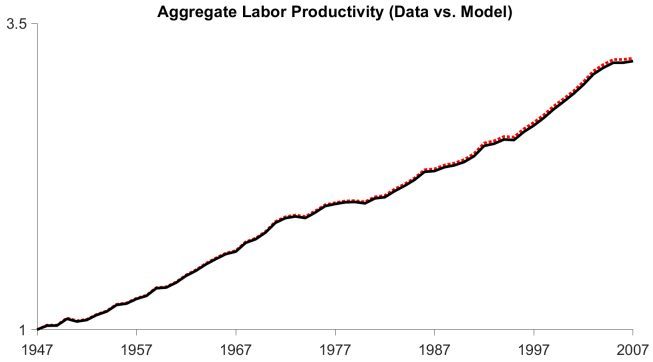
Figure 8: Structural Change in the US: Data vs. Model



a. Nominal Value Added Shares



b. Hours Worked Shares



c. Aggregate Labor Productivity

Table 13 shows the results for other developed countries. For 11 out of 21 countries (more than half), calibration results indicate a substitutability result between progressive services sector and the rest of the economy. For countries where it is not the case, the elasticity of substitution between progressive services and the rest of the economy (σ_c) remains close to one. For these countries I re-calibrate the model by now targeting relative hours worked shares instead of nominal value added. Table 14 shows the results of this exercise. It is reassuring that the substitutability between progressive services and the rest of the economy is restored for some countries. If it is not the case, σ_c either takes a value of 1 (so the aggregator is Cobb-Douglas), or a value very close to 1. For these countries, I observe that the elasticity of substitution between goods and stagnant services sectors takes a value greater than 1, implying a substitutability result for the inner layer of household problem. Since stagnant services sector turns out to be a luxury with respect to goods, the substitutability between stagnant services and goods sectors would slow down structural change from goods to stagnant services.

Table 13: Calibration Results for Other Countries, 1970-2007

	α_g	α_s	α_p	α_r	σ_c	σ_r	$\epsilon_s - \epsilon_g$
Australia	0.62	0.38	0.26	0.74	1.10	0.00	1.08
Austria	0.67	0.33	0.28	0.72	0.86	0.00	0.46
Belgium	0.61	0.39	0.25	0.75	1.19	0.19	2.72
Canada	0.52	0.48	0.23	0.77	1.17	0.00	0.07
Denmark	0.50	0.50	0.27	0.73	0.81	0.00	0.64
Finland	0.64	0.36	0.22	0.78	1.17	0.57	1.55
France	0.56	0.44	0.22	0.78	1.02	0.28	2.44
Germany	0.64	0.36	0.21	0.79	0.99	0.00	4.34
Greece	0.62	0.38	0.21	0.79	1.37	0.00	1.66
Ireland	0.63	0.37	0.22	0.78	1.06	0.90	0.74
Italy	0.61	0.39	0.25	0.75	0.49	0.00	0.00
Japan	0.63	0.37	0.25	0.75	1.24	0.00	-0.04
Korea	0.76	0.24	0.25	0.75	0.78	0.41	0.00
Luxembourg	0.76	0.24	0.25	0.75	0.68	1.70	8.85
Netherlands	0.54	0.46	0.23	0.77	0.92	1.21	3.60
Norway	0.59	0.41	0.33	0.67	0.29	0.62	1.28
Portugal	0.49	0.51	0.21	0.79	0.51	1.01	0.24
Spain	0.68	0.32	0.17	0.83	0.99	1.02	5.62
Sweden	0.52	0.48	0.25	0.75	0.77	0.43	0.79
UK	0.61	0.39	0.24	0.76	1.05	0.58	3.81
USA	0.48	0.52	0.23	0.77	1.04	0.54	2.36

Table 14: Calibration Results for Other Countries (Hours Worked Shares), 1970-2007

	α_g	α_s	α_p	α_r	σ_c	σ_r	$\epsilon_s - \epsilon_g$
Austria	0.71	0.29	0.22	0.78	1.33	0.00	0.90
Denmark	0.58	0.42	0.27	0.73	0.93	0.00	2.60
Germany	0.71	0.29	0.23	0.77	1.07	0.26	4.68
Italy	0.81	0.19	0.20	0.80	0.86	1.51	12.22
Korea	0.88	0.12	0.14	0.86	0.97	1.05	4.97
Luxembourg	0.60	0.40	0.31	0.69	1.34	0.00	0.13
Netherlands	0.57	0.43	0.27	0.73	1.00	0.92	2.92
Norway	0.64	0.36	0.29	0.71	0.94	0.61	2.36
Portugal	0.81	0.19	0.22	0.78	1.00	1.01	3.84
Spain	0.79	0.21	0.22	0.78	1.13	0.49	3.63
Sweden	0.58	0.42	0.21	0.79	0.99	1.35	5.94

In summary, calibrations bring forth two important results for structural change: Progressive services and the rest of the economy are the substitutes; if not the case, the share of progressive services remains mostly stable, and the substitutability between goods and stagnant services sectors would slow down structural change from goods to stagnant services. In either case, a non-trivial lower bound for the share of progressive services exists within total services, and this fact would prevent stagnant services to seize the whole economy. It also rationalizes why Baumol's cost disease becomes less relevant over time and, as the simulations in the next sub-section show, it would constitute the reason why the effects of Baumol's cost disease on productivity growth-slowdown would be limited in the future.

In Appendix F I present calibration and simulation results for an alternative model of Baumol's cost disease.

5.2 Simulations

To assess how structural change would affect aggregate productivity in the future, I simulate the model for each country and project aggregate productivity growth rates under certain scenarios. In the first set of simulations I assume that countries would preserve average productivity growth rates of 1970-2007 in each sector and the wedges would be equal to their averages between 1970 and 2007. Consistent with the KLEMS methodology I aggregate productivity growth rates across sectors as a Tornqvist index. Before presenting the results of these simulations, it would be appropriate to consider how good the model matches the aggregate productivity in each

country and accounts for productivity growth slowdown across different time-periods: Table 15 shows that the model does a good job in this regard.

Table 15: Aggregate Productivity Growth: Data vs. Model

	Actual		Model	
	1970-90	1990-2007	1970-90	1990-2007
Australia	1.63	1.86	1.65	1.88
Austria	3.00	1.88	3.01	1.90
Belgium	3.40	1.26	3.41	1.28
Canada	1.62	1.69	1.62	1.68
Denmark	2.58	1.10	2.64	1.10
Finland	3.36	2.49	3.34	2.50
France	3.45	1.73	3.43	1.73
Germany	3.01	1.94	3.00	1.98
Greece	2.27	1.93	2.17	1.80
Ireland	3.80	2.78	3.80	2.80
Italy	2.42	0.98	2.48	1.02
Japan	3.62	2.02	3.62	2.05
Korea	5.98	4.26	5.96	4.26
Luxembourg	3.69	0.89	3.67	1.10
Netherlands	2.99	1.25	3.01	1.26
Norway	4.00	2.40	3.96	2.42
Portugal	4.21	1.66	4.07	2.17
Spain	3.09	1.12	2.99	1.07
Sweden	1.49	2.37	1.53	2.35
UK	1.32	2.12	1.35	2.12
USA	1.55	1.92	1.55	1.92

Table 16 and Figure 9 present the simulation results. Apart from Australia, Italy, Japan, and Sweden, the predicted effects of Baumol's cost disease on productivity growth slowdown between 2050-2029 and 2029-2009 would been smaller than the one observed between 2007-1990 and 1990-1970.[8] From 2029-2009 to 2050-2029 Baumol's cost disease on average would decrease aggregate productivity growth rate 0.16 percentage points - almost half of its effect between 1990-1970 and 2007-1990. Figure 10 compares simulation results based on nominal value added shares to those on hours worked shares: Although simulation results based on hours worked shares suggest much lower values for productivity growth slowdown in some countries (for example, Korea) in general they are comparable to the ones based on nominal value added and not systematically

[8]Since my assumptions regarding the wedges require a quick adjustment, I omit 2008 and report results starting from 2009.

greater or lower across countries.

Table 16: Simulation Results for Future Productivity Growth

	Baumol's Cost Disease	Aggregate Productivity Growth (Predicted)		Difference
	2007-1970	2029-2009	2050-2029	(Predicted Effect of Baumol's Cost Disease)
Australia	-0.02	1.31	1.13	-0.18
Austria	-0.53	1.73	1.53	-0.21
Belgium	-0.32	1.80	1.67	-0.13
Canada	-0.09	1.39	1.30	-0.08
Denmark	-0.19	1.42	1.27	-0.15
Finland	-0.46	2.08	1.85	-0.23
France	-0.32	1.99	1.82	-0.17
Germany	-0.32	2.20	2.10	-0.11
Greece	-0.52	1.31	1.13	-0.18
Ireland	-0.22	2.91	2.76	-0.15
Italy	-0.12	1.16	0.95	-0.21
Japan	-0.04	2.45	2.33	-0.12
Korea	-0.88	3.33	2.72	-0.62
Luxembourg	-0.37	3.15	3.14	-0.02
Netherlands	-0.16	1.95	1.90	-0.04
Norway	-1.15	2.71	2.45	-0.25
Portugal	-0.03	2.80	2.79	-0.01
Spain	-0.17	1.16	0.99	-0.18
Sweden	-0.09	1.37	1.21	-0.16
UK	-0.10	1.36	1.31	-0.05
USA	-0.17	1.62	1.59	-0.03

Notes: The values for the effect of Baumol's cost disease for the period of 1970-2007 are taken from the seventh column of Table 7. The predicted effect of Baumol's cost disease is calculated as the difference between the productivity growth rate of the period 2029-2050 from that of the period 2009-2029.

Why would Baumol's cost disease decline aggregate productivity growth less in the future? For most countries considered in this study, structural change within the goods sector, from agriculture to industry, has almost completed. Although structural change within the goods sectors exerted considerable impacts on aggregate productivity growth for countries in transition (Greece, Korea, Spain) in the past, it is not reasonable to expect that it would display the effects in the same magnitude for the future. Similarly, structural change from the goods to services sector has already advanced, and the services now comprises of more than 80% of the aggregate economy in developed countries. For these countries, what happens inside the services sector to a greater extent affects how aggregate productivity growth evolves. Within the services, the progressive services sub-sector displays a much greater productivity growth than the stagnant

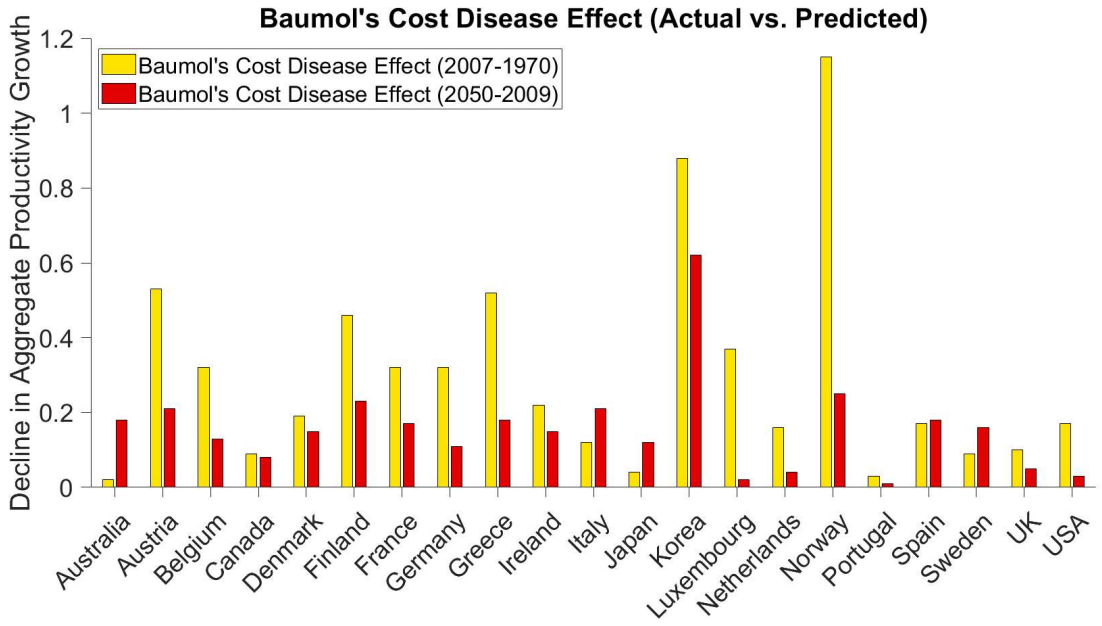


Figure 9: Baumol's Cost Disease Effect on Aggregate Productivity Growth

Notes: The bars show how much Baumol's cost disease declined or would decline aggregate productivity growth rate in each country.

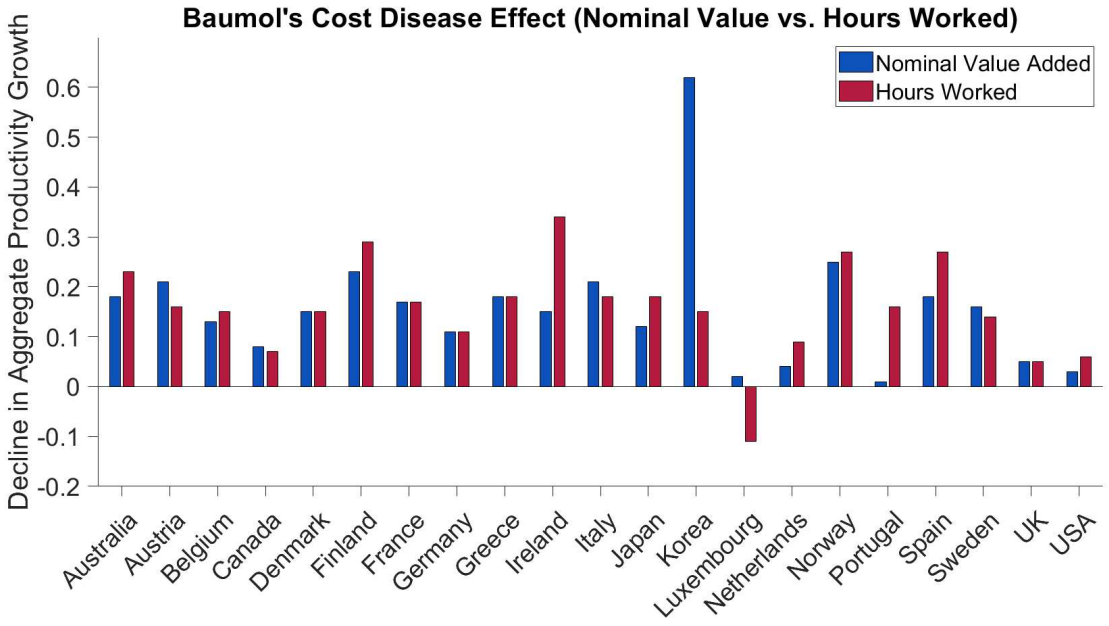


Figure 10: Comparison of Simulations Based on Nominal Value Added and Hours Worked Shares

Notes: The bars show how much Baumol's cost disease would decline aggregate productivity growth rate in each country between 2050 and 2009.

services, and calibration results suggest that the progressive services and the rest of the economy are the substitutes. This substitutability prevents the stagnant services to seize the entire economy, therefore also prevents it to depress the aggregate productivity growth further. To see this point, consider the projected share of the stagnant services sub-sector within total services for the US in Figure 11: The increase in projected share of the stagnant services within total services slows down over time, and the figure suggests that the share of this services sub-sector would start to decline after a certain point.

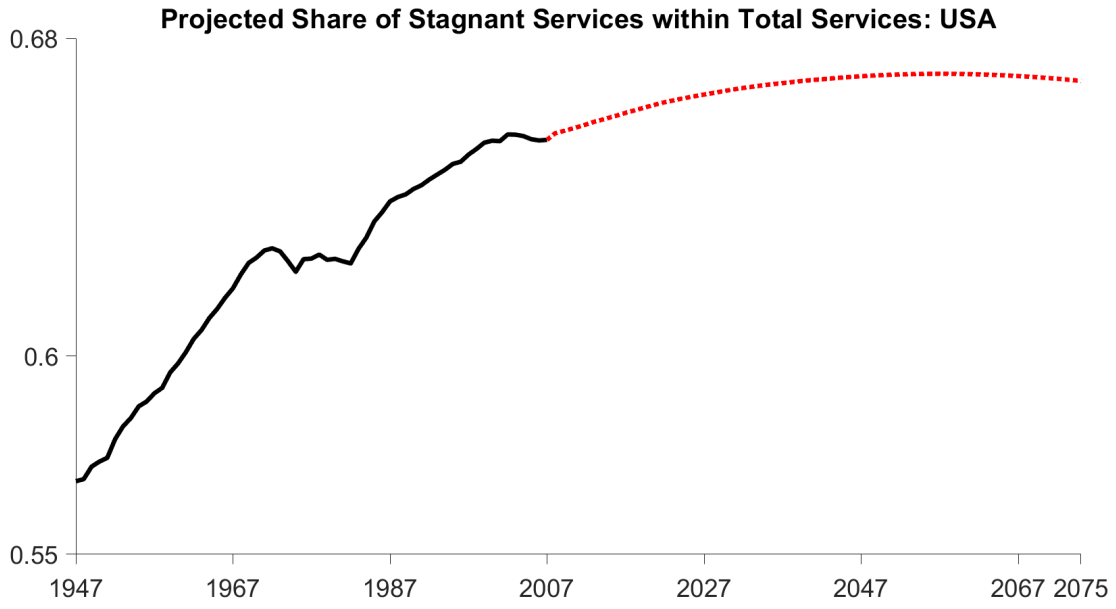


Figure 11: Projected Share of the Stagnant Services within Total Services: USA

For countries where calibrations do not suggest any substitutability between progressive services and other sectors in the economy, my results concerning Baumol's cost disease remain intact: It is because the elasticity of substitution that governs the share of progressive services against the rest of the economy stays around 1 (so, the share of progressive services remains mostly stable), and the goods and stagnant services turn out to be the substitutes. These facts are in line with the U-shaped pattern we document in Section 3.2, as also predicted by simulations for individual countries. Having said that, transition dynamics concerning structural change within the services sector are usually very slow. These slow transition dynamics could also explain why previous works in the literature (for example, Baumol et al. (1985) and Jorgenson and Timmer (2011)) did not consider the relative stability of progressive services

sector in aggregate economy could counteract Baumol's cost disease.

In summary, the results present ample counter-evidence against zero-productivity growth prediction of William Baumol: His dismal vision would not happen. Whether its implications for cross-country productivity differences are confirmed by the data constitutes the next part of this paper.

6 Model for Cross-Country Productivity Differences

This section introduces a simplified version of the model I consider for Baumol's cost disease. Instead of using non-homothetic CES, I model the household side to have the generalized Stone-Geary preferences. This choice is motivated by certain facts. Although analyzing future effects of Baumol's cost disease requires a preference specification that can display persistent income effects, it is not the case here. As we shall see, the generalized Stone-Geary preferences remain adequate and tractable for the research question in hand. Because of the level of disaggregation I need for this part of the analysis, other preferences used in the structural change literature (PIGL and non-homothetic CES) may not be fully satisfactory. [9]

6.1 Demand Side

For the household side the model preserves standard assumptions of the literature. As a departure, I do not model the agriculture sector separately. This choice reflects some facts. First, the literature (Duarte and Restuccia (2010)) has already demonstrated the role of this sector in the catching-up process. Second, in the end years of this study (2007 or 2015), the share of this sector is already very small in many countries (for example, in Belgium it accounts for less than 1% of total value added in 2015). Although for some countries the agriculture constitutes a high share of the economy in the beginning year of this study (in Austria and Italy, for example, the share of agriculture accounts for more than 20% of aggregate employment in 1970), the priority I give to the services in this study requires subsuming this sector under the goods.

As in the previous part, the problem of the representative household consists of two layers. In the outer layer, he chooses between the goods and services sectors. In the inner layer, he allocates

[9] Only under restrictive assumptions, PIGL, introduced by Boppart (2014), does have an extension to more than two sectors. Since its aggregate consumption index does not have a natural counterpart in the data, the non-homothetic CES requires a complicated calibration process which remains mostly problematic for disaggregation level I need. For details see Alder, Boppart, and Mueller (2019).

among the services sub-sectors. He inelastically supplies labor, only input in production. I abstract from the intertemporal choice, the model does not feature capital good and remains static. The problem of the representative household is:

$$\max_{C_{gt},C_{st}} [\omega_a^{\frac{1}{\epsilon}} C_{gt}^{\frac{\epsilon-1}{\epsilon}} + \omega_s^{\frac{1}{\epsilon}} (C_{st} + \bar{C}_s)^{\frac{\epsilon-1}{\epsilon}}]^{\frac{\epsilon}{\epsilon-1}} \quad \text{s.t.} \quad P_{gt}C_{gt} + P_{st}C_{st} = w_t$$

where C_{gt} and C_{st} are the consumption of the goods and services sectors, and P_{gt} and P_{st} represent their prices at time t. $\epsilon \geq 0$ denotes the elasticity of substitution between the goods and services. In the case where $\bar{C}_s = 0$ and $\epsilon = 0$, the utility function represents the Leontief preferences; if $\epsilon = 1$, the aggregate consumption good index becomes Cobb-Douglas. A value of $\epsilon < 1$ is often needed to account for structural change from the goods to services.

$\bar{C}_s$ represents the luxury consumption requirement for the services. $\bar{C}_s > 0$ is a standard assumption in the structural change literature to account for the later increase in the share of services sector. I follow a pragmatic approach and do not introduce any positivity constraints on $\bar{C}_s$. Although I consider only standard drivers of structural change here (income and price effects), other factors -trade, investment and intermediate demands- as well can affect the share of a sector. With no restrictions on $\bar{C}_s$, I aim to incorporate the forces not explicitly considered in the model.

In the inner layer of the household problem I consider the allocation problem within the services sector. I use a nested Stone-Geary utility specification. In other words, a different elasticity of substitution governs structural change within the services. The problem of the representative household for the services could be expressed as follows:

$$\max_{\{C_{it}\}_1^{11}} \sum_{i=11}^{11} [\omega_i^{\frac{1}{\eta}} (C_{it} + \bar{C}_i)^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}} \quad \text{s.t.} \quad \sum_{i=11}^{11} P_{it}C_{it} = P_{st}C_{st}$$

$$\text{and} \quad P_{st} = [\sum_{i=1}^{11} \omega_i P_{it}^{1-\eta}]^{\frac{1}{1-\eta}}$$

where η represents the elasticity of substitution among the services sub-sectors. $\bar{C}_i$ represent the income effects for the $i = 1, ..., 11$ the service sub-sectors. As in the case of the problem between the goods and services, I do not introduce any restrictions on $\bar{C}_i$. I expect them to capture not-explicitly-considered forces that drive structural change within the services.

When $\bar{C}_i = 0$ for each i, for a value of $\eta > 1$ the direction of structural change within the services will be from the low-productivity growth services sub-sectors to the high-productivity growth ones. Since the high-productivity growth service sub-sectors for a country can be different than ones I identify in this paper, a value of η greater than 1 does not necessarily mean that structural change within the services favors the progressive services sector.

6.2 Supply Side

The economy consists of 11 services sub-sectors ($i = 1, 2, ..., 11$) and a sector that produces the goods (g). Each sector is characterized by linear production functions. I allow the labor productivity to change over time and take it exogenously. Because of the discrepancy between the nominal value added and hours worked shares in the data, I also introduce the wedges. The problem of the representative firm is:

$$\max_{L_{it}} P_{it}Y_{it} - (1+\tau_{it})w_t L_{it} \quad \text{where} \quad Y_{it} = A_{it}L_{it}, \quad i = g, 1, 2, ..., 11$$

Aggregate labor input is normalized to 1; therefore, L_{it} also represents the share of sector in total employment. The first-order conditions of the firm's problem renders the following results:

$$\frac{P_{it}}{P_{gt}} = \frac{(1+\tau_{it})}{(1+\tau_{gt})}\frac{A_{gt}}{A_{it}}, \quad i = 1, 2, ..., 11$$

Rearranging and imposing the market-clearing conditions yields:

$$\frac{P_{it}C_{it}/L_{it}}{P_{gt}C_{gt}/L_{gt}} = \frac{(1+\tau_{it})}{(1+\tau_{gt})}, \quad i = 1, 2, ..., 11$$

Again, this equation would help me to cover the hours worked shares from the nominal value added shares.

6.3 Market Equilibrium

The market clearing conditions are as follows:

$$Y_{it} = C_{it}, \quad i = g, 1, 2, ..., 11$$

$$1 = L_{gt} + \sum_{i=1}^{11} L_{it}$$

6.4 Characterization of Structural Change

To motivate the role of the elasticity of substitution in structural change, in what follows I report the results without income effects. The first-order conditions of the representative household together with the efficiency and market-clearing conditions yield the following result for the allocation between the goods and services sectors:

$$\frac{P_{st}C_{st}}{P_{gt}C_{gt}} = \frac{\omega_s}{\omega_g}\left[\frac{P_{gt}}{P_{st}}\right]^{\epsilon-1}$$

Without income effects, the first-order condition of the representative agent yields following result for the allocation within the services:

$$\frac{P_{it}C_{it}}{P_{jt}C_{jt}} = \frac{\omega_i}{\omega_j}\left[\frac{P_{jt}}{P_{it}}\right]^{\eta-1}$$

A value of $\epsilon \in [0, 1)$, all else equal, is a necessary condition for making the model consistent with the structural change facts between the goods and services. Although the literature is abundant with the estimates of ϵ, it is not the case for η. We cannot know a priori what kind of value for η is needed to make the model consistent with structural change facts within the services.

When I combine market clearing conditions with allocation results between the goods and services and those within the services, I obtain the following results for nominal value added shares:

$$\frac{P_{gt}C_{gt}}{P_tC_t} = \frac{\omega_g P_{gt}^{1-\epsilon}\left(1 + P_{st}\bar{C}_s\right)}{\omega_g P_{gt}^{1-\epsilon} + \omega_s P_{st}^{1-\epsilon}}$$

$$\frac{P_{st}C_{st}}{P_tC_t} = \frac{\omega_s P_{st}^{1-\epsilon}\left(1 + P_{st}\bar{C}_s\right)}{\omega_g P_{gt}^{1-\epsilon} + \omega_s P_{st}^{1-\epsilon}} - P_{st}\bar{C}_s$$

$$\frac{P_{it}C_{it}}{P_{st}C_{st}} = \frac{\omega_i P_{it}^{1-\eta}\left(1 + P_{1t}\bar{C}_1 + P_{2t}\bar{C}_2 + ... + P_{11t}\bar{C}_{11}\right)}{\omega_1 P_{1t}^{1-\eta} + \omega_2 P_{2t}^{1-\eta} + ... + \omega_{11} P_{11t}^{1-\eta}} - P_{it}\bar{C}_i \quad , i = 1, 2, ..., 11$$

Although the equations above refer to consumption value added shares, I follow a pragmatic approach and match them to nominal value added shares.

7 Quantitative Analysis for Cross-Country Productivity Differences

7.1 Calibration

To match data as closely as possible, I use the country-specific parameters and calibrate 27 parameters for each country. I derive the parameters that govern structural change within the services sector $\{\omega_1, \omega_2, \omega_3, \omega_4, \omega_5, \omega_6, \omega_7, \omega_8, \omega_9, \omega_{10}, \omega_{11}\, \eta, \bar{C}_1, \bar{C}_2, \bar{C}_3, \bar{C}_4, \bar{C}_5, \bar{C}_6, \bar{C}_7, \bar{C}_8, \bar{C}_9, \bar{C}_{10}, \bar{C}_{11}\}$ by minimizing the sum of squared differences between the data and model. I target nominal value added shares of each services sub-sector within the services. I derive the remaining parameters that govern structural change between the goods and services (that is, $\{\omega_g, \omega_s, \epsilon, \bar{C}_s\}$) again by minimizing the sum of squared differences between the data and model. I target the nominal value added share of services sector, therefore by construction I also match the nominal value added share of the goods sector.

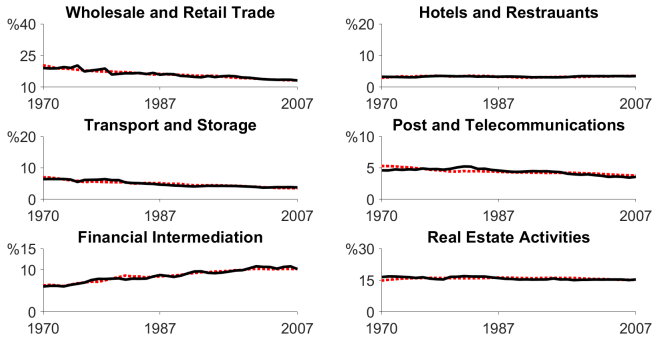
The model usually fits data very well (Figure 12 shows the model's fit for the US - for other countries I refer to the reader to Appendix H). As Table 17 demonstrates, the calibration results I obtain for a more disaggregated level of the services sector with a different preference specification mostly agree with the ones from the Baumol's cost disease part. First, for all countries except six of them the elasticity of substitution for the services sub-sectors (η) is greater than that between the goods and services (ϵ). A standard structural change model that mingles the services sub-sectors with other broad sectors of the economy under a uniform elasticity of substitution would not capture this difference. Second, for all countries except seven of them the elasticity of substitution governing structural change within the services is either greater than 1 or slightly below it (more specifically, between 0.90 and 1). This result shows that the substitutability characterizes structural change within the services sector, and its direction from the low-productivity growth services sub-sectors to high-productivity growth ones.

Table 17: Calibration Results for the Elasticity of Substitution

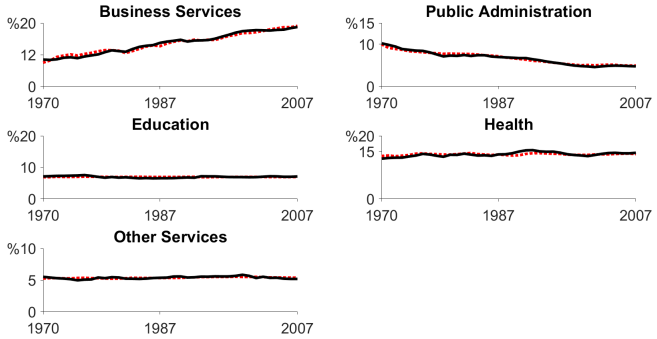
	η	ϵ
Australia	1.21	0.00
Austria	0.09	0.14
Belgium	2.19	0.19
Canada	0.94	0.00
Denmark	1.27	0.42
Finland	1.03	0.70
France	0.60	0.40
Germany	0.24	1.18
Greece	1.42	0.85
Ireland	1.50	0.43
Italy	0.76	0.56
Japan	1.14	0.00
Korea	1.13	0.96
Luxembourg	0.93	1.19
Netherlands	0.61	0.65
Norway	0.61	0.43
Portugal	0.99	1.86
Spain	1.34	0.32
Sweden	0.75	1.05
UK	1.17	0.48
USA	0.96	0.52

Figure 12: Data vs. Model: US

a. Goods and Services



b. Services



c. Services-Continues

7.2 Counterfactuals

Concerning productivity growth in the services many developed countries could not catch-up the US, so they also fall behind him in aggregate labor productivity. The counterfactuals in this sub-section aim to characterize the most problematic services sub-sectors. To assess the effect of individual services sub-sectors on aggregate relative productivity, I equate the productivity growth in a certain sub-sector to its counterpart in the US between 1970-2007. These counterfactuals, as shown in Table 18, show that the Wholesale and Retail Trade, Financial Intermediation, and Business Services are the services sub-sectors that affect aggregate relative productivity most, and confirm the results of Buiatti, Duarte and Saenz (2018) for a larger set of countries. For all countries except for Norway, catching up the productivity growth rate of the US in the Wholesale and Retail Trade increases aggregate relative productivity. Although the share of this services sub-sector decreases monotonically within total services, it still remains the largest services sub-sector for most countries in the period considered this study. For all countries except for the UK, displaying the productivity growth rate of the US in the Business Services pushes aggregate relative productivity upward. Only four countries (Denmark, Finland, Korea, and Portugal) do not benefit from having the productivity growth rate of the US in the Financial Intermediation. Considering that these service sub-sectors also supply intermediates to other sectors, their total effect might be greater than what is suggested here.

Table 18: Counterfactuals

Country	Wholesale and Retail Trade	Hotels and Restaurants	Transport and Storage	Post and Tele-communications	Financial Intermediation	Real Estate Activities	Business Services	Public Administration	Education	Health and Social Work	Other Services	Goods
Australia	8.32	-0.14	0.87	-0.24	3.40	-0.05	5.30	1.92	0.72	-1.29	-0.97	-5.57
Austria	5.66	-2.04	0.40	-0.28	1.90	-1.19	2.22	2.25	-1.17	-0.57	0.38	-21.94
Belgium	12.27	-0.91	0.80	1.25	2.38	-3.53	0.23	4.94	-4.44	-0.36	-2.06	-26.20
Canada	4.75	-0.32	0.86	1.32	2.48	-5.23	1.09	2.12	-1.20	-0.91	0.33	-5.07
Denmark	4.74	0.26	1.40	0.02	-0.72	5.98	0.35	2.97	-1.02	-1.65	-0.45	-9.05
Finland	2.84	-0.30	0.69	-1.76	-0.63	-4.92	2.88	3.32	-0.21	1.87	-0.35	-29.40
France	3.59	0.25	-0.97	-1.08	1.99	-7.48	4.14	1.27	-0.23	-0.75	-0.85	-23.16
Germany	6.23	0.40	-1.42	-0.02	1.62	-2.15	3.77	-1.98	-1.25	-2.73	-1.20	-14.72
Greece	7.53	0.50	-2.16	0.10	0.87	4.23	1.27	2.73	1.19	0.03	-0.31	-8.21
Ireland	1.31	0.06	2.04	-0.11	7.34	4.22	7.03	3.05	-1.88	-2.76	-1.50	-30.03
Italy	8.69	1.11	0.94	0.42	5.04	2.00	6.76	1.76	-0.25	-0.82	-0.10	-11.01
Japan	2.24	0.98	3.54	1.45	1.51	1.50	1.89	1.15	1.37	2.19	1.47	-10.49
Korea	1.50	-1.40	-1.93	-2.57	-4.64	3.85	1.01	4.09	0.41	-0.32	-0.98	-27.84
Luxembourg	9.37	4.71	-1.81	-2.72	-16.64	19.83	19.54	-0.51	-6.33	-2.79	-0.24	-2.23
Netherlands	4.24	-0.43	0.42	-0.27	1.09	-2.95	3.53	-0.29	-0.27	-2.59	0.81	-16.69
Norway	-7.94	1.61	-2.26	-2.32	4.13	25.57	1.43	2.86	-2.68	-1.56	-1.46	-66.20
Portugal	9.51	-1.18	-1.08	-1.24	-3.98	-10.42	3.21	-0.60	-2.90	-1.84	-0.21	-14.52
Spain	5.80	0.39	-0.54	-0.01	1.34	1.74	1.90	4.07	-0.40	0.70	0.18	-12.30
Sweden	4.38	0.30	0.91	-0.07	0.50	0.71	4.60	3.79	-0.09	-0.27	-1.01	-15.19
UK	4.68	0.27	-0.33	-0.46	1.43	4.31	-2.22	2.70	0.54	-2.07	-1.12	-1.54
Max	12.27	4.71	3.54	1.45	7.34	25.57	19.54	4.94	1.37	2.19	1.47	-1.54
Min	-7.94	-2.04	-2.26	-2.72	-16.64	-10.42	-2.22	-1.98	-6.33	-2.79	-2.06	-66.20
Average	4.99	0.21	0.02	-0.43	0.52	1.80	3.50	2.08	-1.00	-0.93	-0.48	-17.57
Median	4.74	0.26	0.41	-0.18	1.47	1.10	2.55	2.47	-0.34	-0.87	-0.40	-14.62

Notes: The counterfactuals show how much relative aggregate productivity would change in percentage point terms if a country had same productivity growth rate of the US in a sub-sector.

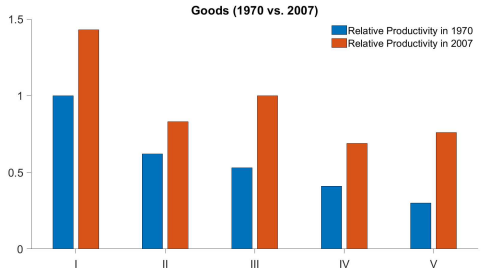
The services sub-sectors that have the greatest impacts on aggregate relative productivity largely make up the progressive/business services sector. Since the split between progressive/business and stagnant services sectors captures well the evolution of productivity in total services for the US, this split looks like a natural choice for analyzing cross-country productivity differences. To this end, I calibrate the initial relative productivity levels for the progressive/business stagnant services and goods sectors in each country. Given the sectoral-level productivity growth rates, I choose the initial levels of relative productivity for the sectors that minimize the sum of squared differences between the model-implied levels of relative aggregate productivity and the data, and obtain time series for sectoral relative productivity levels.[10]

Figure 13 shows how cross-country productivity differences behave differently across sectors. Duarte and Restuccia (2010) already noted the catch-up in the goods sector, and the lack of it in the services. My results also confirm that from 1970 to 2007 countries in each quintile improved their relative productivity levels with respect to the US in the goods sector. But only the countries in the first and fifth quintiles improved their relative productivity levels in the services; all other quintiles declined. When I consider how the different services subgroups behave, however, a different picture emerges: The progressive/business and stagnant services sectors display entirely different patterns. Although the countries in each quintile either improved or kept constant their relative productivity levels in the stagnant services sector, there is no single quintile that did not decline in the progressive/business services. These results show that only a subset of the services, the progressive/business services sector, pushed all the declines in the relative productivity levels for the services and aggregate economy. The results for the end year of the study, 2007, point stark differences between different services sub-sectors: For a typical country its relative productivity level with respect to the US in the progressive/business services is usually half of that in the stagnant services sector (Figure 14).

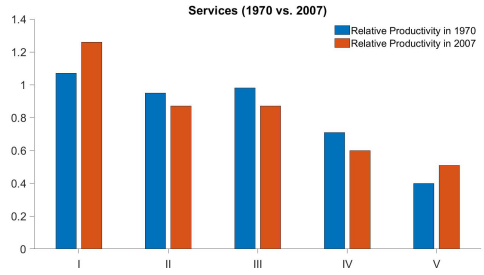
To see these results in a context let's reflect upon what Baumol's cost disease implies for cross-country productivity differences. Baumol's cost disease would induce the stagnant services sector to seize the whole services and whole economy, and under the assumption that productivity does not grow in the stagnant services sector, aggregate productivity growth rate would gradually

[10]The aggregate productivity index implied by the WORLD KLEMS usually does not match well to the aggregate productivity index in the Total Economy Database. To overcome this problem, I pick up the relative productivity levels from the Total Economy Database for the initial year (1970) and extrapolate them with productivity growth rates from the KLEMS. The constructed relative productivity indexes exhibit qualitatively similar aggregate relative productivity patterns in the third part of this paper.

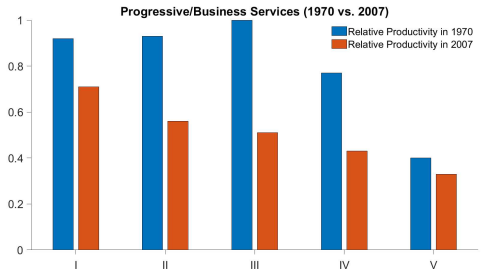
Figure 13: Sectoral Productivity Differences across Time



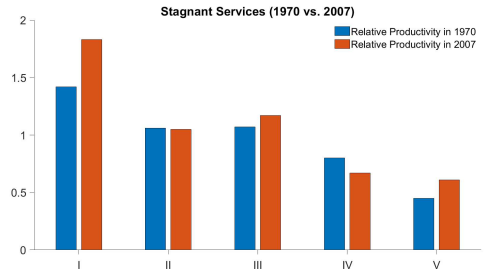
a. Goods (1970 vs. 2007)



b. Services (1970 vs. 2007)



c. Progressive/Business Services (1970 vs. 2007)



d. Stagnant Services (1970 vs. 2007)

Notes: I rank the countries with respect to their GDP per capita in 1970. The first quintile represents the most-developed countries in 1970 in my sample, and the fifth quintile the least-developed ones in the same year. The bars show the average relative productivity of each quintile with respect to the US in each sector. The blue-colored bars show the average relative productivity level with respect to the US in 1970, the red-colored bars those in 2007.

converge to zero. Since the US represents the technology frontier, aggregate productivity growth rate would first decrease in the US and those in other countries would follow it with a lag. Baumol's cost disease implies that productivity differences between the US and other countries should decline over time, and in the limit there should be *absolute convergence* - that is, all countries would share same productivity level. The declines in relative aggregate productivity that started in the second half of the 1990's and continue well into 2015, therefore pose a challenge to Baumol's cost disease. As we shall see, the substitutability between the progressive/business and stagnant services could actually solve this puzzle.

Duernecker, Herrendorf, and Valentinyi (2019) argue that the substitutability between the progressive/business and stagnant services would limit Baumol's cost disease for the US in the future. For many countries I show that the progressive/business services sector also drives the productivity growth resurgences that started in the second half of the 1990's. To analyze how

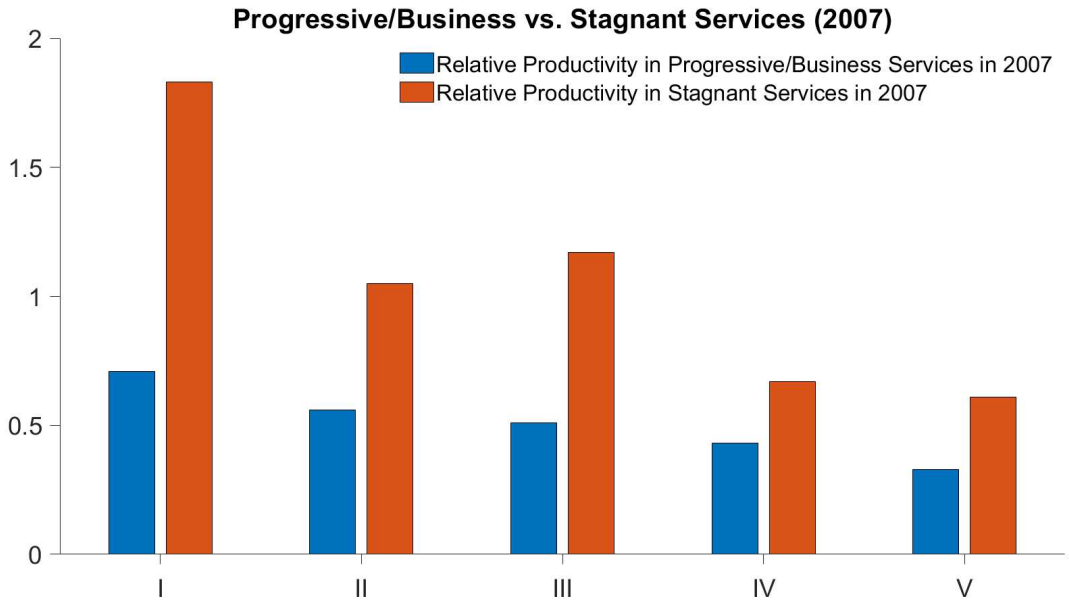


Figure 14: Progressive/Business vs. Stagnant Services in 2007

Notes: The blue-colored bars represent the average relative productivity level with respect to the US in the progressive/business services for each quintile in 2007, the red-colored bars those in the stagnant services for the same year.

progressive/business services shape cross-country productivity differences, I simplify the model I consider in the previous part of this paper: Instead of 11 sub-sectors, the services sector would comprise of only 2 sub-sectors, progressive/business and stagnant services. The aggregator for the services sector in this case becomes:

$$C_{st} = [\omega_p^{\frac{1}{\eta}} C_{pt}^{\frac{\eta-1}{\eta}} + \omega_u^{\frac{1}{\eta}} (C_{ut} + \bar{C_u})^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}}$$

where the η now denotes the elasticity of substitution between the progressive/business and stagnant services sectors. $\bar{C_u}$ captures the income effects, but again I do not put any restrictions on it. The stagnant services is denoted by u.

The results in Table 19 make a strong case in favor of the substitutability between the progressive/business and stagnant services sectors. The elasticity of substitution that governs structural change between these two services sub-sectors either exceeds 1 or takes a value close to it.[11] To see how the progressive/business services affects cross-country productivity differences,

[11]The reader should notice that if the elasticity of substitution is greater than 1 in the US, and lower than 1 in other countries, my argument about the role of structural change would still remain valid. I, however, do not

Table 19: Elasticity of Substitution between the Progressive/Business and Stagnant Services

	η	ϵ
Australia	0.51	0.00
Austria	1.04	0.21
Belgium	1.98	0.13
Canada	1.10	0.00
Denmark	1.02	0.12
Finland	1.12	0.73
France	0.97	0.38
Germany	1.47	0.28
Greece	0.77	0.77
Ireland	0.96	0.38
Italy	0.81	0.41
Japan	1.15	0.00
South Korea	0.75	1.01
Luxembourg	2.25	0.68
Netherlands	1.62	0.06
Norway	0.91	0.41
Portugal	0.00	2.99
Spain	1.23	0.20
Sweden	0.78	0.83
UK	1.06	0.00
US	1.21	0.50

I run a counterfactual where starting in 1995 productivity in the progressive/business services would grow at such a rate that in the end year of the sample, 2007, the relative productivity level in the progressive/business services sector would be equal to that in the stagnant services in each country. Figures 15 and 16 show the results of these counterfactuals. As these graphs demonstrate, the progressive/business services sector entirely accounts for almost all declines in aggregate productivity. Countries would continue overtaking and even excelling the US in this counterfactual, except for the growth miracles (Korea, Ireland, and Norway) and the countries where low productivity growth inhere in every sector (Italy, Spain, and Greece).

How does structural change within the services sector relate to cross-country productivity differences? Recall that the relative productivity index of the progressive/business services with respect to stagnant services increases over time, and the share of progressive/business services displays a shallow U-shaped pattern within total services. In the second half of the 1990's,

want to make a case for such an unlikely result.

Figure 15: The Catch-Up in the Progressive/Business Services

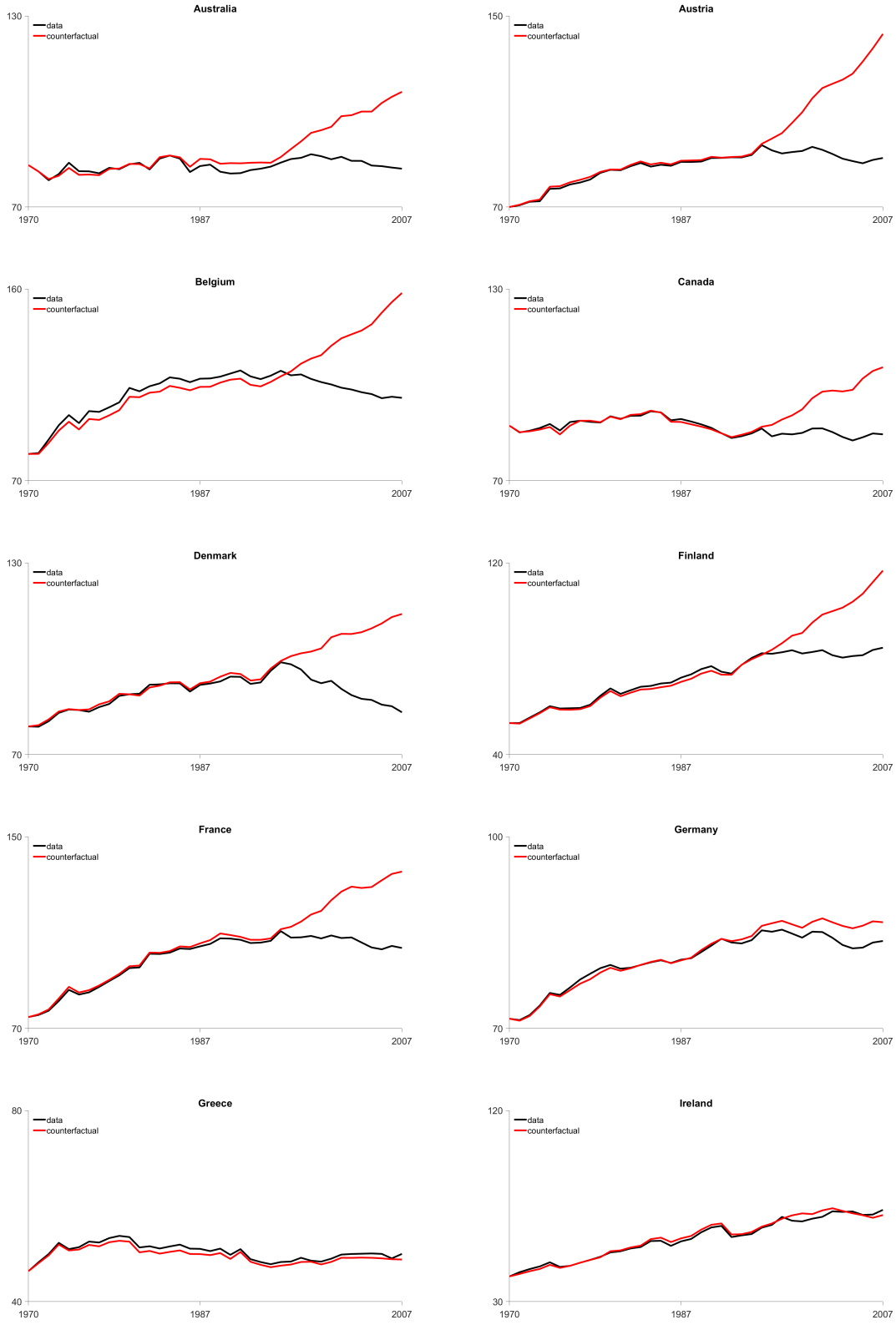
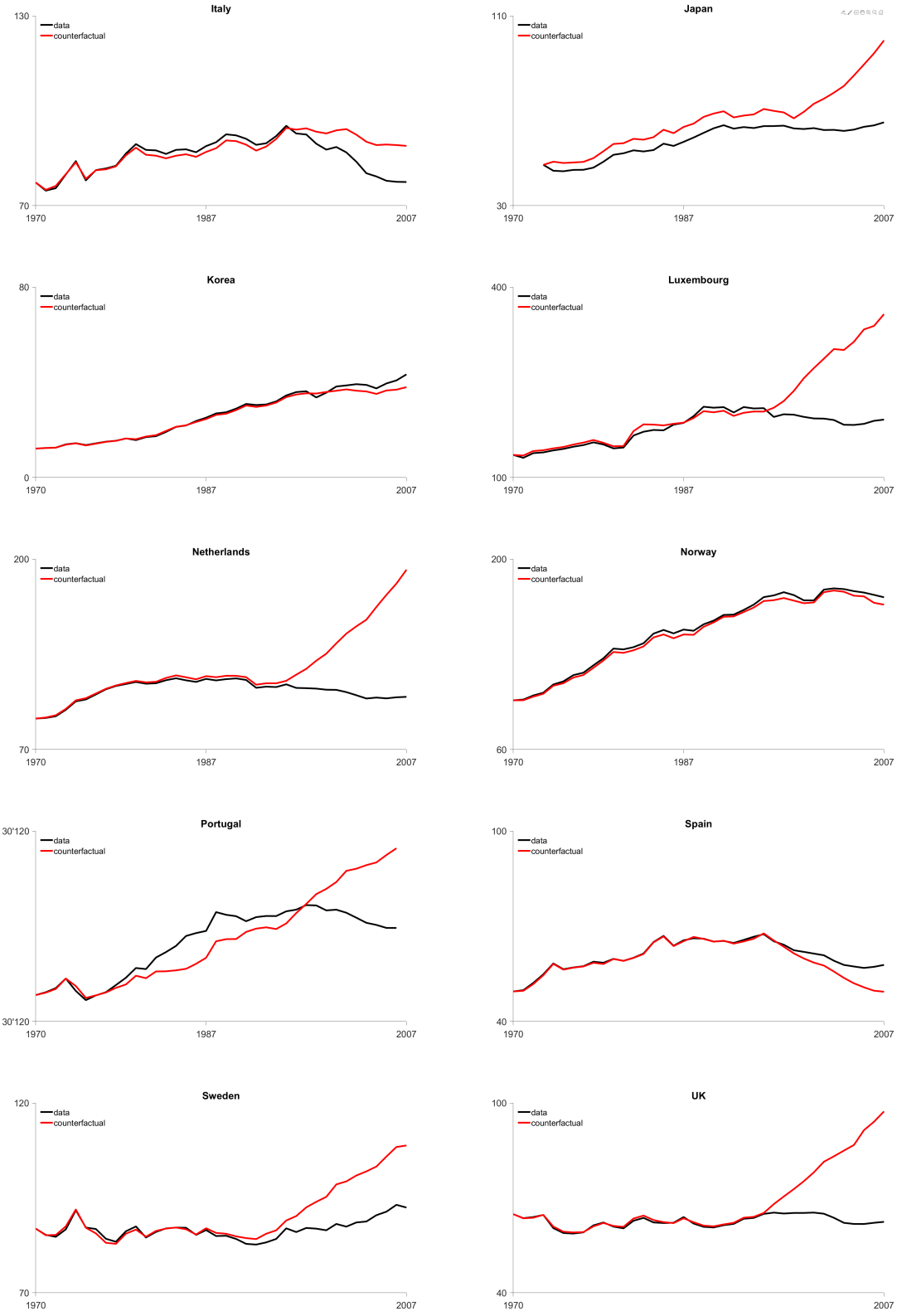


Figure 16: The Catch-Up in the Progressive/Business Services - Continued



productivity growth soared in the progressive/business services sector in many countries, but somehow increased more in the US. Despite this productivity growth resurgence, the share of progressive/business services either remained stable or increased within total services. If the progressive/business and stagnant services were the complements, as Baumol's cost disease would predict, the share of the progressive/business services sub-sector within total services would have been lowered by productivity growth resurgence in this services sub-sector. Depending on the magnitudes of the elasticity of substitution and income effects, the decline in the share of the progressive/business services might have been great enough to offset the productivity growth resurgence in this services sub-sector. Therefore, we might not have observed productivity growth resurgences in aggregate services and aggregate economy.[12] To sum up, structural change facts for the services sector that would limit Baumol's cost disease in the US also advance aggregate productivity differences between this country and others.

I analyze cross-country productivity differences also with the recent and revised data, and update the results to 2015: Reassuringly, they remain robust (Figure 17). Although developed countries either improved or maintained their relative productivity levels with respect to the US in the stagnant services sector, their relative productivity levels all except for the first quartile declined in the progressive/business services. The revised data, however, implies lesser relative productivity differences between these two services groups in the end year of the sample (Figure 18). Smaller productivity differences between these services sub-groups indeed gives more role to the structural change in shaping cross-country productivity differences. My results about the substitutability between the progressive/business and stagnant services also remain intact with the revised data, as it can be seen from Table 20.[13]

Sectoral productivity levels in the end year of the study, 2015, for all 40 countries I have data show sectoral underpinnings of development (Figure 19). For example, what differentiates Greece and Portugal, two countries in the fourth quintile, from Turkey, a country in the fifth quintile, is their greater relative productivity in the goods sector. Countries in the fourth quintile also display a greater relative productivity in the progressive/business services than those in

[12]For the US, a value as low as 0.50 for the elasticity of substitution between the progressive/business and stagnant services is enough to offset the positive effects of the productivity growth resurgence in the progressive/business services on aggregate productivity growth. The results of this counterfactual are available upon request.

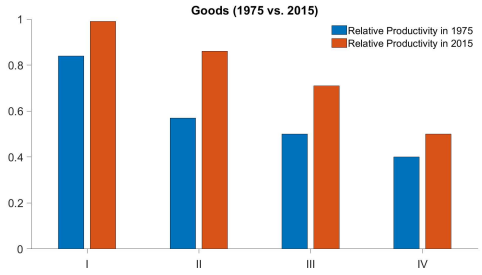
[13]I calibrate the model for every country I have data, but report the results only for the countries I have longer series. For the 65% of the countries in my sample (in total, 40 countries) the calibration results show that the progressive/business and stagnant services are the substitutes. These results are available upon request.

Table 20: Elasticity of Substitution between the Progressive/Business and Stagnant Services

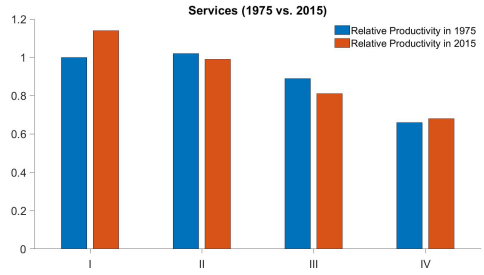
	η	ϵ
Austria	1.04	0.27
Belgium	1.77	0.18
Denmark	1.05	0.87
Finland	0.77	0.71
France	0.79	0.51
Germany	1.71	0.00
Italy	0.62	0.64
Japan	1.09	0.00
Netherlands	1.69	0.23
Norway	0.94	0.56
Spain	1.07	0.57
UK	1.09	0.55
USA	1.01	0.46

the fifth quintile, but this difference is somehow minor with respect to that in the goods sector. Productivity differences in the goods sector still determine the difference between the third and fourth quintiles (say, between Italy/Spain and Greece/Portugal). The stagnant services sector also contributes to these differences. After the third quintile, however, the services sector takes charge. France and Germany, two countries in the second quintile, differ from Italy and Spain because of their greater productivity levels in aggregate services. The progressive/business services sector makes the greatest impact in differentiating the first quintile from the second. More dramatically, concerning stagnant services, countries in the second quintile have comparable relative productivity levels with respect to the countries in the first quintile: It is their lower relative productivity levels in the progressive services that pull them back. As far as 2015 is concerned, it looks that some developed countries have been catching up the frontier (the US) in the progressive/stagnant services sector. Since my results make a strong case that this services sub-group would become more dominant over time, it is not unreasonable to expect aggregate productivity divergences not only between the US and other developed countries but also among country groups in the future.

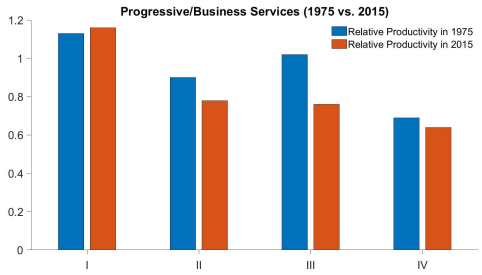
Figure 17: Sectoral Productivity Differences across Time



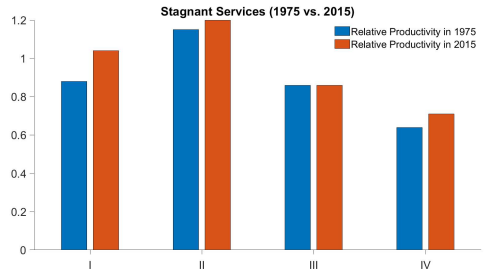
a. Goods (1975 vs. 2015)



b. Services (1975 vs. 2015)



c. Progressive/Business Services (1975 vs. 2015)



d. Stagnant Services (1975 vs. 2015)

Notes: I rank the countries with respect to their GDP per capita in 1975. The first quintile represents the most-developed countries in 1975 in my sample, and the fifth quintile the least-developed ones in the same year. The bars show the average relative productivity of each quintile with respect to the US in each sector. The blue-colored bars show the average relative productivity level with respect to the US in 1975, the red-colored bars those in 2015.

8 Conclusion

In this paper I identify common high- and low-productivity growth services sub-sectors across countries, and analyze structural change facts for the services sector with respect to these classifications. I concentrate upon the implications of structural change within the services sector for Baumol's cost disease and cross-country productivity differences. My results show that one can identify common high- and low-productivity growth services sub-sectors across countries, and theses definitions remain robust across time and data. Developed countries display same structural change characteristics in the services sector: The share of the progressive services sector remains remarkably stable around $25-35\%$ of aggregate economy and the substitutability of this services sub-sector with the rest of the economy would sap Baumol's cost disease for future productivity growth.

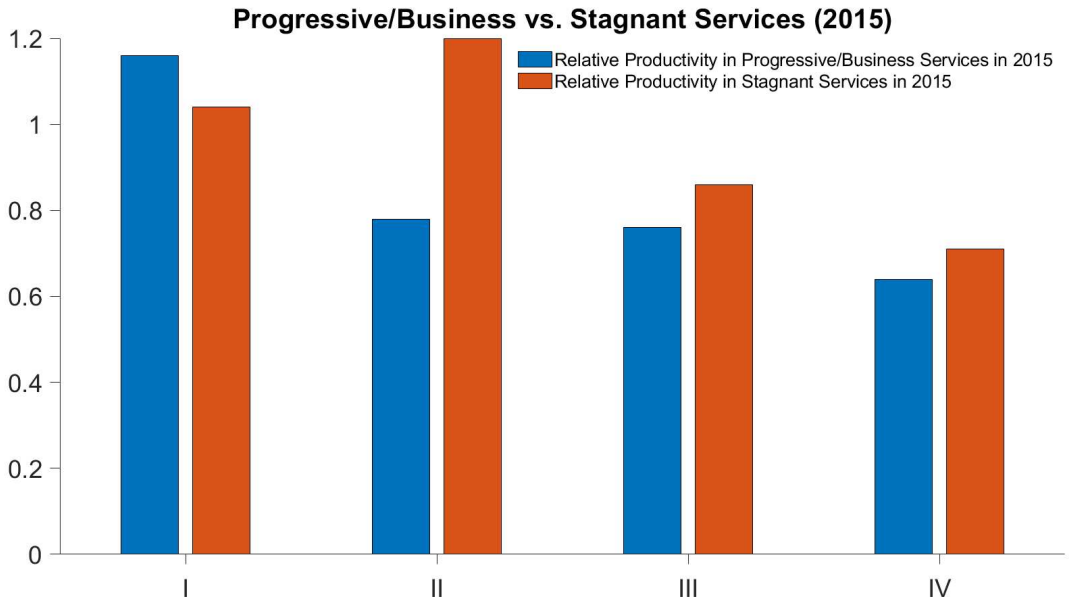


Figure 18: Progressive/Business vs. Stagnant Services in 2015

Notes: The blue-colored bars represent the average relative productivity level with respect to the US in the progressive/business services for each quintile in 2015, the red-colored bars those in the stagnant services for the same year.

I later analyze aggregate productivity differences between the US and other developed countries. My results show that the progressive/business services sector can entirely justify why many developed countries have started falling behind the US in the second half of 1990's after a sustained catch-up with the end of the Second World War. My results point diverse relative productivity patterns across the services sub-sectors: Although many developed countries have caught up the US in the stagnant services sector, they have fallen behind him in the progressive/business services. I argue that structural change within the services sector also contributes to productivity differences between the US and other developed countries. Because of the substitutability between these services sub-sectors, structural change favors the progressive/business services where developed countries do not perform well against the US, and therefore prompts the declines in aggregate relative productivity. Even if developed countries caught up the productivity growth rate of the US in the progressive/business services sector from now on, their relative productivity levels in aggregate services could still decline, because the share of the progressive/business would increase within the aggregate services. This result implies that the declines in aggregate relative productivity tend to persist over time, and justifies that many

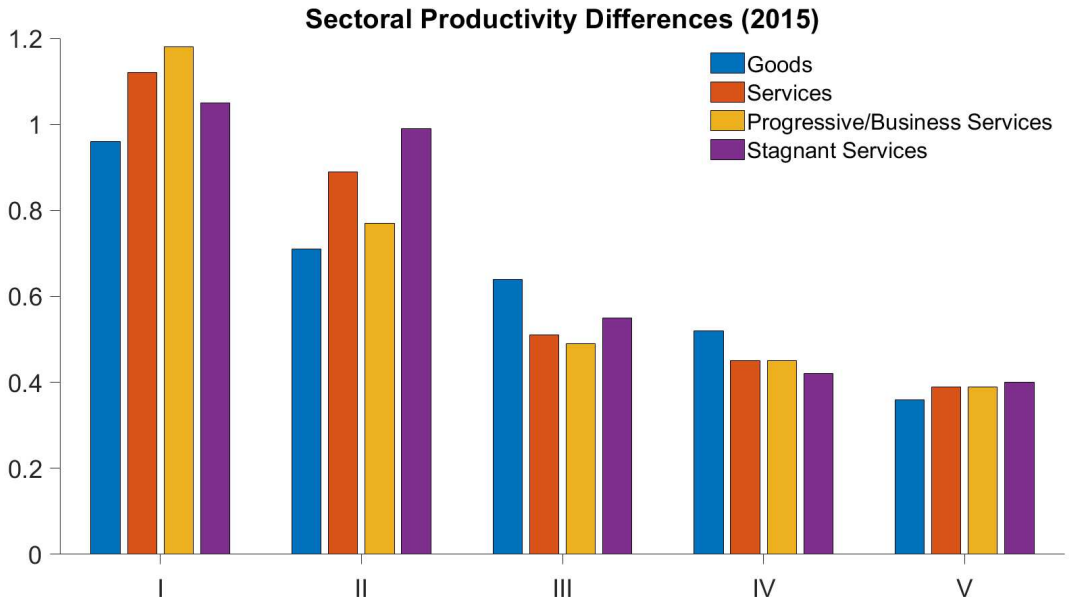


Figure 19: Sectoral Productivity Levels in 2015

Notes: I rank the countries with respect to their GDP per capita in 2015. The first quintile represents the most-developed countries in 2015 in my sample, while and the fifth quintile the least-developed ones. The bars show the average relative sectoral productivity levels with respect to the US in each quintile in 2015.

countries have not reverted back to their course of the catch-up despite lackluster productivity growth performance of the US after 2007. Any explanation that does not take into account structural change would struggle to explain cross-country productivity differences after this time.

What accounts for productivity growth differences among the services sub-sectors? Since the trade does not exert much influence on the services, and the stagnant services sector largely comprises of the skill-intensive sub-units we should seek alternative explanations. Even among the skill-intensive services sub-sectors, Finance and IC behave differently from others in terms of productivity growth. These facts also pose challenges to the models that emphasize human capital for economic growth.

Do productivity growth differences between the US and other developed countries reflect the measurement problems? Since my results remain largely unchanged with the revised data, I find difficult to give an affirmative answer to this question. If the US had actually not a low productivity level in the stagnant services, then it means that productivity differences between him and other developed countries are actually understated in the services sector. If developed countries had relative productivity levels in the progressive/business services actually compa-

rable to those in the stagnant services, then one should explain why mismeasurement were a much problem in the part of the services where productivity is measured better. The indirect evidence about cross-country productivity differences also support the findings of this paper. It is well known that aggregate price level increases over development, and this fact is often interpreted as the evidence of lower cross-country productivity differences in the services. But this result reflects the final consumption expenditures in which the stagnant services accounts for a large share of the services. Lastly, one should also consider that productivity growth in the progressive/business services took off in other countries as well during the second-half of the 1990's. So perhaps higher productivity growth performance of the US in this services sub-sector does not reflect different measurement practices.

Why do other developed countries fail to catch up the US in the progressive/business services sector? For the Wholesale and Retail Trade, the services sub-sector that has the greatest impact on productivity differences, the land-size regulations could play a role (Guner, Ventura, and Xe, 2008). The fact that productivity growth took off in other developed countries as well suggests that technology diffusion was active in the services. But since these countries did not achieve productivity growth rates that the US achieved, it is of interest to consider why they could not fully benefit from these new technologies. Does management account for these differences (Bloom, Sadun, and van Reenen, 2012)? Since the progressive/business services is more related to the production side of the economy, intersectoral linkages could also affect aggregate productivity. Perhaps, the intermediate goods multiplier was so huge in every country that even small productivity growth differences in some services sub-sectors were amplified through the linkages and led to aggregate productivity differences between the US and other developed countries. Or perhaps, the production structure were different in the US and productivity improvements in certain services sub-sectors transmitted better to other services sub-sectors and pushed aggregate productivity growth more in the US. These, and similar questions, should be better left for future research.

The services sector now makes up $75-80\%$ of the GDP in developed countries and consists of diverse sub-units. This papers shows that the heterogenous character of the services has dramatic consequences for aggregate productivity. My message is clear: We can no longer treat such a large and heterogeneous sector of the economy as unified. Especially, it does not make sense to consider the progressive services sector, a services sub-sector so different from the

rest of the services, together with other services sub-sectors. The databases that supply cross-country sectoral data (the WORLD KLEMS, OECD STAN, 10-Sector Database) should take into account these differences across services sub-sectors and supply longer and more detailed data on them for a larger number of countries.

I hope structural change facts I present here could motivate some future research. As a start, I want to emphasize that it is largely the stagnant services sub-sectors that drive the hours worked differences between the US and European countries (Jorgenson and Timmer, 2011). The rise of the business services sector could be linked to the global decline of the labor share (Koh, Santaeulalila-Llopis, and Zheng, 2016). Concerning the composite intermediate good, the complementarity between the goods and business services sectors, and the substitutability among the services sub-sectors could shed light on productivity growth slowdowns and revivals (Baqaee and Farhi, 2018). The positive correlation between nominal and real value added shares of the services sector largely reflects a misspecification that does not separate the progressive services from the rest of the services (Sen, 2019). Since the progressive/business services sector mostly supplies intermediate and capital goods, it is of interest to consider how it affects business cycles and inequality. Recent work by Bostanci (2019) takes a first step in the inequality part.

Structural change within the services sector does not conform to what Baumol's cost disease suggests. What stands behind this result? I argue that it is because that supply-side forces overlooked by Baumol, intermediate and investment demands, to a greater extent affects structural change within the services. Although Ngai and Pissarides (2007) argue that the demand for intermediate and capital goods could slow down structural change from the goods to services, their claim does not withstand recent research: Investment value-added is not produced by the industry alone and structural change within investment value-added favors the services (Herrendorf, Rogerson, and Valentinyi (2018)); the services sector becomes a net supplier of intermediate goods, and its share in aggregate intermediate input has been increasing (Grobovsek (2018)). Therefore, the argument in Ngai and Pissarides (2007) looks more relevant to structural change within the services than that between the goods and services sectors.[14]

Although I concentrate upon the OECD countries in this study, I believe that we need to understand better the experience of developing countries. Whether they exhibit similar

[14]To their credit, Ngai and Pissarides (2007) also hypothesize that structural change within broad sectors could favor high-productivity growth sub-sectors. It would not be wrong to argue that they somehow anticipate the results in Duernecker, Herrendorf, and Valentinyi (2019).

productivity-growth heterogeneity within the services, and implications of this heterogeneity for their development trajectory should be topics to be explored in the future. Analyzing India's economy at more disaggregated level, Serrano-Quintero (2020) takes a first step in this direction.

My final message is for economic modeling. Structural change models should incorporate supply-side forces, since they to a greater extent shape structural change within the services, with significant consequences for aggregate productivity. Although recent research by Garcia-Santana, Pijoan-Mas, and Villacorta (2016) and Herrendorf, Rogerson, and Valentinyi (2018) advance in integrating investment to structural change models, more works explicitly considering the network structure of the economy are needed. As Oulton (2001) argues, the rise of the services sub-sectors that supply intermediate and capital goods implies different results for Baumol's cost disease. Recent research by Miranda-Pinto and Young (2019) shows a substitutability result between value-added and intermediate inputs for the services sub-sectors, suggesting that Oulton's argument could be true.[15] What these results, more flexible sectoral production functions and changes in the input/output table imply for aggregate productivity should be fully explored in the future. Such models could also bring forth new insights for the balanced-growth facts.

[15]In the case where the elasticity of substitution between value added and intermediate inputs differs from 1, sectoral value added would not have any meaning. The results in Miranda-Pinto and Young (2019) are also destructive for the sectoral value added functions commonly used in the structural change literature.

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Appendix

Appendix A: Data Sources and Description

I analyze the data based on both the ISIC Rev.3.1 and ISIC Rev.4 classifications and report the results for both. Doing separate analyses for two different data classifications might seem overstretched, but this choice is motivated by certain concerns. My main objective in this study is to report structural change facts on the services sector from a productivity-growth perspective for the largest number of countries. Although the WORLD KLEMS, together with the OECD STAN, provide sectoral data compatible with the ISIC Rev.4 classification for as much as 40 countries, their data coverage for most countries starts after 1995. Unfortunately, such a time coverage would not help me to fulfill what I want to do in this study. Although I can go back as far as 1970 for 13 countries, it reduces my country coverage to a core of West European countries, limiting the extent of this research. One particular solution could be to extrapolate the data by combining different releases of the WORLD KLEMS. Unfortunately, the data made available by the WORLD KLEMS are usually not detailed enough to make a precise mapping between two different data classifications. This is particularly a concern for the Information and Communication sub-sector in the services. This novel services sub-sector introduced by the ISIC Rev.4 classification relates to various industries in the ISIC Rev 3.1., even the ones in the manufacturing. The productivity patterns implied by these two different sector classifications also differ from each other. To associate my research more closely with the existing studies in the literature and ensure robustness, I decide to analyze the data compatible with both classifications.

For the data compatible with the ISIC Rev. 3.1 I mostly rely on the March 2011 update of the November 2009 release of the EU KLEMS. I omit the categories "Private Households with Employed Persons" and "Extra-Territorial Organization and Bodies", because of the lack of data for most countries. The following gives a list of 21 countries considered in this study: Australia (1970-2007, EU KLEMS), Austria (1970-2007, EU KLEMS), Belgium (1970-2007, EU KLEMS), Canada (1961-2007, WORLD KLEMS), Denmark (1970-2007, EU KLEMS), Finland (1970-2007, EU KLEMS), France (1970-2007, EU KLEMS), Germany (1970-2007, EU KLEMS), Greece (1970-2007, EU KLEMS), Ireland (1970-2007, EU KLEMS), Italy (1970-2007, EU KLEMS), Japan (1973-2007, EU KLEMS), Korea (1970-2007, EU KLEMS), Luxembourg (1970-2007, EU KLEMS), Netherlands (1970-2007, EU KLEMS), Norway (1970-2007, OECD STAN), Portugal (1970-2006, EU KLEMS), Spain (1970-2007, EU KLEMS), Sweden (1970-2007, EU KLEMS),

UK (1970-2007, EU KLEMS), USA (1947-2007, WORLD KLEMS). The years in the brackets show the years I can compute sectoral productivity growth rates.

For the data compatible with ISIC Rev.4 I can extend time coverage of the study as far as to 2015, but do a longer term analysis (roughly, from 1970 to 2015) only for 13 countries. Combining the WORLD KLEMS and OECD STAN increases country coverage to 40, and countries as diverse as Mexico, Costa Rica, and the New Zealand are now included to the study. But for the newly-added countries I can do a detailed productivity analysis for the period between 1995 and 2015 only, and for some the time coverage is even shorter. I should also note the unbalanced nature of the OECD STAN database leads to the detailed analyses for some countries in some parts of the paper, but not so detailed analyses in others. This might be of concern, but in the end I decide to utilize available data as the most efficiently as possible.

For the data compatible with the ISIC Rev.4 my main source is the September 2017 release of the EU KLEMS. I also benefit from the OECD STAN though. I omit the categories "Activities of Households as Employers; Undifferentiated Goods- and Services-Producing Activities of Households for Own Use" and "Activities of Extraterritorial Organizations and Bodies" for the lack of data for most countries. The following gives a list of the countries considered in this study. Australia (1989-2015, OECD STAN), Austria (1970-2015, EU KLEMS), Belgium (1970-2015, EU KLEMS), Bulgaria (2000-2015, EU KLEMS), Canada (1997-2015, OECD STAN), Chile (2014-2015, OECD STAN), Costa Rica (1991-2015, OECD STAN), Croatia (2008-2015, EU KLEMS), Czech Republic (1995-2015, EU KLEMS), Denmark (1970-2015, OECD STAN), Estonia (1995-2015, EU KLEMS), Finland (1975-2015, OECD STAN), France (1970-2015, OECD STAN), Germany (1970-2015, EU KLEMS), Greece (1995-2015, EU KLEMS), Hungary (1995-2015, OECD STAN), Iceland (1997-2015, OECD STAN), Ireland (1998-2015, OECD STAN), Israel (1995-2015, OECD STAN), Italy (1970-2015, EU KLEMS), Japan (1973-2015, OECD STAN), Korea (2004-2015, OECD STAN), Latvia (2000-2015, EU KLEMS), Lithuania (1995-2015, EU KLEMS), Luxembourg (1995-2015, EU KLEMS), Mexico (1993-2015, OECD STAN), Netherlands (1970-2015, EU KLEMS), New Zealand (2000-2015, OECD STAN), Norway (1970-2015, OECD STAN), Poland (2000-2015, EU KLEMS), Portugal (1995-2015, EU KLEMS), Romania (1995-2015, EU KLEMS), Slovakia (1995-2015, EU KLEMS), Slovenia (1995-2015, EU KLEMS), Spain (1970-2015, EU KLEMS), Sweden (1993-2015, OECD STAN), Switzerland (1997-2015, OECD STAN), Turkey (2004-2015, OECD STAN), UK (1970-2015, EU KLEMS),

USA (1970-2015, EU KLEMS). The years in the brackets show the years I can compute sectoral productivity growth rates.

In the OECD STAN the hours worked data is usually shorter than the number of people engaged data. For these countries I use the method in Duarte and Restuccia (2010). I calculate the ratio of the hours worked share to the employment share for each sector. I take the average of these ratios and use the employment data to extrapolate the hours worked. If the hours worked data is not available for a country, I use the total hours worked data from the Total Economy Database and obtain the sectoral hours worked data by applying the employment shares.

For Canada, Chile, Japan, Israel, New Zealand, and Switzerland, the productivity growth rates for the Arts, Entertainment and Other Recreation sector include the Other Services sector. For Israel: Accommodation and Food includes the Wholesale and Retail Trade; Public Administration includes Health and Education. For New Zealand: Real Estate Activities includes Business Services; Public Administration includes Health and Education.

Appendix B: Robustness Checks on the Categorization of Services Sub-sectors

In this appendix I present additional robustness checks on the categorization of services sub-sectors. First, I consider whether my classification of progressive and stagnant services remains robust for two countries that I can calculate labor productivity growth rates for a longer period. Second, I redo the categorization of services sub-sectors for recently available data compatible with ISIC Rev.4.

For two countries, Canada and the US, I can calculate labor productivity growth rates for a longer period (for Canada, since 1961 and for the US, since 1947). Table 21 displays the results: It is assuring that the categorization of high-productivity growth services sub-sectors remains the same.

To provide additional checks for the categorization of the services sectors I present the results for the data compatible with the ISIC Rev.4 classification system which was introduced to make the national accounts compatible with the rise of the services sector. The services categories in the ISIC Rev.4 usually overlap with the ones in the ISIC Rev.3.1, but the ISIC Rev.4 introduces Information and Communication; and Arts, Entertainment, and Recreation as two additional services sub-sectors. Table 22 displays the list of services sub-sectors according to the ISIC Rev.4.

Tables 23-24 show productivity growth rates of the services sub-sectors and whether a services sub-sector displays a productivity growth rate greater than the aggregate services respectively. Information and Communication now replaces Post and Telecommunications, and it is ensuring that our definition of high-productivity growth services sub-sectors remains robust, despite the fact that the data now also includes the Great Stagnation period. The number of services sub-sectors that display above-average productivity growth but differs from any of the four high-productivity services sub-sectors I identify also decreases when the period is longer, providing additional support to my categorization. Tables 25-26 presents information about productivity growth rates of the services sub-sectors and whether a services sub-sector displays an above-average productivity growth for any country I have data. For the newly-added countries on the list the time coverage is shorter and varies considerably across countries - one should then beware the noisy information supplied by this table. Despite the noise, the picture emerged from this table is again clear: Four services sub-sectors (Wholesale and Retail Trade; Transportation and Storage; Information and Communication; Finance and Insurance) display a higher productivity

growth rate than others and the set of these high-productivity growth services sub-sectors remains robust across countries and time. Table 27 presents productivity growth rates for sectoral aggregates for any country I have data and Table 28 summarizes the categorization of services sub-sectors. Last, Table 29 presents country codes used in the Figures 2-3 in the main body of the text.

Table 21: Canada and the US: Productivity Growth within the Services Sector

Country	Wholesale and Retail Trade	Hotels and Restaurants	Transport and Storage	Post and Telecommunications	Financial Intermediation	Real Estate Activities	Business Services	Public Administration	Education	Health and Social Work	Other Services	Aggregate Services
Canada	2.67	-0.33	2.41	3.68	1.69	1.44	0.91	0.77	0.96	0.56	0.45	**1.26**
USA	3.44	-0.83	2.11	4.82	2.14	1.02	1.78	-0.50	1.15	-0.14	-0.54	**1.35**
Canada	■		■	■	■	■						
USA	■		■	■	■		■					

Source: WORLD KLEMS and my calculations

Table 22: List of Services Sub-Sectors According to the ISIC Rev.4

ISIC Code	Name of services sub-Sector
G	Wholesale and Retail Trade
H	Transportation and Storage
I	Accommodation and Food Service Activities
J	Information and Communication
K	Financial and Insurance Activities
L	Real Estate Activities
M-N	Professional, Scientific, Technical, Administrative and Support Service Activities
O	Public Administration and National Defense; Compulsory Social Security
P	Education
Q	Health and Social Work
R	Arts, Entertainment and Recreation
S	Other Service Activities

Source: WORLD KLEMS

Table 23: Labor Productivity Growth Rates for Services Sub-Sectors (1970-2015)

Country	Wholesale and Retail Trade	Transportation and Storage	Accommodation and Food	IC	Finance and Insurance	Real Estate Activities	Business Services	Public Administration	Education	Health	Arts and Entertainment	Other Services	Aggregate Services
Austria	2.21	2.49	1.04	2.83	2.65	0.83	0.78	1.05	0.83	0.19	0.38	0.45	**1.57**
Belgium	1.31	2.09	1.03	3.10	1.96	0.66	1.28	0.91	0.83	-0.13	-0.08	1.18	**1.23**
Denmark	2.54	2.00	-0.44	4.93	2.87	-0.97	0.93	0.32	0.55	0.29	-0.04	1.01	**1.36**
Finland	2.40	1.63	0.62	3.91	2.86	1.15	-0.25	0.98	0.01	-0.37	0.00	-0.23	**1.29**
France	2.40	3.22	0.28	2.82	1.89	1.07	-0.08	1.30	-0.26	0.98	0.74	1.07	**1.43**
Germany	2.48	2.57	-0.61	3.95	1.28	1.33	0.86	2.55	0.38	0.47	0.57	0.73	**1.85**
Italy	1.51	1.99	-0.66	1.02	-0.54	-2.69	-1.97	0.84	0.39	0.19	0.18	0.02	**0.60**
Japan	3.04	0.98	-0.45	2.75	3.46	0.76	1.50	1.89	1.63	-0.41	-0.49		**1.62**
Netherlands	2.70	2.50	-0.34	2.51	2.98	1.39	0.63	2.17	0.38	0.42	-0.66	-1.45	**1.58**
Norway	4.05	2.43	-1.06	3.88	1.53	-1.79	0.56	1.63	0.70	0.32	-0.12	-0.21	**1.84**
Spain	1.33	2.62	-0.72	2.11	1.84	-0.36	-1.14	0.02	0.44	-0.37	-0.20	0.05	**0.71**
UK	1.78	2.51	0.11	2.63	1.46	0.92	2.65	0.67	0.09	1.35	1.06	2.40	**1.76**
USA	2.85	1.50	0.70	3.61	2.64	0.44	0.73	1.50	0.72	-0.01	1.14	0.36	**1.55**
Max	4.05	3.22	1.04	4.93	3.46	1.39	2.65	2.55	1.63	1.35	1.14	2.40	**1.85**
Min	1.31	0.98	-1.06	1.02	-0.54	-2.69	-1.97	0.02	-0.26	-0.41	-0.66	-1.45	**0.60**
Average	2.35	2.19	-0.04	3.08	2.07	0.21	0.50	1.22	0.51	0.22	0.19	0.45	**1.41**
Median	2.40	2.43	-0.34	2.83	1.96	0.76	0.73	1.05	0.44	0.19	0.00	0.40	**1.55**

Notes: The sources are the WORLD KLEMS, OECD STAN and my calculations. The results for data compatible with the ISIC Rev.4.

Table 24: Services Sub-Sectors with High-Productivity Growth (1970-2015)

Country	Wholesale and Retail Trade	Transportation and Storage	Accommodation and Food	IC	Finance and Insurance	Real Estate Activities	Business Services	Public Administration	Education	Health	Arts and Entertainment	Other Services
Austria	■	■		■	■							
Belgium	■	■		■	■		■					
Denmark	■	■		■	■							
Finland	■	■		■	■							
France	■	■		■	■							
Germany	■	■		■				■				
Italy	■	■		■				■				
Japan	■			■	■			■	■			
Netherlands	■	■		■	■			■				
Norway	■	■		■								
Spain	■	■		■	■							
UK	■	■		■			■					■
USA	■			■	■							
Total	13	**11**	**0**	**13**	**9**	**0**	**2**	**4**	**1**	**0**	**0**	**1**
Percentage	**100%**	**84.62%**	**0%**	**100%**	**69.23%**	**0%**	**15.38%**	**30.77%**	**7.69%**	**0.00%**	**0.00%**	**7.69%**

Notes: The sources are the WORLD KLEMS, OECD STAN and my calculations. Black square indicates whether a services sub-sector displays a productivity growth rate greater than that of the average services within a country.

Table 25: Labor Productivity Growth Rates for the Services Sub-Sectors, 1995-2015

Country	Wholesale and Retail Trade	Transportation and Storage	Accommodation and Food	IC	Finance and Insurance	Real Estate Activities	Business Services	Public Administration	Education	Health	Arts and Entertainment	Other Services	Aggregate Services
Australia	2.24	2.54	-0.02	3.73	3.84	0.05	0.25	1.06	0.40	1.44	0.25	1.03	1.59
Austria	2.21	2.49	1.04	2.83	2.65	0.83	0.78	1.05	0.83	0.19	0.38	0.45	1.57
Belgium	1.31	2.09	1.03	3.10	1.96	0.66	1.28	0.91	0.83	-0.13	-0.08	1.18	1.23
Bulgaria	3.29	2.65	4.61	5.61	8.54	-2.53	0.87	1.64	1.19	1.47	2.92	2.33	2.93
Canada	2.54	1.26	0.61	0.69	1.70	0.14	1.15	0.88	0.37	0.03	0.90		1.24
Chile	2.90	-2.09	-5.56	14.61	2.51	2.76	4.79	-3.63	-6.47	1.80	0.86		1.02
Costa Rica	-0.01	-0.30	0.52	6.81	4.67	-0.90	0.04	-1.07	0.63	1.29	-7.60	2.86	1.21
Croatia	1.52	-2.81	1.15	-1.14	2.00	-3.73	-1.94	-0.83	-1.20	-0.45	2.94	-1.61	0.10
Czech Republic	6.32	-0.45	-3.74	3.03	3.29	-0.63	0.68	1.32	1.09	-2.39	-2.06 -	3.33	1.67
Denmark	2.54	2.00	-0.44	4.93	2.87	-0.97	0.93	0.32	0.55	0.29	-0.04	1.01	1.36
Estonia	4.31	4.50	2.51	2.53	7.19	5.74	2.38	-0.38	0.24	0.94	3.25	-1.98	3.17
Finland	2.40	1.63	0.62	3.91	2.86	1.15	-0.25	0.98	0.01	-0.37	0.00	-0.23	1.29
France	2.40	3.22	0.28	2.82	1.89	1.07	-0.08	1.30	-0.26	0.98	0.74	1.07	1.43
Germany	2.48	2.57	-0.61	3.95	1.28	1.33	0.86	2.55	0.38	0.47	0.57	0.73	1.85
Greece	-1.71	5.27	0.56	0.99	1.93	-2.69	-3.17	0.56	0.12	-2.31	0.70	-0.63	0.58
Hungary	1.90	3.28	-0.30	4.34	-2.71	-1.12	-1.82	0.34	1.80	1.38	2.68	-0.48	1.12
Iceland	2.18	3.51	3.33	1.40	0.68	-0.25	1.09	1.92	-1.51	-0.52	1.82	3.31	1.11
Ireland	1.50	-15.53	-0.08	11.46	1.21	-2.86	6.17	0.75	-0.70	0.62	16.00	-47.44	1.66
Israel	1.97	1.57		1.98	-0.08	-1.79	0.19	-0.95			-1.45		0.49
Italy	1.51	1.99	-0.66	1.02	-0.54	-2.69	-1.97	0.84	0.39	0.19	0.18	0.02	0.60
Japan	3.04	0.98	-0.45	2.75	3.46	0.76	1.50	1.89	1.63	-0.41	-0.49		1.62
Korea	4.86	2.48	1.89	2.89	5.26	1.59	0.52	2.19	1.22	-2.88	2.57	2.30	2.42
Latvia	6.55	3.71	3.75	-4.22	7.67 -	3.52	-5.54	2.71	3.31	3.90	0.49	-1.59	3.55
Lithunia	5.00	3.42	1.82	2.39	2.43	-0.93	4.22	2.40	2.83	3.73	0.89	-0.62	3.52
Luxembourg	2.33	-0.06	-2.66	2.77	0.18	-5.63	-1.55	0.81	-1.35	-1.06	-0.90	-1.71	0.06
Mexico	0.74	0.29	-0.28	5.40	6.66	-0.36	-0.13	-1.27	-0.68	-0.40	-0.10	-0.69	0.70
Netherlands	2.70	2.50	-0.34	2.51	2.98	1.39	0.63	2.17	0.38	0.42	-0.66	-1.45	1.58
New Zealand	1.71	2.29	0.95	2.85	2.47	1.63		0.54			-1.69		1.30
Norway	4.05	2.43	-1.06	3.88	1.53	-1.79	0.56	1.63	0.70	0.32	-0.12	-0.21	1.84
Poland	2.35	1.48	0.83	3.56	2.92	1.02	2.18	0.53	-0.27	4.31	-0.43	3.62	2.00
Portugal	1.47	1.18	-0.87	-0.22	4.13	-0.84	-0.90	0.30	-0.75	-0.98	-1.05	0.60	0.27
Romania	7.26	2.36	-0.15	4.18	2.34	3.73	6.47	-3.70	1.33	-2.11	-0.13	3.19	2.34
Slovakia	1.47	1.38	-0.96	1.70	-3.54	0.75	2.98	2.90	4.25	1.32	7.06	1.24	1.72
Slovenia	2.75	2.71	0.00	2.15	2.91	-5.06	-0.92	1.30	-0.77	-0.13	-2.50	0.27	0.97
Spain	1.33	2.62	-0.72	2.11	1.84	-0.36	-1.14	0.02	0.44	-0.37	-0.20	0.05	0.71
Sweden	3.40	1.76	0.13	5.15	2.62	0.71	1.46	0.70	-0.19	-0.61	0.22	1.22	1.44
Switzerland	3.68	0.56	-0.54	0.33	2.09	-3.76	-0.74	-0.78	-2.43	0.65	-1.68		0.71
Turkey	4.91	2.67	-0.05	0.91	12.05	-13.67	-3.58	-0.59	-0.89	-2.12	16.70	3.52	1.43
UK	1.78	2.51	0.11	2.63	1.46	0.92	2.65	0.67	0.09	1.35	1.06	2.40	1.76
USA	2.85	1.50	0.70	3.61	2.64	0.44	0.73	1.50	0.72	-0.01	1.14	0.36	1.55
Max	7.26	5.27	4.61	14.61	12.05	5.74	6.47	2.90	4.25	4.31	16.70	3.62	3.55
Min	-1.71	-15.53	-5.56	-4.22	-3.54	-13.67	-5.54	-3.70	-6.47	-2.88	-7.60	-47.44	0.06
Average	2.70	1.45	0.18	3.15	2.80	-0.73	0.55	0.64	0.22	0.26	1.08	-0.86	1.47
Median	2.40	2.19	0.00	2.83	2.49	-0.30	0.63	0.82	0.38	0.19	0.24	0.40	1.43

Notes: The sources are the WORLD KLEMS, OECD STAN and my calculations. The results are for the data compatible with the ISIC Rev.4.

Table 26: Services Sub-Sectors with High-Productivity Growth

Country	Wholesale and Retail Trade	Transportation and Storage	Accommodation and Food	IC	Finance and Insurance	Real Estate Activities	Business Services	Public Administration	Education	Health	Arts and Entertainment	Other Services
Australia	■	■		■	■							
Austria	■	■		■	■							
Belgium	■	■		■	■		■					
Bulgaria	■		■	■	■							
Canada	■	■			■							
Chile	■			■	■	■	■			■		
Costa Rica				■	■					■		■
Croatia	■		■		■						■	
Czech Republic	■			■	■							
Denmark	■	■		■	■							
Estonia	■	■			■	■					■	
Finland	■	■		■	■							
France	■	■		■	■							
Germany	■	■		■				■				
Greece		■		■	■						■	
Hungary	■	■		■					■	■	■	
Iceland	■	■	■	■				■			■	■
Ireland				■			■				■	
Israel	■	■		■								
Italy	■	■		■				■				
Japan	■			■	■			■	■			
Korea	■	■		■	■							
Latvia	■	■	■		■					■		
Lithuania	■						■			■		
Luxembourg	■			■	■			■				
Mexico	■			■	■							
Netherlands	■	■		■	■			■				
New Zealand	■	■		■	■	■						
Norway	■	■		■								
Poland	■			■	■		■			■		■
Portugal	■	■			■			■				■
Romania	■	■		■	■	■	■					■
Slovakia							■	■	■		■	
Slovenia	■	■		■	■			■				
Spain	■	■		■	■							
Sweden	■	■		■	■		■					
Switzerland	■				■							
Turkey	■	■			■						■	■
UK	■	■		■			■					■
USA	■			■	■							
Total	**36**	**26**	**4**	**31**	**30**	**4**	**9**	**9**	**3**	**6**	**8**	**7**
Percentage	**90%**	**65.00%**	**10%**	**77.50%**	**75.00%**	**10%**	**22.50%**	**22.50%**	**7.50%**	**15.00%**	**20.00%**	**17.50%**

Notes: The sources are the WORLD KLEMS, OECD STAN and my calculations. Black square indicates whether a services sub-sector displays a productivity growth rate greater than that of the average services within a country.

Table 27: Labor Productivity Growth Rates for Sectoral Aggregates (1995-2015)

Country	Aggregate	Goods	Services	Progressive Services	Stagnant Services	Progressive inc. Business Services	Stagnant exc. Business Services	Progressive/Goods	Progressive-Stagnant
Australia	1.74	2.35	1.54	3.05	0.55	2.44	0.63	1.29	2.49
Austria	1.41	2.37	0.90	1.80	0.30	1.35	0.41	0.76	1.49
Belgium	0.97	2.71	0.40	1.83	-0.35	0.75	-0.15	0.68	2.18
Bulgaria	3.18	3.12	2.93	4.56	1.57	3.79	1.86	1.46	2.98
Canada	1.21	1.43	1.24	1.94	0.76	1.74	0.76	1.36	1.18
Chile	0.89	0.71	1.02	3.22	-0.53	3.52	-1.22	4.52	3.75
Costa Rica	2.11	1.68	2.09	3.16	1.25	3.07	1.25	1.88	1.91
Croatia	0.74	1.13	0.10	0.89	-0.60	0.37	-0.26	0.79	1.49
Czech Republic	2.49	3.64	1.67	3.97	-0.06	3.38	-0.22	1.09	4.04
Denmark	1.02	1.82	0.74	2.34	-0.26	1.59	-0.03	1.29	2.60
Estonia	4.35	6.28	3.17	4.76	1.82	4.46	1.52	0.76	2.93
Finland	1.38	2.79	0.59	2.30	-0.39	1.52	-0.24	0.82	2.69
France	1.11	1.93	0.77	1.85	0.24	1.27	0.46	0.96	1.61
Germany	1.30	2.11	0.92	2.16	0.19	1.02	0.70	1.02	1.97
Greece	1.01	1.44	0.58	0.82	0.01	0.15	0.51	0.57	0.82
Hungary	2.54	4.68	1.12	2.00	0.55	1.27	0.87	0.43	1.45
Iceland	1.79	3.41	1.11	2.18	0.29	1.96	0.13	0.64	1.90
Ireland	3.53	6.84	1.66	2.39	1.11	2.99	-0.37	0.35	1.28
Israel	1.21	2.97	0.49	1.96	-0.40	1.81	-0.62	0.66	2.36
Italy	0.37	0.63	0.13	1.21	-0.66	0.29	-0.06	1.91	1.87
Japan	1.22	2.34	0.63	1.12	0.26	1.33	-0.23	0.48	0.87
Korea	3.14	4.67	2.42	4.40	1.12	3.42	1.31	0.94	3.28
Latvia	4.05	4.46	3.55	5.17	1.93	3.65	3.02	1.16	3.24
Lithuania	4.35	5.58	3.52	4.22	2.72	4.15	2.46	0.76	1.50
Luxembourg	0.41	0.26	0.06	1.25	-1.17	-0.57	-0.81	4.91	2.43
Mexico	0.71	0.17	1.03	2.03	0.05	1.77	0.20	11.66	1.98
Netherlands	1.20	1.56	1.13	2.66	0.16	1.86	0.12	1.70	2.50
New Zealand	0.92	0.07	1.30	2.16	0.81	2.03	0.27	30.70	1.35
Norway	0.80	0.17	1.49	3.10	0.50	2.35	0.67	18.14	2.60
Poland	2.99	4.38	2.00	2.57	1.46	2.66	1.13	0.59	1.11
Portugal	1.16	2.05	0.27	1.82	-0.75	1.11	-0.59	0.89	2.57
Romania	4.04	4.69	2.34	4.08	0.79	4.62	-0.21	0.87	3.29
Slovakia	3.63	6.51	1.72	0.69	2.54	1.07	2.51	0.11	-1.85
Slovenia	2.62	4.35	0.97	2.93	-0.35	1.94	-0.08	0.67	3.27
Spain	0.65	1.48	0.27	1.30	-0.46	0.62	-0.11	0.88	1.76
Sweden	1.81	2.62	1.46	3.41	0.34	2.91	-0.01	1.30	3.08
Switzerland	1.01	1.62	0.71	2.50	-0.72	1.82	-0.77	1.54	3.22
Turkey	3.17	5.05	1.43	4.00	-1.11	2.62	-0.60	0.79	5.11
UK	1.24	1.24	1.21	2.18	0.62	2.04	0.32	1.76	1.57
USA	1.61	2.43	1.40	2.70	0.64	2.33	0.49	1.11	2.06
Max	4.35	6.84	3.55	5.17	2.72	4.62	3.02	30.70	5.11
Min	0.37	0.07	0.06	0.69	-1.17	-0.57	-1.22	0.11	-1.85
Average	1.88	2.74	1.30	2.57	0.37	2.06	0.38	2.60	2.20
Median	1.34	2.36	1.13	2.32	0.27	1.90	0.17	0.95	2.12

Notes: The sources are the WORLD KLEMS, OECD STAN and my calculations. The results are for the data compatible with the ISIC Rev.4. The values show labor productivity growth rates for more aggregated sectors. The Progressive/Goods column shows the ratio of average labor productivity growth rate in the progressive services with respect to that in the goods for each country. The Progressive-Stagnant column shows the difference between average labor productivity in the progressive services and that in the stagnant services for each country.

Table 28: Categorization of Services Sub-Sectors

	ISIC Rev.4
Progressive Services	Wholesale and Retail Trade
	Transportation and Storage
	Information and Communication
	Financial and Insurance Activities
Stagnant Services	Accommodation and Food
	Real Estate Activities
	Professional, Scientific, Technical, Administrative and Support Service Activities
	Public Administration and National Defense; Compulsory Social Security
	Education
	Health and Social Work
	Arts, Entertainment and Recreation
	Other Service Activities

Table 29: Country Codes

Australia	AUS	Japan	JAP
Austria	AUT	Korea	KOR
Belgium	BEL	Latvia	LVA
Bulgaria	BGR	Lithuania	LTU
Canada	CAN	Luxembourg	LUX
Chile	CHL	Mexico	MEX
Costa Rica	CRI	Netherlands	NLD
Croatia	HRV	New Zealand	NZL
Czech Republic	CZE	Norway	NOR
Denmark	DNK	Poland	POL
Estonia	EST	Portugal	POR
Finland	FIN	Romania	ROU
France	FRA	Slovakia	SVK
Germany	DEU	Slovenia	SVN
Greece	GRC	Spain	ESP
Hungary	HUN	Sweden	SWE
Iceland	ISL	Switzerland	CHE
Ireland	IRE	Turkey	TUR
Israel	ISR	United Kingdom	GBR
Italy	ITA	United States	USA

Appendix C: Structural Change Facts for the Services in Other Developed Countries

Figure 20 shows the share of progressive services in aggregate value added for developed countries where I have longer data series. Figure 21 repeats it for the share of progressive/business services within total services; Figure 22 compares the shares of stagnant services and business services/real estate within aggregate economy.

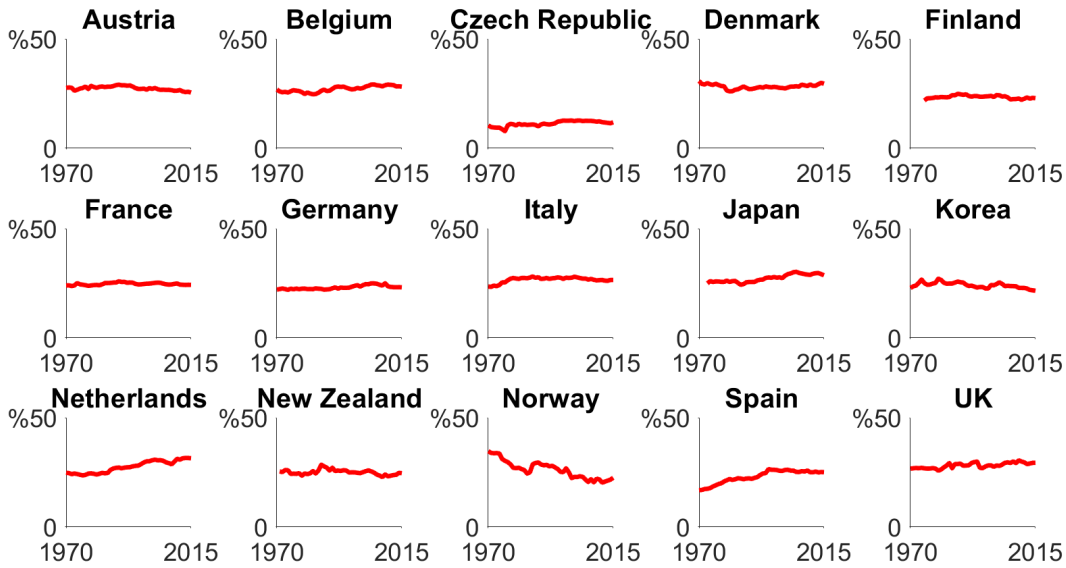


Figure 20: Progressive Services, Other Countries

Notes: The data sources are the WORLD KLEMS and OECD STAN. The figures refer to the nominal value-added share of the progressive services sector in aggregate economy.

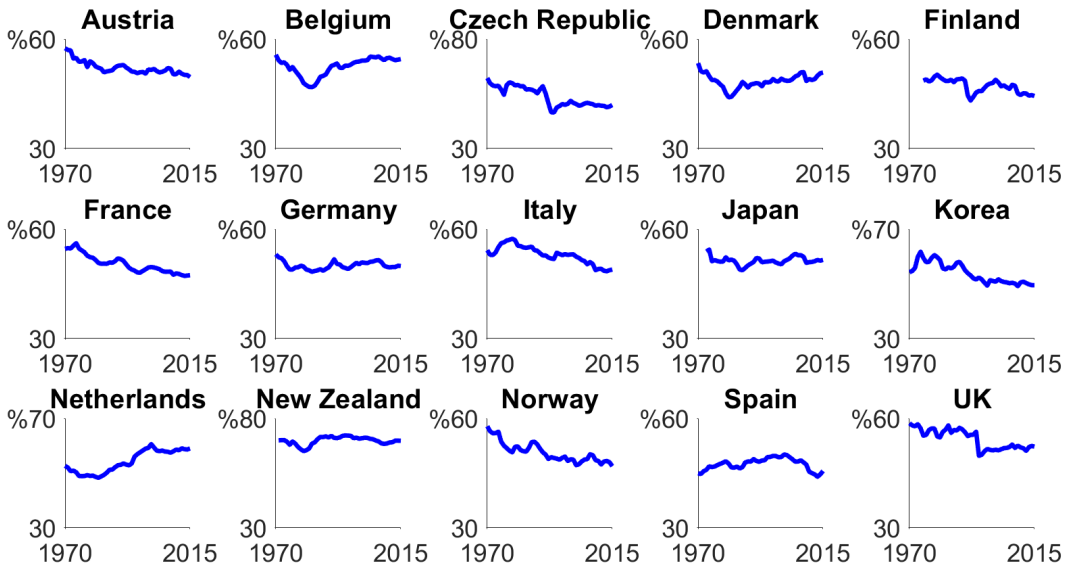


Figure 21: Progressive/Business Services, Other Countries

Notes: The data sources are the WORLD KLEMS and OECD STAN. The figures refer to the nominal value-added share of the progressive/business services sector in the aggregate services.

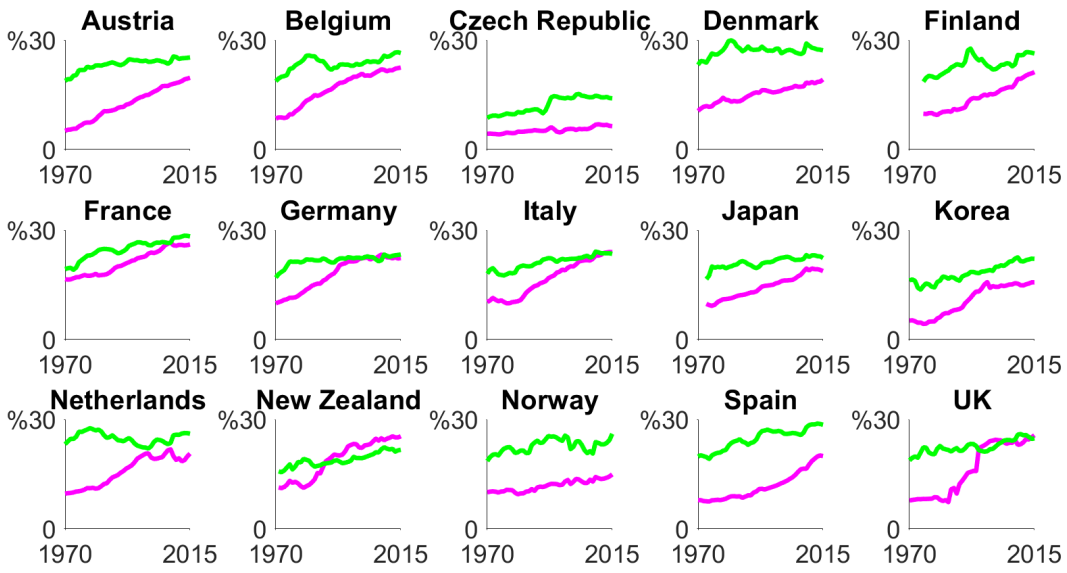


Figure 22: Stagnant Services vs. Business Services/Real Estate Activities, Other Countries

Notes: The data sources are the WORLD KLEMS and OECD STAN. The figures compare the nominal value-added share of the stagnant services sector excluding business services and real estate with that of the composite of business services and real estate in aggregate economy. The green line shows the share of the stagnant services sector excluding business services and real estate; the pink line that of the composite of business services and real estate.

Appendix D: Baumol's Cost Disease Between 1970 and 2015

This sub-section extends the results of accounting exercises for Baumol's cost disease for data compatible with the ISIC Rev.4. Table 30 compares actual and counterfactual aggregate productivity growth rates. Table 31 shows how much Baumol's cost disease accounts for the productivity growth slowdowns from 1995-1970 to 2015-1995. Table 32 shows which sectoral splits capture Baumol's cost disease better.

Table 30: Counterfactual Aggregate Labor Productivity Growth Rates (1970-2015)

Country	Data	Counterfactual	Difference
Austria	2.34	2.77	-0.44
Belgium	2.23	2.81	-0.58
Denmark	2.06	2.54	-0.48
Finland	2.36	2.72	-0.37
France	2.18	2.70	-0.52
Germany	2.20	2.39	-0.19
Italy	1.55	2.07	-0.52
Japan	2.11	2.45	-0.33
Netherlands	2.01	2.30	-0.29
Norway	2.31	2.63	-0.32
Spain	1.87	2.63	-0.76
UK	2.07	2.25	-0.17
USA	1.67	1.89	-0.21
Max	2.36	2.81	-0.17
Min	1.55	1.89	-0.76
Median	2.11	2.54	-0.37
Average	2.07	2.47	-0.40

Notes: The sources are the WORLD KLEMS, OECD STAN and my calculations. The results are for the data compatible with the ISIC Rev.4. The counterfactual aggregate productivity growth rates are calculated by Nordhaus (2008) method discussed in the main body of the text.

Table 31: Baumol's Cost Disease and Productivity Growth Slowdown

	Productivity Growth							
	Data			**Counterfactual**			**Baumol's Effect**	**Baumol's Effect (in percentage)**
	1970-1995	1995-2015	Difference	1970-1995	1995-2015	Difference		
Austria	3.03	1.61	-1.42	3.26	2.27	-0.99	-0.44	30.69
Belgium	3.29	1.11	-2.18	3.60	1.98	-1.63	-0.55	25.31
Denmark	2.85	1.24	-1.60	3.08	1.97	-1.10	-0.50	31.11
Finland	3.33	1.38	-1.95	3.53	1.91	-1.62	-0.33	16.84
France	3.11	1.20	-1.91	3.52	1.84	-1.69	-0.22	11.56
Germany	2.85	1.52	-1.33	2.89	1.88	-1.01	-0.32	24.36
Italy	2.27	0.80	-1.47	2.82	1.29	-1.53	0.06	
Japan	2.98	1.25	-1.73	3.16	1.73	-1.43	-0.30	17.33
Netherlands	2.72	1.26	-1.46	2.86	1.71	-1.15	-0.31	21.13
Norway	3.53	1.04	-2.49	3.04	2.21	-0.83	-1.66	66.63
Spain	2.83	0.86	-1.97	3.58	1.64	-1.94	-0.03	1.45
UK	1.83	2.32	0.49	2.23	2.27	0.04	0.45	
USA	1.78	1.56	-0.23	1.98	1.79	-0.19	-0.03	14.99
Max	3.53	2.32	0.49	3.60	2.27	0.04	0.45	66.63
Min	1.78	0.80	-2.49	1.98	1.29	-1.94	-1.66	1.45
Median	2.85	1.25	-1.60	3.08	1.88	-1.15	-0.31	21.13
Average	2.80	1.32	-1.48	3.04	1.88	-1.16	-0.32	23.76

Notes: The sources are the WORLD KLEMS, OECD STAN and my calculations. The results are for the data compatible with the ISIC Rev.4. Baumol's Effect is calculated as the difference between actual productivity growth rates difference between 1995-1970 and 2015-1995 and the counterfactual one for same periods. If the counterfactual productivity growth rates did not show much difference across time periods but the actual ones did, we conclude that Baumol's cost disease accounts for productivity-growth differences across time. The effect of Baumol's cost disease in percentage terms is only expressed for the countries where Baumol's cost disease exerted a negative effect on productivity growth from 1995-1970 to 2015-1995.

Table 32: Sector Splits for Baumol's Cost Disease

	Goods vs. Services	Goods vs. 12 Services Sub-sectors	5 Goods Sub-sectors vs. Services	Goods vs. Progressive and Stagnant Services	Goods vs. Progressive/Business and Stagnant Services
Austria	0.35	0.18	0.14	0.22	0.28
Belgium	0.41	0.09	0.32	0.18	0.38
Denmark	0.18	0.02	0.14	0.01	0.13
Finland	0.27	0.10	0.20	0.07	0.22
France	0.37	0.16	0.19	0.24	0.32
Germany	0.20	0.03	0.23	0.07	0.18
Italy	0.52	0.16	0.35	0.43	0.49
Japan	0.30	0.07	0.23	0.13	0.24
Netherlands	0.29	0.08	0.21	0.15	0.35
Norway	0.67	1.12	0.45	1.01	0.81
Spain	0.55	0.31	0.26	0.37	0.52
UK	0.10	0.18	0.10	0.04	0.07
USA	0.34	0.13	0.19	0.26	0.37

Notes: The data sources are the WORLD KLEMS, OECD STAN and my calculations. The results are for data compatible with the ISIC Rev.4 between 1970 and 2015. I calculate two counterfactual aggregate productivity growth rates: First, by fixing the nominal value added and hours worked shares of 17 industries at their initial values (1970 and 1971); second, by fixing same shares of same 17 industries at their end values (2014 and 2015). The difference between these two counterfactual productivity growth rates is considered as an alternative measure of Baumol's cost disease in Nordhaus (2008). I apply the same procedure to the sectoral aggregates considered in table. For example, in the sectoral split between the goods and 12 services sub-sectors (third column) I consider the shares of the goods and 12 services sub-sectors at their initial and end values, and keep productivity growth rates of in total 13 sub-sectors as in the data. This exercise differs from the previous one in the sense while the disaggregation level for the services sector remains the same, the goods sector is now more aggregated. My purpose in doing it is to see the relevancy of structural change within the services for Baumol's cost disease. I then calculate the difference between these two counterfactual productivity growth rates. If this difference is close to the one obtained by considering all 17 industries, then I conclude that the sectoral split captures well Baumol's cost disease. The numbers in table represent the absolute value of the difference between these two differences. The lower the numbers in the table the better the related sectoral split captures Baumol's cost disease.

Appendix E: An Alternative Model for Baumol's Cost Disease

This appendix presents an alternative model for Baumol's cost disease. Differently from the model presented in the main body of the text, the outer layer of the consumer problem represents the allocation between the goods and services, and in the inner layer I concentrate upon the allocation problem between progressive and stagnant services. More formally, the allocation problem for the outer layer now becomes:

$$\min_{C_{gt},C_{st}} P_{gt}C_{gt} + P_{st}C_{st} \quad \text{s.t.} \quad (\alpha_g^{\frac{1}{\sigma_c}} C_t^{\frac{\epsilon_g - 1}{\sigma_c}} C_{gt}^{\frac{\sigma_c - 1}{\sigma_c}} + \alpha_s^{\frac{1}{\sigma_c}} C_t^{\frac{\epsilon_s - 1}{\sigma_c}} C_{st}^{\frac{\sigma_c - 1}{\sigma_c}})^{\frac{\sigma_c}{\sigma_c - 1}} \geq C_t$$

Now s denotes the services sector. The inner layer now represents the allocation problem between the progressive and stagnant services sectors:

$$\min_{C_{pt},C_{ut}} P_{pt}C_{pt} + P_{ut}C_{ut} \quad \text{s.t.} \quad (\alpha_p^{\frac{1}{\sigma_s}} C_t^{\frac{\epsilon_p - 1}{\sigma_s}} C_{pt}^{\frac{\sigma_s - 1}{\sigma_s}} + \alpha_u^{\frac{1}{\sigma_s}} C_t^{\frac{\epsilon_u - 1}{\sigma_s}} C_{ut}^{\frac{\sigma_s - 1}{\sigma_s}})^{\frac{\sigma_s}{\sigma_s - 1}} \geq C_{st}$$

Now u denotes the stagnant services and C_{st} becomes the consumption quantity for the services sector.

The first-order conditions for the outer layer yield the following results:

$$\frac{P_{gt}C_{gt}}{P_{st}C_{st}} = \frac{\alpha_g}{\alpha_s}\left[\frac{P_{gt}}{P_{st}}\right]^{1-\sigma_c} C_t^{\epsilon_g - \epsilon_s}$$

$$P_t = (\alpha_g C_t^{\epsilon_g - 1} P_{gt}^{1-\sigma_c} + \alpha_s C_t^{\epsilon_s - 1} P_{st}^{1-\sigma_c})^{\frac{1}{1-\sigma_c}}$$

where P_t represents model-implied aggregate price index.

Similarly, the first-order conditions of the inner-layer optimization problem yield the following results:

$$\frac{P_{pt}C_{pt}}{P_{ut}C_{ut}} = \frac{\alpha_p}{\alpha_u}\left[\frac{P_{pt}}{P_{ut}}\right]^{1-\sigma_s} C_t^{\epsilon_p - \epsilon_u}$$

$$P_{st} = (\alpha_p C_t^{\epsilon_p - 1} P_{pt}^{1-\sigma_s} + \alpha_u C_t^{\epsilon_u - 1} P_{ut}^{1-\sigma_s})^{\frac{1}{1-\sigma_s}}$$

where P_{st} represents model-implied price index for the services sector.

Appendix F: Quantitative Analysis for the Alternative Model of Baumol's Cost Disease

To calibrate the alternative model of Baumol's cost disease in addition to the relative nominal value added shares of $\frac{VA_{gt}}{VA_{st}}$ and $\frac{VA_{pt}}{VA_{ut}}$, I also target the relative quantity of the services with respect to aggregate economy $\frac{C_{st}}{C_t}$ and its relative price with respect to aggregate price index $\frac{P_{st}}{P_t}$. I normalize $\epsilon_g = 0.85$ and $\epsilon_u = 0.58$ so that the model would satisfy the regularity conditions. Again, I normalize $\alpha_g = 1 - \alpha_s$ and $\alpha_u = 1 - \alpha_p$. I obtain model parameters by matching the data targets as closely as possible. Table 33 shows the calibration results for the alternative Baumol's cost disease model.

Table 33: Calibration Results for Alternative Model of Baumol's Cost Disease, 1970-2007

	α_g	α_s	α_p	α_u	σ_c	σ_s	$\epsilon_s - \epsilon_g$	$\epsilon_u - \epsilon_p$
Australia	0.45	0.55	0.42	0.58	0.45	1.04	0.26	0.44
Austria	0.48	0.52	0.44	0.56	0.44	1.03	0.14	0.55
Belgium	0.47	0.53	0.39	0.61	0.32	1.05	-0.22	0.36
Canada	0.41	0.59	0.38	0.62	0.68	1.06	0.42	0.40
Denmark	0.36	0.64	0.42	0.58	0.54	0.83	0.30	1.60
Finland	0.48	0.52	0.42	0.58	0.53	1.01	0.09	0.58
France	0.43	0.57	0.32	0.68	0.27	1.01	-0.41	0.44
Germany	0.49	0.51	0.33	0.67	0.22	1.02	0.07	0.43
Greece	0.48	0.52	0.39	0.61	0.29	1.02	0.50	0.48
Ireland	0.50	0.50	0.43	0.57	0.91	1.30	0.29	0.29
Italy	0.49	0.51	0.41	0.59	0.34	1.04	0.08	0.48
Japan	0.49	0.51	0.44	0.56	0.40	1.02	0.07	0.55
Korea	0.55	0.45	0.56	0.44	1.05	1.16	0.26	0.54
Luxembourg	0.36	0.64	0.53	0.47	0.52	1.02	0.29	0.39
Netherlands	0.43	0.57	0.38	0.62	0.41	1.04	0.11	0.37
Norway	0.40	0.60	0.47	0.53	1.04	1.04	0.20	0.57
Portugal	0.42	0.58	0.46	0.54	0.43	0.58	0.57	2.49
Spain	0.55	0.45	0.38	0.62	0.43	1.20	0.30	0.28
Sweden	0.38	0.62	0.41	0.59	0.69	0.81	0.36	1.06
UK	0.45	0.55	0.46	0.54	0.21	0.57	-0.85	5.51
USA	0.35	0.65	0.36	0.64	0.61	0.96	0.43	0.92

The calibration results yield the expected outcomes for most countries. The goods and services are gross complements ($\sigma_c < 1$); the services sector is a luxury against the goods ($\epsilon_s - \epsilon_g > 0$); the progressive and stagnant services are gross substitutes ($\sigma_s > 1$); the stagnant

services sector is a luxury with respect to the progressive services ($\epsilon_u - \epsilon_p > 0$). For only five countries (Denmark, Portugal, Sweden, UK, and USA) I do not obtain a substitutability result between the progressive and stagnant services sectors. For these countries when I target relative hours worked shares instead of nominal value added ones, the substitutability result is vindicated only for Portugal.

I simulate the alternative Baumol's cost disease model for each country under the assumption that between 2009 and 2050 countries would retain the average sectoral labor productivity growth rates of the period between 1970 and 2007, and sectoral wedges would be equal to their average values of the same period. Figure 23 shows the results of these simulations by comparing the effect of Baumol's cost disease on aggregate productivity growth between 1970-2007 to its predicted effect for 2009-2050. Apart from Australia, Italy, Japan, Portugal, and Sweden, Baumol's cost disease would depress aggregate productivity growth less in the future than it did in the past. On average its future effect for the productivity growth slowdown would be 43% of its past effect. Lastly, Figure 24 compares the results of the alternative model with the one used in the main body of the text. For most countries the alternative model implies lesser effects for Baumol's cost disease, but in general our results change little with respect to this different modelling assumption.

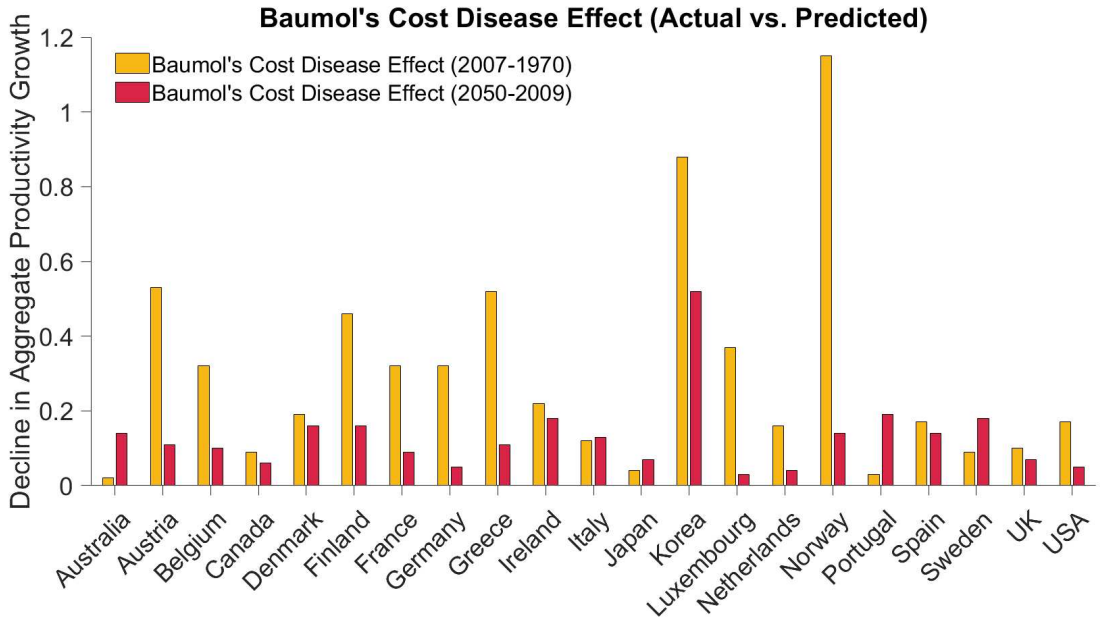


Figure 23: Baumol's Cost Disease Effect on Aggregate Productivity Growth

Notes: The bars show how much Baumol's cost disease declined or would decline aggregate productivity growth rate in each country.

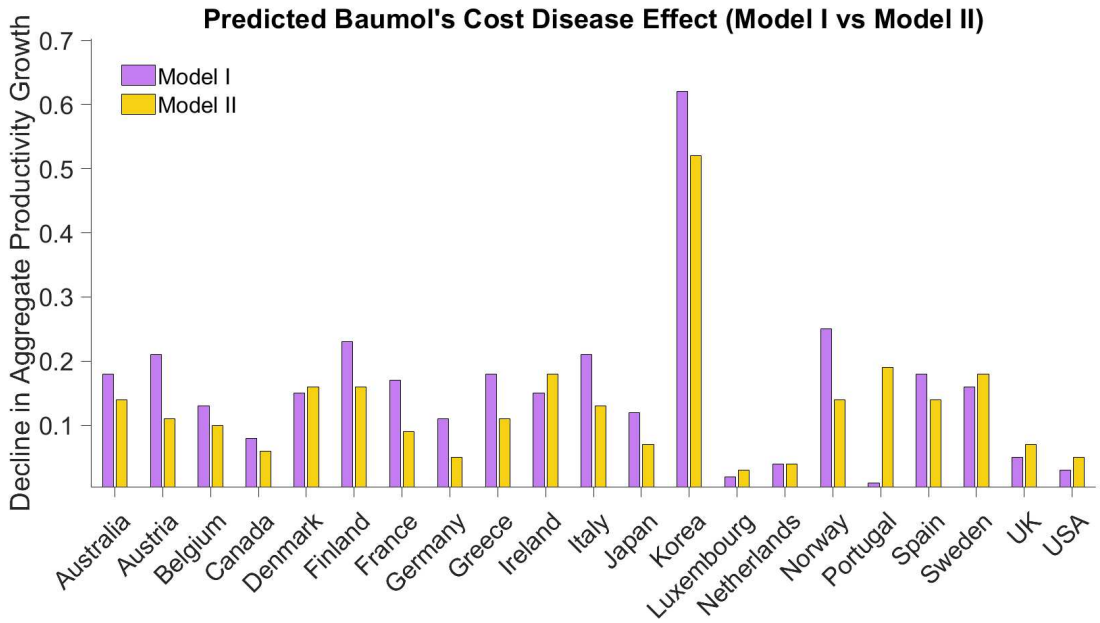


Figure 24: Comparison of Different Models

Notes: The bars show how much Baumol's cost disease declined or would decline aggregate productivity growth rate in each country. Model I refers to the simulation results of the model introduced in the main body of the text; Model II those of the model used in the Appendix E.

Appendix G: Quantitative Analysis of Baumol's Cost Disease for Data Compatible with the ISIC Rev.4

I calibrate the model and perform simulations also by using the revised dataset compatible with the ISIC Rev.4. This would ensure the robustness of our results and provide a long-term perspective needed for analyzing Baumol's cost disease. Because of data unavailability, I calibrate the model only for 13 countries. Table 34 shows calibration results for the model used in the main body of the text. From these results we observe that the substitutability between progressive services and the rest of economy holds true for all countries except for six. For these six countries I re-calibrate the model now by targeting relative hours worked shares instead of nominal value added ones. Table 35 presents the results of this exercise: It is reassuring that the substitutability result between progressive services and the rest of the economy is retained for all of them except for two. But for these two countries (Finland and Norway) the elasticity of substitution remains very close to one, implying that the share of progressive services would be mostly stable and transition dynamics would be slow.

Table 34: Calibration Results for the Revised Data: Nominal Value Added

	α_g	α_s	α_p	α_r	σ_c	σ_r	$\epsilon_s - \epsilon_g$
Austria	0.67	0.33	0.28	0.72	0.87	0.00	0.38
Belgium	0.61	0.39	0.26	0.74	1.24	0.40	2.40
Denmark	0.49	0.51	0.28	0.72	1.03	0.11	-0.17
Finland	0.61	0.39	0.22	0.78	0.61	0.18	-0.80
France	0.53	0.47	0.24	0.76	1.01	0.40	1.80
Germany	0.61	0.39	0.21	0.79	0.49	3.44	36.27
Italy	0.66	0.34	0.26	0.74	1.04	0.55	3.39
Japan	0.64	0.36	0.25	0.75	1.21	0.37	1.02
Netherlands	0.55	0.45	0.23	0.77	0.89	1.21	3.52
Norway	0.57	0.43	0.32	0.68	0.46	0.45	0.52
Spain	0.70	0.30	0.18	0.82	0.89	1.28	8.09
UK	0.61	0.39	0.27	0.73	1.04	0.54	3.65
USA	0.47	0.53	0.27	0.73	1.07	0.58	0.96

I again simulate the model under the scenario that countries now retain average sectoral productivity growth rates of 1995-2015 for the next 60 years and wedges would be equal to their average values between 1970 and 2015. Figure 25 compares the effect of Baumol's cost disease between the periods 1970-1995 and 1995-2015 to its predicted effect for the next 60 years

Table 35: Calibration Results for the Revised Data: Hours Worked Shares

	α_g	α_s	α_p	α_r	σ_c	σ_r	$\epsilon_s - \epsilon_g$
Austria	0.71	0.29	0.21	0.79	1.04	0.88	4.18
Finland	0.66	0.34	0.24	0.76	0.95	0.00	0.16
Germany	0.71	0.29	0.25	0.75	1.06	0.00	4.56
Netherlands	0.58	0.42	0.29	0.71	1.00	0.94	2.97
Norway	0.61	0.39	0.31	0.69	0.93	0.46	2.98
Spain	0.79	0.21	0.23	0.77	1.13	0.53	3.85

(2015-2075). For almost all countries the results imply lesser effects of Baumol's cost disease for future productivity growth (Finland is a notable exception). On average, the effect of Baumol's cost disease for future productivity growth slowdown would be 1/3 of its past effect. For the revised data I also calibrate the alternative Baumol's cost disease model and simulate it under same scenarios. The results of the alternative model are similar to what Figure 24 suggests. These results are available upon by request.

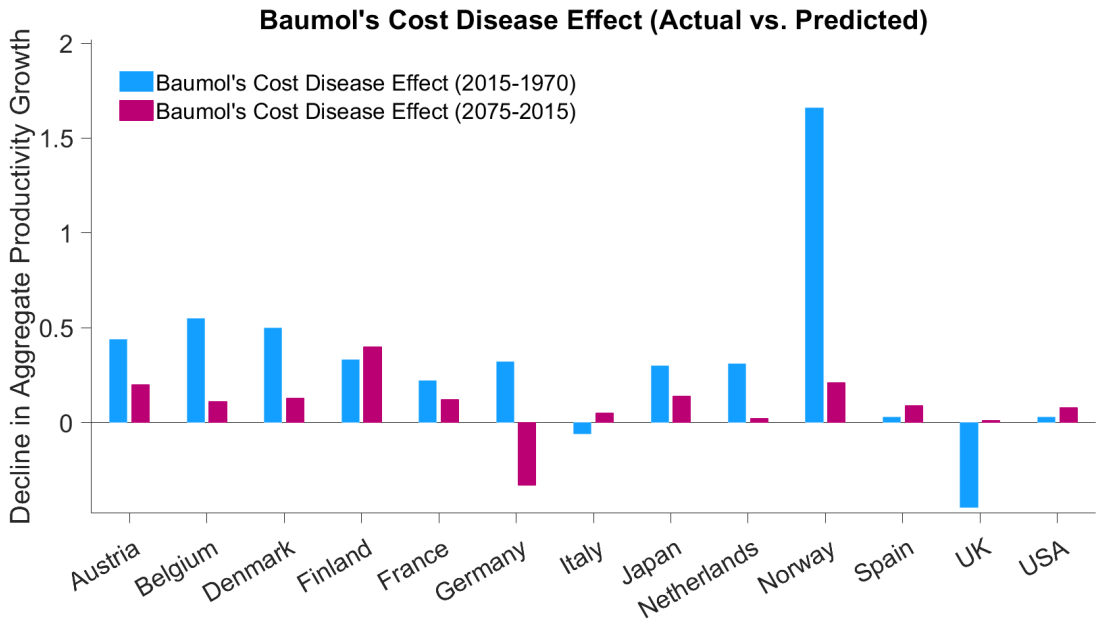
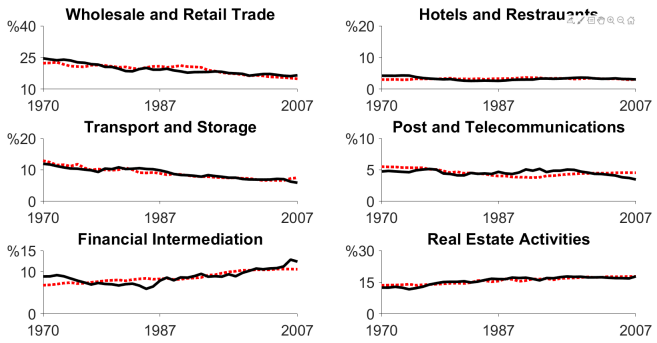


Figure 25: Baumol's Cost Disease Effect on Aggregate Productivity Growth

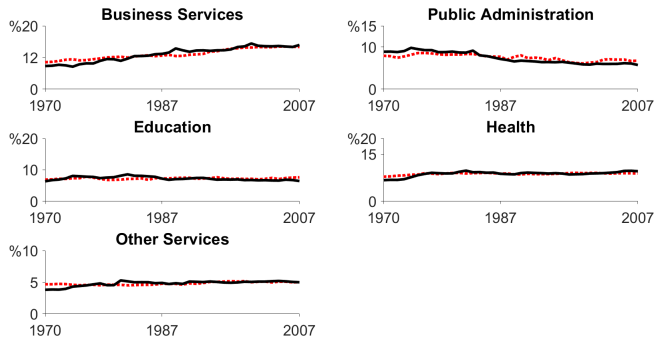
Notes: The bars show how much Baumol's cost disease declined or would decline aggregate productivity growth rate in each country.

Appendix H: Calibration Results for the Cross-Country Productivity Section

Figure 26: Data vs. Model: Australia



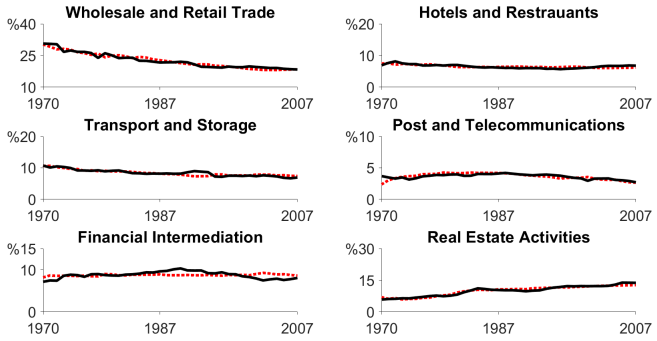
a. Services



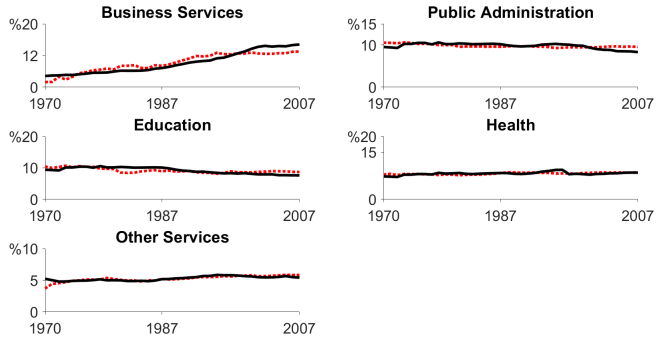
b. Services-Continued

c. Goods and Services

Figure 27: Data vs. Model: Austria



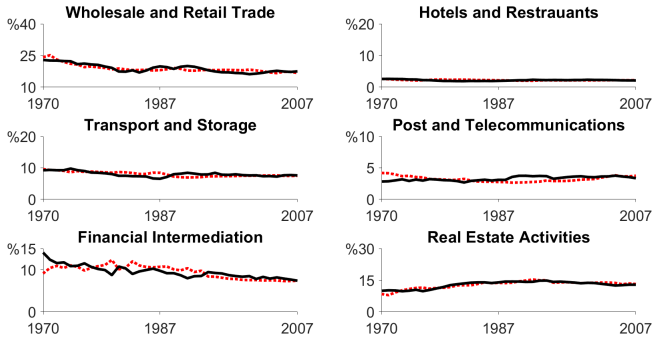
a. Services



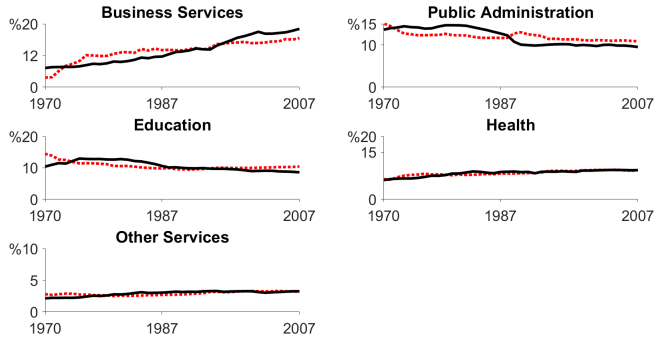
b. Services-Continued

c. Goods and Services

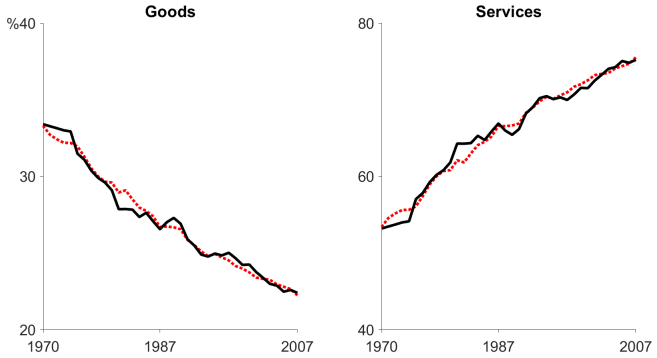
Figure 28: Data vs. Model: Belgium



a. Services

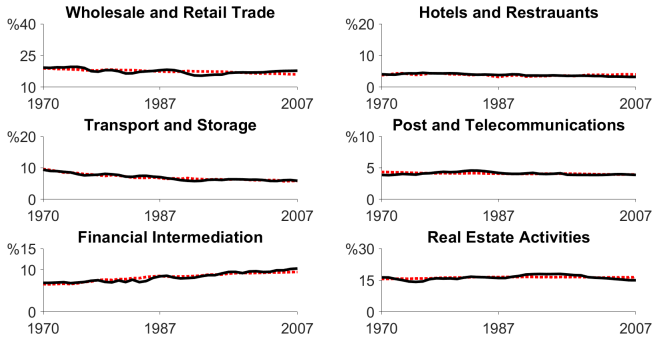


b. Services-Continued

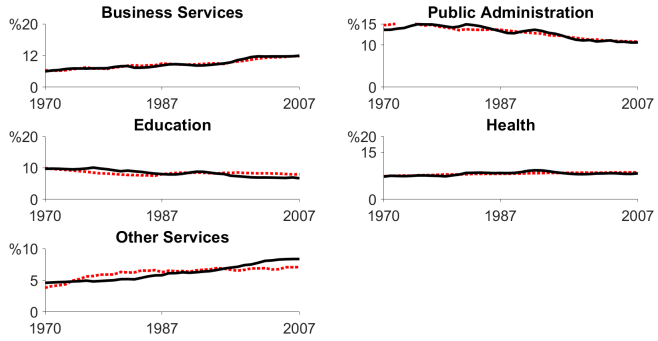


c. Goods and Services

Figure 29: Data vs. Model: Canada



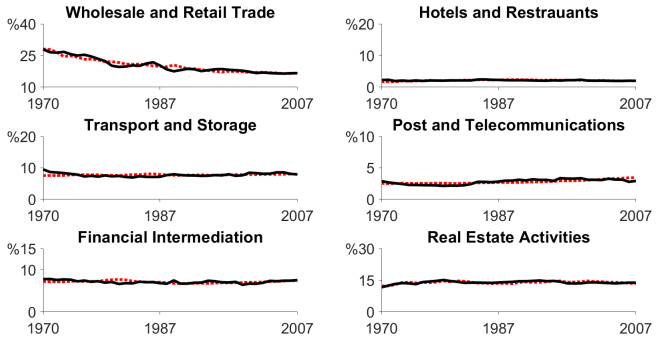
a. Services



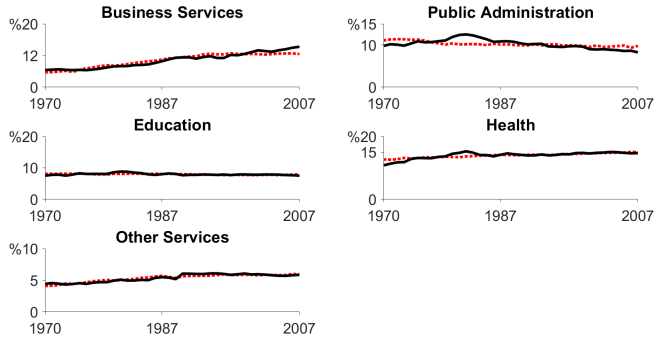
b. Services-Continued

c. Goods and Services

Figure 30: Data vs. Model: Denmark



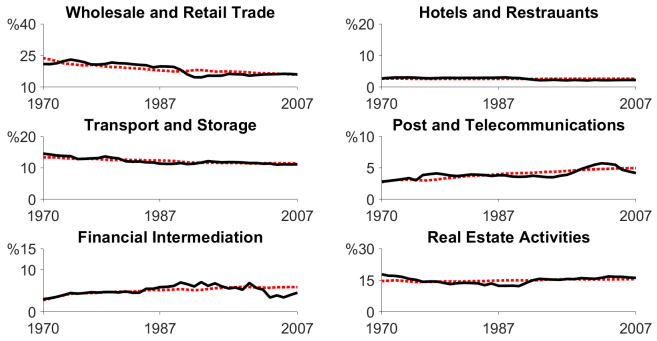
a. Services



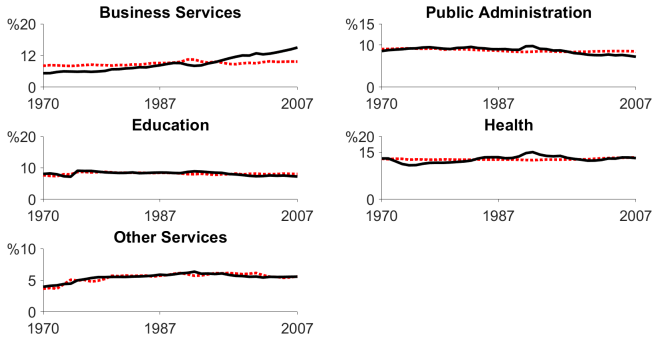
b. Services-Continued

c. Goods and Services

Figure 31: Data vs. Model: Finland



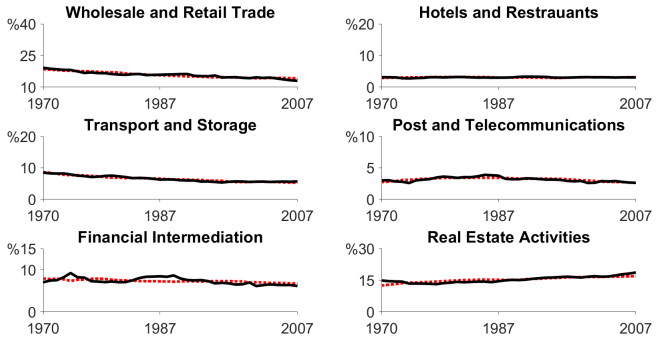
a. Services



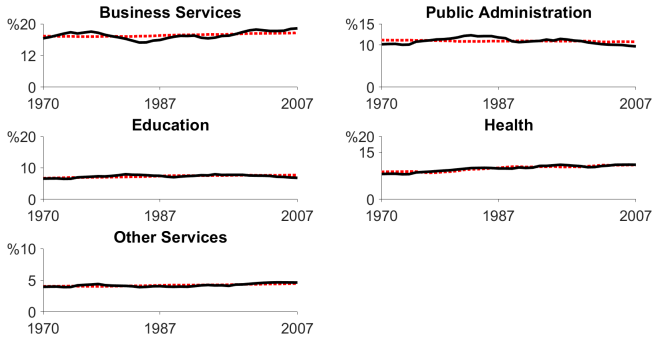
b. Services-Continued

c. Goods and Services

Figure 32: Data vs. Model: France



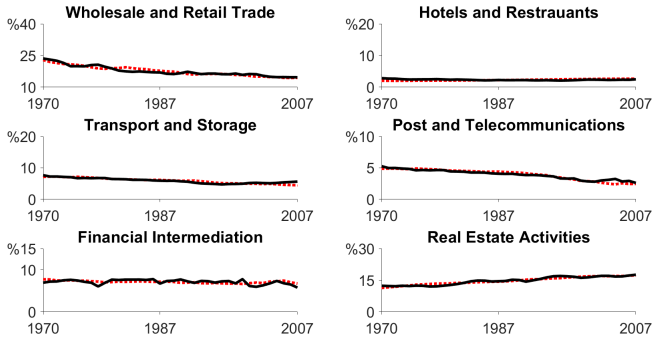
a. Services



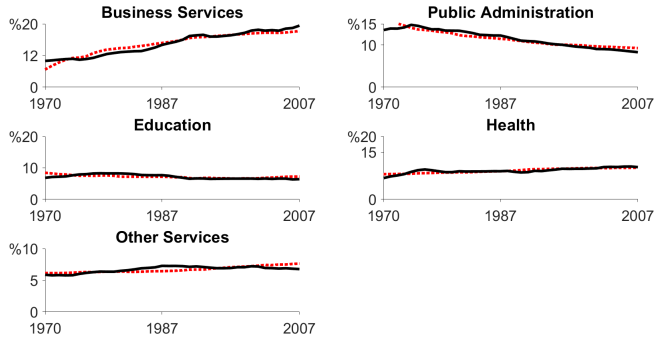
b. Services-Continued

c. Goods and Services

Figure 33: Data vs. Model: Germany



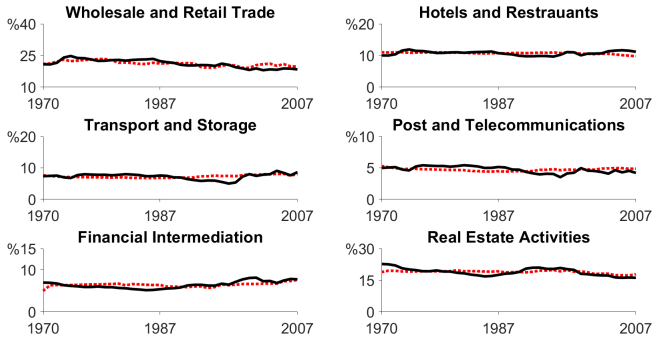
a. Services



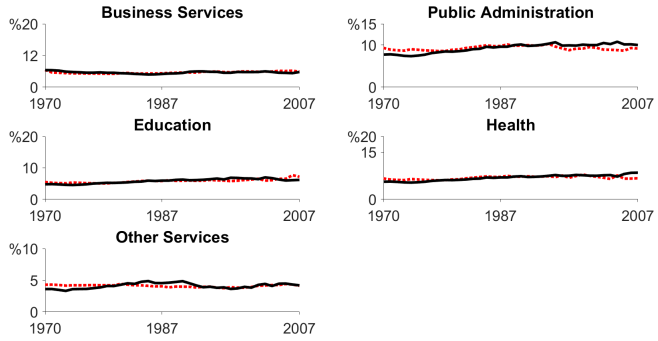
b. Services-Continued

c. Goods and Services

Figure 34: Data vs. Model: Greece



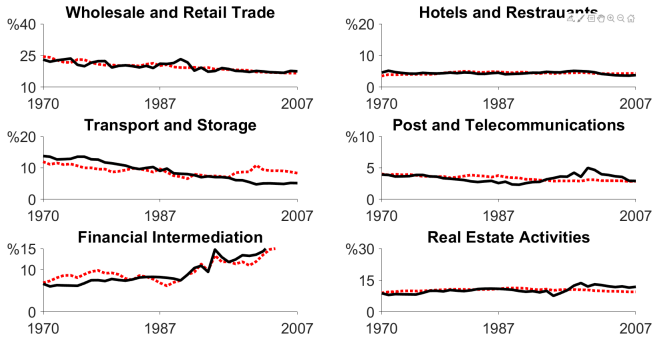
a. Services



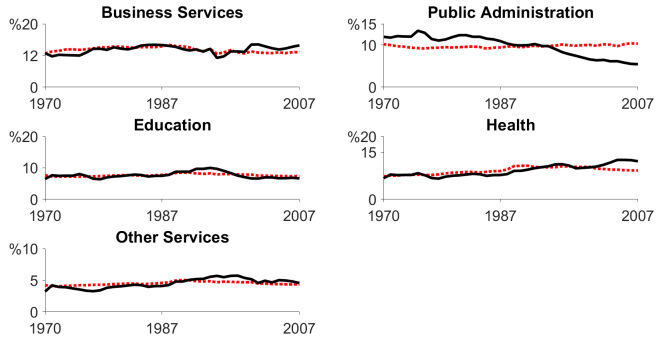
b. Services-Continued

c. Goods and Services

Figure 35: Data vs. Model: Ireland



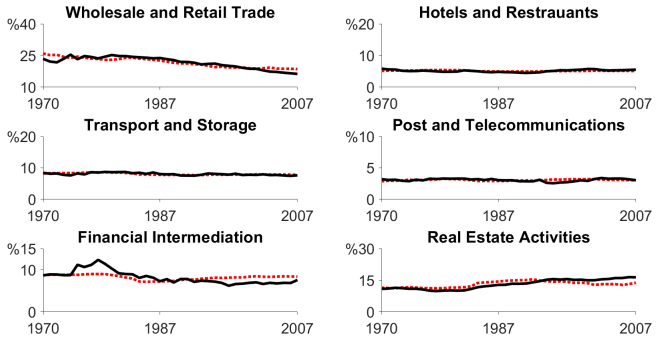
a. Services



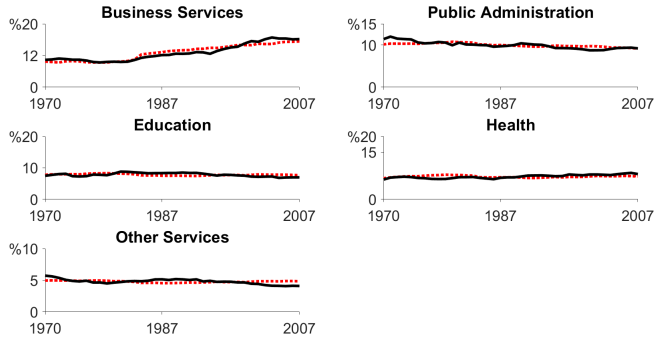
b. Services-Continued

c. Goods and Services

Figure 36: Data vs. Model: Italy



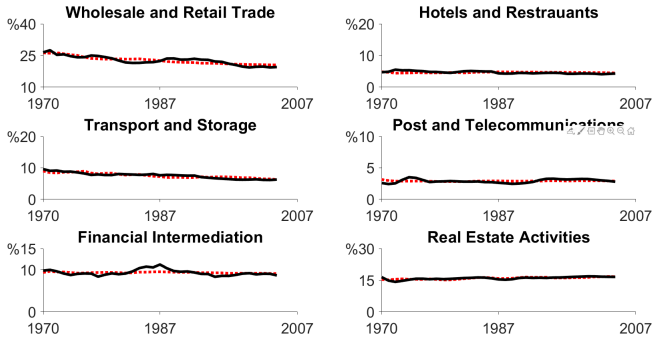
a. Services



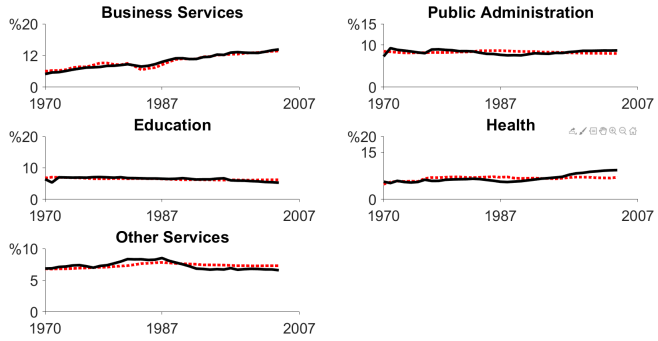
b. Services-Continued

c. Goods and Services

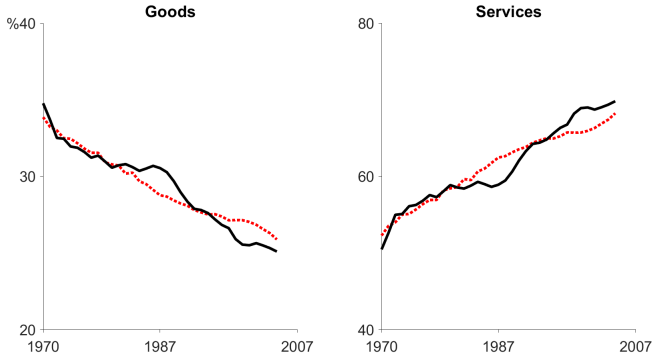
Figure 37: Data vs. Model: Japan



a. Services

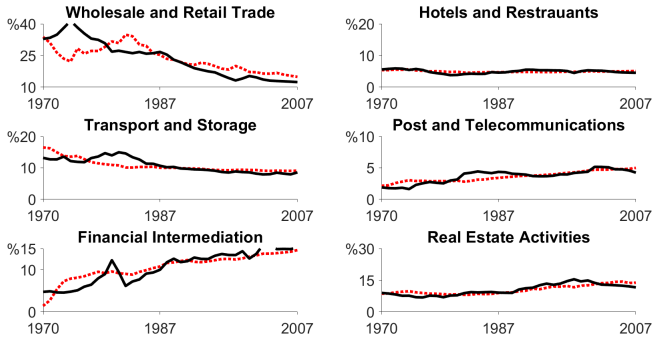


b. Services-Continued

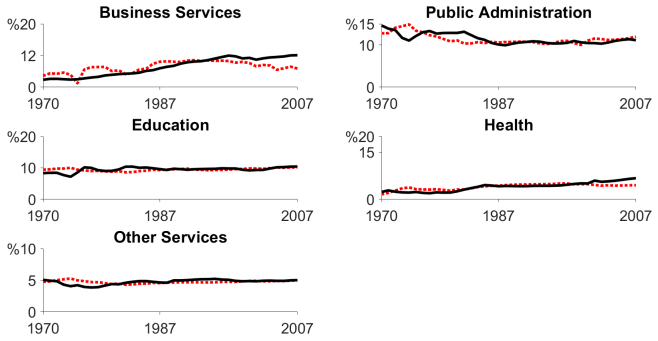


c. Goods and Services

Figure 38: Data vs. Model: Korea



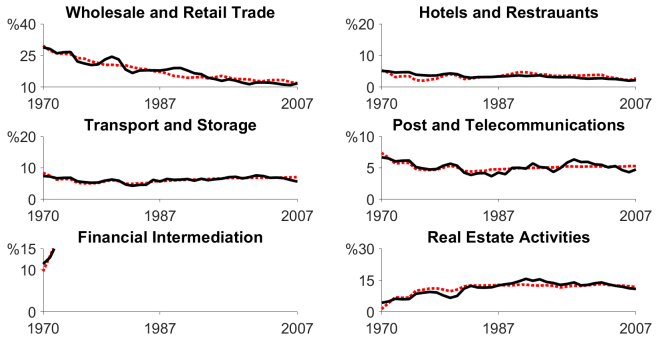
a. Services



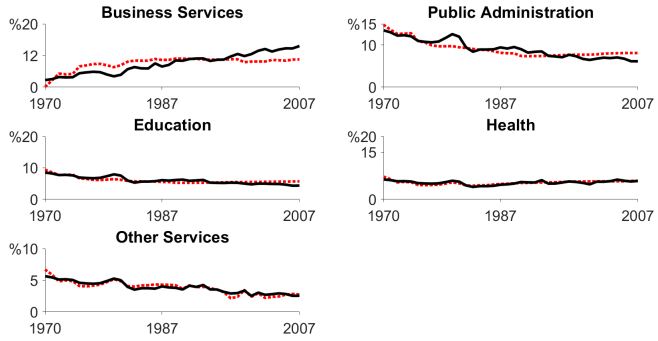
b. Services-Continued

c. Goods and Services

Figure 39: Data vs. Model: Luxembourg



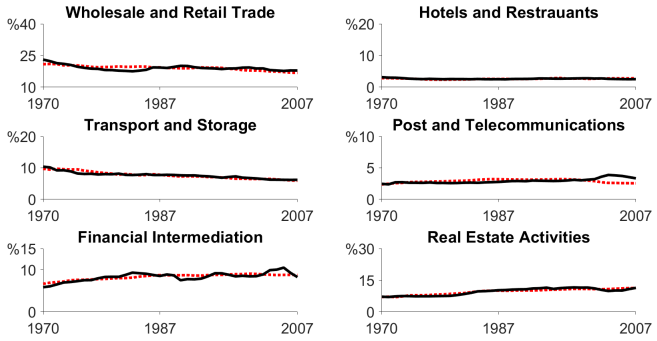
a. Services



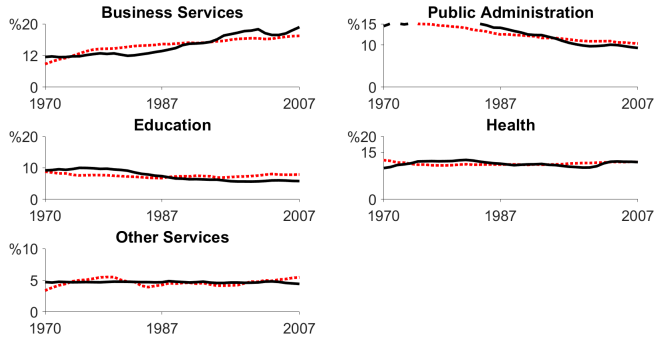
b. Services-Continued

c. Goods and Services

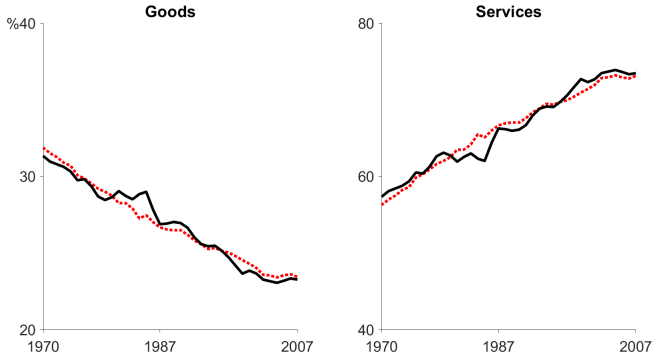
Figure 40: Data vs. Model: Netherlands



a. Services

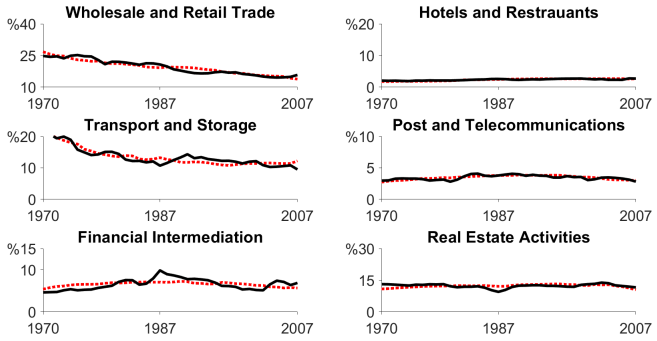


b. Services-Continued

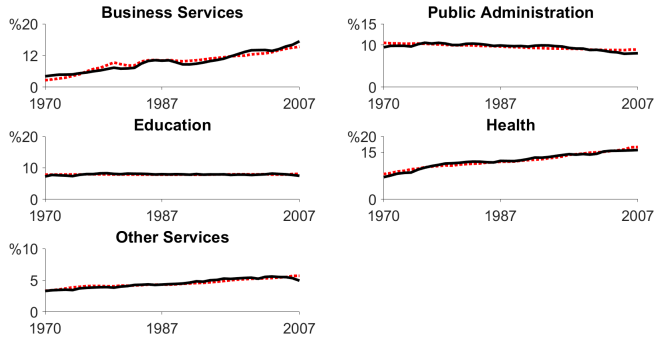


c. Goods and Services

Figure 41: Data vs. Model: Norway



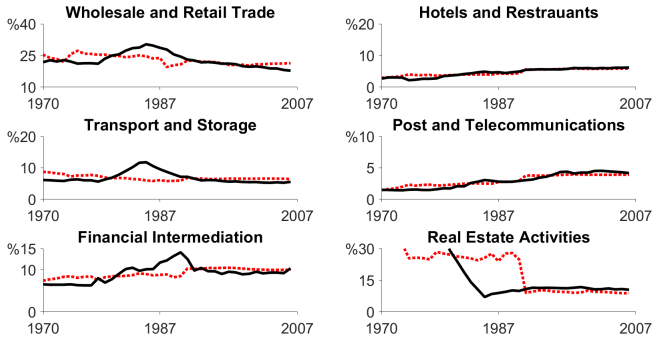
a. Services



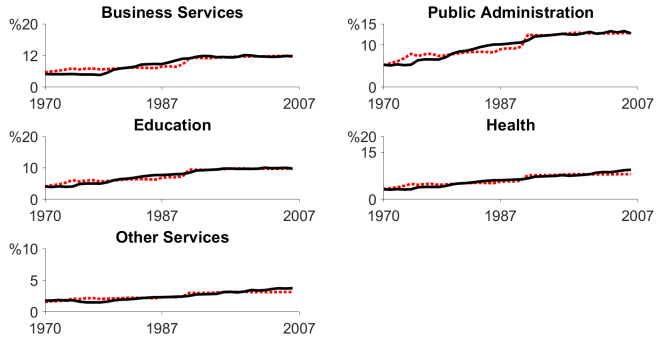
b. Services-Continued

c. Goods and Services

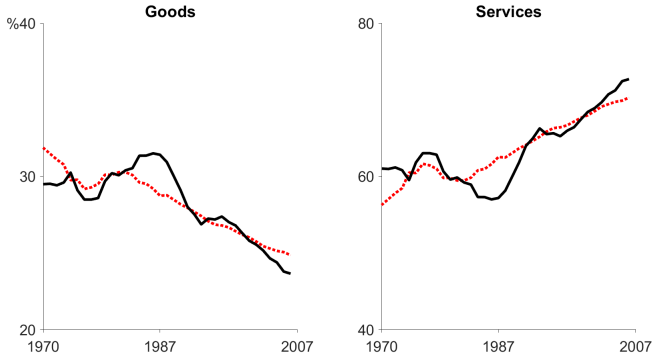
Figure 42: Data vs. Model: Portugal



a. Services

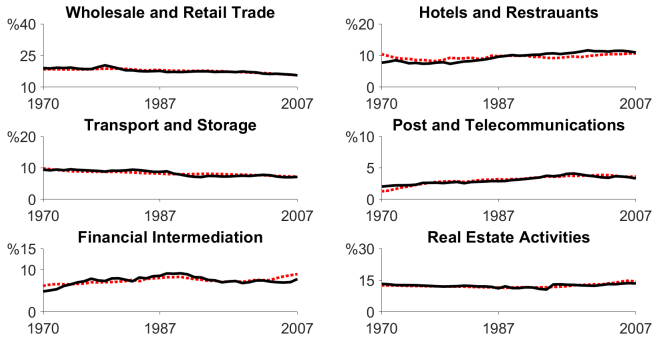


b. Services-Continued

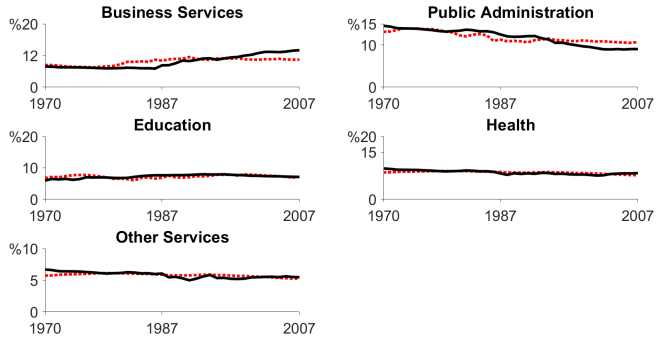


c. Goods and Services

Figure 43: Data vs. Model: Spain



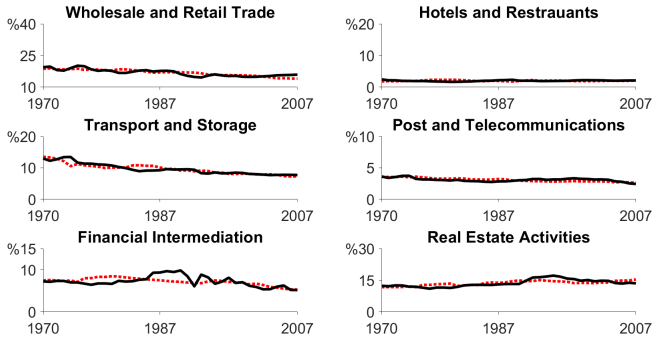
a. Services



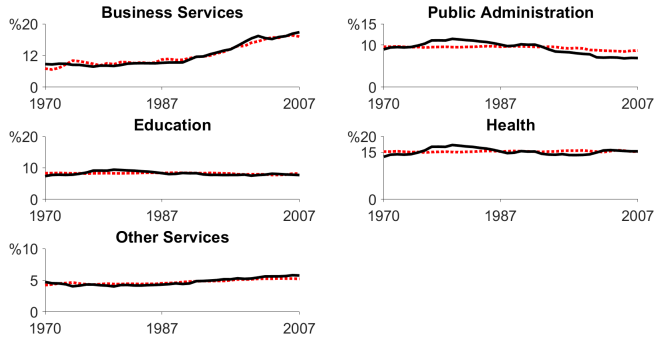
b. Services-Continued

c. Goods and Services

Figure 44: Data vs. Model: Sweden



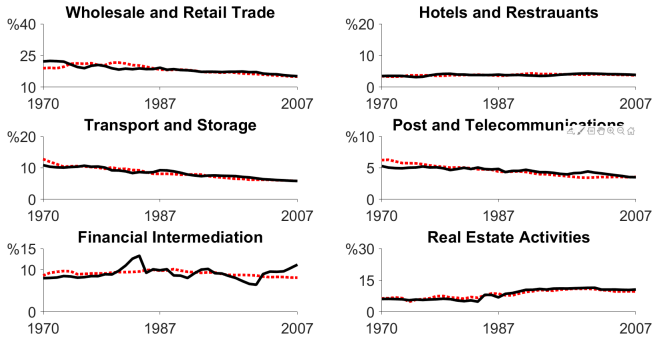
a. Services



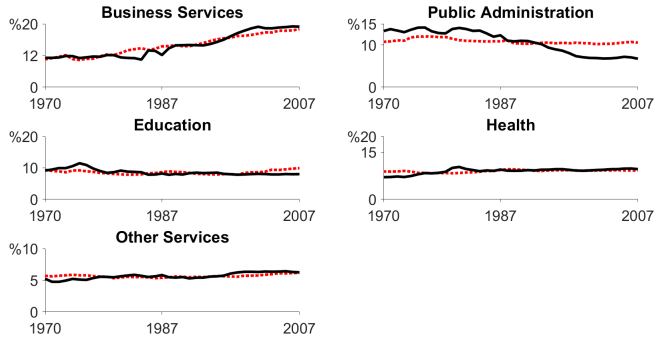
b. Services-Continued

c. Goods and Services

Figure 45: Data vs. Model: UK



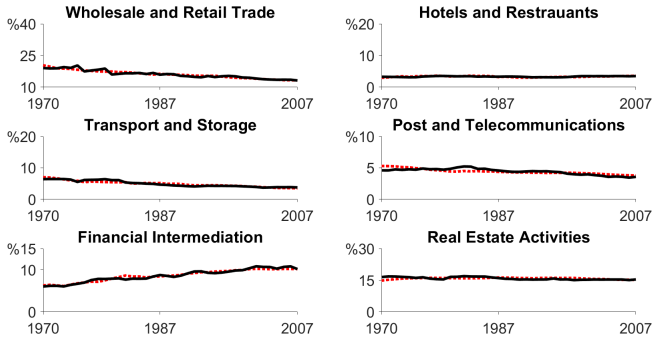
a. Services



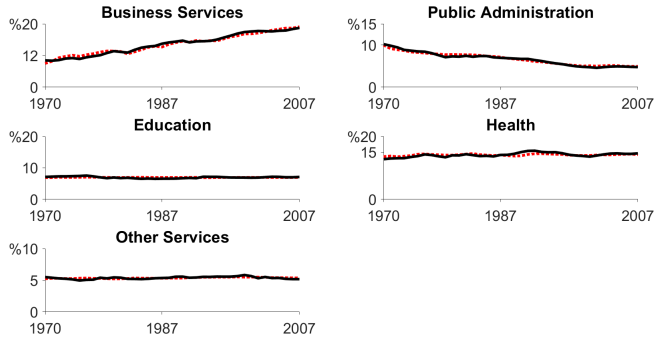
b. Services-Continued

c. Goods and Services

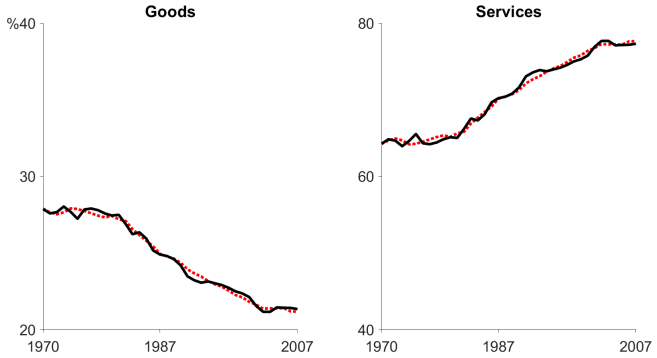
Figure 46: Data vs. Model: USA



a. Services

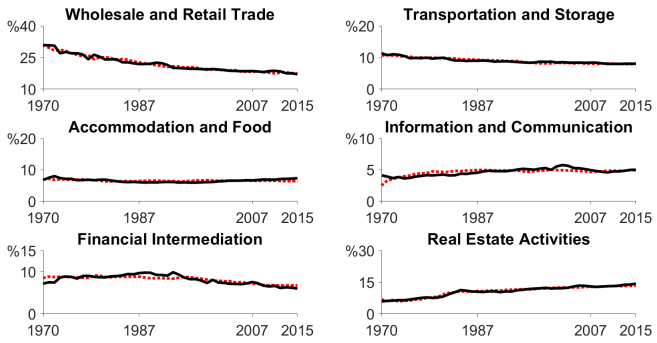


b. Services-Continued

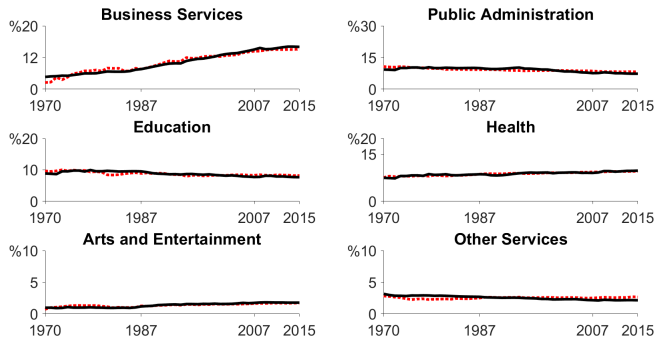


c. Goods and Services

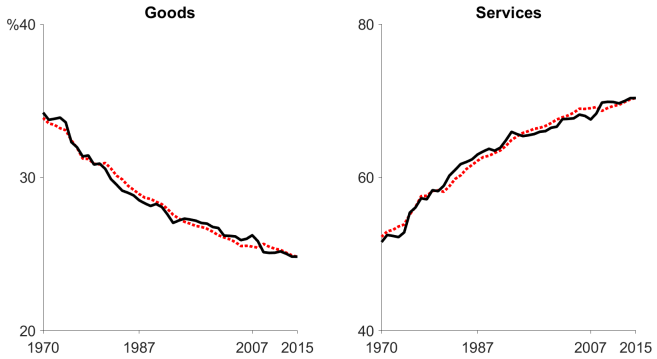
Figure 47: Data vs. Model: Austria - Revised



a. Services

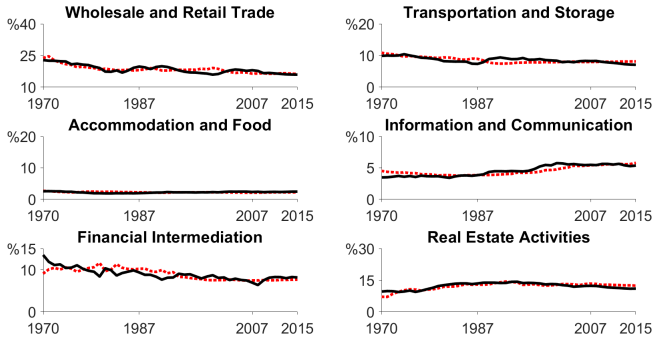


b. Services-Continued

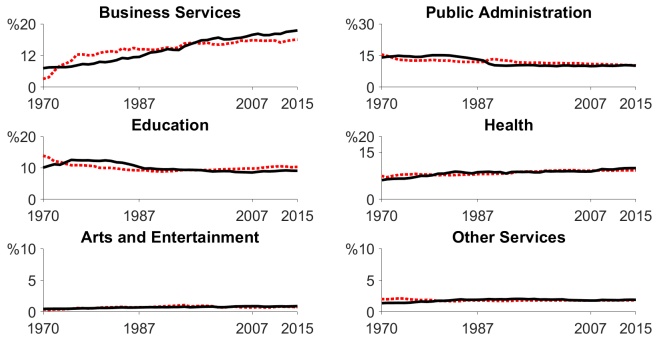


c. Goods and Services

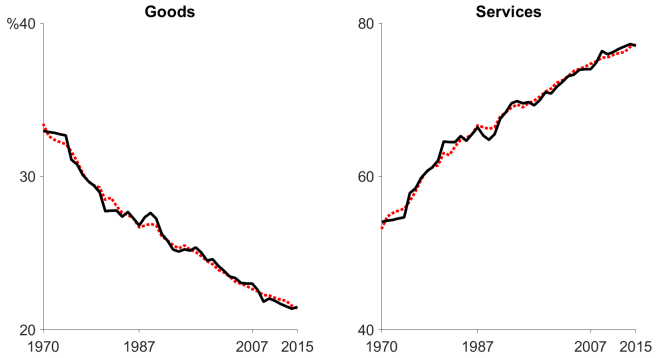
Figure 48: Data vs. Model: Belgium - Revised



a. Services

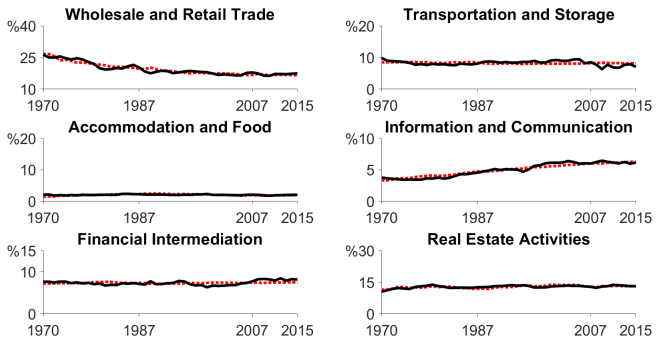


b. Services-Continued

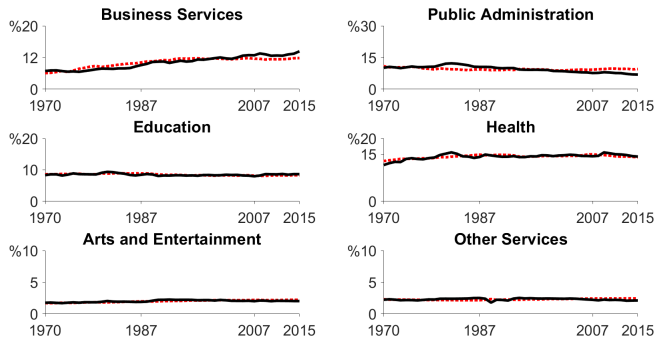


c. Goods and Services

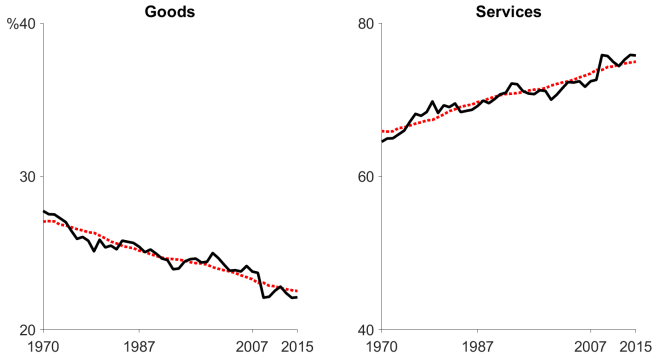
Figure 49: Data vs. Model: Denmark - Revised



a. Services

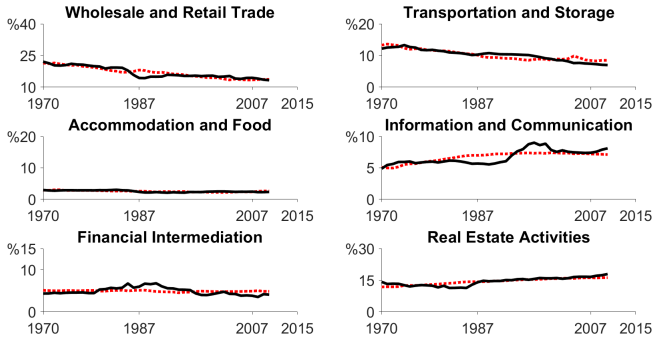


b. Services-Continued

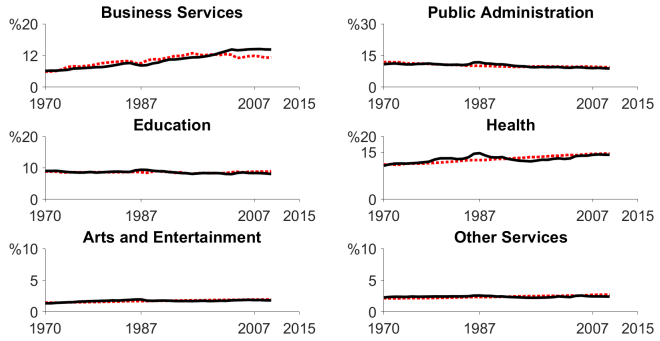


c. Goods and Services

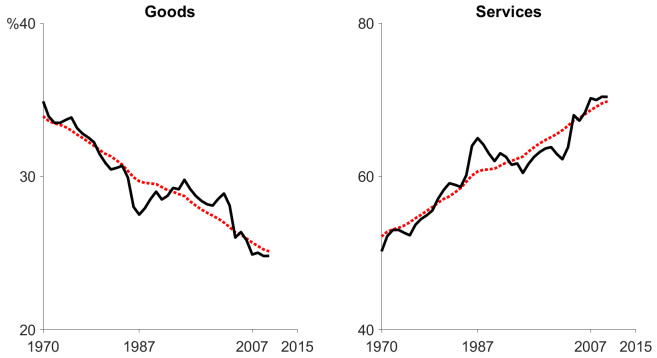
Figure 50: Data vs. Model: Finland - Revised



a. Services

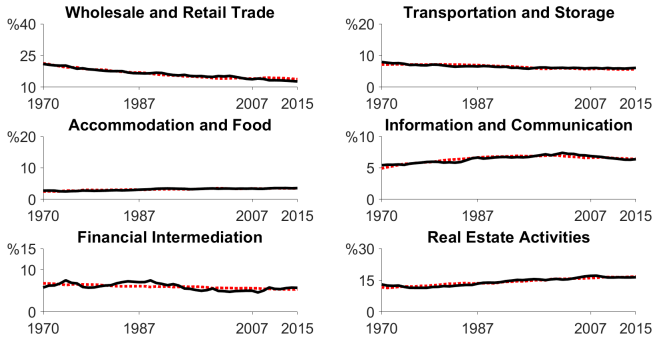


b. Services-Continued

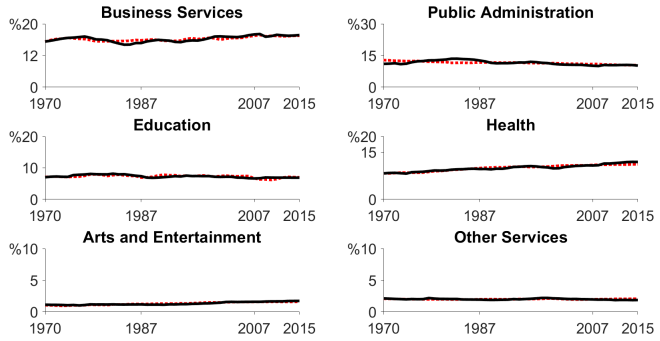


c. Goods and Services

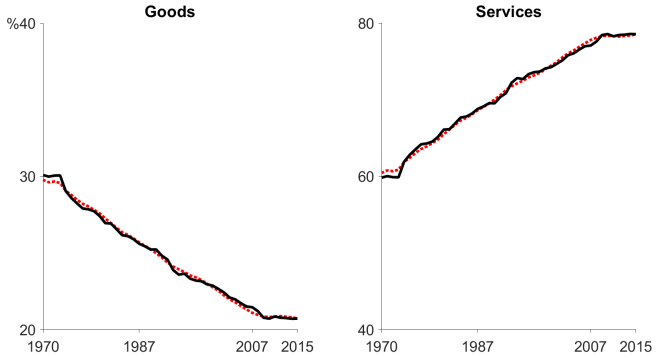
Figure 51: Data vs. Model: France - Revised



a. Services

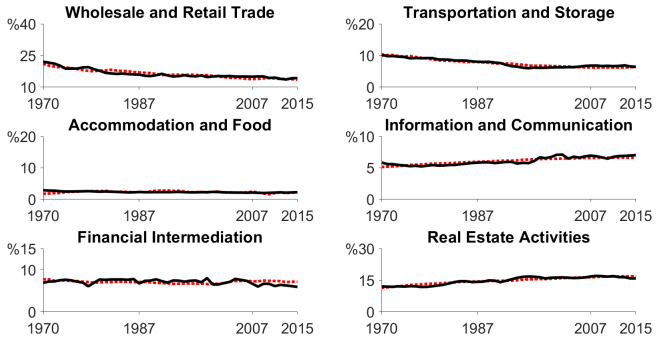


b. Services-Continued

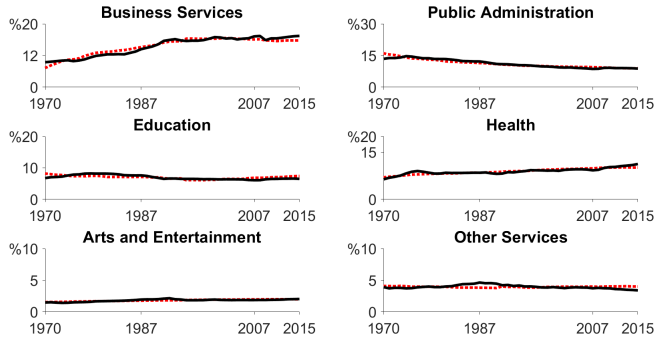


c. Goods and Services

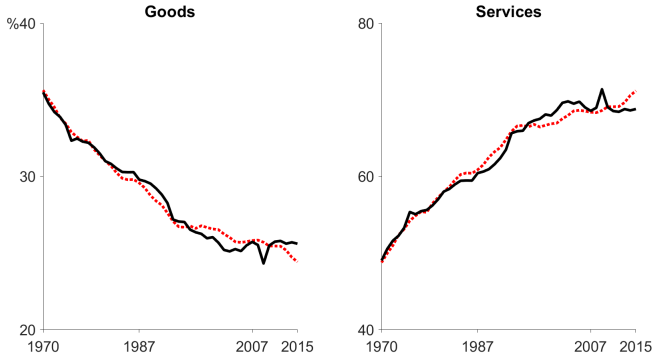
Figure 52: Data vs. Model: Germany - Revised



a. Services

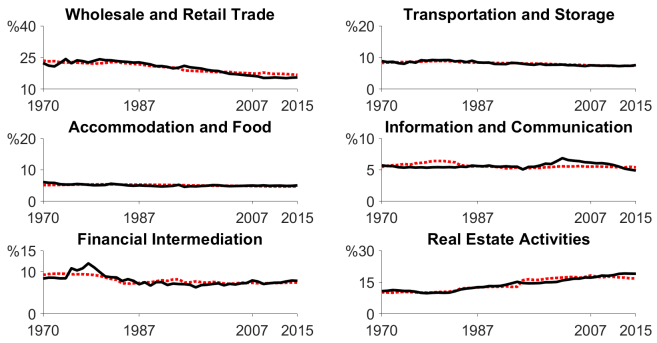


b. Services-Continued

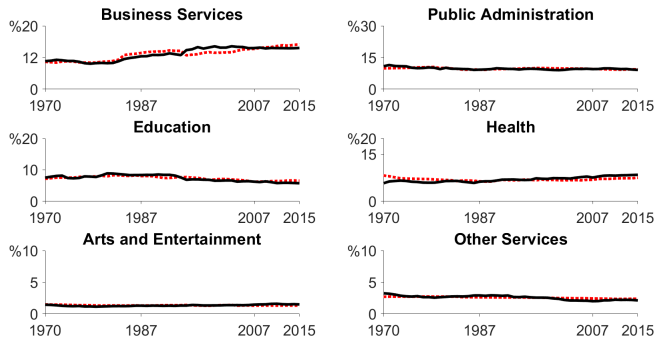


c. Goods and Services

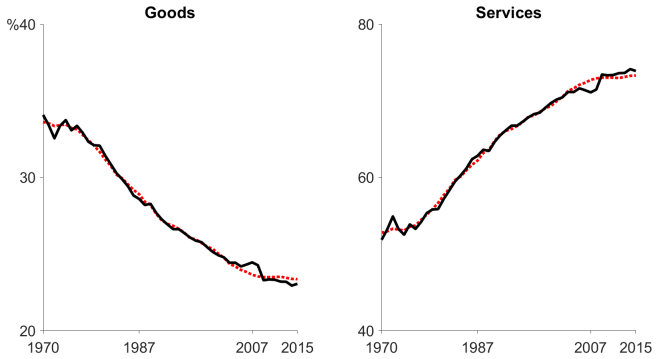
Figure 53: Data vs. Model: Italy - Revised



a. Services

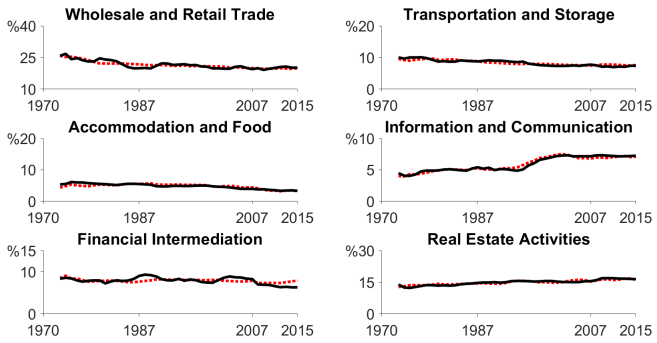


b. Services-Continued

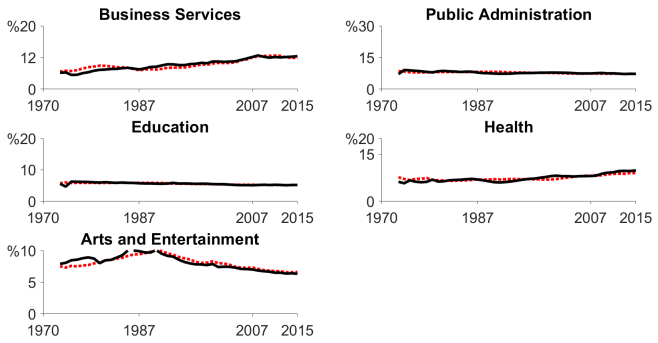


c. Goods and Services

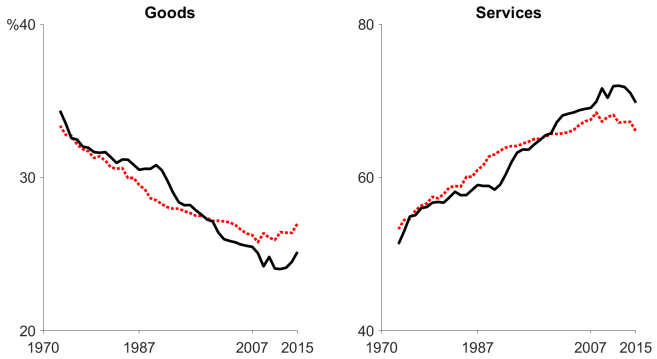
Figure 54: Data vs. Model: Japan - Revised



a. Services

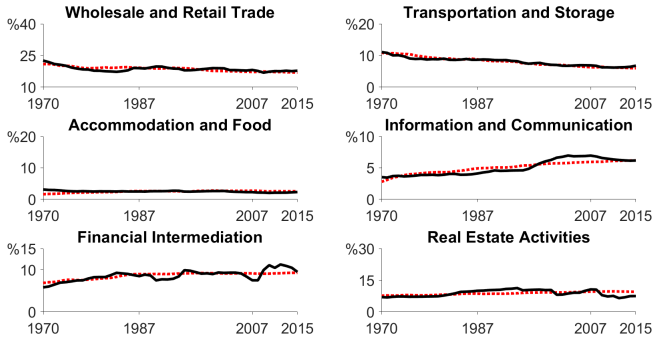


b. Services-Continued

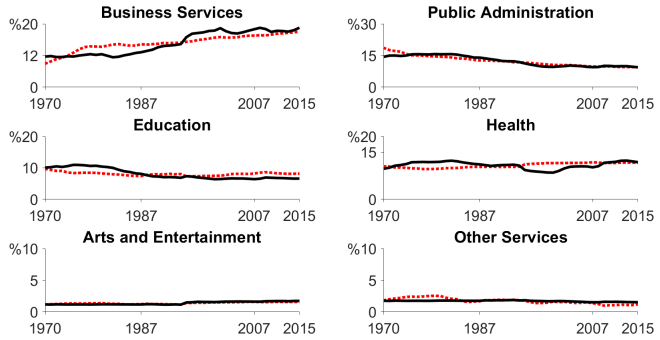


c. Goods and Services

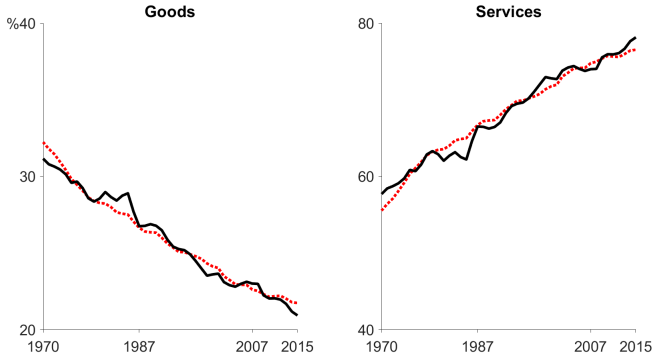
Figure 55: Data vs. Model: Netherlands - Revised



a. Services

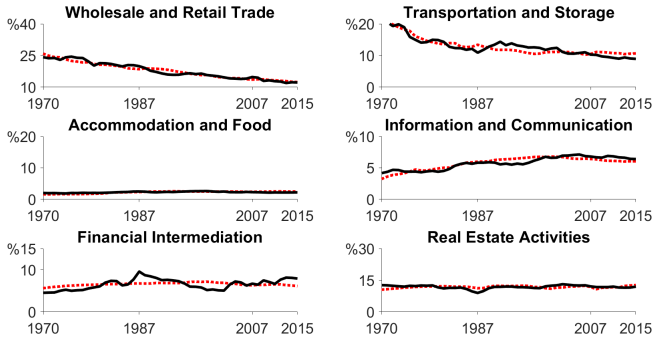


b. Services-Continued

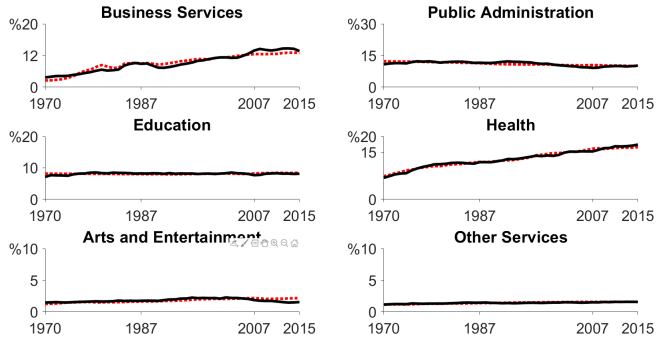


c. Goods and Services

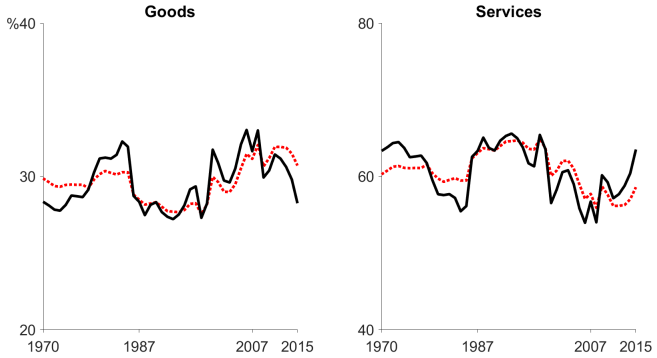
Figure 56: Data vs. Model: Norway - Revised



a. Services

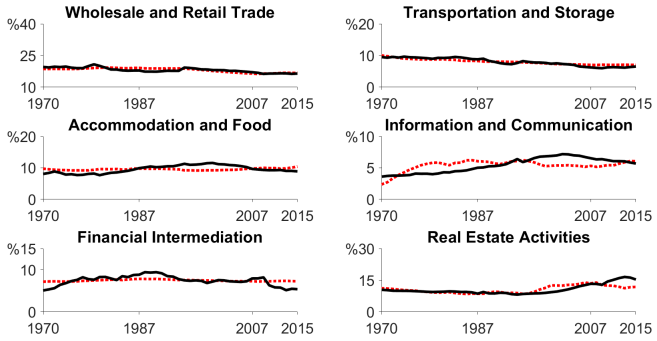


b. Services-Continued

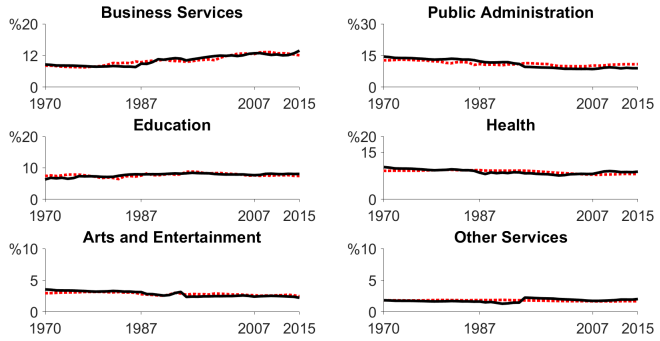


c. Goods and Services

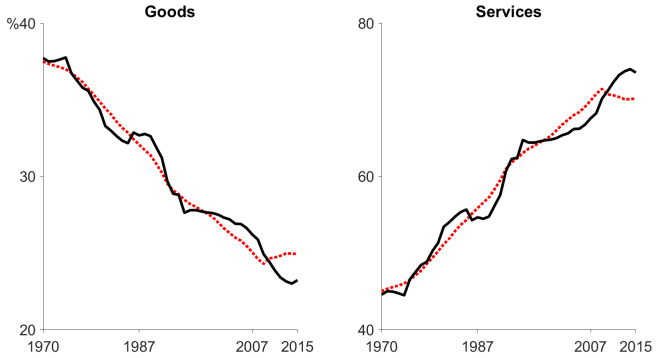
Figure 57: Data vs. Model: Spain - Revised



a. Services

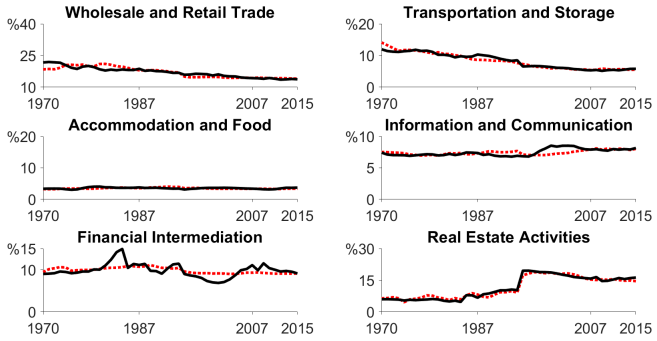


b. Services-Continued

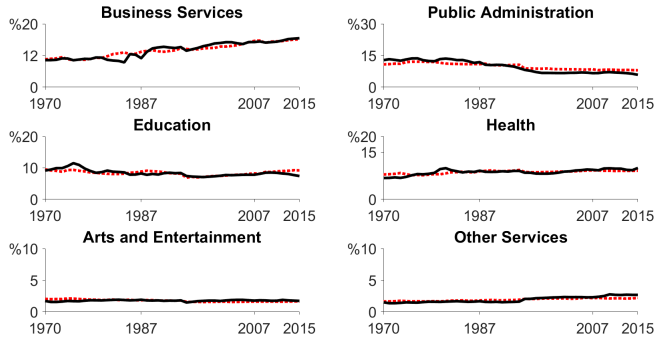


c. Goods and Services

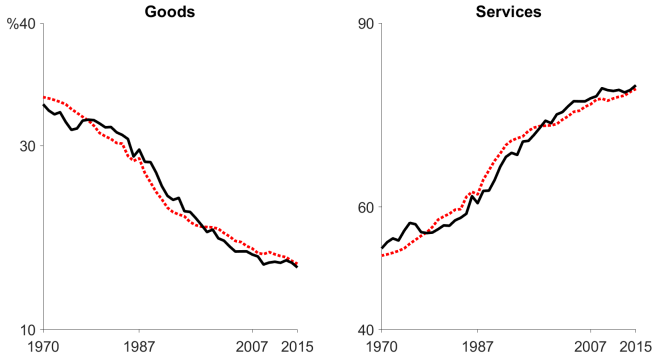
Figure 58: Data vs. Model: UK - Revised



a. Services

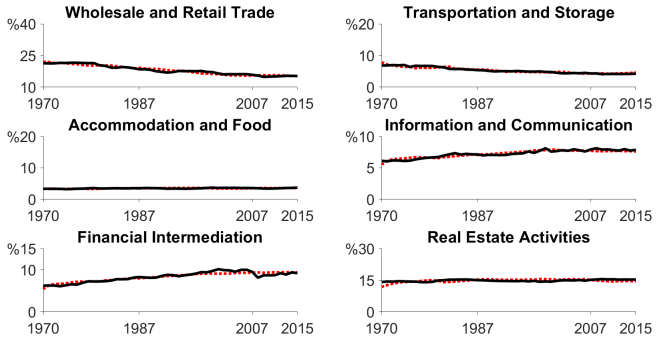


b. Services-Continued

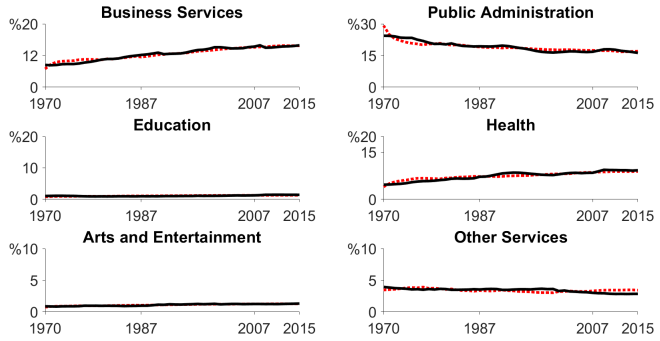


c. Goods and Services

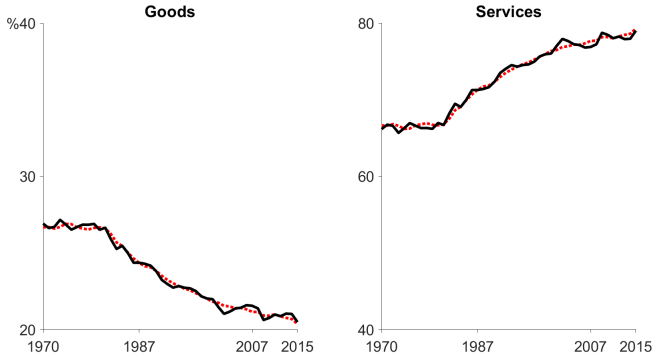
Figure 59: Data vs. Model: USA - Revised



a. Services



b. Services-Continued



c. Goods and Services