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Abstract

This paper studies how the variation in sectoral productivities shapes the sectoral composition of the Spanish economy from 1980 to 2015. I first document an asymmetric behavior of sectoral productivities: the productivity of services declines over time, whereas the productivity of manufacturing increases until the 1990s, before slowing down. I feed the path of sectoral productivities observed in the data into a model of structural transformation with two sectors (services and manufacturing) which are connected by an Input-Output matrix. The model reproduces the variation of the gross output services share of the Spanish economy between 1980 and 2015. The model implies that – even absent changes in the trends of sectoral productivities – the annual growth rate of GDP between 2015 and 2050 shrinks by 0.6 percentage points with respect to the average growth rate between 1980 and 2015. Hence, annual GDP growth would decline from 2.3% to 1.7%. If sectoral productivities were to equal the levels observed in the Euro Area between 1980 and 2015, the average growth rate of Spanish GDP between 2015 and 2050 would be 2.1%.

Keywords: sectoral analysis, Input-Output matrix, Spanish economy.

JEL classification: O11, O14, O4.

Resumen

Este artículo estudia la variación de la composición sectorial de la economía española desde 1980 hasta 2015 desarrollando un modelo de equilibrio general de transformación estructural con dos sectores: servicios y manufacturas. Utilizando las sendas de productividad sectoriales observadas en los datos como *shocks* exógenos, el modelo reproduce la variación de la cuota de los servicios en el producto bruto total de la economía española entre 1980 y 2015. Incluso en ausencia de cambios en las tendencias de las productividades sectoriales, en el modelo la tasa de crecimiento anual del PIB entre 2015 y 2050 se reduce en 0,6 puntos porcentuales con respecto a la tasa de crecimiento promedio hasta 2015. Por lo tanto, el crecimiento anual del PIB disminuiría de 2,3% a 1,7%. Si las productividades sectoriales fueran iguales a los niveles de la zona del euro, la tasa media de crecimiento del PIB español entre 2015 y 2050 sería del 2,1%.

Palabras clave: análisis sectorial, matriz de *Input-Output,* economía española.

Códigos JEL: O11, O14, O4.

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1 Introduction

Over time advanced economies experience a process of structural transformation, in which the sectoral composition of economic activity shifts from the manufacturing sector into services (Kongsamut et al., 2001; Duarte and Restuccia, 2010; Herrendorf et al., 2013). The Spanish economy is no exception. The relative importance of services has been rising steadily over time, starting to peaking up relatively later – but a faster rate – than in the United States and other European countries. For instance, the share of services in employment grew from a value of 35% in 1960 to a value above 70% in 2015 (Gonzalez-Diez and Moral-Benito, 2019). This paper revisits the variation in the sectoral composition of the Spanish economy and the rise of the services sector and makes four main novel contributions.

First, I study the change in the relevance of manufacturing and services industries by measuring the contribution of each sector in the aggregate levels of Spanish gross output. I show that the share of services in gross output increased from a value of 48% in 1980 to 66% in 2015. Part of this variation was driven by a rise in the relevance of services industries within the Input-Output matrix of the Spanish economy. Indeed, the services share of intermediate inputs used by services industries increased from 57% in 1980 to 80% in 2005, whereas the services share of intermediate inputs used by manufacturing industries increased from 16% in 1980 to 30% in 2005. This evidence points out that also the network structure connecting the different industries of the economy undergoes radical changes in its sectoral composition, a phenomenon that Galesi and Rachedi (2019) refer to as services deepening.

Second, I look at the dynamics of aggregate and sectoral productivities between 1980 and 2015. I uncover a set of novel facts: (*i*) aggregate value added productivity was increasing in the 1980s at an annual growth rate similar to the one observed in the United States, before experiencing a stagnant period of no growth during the 1990s. From then on, aggregate productivity started declining at a steady rate. Overall, the level of aggregate productivity in 2015 equals the level in 1980, implying that on average productivity did not grow throughout these thirty-five years. Then, (*ii*) the dynamics of aggregate productivity masks vast heterogeneity in sectoral productivities. On the one hand, manufacturing productivity grew at an average annual rate of 0.6% between 1980 and 2015. This increase is mainly concentrated between 1980 and 1995, in which the growth rate reached a peak average rate of 2.3%. From 1995 on, manufacturing productivity has been stagnant until the early 2000, and then dropped down over the last decade. On the other hand, services productivity was fairly constant during the 1980s, and from then on has been decreasing at a stable pace. Overall, services productivity shrunk by annual growth rate of -0.3% between 1980 and 2015. Finally, (*iii*) consistently with the evidence of Duernecker et al. (2019) and Duarte and Restuccia (2020), I highlight substantial heterogeneity in the dynamics of productivity even when looking at the distinct industries within the services sector. For instance, the productivity of information services increased by an annual growth rate of 0.8% between 1980 and 2015, whereas the productivities of accommodation and food services and professional services dropped by -2.1% and -3.2%, respectively.

Third, I build a model of structural transformation and services deepening and calibrate it to the variation in the sectoral composition of the Spanish economy between 1980 and 2015. The model consists of a static version of the environment of Galesi and Rachedi (2019): the economy has two sectors – services and manufacturing – connected by an Input-Output matrix. Accordingly, the final gross output of each sector can either be consumed or used as an intermediate inputs in the production of each industry. Each sector derives gross output by combining labor and intermediate inputs with a Cobb-Douglas technology. The gross output of each sector depends also on the level of sector-specific productivities, that grow over time at different exogenous rates. The model features a representative household which derives utility from aggregate consumption. Importantly, the functions that bundle together either the consumption of both sectors into an aggregate consumption good or the intermediate inputs of both sector into a final intermediate good are CES aggregators with a non-unitary elasticity of substitution across sectors. In this setup, the variation of the sectoral composition of the economy comes from a Baumol (1967) disease mechanism similar to the one emphasized by Ngai and Pissarides (2007), which builds on two ingredients: as long as (*i*) manufacturing productivity increases more rapidly than the productivity of services, and (*ii*) the elasticity of substitution of consumption and intermediate inputs is below one, then the share of services rises over time.

Then, I calibrate the model to the Spanish economy. Namely, I feed the model with the paths of sectoral productivities observed in the data between 1980 and 2015, choose an elasticity of substitution of consumption and intermediate inputs very close to zero (Herrendorf et al., 2013), and set the parameters such that the model can replicate the services share of gross output of 1980. This calibration strategy manages to deliver a model-implied path for the services share of gross output between 1980 and 2015 which tracks remarkably well the dynamics of the share observed in the data. Hence, the model is an ideal laboratory to look at the causes and implications of structural transformation for the Spanish economy. Importantly, I find a relevant role for services deepening in accounting for the time variation of the services share of gross output. Indeed, when I abstract from the changes in the sectoral composition of intermediate inputs and consider an Input-Output matrix which is kept constant with the sectoral split of 1980, then the model explains just 60% of the rise of services in gross output. This finding confirms the results of Galesi and Rachedi (2019), that emphasize that the presence of services deepening via the variation in the services share of intermediate inputs can improve the fit of structural transformation models.

Fourth, I use the model to look at the implications of structural transformation on the dynamics of the Spanish economy going forward, from 2015 to 2050. More precisely, I assume that from 2015 to 2050 the Spanish economy will experience the same path of sectoral productivities observed in the data from 1980 to 2015, and compare the implied average annual growth rate of GDP over 1980-2015 and 2015-2050. This approach allows me to isolate the role of rising services in the determination of aggregate productivity over the two periods of interest, while avoiding to impose any additional stance of the future trends of sectoral productivity. In this way, I can ask how much the average growth rate of GDP will change going forward due to the reallocation towards services even in the case there is no variation in the underlying path of sectoral productivities.

The model implies that the rise of services – which is the sector with relatively lower (and even negative) productivity growth – will dampen substantially GDP growth: the average annual GDP growth from 2015 to 2050 will be 0.6 percentage points lower than the average annual GDP growth from 1980 to 2015. Since real GDP grew at an annual rate of 2.3% over the last thirty-five years, the model implies that over the next three decades annual GDP will grow at a rate of 1.7%. Finally, I consider a counterfactual case in which the path of sectoral productivities from 2015 to 2050 follows the path observed in the data in Euro area countries from 1980 to 2015. In this alternative scenario the economy keeps experiencing a rise of the services sector, but with a level of sectoral productivities which is higher than the one observed in the Spanish economy. In this alternative exercise, the model implies that the drop in GDP growth going forward would be very limited, as the average growth rate from 2015 to 2050 would equal 2.1%. Hence, if the sectoral productivities of the Spanish economy manages to increase over time, the process of structural transformation would have a much smaller dampening effect of the future path of GDP growth.

2 Empirical Evidence

This section reports the empirical evidence on both the changes in the sectoral composition of the Spanish economy and the rise of services, and the trends in aggregate and sectoral productivities.

I start by showing the variation in the services share of the Spanish economy over time. I look at the services share of five different variables: gross output, value added, employment, services intermediate inputs, and manufacturing intermediate inputs. I assume that the whole economy equals the sum of services and manufacturing industries, so that my empirical evidence connects explicitly to the model-based moments describing the process of structural transformation from manufacturing to services. All the moments are derived by using information of the World KLEMS project (Jorgenson, 2007). For each variable I report the services share in 1980, 2005, and 2015. I consider the year 2005 as it is the last period of time in which the World KLEMS data give information on the sectoral composition of intermediate inputs.

Table 1 reports the services shares of the Spanish economy in 1980, 2005, and 2015. The table shows that the services share of the economy has been rising substantially from the 1980s, generating for instance a 38.4% increase in the services share of gross output between 1980 and 2015. A similar change also characterizes the services share of employment. Instead, the rise of services when looking at the sectoral composition of value added is much more muted, as the overall change is 23.9%. The lower increase of the services share of value added relative to the variation in the services share of gross output is due to the fact that gross output equals the sum of value added and intermediate inputs, and the sectoral composition of intermediate inputs has been also changing dramatically over the recent decades. The services share of intermediate inputs used by the services sector has increased by 21.9% between 1980 and 2005, whereas the analogous share computed over the intermediate inputs used by the manufacturing sector has almost doubled over the same period of interest. Hence, the shifts in the sectoral composition of the Input-Output matrix of the economy add to the variation in the services share of value added to then generate an even larger change in the rise of services at the gross output level.

Importantly, as shown by Gonzalez-Diez and Moral-Benito (2019) and Galesi and Rachedi (2019), these trends are roughly in line with the experience of other advanced economies, with the only difference that Spain has been experiencing the process of servicization relatively later, to then catch up at a faster rate.

Table 1: The Change in the Sectoral Composition of the Spanish Economy

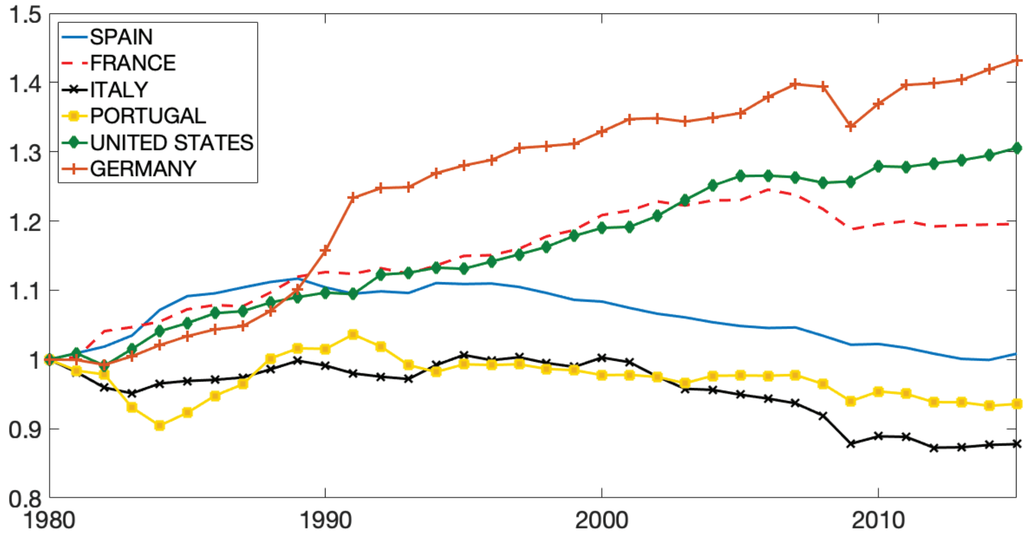
	1980	2005	2015	Δ% 1980-2005	Δ% 1980-2015
Services Share of Gross Output	47.8%	66.2%	67.6%	+38.4%	+41.2%
Services Share of Value Added	65.6%	81.3%	83.8%	+23.9%	+27.8%
Services Share of Employment	61.0%	78.7%	84.1%	+37.9%	+36.2%
Services Share of Services Intermediate Inputs	57.0%	69.5%	-	+21.9%	-
Services Share of Manufacturing Intermediate Inputs	15.6%	30.0%	-	+92.4%	-

Note: This table reports the variation in the sectoral composition of the Spanish economy in 1980, 2005, and 2015. In particular, it shows the services share of gross output, value added, employment, the intermediate inputs used by the services sector, and the intermediate inputs used by the manufacturing sector. Source: World KLEMS Data.

Then, I turn into the analysis of the dynamics of value added productivity between 1980 and 2015, and again I use information from the World KLEMS Data. I start by looking at the aggregate productivity, and compare the experience of the Spanish economy with that of a selected group of advanced economies: France, Germany, Italy, Portugal, and the United States. Figure 1 reports the dynamics of aggregate productivity for each of these countries between 1980 and 2015, by normalizing the first observation to one.

Figure 1 shows that the country with the highest growth rate of aggregate productivity between 1980 and 2015 is Germany, with an average annual rate of 1%, and a dramatic acceleration amidst the reunification. After Germany, the country with the highest growth is the United States, which experienced an average annual growth rate of 0.8%. The productivity of France has been growing at a rate very similar to the one of the United States until the early 2000s, before experiencing a decade of stagnant growth: the level of the productivity

Figure 1: Value Added Productivity



Note: This figure shows the level of value added productivity for a group of selected countries (i.e., France, Germany, Italy, Portugal, Spain, and the United States) between 1980 and 2015. The productivities are normalized to be 1 in 1980. Source: World KLEMS Data.

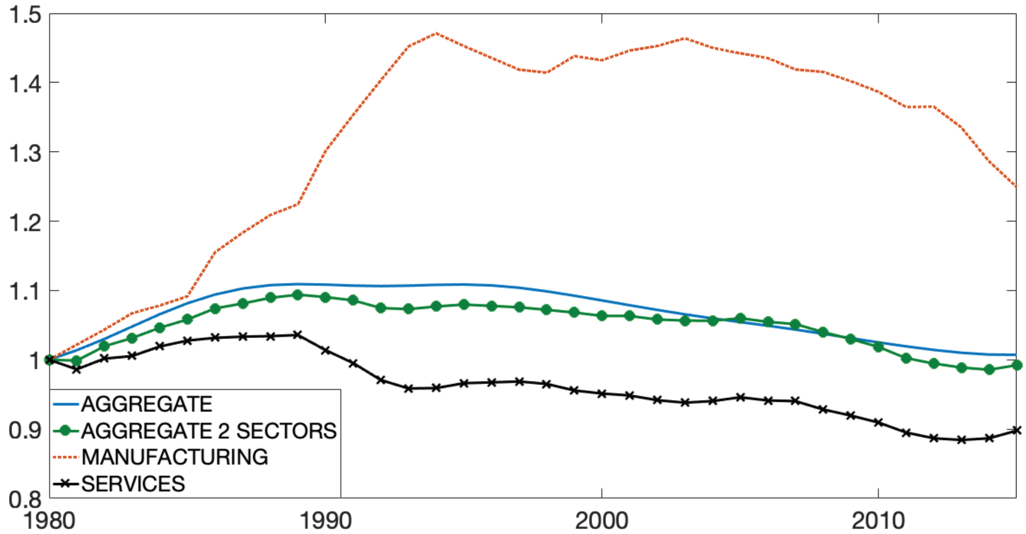
in 2015 equals that of 1999. As a result, the average annual growth rate for the productivity of France is 0.5%. On the other hand, both Italy and Portugal are characterized by a declining productivity: the 2015 level of productivity in Italy is 12% lower than the level observed in 1980, whereas the cumulative drop for the case of Portugal equals 6%. These patterns imply an average annual growth rate of productivity of -0.4% for Italy and -0.2% for Portugal.

The Spanish experience lies in the middle between the trends of the United States and France on the on hand, and those of Italy and Portugal on the other hand. The productivity of Spanish value added grew at a pace remarkably similar to that of the United States and France between 1980 and 1995: over these years the average annual growth rate was above 1%. Then, from the 1995, productivity started to slowing down, to then reach in 2015 the same level it had back in 1980. This result implies that the improvements in Spanish productivity between 1980 and 1995 have been lost over the following two decades. This evidence is consistent with that of Gopinath et al. (2017) and Garcia-Santana et al. (2020), that pointed out how rising misallocation of resources has been driving down the level of productivity of the Spanish economy.

Then, I show that the dynamics of aggregate productivity of the Spanish economy mask a vast heterogeneity in the sectoral trends of value added TFP. Figure 2 reports the productivities of aggregate value added, services value added, and manufacturing value added, together with a measure of aggregate value added productivity that considers total output as just the sum of services and manufacturing. The first observation is that as manufacturing and services account for a very large share of total value added, the trend of aggregate productivity coincides with that of the alternative aggregate series which is just based on services and manufacturing. This evidence corroborates the fact that the focus of this paper on just two sectors – services and manufacturing – is able to capture most of the variation in aggregate productivity. The second observation is that manufacturing productivity has been experiencing a dramatic growth until the mid 1990s: the average annual growth rate of manufacturing productivity between 1980 and 1995 is 2.5%. From then on, it went through a decade of no growth, before going down from the late 2000s on. Overall, the annual growth rate of manufacturing productivity between 1980 and 2015 is 0.6%. On the other hand, services productivity has been rather stagnant until the 1990, before decreasing at a constant rate: the annual growth rate of services productivity between 1980 and 2015 is -0.3%.

What drives the poor performance of the productivity of services value added? I address this question by looking at the dynamics of productivity of the industries within the services sector, to highlight that the broad classification of services is actually bundling all together industries with very different fortunes over time, in line with the evidence of Duernecker et al. (2019) and Duarte and Restuccia (2020). In particular, I look at eleven industries within the boundaries of the services sector: wholesale and retail trade, transportation services, accommodation and food services, information services, financial services, real estate services, professional services, the government and public services, education ser-

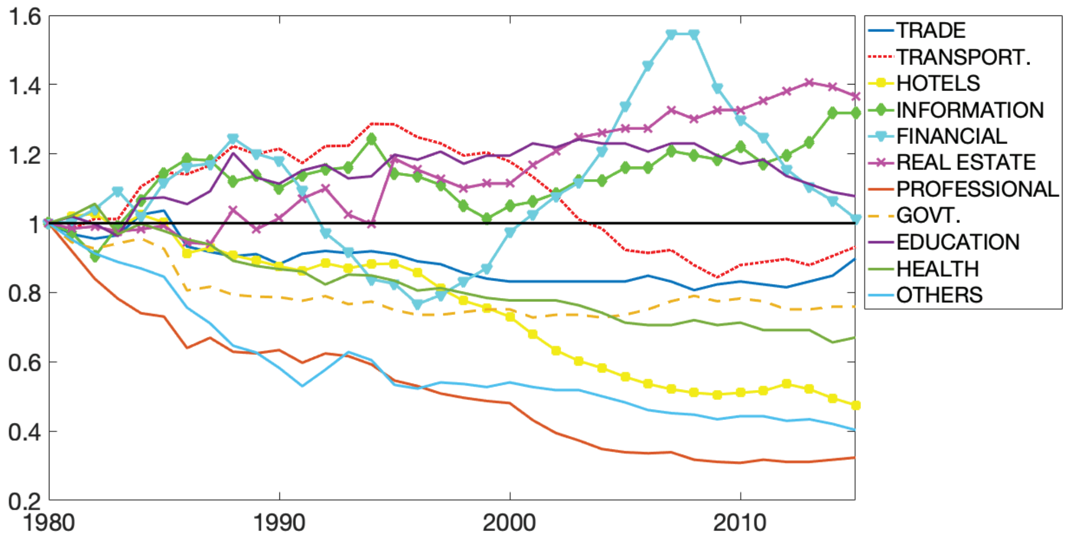
Figure 2: Value Added Productivity Across Sectors



Note: This figure shows the level of value added productivity for a group of selected countries (i.e., France, Italy, Portugal, Spain, and the United States) between 1980 and 2015. The productivities are normalized to be 1 in 1980. Source: World KLEMS Data.

vices, health care services, and other services. Then, I look at the value added productivity for each of this sector between 1980 and 2015, again by normalizing the first observation to one, and report all the series in Figure 3.

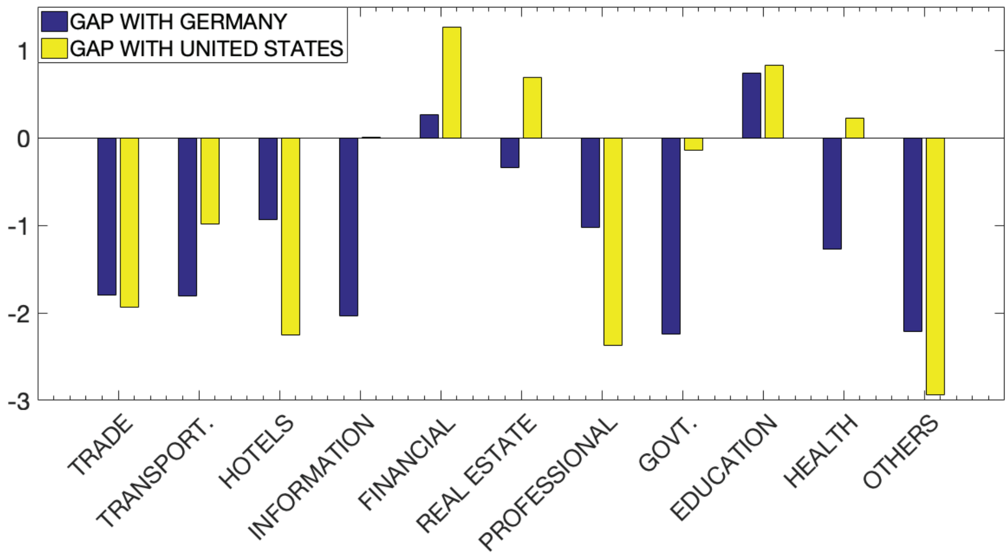
Figure 3: Value Added Productivity of Services Industries



Note: This figure shows the change in productivity at the sectoral level for different service industries (i.e., wholesale and retail trade, transportation services, accommodation and food services, information services, financial services, real estate services, professional services, government and public services, education services, health services, and other services) of the Spanish economy between 1980 and 2015. The productivities are normalized to be 1 in 1980. Source: World KLEMS Data.

Figure 3 shows that there is a vast heterogeneity in the growth rates of value added productivity within the services sector. For instance, the annual growth rate of the productivity of professional services is -3.2%. Similar highly negative growth rates characterize also the accommodation and food services, which have an annual rate for their productivity that equals -2.1%. On the other hand, there are few services industries with booming productivity, such as information services, whose value added TFP has been increasing at an average annual rate of 0.8%.

Figure 4: Services Productivity Gap with Germany and the United States



Note: This figure shows the wedge of the change in productivity at the sectoral level for different services industries (i.e., wholesale and retail trade, transportation services, accommodation and food services, information services, financial services, real estate services, professional services, government and public services, education services, health services, and other services) of the Spanish economy between 1980 and 2015 and the change in productivity observed for the same set of industries and over the same period of time in Germany and the United States. Source: World KLEMS Data.

I then compute the average annual growth rate for the productivity of each of these industries, and compare it to the analogous moments for the same set of industries of Germany and the United States. In this way, I derive a measure of the productivity gap, that is, the difference between the growth rate of a given industry in Spain relative to the growth rate of the same industry in either

Germany or the United States. A positive number suggests that a given industry grows faster in Spain than elsewhere, whereas a negative number suggests that the improvements in the productivity of that industry in Spain are lower than in foreign economies. Figure 4 reports the results of this exercise. A positive – yet limited – gap emerges only for the financial, real estate, and education services (and also heath care services when comparing it to the United States).[1]

Overall, the findings of Figure 4 and Figure 2 taken together hint to the fact that the negative growth rate of industries such as accommodation and food services and professional services may be behind the poor performance of productivity of the services sector in Spain, especially when comparing it to other economies.

3 Model

The economy is populated by an infinitely-lived risk-neutral[2] representative household which supplies inelastically labor N_t and has preferences over consumption C_t, such as it maximizes the expected discounted life-time utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t C_t, \tag{1}$$

where β is the time discount of households. Aggregate consumption is defined as

$$C_t = \left[\omega_C^{\frac{1}{\nu_C}} \, C_{s,t}^{\frac{\nu_C - 1}{\nu_c}} + (1 - \omega_C)^{\frac{1}{\nu_C}} \, C_{m,t}^{\frac{\nu_C - 1}{\nu_C}} \right]^{\frac{\nu_C}{\nu_C - 1}}, \tag{2}$$

[1] The productivity gap of the public sector vis-á-vis Germany could be driven by different accounting standards used to compute the number of federal public employees. For an analysis of the components of the public sector gross output and value added – and their changes over time – see Moro and Rachedi (2018).

[2] Since the quantitative analysis is derived on a sequence of steady-state, the risk aversion of the household does not alter the results of the paper. For studies on the business cycle implications of structural transformation models, see Moro (2012, 2015), Galesi and Rachedi (2019), and Rubini and Moro (2019), and also Moro and Valdes (2019) for a review of the literature.

in which $C_{s,t}$ is services consumption goods, $C_{m,t}$ is manufacturing consumption goods, ω_C denotes the share of services in the CES aggregator, and ν_C is the elasticity of substitution between services and manufactured consumption goods. Accordingly, the budget constraint of the representative household reads

$$P_{s,t}C_{s,t} + P_{m,t}C_{m,t} = N_t \tag{3}$$

in which $P_{s,t}$ and $P_{m,t}$ denote the price of services and manufacturing, respectively, whereas I set the wage to unity as it is the numeraire of the economy. The household consumes services and manufacturing consumption goods such as this optimal condition holds

$$\frac{C_{s,t}}{C_{m,t}} = \frac{(1-\omega_C)}{\omega_C}\left(\frac{P_{m,t}}{P_{s,t}}\right)^{\nu_C}. \tag{4}$$

Hence, in the empirically relevant case in which the elasticity of substitution is below one (Herrendorf et al., 2013), then an increase in the price of services relative to the price of manufacturing reduces the consumption of manufacturing goods, thus raising the services share of consumption.

Then, the production side of the model features two sectors – services and manufacturing – each one consisting of a representative firm assembling final output using labor and intermediate inputs, and a firm transforming services and manufacturing goods into intermediate inputs. The representative services final-good firm produces gross output $Y_{s,t}$ with a Cobb-Douglas technology

$$Y_{s,t} = A_{s,t}N_{s,t}^{\alpha_S}H_{s,t}^{1-\alpha_S} \tag{5}$$

in which $A_{s,t}$ denotes services productivity, $N_{s,t}$ is services employment, $H_{s,t}$ is services intermediate inputs, and α_S denotes the share of labor in services gross output.[3] The firm chooses employment and intermediate inputs to maximize profits

$$\max_{N_{s,t},H_{s,t}} P_{s,t}Y_{s,t} - N_{s,t} - P_{H,s,t}H_{s,t} \tag{6}$$

where $P_{H,s,t}$ is the price of intermediate inputs used in the services sector, which yields the following standard first-order conditions for labor

$$N_{s,t} = \alpha_S P_{s,t}Y_{s,t} \tag{7}$$

and intermediate inputs

$$H_{s,t} = \frac{(1-\alpha_S)\, P_{s,t}Y_{s,t}}{P_{H,s,t}}. \tag{8}$$

The final-good firm purchases $H_{s,t}$ from the intermediate-input firm, which in turn purchases materials from both the services and manufacturing sector and convert them into intermediate inputs. The firm produces the intermediate inputs $H_{s,t}$ with the CES aggregator

$$H_{s,t} = \left[\omega_S^{\frac{1}{\nu_S}}\, S_{s,t}^{\frac{\nu_S-1}{\nu_S}} + (1-\omega_S)^{\frac{1}{\nu_S}}\, M_{s,t}^{\frac{\nu_S-1}{\nu_S}}\right]^{\frac{\nu_S}{\nu_S-1}}, \tag{9}$$

where $S_{s,t}$ denotes the intermediate inputs produced by the services sector and then used by the services sector itself, while $M_{s,t}$ is the intermediate inputs used by the services sector but produced by the manufacturing sector. The parameter ω_S denotes the share of services in the CES aggregator, whereas ν_S is the elasticity of substitution between services and manufactured intermediate inputs. The maximization problem of the intermediate-input producer reads

$$\max_{S_{s,t},M_{s,t}} P_{H,s,t}H_{s,t} - P_{s,t}S_{s,t} - P_{m,t}M_{s,t} \tag{10}$$

[3]The Cobb-Douglas technology implies that at the sectoral level there is no variation over time in the share of labor in gross output. Karabarbounis and Neiman (2014) document a secular decline in the labor share, but their analysis focuses on the contribution of labor in total value added, and highlights a secular increase in the broad remuneration of capital within value added. Hence, the declining labor share does not affect my analysis as the model abstracts from capital. Rather, the Cobb-Douglas technology is motivated by the evidence of Moro (2012, 2015), and Duarte (2020), which shows that the share of intermediate inputs in gross output is rather constant over time, for both services and manufacturing.

which yields the optimal amount of services and manufacturing intermediate inputs to purchase

$$S_{s,t} = \omega_S \left(\frac{P_{s,t}}{P_{H,s,t}} \right)^{-\nu_S} H_{s,t} \tag{11}$$

and

$$M_{s,t} = (1 - \omega_S) \left(\frac{P_{m,t}}{P_{H,s,t}} \right)^{-\nu_S} H_{s,t}, \tag{12}$$

and also implicitly defines the price of total services intermediate inputs $P_{H,s,t}$ as

$$P_{H,s,t} = \left[\omega_S \, P_{s,t}^{1-\nu_S} + (1 - \omega_S) \; P_{m,t}^{1-\nu_S} \right]^{\frac{1}{1-\nu_S}} . \tag{13}$$

Analogously, in the manufacturing sector the representative final-good firm produces gross output $Y_{m,t}$ with a Cobb-Douglas technology

$$Y_{m,t} = A_{m,t} N_{m,t}^{\alpha_M} H_{m,t}^{1-\alpha_M} \tag{14}$$

in which $A_{m,t}$ denotes manufacturing productivity, $N_{m,t}$ is manufacturing employment, $H_{m,t}$ is manufacturing intermediate inputs, and α_M denotes the share of labor in manufacturing gross output. Importantly, I let the share of labor to differ across sectors to capture the fact that in the data the services sector is as twice as intensive in labor than manufacturing. The firm chooses employment and intermediate inputs to maximize profits

$$\max_{N_{m,t}, H_{m,t}} P_{m,t} Y_{m,t} - N_{m,t} - P_{H,m,t} H_{m,t} \tag{15}$$

where $P_{H,m,t}$ is the price of intermediate inputs used in the services sector. The standard first-order condition for labor equals

$$N_{m,t} = \alpha_M P_{m,t} Y_{m,t} \tag{16}$$

and the optimal condition for intermediate inputs is

$$H_{m,t} = \frac{(1 - \alpha_M) \, P_{m,t} Y_{m,t}}{P_{H,m,t}} . \tag{17}$$

The bundle of intermediate inputs $H_{m,t}$ is purchased from the intermediate-input producer, which uses the CES aggregator

$$H_{m,t} = \left[\omega_M^{\frac{1}{\nu_M}} S_{m,t}^{\frac{\nu_M - 1}{\nu_M}} + (1 - \omega_M)^{\frac{1}{\nu_M}} M_{m,t}^{\frac{\nu_M - 1}{\nu_M}} \right]^{\frac{\nu_M}{\nu_M - 1}}, \tag{18}$$

where $S_{m,t}$ denotes the intermediate inputs produced by the services sector and then used by manufacturing , while $M_{m,t}$ is the intermediate inputs both produced and used by the manufacturing sector. The parameter ω_M denotes the share of services in the CES aggregator, whereas ν_M is the elasticity of substitution between services and manufactured intermediate inputs. The maximization problem of the intermediate-input producer reads

$$\max_{S_{m,t}, M_{m,t}} P_{H,m,t} H_{m,t} - P_{s,t} S_{m,t} - P_{m,t} M_{m,t} \tag{19}$$

which yields the optimal amount of services and manufacturing intermediate inputs to purchase

$$S_{m,t} = \omega_M \left(\frac{P_{s,t}}{P_{H,m,t}} \right)^{-\nu_M} H_{m,t} \tag{20}$$

and

$$M_{m,t} = (1 - \omega_M) \left(\frac{P_{m,t}}{P_{H,m,t}} \right)^{-\nu_M} H_{m,t}, \tag{21}$$

and again implicitly defines the price of total manufacturing intermediate inputs $P_{H,m,t}$ as

$$P_{H,m,t} = \left[\omega_M \, P_{s,t}^{1-\nu_M} + (1 - \omega_M) \, P_{m,t}^{1-\nu_M} \right]^{\frac{1}{1-\nu_M}}. \tag{22}$$

In this setup, Equations (11), (12), (20), and (21) characterize the Input-Output of the economy. The optimal conditions define a mechanism analogous to that of the first-order condition of consumption, in which an increase in the relative price of services raises the share of services within the Input-Output matrix, as long as the elasticities of substitution of intermediate inputs across sectors ν_S amd ν_M are below one.

The resource constraint at the sectoral level implies that the gross output is split into consumption goods or intermediate inputs used by either industry, that is

$$Y_{s,t} = C_{s,t} + S_{s,t} + S_{m,t}, \tag{23}$$

and

$$Y_{m,t} = C_{m,t} + M_{s,t} + M_{m,t}. \tag{24}$$

Finally, the labor market clearing posits that the labor endowment of the household equals the sum of the sectoral employment

$$N_t = N_{s,t} + N_{m,t}, \tag{25}$$

under the implicit assumption that labor is perfectly mobile across sectors.

3.1 The Rise of Services: An Analytical Characterization

I uncover the mechanisms behind the endogenous variation in the services share of the economy in the model, by deriving analytically the relationship between the changes in the sectoral productivities and the sectoral composition of both value added and intermediate inputs.

First, I characterize the process of structural transformation, and isolate it by looking at the variation in the services share of value added. Under the assumptions that the production of the final good only requires labor, so that $\alpha_S = \alpha_M = 1$, then sectoral prices equal the inverse of sectoral productivities, that is, $P_{s,t} = 1/A_{s,t}$ and $P_{m,t} = 1/A_{m,t}$, and the relative price of services in terms of manufacturing goods equals the ratio between manufacturing and services productivity, that is, $\frac{P_{s,t}}{P_{m,t}} = \frac{A_{m,t}}{A_{s,t}}$. Thus, the relative price of services increases when the manufacturing sector becomes more productive than the services sector.

In this setup, it turns out that the services share of value added coincides with the services share of employment, that is

$$\frac{P_{s,t}Y_{s,t}}{P_{s,t}Y_{s,t}+P_{s,t}Y_{m,t}}=\frac{N_{s,t}}{N_{s,t}+N_{m,t}}=\frac{\omega_C\left(\frac{A_{m,t}}{A_{s,t}}\right)^{1-\nu_C}}{\omega_C\left(\frac{A_{m,t}}{A_{s,t}}\right)^{1-\nu_C}+(1-\omega_C)}. \qquad (26)$$

The derivative of the services share of employment with respect to changes in the relative productivity of manufacturing vis-á-vis the productivity of services is

$$\frac{\partial\left(\frac{N_{s,t}}{N_{s,t}+N_{m,t}}\right)}{\partial\frac{A_{m,t}}{A_{s,t}}}=\frac{\omega_C\left(1-\omega_C\right)\left(1-\nu_C\right)\left(\frac{A_{m,t}}{A_{s,t}}\right)^{-\nu_C}}{\left[\omega_C\left(\frac{A_{m,t}}{A_{s,t}}\right)^{1-\nu_C}+(1-\omega_C)\right]^2}. \qquad (27)$$

A rise in the relative productivity of manufacturing increases the relevance of services value added only as long as the elasticity of substitution $\nu_C < 1$, which means that services consumption and manufacturing consumption are complementary.[4] This positive derivative captures the Baumol (1969) cost disease channel, according to which the relative productivity affects the sectoral allocation of consumption by changing the relative price across sectors. Since the household considers the consumption of manufacturing and services as complementary goods, the rise in the productivity of the manufacturing sectors makes it optimal to shift the employment towards services. In this way, the reallocation of employment boosts the final output of services, which can keep up with the rising production of the highly productive manufacturing sector.

[4] With a unitary elasticity of substitution, such that the CES aggregator becomes a Cobb-Douglas function, the services share of employment is constant over time, independently of the variation in sectoral productivities Ngai and Pissarides (2007). In the analysis, we follow Herrendorf et al. (2013), and set the elasticity of substitution of consumption across sectors to be below one. The literature on multi-sector models that look at business cycle frequency tends to assume an elasticity of substitution of consumption across sectors above one (Bouakez et al., 2018; Pasten et al., 2020). However, this strand of papers look at the short-term elasticity of substitution, whereas here the focus is on the long-run complementarities between services and manufacturing. Moreover, Hobijn and Nechio (2019) show how the value of the elasticity depends on the level of disaggregation across sectors: the elasticity is above one only for very fine levels of disaggregation that dig deeper than 2-digit NAICS industries (i.e., the elasticity is above one when considering at least 20 industries). The parameter ν_C should not be confused with the elasticity of substitution across varieties used typically by New Keynesian models, or models featuring monopolistic competition (Christiano et al., 2005). In this strand of the literature, the elasticity governs the substitution of varieties within a sector, whereas I focus on the elasticity of substitution across sectors.

Second, I characterize the variation in the services share of intermediate inputs. In this case, I assume that the production of the final good only requires intermediate inputs, $\alpha_S = \alpha_M = 0$. Then, the services share of intermediate inputs used by the services sector and the manufacturing sector equal respectively

$$\frac{P_{s,t}S_{s,t}}{P_{s,t}S_{s,t} + P_{m,t}M_{s,t}} = \frac{\omega_S \left(\frac{A_{m,t}}{A_{s,t}}\right)^{1-\nu_S}}{\omega_S \left(\frac{A_{m,t}}{A_{s,t}}\right)^{1-\nu_S} + (1-\omega_S)} \tag{28}$$

and

$$\frac{P_{s,t}S_{m,t}}{P_{s,t}S_{m,t} + P_{m,t}M_{m,t}} = \frac{\omega_M \left(\frac{A_{m,t}}{A_{s,t}}\right)^{1-\nu_M}}{\omega_M \left(\frac{A_{m,t}}{A_{s,t}}\right)^{1-\nu_M} + (1-\omega_M)}. \tag{29}$$

In this case, the derivatives of the services share of intermediate inputs used in either sector with respect to an increase in the relative productivity of manufacturing can be defined as

$$\frac{\partial \left(\frac{P_{s,t}S_{s,t}}{P_{s,t}S_{s,t}+P_{m,t}M_{s,t}}\right)}{\partial \left(\frac{A_{m,t}}{A_{s,t}}\right)} = \frac{\omega_S (1-\omega_S)(1-\nu_S) \left(\frac{A_{m,t}}{A_{s,t}}\right)^{-\nu_S}}{\left[\omega_S \left(\frac{A_{m,t}}{A_{s,t}}\right)^{1-\nu_S} + (1-\omega_S)\right]^2} \tag{30}$$

and

$$\frac{\partial \left(\frac{P_{s,t}S_{m,t}}{P_{s,t}S_{m,t}+P_{m,t}M_{m,t}}\right)}{\partial \left(\frac{A_{m,t}}{A_{s,t}}\right)} = \frac{\omega_M (1-\omega_M)(1-\nu_M) \left(\frac{A_{m,t}}{A_{s,t}}\right)^{-\nu_M}}{\left[\omega_M \left(\frac{A_{m,t}}{A_{s,t}}\right)^{1-\nu_M} + (1-\omega_M)\right]^2} \tag{31}$$

Both derivatives are positive as long as the elasticities of substitution of inputs is below one, that is, $\nu_S < 1$ and $\nu_M < 1$, which imply that manufacturing and services intermediates are relatively poor substitutes. Also this mechanism build on the Baumol disease channel, but this time the variation in relative productivities affects the sectoral composition of the Input-Output matrix, via a process that Galesi and Rachedi (2019) refer to as services deepening.

Overall, in the model the increase in the relative productivity of manufacturing leads to a rise in both the services share of value added (employment) and the services share of intermediate inputs, thereby amplifying the increase in the services share of gross output. For this reason, in the quantitative analysis we mainly focus on the variation in the sectoral composition of gross output, and we also perform a counterfactual exercise which abstracts from the services deepening to measure the relative contribution of the rise in services in value added and intermediate inputs.

4 Quantitative Results

4.1 Calibration

To calibrate the model, I set one period of the model to be one year. Then, I feed the model with the path of sectoral productivities observed in the data to derive the implications of the model on the services share of gross output. Importantly, since the model does not feature any inter-temporal decisions, I solve this exercise as a sequence of steady-states. For this very same reason, the calibration abstracts from setting a value for the time discount parameter β.[5]

The previous section has shown that the rise in the relative productivity of manufacturing increases the services share of either employment or intermediate inputs as long as the elasticity of substitution across sectors is below one. I calibrate the three key elasticities of the model, the one governing the substitution across sectoral consumption goods ν_C, and those capturing the substitution across sectoral intermediate inputs ν_S and ν_M, to be very close to 0, that is, $\nu_C = \nu_S = \nu_M = 0.01$. This choice is consistent with the empirical evidence of Herrendorf et al. (2013), that points out that the aggregator of consumption across services and manufacturing could well be a Leontieff function, with an elasticity of 0.

Given the elasticities, I set the weight of services in aggregate consumption, intermediate inputs used by the services sector, and intermediate inputs used by the manufacturing sector such as the model is consistent with these shares as observed in the data in 1980. Finally, I calibrate the share of labor in gross output in either sector by matching the average share of labor in gross output between

[5] This is also the reason why neither the assumption on the risk-neutrality of the household nor the fact that labor supply is inelastic alter the results of the analysis.

1980 and 2015, which yields the values of $\alpha_S = 0.5217$ and $\alpha_M = 0.2184$.[6] These values confirm the fact that the service sector is as twice as more intensive in labor than manufacturing. All calibrated parameters are reported in Table 2.

Table 2: Calibrated Parameter

Parameter	Description	Target/Source
$A_{s,t}$	Productivity of Services	Data on 1980-2015
$A_{s,t}$	Productivity of Manufacturing	Data on 1980-2015
$\omega_C = 0.8588$	Weight of Services in Aggregate Consumption	Services Share of Gross Output as of 1980
$\nu_C = 0.01$	Elasticity of Substitution of Consumption Across Sectors	Herrendorf et al. (2013)
$\alpha_S = 0.5217$	Share of Labor in Services Gross Output	Data
$\alpha_M = 0.2184$	Share of Labor in Manufacturing Gross Output	Data
$\omega_S = 0.6909$	Weight of Services in Intermediate Inputs Used by the Services	Services Share of Services Intermediate Inputs as of 1980
$\nu_S = 0.01$	Elasticity of Substitution of Services Intermediate Inputs Across Sectors	$\nu_S = \nu_C$
$\omega_M = 0.2365$	Weight of Services in Intermediate Inputs Used by the Manufacturing	Services Share of Manufacturing Intermediate Inputs as of 1980
$\nu_M = 0.01$	Elasticity of Substitution of Manufacturing Intermediate Inputs Across Sectors	$\nu_M = \nu_C$

Then, I consider also a counterfactual version of the model which abstracts from the process of services deepening, that is, I consider an economy in which the services share of value added changes endogenously over time but there is no variation in the sectoral composition of the Input-Output matrix. This economy sets the elasticities of substitution of intermediate inputs to $\nu_S = \nu_M = 1$, such as the aggregator becomes a Cobb-Douglas function, and I calibrate the weight

[6] I derive the labor share of gross output in the data as the ratio of the sectoral compensation of employees over the sum of the sectoral compensation of employees and the sectoral expenditure in intermediate inputs. In this way, the derivation of the labor share abstracts from the compensation of capital, consistently with the fact that in the model there is no capital.

of services in the aggregators such as the model is consistent with the services share of intermediate inputs as of 1980. In this way, the comparison of the baseline model with this counterfactual economy isolates the contribution of services deepening in accounting for the rise in the services share of gross output.

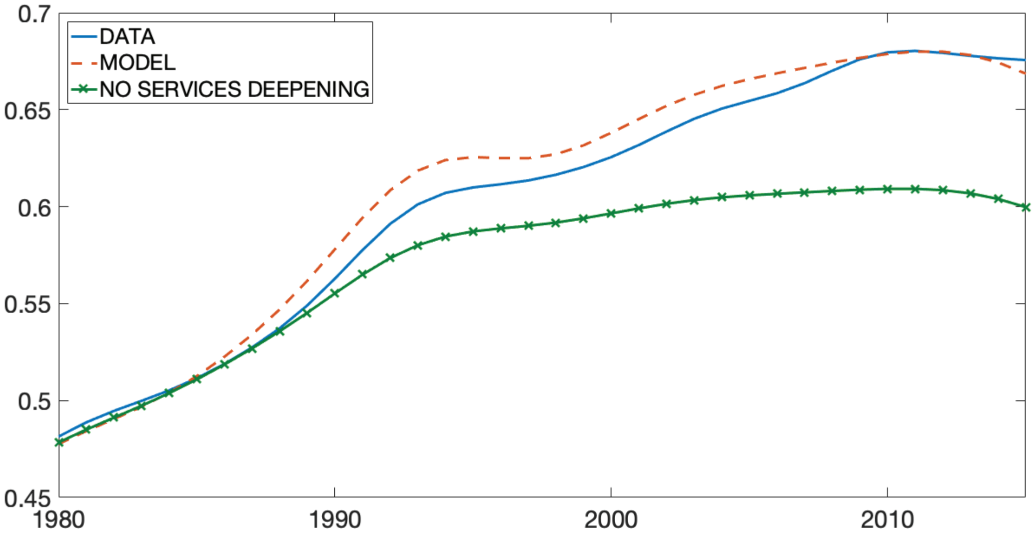
4.2 The Services Gross Share

Once I feed into the model the paths of productivity of the services and manufacturing sector observed in the data between 1980 and 2015, the model can successfully imply a path for the services share of gross output which tracks remarkably well the one observed in the data. Figure 5 reports the services share of gross output of Spanish economy between 1980 and 2015, together with the services share of gross output implied by both the baseline model and the model without services deepening. The baseline model can account really well for the size of the services sector in the last year of the sample, although it generates a bit of overshooting especially throughout the 1990 decade. However, the average annual difference between the services share of gross output implied by the model and that of the data is well below 1%.

To generate this successful fit the necessary feature is a very low elasticity of substitution of consumption and intermediate inputs across sectors, which I set to $\nu_C = \nu_S = \nu_M = 0.01$, at the lower end of the estimates of Herrendorf et al. (2013). If I set the elasticity to substitution to the higher value of $\nu_C = \nu_S = \nu_M = 0.4$, in line with the calibration choice in Duarte and Restuccia (2010), then the gross output share implied by the model as of 2015 is 61%, which means that this version of the model accounts for 62% of the the rise of the services share in gross output observed in the data.

What is the role for the changes in the sectoral composition of the Input-Output matrix to generate the fit of the model on the variation in the services share of gross output? The role of services deepening can be measured by comparing the implications of the baseline model with that of the model with no

Figure 5: The Services Share of Gross Output in the Model and the Data



Note: This figure shows services share of gross output of the Spanish economy observed in the data between 1980 and 2015 (i.e., "Data"), with that one implied by the baseline model (i.e., "Model"), and the implications of the counterfactual version of the model with no variation in the sectoral composition of intermediate inputs (i.e., "No Services Deepening").

change in the services share of intermediate inputs. Figure 5 shows that the model with no services deepening starts underestimating the change in the services share of gross output from the early 1990s on, and ends up implying a share of 60% as of 2015. This result highlights that services deepening accounts for 38% of the performance of the model in explaining the variation in the services share of gross output between 1980 and 2015, and confirms the findings of Galesi and Rachedi (2019) on the crucial role of the changes in the sectoral variation of the Input-Output matrix to understand the overall increase in the services share of the economy.

Hence, the model successfully replicates the variation in the services share of gross output of the Spanish economy between 1980 and 2015, and more than a third of this performance is due to the variation in the sectoral composition of intermediate inputs.

5 The Spanish Economy from 2015 to 2050

The results of the previous section on the fact that the model-implied path for the services share of gross output between 1980 and 2015 tracks remarkably well the dynamics of the share observed in the data guarantees that the model is an ideal laboratory to look at the causes and implications of structural transformation for the Spanish economy. Hence, we use the model to look at the implications of GDP growth going forward, from 2015 to 2050, and compare them with the observed GDP growth between 1980 and 2015. Hernandez de Cos et al. (2011), Cuadrado and Moral-Benito (2016), Fu and Moral-Benito (2018) have also derived implications on the future path of aggregate productivity and GDP growth of the Spanish economy. However, their approach used reduced-form techniques. Instead, the predictions of this paper are based on a structural approach, in which the model derives endogenously the future path of aggregate productivity and GDP given exogenous measures of sectoral TFP.

To perform this exercise, I need to take a stand on the dynamics of sectoral productivities between 2015 and 2050, as the sectoral composition of the economy – and the implied paths for aggregate productivity and GDP – depend crucially on this choice. Hence, I take a very transparent approach: I assume that from 2015 to 2050 the paths of sectoral productivities equal exactly the trends observed in the data between 1980 and 2015. In this way, the comparison of the variation in GDP growth between the two periods of interest does not hinge on any underlying variation in sectoral productivities, but only depends on the endogenous changes in the sectoral composition of the economy. As the Spanish economy would switch more and more towards the services sector with a relatively lower level of productivity, then the level of aggregate productivity would decrease, dampening the implied GDP growth of the economy.

Table 3 reports the results of the exercise. First, it is worth noticing that the model implies that in 2050 the services share of gross output will be 80%, well above the 67.6% observed in the data as of 2015. Hence, the Spanish economy will become even more intense in the services sector, and the low productivity of services would dampen the overall level of aggregate productivity. Indeed, the model implies that from 2015 to 2050 the average annual growth of Spanish GDP would be 0.6 percentage point lower than what it has been between 1980 and 2015. This result implies that if the GDP growth observed in the data between 1980 and 2015 has been 2.3%, going forward over the next three decades the growth rate would slow down to 1.9%.

What would be the growth rate of GDP if there were no changes in the Input-Output matrix from 2015 to 2050? In this case, the rise of the services share of gross output would be around 75%, much lower than in the baseline case. As a result, the dampening of the annual GDP growth would also be less relevant: the model without services deepening implies that annual GDP growth would slow down from an average value of 2.3% between 1980 and 2015, to 2.1% between 2015 and 2050.

Table 3: The Average Annual Growth Rate of Spanish GDP

	1980-2015	2015-2050
Data	2.3%	-
Baseline Model	2.3%	1.7%
Model Without Services Deepening	2.3%	1.9%
Model with EU Sectoral Productivities	2.5%	2.1%

Note: This table reports the average growth rate of Spanish GDP between 1980-2015 and 2015-2050 as observed in the data vis-á-vis the prediction of the baseline model, a version without services deepening in which the sectoral composition of the Input-Output matrix is constant over time, and a version of the model which uses the average trends in sectoral productivities observed in other large European countries between 1980-2015.

Finally, I look at the predictions of the model from 2015 to 2050 by assuming that the sectoral productivities will follow the trends observed between 1980 and 2015 in the Euro area countries. In particular, I consider the trend of services and manufacturing industries averaging the values observed in Austria, Belgium, Finland, France, Germany, Italy, and the Netherlands.[7] In this case, the growth rate of manufacturing productivity and the growth rate of services productivity is 0.8% and 0.2%, above the value observed respectively in the Spanish economy: 0.6% and -0.3%. If I feed these trends in the model, then the relatively higher level of productivities imply a milder drop in GDP growth: the average annual GDP growth from 2015 to 2050 will be 2.1%, just 0.2 percentage points the average observed in the previous three decades.

A natural question that emerges is whether the negative effects on aggregate productivity due to the rise of services are larger in Spain vis-á-vis other economies. To answer this question, I can compare the change in aggregate productivity due to the reallocation of employment (or economic activity more broadly) across sectors such as the share of manufacturing drops by 1% and the share of services rises by 1%. In this case, aggregate productivity growth would drop by -0.9%, which is the difference in the Spanish economy between the average productivity growth of manufacturing of 0.6% and the average productivity growth of services of -0.3%. A similar reallocation of resources in Euro area countries would imply a milder drop of aggregate productivity of 0.6%, which is the difference between the average productivity growth of manufacturing of 0.8% and the average productivity growth of services of 0.2% observed in Euro area countries.

Overall, this exercise makes three main points: (*i*) the rise in the services share of the Spanish economy together with the fact that services are characterized by a relatively lower sectoral productivity will imply that going forward the aggregate productivity and GDP growth of Spain will slow down, (*ii*) if the paths

[7] These countries are the only Euro-area economies with information on services and manufacturing productivity dating back to the 1980 in the World KLEMS database.

of sectoral productivities of the Spanish economy manage to improve over time to the similar levels observed in other Euro area countries, then the variation in the sectoral composition of the economy towards the services sector would have a limited effect of the future path of GDP growth, and (*iii*) since the difference in productivity growth between manufacturing and services is larger in Spain than in other economies, then the Spanish economy is relatively more exposed to the dampening of GDP growth due to the rise of services.

6 Conclusions

This paper shows that the rise of the services sector in the Spanish economy may dampen GDP growth by 0.6 percentage points in the future, from an average annual growth rate of 2.3% between 1980 and 2015 to a rate of 1.7% between 2015 and 2050. This result is due to the fact that the services sector is much less productive than manufacturing, and therefore the shifts of economy activity towards services would dampen aggregate productivity and therefore GDP growth. However, if sectoral productivities were to equal the levels observed in the Euro Area between 1980 and 2015, the average growth rate of Spanish GDP between 2015 and 2050 would be 2.1%. Most of the gap of the productivity of the Spanish services sector with respect to other European advanced economies is concentrated in industries such as the professional services and accommodation and food services.

An important caveat of this analysis is that the implications of the model on the growth rate of GDP from 2015 on are derived under the assumption that the path of sectoral productivity going forward equals the one observed in the data from 1980 to 2015. However, the future productivity of the Spanish economy may differ from the historical one because of a change in either the overall level of aggregate TFP (i.e., the part of productivity that is common across sectors), or the level of sectoral TFPs (i.e., the part of productivity which is idiosyncratic to each industry). In future research, I will dig deeper these dynamics to disentangle the contribution of the trends in aggregate productivity vis-á-vis sector-specific productivity to the overall variation in the TFP of the Spanish economy.

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