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WHY IS EUROPE FALLING BEHIND? STRUCTURAL TRANSFORMATION AND SERVICES' PRODUCTIVITY DIFFERENCES BETWEEN EUROPE AND THE U.S.

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Abstract

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JEL: O41, O47, O57; *Keywords*: Structural Transformation, Service Sector, Nonhomothetic CES preferences, Labor Productivity.

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1 Introduction

Labor productivity in Europe has been falling behind the United States since the beginning of the 1990s, reversing a previously observed pattern of convergence between these two economies. Figure 1 illustrates how this process of catch-up came to a halt and later reversed for all European countries. Except for the Netherlands, labor productivity for European countries is diverging from the U.S.: Average annual labor productivity growth (measured as GDP per hour of work) in the U.S. accelerated from 1.3 percent in the 1970-1990 period to 1.7 percent from 1995 to 2006 while the European countries on average experienced a labor productivity growth slowdown between these two time periods from 2.9% to 1.5%. The divergence is a combination of the U.S. taking off together with a European slowdown. In other words, the picture is glimmer for Europe either in relative or in absolute terms.

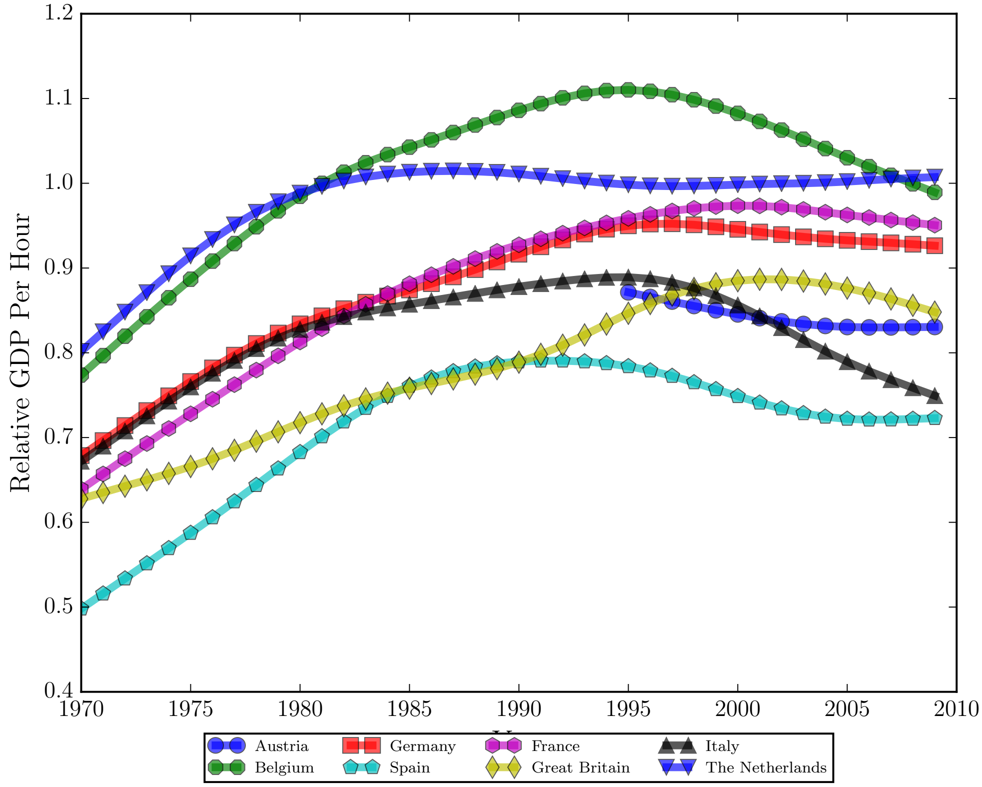
During this period, these economies underwent large scale sectoral (re)allocations of labor in a process commonly known as structural change (Kuznets (1957); Herrendorf et al. (2013); Herrendorf et al. (2014)). With Europe and the U.S. at their later stages of structural transformation (the so-called post-industrial society for advanced nations), labor reallocated further away both from agriculture and manufacturing toward services. As Duarte and Restuccia (2010) suggest, through the lenses of structural transformation it is possible to conclude that the service sector is responsible for most cases of relative stagnation and even declines in aggregate productivity observed at later stages of economic development since no other country experienced the productivity gains in the service sector witnessed in the U.S.

We believe that to understand the relative under-performance of Europe *vis-á-vis* the U.S. it is crucial to break down the service sector. The service economy is the predominant (and growing) sector for the vast majority of advanced nations and its lack of labor productivity gains is an increasing cause of concern for their long-run economic growth. In this paper, we use the lenses of structural transformation following the spirit of Duarte and Restuccia (2010) and decompose the service sector into sub-sectors comparable across Europe and the U.S. to investigate how changes in labor allocation and productivity within services help explain the service sector's labor productivity.

First, we use the World KLEMS database decomposing services into 11 comparable sub-sectors[1] to illustrate that indeed a compositional analysis of the service sector reveals that the aggregate productivity differences in services between Europe and the U.S. hide interesting idiosyncrasies in productivity performance and labor shares within services. Second, motivated by these facts, we develop a structural change model that combines the CES non-homothetic preferences crafted by Comin et al. (2015) with production functions whose

[1]We classify these sectors according to the ISIC Rev. 3 at one digit level.

Figure 1: Relative Labor Productivity



Notes: GDP per hour worked, relative to the United States. Source: OECD

unique input is labor as in Duarte and Restuccia (2010) disaggregating services into 11 subsectors comparable between Europe and the U.S.. Third, we calibrate the model to account for the the U.S. development experience and use the model to measure comparable labor productivity levels for the disaggregated service sector for all European countries in our sample. Our simulations show that the model is quantitatively able to reproduce the labor allocation in all sectors for all countries in our sample. Fourth, we perform counterfactual exercises to identify what kind of services have been dragging down most of the aggregate service labor productivity in Europe. Last, we empirically explore our country-sector panel measures of labor productivity levels to analyse how institutional differences in taxation, pro-business attitudes, ICT diffusion and rates of innovation are correlated with sectoral productivity.

Our quantitative experiment suggests substantial differences in sectoral labor productivity of services across countries. The European countries are in generally more productive than the U.S. in telecommunications, education and health and social work. However, and more importantly given their large labor shares, the European countries are less productive in wholesale and retail trade and business services, with a relative labor productivity in 1970 average of approximately 50% and 60% of that of the U.S., respectively.

Led by the counterfactual exercises, we identify wholesale and retail trade and business services as the two sectors that are responsible for most of the lack of catch-up in labor productivity of services between Europe and the U.S. In particular, we find that if Europe would have had the same gains in labor productivity as the U.S. in wholesale and retail trade and business services *alone* since 1990, it would have had a 3.9% and a 4.8% higher aggregate labor productivity, respectively. The highest effects of wholesale and retail trade are found in Belgium (8.3%) and Italy (6.9%), and the highest effects of business services take place in Spain (6.9%) and Italy (6.6%). In fact, if Europe had caught up with its labor productivity of wholesale and retail trade and business services by 2009 with respect to the U.S., the aggregate labor productivity in Europe would have been 16.6% and 10.7% higher, respectively.

Why have wholesale and retail and business services labor productivity had such a worse performance than other sectors in Europe? We empirically explore our estimated country-sector panel of labor productivity levels to investigate which institutional characteristics are associated with the different performances of sectoral productivity across sectors. Our results suggest that differences in taxation, pro-business attitudes, ICT diffusion and rates of innovation are disproportionally correlated with the productivity of wholesale, retail and business services relative to the rest of the sectors in the economy. Since the factors considered are mostly associated with sectoral productivity levels in wholesale and retail trade and business services, which are exactly the sectors that we identified as being at the core of the falling behind, our results suggest that a more comprehensive empirical analysis of the determinants of the service productivity gap between Europe and the United States should start by looking at differences in taxation, regulation, ICT diffusion, and the scope of innovation among these two sectors.

This paper is related primarily to the literature of structural transformation that dates back to the works of Kuznets (1957) who documented the sweeping changes across the different industries in the process of economic development. More recent contributions to structural change build upon the works of Kongsamut et al. (2001) and Ngai and Pissarides (2007) who emphasized the role of income and sector-biased productivity channels respectively as the drivers of structural transformation. Several attempts have been made to incorporate both mechanisms in a single framework, such as Buera and Kaboski (2009), Duarte and Restuccia (2010), and Ferreira and Silva (2014) among many others.[2]. Our paper complements Buera and Kaboski (2012) explanation of the rise of the service sectors by showing

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

that a large increase in the labor share of services has also in fact been driven by business to business services.

Both higher levels of disaggregation and sector specific distortions (such as taxes and market regulation) have been identified as fertile areas of research to understand the mechanisms behind the structural transformation. Our paper makes use of the model proposed by Comin et al. (2015), with some minor modifications, to study productivity differences in the service sector with a highly disaggregated structural transformation model and shows that the model is quantitatively successful in capturing the structural transformation across all sectors and countries in our sample.

Our paper also talks to a vast literature that studies cross-country productivity differences and productivity determinants, generally with empirical methodologies. A few examples are Baily and Solow (2001), Nicoletti and Scarpetta (2003), Dew-Becker and Gordon (2012), and Cette et al. (2016). More closely related to our research question, Inklaar et al. (2008) provide some insights on what factors might be behind the differences in productivity between Europe and the U.S. They find that the most important factors are lower growth contributions from investment in information and communication technology in Europe, the relatively small share of technology-producing industries in Europe, and slower multi-factor productivity growth. In particular, they find that the latter effect is more notorious in the service sector. We complement their analysis by showing which service sectors are particularly responsible for the observed differences in productivity growth. Moreover, we also show empirically that differences in investment in information and communication technology are more correlated with labor productivity growth in the same sectors that are responsible for large differences in aggregate labor productivity.

The rest of the paper is organized as follows: Section 2 discusses the main stylized facts of structural transformation with particular emphasis on the disaggregation within services. Section 3 develops a simple conceptual framework that extends the structural transformation model of Comin et al. (2015) to include service sub-sectors and calibrates the baseline model. Section 4 uses the calibrated model to measure the first period levels of sectoral productivity in Europe, evaluates the model performance and presents the counterfactual exercises that quantify the relevance of each sector in aggregate labor productivity. Section 5 explores the cross-country and cross-sector panel to investigate how differences in taxation, regulation and technology are correlated with differences in services sectoral labor productivity. Finally, Section 6 provides the concluding remarks and discussion.

2 Facts on a Disaggregated Service Sector

In this section we describe our dataset and document the main stylized facts of the labor reallocation taking place within services for a set of European countries and the U.S. We show that there is an important cross-country variation in sectoral labor reallocation and sectoral labor productivity dynamics of the sub-service sectors, even though the aggregate allocations of labor toward services are similar across our sample. This similarity is not surprising given that these countries are at their late stages of development with higher weights on services as a share of their economy activity.

Table 1: Sectors' Classification its Data Correspondence

	Data Classification ISIC Rev. 3	
Code	Name	Section
`agr`	Agriculture, hunting and forestry	A
	Fishing	B
`man`	Mining and quarrying	C
	Manufacturing	D
	Electricity, gas, and water supply	E
	Construction	F
`trd`	Wholesale and retail trade	G
`rst`	Hotels and restaurants	H
`trs`	Transport and storage	I(60-63)
`com`	Post and telecommunication	I(64)
`fin`	Financial intermediation	J
`res`	Real estate activities	K(70)
`bss`	Renting and business activities	K(71-74)
`gov`	Public administration and defense	L
`edu`	Education	M
hlt	Health and social work	N
`per`	Other community, social and personal activities	O

We use the World KLEMS[3] industry-level data on hours worked and value added. All of our data series are trended using the Hodrick-Prescott filter with a smoothing parameter $\lambda = 100$ since our focus is on long-run trends of labor allocation and productivity. Our objective is to have the most disaggregated service sector possible comparable across the largest set of European countries, given the data constraints, and the U.S. To reach this goal, we restrict our sample to 9 countries from 1970 to 2009. The countries we investigate

[3]For more details see O'Mahony and Timmer (2009). There are other papers with a similar objective to our paper that use the same database. Se for instance Timmer et al. (2014), Van Ark et al. (2003) and Inklaar et al. (2008).

in this paper are Austria, Belgium, France, Germany, Italy, Spain, The Netherlands, Great Britain and the U.S. Table 1 presents the most disaggregated service sectors classification possible in order to have comparable measures across the European countries with the U.S..

We use the International Standard Industry Classification (ISIC) Rev. 3 to classify 13 comparable sectors. Given our particular interest in the service economy, we classify agriculture and manufacturing in the standard[4] way they are classified when the analysis is restricted to 3 sectors only. However, we disaggregate the service sector into 11 different sub-services. By doing this, we achieve a higher degree of homogeneity within the new classified services.

2.1 Service Sector Structural Transformation

The first fact emerging out of the disaggregated services labor shares is that, in any given period, they vary widely within a country and across countries. Table 2 presents the average sectoral labor shares of services for the European countries[5] and how these shares compare relative to the U.S. in the first and last periods of our sample. In the first period, 13.5% of total labor in Europe is allocated to wholesale and retail (trd) while only 0.35% is allocated to real estate (res). This is expected given the high level of heterogeneity in the service sector, where services can range from transportation to social work. What is more surprising is the large variation in the cross-country experience of within service dynamics, even though the labor allocation into aggregate services is similar. Columns 3 and 4 of Table 2 show that the total labor that is allocated to health and social work in Europe is only 40% of the allocation for the same sector in the U.S.

The second salient fact is that labor is allocated disproportionally to particular service sub-sectors as labor shifts away from agriculture and manufacturing into the service sector. While we observe an increase in the labor share of services that could be thought of as substitutes for home production, which is in line with the ideas of Buera and Kaboski (2012), we also observe that the rise of the service sector was strongly driven by the surge in the business services and health and social work labor shares. Between 1970 and 2009, business services (bss) was the sub-sector that received most of the labor reallocated away from agriculture and manufacturing. The business services labor share increased so much that it jumped from being the 6th sector with highest labor share in the European economy to being 1st, despite the fact that the majority of all other service sub-sectors increased their

[4]See for instance Duarte and Restuccia (2010)

[5]There are stark differences in labor reallocation of services even between the European countries. However, for the sake of a broad comparison between Europe and the U.S., we show the European average only. We show in the appendix the structural transformation of the service sector of all the countries in our sample.

Table 2: Structural Transformation Within services for Europe *vis-à-vis* the U.S.

	Employment Share in Europe - 1970			Employment Share in Europe - 2009		
	Sector	*%*	*Relative to US*	*Sector*	*%*	*Relative to US*
1	trd	13.53	0.97	bss	14.99	1.08
2	gov	6.14	0.81	trd	14.79	1.09
3	hlt	4.46	0.39	hlt	9.33	0.54
4	trs	4.08	1.18	per	6.98	1.03
5	per	4.04	1.01	gov	6.46	2.08
6	bss	3.91	0.61	rst	5.34	0.81
7	edu	3.19	0.49	edu	5.33	0.68
8	rst	3.05	0.78	trs	4.48	1.32
9	fin	2.05	0.59	fin	2.99	0.68
10	com	1.63	0.6	com	1.39	0.87
11	res	0.36	0.45	res	1.00	0.74

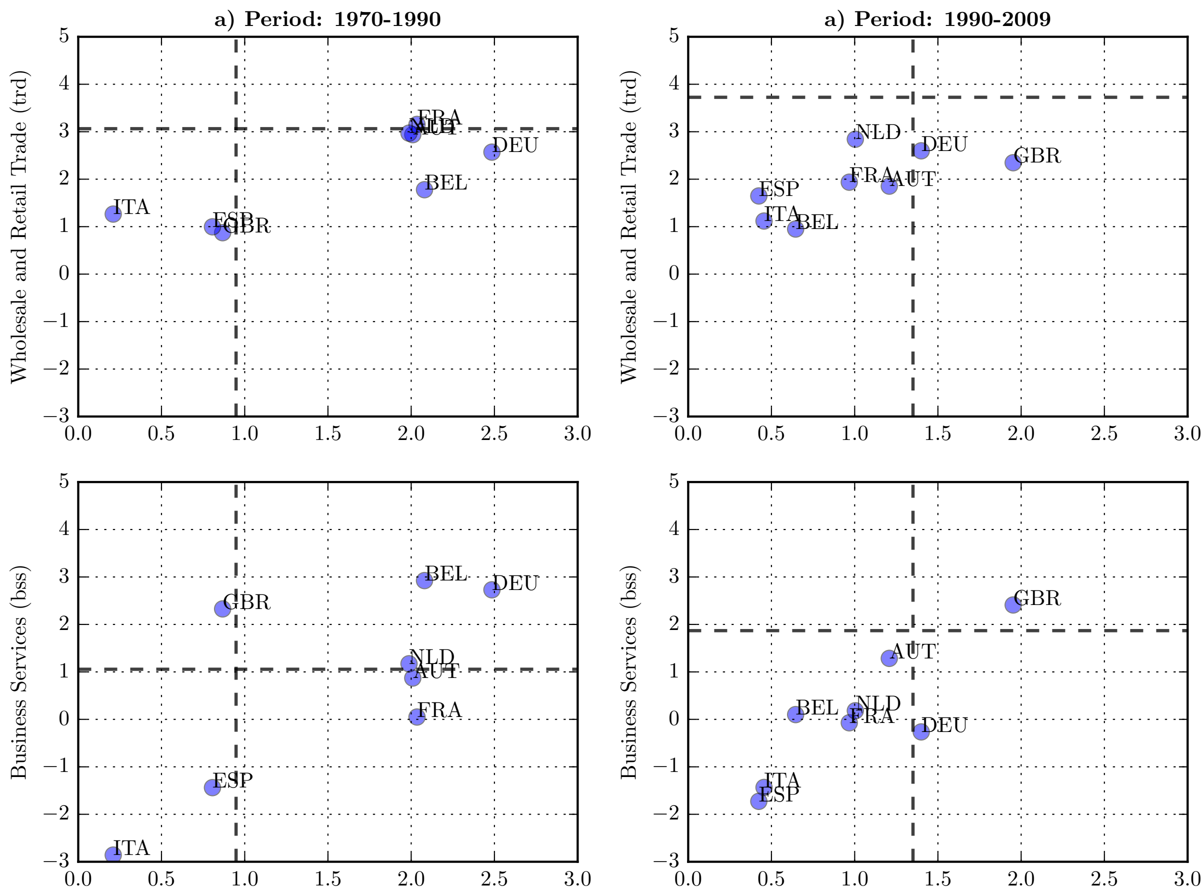
labor share during the same period. In contrast, the labor share remained relatively constant for some sub-sectors like in government (gov) and wholesale and retail (trd).

The third and final fact is that the structural transformation taking place within services is similar across countries. If we look at the ratios of the labor shares in Europe relative to the U.S. together with the labor shares levels in Europe in Table 2, we can back out the labor shares in the U.S. After doing this, we find that both Europe and U.S. experienced similar patterns in the labor reallocation within services. The trends have different magnitudes, but the broad qualitative movement is the same. For instance, the business services labor share in the U.S. was approximately 6.5% in 1970, and by 2009 it was at a slightly lower level than Europe. Hence, the trend in labor share growth in business services was slightly higher in Europe.

2.2 Services Sectoral Labor Productivity

From 1970 to 2009, the U.S. annualized labor productivity growth rate in the service sector was approximately 1.1%. Besides Italy and Spain, all European countries experienced a higher growth rate than the U.S. in aggregate service labor productivity for the same period. However, simply looking at the whole sample hides two very distinct phases - one of strong catch-up (1970-90) and another of stagnation and divergence (1990-09). Hence, we perform a sub-sample analysis following the 1990 cut off. According to this breakdown, we find that the U.S. accelerated from approximately 1% growth in service labor productivity in the 1970-90 period to 1.4% in the 1990-09 period. At the same time, most European countries

Figure 2: Average Growth in Services' Productivity



Notes: Scatter plots of value added per hour of the aggregate service sector with the value added per hour of Business Services and Wholesale and Retail Trade. Annualized percentage growth rates during the sample period are given for each country. The horizontal lines indicate the service sub-sectoral growth rates observed in the United States, and the vertical line indicates the aggregate service growth rate of the United States for both a) 1970-1990 and b) 1990-2009 periods.

experienced a major slowdown in services between the two periods[6], with the European average growth rate in services falling from 1.6% to 1%.

Figures 13 to 18 plot the annualized growth rate of services with that of the sectoral

[6]One strong exception is Great Britain which accelerated even faster than the U.S. from approximately 1% to 2%. The acceleration in the service sector by Great Britain between 1990-09 helps explain why it was also the only European country in our sample that continued to converge to the U.S. in aggregate labor productivity. However, not all went well during the entire period for Great Britain, as it also experienced a slowdown in aggregate labor productivity in the 2000-09 period. Services are again at the root of this downturn. The counterfactual exercises in the quantitative section provide insight into which type of services caused the slowdown in aggregate labor productivity of Great Britain.

labor productivity for each country. We present 3 pairs of figures: one for the entire sample (Figs 13 and 14), one for the first period of convergence (Figs 15 and 16), and one for the second period of divergence or stagnation (Figs 17 and 18). From these figures, we note that there is significant heterogeneity in the sectoral labor productivity performances. That is, countries that had a relative higher annualized growth rate of labor productivity in aggregate services also had relative lower annualized productivity growth rates in some particular types of services when compared with the U.S. In general, European countries had a higher productivity growth in health and social work (hlt) and personal services (per) while they had a lower performance in wholesale and retail Trade (trd).

The two sectors that had a very distinct behaviour were trd and bss. We focus on these two sectors as their behaviour together with their importance in total labor are crucial to understand the dynamics of labor productivity of aggregate services.

Figure 2 compare the relative performance of these two sectors in the two periods. It is interesting to note that wholesale and retail trade has strong gains in labor productivity and that the U.S. is the leading country in this sector in both periods. Between the two periods, the U.S. accelerated from 3% to almost 4% while the European economies maintained the same growth rate between the two periods.

According to the same figure, business services (bss) have a slightly different story, as not only the U.S. accelerated between the two periods doubling its growth rate from 1% to 2%, but in addition most European countries suffered a slowdown in this sector. Is is important to note that the bss includes the IT industry that could potentially explain these observations as the digital revolution of the 90's originated mostly in the U.S. However, given the transferability of this technology and the available human capital in most European countries, it is somewhat surprising that the European countries did not catch-up at later stages of the second period considered.

Part of the reason might be the one posed by Bloom et al. (2012), whereby U.S. firms use better the same available technology due to management practices that are more efficient in ripping off the benefits of digital technologies. Our paper is silent not aim at explaining in depth the sectoral labor productivity dynamics, but rather how their composition explains the aggregate service productivity. Nevertheless, by doing so, we highlight potential sectors that seem to be crucial to understand the aggregate performance of labor productivity. Our paper shows that business services is a key sector and that studies such as Bloom et al. (2012) are relevant to understand not only the roots of sectoral differences but also of aggregate differences.

Although the facts on disaggregated services give a clear initial indication of the sectors that are responsible for the slowdown in the productivity of services of the European countries, it is still crucial to develop a model of structural transformation for two reasons. First, to estimate the levels of labor productivity because of the lack of comparable (PPP-adjusted) sectoral output data for our level of disaggregated services. Second, the process of reallocation of labor is endogenous to the level and changes over time of sectoral labor productivity. We develop such model in the next section.

3 Model

We build a multi-sector model of an economy that at each point in time produces agricultural, manufacturing and 11 types of service goods following Comin et al. (2015) and Duarte and Restuccia (2010). The main departure from Duarte and Restuccia (2010)[7] is the introduction of nonhomothetic CES aggregator, and from Comin et al. (2015) the extension of the number of sectors and abstraction from capital[8]. The only input used in the production of each good is labor measured in terms of total hours of work, and the reallocation of labor across different sectors is driven by income and substitution effects. We calibrate the economy to the World KLEMS data and the U.S. initial period data on labor allocation and show that the model is able to explain the salient features of the structural transformation of the U.S. from 1970 to 2009.

3.1 Environment

Firms

At each point in time, thirteen goods are produced: agriculture, manufacturing and eleven types of services[9]. Let I be the set of goods produced every period. All goods have the same constant-returns to scale production technology:

$$Y_{it} = A_{it} L_{it} \qquad \forall i \in I, \tag{1}$$

where Y_i is the output, L_i is the labor input (total hours worked) and A_i is the productivity

[7] We build a version of the model with Stone-Geary preferences and compare it with our main model in appendix A. The Stone-Geary restriction on the income channel on high levels of income appears to worsen the fit for some types of services. Moreover, it consistently underpredicts or overpredicts some sector's labor shares. See Figure 12.

[8] Even though capital is not explicitly incorporated in our model, it can still indirectly affect the labor allocation across sectors in the quantitative exercise. The reason being that our observed sectoral measure of labor productivity (value added per hour worked) is affected by capital. Hence, changes in capital imply changes in the observed sectoral labor productivity that are fed into the model in the quantitative exercise.

[9] The eleven type of services are the ones described in the previous section of this paper.

parameter in sector i[10]. We assume perfectly competitive markets and a continuum of homogeneous firms in each sector. At each date, given the price of the output of good i and wage w, a representative firm makes a static choice of labor input by maximizing its profit:

$$\max_{L_i > 0} \{p_i A_i L_i - w L_i\}. \tag{2}$$

Households

The economy is populated by a continuum of households with measure one. Households are endowed with L hours each period which are supplied inelastically to the market. A representative household has the following preferences over goods and services produced:

$$\sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\theta} - 1}{1-\theta}, \tag{3}$$

where $\beta \in (0,1)$ is the discount factor, θ is the reciprocal of the elasticity of intertemporal substitution and C_t is the aggregate consumption at time t. The aggregate consumption represents the aggregation of the consumption of individual sectoral goods $\{C_{it}\}_i^I$ according to the CES nonhomothetic aggregator proposed by Comin et al. (2015)

$$\sum_i^I \Omega_i^{\frac{1}{\sigma}} C^{\frac{\varepsilon_i - \sigma}{\sigma}} c_i^{\frac{\sigma-1}{\sigma}} = 1, \tag{4}$$

where $\sigma \in (0,1)$ is the elasticity of substitution, $\epsilon_i \geq 1$ is the income elasticity for good i and $\Omega_i > 0$ are constant weights for each good i, $\sum_i \Omega_i = 1$. There are three main reasons[11] as for why the nonhomothetic CES preference structure is a particularly good candidate to explain the structural transformation in our model of thirteen sectors. First, it naturally extends for any given number of sectors while the same is not true for other type of preferences such as in Boppart (2014), Herrendorf et al. (2013) and Duarte and Restuccia (2010). Secondly, it gives rise to heterogeneous sectoral log-linear Engel curves that are consistent with the empirical evidence (Aguiar and Bils (2015), Comin et al. (2015)). Finally, the income effects on the

[10] Since we abstract from capital, we do not take into account explicitly the forces of capital deepening analyzed for instance in Acemoglu and Guerrieri (2008) and Sáenz (2016). However, notice that as long as capital income shares are constant across sectors our main results are not altered since the model collapses back to a labor-theory of structural transformation. The reason is that the measure of sectoral labor productivity is going to carry on the effect of different capital intensities even when they are not explicitly modeled.

[11] There is greater detail in the exposition of other useful features of the nonhomothetic preferences in Comin et al. (2015). In our paper, we highlight the most useful ones for our particular purpose of decomposing extensively the service sector.

relative consumption of sectoral goods and services do not level off as income rises, contrary to structural transformation demand-side theories that rely on Stone-Geary preferences. Hence, it allows the demand channel to have a strong role at later stages of the structural transformation of Europe and the U.S., making it particularly useful in our study of the service economy.

In our model, there are no intertemporal decisions[12]. Aggregate consumption is given by the total labor income available to households. Given total income, households then make a static decision in each period on consumption of sectoral goods given preferences (3) and (4). Hence, the household's full path solution to maximizing their lifetime utility (3) is given by the sequence of the optimum static decisions on sectoral consumption. At each point in time, the intratemporal problem households face is given by

$$\max_{c_i \geq 0} \sum_i \Omega_i^{\frac{1}{\sigma}} C^{\frac{\varepsilon_i}{\sigma}} c_i^{\frac{\sigma-1}{\sigma}}$$

s.t.

$$\sum_i p_i c_i = wL, \tag{5}$$

where p_i is the price of the sectoral good i and w is the wage per hour worked. Given, prices (p_i, w) the aggregate consumption is going to be given as well by $C = \frac{wL}{P(C;\{p_i\}_i^I)}$, where P is the price index associated with the nonhomothetic CES aggregator given in (4). In our model, income and sectoral prices determine the aggregate consumption available to the household. Given the aggregate consumption, households then choose sectoral consumption of all sectors optimally.

Market Clearing

At each date, the market for each sectoral good and service clears

$$c_i = Y_i \qquad \forall i \in I, \tag{6}$$

and the labor market also clears. The demand for labor of all sectoral firms must equal the exogenous supply of labor by households at every point in time:

$$\sum_i^I L_i = L. \tag{7}$$

[12] Comin et al. (2015) show that when the model explicitly incorporates savings, the intertemporal decision is separable from the intratemporal decision. Given this separability, the decisions on sectoral consumption do not affect savings decisions. This justifies taking savings decisions as given in this paper.

3.2 Equilibrium

DEFINITION: *A competitive equilibrium at date t is a set of allocations $\{c_i^*, L_i^*\}_i^I$ and prices $(\{p_i^*\}_i^I, w^*)$ such that:*

1. *Given prices $(\{p_i^*\}_i^I, w^*)$, household's allocations $\{c_i^*\}_i^I$ solve the household's problem in (5);*

2. *Given prices $(\{p_i^*\}_i^I, w^*)$, firm's allocations $\{L_i^*\}_i^I$ solve the firm's problem in (2);*

3. *Equations (6) and (7) hold: both goods and labor markets clear.*

We let labor be the *numéraire* good and normalize the wage rate w to be one. The firm's optimization problem first order-condition at each date yields the following equation for the price of each sectoral good:

$$p_i = \frac{1}{A_i} \qquad \forall i \in I. \tag{8}$$

The sectoral price is the inverse of sectoral labor productivity just as in Duarte and Restuccia (2010). One can think of factors that affect domestic sectoral prices other than labor productivity. One example that immediately comes to mind is international trade and its influence on domestic prices. The nonhomothetic CES preference structure, by separating the income and substitution effects of structural transformation, allows us to determine how important such an additional force is in explaining the labor reallocation due to price effects only. We show in the quantitative section of this paper that labor productivity alone can explain well most domestic prices and labor reallocation in the economies we study. Hence, we conclude that either labor productivity takes into account most of the effects of other forces such as international trade or that they do not seem to be quantitatively important in explaining the bulk of labor reallocation. This is not necessarily true for non-advanced countries where trade and capital deepening are fundamental in order to address properly their process of structural transformation.[13]

The household's first-order condition associated with the maximization in (5) imply that the intratemporal allocation of sectoral consumption goods satisfies

$$c_i = \Omega_i \left(\frac{p_i}{P}\right)^{-\sigma} C^{\epsilon_i} \qquad \forall i \in I, \tag{9}$$

[13]See Sáenz (2016) for more details on the structural transformation process for late starter countries.

where P is the price index aggregator given by

$$P \equiv \frac{\sum_i^I p_i c_i}{C} = \frac{1}{C}\left[\sum_i^I \Omega_i C^{\epsilon_i - \sigma} p_i^{1-\sigma}\right]^{\frac{1}{1-\sigma}}. \tag{10}$$

The sectoral demand c_i given by equation (9) implies that the elasticity of the relative demand for two different goods with respect to aggregate consumption is $\epsilon_i - \epsilon_j$, and that the elasticity of substitution between goods of different sectors is σ. Note that both of these elasticities are constant. Define $\omega_i \equiv \frac{c_i p_i}{CP}$ as the expenditure share of good i in total expenditure, then:

$$\omega_i = \Omega_i \left(\frac{p_i}{P}\right)^{1-\sigma} C^{\epsilon_i - 1}. \tag{11}$$

Market clearing on the goods market and firm profit maximization imply that $L_i = PC\omega_i$. Hence, the paths of relative sectoral employment shares follow those of relative consumption expenditure share

$$\frac{L_i}{L_j} = \frac{\omega_i}{\omega_j}. \tag{12}$$

The intuition is that if the relative demand for sectoral good i increases, then the firm's relative demand for labor to produce good i will also increase so that supply can meet the rise in demand. If we substitute (11) into (12) we find the labor shares:

$$\frac{L_i}{L} = \frac{\Omega_i C^{\epsilon_i} A_i^{\sigma-1}}{\sum_i \Omega_i C^{\epsilon_i} A_i^{\sigma-1}}. \tag{13}$$

The labor share of sector i is affected by both income effects and substitution effects: as aggregate consumption rises, the labor share of sector i will rise if the income elasticity of demand of good i is higher relative to all other sectors and will fall if the elasticity is small relative to all other sectors; given that the elasticity of substitution $0 < \sigma < 1$[14], when the productivity of good i increases relative to all other goods, the labor share of good i falls. In contrast to Stone-Geary preference models of structural transformation, both effects are separable and are independently driven by different parameters.

3.3 Calibration

We calibrate the model to the U.S. data from 1970 to 2009. The parameter space is given by $\{\Omega_i, \epsilon_i, A_{it}, \sigma\}$ with sectors $i \in I$ and t from 1970 to 2009. Our calibration strategy relies on

[14]We assume that goods are gross complements which is the empirical relevant case. Our empirical estimates support gross complementarity as did the estimates in Comin et al. (2015)

two distinct steps. The first one, inspired by Comin et al. (2015), is to estimate (ϵ_i, σ) with the intratemporal decision model moment using cross-country variation. Given (ϵ_i, σ), the second step is to first normalize A_i for all sectors in the initial period, 1970, to one, secondly use the growth rates of sectoral labor productivity of the U.S. data to get the entire path of A_{it}, and finally pick Ω_i of each sector to match its labor share in the U.S in 1970.

For our first step, we use the labor share equation (13), choose manufacturing as the reference sector, and take the logarithm on both sides to find the following model moment:

$$\log\left(\frac{L^c_{i,t}}{L^c_{m,t}}\right) = \zeta^c_{im} + (1-\sigma)\log\left(\frac{A_{mt}}{A_{it}}\right) + (\epsilon_i - \epsilon_m)\log C^c_t + \nu^c_{im,t} \quad \forall i \in I \setminus \{man\} \tag{14}$$

where i denotes a sector with the exception of manufacturing in country c and time t. We allow for country fixed-effects ζ^c_{im}, and $\nu^c_{im,t}$ are the error terms. Note that there are two cross-equation restrictions. The price elasticity is the same across countries and sectors, and income elasticities are the same across countries for a given sector. The difference between our moment condition and the one used in Comin et al. (2015) is that we replace sectoral prices with the inverse of sectoral labor productivity. We explore this difference by estimating the model moment with prices and show that the labor productivity alone is able to explain accurately the labor reallocation that took place in our sample of countries between 1970 and 2009.

Our identification strategy is to use within country-sector time variation to identify the income and price elasticities. We estimate the panel of each sector using the World KLEMS data on sectoral labor shares in terms of total hours worked, sectoral labor productivity in terms of value added per hour worked and real GDP of 8 European countries and the U.S. from 1970 to 2009. An interesting feature of this moment condition is that we only need the ratio of the labor productivity of each sector relative to manufacturing in each country. Hence, only having data on labor productivity in local currency does not create an impediment to the empirical estimation.

We estimate (14) jointly imposing the cross-equation restrictions that price and income elasticities have to be the same across countries. Table 3 reports our estimates for our sample from 1970 to 2009 of 9 countries: the U.S., Austria, Belgium, France, Germany, Great Britain, Italy, Spain, and the Netherlands. Our estimate of the price elasticity of substitution across sectors, 0.43, is smaller than the one reported in Comin et al. (2015) of 0.84 for the OECD countries and 10-sector regression. The main difference in magnitude comes from the fact that we use sectoral labor productivity only instead of sectoral prices. When we run the same regression with prices instead of labor productivity, we find an elasticity of 0.88 which is in the close neighborhood of the one found in Comin et al. (2015). The different estimate's magnitudes do not seem to change the quality of the model fit as we get very similar fits of the sectoral labor shares. Hence, the within country-sector dynamics of sectoral labor productivity captures most of the sectoral prices dynamics.

Table 3: Elasticities Estimates

Sector	Parameter	Estimates
	σ	0.43***
		(0.12)
Agriculture	$\epsilon_{agr} - \epsilon_{man}$	-0.28***
		(0.11)
Wholesale and Trade	$\epsilon_{trd} - \epsilon_{man}$	0.46***
		(0.11)
Restaurants and Hotels	$\epsilon_{rst} - \epsilon_{man}$	0.40**
		(0.17)
Transportation	$\epsilon_{trs} - \epsilon_{man}$	0.54***
		(0.10)
Comunication	$\epsilon_{com} - \epsilon_{man}$	0.89***
		(0.18)
Finance	$\epsilon_{fin} - \epsilon_{man}$	0.66***
		(0.13)
Real Estate	$\epsilon_{res} - \epsilon_{man}$	0.91***
		(0.19)
Business Services	$\epsilon_{bss} - \epsilon_{man}$	1.53***
		(0.16)
Government	$\epsilon_{gov} - \epsilon_{man}$	0.13
		(0.09)
Education	$\epsilon_{edu} - \epsilon_{man}$	0.36***
		(0.11)
Health	$\epsilon_{hlt} - \epsilon_{man}$	0.70***
		(0.17)
Personal	$\epsilon_{per} - \epsilon_{man}$	0.51***
		(0.20)
	R^2	0.95
	Fixed Effects	Y
	Observations	360

Notes: Estimation based on World KLEMS data for Austria, Belgium, France, Germany, Italy, the Netherlands, Spain, Great Britain, and the United States. Standard errors clustered by country in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The sector with the highest difference in income elasticity to manufacturing is business services, and the sector with the lowest difference is agriculture. These results imply that as income rises, labor is heavily allocated towards business services and away from agriculture. Besides government, all estimates are statistically significant at the 95% confidence level. The government sector has the same income elasticity as manufacturing because its estimate is not being statistically different from zero.

Now that we have estimated the elasticities, the second step objective in the calibration is to pin down Ω_i by matching the initial labor shares of sectors for the U.S. economy in 1970. We normalize $A_i = 1$ for all sectors for the initial period in the sample. The entire sequence for the sectoral labor productivity will be given by using the observed growth rate of that productivity into the initial normalized level. We do the same for the entire path of aggregate output by using the observed growth rate of real output into the normalized initial level. Given these normalizations, we can use the labor share equation (13) to get:

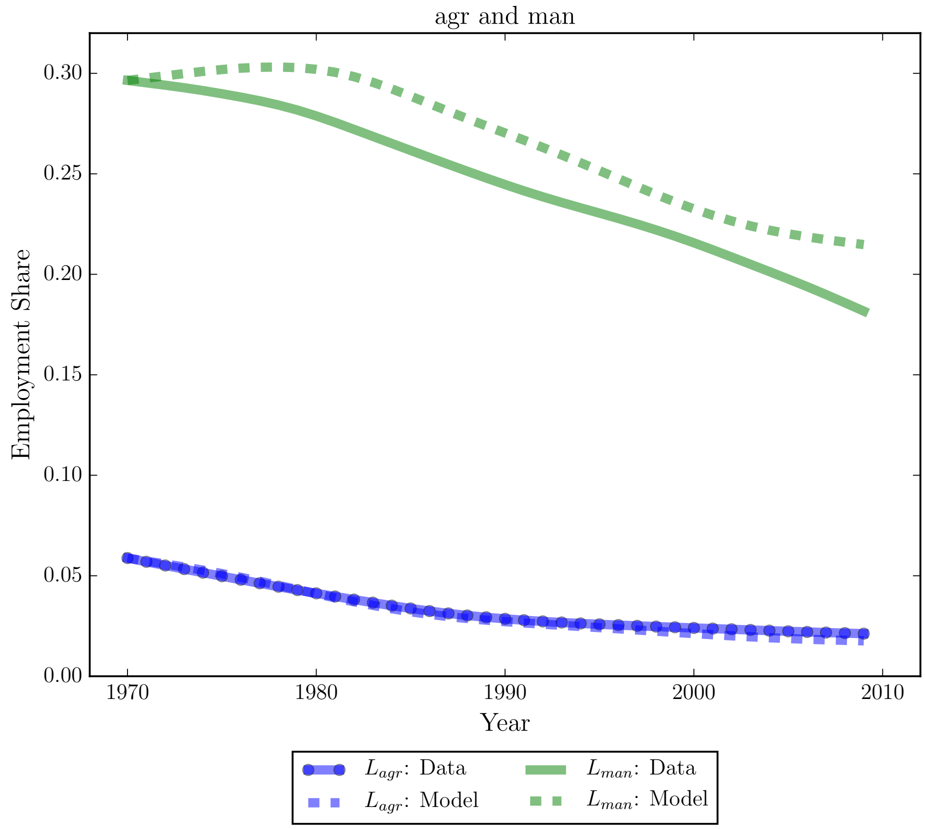
$$\frac{L_i}{L} = \frac{\Omega_i}{\sum_i \Omega_i} \tag{15}$$

In addition, recall that $\sum_i \Omega_i = 1$. Since there is a degree of freedom of scale, we get that the sectoral constants will be pinned down by the sectoral labor shares of the U.S. in 1970:

$$\Omega_i = \frac{L_{i,1970}^{US}}{L_{1970}^{US}} \qquad \forall i \in I$$

We feed the paths of sectoral labor productivity $\{\{A_{it}\}_i^I\}_{t=1970}^{2009}$ and aggregate output $\{C_t\}_{t=1970}^{2009}$ to the calibrated model economy and simulate the model. We show the simulated labor shares for all sectors in the U.S. and how they compare against the U.S. data in Figure 4. The data on sectoral labor shares is represented by solid lines while the model implied sectoral labor shares are shown in dashed lines. The equilibrium allocation of hours across all sectors in the model closely matches the process of structural transformation in the United States during the calibrated period, with the exception of whole sale and retail (trd) and government (gov). The model failure in matching the labor share in the government (gov) is expected since market forces of structural transformation are arguably less stronger to predict some kinds of public spending such as military expenditure. Perhaps more surprisingly, the model does not fair well in matching the labor shares of wholesale and retail (trd). The reason behind this fact is two folded: the income elasticity estimate is relatively small, 0.46, and there were during the sample period strong relative gains of labor productivity in this sector. Hence, either international trade played a more important role in the determination of sectoral prices of wholesale and retail, or the U.S. has higher income elasticity than the international cross-country experience seems to imply, or a combination of both. We argue that the higher income elasticity is the most relevant factor given that the model is able to match well the labor share of trd for the European countries.

Figure 3: Share of Hours by Sector of the Calibrated Model vs. U.S. Data: Non-Service Sectors

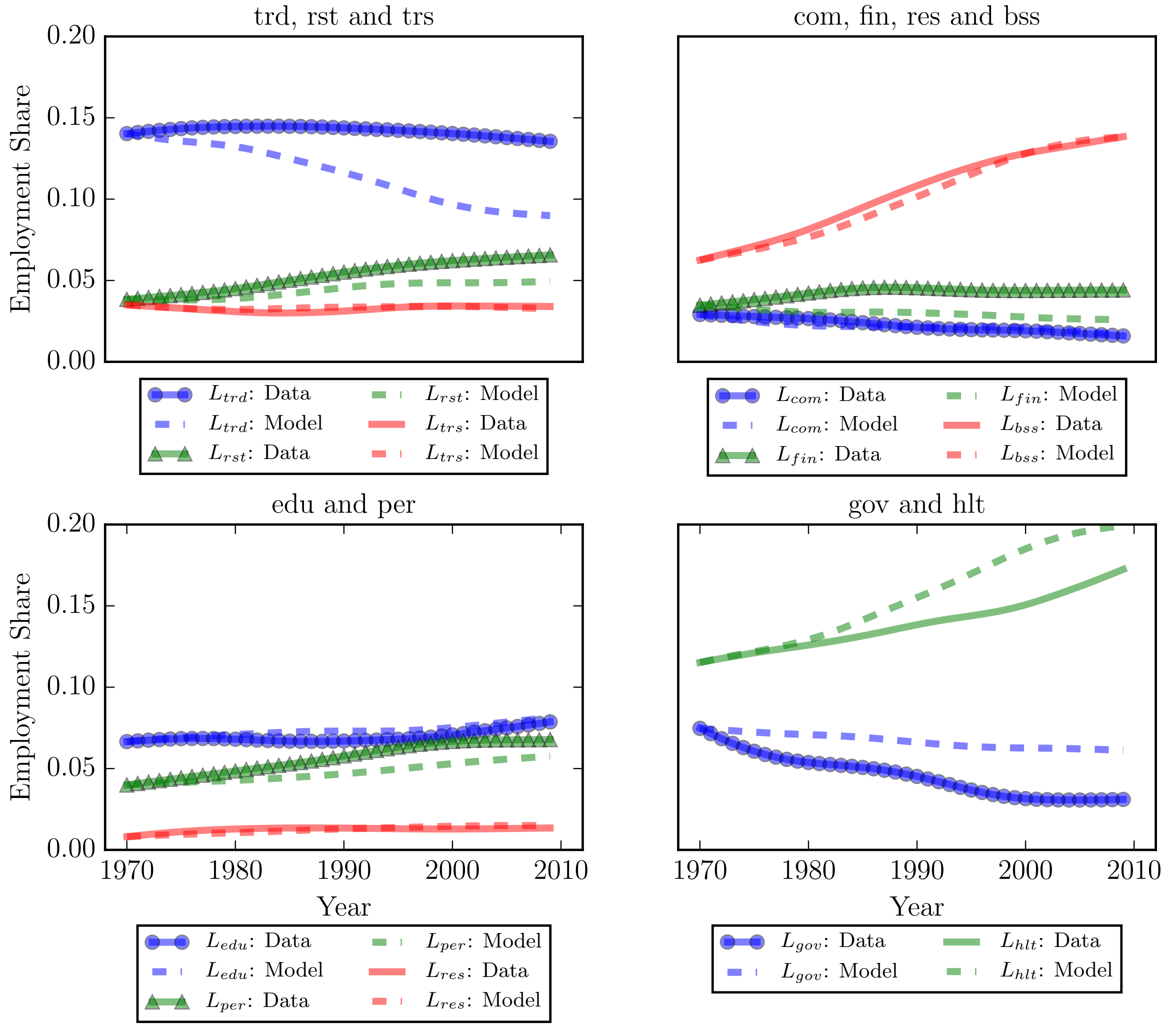


In any event, the calibrated model fit is remarkable given the high number of sectors and the discipline in picking the model parameters. For instance, the model successfully captures the significant increase in the business services and health labor shares. We discipline our model by picking the same preferences parameters for all countries in our sample. Moreover, we pick parameters to match the initial period only. Hence, all the sectoral labor shares trends are captured by the structural transformation forces within the model.

4 Quantitative Analysis

In this section, we use the calibrated model to study the structural transformation of services in European countries and how they compare to the U.S. First, we use the model as a measurement device to measure internationally comparable levels of sectoral labor productivity for all the 13 sectors. Second, we feed the relative sectoral labor productivity and relative

Figure 4: Share of Hours by Sector of the Calibrated Model vs. U.S. Data: Service Sectors



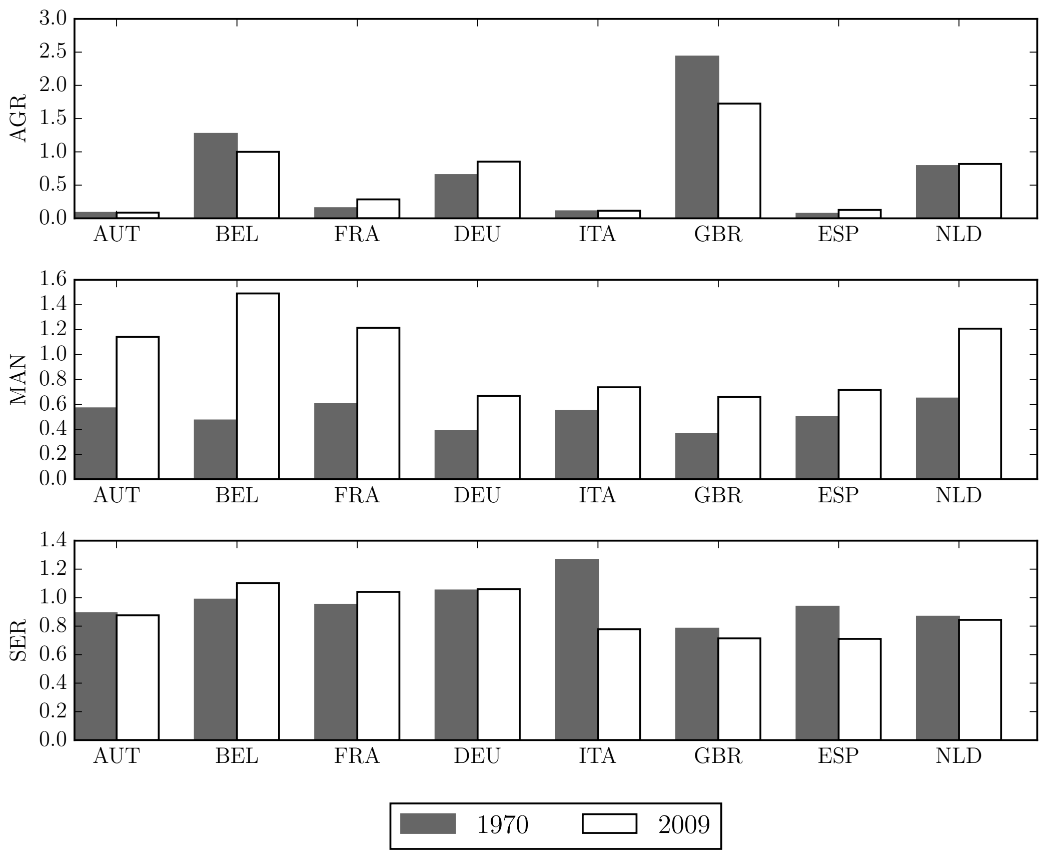
GDP of each country to the model to simulate the structural transformation of each European country. Finally, we perform a set of counterfactual exercises that allow us to identify which particular types of services were more accountable for the drag in labor productivity growth in Europe.

4.1 Measurement of Sectoral Labor Productivity

We use the calibrated model as a measuring device to measure internationally comparable labor productivity levels at the ISIC Rev. 3 one digit industry level. The model is used as an accounting tool that allows overcoming the lack of sectoral PPP-adjusted value added data. We measure the labor productivity levels for 13 sectors of the 8 European countries in our sample. We start by using the calibrated parameters to back out initial levels of sectoral labor productivity that match the model predictions to 1) labor shares of each sector in 1970 and 2) aggregate labor productivity relative to that of the United States in 1970. Then, having initial sectoral productivity for all sectors, we use the World KLEMS growth rates of labor productivity to get the levels of labor productivity for the entire period. The World KLEMS productivity measures are denominated in local currency. We compute yearly changes of labor productivity, which are then employed with the initial productivity levels to construct comparable time series of labor productivity. Since the latter are outputs of the same calibrated model, the series we obtain are perfectly comparable across countries, without the risk of mismeasurement due to exchange rates or PPP adjustments.

In Figures 5-6 we plot the first and last period level of labor productivity for each sector across countries relative to that of the United States. Figure 5 shows that European

Figure 5: Relative Labor Productivity Across Sectors



Notes: Model implied sectoral labor productivity for the first and last year, relative to the level of the United States.

countries caught up with the U.S. from 1970 to 2009 in manufacturing productivity, while they stagnated or even diverged in the productivity of service sector. A similar pattern of relative productivity is also evidenced in Duarte and Restuccia (2010). Within services, the European countries are in generally more productive than the U.S. in telecommunications, education, and health and social work. However, the European countries are less productive in wholesale and retail trade and business services, with a relative labor productivity in 1970 averaging approximately 0.5 and 0.6[15], respectively. Also, their relative labor productivity fell from 1970 to 2009. Notice that the employment shares of these two sectors have been relatively large in the years of our study. Hence, we should expect that the levels of labor productivity in trade and business services have mattered a great deal in determining the relative aggregate labor productivity of Europe. Later in the paper, we will show how our counterfactual exercises confirm this view.

It is interesting to note that health and social work is much less productive in the U.S. than in Europe. Moreover, its labor productivity grew at a slower pace in the former than in the latter. For instance, we found Italy, Spain, and Germany to be four times as productive as the U.S. in this sector. In fact, in Germany, this gap widened even further to five times as productive by 2009. The labor productivity implied by the model in this sector is a source of major concern for the U.S. as it employed approximately 17% of the total of hours of work in 2009.

Nevertheless, the finding that Europe is more productive than the U.S. in education and health and social work should be taken with some caution. While in the U.S. both education and health are services mainly provided by the private sector, in most European countries education and health systems are managed by the government, and the labor hired in these two sub-sectors qualifies as public employment. Productivity in the public sector is measured with a cost-based approach, which differs from the methodology applied to the private sector. This fact raises concerns on the extent of comparability of sectoral productivity in eduction and health between Europe and the U.S., even though we use our model to correct potential measurement biases in the available data.

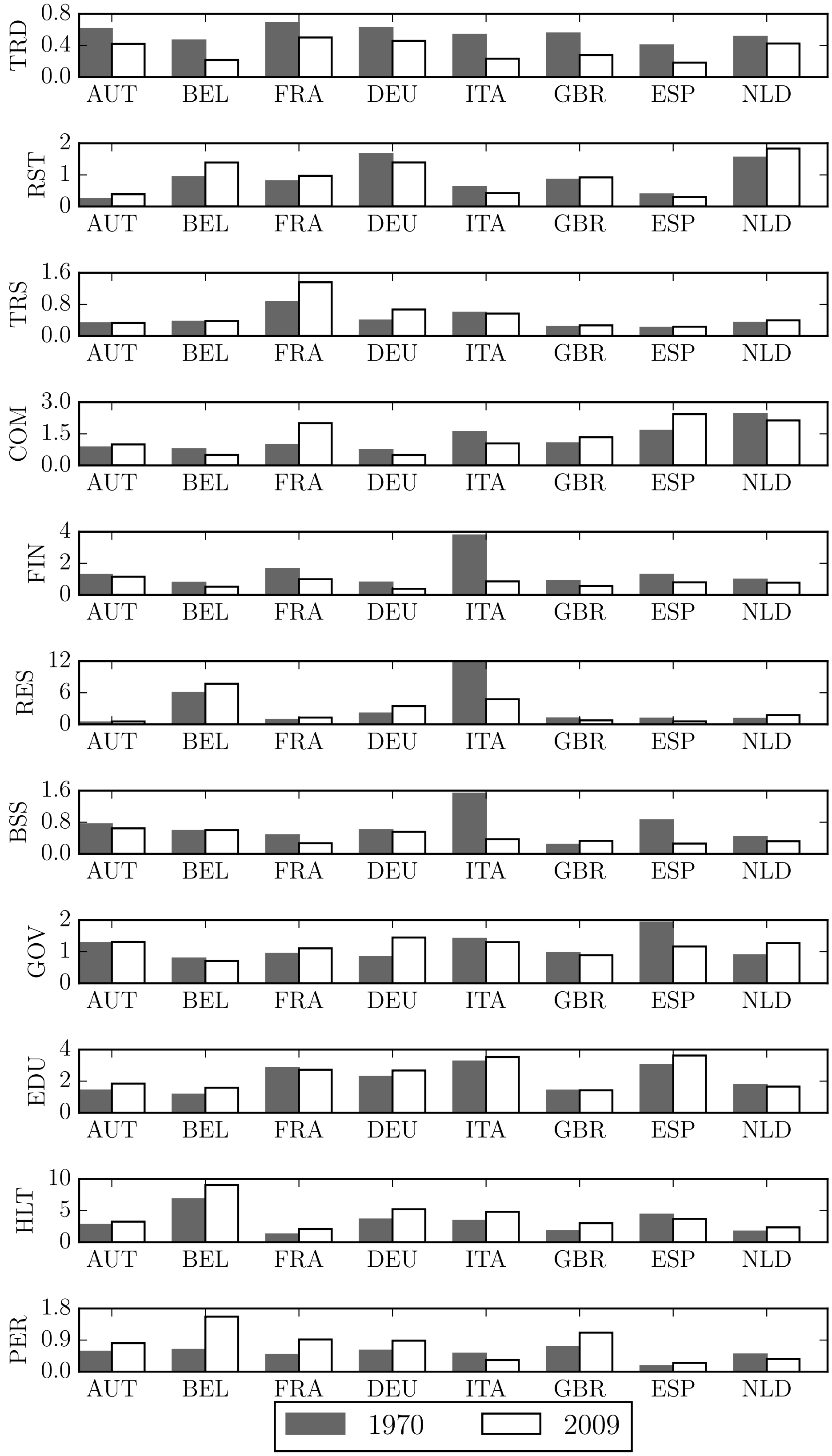
4.2 Structural Transformation of the Service Sector in Europe

Given the exogenous paths for sectoral labor productivity, the model delivers the allocation of labor hours and output across sectors. Also, aggregate labor productivity for each country can be computed as an average of sectoral productivity levels, weighted by the labor shares of each sector. At this stage, we evaluate the model's ability to replicate the data by comparing its predictions on the allocation of hours and aggregate productivity with the available data.

The model is quantitatively successful in accounting for the structural transformation

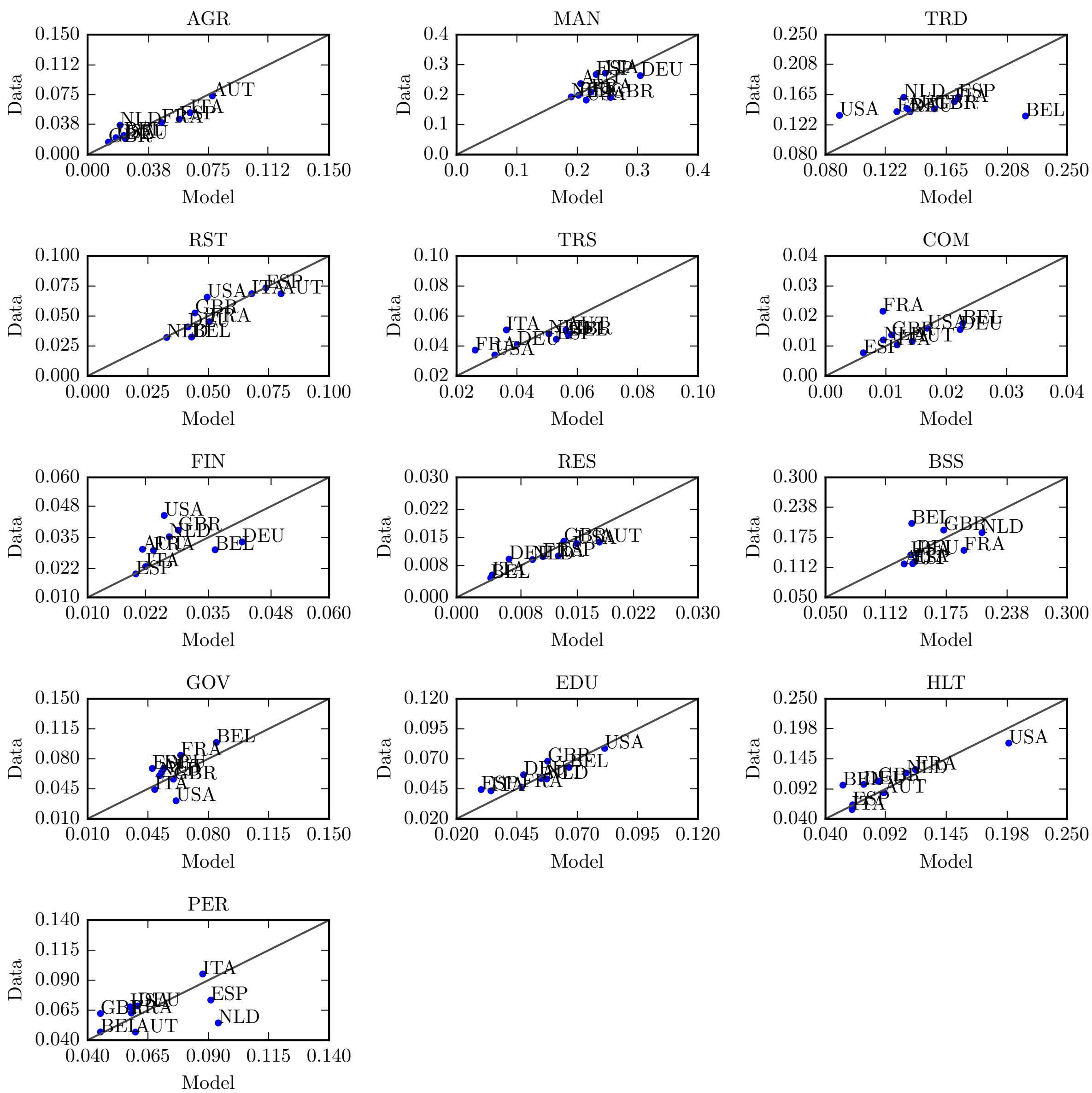
[15] We use the U.S. as reference. Hence, a 0.6 value for a particular country-sector means that the productivity level is 60% of that of the U.S.

Figure 6: Relative Labor Productivity across Service Sub-Sectors



in all the countries of our sample accurately. This result confirms the ability of the non-homothetic CES preference structure in accounting for labor reallocation across sectors, as discussed in Comin et al. (2015). In Figure 7 we plot how the model implied labor shares compare to the data in the last period. These figures show that, overall, the model predictions are in line with the observed labor shares, with the exceptions of wholesale and retail trade for the U.S. and Belgium, and personal services for the Netherlands. In Figures 27 to 34,

Figure 7: Shares of Hours in the last year - Data vs. Model

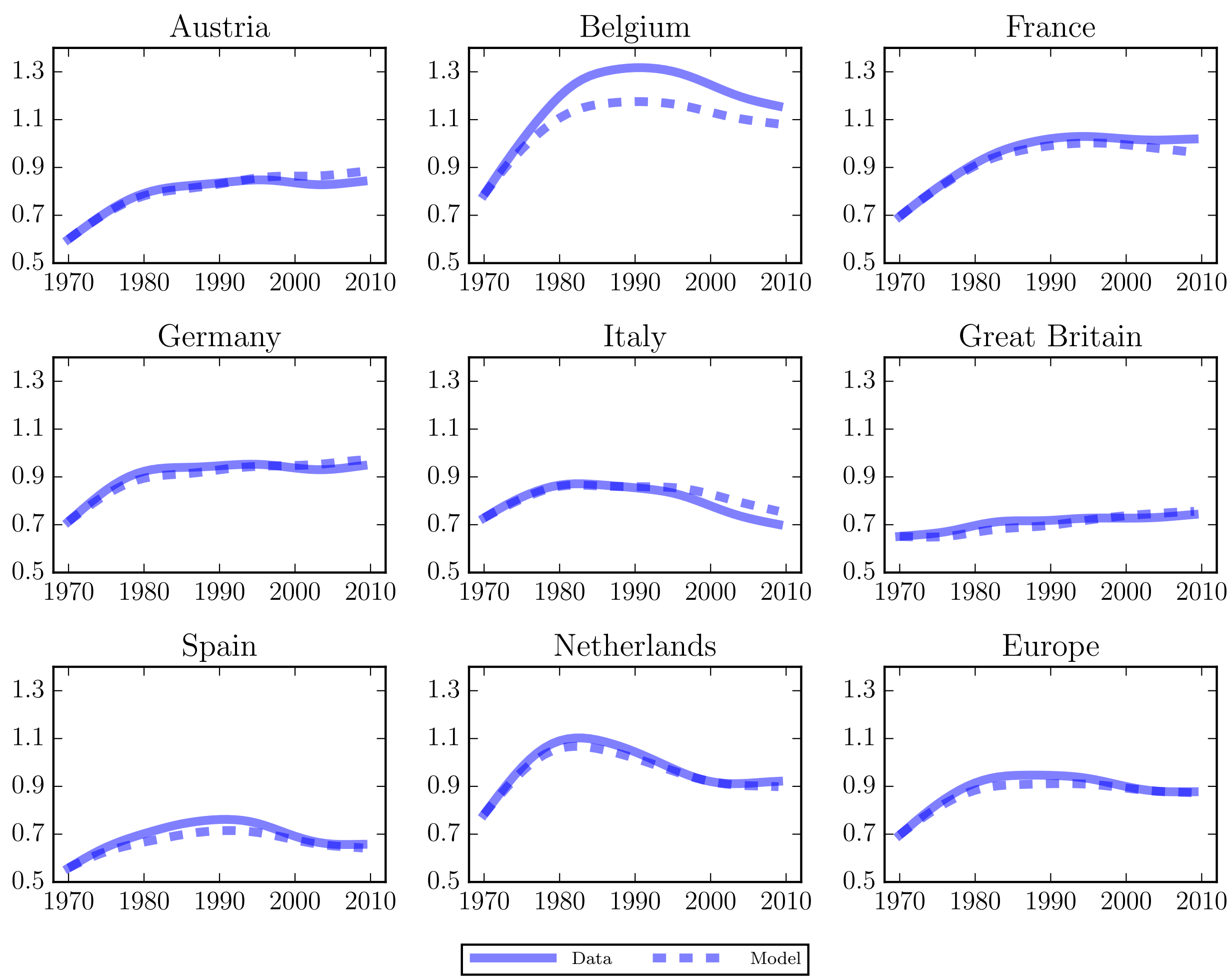


Notes: Sectoral employment shares as observed in the data (vertical axis) and implied by the model (horizontal axis) for 2009. The 45-degree line is included in each plot.

we illustrate the entire path of implied labor shares for all countries and sectors, and how they compare to the data. The model predictions are remarkably sharp, confirming the quantitative strength of our theoretical setup.

Since the sectoral productivity growth rates fed into the model come directly from the data, if the model captures the labor shares well, then the implied aggregate labor productivity is going to be similar to the one observed in the data. In Figure 8 we show that this is precisely the case. The strikingly good replication of the relative aggregate productivity

Figure 8: Relative Aggregate Labor Productivity - Data vs. Model



Notes: Aggregate labor productivity is the average of each sector's productivity level, weighted by its employment share. Employment shares are either from the data (solid lines) or implied by the model (dashed lines). Europe's aggregate productivity is the average of the eight European countries' aggregate productivity, weighted by their national GDP.

is another testament to the model's ability to capture the structural transformation process of the European countries. Interestingly, the model accounts well for it regardless of the peculiar shape of the path of aggregate productivity. For instance, the model predicts very precisely the cases of divergence as well as those of stagnation. From these findings, we are convinced that the sharpness in the prediction of our model does not fade away when we increase the degree of sector disaggregation by opening up the service sector. This result is reassuring that our theoretical framework is quantitatively valid, and supports the credibility of the exercises we expose hereafter.

4.3 Counterfactual Exercises: Keeping the Pace, Taking Off, and Catching Up with the U.S.

We will now discuss the results of some counterfactual exercises, through which we aim to identify the sectors quantitatively responsible for the fall of the European labor productivity behind the U.S.. We perform three distinct exercises that try to answer the question of how different would aggregate labor productivity be if each country had experienced an alternative growth rate in the labor productivity of some sector.

In the first counterfactual exercise, we simulate the relative aggregate labor productivity of Europe assuming that the European countries kept the pace with U.S. sectoral productivity growth during the entire period of our study, from 1970 to 2009. Table 4 shows the percentage difference in aggregate labor productivity in 2009 between the alternative scenario and the benchmark case. The exercise is carried over by applying the counterfactual hypothesis to each sector at a time. In other words, we assess the change in aggregate labor productivity by having the productivity of only one sector growing at the U.S. rates, while all the other ones keep growing at their actual rates from the data. Each row of Table 4 corresponds to a different sector, and reports the results of the counterfactual on its sectoral productivity. The last two rows are obtained by letting respectively all service sub-sectors and all sectors adopt U.S. sectoral productivity growth. We report the counterfactual results for each country individually and, in the last column, for Europe overall. In this case, we take an average of the aggregate labor productivity of all European countries.

We see that all countries would have a lower aggregate productivity in 2009 if they grew at the U.S. pace in labor productivity of manufacturing. This result suggests that the European manufacturing sector had productivity gains larger than those in the U.S., and confirms the importance that manufacturing had during the period of convergence in aggregate labor productivity between European countries and the United States.

Within services, the three sectors that have the highest impact in aggregate labor productivity are wholesale and retail trade, business services, and finance. The aggregate labor

Table 4: Counterfactual #1 - Keeping the U.S. Pace - % Change in the 2009 Aggregate Labor Productivity

	AUT	BEL	FRA	DEU	ITA	GBR	ESP	NLD	Europe
Counterfactual:									
(1) $g_i = g_i^{USA}$									
`agr`	-0.2	0.9	-2.8	-1.0	-0.4	1.7	-3.0	-0.1	-0.6
`man`	-14.6	-23.7	-15.6	-13.5	-6.8	-13.4	-8.0	-12.3	-13.5
`trd`	5.1	12.3	4.2	4.2	12.0	9.6	11.1	2.4	7.6
`rst`	-2.7	-1.6	-0.8	0.6	1.7	-0.3	1.2	-0.6	-0.3
`trs`	-0.1	-0.2	-1.5	-2.1	0.1	-0.7	-0.5	-0.7	-0.7
`com`	-0.6	1.5	-2.9	1.4	1.7	-1.0	-1.9	0.7	-0.1
`fin`	0.4	1.4	1.9	2.7	6.0	1.6	1.7	0.8	2.1
`res`	-0.5	-0.3	-0.4	-0.5	1.0	0.4	0.6	-0.5	0.0
`bss`	1.7	-0.4	7.2	0.9	14.5	-4.6	11.8	4.5	4.4
`gov`	-0.1	0.7	-1.1	-3.4	0.5	0.5	3.0	-2.0	-0.3
`edu`	-1.6	-2.0	0.2	-1.0	-0.5	-0.1	-1.1	0.3	-0.7
`hlt`	-2.1	-3.6	-6.5	-4.6	-4.1	-6.4	2.0	-4.1	-3.7
`per`	-1.7	-4.1	-3.2	-1.9	2.4	-1.9	-2.8	1.8	-1.4
(2) $g_i = g_i^{USA}$ in services	-2.6	2.6	-3.6	-3.8	40.3	-3.6	26.8	2.3	7.3
(3) $g_i = g_i^{USA} \quad \forall i$	-16.8	-21.3	-20.9	-17.5	29.4	-14.9	12.5	-10.6	-7.5

Notes: We simulate the economy in each European country by feeding the U.S. growth rate in sectoral labor productivity for the entire periods to each European country. We compute what would be their aggregate labor productivity by 2009 under this scenario and show in the table the percentage difference to the benchmark case.

productivity of every country and Europe overall in 2009 would be noticeably larger if the productivity in these sectors grew in Europe as much as in the United States. It also turns out that adopting the U.S. pace in health and social work would make aggregate productivity worse with the only exception of Spain. The other types of services individually do not seem to give quantitatively significant differences in aggregate labor productivity. However, when services are considered in combination, as for the counterfactual exercise whose results are reported in the next to the last row, they seem to make a big difference for countries that experienced a divergence in relative aggregate labor productivity. Spain and Italy both would have tremendously benefited if they had the U.S. growth rates in labor productivity in all services. Spain would have had increased its aggregate labor productivity by 26.6% while Italy would have increased it by 40.3%. These significant effects lead to an increase in aggregate productivity for Europe overall, had all the countries experienced U.S. growth in

Table 5: Counterfactual #2 - Taking off with the U.S. in 1990 - % Change in the 2009 Aggregate Labor Productivity

	AUT	BEL	FRA	DEU	ITA	GBR	ESP	NLD	Europe
Counterfactual:									
(1) $g_i = g_i^{USA}$									
`agr`	-0.7	1.0	-1.3	-1.3	-0.5	-0.3	-0.4	0.3	-0.4
`man`	-3.4	-2.4	-1.6	-2.3	4.9	-2.8	3.8	1.0	-0.3
`trd`	4.7	8.3	4.5	2.9	6.9	3.6	5.4	2.2	4.8
`rst`	-0.3	-0.2	0.2	0.6	0.5	-0.7	1.6	0.5	0.3
`trs`	0.9	0.3	-0.1	-1.1	0.1	-0.2	1.4	-0.3	0.1
`com`	-0.4	1.0	-1.6	-0.1	-1.3	-2.6	-0.8	-1.8	-1.0
`fin`	-0.6	-0.8	0.9	2.0	0.5	-0.7	0.2	0.6	0.3
`res`	0.2	0.7	0.0	0.0	0.6	0.5	1.3	0.3	0.5
`bss`	1.3	3.7	4.8	4.7	6.6	-1.3	6.9	4.8	3.9
`gov`	0.1	0.2	-0.6	-0.9	-1.2	-0.8	-0.4	-0.5	-0.5
`edu`	-0.4	0.6	0.5	0.1	0.1	0.4	-1.5	1.2	0.1
`hlt`	-1.0	-1.1	-1.2	-3.6	-0.8	-4.1	0.2	-0.2	-1.5
`per`	-0.9	-1.1	-1.4	-0.6	0.8	-1.0	-0.7	-0.7	-0.7
(2) $g_i = g_i^{USA}$ in services	3.5	12.0	5.9	3.9	13.2	-6.8	14.5	6.2	6.5
(3) $g_i = g_i^{USA} \quad \forall i$	-0.7	10.4	2.8	0.1	18.4	-9.7	18.5	7.6	5.9

Notes: We simulate the economy in each European country by feeding the U.S. growth rate in sectoral labor productivity since 1990 to each European country. We compute what would be their aggregate labor productivity by 2009 under this scenario and show in the table the percentage difference to the benchmark case.

labor productivity of every type of service.

In the second counterfactual exercise, we focus on the take-off of the U.S. and slowdown of Europe in the period after 1990. We simulate the model assuming that after 1990 the European countries followed the U.S. take-off. Table 5 presents the results of this exercise. Each sector at a time (or a set of them, in the last two rows) is assumed to grow in labor productivity at the same rate of its U.S. counterpart after 1990. We notice that the large aggregate productivity gains from keeping the U.S. pace in wholesale and retail trade and business services, observed in the first counterfactual, also emerge in this exercise. The same goes for the case in which the U.S. growth in aggregate service productivity is followed: adopting it for the entire period or only for the years after 1990 have a similar implication. This evidence leads us to conclude that most of the effects we saw for the entire period are coming from changes that took place after 1990. There are some exceptions across

Table 6: Counterfactual #3 - Catching Up with the U.S. - % Change in the 2009 Aggregate Labor Productivity

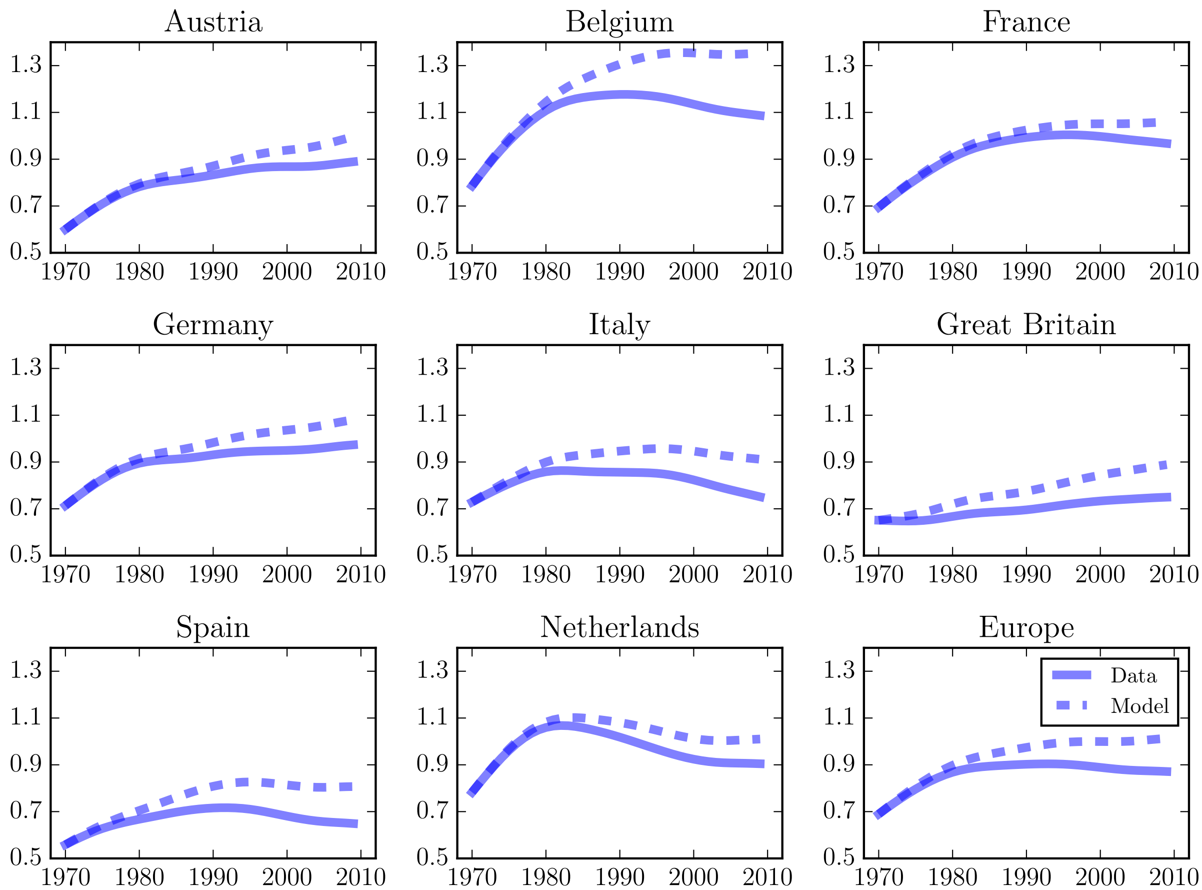
	AUT	BEL	FRA	DEU	ITA	GBR	ESP	NLD	Europe
Counterfactual:									
(1) Catch-up in `trd`	12.1	24.5	9.5	11.0	21.4	18.6	24.4	11.7	16.6
(2) Catch-up in `bss`	4.5	5.1	15.5	6.5	11.0	14.3	12.4	16.0	10.7
(2) Catch-up in `fin`	-0.6	2.3	0.0	3.6	0.6	2.1	0.7	0.9	1.2

Notes: We simulate the economy in each European country by finding what would be the annualized growth rate in each key service sector that would allow them to fully catch-up with the U.S in that particular sector by 2009. We feed this alternative service sectoral labor productivity growth rate to the model. We compute what would be their aggregate labor productivity by 2009 under this scenario and show in the table the percentage difference to the benchmark case.

countries. For Great Britain, adopting the U.S. rates in trade or business services after 1990 is deleterious, while the adoption of the entire period appears beneficial in Table 4. It seems that Great Britain took off even more than the U.S. in these two sectors specifically. On the other hand, the differences in aggregate productivity in 2009 for Spain and Italy under the second counterfactual for the cases of trade, business services, and services overall are much smaller than those of the corresponding exercises in the first counterfactual. Hence, for these two countries, we cannot say that most of the productivity gap opened up after 1990: they would have benefited from the U.S. pace for the entire period. The last remark is about finance. While this type of service is identified as an important source of productivity difference over the entire period, it does not seem to matter much in the years after 1990. In conclusion, during the period of the falling behind the two sectors in which the widening of the productivity gap is the most clearly visible are wholesale trade and retail and business services. This result begs the question: what were the factors that prevented Europe from taking-off, specifically in these sectors? We explore such factors in the next section.

Finally, we focus on the services that we have identified as the most responsible for the drag in relative aggregate labor productivity of Europe. In this final counterfactual exercise, we consider three cases in which European countries would fully catch up with the U.S. by 2009 in wholesale and retail trade, finance, and business services, respectively. The model is simulated having the productivity of each of these sectors at a time growing at the annualized average rate that would make it as productive as in the U.S. in 2009. We measure the difference in aggregate labor productivity in 2009 implied by each complete catch-up with respect to the benchmark case. Table 6 shows these findings. The results are

Figure 9: The Importance of Wholesale and Retail Trade

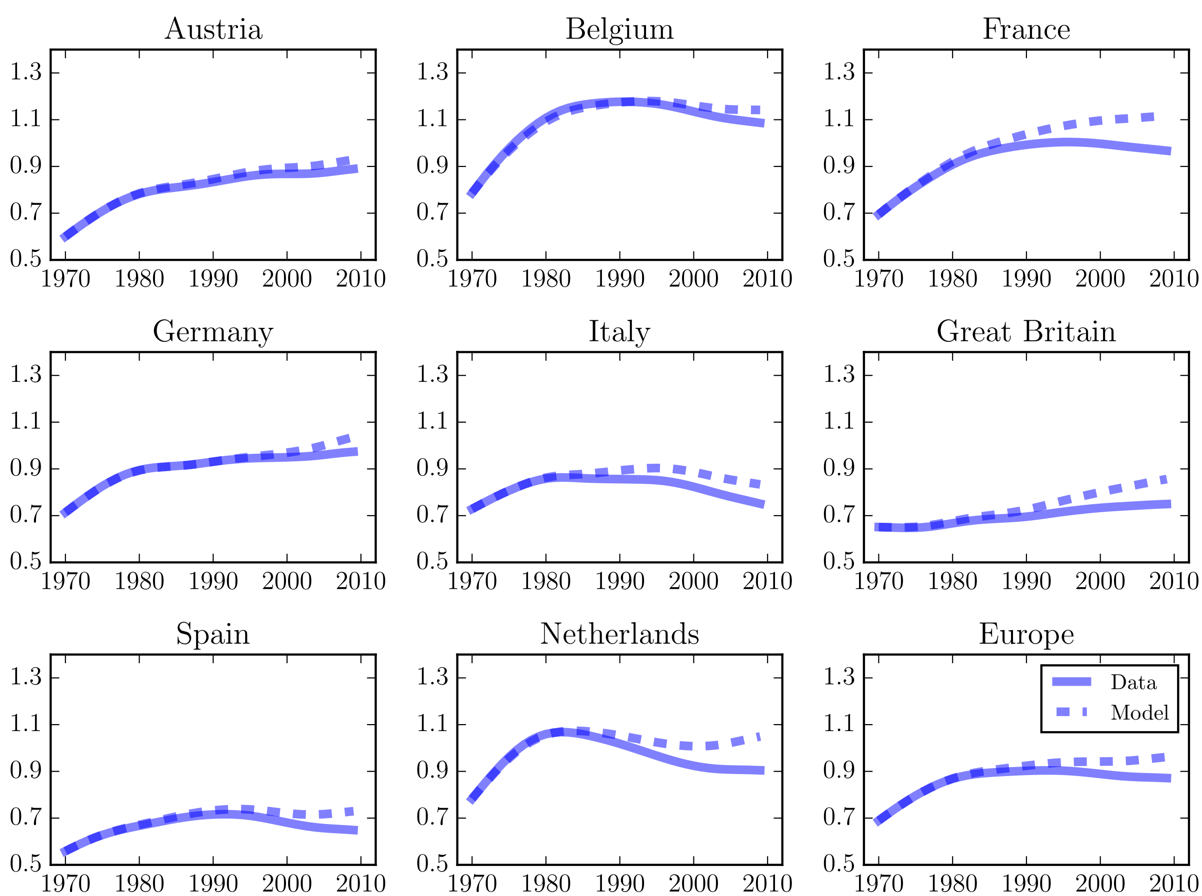


Notes: Relative Aggregate Labor Productivity cross countries, data vs. model under the Full Catch-Up in TRD Counterfactual.

large in magnitude, especially for the case of wholesale and retail trade: a full catch-up in this sector would increase aggregate labor productivity by 16.6% on average in Europe, with countries like Spain and Belgium increasing by 24.4% and 24.5%, respectively. With a full catch-up in business services the average increase would be 10.7%. In the case of finance, the full catch-up generates an increase in aggregate productivity, but its magnitude is not as large as in the other cases. This could reflect the fact that the employment share of finance has always been considerably smaller than those of trade and business services, and the fact that in 1970 labor productivity of the European financial sector was not that distant from the U.S. one already.

Figures 9 and 10 illustrate how the catch-up in wholesale and retail trade and business services alone would change the path of labor productivity in each country and Europe overall. It is interesting to note that a full catch-up in either of these two sectors would have been sufficient for the convergence process in Europe to continue, as opposed to the reversal to divergence that we actually observe. If there had been a catch-up in both sectors, the effect on aggregate labor productivity would have been even stronger. It is important to understand exactly which forces prevented the catch-up in these two sectors, while it took place in other sectors, such as manufacturing. While in the next section we will address factors that might explain productivity differences across sectors and countries, we leave the task of giving a conclusive answer to these relevant questions for future research.

Figure 10: The Importance of Business Services



Notes: Relative Aggregate Labor Productivity across countries, data vs. model under the Full Catch-Up in BSS Counterfactual.

5 Cross-Country and Cross-Sector Empirical Exploration of Labor Productivity Differences in Services

In this section we use a panel of model implied sectoral productivity levels to conduct an empirical exploration of which factors are associated with productivity differences across countries and sectors. In the quantitative exercise, we used the model as a measuring device for sectoral productivity levels in Europe. The output of this procedure is a set of model implied productivity levels of the thirteen sectors considered, for the United States and the eight European countries of our study, spanning all the years from 1970 to 2009. The main advantage of these productivity measures is that of being perfectly cross-country comparable because they are outputs of the same model. Issues related to the use of exchange rate and the PPP adjustment are absent in these data.

The factors we consider are intended to capture differences among countries concerning their institutional and policy environment (for instance, the level of taxation and extent and quality of market regulation), the degree of penetration of information and communication technologies, and attitude toward innovation. The sources of all the indicators used are detailed in the data appendix. When data availability consents it, we exploit the panel structure: identification will come not only from cross-country differences but also from time variation.

Interestingly, the disaggregated nature of our data permits us to detect whether a given country-specific characteristic affects the various sectors differently. In other words, within country variation across sectors is another source of identification. The estimation strategies we use are cross-section least squares regression and panel regression with country and year effects. The intent of our analysis is not to shed conclusive light on the empirical determinants of productivity, nor do we claim that our coefficient estimates can have a causal interpretation. Rather, the empirical results we discuss in this section should be merely taken as insightful findings on correlations between productivity levels and country-specific characteristics. We think these results can be informative and instruct further research.

Table 7 collects the coefficient estimates of all the factors considered. Each column regards a specific sector. We explore how differences in taxation, regulation, and technology between European countries and the U.S. can be correlated with differences in sectoral labor productivity. From the empirical results, it is clear that variation in sectoral productivity is correlated with variation among countries (and along years) in the level of taxation, quality of regulation, diffusion of ICT, and propensity to innovate. However, we also see that there is a great amount of difference in how each sector is associated with a given factor. Looking at the entire set of indicators, the two sectoral productivity levels that are more responsive

Table 7: Empirical Estimates

	trd	trs	rst	com	fin	res
			A. Taxation			
Consumption Tax	-3.7110	0.5778	-1.2347**	-9.1565	-6.2396**	-19.6107*
	(2.6230)	(1.0180)	(0.5237)	(15.3199)	(2.4045)	(9.6821)
Capital Income Tax	-3.7852**	-2.9760**	0.7801	15.9525	-1.9996	-7.0426
	(1.2959)	(0.9521)	(0.7509)	(11.8085)	(2.7166)	(6.5103)
Labor Income Tax	1.7374	4.4721	-0.2140	-3.1662	-1.3259	-9.9822
	(1.3221)	(2.7189)	(0.4308)	(18.4727)	(2.3391)	(12.4805)
			B. Regulation			
Rule of Law	0.0109***	0.0092	0.0068	-0.0033	0.0024	0.0104
	(0.0022)	(0.0051)	(0.0040)	(0.0145)	(0.0087)	(0.0076)
Government Size	0.0089**	0.0025	0.0011	0.0030	0.0021	-0.0016
	(0.0027)	(0.0039)	(0.0040)	(0.0155)	(0.0070)	(0.0104)
Regulatory Efficiency	0.0175*	0.0117	0.0245**	0.0017	0.0195	0.0214
	(0.0087)	(0.0126)	(0.0102)	(0.0326)	(0.0235)	(0.0228)
Open Markets	0.0133*	0.0045	0.0084	0.0172	0.0220	-0.0155*
	(0.0061)	(0.0057)	(0.0081)	(0.0331)	(0.0121)	(0.0080)
			C. Diffusion of ICT			
Internet Users	0.0200***	0.0159**	0.0087	0.0041	-0.0010	0.0161
	(0.0030)	(0.0055)	(0.0062)	(0.0233)	(0.0108)	(0.0127)
Secure Servers	0.0006***	0.0004**	0.0003	0.0002	0.0000	0.0005
	(0.0001)	(0.0002)	(0.0001)	(0.0007)	(0.0003)	(0.0003)
Broadband Subscriptions	0.0385***	0.0374**	0.0128	0.0446	-0.0101	0.0176
	(0.0094)	(0.0153)	(0.0198)	(0.0582)	(0.0245)	(0.0294)
			D. Innovation			
Patents	2.7985**	0.5867	-0.4413	-5.9836	1.0771	2.0425
	(0.9493)	(0.3474)	(0.3242)	(3.7549)	(1.0859)	(1.3960)
R&D Expenditure	0.1938**	0.2309**	0.1203	-0.3848*	-0.1736	0.4640***
	(0.0702)	(0.0929)	(0.0767)	(0.2002)	(0.2115)	(0.1217)

	bss	gov	edu	hlt	per
			A. Taxation		
Consumption Tax	-3.7605***	0.6234	-2.1134	0.4121	-1.1514
	(0.7942)	(1.1231)	(1.5997)	(1.5412)	(1.0161)
Capital Income Tax	-2.0396**	-1.6620	1.5035	-0.9141	-0.6515
	(0.7498)	(1.1218)	(1.4952)	(2.0600)	(0.9304)
Labor Income Tax	-1.4231	-2.0782	1.1183	-0.7991	1.3970
	(1.4369)	(1.6456)	(1.7189)	(2.2688)	(1.9428)
			B. Regulation		
Rule of Law	0.0130**	-0.0034	-0.0050	0.0023	0.0038*
	(0.0049)	(0.0019)	(0.0029)	(0.0028)	(0.0018)
Government Size	0.0077	0.0002	0.0019	0.0006	-0.0046**
	(0.0061)	(0.0034)	(0.0027)	(0.0029)	(0.0019)
Regulatory Efficiency	0.0458***	-0.0078	-0.0101	0.0029	0.0006
	(0.0090)	(0.0061)	(0.0076)	(0.0090)	(0.0080)
Open Markets	0.0171	-0.0010	-0.0051	0.0009	-0.0017
	(0.0122)	(0.0038)	(0.0051)	(0.0059)	(0.0070)
			C. Diffusion of ICT		
Internet Users	0.0199**	-0.0049	-0.0082*	0.0011	0.0019
	(0.0085)	(0.0030)	(0.0038)	(0.0041)	(0.0050)
Secure Servers	0.0007***	-0.0001	-0.0002	0.0000	-0.0000
	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Broadband Subscriptions	0.0267	-0.0055	-0.0264**	0.0001	0.0120
	(0.0267)	(0.0084)	(0.0095)	(0.0113)	(0.0097)
			D. Innovation		
Patents	0.8850*	0.4837	0.0605	-0.4582	-0.3817
	(0.3940)	(0.5475)	(0.3201)	(0.6005)	(0.2624)
R&D Expenditure	0.2264*	-0.1038**	-0.0981	0.0342	0.0605
	(0.1111)	(0.0349)	(0.0615)	(0.0560)	(0.0670)

Notes: Standard errors clustered by country in parenthesis. Countries considered: Austria, Belgium, France, Germany, Italy, the Netherlands, Spain, Great Britain, and the United States. In each column the dependent variable is the model implied productivity level of the sector indicated in the header. Panel A: panel regression of productivity levels on consumption, capital, and labor tax rate, including country and year fixed effects (years from 1970 to 2009). Panel B: cross-section regression of 1995-2009 change in productivity levels on average values of the Economic Freedom Indicators; each row represents a separate regression. Panel C: cross-section regression of 1995-2009 change in productivity levels on average values of the ICT diffusion measures; each row represents a separate regression. Panel D: panel regression of productivity levels on the number of patents per thousand people, including country and year fixed effects (years from 1970 to 2009); cross-section regression of 1995-2009 change in productivity levels on average values of R&D expenditure as a percentage of GDP. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

to changes in the factors considered are those of wholesale and retail trade (ten significant coefficient estimates, out of twelve) and business services (eight significant coefficient estimates). All the other sectors have their productivity significantly associated with much fewer indicators, if any at all.

We conclude that productivity levels in wholesale and retail trade and business services are harmed by high levels of taxation, sustained by a business-friendly regulatory environment, and boosted by widespread ICT and innovating efforts. This finding confirms and extends the conclusions of Cette et al. (2016) about the negative impact of market regulation on productivity. An interesting aspect of our results is that the counterfactual exercise in the previous section has identified these two sectors among the most likely responsible for the low productivity of the European service sector and the falling behind of Europe with respect to the United States. Because the factors considered are specifically associated with sectoral productivity levels in wholesale and retail trade and business services, exactly the sectors at the core of the falling behind, our results suggest that a more comprehensive empirical analysis of the determinants of the service productivity gap between Europe and the United States should start by looking at differences in taxation, regulation, ICT diffusion, and the scope of innovation among these two sectors.

Looking at the estimates in detail, Panel A considers various tax rates and how they correlate with sectoral labor productivity. The coefficients that have statistical significance are all negative, suggesting that higher taxation tends to be associated with lower productivity. Wholesale and retail trade and transport services are affected by capital income tax, while restoration, financial, and real estate services are affected by consumption tax rate. A negative impact on business services comes both from consumption and capital income tax.

Panel B shows the estimated correlations with four indicators capturing the regulatory environment and the ease of doing business in a country. Productivity in wholesale and retail trade is positively associated with each of them, suggesting that this sector is more productive in countries with a more pro-business institutional framework. Business services' productivity is increasing in the quality of the rule of law and the degree of efficiency in regulation. Positive associations between some of the indicators and sectoral productivities are also found for restoration and personal services, while productivity levels in the latter as well as in real estate services seem to be respectively harmed by reductions in the government size and larger market openness.

Panel C looks at the extent of ICT diffusion in a country and its correlation with sectoral productivity. The intuition is that consumers' familiarity with the Internet and the development of an ICT infrastructure in a country are prerequisites for enterprises adopting new ICT-oriented business models, with the potential of boosting productivity. All the indicators of ICT diffusion are positively related with productivity levels in wholesale and retail trade and transport, suggesting that these sectors enjoy productivity gains in countries with widespread ICT diffusion. The degree of Internet usage and installation of secure servers is also positively associated with productivity in business services. Perhaps surprisingly, we find that education services tend to be less productive in countries largely relying on ICT.

The last panel contains estimated coefficients for two measures of the level of innovation. We intend to see whether propensity to invest into and generate innovation is associated with sectoral productivity levels. We find that productivity of wholesale and retail trade and business services is increasing in the degree of innovation. Large R&D expenditures are also associated with high productivity levels of transportation and real estate services. On the other hand, the productivity of the communication sector and the government sector are negatively affected by R&D investments.

6 Conclusion

In this paper we propose a multisector model of structural transformation that disaggregates services in order to quantitatively study the labor productivity differences between Europe and the U.S. in the service sector. We conclude that the structural transformation within the service sector is an important phenomenon, which helps understand why European countries have suffered a lower labor productivity than the U.S., especially since the 90's.

Although the reallocation of labor toward the various types of services has followed similar patterns both in Europe and the U.S., the levels of labor shares are largely different among service sub-sectors and between the two regions. At the same time, the service sub-sectors' labor productivities are remarkably different between the U.S. and Europe. Hence, the interaction of cross-country variations in labor share and labor productivity within the service sector is a major determinant of differences in the aggregate productivity of these economies.

We identify wholesale and retail trade and business services as the types of services that principally caused low service productivity in Europe, and ultimately lead to the divergence of European aggregate productivity from U.S. levels since the 90's. Wholesale and retail trade has always employed a large share of labor, while business services has experienced an astonishing increase in its employment share over the period of our analysis. These patterns are similar both in the U.S. and in Europe. However, labor productivity growth in these sectors has been particularly slower in Europe than in the United States. High and/or increasing labor shares and underperforming labor productivity growth in these two sectors is at the core of the outcome uncovered by our quantitative analysis.

Having established that wholesale and retail trade and business services are the main culprits of Europe's lack of catch-up with the U.S. in services labor productivity, we study which country-specific characteristics could have affected sectoral labor productivity. Our empirical analysis suggests that high taxation, restrictive regulation, limited diffusion of ICT, and little propensity to innovate are qualities of a country associated with low labor productivity in wholesale and retail trade and business services. Interestingly, while the significance of the correlation is clear for the two types of services which lead to the falling-behind of Europe, the factors mentioned do not seem to be related to productivity differences in other sectors.

Our findings together with the rising importance of services in the economy imply that the efforts of a deeper understanding of the labor productivity differences between Europe and the U.S. should be focused on wholesale and retail trade and business services. Moreover, our empirical analysis provide hope for policy since we find that institutional differences are strongly correlated with these two sectors.

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Appendix

A Model with Stone-Geary preferences

In this appendix we compare the results of the quantitative exercise in Section 4 with those of a similar exercise built on a different model, characterized by Stone-Geary preferences. The theoretical setup is identical to the baseline one in Section 3 with regard to the number of sectors and the production side of the economy. On the contrary, the consumption side is modeled as in Duarte and Restuccia (2010) and Ferreira and Silva (2014). The non-homothetic CES aggregator is replaced by Stone-Geary preferences over consumption of agriculture good, manufacturing good, and a homothetic CES composite of services. The utility function features non-homotheticity through the inclusion of subsistence consumption of the agriculture good ($\bar{a}$) and home production of services ($\bar{s}$). The households' problem becomes

$$\max_{c_i \geq 0} \quad a \log(c_a - \bar{a}) + (1-a)\frac{1}{\rho} \log \left\{ b c_m^{\rho} + (1-b) \left[\left(\sum_{j=1}^{11} \omega_j c_{s_j}^{\varepsilon} \right)^{\frac{1}{\varepsilon}} + \bar{s} \right]^{\rho} \right\}$$

$$s.t. \qquad p_a c_a + p_m c_m + \sum_{j=1}^{11} p_{s_j} c_{s_j} = wL$$

As in the baseline model, the first order conditions associated with the firms' optimization problem imply that

$$p_i = \frac{1}{A_i} \quad \forall \, i \in I \tag{16}$$

From the solution to the household's problem and relying on the result of equation (16), the maximizing condition relative to sector a can be combined to that relative to any service sub-sector s_j to obtain

$$L_a = (1-a)\frac{\bar{a}}{A_a} + a \left(L + \frac{\Theta_j^{\varepsilon-1}}{\omega_j} \frac{\bar{s}}{A_{s_j}} \right) \tag{17}$$

where

$$\Theta_j = \left(\sum_{k=1}^{4} \omega_k \left(\frac{\omega_k A_{s_k}}{\omega_j A_{s_j}} \right)^{\frac{\varepsilon}{1-\varepsilon}} \right)^{\frac{1}{\varepsilon}}$$

Similarly, from the first order conditions relative to sector m and to sector s_j the following equation is derived:

$$L_m = \frac{(L - L_a) + \frac{\Theta_j^{\varepsilon-1}}{\omega_j} \frac{\bar{s}}{A_{s_j}}}{1 + x} \tag{18}$$

with

$$x = \left(\frac{b}{1-b}\right)^{\frac{1}{\rho-1}} \left(\frac{A_m}{A_{s_j}}\right)^{\frac{\rho}{\rho-1}} \left(\frac{\Theta_j^{\varepsilon-1}}{\omega_j}\right)^{\frac{\rho}{\rho-1}}$$

Household's first order conditions imply also that for any s_j, s_k

$$L_{s_k} = \left(\frac{\omega_k}{\omega_j}\right)^{\frac{1}{1-\varepsilon}} \left(\frac{A_{s_k}}{A_{s_j}}\right)^{\frac{\varepsilon}{1-\varepsilon}} L_{s_j} \tag{19}$$

The latter equation implies that

$$\sum_{k=1}^{4} L_{s_k} = L_{s_j} \sum_{k=1}^{4} \left(\frac{\omega_k}{\omega_j}\right)^{\frac{1}{1-\varepsilon}} \left(\frac{A_{s_k}}{A_{s_j}}\right)^{\frac{\varepsilon}{1-\varepsilon}} = L_{s_j} \frac{\Theta_j^{\varepsilon}}{\omega_j}$$

Therefore, labor market clearing requires

$$L_{s_j} = (L - L_a - L_m) \frac{\omega_j}{\Theta_j^{\varepsilon}} \tag{20}$$

Given sectoral labor productivities, equations (16) to (20) fully determine the equilibrium in this economy.

This setup is well known for generating structural transformation through two channels: an income effect mechanism and a substitution effect mechanism. The income effect channel rests on the non-homotheticity of demand. As income increases, households are willing to consume less agriculture and manufacturing good and more services. The supply side adapts to the change in demand by employing less labor in agriculture and manufacturing, and more in services. This is clearly visible in equations (17) and (18): as productivity levels A_a and A_{s_j} increase, and with them income, L_a and L_m decrease. However, notice that this mechanism vanishes as productivity keeps increasing: in the limit, the terms in (17) and (18) containing $\bar{a}$ and $\bar{s}$ go to zero. In a sense, we can say that homotheticity becomes irrelevant at advanced stages of development, while it has a fundamental importance in explaining the fall in agriculture employment share at an early phase. The property just described is a first important departure from the model we use in the paper. Indeed, in that case the homotheticiy introduced through the parameters ε_i never disappears. For this reason, our baseline model appears more suited to study an income channel of structural transformation in the context of the developed economies we are considering.

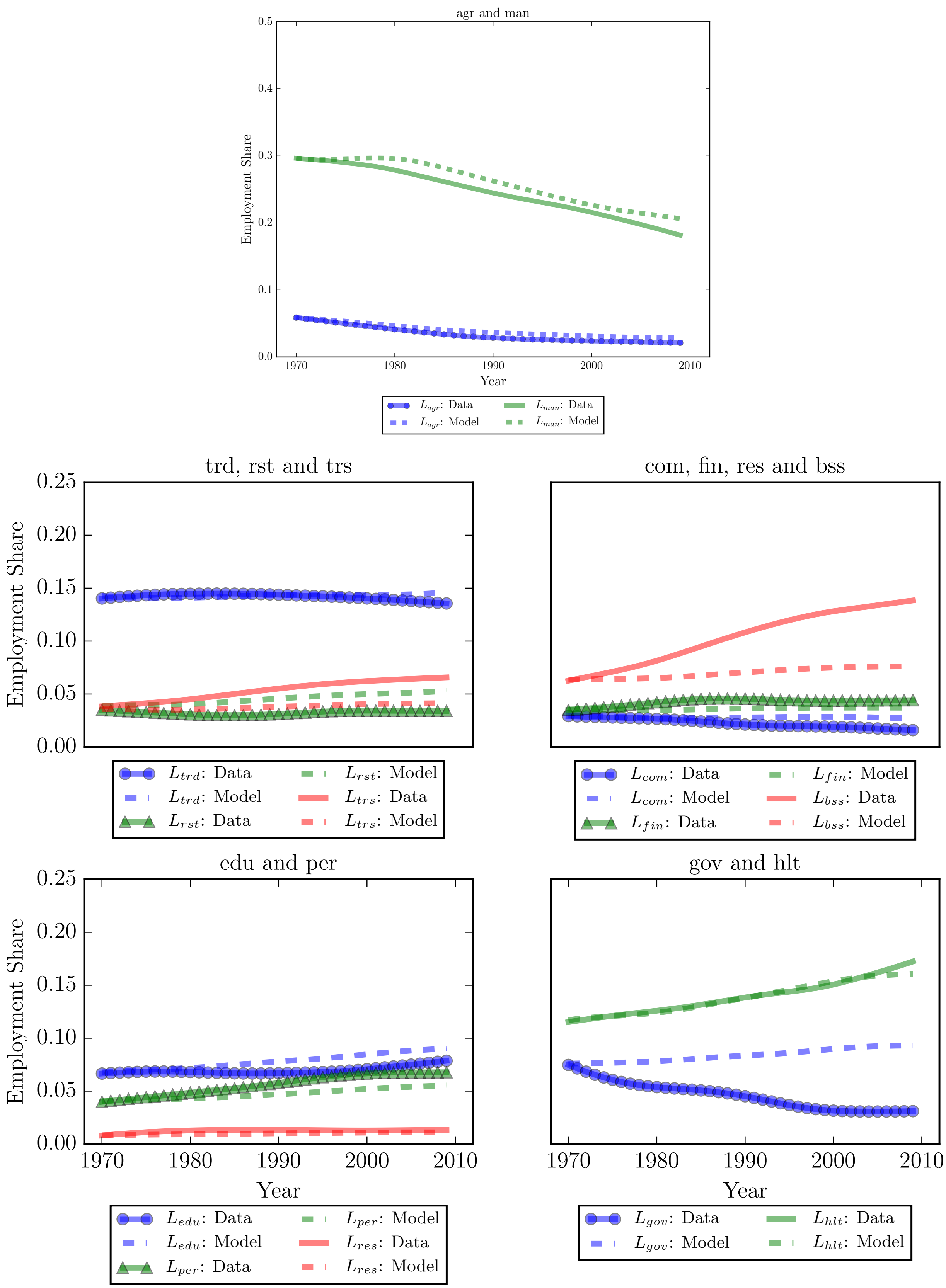
The substitution channel derives from the effect of sectoral biases in productivity changes. If productivity in one sector grows faster than in the other ones, less labor is needed in producing its good, and the employment in excess will be absorbed by slower growing sectors. This mechanism can be seen in equation (19), where the relative labor allocation among services is driven by the relative productivity levels among them. While both income and substitution effects interact in the determination of labor distribution across agriculture, manufacturing and overall services, within the service sector the substitution effect is the unique source of structural transformation among the different types of services. This is a second major difference with respect to the model used in the paper. In that case, each singular service has its own ε_i, letting the income effect mechanism be functioning for all of them.

A.1 Calibration

We calibrate the model to capture the observed structural transformation in the United States from 1970 to 2009. Initial levels of sectoral productivities are normalized to 1. Then, these initial levels are let change at growth rates obtained from the World KLEMS database. This procedure delivers series of productivity levels for all the sectors and years considered. The parameter a is set at 0.01, to represent the U.S. converging toward a 1% labor share in agriculture in the long run. We take from Duarte and Restuccia (2010) the values of the parameters b and ρ, respectively 0.04 and -1.5. Given a, b, ρ, and ε, we can pin down values for $\bar{a}$ and $\bar{s}$ to match the initial labor allocation in manufacturing and agriculture in 1970. The value of ε is set to minimize the distance between the model implied series of labor allocations in `hlt` and the actual one from 1970 to 2009. This target requires ε at -0.234, which commands $\bar{a}$ at 0.017 and $\bar{s}$ at 0.371. Given ε, the weights $\{\omega_j\}$ are calibrated to capture the actual ratios of labor allocations across service sub-sectors in 1970 and the constraint $\sum_j \omega_j = 1$.

By feeding the series of sectoral productivities into the calibrated model we obtain predictions of employment shares. Figure 11 plots these model predictions against actual employment shares, and it can be compared with Figure 4. The model is able to capture relatively well the data, with the only exceptions of business services and government sector. Recall that the baseline model has also problems in capturing government employment, as well as that of wholesale and retail trade.

Figure 11: Share of Hours by Sector of the Calibrated Model vs. U.S. Data



A.2 Quantitative exercise

The calibrated model is used to measure the initial sectoral productivity levels in eight European countries: Austria, Belgium, France, Germany, Italy, the Netherlands, Spain, and Great Britain. For any sector $i \in I$, we pin down the value of the initial productivity $A_{i,1970}$ in such a way that the model predicted employment share $L_{i,1970}$ matches exactly the one observed in the data. Then, the entire series of sectoral productivity are recovered by letting the initial levels grow at the rates reported in the World KLEMS database. Finally, the sectoral productivity series are fed into the model to get sectoral employment shares in all the periods for each country. To assess the quality of the result obtained, in Figure 12 we compare model predicted and actual sectoral employment shares in the last year of our time horizon, 2009. This test is directly comparable to the one carried on for the baseline model, in Figure 7. Both the models overall perform rather well, being able to predict last year employment shares remarkably close to the actual ones. However, the Stone-Geary setup appears slightly inferior. In particular, it has a noticeable wrong prediction of 2009 employment shares in agriculture for Italy and Spain, and it systematically understates 2009 employment share in business services in all the countries considered. On the other hand, the only important failure of the non-homothetic CES setup is in the prediction of last period employment share in wholesale and retail trade. However, in this case the error is fully driven by only two countries (Belgium and the United States) and it is not systematic (the employment share is overstated for Belgium and understated for the U.S).

We conclude the quantitative exercise by a counterfactual analysis in which we allow sectoral productivities in Europe to grow at U.S. rates. Table 8 reports how the change in aggregate productivity in Europe[16] is different by adopting the counterfactual for each sector separately. The counterfactual exercise evidences that the largest improvements in aggregate productivity growth over the entire period would have taken place if Europe had adopted U.S. sectoral productivity growth in wholesale and retail trade and financial services. Smaller improvements would have come also from a similar adoption in business services. On the shorter time horizon corresponding more precisely to the lagging-behind phase (1995-2009), Europe could have done better by following U.S. sectoral productivity growth in manufacturing, trade, real estate and business services.

By this analysis we can conclude that the reasons of the falling-behind of Europe should be searched for in the slow productivity growth of services. More specifically, whole sale and retail trade, financial services, and business services appear to have been the main responsible for the low rate of growth in services. This conclusion is similar to the main findings obtained

[16]European aggregate productivity is an average of each country productivity, weighted by national GDP.

Figure 12: Labor Share Levels in the Last Year for each Sector

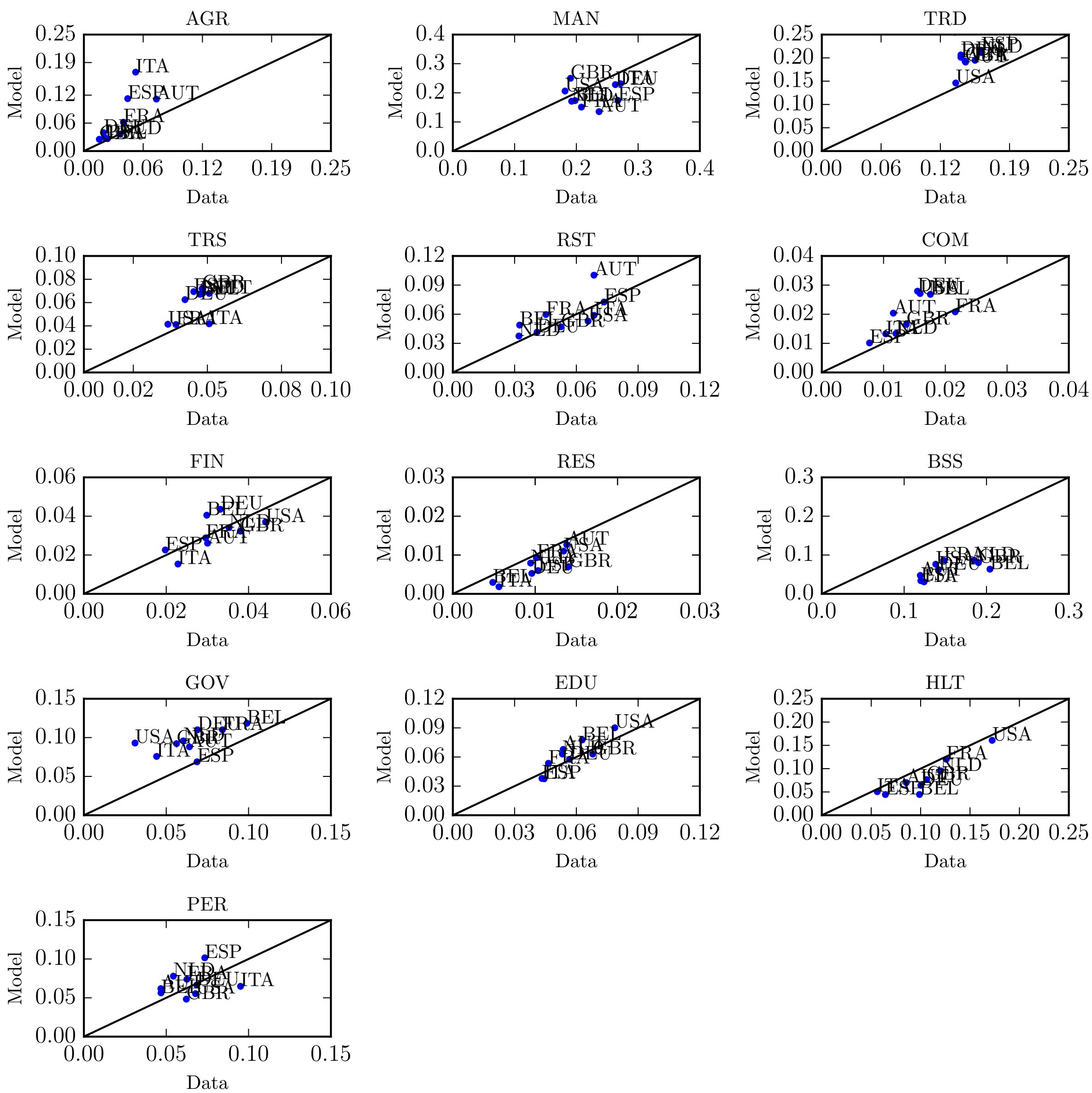


Table 8: Counterfactual results

	Change in Aggregate Productivity		
	1970-2009	1970-1995	1995-2009
Baseline	-10.32	11.85	-19.82
Counterfactual in:			
`agr`	-10.05	12.45	-20.01
`man`	-23.86	-9.06	-16.28
`trd`	-4.39	17.73	-18.79
`trs`	-10.43	11.41	-19.61
`rst`	-10.83	11.15	-19.78
`com`	-10.28	12.2	-20.04
`fin`	-9.76	12.65	-19.89
`res`	-11.81	7.32	-17.83
`bss`	-10.18	11.26	-19.27
`gov`	-10.32	11.86	-19.83
`edu`	-10.92	10.83	-19.63
`hlt`	-25.87	-6.13	-21.03
`per`	-11.48	10.57	-19.94

Notes: Reported figures are percentage changes in aggregate labor productivity of Europe (weighted average of eight countries), relative to the U.S., as resulting from the calibrated model and the counterfactual exercises. Each row beginning with a sectoral code contains results from having the productivity of that sector growing in the European countries as in the U.S., for the time horizon indicated in the column header.

with the non-homothetic CES setup.

B Data Appendix

- *Taxation*

  Tax rates on consumption, capital income, and labor income come from the updated database in McDaniel (2007), a panel with observations for all the countries considered in the paper, for the entire period from 1970 to 2009.

- *Regulation*

  The indicators we look at come from the Index of Economic Freedom publication, released yearly since 1995 for all the countries considered by the Heritage Foundation. The content of each indicator is the following:

  - Rule of Law: it assesses the degree of protection of property rights under national law, and the perceived level of corruption.
  - Government Size: it is decreasing in the overall amount of tax revenue and public expenditure as percentages of GDP.
  - Regulatory Efficiency: it summarizes the extent and complexity of bureaucratic procedures needed to start, operate, and close a business, regulatory burden on wages, hiring, and layoffs, and the degree of price stability and price control.
  - Open Markets: it captures how much an economy is open to international trade and capital flows, as well as the efficiency and independence from the government of the banking sector.

- *ICT diffusion*

  We use the following measures from the World Development Indicators by the World Bank:

  - Internet Users: Individuals who have used the Internet in the previous 12 months, per 100 people. Available for all the countries considered since 1990.
  - Secure Servers: Servers using encryption technology, per 1 million people. Available for all the countries considered since 2001.
  - Broadband Subscriptions: Subscriptions to high-speed access to the public Internet, per 100 people. Available for all the countries considered since 1999.

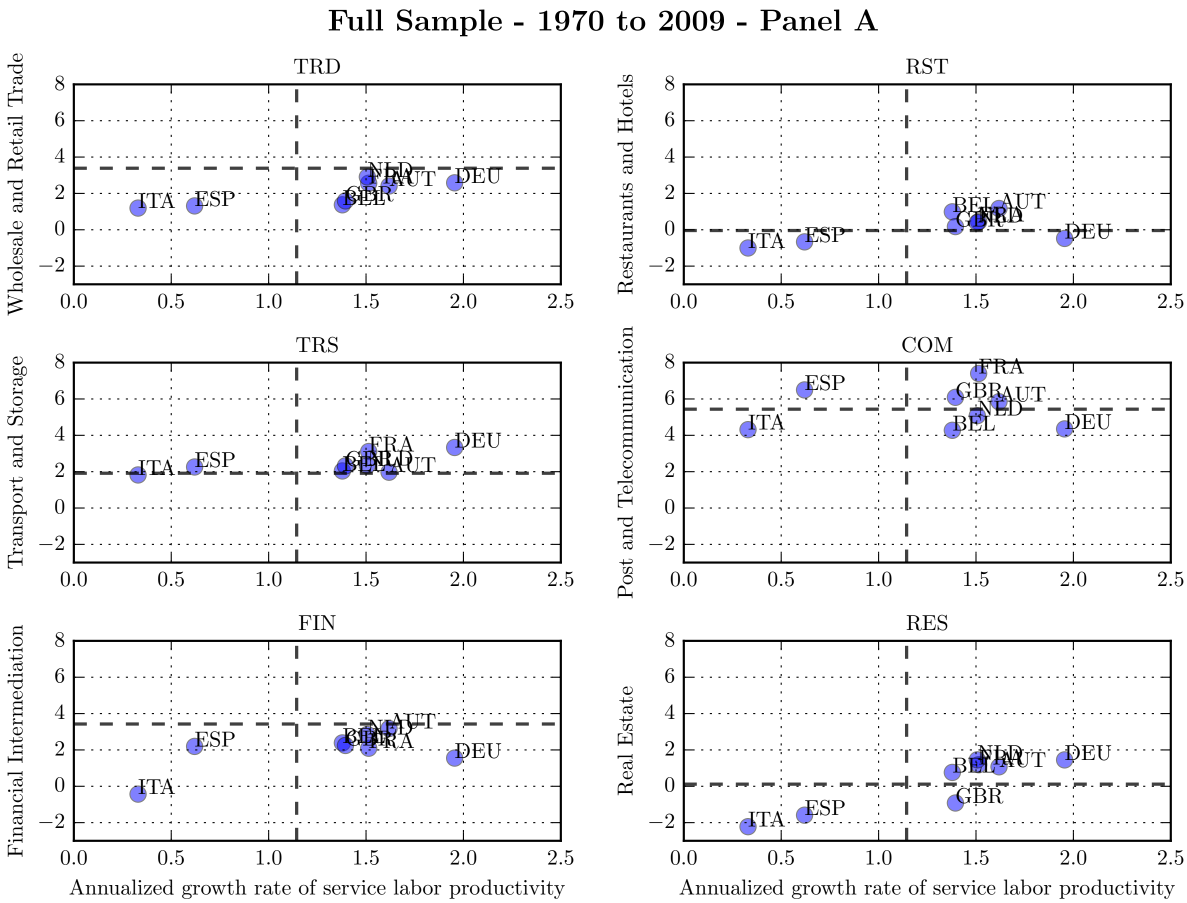
- *Innovation*

  We use the following measures from the World Development Indicators by the World Bank:

  - Patents: Patent applications for new inventions by country residents, per 1000 people. Available for all the countries considered in the all the years between 1970 to 2009.
  - R&D Expenditure: Total private and public expenditure to increase knowledge (it covers basic and applied research), as a percentage of GDP. Available for all the countries considered since 1996.

C Graphical appendix

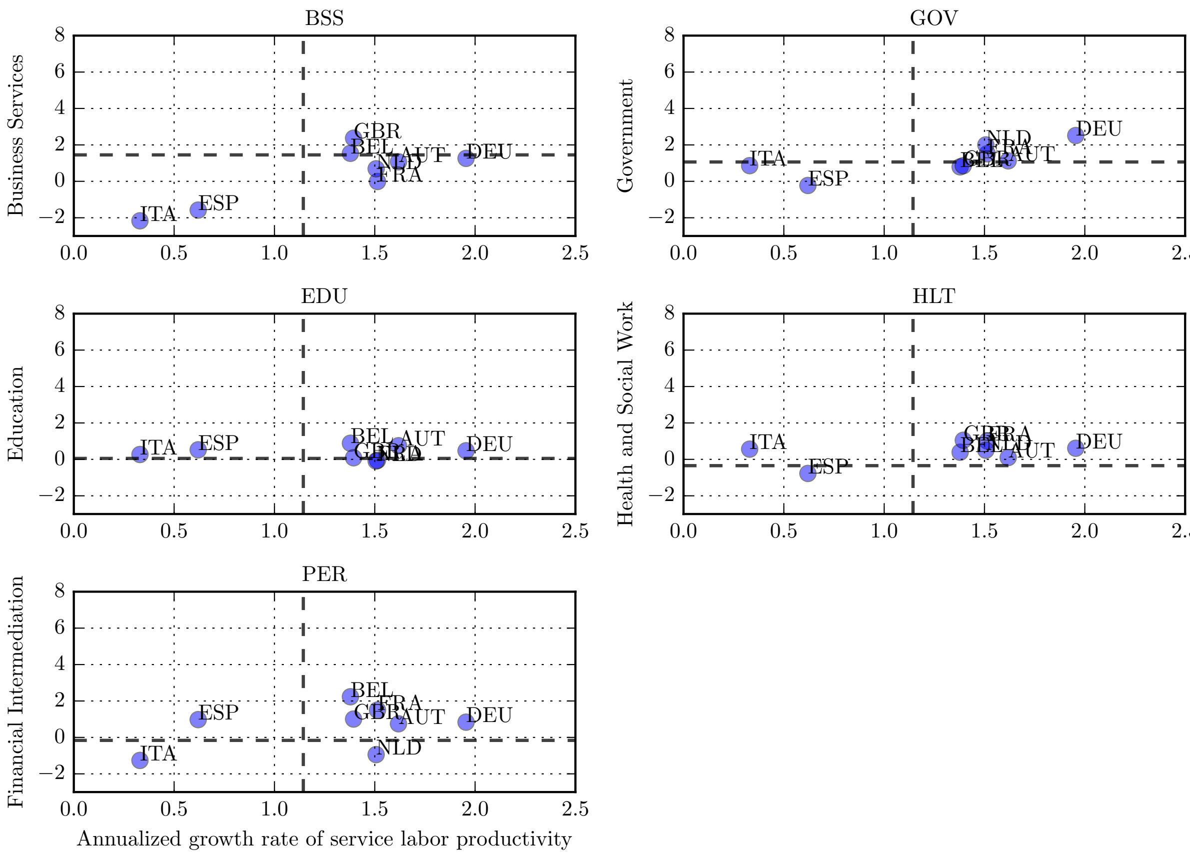
Figure 13: Average growth in Services' productivity - TRD, RST, TRS, COM, FIN, RES



Notes: Scatter plots of value added per hour of the aggregate service sector with the value added per hour of each type of service. Annualized percentage growth rates during the sample period are given for each country. The horizontal lines indicate the service sub-sectoral growth rates observed in the United States, and the vertical line indicates the aggregate service growth rate of the United States for the full sample from 1970 to 2009.

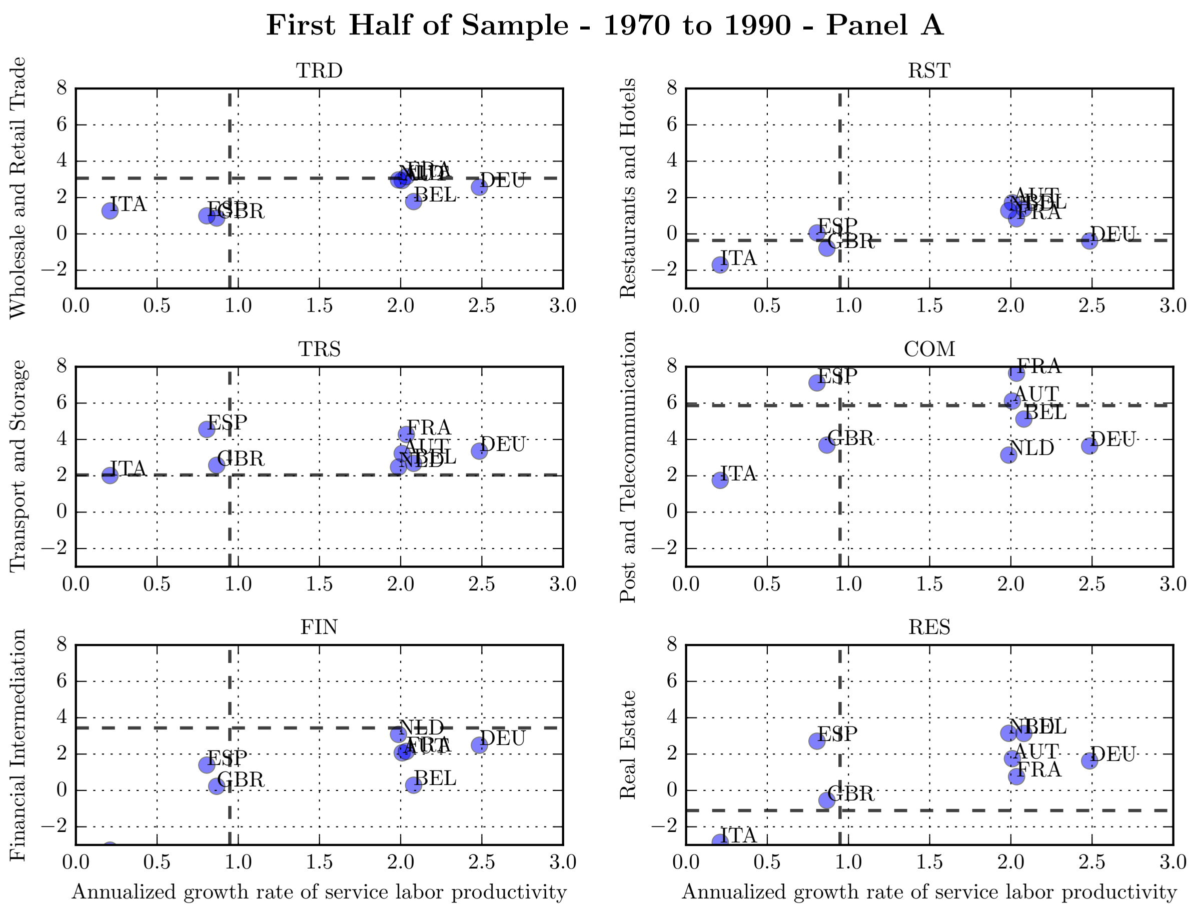
Figure 14: Average growth in Services' productivity - BSS, GOV, EDU, HLT, PER

Full Sample - 1970 to 2009 - Panel B



Notes: Scatter plots of value added per hour of the aggregate service sector with the value added per hour of each type of service. Annualized percentage growth rates during the sample period are given for each country. The horizontal lines indicate the service sub-sectoral growth rates observed in the United States, and the vertical line indicates the aggregate service growth rate of the United States for the full sample from 1970 to 2009.

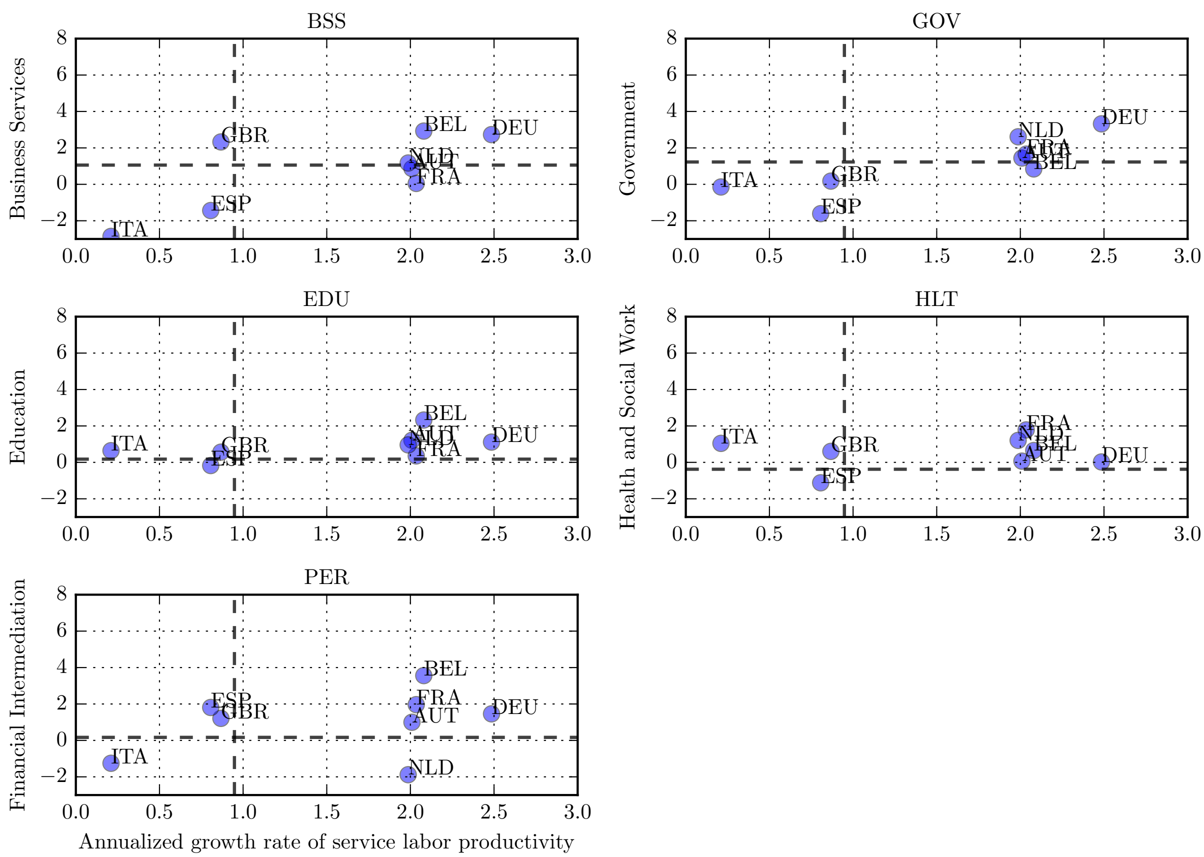
Figure 15: Average growth in Services' productivity - TRD, RST, TRS, COM, FIN, RES



Notes: Scatter plots of value added per hour of the aggregate service sector with the value added per hour of each type of service. Annualized percentage growth rates during the sample period are given for each country. The horizontal lines indicate the service sub-sectoral growth rates observed in the United States, and the vertical line indicates the aggregate service growth rate of the United States for the full sample from 1970 to 1990.

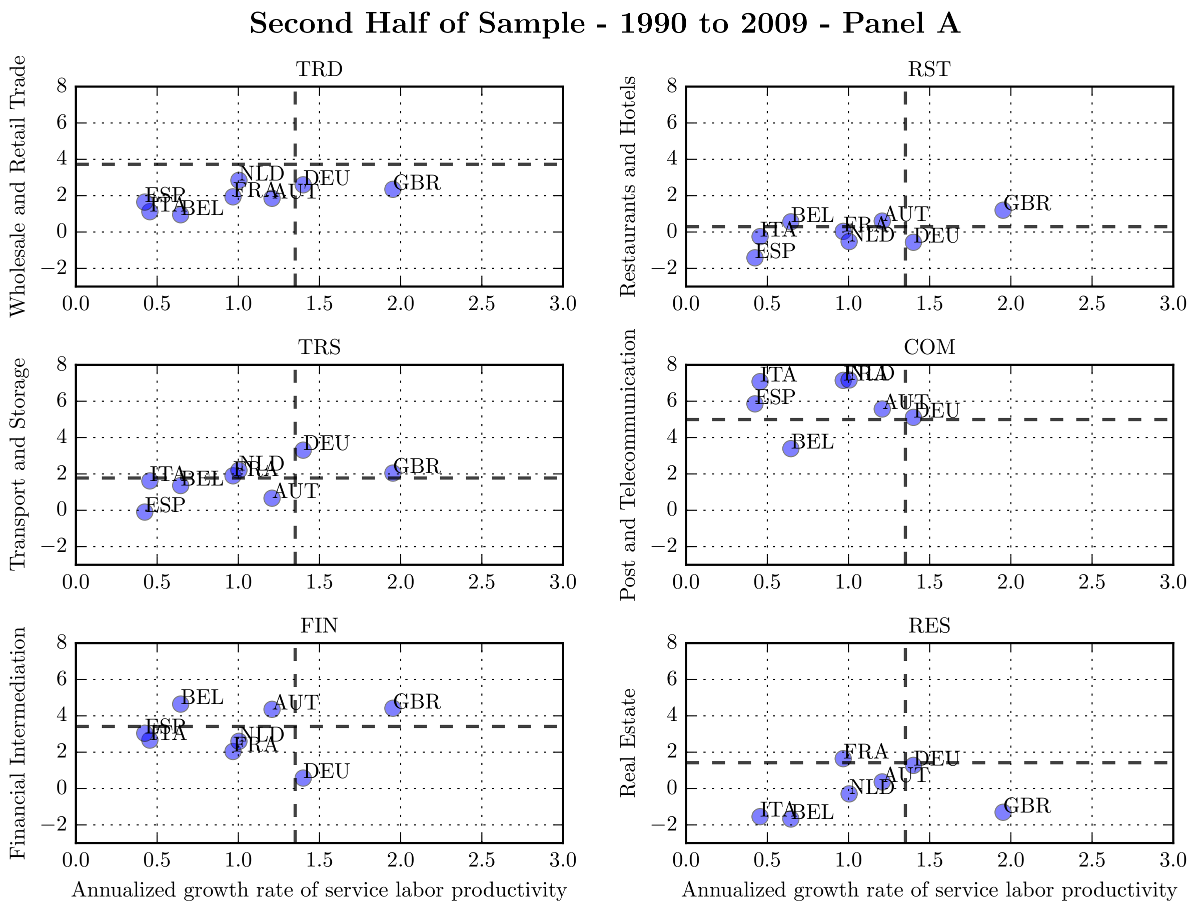
Figure 16: Average growth in Services' productivity - BSS, GOV, EDU, HLT, PER

First Half of Sample - 1970 to 1990 - Panel B



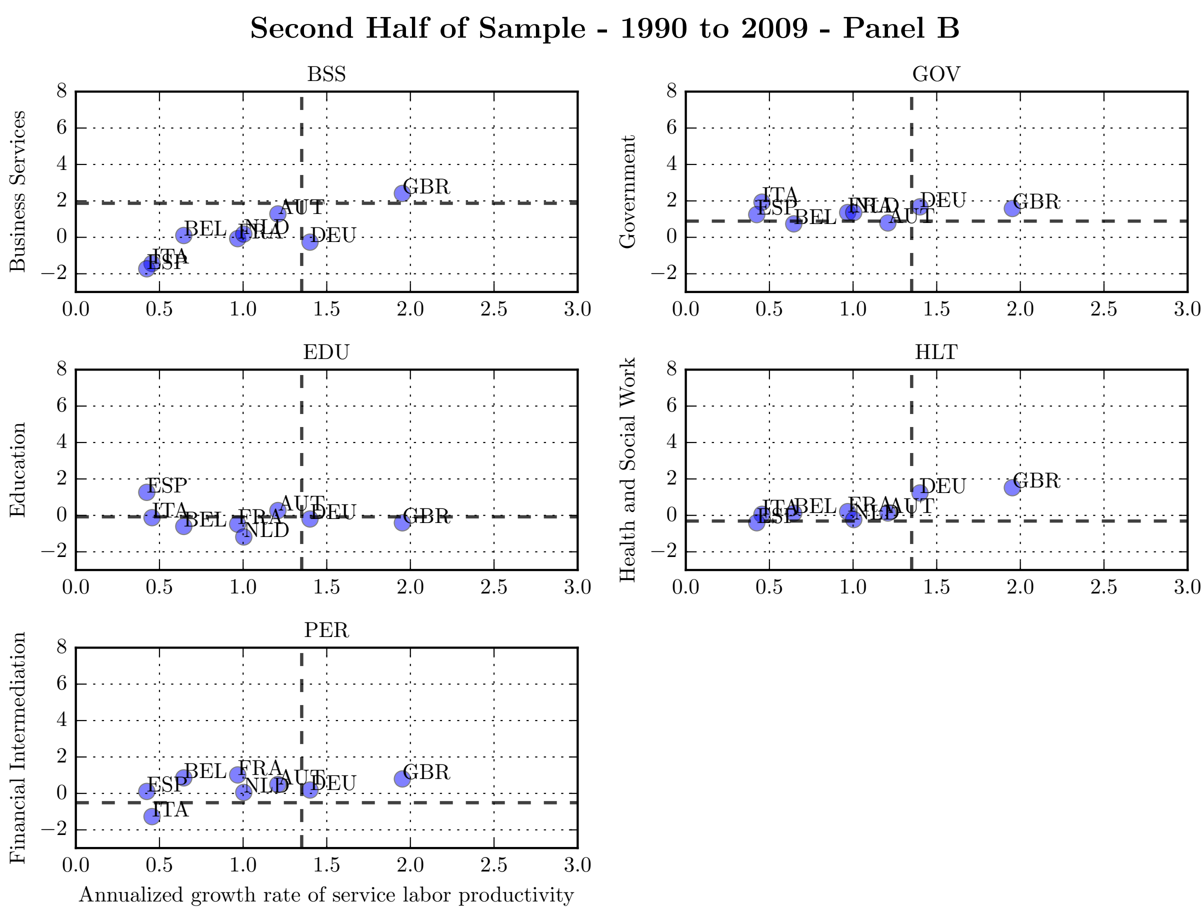
Notes: Scatter plots of value added per hour of the aggregate service sector with the value added per hour of each type of service. Annualized percentage growth rates during the sample period are given for each country. The horizontal lines indicate the service sub-sectoral growth rates observed in the United States, and the vertical line indicates the aggregate service growth rate of the United States for the full sample from 1970 to 1990.

Figure 17: Average growth in Services' productivity - TRD, RST, TRS, COM, FIN, RES



Notes: Scatter plots of value added per hour of the aggregate service sector with the value added per hour of each type of service. Annualized percentage growth rates during the sample period are given for each country. The horizontal lines indicate the service sub-sectoral growth rates observed in the United States, and the vertical line indicates the aggregate service growth rate of the United States for the full sample from 1990 to 2009.

Figure 18: Average growth in Services' productivity - BSS, GOV, EDU, HLT, PER



Notes: Scatter plots of value added per hour of the aggregate service sector with the value added per hour of each type of service. Annualized percentage growth rates during the sample period are given for each country. The horizontal lines indicate the service sub-sectoral growth rates observed in the United States, and the vertical line indicates the aggregate service growth rate of the United States for the full sample from 1990 to 2009.

Figure 19: Relative Labor Productivity across Sectors

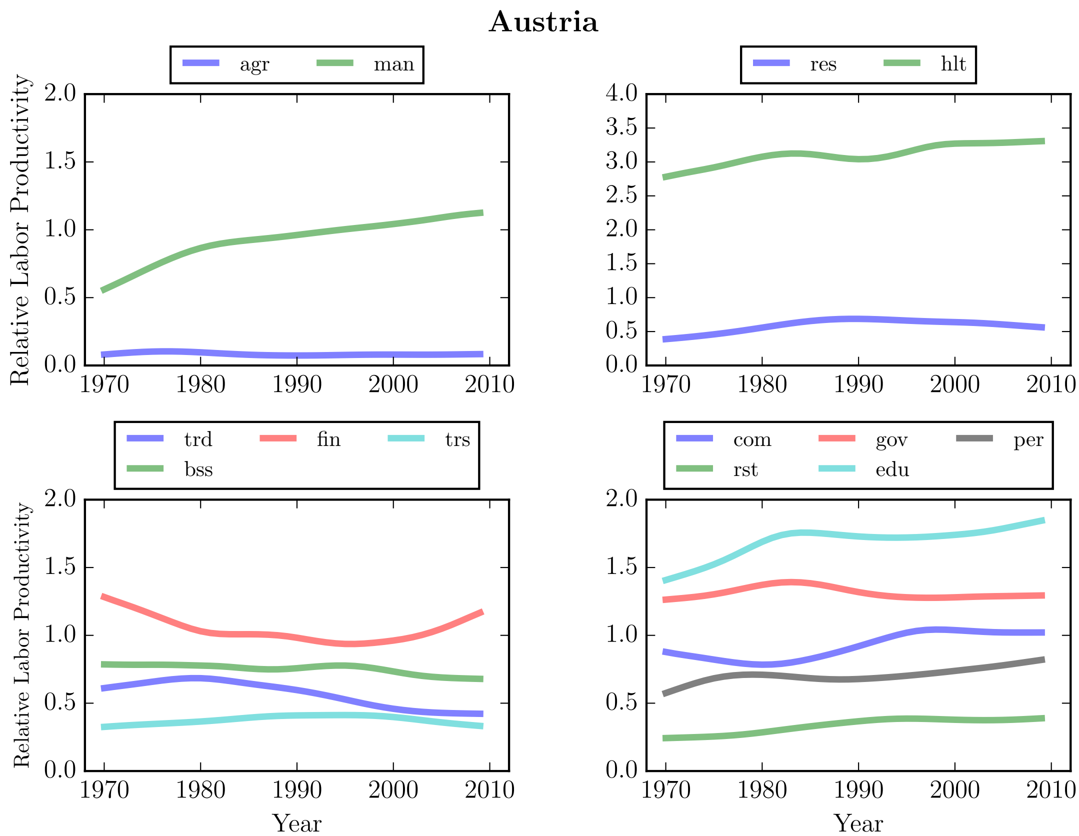


Figure 20: Relative Labor Productivity across Sectors

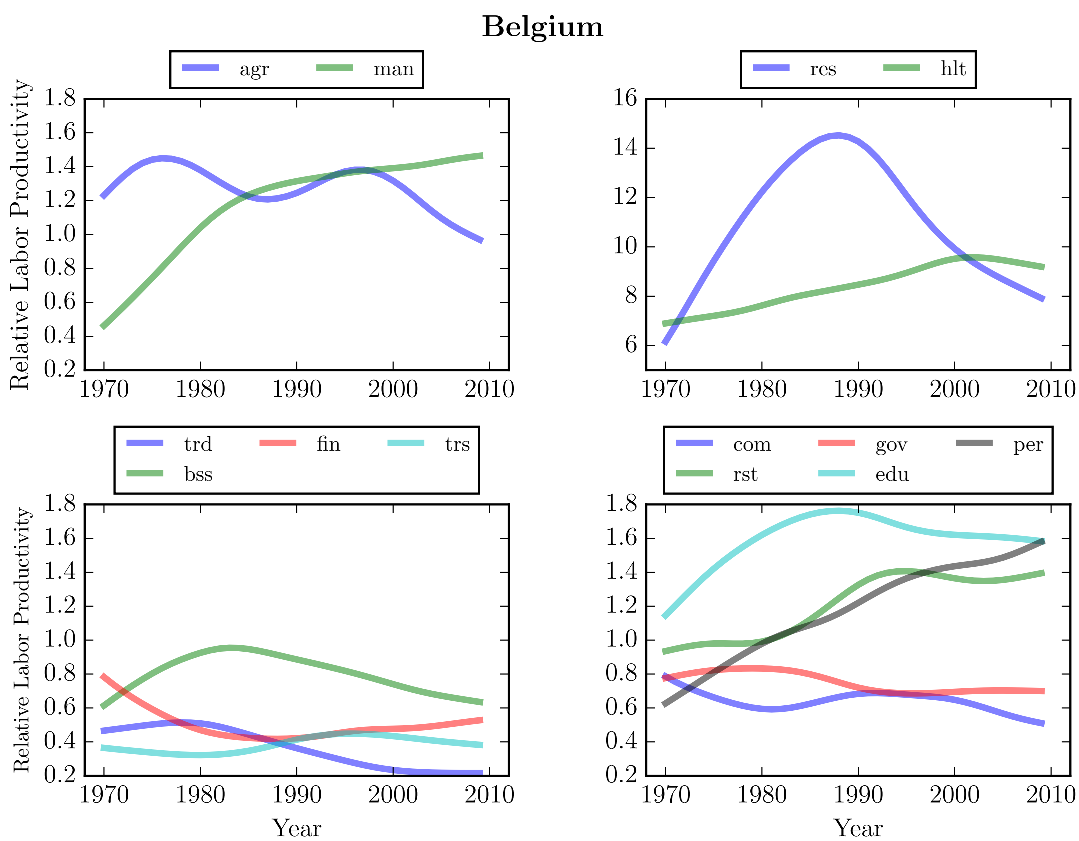


Figure 21: Relative Labor Productivity across Sectors

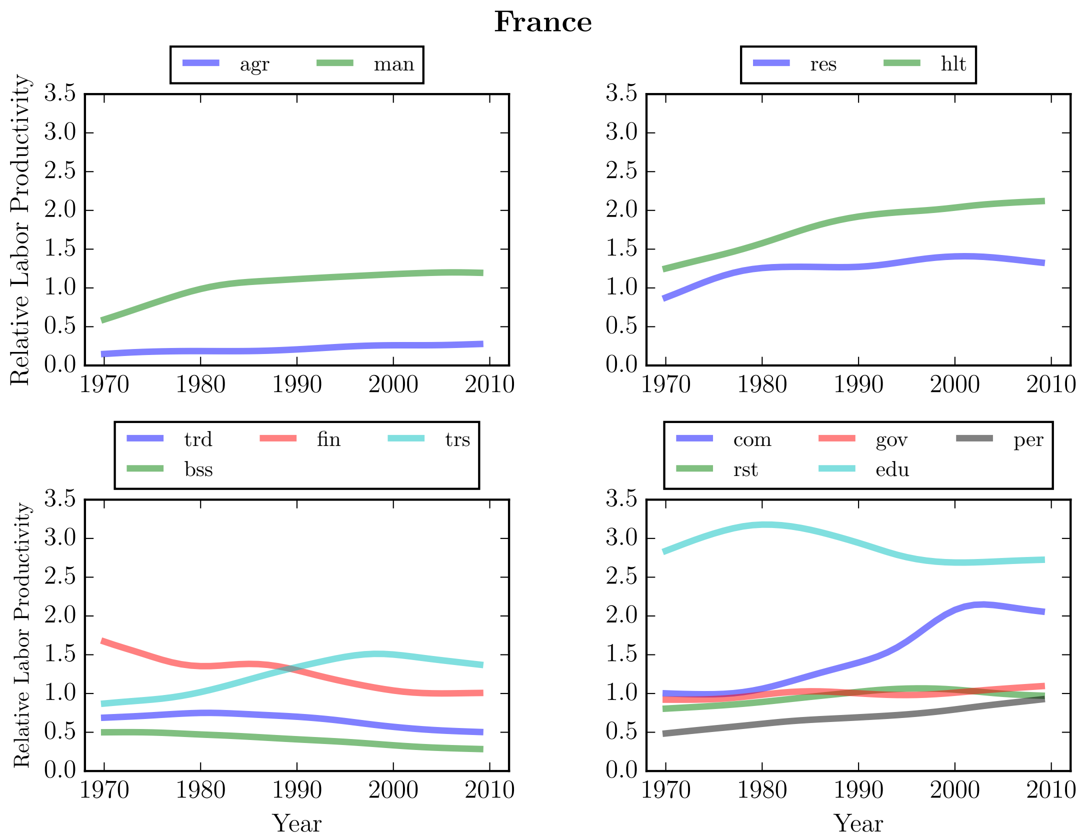


Figure 22: Relative Labor Productivity across Sectors

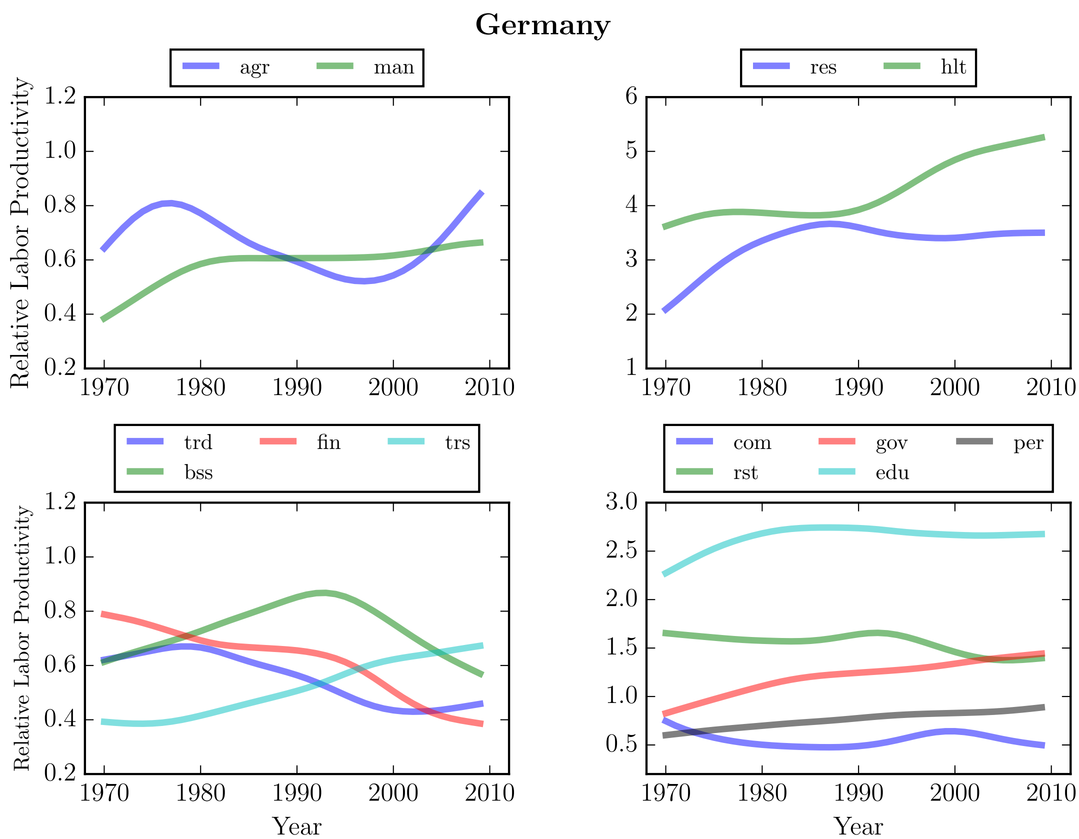


Figure 23: Relative Labor Productivity across Sectors

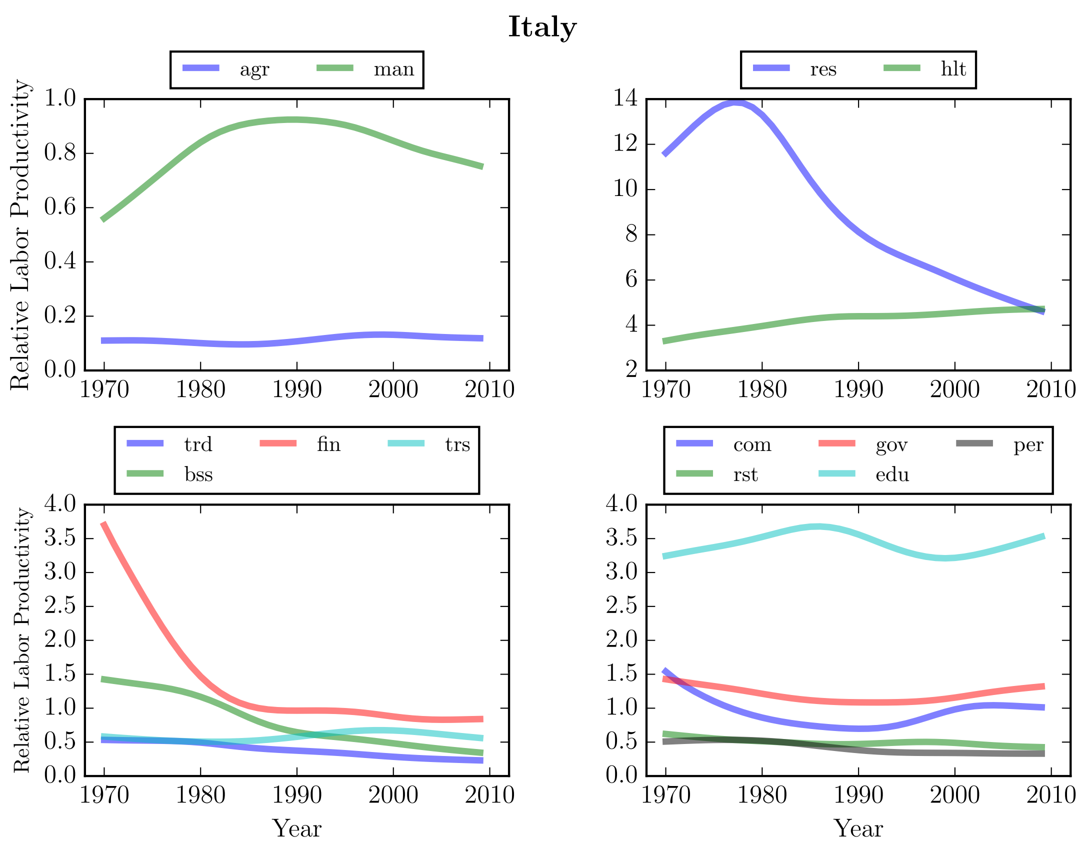


Figure 24: Relative Labor Productivity across Sectors

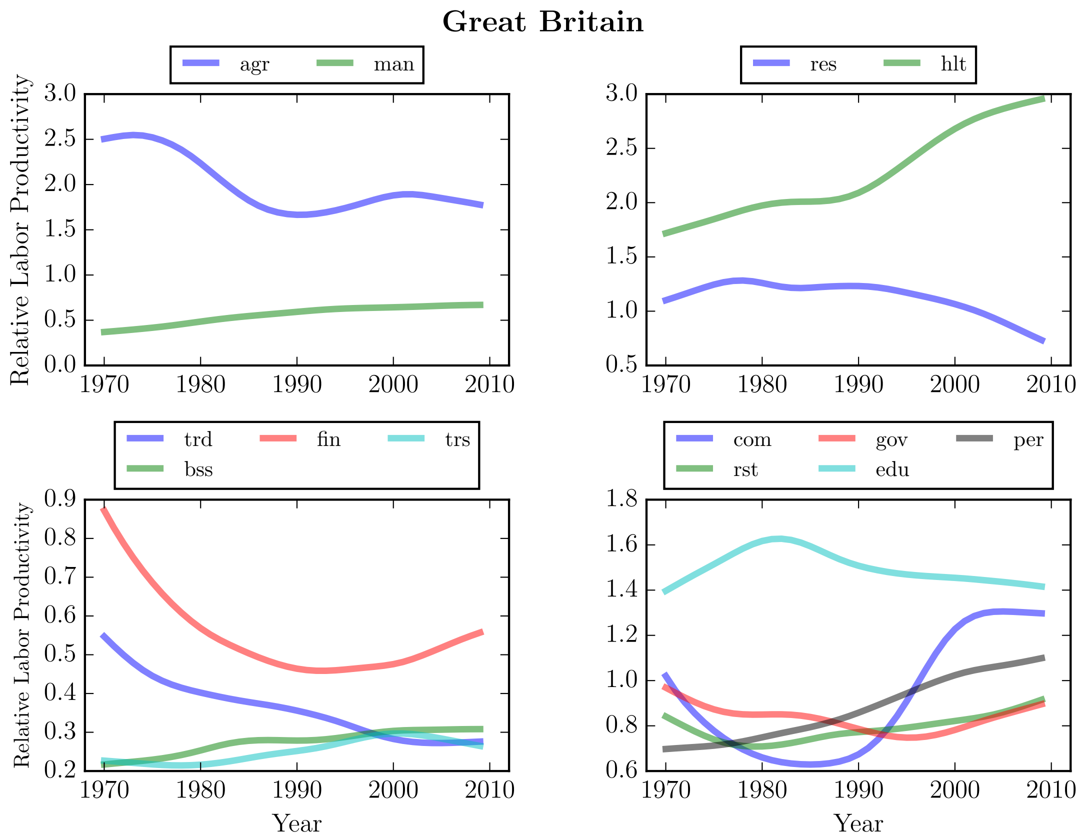


Figure 25: Relative Labor Productivity across Sectors

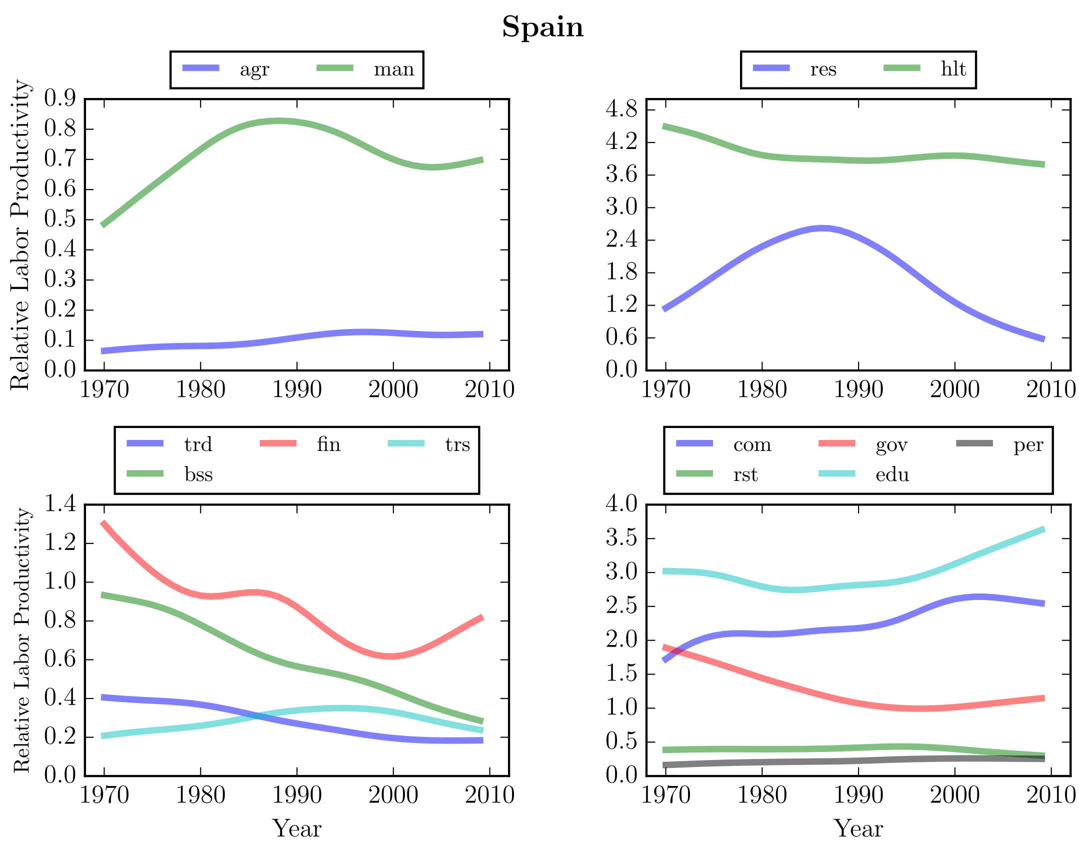


Figure 26: Relative Labor Productivity across Sectors

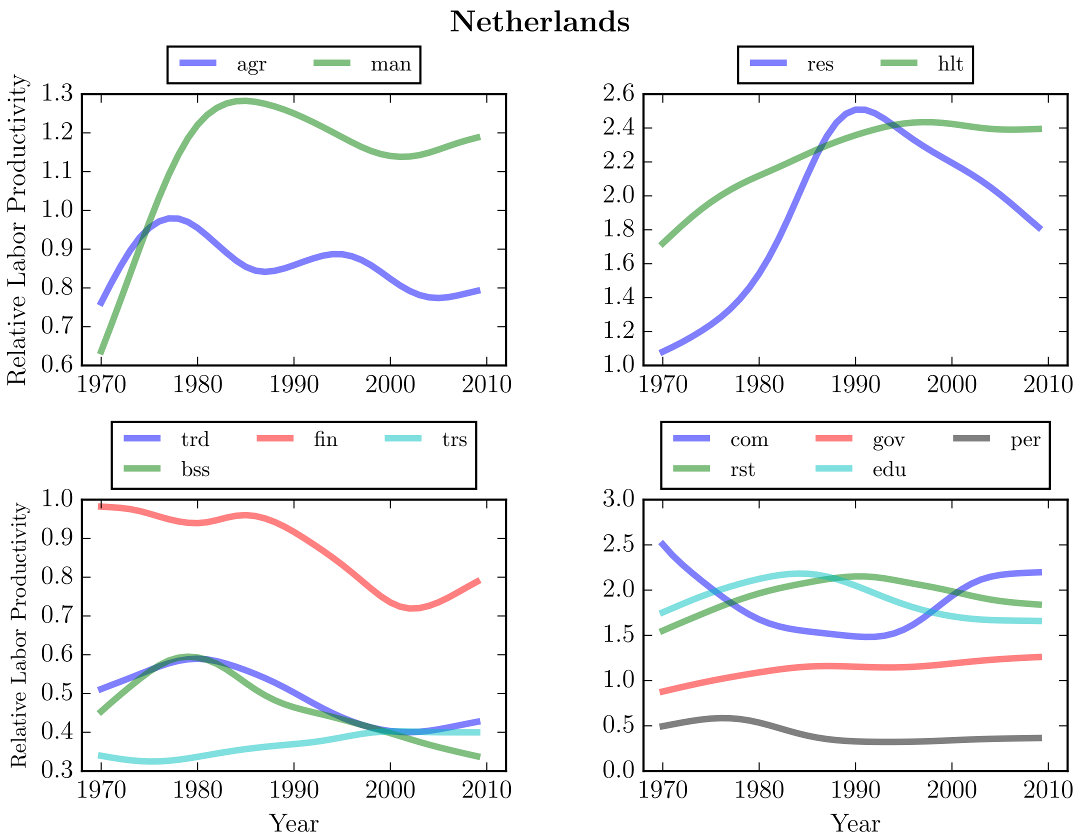


Figure 27: Sectoral Employment Shares - Calibrated Model vs. Data - Austria

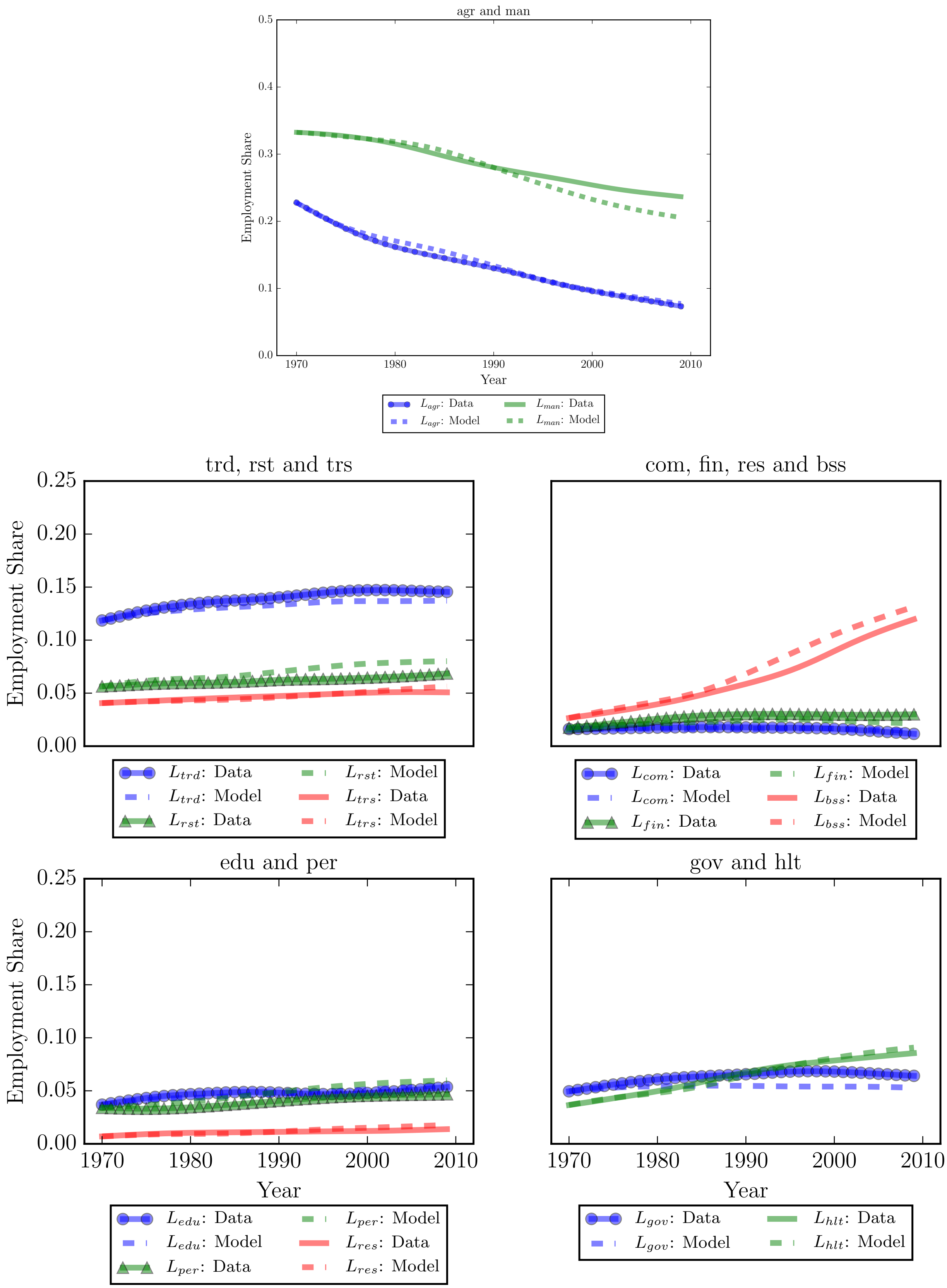


Figure 28: Sectoral Employment Shares - Calibrated Model vs. Data - Belgium

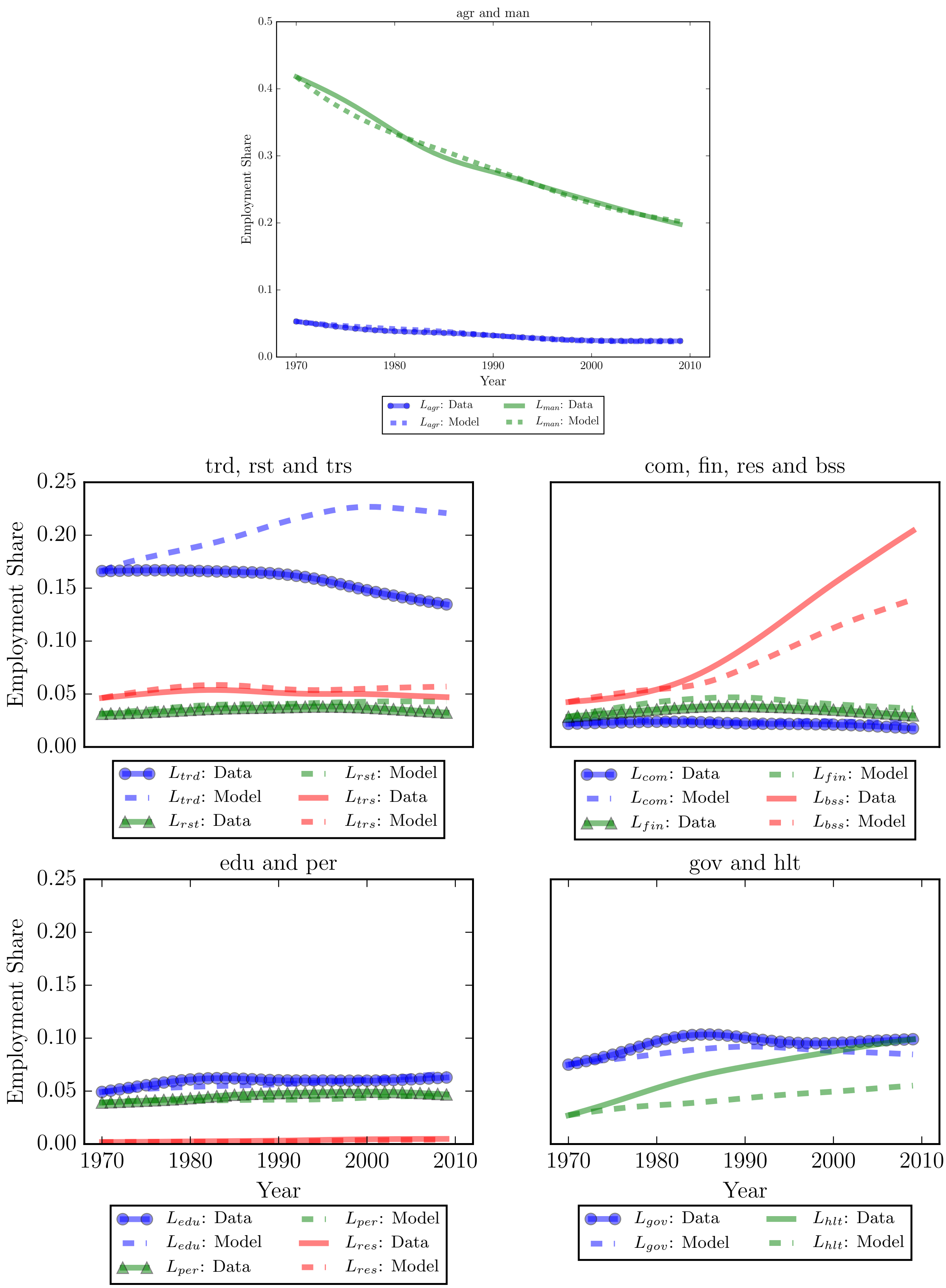


Figure 29: Sectoral Employment Shares - Calibrated Model vs. Data - France

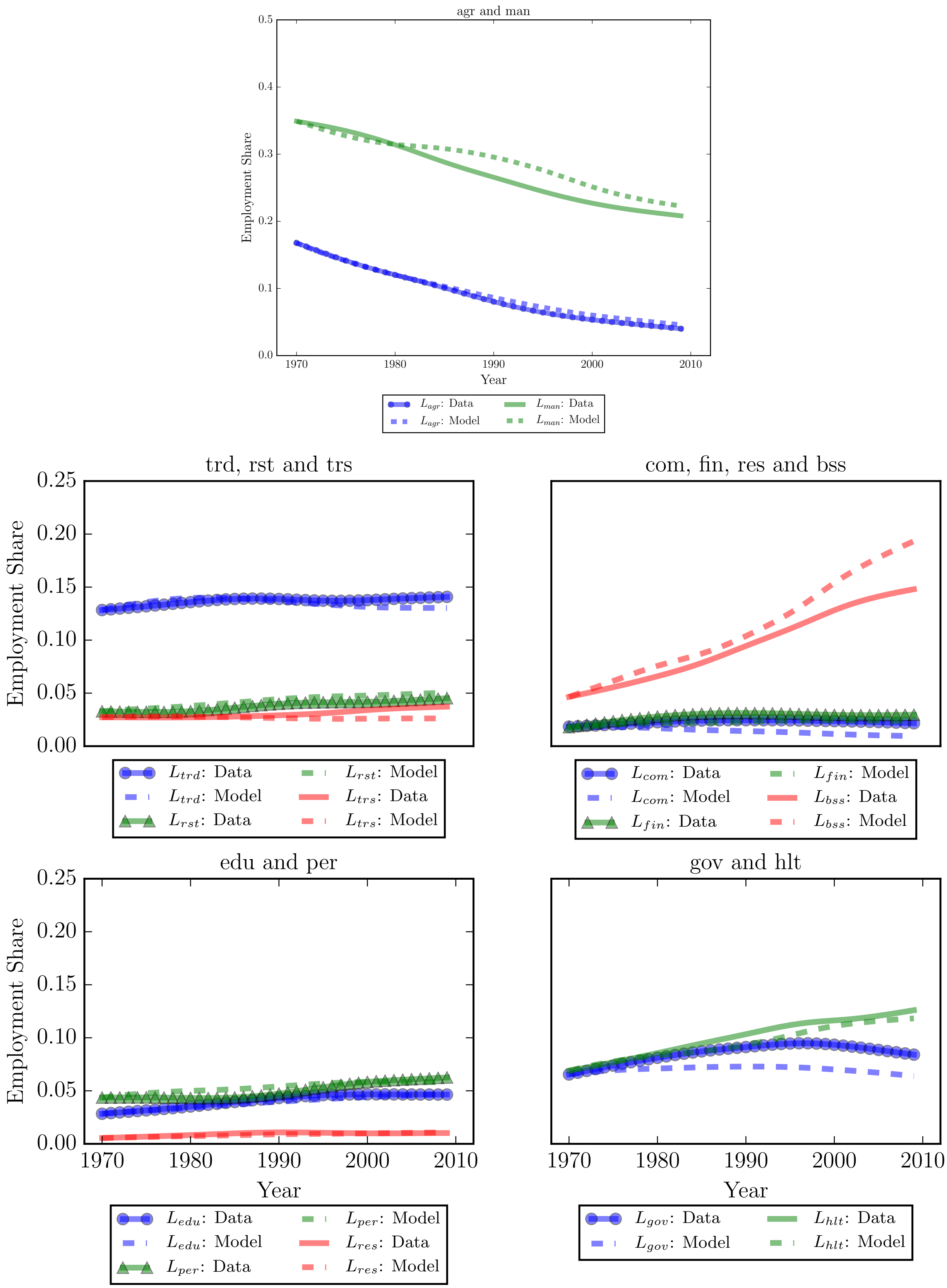


Figure 30: Sectoral Employment Shares - Calibrated Model vs. Data - Germany

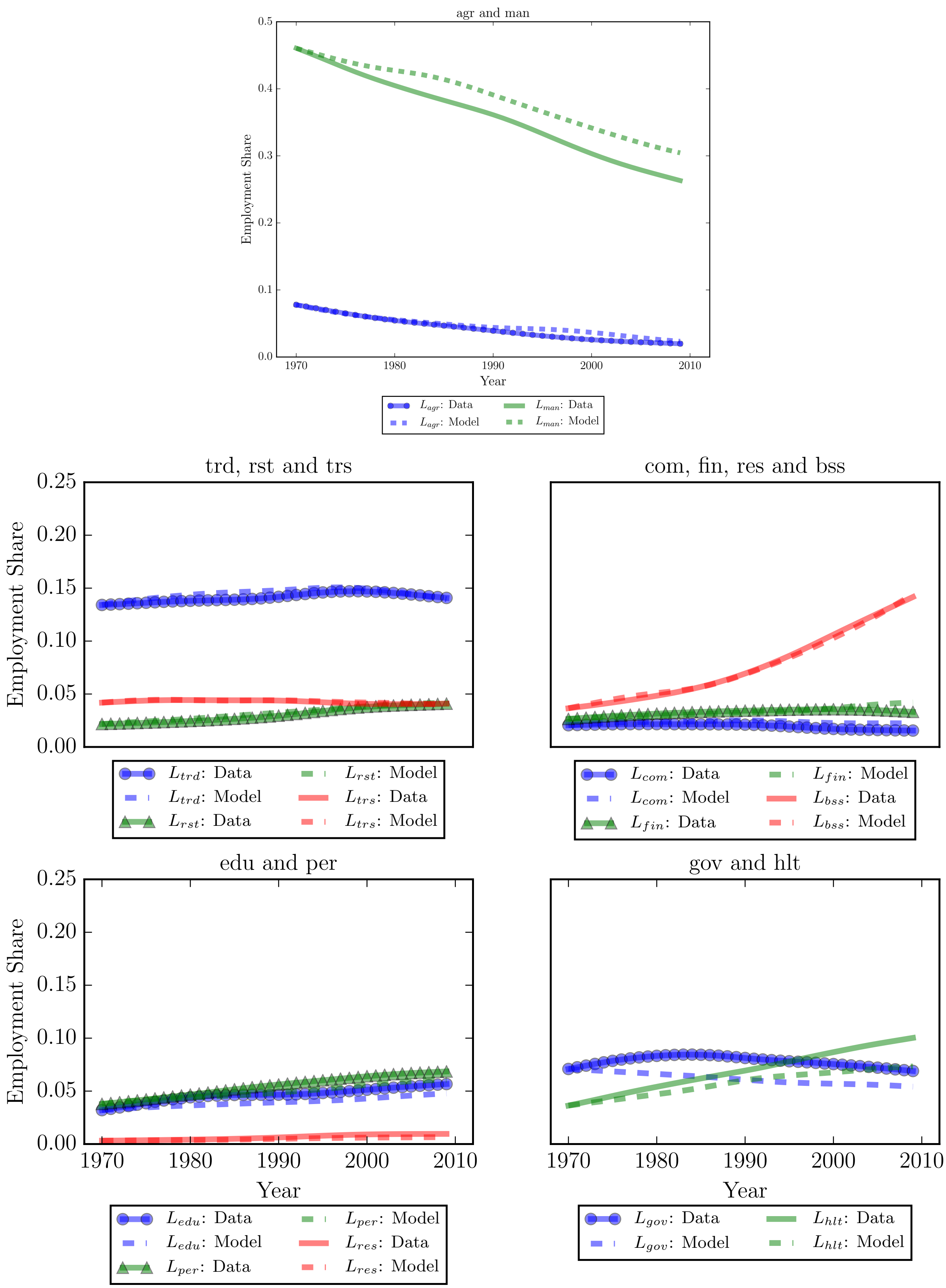


Figure 31: Sectoral Employment Shares - Calibrated Model vs. Data - Italy

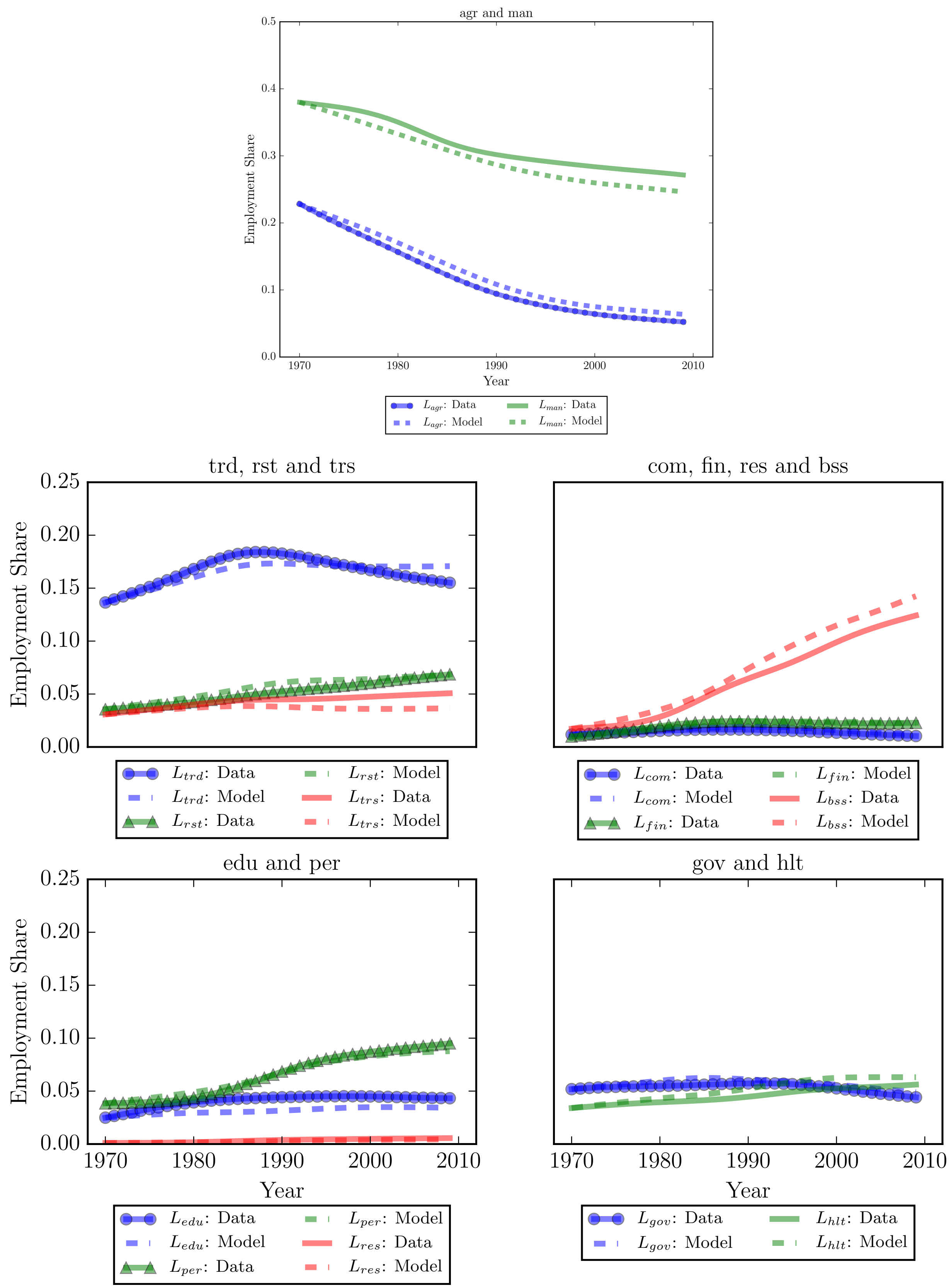


Figure 32: Sectoral Employment Shares - Calibrated Model vs. Data - Netherlands

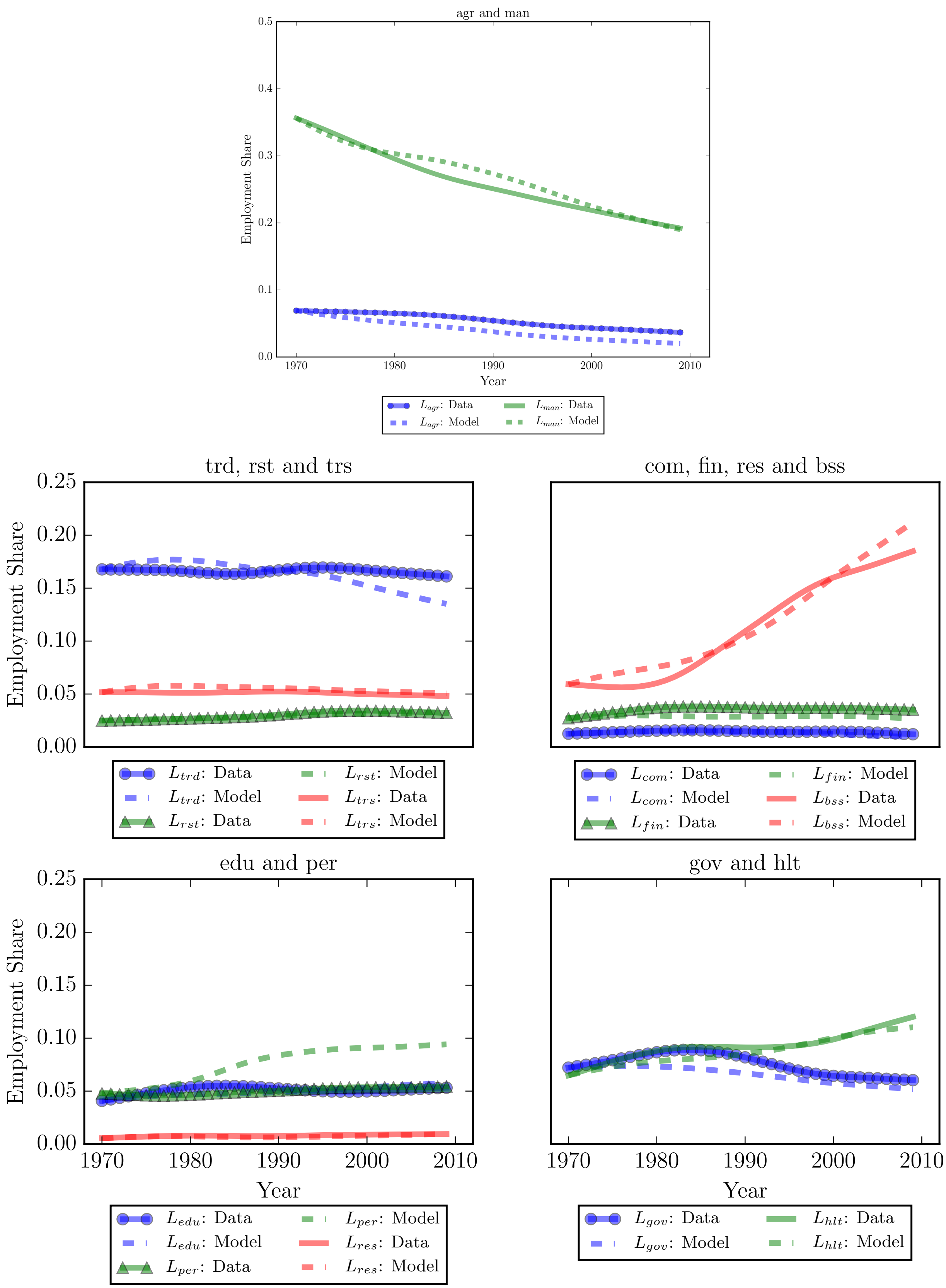


Figure 33: Sectoral Employment Shares - Calibrated Model vs. Data - Spain

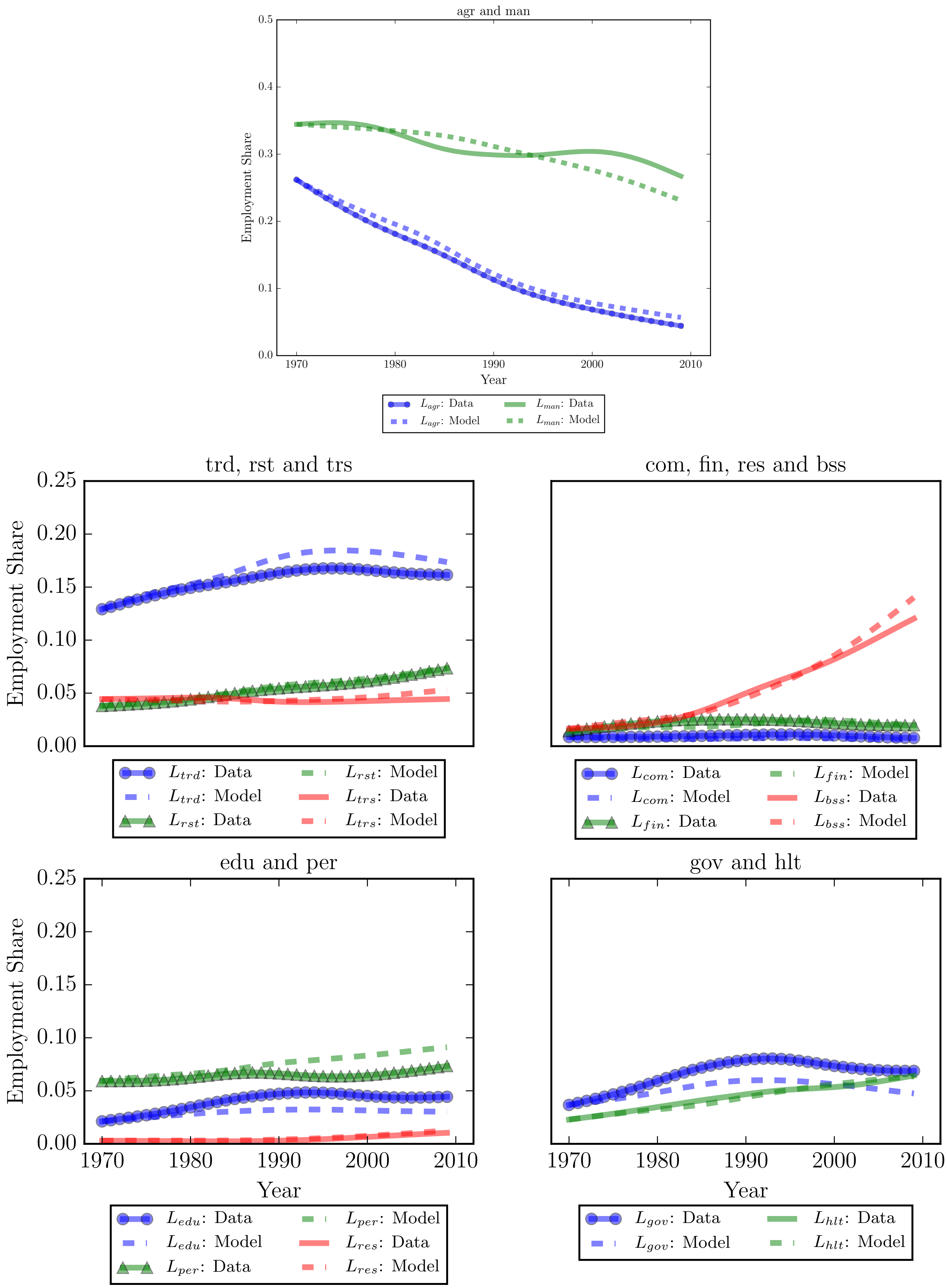


Figure 34: Sectoral Employment Shares - Calibrated Model vs. Data - Great Britain