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The Labor Share in the Service Economy

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Abstract

Much research has documented a decline in the aggregate labor share in the United States and other countries. Yet, I document that this is not a general phenomenon across industries. In fact, there has been a divergence between services and non-services industries in the United States since 1980. Over this period, the labor share for services industries increased by an average of 6 percentage points, whereas for the rest of industries it decreased by an average of 14 percentage points. A similar diverging pattern is also present in several European countries. By exploiting industry-level data, I find that the divergence is occurring in the large majority of sub-industries, and is correlated with changes in labor intensity across sub-industries. In order to understand the underlying mechanisms behind this divergence, I build a quantitative two-sector model and show that the decline in the aggregate labor share and the divergence across industries are both consistent with the observed declining trend in the relative price of investment goods. Critically, differences in the substitutability between capital and labor, and differences in technical change across industries can account for the divergence.

JEL Codes: E21, E24, E25

Keywords: Labor share, service economy.

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1 Introduction

There has been a global decline over recent decades in the aggregate share of income that goes to labor. For example, in the United States the labor share was mostly stable at around 66% prior to the 1980s, then started a steady downward trend that has lasted for the past 35 years. As a result, the labor share had decreased to 60% by 2015. Yet, I document that this change is not pervasive across industries. In fact, there has been a general divergence between services and non-services industries in the United States over the last three decades. From 1980 to 2015, the labor share for services industries increased by an average of 6 percentage points, whereas for the rest of the industries it decreased by an average of 14 percentage points.[1] A similar diverging pattern is present in several European countries.[2]

Previous studies that document the aggregate fall in the labor share in the United States and other countries include Blanchard (1997), Elsby, Hobijn, and Sahin (2013), Piketty (2014), and Karabarbounis and Neiman (2014). Much of this research emphasizes the aggregate declining trend. This paper, however, explores the heterogeneity in the trend of the labor share across industries. By doing so, it delves deeper into the mechanisms behind the evolution of the labor share not evident using aggregate data alone.

This paper makes two primary contributions. First, I document the diverging trends mentioned above using disaggregated industry-level data for the United States and Europe. In particular, I decompose the changes in industry's labor share between changes in the labor share across sub-industries and changes in the overall composition of the industry. Second, I propose a quantitative two-sector model to explain the industry trends of the labor share. This model shows that the sharp decline in the relative price of investment goods can account for both the aggregate decline in the labor share and the divergence across sectors.

I exploit U.S. aggregate industry-level data from the National Income and Product

[1] Services industries include information, professional and business services, education, health, arts and entertainment, accomodation, and food services. These industries accounted for about 40% of gross value added in the United States in 2015. This classification of industries is similar to the one used by Autor, Dorn, Katz, Patterson, and van Reenen (2017b).

[2] For instance, as documented in Section 3, this divergence has also occurred in four of the largest economies in the European Union: Germany, France, Spain, and Italy.

Accounts and the Bureau of Labor Statistics to document the changes in the labor share across industries. I find that, consistent with the aggregate decline, the labor share has fallen in most non-services sub-industries. In services industries, however, I document the opposite pattern: The labor share has increased in the large majority of sub-industries, and this accounts for more than two-thirds of the sector's average increase. The rest is explained by compositional changes that shifted economic activity toward sub-industries with relatively higher labor share.

I also document a change in labor intensity inside industries that is related to the sectoral divergence. Within services, sub-industries that were relatively more labor intensive (i.e., had a higher initial labor share in the 1980s) tended to become even more labor intensive. Within non-services, the reverse phenomenon occurred: Sub-industries that were relatively more labor intensive tended to become more capital intensive.

The contrasting pattern between industries calls for an explanation of the aggregate decline in the labor share that is consistent with the divergence between services and non-services industries. To provide this explanation I propose a quantitative two-sector model that builds on Karabarbounis and Neiman (2014) and Alvarez-Cuadrado, Long, and Poschke (2015).

The model has two productive sectors, namely services and non-services, whose goods are consumed by a representative consumer. Non-services goods can be used both for consumption and investment, whereas services goods are only used for consumption. Firms in each sector behave competitively and use capital and labor for production using a sector specific constant elasticity of substitution (CES) technology.

The model has three key ingredients. (i) Differences in capital and labor substitutability in production across the two sectors. (ii) Differences in the degree of technical change across the two sectors. (iii) Investment-specific technological change. The first ingredient allows for differential responses across sectors to shocks in the economy.[3] The second ingredient highlights the potential role of changes in the production technology

[3] In the model, the labor shares respond to shocks that affect the rental rate of capital, capital-augmenting technology, and the relative price of services to non-services goods. Importantly, the magnitude and direction of the response also depends on the elasticity of substitution between capital and labor and distributional parameters for capital and labor.

of each sector in explaining the divergence. The third ingredient is critical to induce changes in the relative price of investment and capital goods, which affects the tradeoff between factors for both sectors.[4]

Using changes in investment-specific technology the model matches the sharp decline in the relative price of investment goods observed in the United States over the last three decades. This is the same mechanism used in Karabarbounis and Neiman (2014) to argue that, as the cost of investment and capital goods declines relative to labor, firms substitute capital for labor. Consequently, the aggregate labor share falls. They find that this mechanism accounts for half of the observed decrease in the aggregate labor share.

I calibrate the model to match the observed sectoral labor shares of the United States in 1980 and conduct two experiments to quantify how much of the divergence can be accounted for by the first ingredient, differences in the elasticity of substitution across sectors, and the second ingredient, differences in technical change across sectors. The third ingredient, investment-specific technological change, directly affects the accumulation of capital. Its effect on the labor share is shaped by differences in the elasticity of substitution between factors and sector specific technical change. In both experiments, investment specific technology changes to match the observed decline in the relative price of investment goods.

When I consider differences in the degree of substitutability between capital and labor across sectors, I find that the decline in the relative price of investment goods can account for half of the decrease in the labor share in non-services industries, and most of the increase in the labor share within services industries, observed over the last 35 years in the United States. In the model, the decrease in the relative price of capital increases the demand for non-service goods and the aggregate demand for labor, thus increasing the wages. In this experiment I allow for capital and labor to behave as complements in the services sector and as substitutes in the non-services sector. As a consequence, the ratio of capital to labor is more responsive in the non-services sector,

[4]After the seminal contribution of Greenwood, Hercowitz, and Krusell (1997) many important macroeconomic phenomena has been explained in light of the decline of the relative price of investment goods, as reflecting investment-specific technological change. Greenwood, Hercowitz, and Krusell (1997) study the impact on growth in the United States. Krusell, Ohanian, Ríos-Rull, and Violante (2000) argue that this has caused an increase in wage inequality, whereas Civale (2017) shows that it has caused an increase in wealth inequality.

leading to a decline in the labor share. Since capital and labor are complements in services, and wages increase in equilibrium, the demand for capital does not rise as much as in non-services. This reduces the endogenous increase in the capital to labor ratio in the service sector, thus increasing the labor share.

When I consider differences in technical change across sectors—and capital and labor are complements in production—the model can explain three-quarters of the decrease in non-services industries, and half of the increase in services industries. In this experiment I take the changes in sector/input specific technology from Herrendorf, Herrington, and Valentinyi (2013). In this case, the divergence is mostly explained by differences in capital-augmenting technology across sectors that induce a higher increase in capital-to-labor ratio in the non-services sector relative to the services sector. In equilibrium, as the rental rate of capital decreases and the wage rate increases, the labor share in the non-services sector decreases and the labor share in the services sector increases.

Related Literature

This paper is related to several streams of literature. The first stream documents a decline in the share of GDP going to labor in many nations over recent decades. Since the seminal contributions of Elsby, Hobijn, and Sahin (2013) and Karabarbounis and Neiman (2014), much research has studied the fall in the labor share in the United States and overseas.[5] Although there is no general consensus regarding the magnitude and starting point of the fall, most agree that the fall is real and significant.[6] Closest to this paper are probably Jones (2003) and Elsby, Hobijn, and Sahin (2013), who emphasize the heterogeneity of industry's labor shares over time. I expand on this work, and highlight the differences between services and non-services industries to demonstrate that the decline in the labor share is not pervasive across all industries, and that an important subset has actually experienced an increase over recent decades.

[5] See, for example, Dao, Das, Koczan, and Lian (2017) for more recent evidence of the global decline in the labor share, or Abdih and Danninger (2017) for evidence in the United States. Earlier work includes Bentolila and Saint-Paul (2003), Blanchard and Giavazzi (2003), Harrison (2005), Rodriguez and Jayadev (2013), and Estrada and Valdeolivas (2014).

[6] Some measurement concerns raised in the literature include the treatment of self-employment and proprietors' income, as discussed in Gollin (2002) and Elsby, Hobijn, and Sahin (2013); capital depreciation, as explained in Bridgman (2014); housing, as argued in Rognlie (2015); and the treatment of intangible capital, as discussed in Yu, Santaeulàlia-Llopis, and Zheng (2015).

This paper also contributes to recent literature that investigates the causes of the decline in the labor share over the last 35 years. Elsby, Hobijn, and Sahin (2013) argue that trade and international outsourcing are the most important drivers, and present evidence that the sectors that were most exposed to foreign competition had the biggest declines in the labor share (e.g., trade and manufacturing sectors exposed to higher import competition from China). Two recent papers by Autor, Dorn, Katz, Patterson, and van Reenen (2017a,b) using U.S. Economic Census microdata put forward the argument that increasing industry concentration explains the fall in the labor share. Their explanation relies on the rise of "superstar" firms with low labor shares that are increasingly gaining market value. A similar conclusion is reached by Barkai (2016), based on more aggregate data for the United States; by Kehrig and Vincent (2017), who only consider the U.S. manufacturing sector; and by Berkowitz, Ma, and Nishioka (2017), who use firm-level data from China. Finally, Grossman, Helpman, Oberfield, and Sampson (2017) relate the decline in the labor share to the slowdown in U.S. and world productivity growth. As explained above, this paper explores the mechanism proposed by Karabarbounis and Neiman (2014) and highlights differences in substitutability between capital and labor and differences in technical change across industries as potential explanations that are consistent with both the aggregate fall and sectoral divergence.

This paper also relates to the literature on economic growth and structural transformation that emphasizes differences in productivity growth and capital intensity across sectors.[7] It is particularly relevant to the work of Zuleta and Young (2013), who develop a model of induced innovation that can feature different trends in the labor share by sector. On the more quantitative side, important contributions are by Buera and Kaboski (2009, 2012a,b) who analyze the "rise of the service economy." This paper does not provide an explanation for the rise of services industries, but explores differences between services and non-services industries that relate to differences in the evolution of sectoral labor shares.

Finally, this paper is closest to Alvarez-Cuadrado, Long, and Poschke (2015), who investigate the difference in the evolution of the labor share of manufacturing and services in the United States and overseas. The authors present a model of structural

[7] See, for example, Acemoglu and Guerrieri (2008) or Ngai and Pissarides (2007).

transformation in which the degree of capital-labor substitutability and technical change also differs across sectors. Their analysis uses a different definition of services.[8] Other major differences are that I consider the effect of the decline in the relative price of investment goods on the divergent evolution of sectoral labor shares, and document several empirical regularities that are distinct for services and non-services industries.

The rest of the paper is organized as follows. Section 2 discusses the data used in the paper, and Section 3 studies the evolution of the labor share in the United States from 1980 to 2015. Section 4 documents the main empirical findings, Section 5 lays out the benchmark model, and Section 6 calibrates the model and presents the main quantitative results of the paper. Section 7 tests the robustness of the results to departures from the baseline calibration, and Section 8 concludes.

2 Data

This section describes the data sources used in this paper and their main features. The first part of the section discusses industry-level data used for the United States, while the second part of the section discusses the data used for Europe. The last part of the section reviews the U.S. data on the decline in the relative price of investment goods. Further details on the datasets and construction of the variables are contained in Appendix A2.

NIPA and BLS data

The cross-sector analysis of this paper relies on the U.S. Gross Domestic Product by Industry Data of the National Income and Product Accounts (NIPA) published by the Bureau of Economic Analysis (BEA). For each industry, NIPA reports annual data on value added, wages and salaries, total compensation of employees[9], taxes, and full-time and part-time employees at the industry level from 1980 to 2015. Value added and full-

[8] They split the economy into agriculture, manufacturing, and services. As a consequence, they find that the labor share in both manufacturing and services has declined over time and the main difference between the two sectors is the magnitude of the decline, which is much larger in manufacturing.

[9] Wages and salaries plus fringe benefits and non-wage compensation.

and part-time employee data are available from 1980 to 2015 on the basis of the North America Industry Classification System (NAICS) codes. However, data on wages and salaries, total compensation, and taxes are only available on the basis of NAICS codes from 1998 and 1987. Previous data for wages and salaries, total compensation, and taxes are on the basis of Standard Industrial Classification (SIC) codes. Given this data limitation, I only use the 10-industry level of detailed data in Section 3. This level of aggregation extends the empirical analysis back to 1980. For Section 4, when I further explore the differences between services and non-services industries, I use the 60-industry level of detailed data since 1987.

This paper complements the NIPA data with more dissaggregated industry-level data from the Input-Output tables produced by the Bureau of Labor Statistics (BLS). The BLS reports annual data on value added, total compensation of employees, and taxes for about 200 industries. However, the dataset only spans from 1997 to 2015. I use this dataset to implement robustness checks for some of the empirical results discussed in the paper.

KLEMS data

This paper supplements U.S. industry data with the September 2017 release of EU KLEMS Growth and Productivity accounts.[10] The dataset covers all European Union (EU-28) countries and the United States. Consistent data on value added, total compensation, and taxes are available from 1995 to 2015 for most of the countries. The raw series is taken from the national accounts of all individual countries, and is consistent with the official statistics available in Eurostat and NIPA. At the lowest level of aggregation, data were collected for 34 industries. I use this data to document a similar divergence in labor share between services and non-services industries across several European countries.

[10] See Jäger (2017) for further details. Data are available at `http://www.euklems.net`.

The Relative Price of Investment Goods

NIPA reports the price deflator for several categories of investment. The price for each of these categories relative to consumption is computed using these deflators. NIPA controls for quality improvement when calculating quantities and prices of its accounts. However, Gordon (1990) has argued that NIPA deflators underestimate quality improvement, and therefore the actual fall in the relative price of investment. To correct for this bias, DiCecio (2009) extrapolates the quality-adjusted price time series of Gordon to 2010, using the same technique of Cummins and Violante (2002) and Fisher (2006). I adopt the extrapolated time series of DiCecio as a benchmark. When controlling for quality improvement, the relative price of investment goods declined by 57% from 1980 to 2015.

3 Evolution of the Compensation Share

This section studies the evolution of the labor share contrasting services and non-services industries. First, I define the notion of compensation share, a proxy for the labor share. Then, I describe the rise of the services industries and the evolution of the labor share in the United States since 1980 using industry-level NIPA data. Finally, I show that the same empirical patterns are also present in some major European countries.

Definition of the Compensation Share

To render the analysis as comparable as possible with previous research, this paper focuses on the nonfarm U.S. business sector.[11] Nominal value added by industry equals the sum of nominal gross value added plus taxes on production and imports net of subsidies. The industry labor share is defined as the share of sectoral GDP minus

[11] The nonfarm business sector excludes general government, private households, nonprofit organizations serving individuals, and farms. BEA data do not distinguish between nonprofit institutions serving households and businesses, and private households are included in the sub-industry "other services." The analysis, therefore, includes these two but excludes both the government sector and "farms."

taxes that go to labor. Labor income includes all payments to workers and returns from labor earned by self-employed workers. Data on the latter are not available by industry in NIPA. Therefore, I focus on the industry *compensation share*, defined as, total compensation over gross value added and denoted by:[12]

$$S_i = \frac{w_i L_i}{P_i Y_i}$$

where $w_i L_i$ is total labor compensation for workers on employers' payroll and $P_i Y_i$ is nominal gross value added (nominal value added net of taxes) of industry i. Total compensation includes wages and salaries, fringe benefits, and other non wage compensation. The aggregate compensation share can then be expressed as the sum of the compensation shares by industry weighted by nominal gross value added:

$$S = \frac{\sum_i w_i L_i}{\sum_i P_i Y_i} = \frac{\sum_i w_i L_i}{PY} = \sum_i \frac{P_i Y_i}{PY} \frac{w_i L_i}{P_i Y_i} = \sum_i \omega_i S_i$$

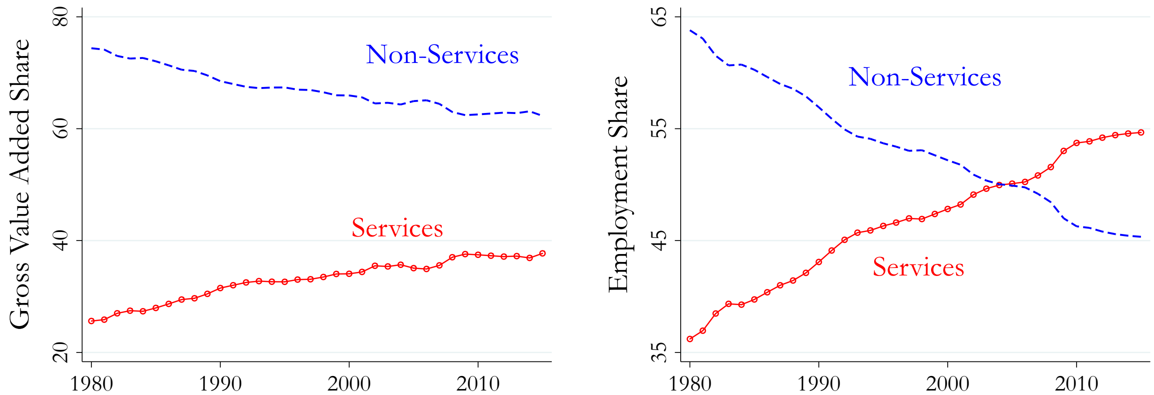
where $\omega_i = \frac{P_i Y_i}{PY}$ is the gross value added share of industry i, and $S_i = \frac{w_i L_i}{P_i Y_i}$ is its compensation share. The aggregate compensation share, S, is therefore a combination of the industries' weight on the economy, ω_i, and the industries' compensation shares, S_i. The next section documents the evolution of the gross value added share, ω_i, and of the compensation share, S_i, since 1980.

The Rise of the Service Economy

The left panel in Figure 1 plots the change in the gross value added share, ω_i, for services and non-services industries between 1980 and 2015. It illustrates the well-documented transition of the U.S. economy from a manufacturing and trade/transportation economy to a service economy: Services was one of only two major industries (with finance and real estate) that experienced an increase in its relative share over these years. As a

[12] Figure 24 in Section A2.2 plots the dynamics of the compensation and labor share for the U.S. from 1987 to 2015 using KLEMS data, and shows that the dynamics of the compensation share track closely with the dynamics of the labor share. This supports the use of the compensation share as a proxy to study the evolution of the labor share across industries.

Figure 1: Gross Value Added and Employment Share, 1980-2015



Notes: This figure plots the evolution of gross value added and employment shares for services industries (red circles line) and non-services industries (dashed blue line) from 1980 to 2015 using industry-level NIPA data. Figure 18 and Figure 19 plot the evolution of gross value added and employment shares for a more disaggregated set of industries.

result of this shift in economic activity, services industries' gross value added share went from 26% in 1980 to about 38% of the total U.S. nonfarm business sector by 2015.

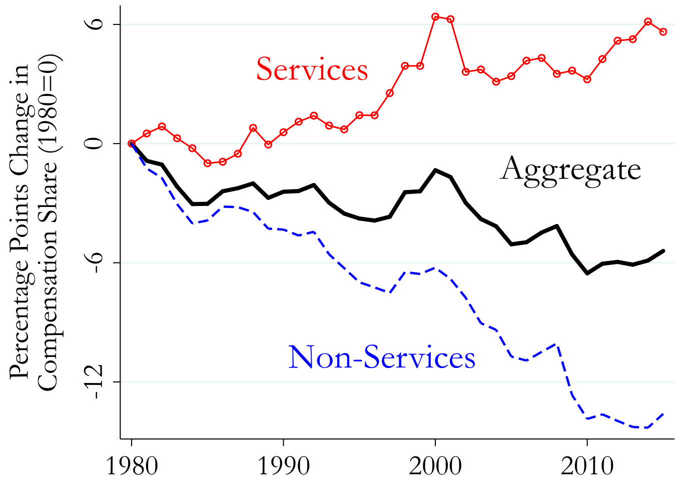
The transition to a services economy is even more evident when looking at the evolution of employment shares by industry. As the right panel in Figure 1 shows, services went through a huge increase in the employment share over the sample period: The employment share for services increased from 35% in 1980 to around 55% in 2015.

This section demonstrates that services industries represents a large part of the U.S. economy, and have become even more important over time. I will now discuss how the aggregate—and, more importantly, how the sectoral compensation shares for services and non-services—have evolved since 1980.

Compensation Share in the Service Economy

As discussed by Elsby, Hobijn, and Sahin (2013), the evolution of the aggregate compensation share in the United States can be divided into three distinct periods during the postwar period. First, between 1950 and the early 1980s, the aggregate compensation share was remarkably constant without an obvious trend. Then, a declining trend started in the early 1980s. Finally, this decline accelerated from the year 2000. As a result, from the early 1980s to 2015, the aggregate compensation share decreased by

Figure 2: Compensation Share in the United States, 1980-2015



Notes: This figure plots the percentage points change in the aggregate (black line), services (red circles), and non-services (dashed blue line) compensation shares from 1980 to 2015 using industry-level NIPA data. All series are normalized to zero in 1980. Figure 20 plots the evolution of the levels.

about 6 percentage points. The solid black line in Figure 2 plots this declining trend starting in the year 1980.[13]

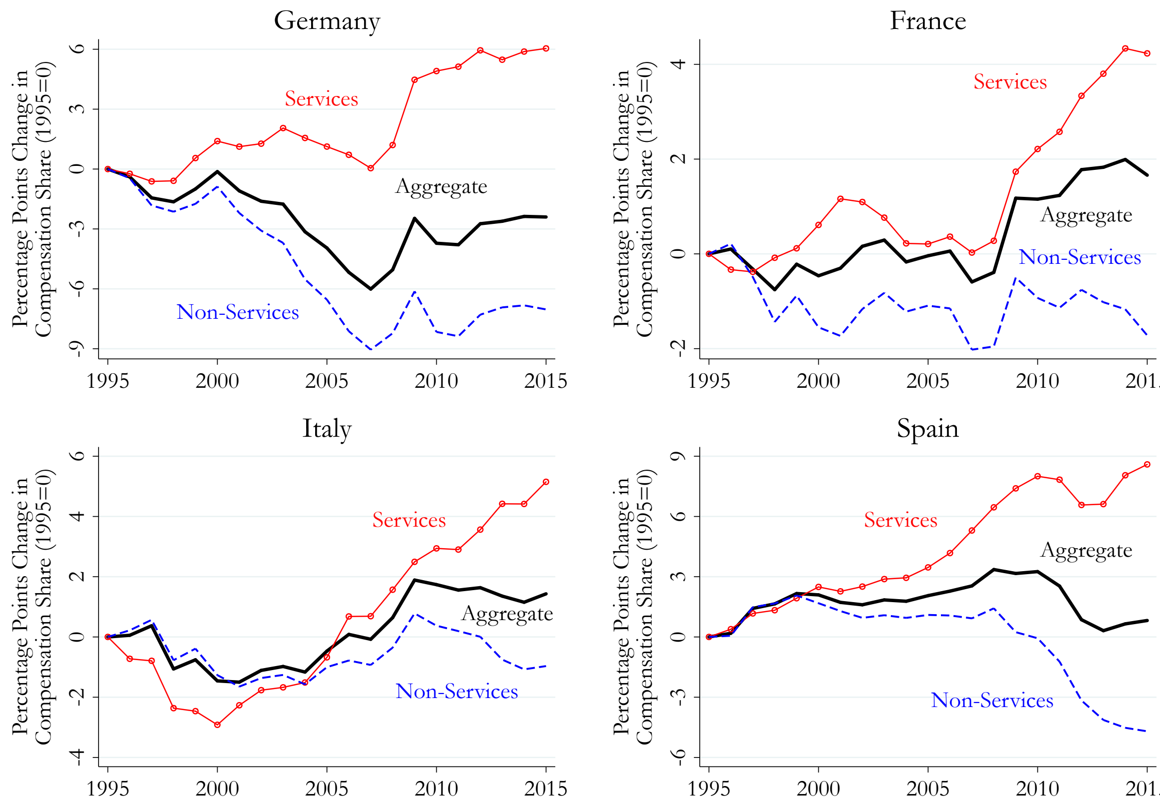
This aggregate measure, however, hides two distinct patterns that have not been emphasized enough in previous work. Figure 2 also plots the average evolution of the compensation share for services (red circles line) and non-services (dashed blue line) industries since 1980. The differences between the two are stark: The non-services industries compensation share decreased, on average, by 14 percentage points, whereas services industries' compensation share increased by 6 percentage points. This is in clear contrast to the historical evolution of industry compensation shares before 1980, when all seemed to move together.

Figure 3 shows that the divergence in the evolution of the compensation share has also occurred in four of the largest economies in the European Union. It plots the aggregate compensation share and sectoral compensation shares for Germany, France, Spain, and Italy.[14] All four countries exhibit a downward-sloping trend for non-services industries and a upward-sloping trend for services industries. In fact, as shown in Section A2.2,

[13] Appendix A3 discusses the historical evolution of the compensation share since 1950.

[14] In 1995, the compensation share in services is larger in all European countries, with the exception of Germany. In Germany, the compensation share is 56.55% in services and 57.25% in non-services.

Figure 3: Compensation Share for the Largest Economies in the European Union, 1995-2015



Notes: This figure shows the aggregate (black line), services (red circles) and non-services (dashed blue line) compensation shares for the four largest economies in the Europe Union. All series are normalized to zero in 1995.

most of the countries in the European Union experienced a similar divergence over recent decades: Nineteen countries experienced a divergence in the compensation share, compared with eight that experienced a convergence. Consistent with the evidence for the United States, this divergence was predominantly the result of a decrease in the compensation share in non-services industries and an increase in services industries.

Why have services industries experienced a steady increase in the compensation share at the same time that non-services industries have undergone a large fall? What drives this diverging pattern? One possibility is that services industries have become more labor intensive and non-services industries less labor intensive. Alternatively, the composition of industries within these two sets of industries could have shifted. Changes in trade barriers, the cost of capital, or the cost of outsourcing, for example, could have changed the aggregate labor intensity within services and non-services industries by shifting the industry's composition. The next section explores the differences between non-services and services industries.

4 Divergence of the Compensation Share

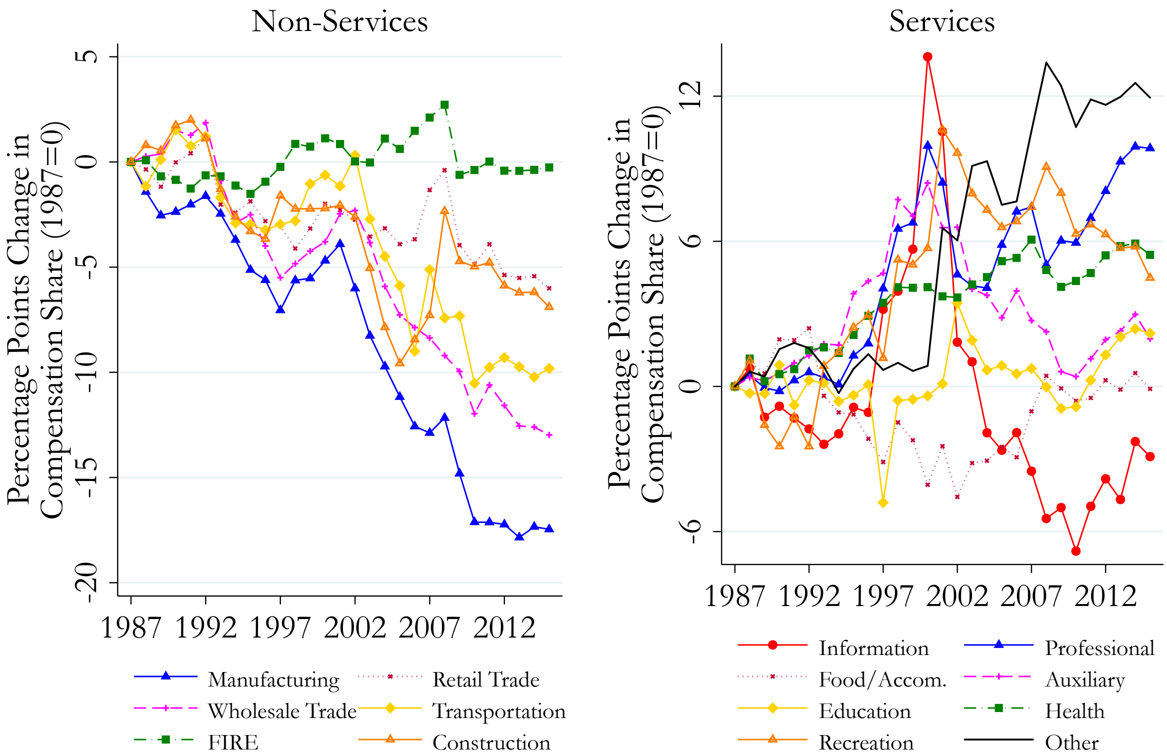
This section delves deeper into the aggregate declining trend and the divergence of the compensation share between non-services and services industries. Using more disaggregated data by industry demonstrates that consistent with previous work, the compensation share has fallen in most non-services sub-industries, and is therefore mostly a within-industry phenomenon. For services industries, the average increase in the share of income going to labor is mostly a within-industry phenomenon too. However, part of the increase is also a consequence of economic activity shifting to sub-industries within services that have a high compensation share.

Figure 4 shows the evolution of the compensation share for some selected sub-industries in services and non-services between 1987 and 2015.[15] Two remarks are in order. First, overall, most services sub-industries tended to become more labor intensive, and most non-services industries tended to become more capital intensive. Second, within industries, the magnitude of the increase or decrease in the compensation share was very heterogeneous, especially after the 2000s.

Within services, except for information, all sub-industries experienced an increase in, or a flat evolution of, the compensation share over the sample period. The largest increases were in other services, health, and professional services, which rose by 12, 9, and 6 percentage points, respectively. As a whole, services industries experienced an average increase of 6 percentage points since 1987. This is in clear contrast to the evolution of the compensation share for non-services industries. With only the exception of finance and real estate (FIRE), which showed no trend, all non-services industries experienced a large fall in compensation share. Traditional non-services industries, such

[15] As explained in Section A2.1, industry definitions in NIPA changed in 1987 from an SIC basis to an NAICS basis. Consistent mapping between the two bases at a more disaggregated level, especially for services sub-industries, is not feasible. The analysis in this section, therefore, starts in 1987, when consistent data on an NAICS basis become available for all sub-industries.

Figure 4: Sub-Industry Compensation Shares, 1987-2015



Notes: This figure plots the change in the compensation share for some selected sub-industries from 1980 to 2015 using industry-level NIPA data. All series are normalized to zero in 1980. Figure 21 plots the evolution of the levels.

as manufacturing, transportation, and construction, fell by 18, 10, and 7 percentage points, respectively. Wholesale and retail trade decreased by 14 and 6 percentange points, respectively. As a group, non-services industries experienced an average decline of around 10 percentage points since 1987.[16] Figure 22 in Appendix A1 plots the change in the compensation share between 1987 and 2015 for all sub-industries and shows that within services, 15 sub-industries had an increase compared to 4 that experienced a decrease. For non-services, only 6 out of 41 had an increase in their compensation share.[17]

Finally, from 2000 on, the heterogeneity has been exacerbated. Especially in non-services industries, a big change occurred in trends for traditional sectors, such as

[16]This includes agriculture (except for farms), mining, and utilities, which are not plotted in Figure 4.
[17]Table 6 in Appendix A1 reports the levels of and differences in the compensation share, gross value added share, and employment share for each services sub-industry and some selected non-services sub-industries from 1987 to 2015.

manufacturing, transportation, and construction. This large decline in the compensation share within non-services industries accounts for most of the accelerated decline in the aggregate compensation share since the 2000s.

How has the composition of sub-industries changed within services and non-services industries? Figure 5 plots the compensation share in 1987 against the change in the gross value added share between 1987 and 2015 for 60 sub-industries within services and non-services. I estimate OLS regressions separately for each set of sub-industries of the form:

$$\Delta\omega_{i,t} = \beta_0 + \beta_1 S_{i,t} + \epsilon_{i,t} \tag{1}$$

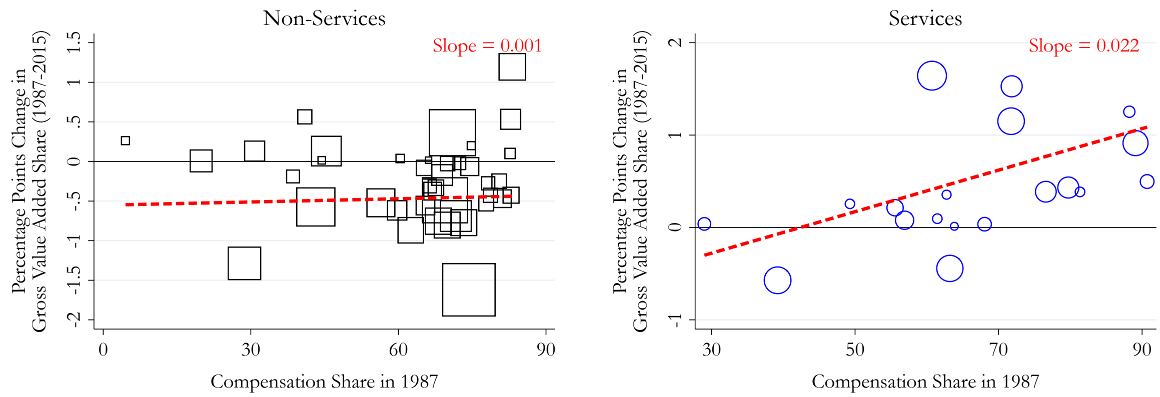
where $\omega_{i,t}$ is the gross value added share of sub-industry i at time t and $S_{i,t}$ is the compensation share of sub-industry i at time t. The coefficients that result from the estimation of equation Equation 1 are also plotted for each sector.

Figure 5 shows that services sub-industries that were more labor intensive tended to expand relative to capital-intensive industries. For example, a 10 percentage points higher compensation share in 1987 is associated with a 0.22 percentage points higher increase in the gross value added share between 1987 and 2015. Thus shifts in composition have also played a role in the increase of the compensation share within services sub-industries. However, no pattern is observed within non-services industries. This is consistent with the idea that the fall in the compensation share within non-services industries is mainly a within-industry phenomenon.

As has been argued before, 2000 was a turning point: The compensation share started falling faster, and the divergence between non-services and services industries widened. To explore whether the effect was different from 2000 on, I estimate Equation 1 from 1987 to 2000 and from 2000 to 2015. The results are reported in Figure 6. Consistent with the idea that the dynamics of the compensation share further changed around the 2000s, Figure 6 shows that most of the compositional effect within services industries is explained by changes during the 2000-2015 period.

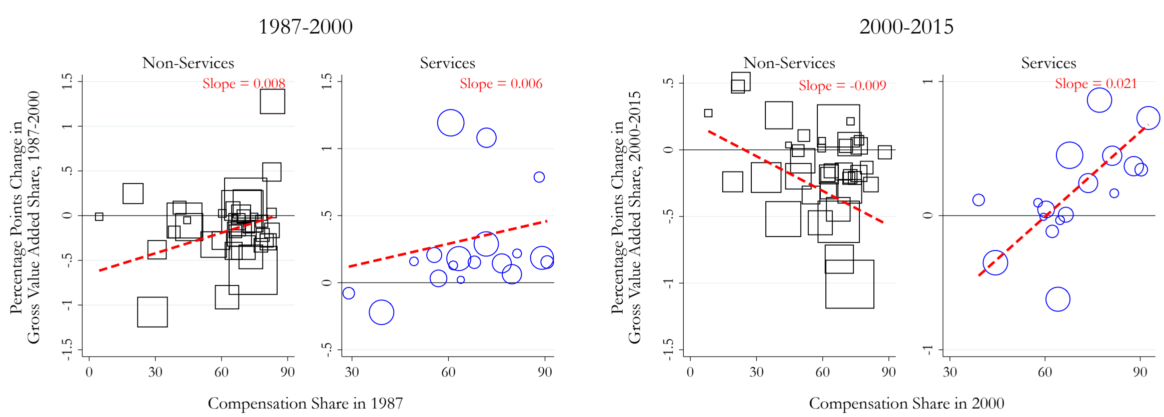
I now more formally address the question of how much of the change in the compensation share in each industry is accounted for by compositional changes across sub-industries or changes in the compensation share within those sub-industries. I

Figure 5: Change in Gross Value Added Share, 1987-2015



Notes: This figure plots the compensation share in 1987 against the change in gross value added share from 1987 to 2015 using industry-level NIPA data. Each blue circle (services) and black square (non-services) represents a NIPA sub-industry, with its size reflecting the sub-industry's gross value added share in 1987. The dotted red line shows the best-fit line, using the 1987 gross value added share as the sub-industry weight. The difference between the slopes is statistically different at a 10% level of significance.

Figure 6: Decomposition of the Change in Gross Value Added Share, 1987-2015



Notes: The left figure plots the compensation share in 1987 against the change in gross value added share from 1987 to 2000. The right figure plots the compensation share in 2000 against the change in gross value added share from 2000 to 2015. Each black square (non-services) and blue circle (services) represents a NIPA sub-industry, with its size reflecting the sub-industry's gross value added share in 1987. The dotted red line shows the best-fit line, using the 1987 gross value added share as the sub-industry weight. The difference between the slopes is statistically different at a 1% level of significance for 2000-2015. Figure 28 plots these correlations using more dissaggregated industry-level BLS data.

implement a "shift-share" analysis of the change in the compensation share within non-services and services industries separately between 1987 and 2015. This analysis confirms the results discussed in this section.

Note that it is possible to decompose the changes in the compensation share over time into two components for each set of sub-industries separately:

$$\Delta S_{\mathbb{I}} = \underbrace{\sum_{i \in \mathbb{I}} \omega_i \Delta S_i}_{\text{"shift"}} + \underbrace{\sum_{i \in \mathbb{I}} \Delta \omega_i S_i}_{\text{"share"}} \tag{2}$$

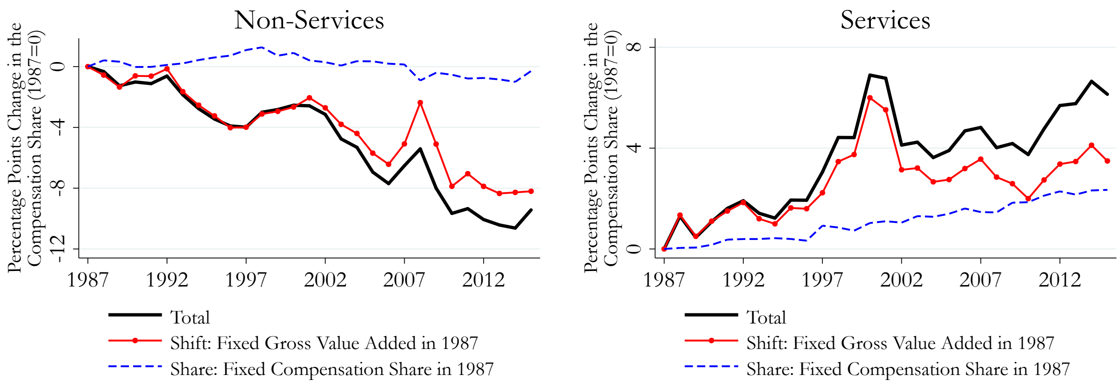
where $\mathbb{I} = \mathbb{S}$ for services and $\mathbb{I} = \mathbb{NS}$ for non-services industries.

The "shift" component measures within-sub-industry contributions to the change in the industry's compensation share. This is the weighted average of the changes in the sub-industry's compensation share. The "share" component measures the between-sub-industry contributions to the change in the industry's compensation share. If this component is positive, more labor-intensive sub-industries have grown relative to less labor-intensive sub-industries. I look at the changes, from 1987 on, for the industry's compensation share, $\Delta S_{\mathbb{I}}$; the within-sub-industry component, ΔS_i; and the between-sub-industry component, $\Delta \omega_i$.

Figure 7 shows the decomposition of the industry's compensation shares, as in Equation 2. Black lines plot the evolution of the compensation share for non-services and services industries between 1987 and 2015. Over these years, the compensation share for non-services industries declined by about 10 percentage points. For services, it increased by about 6 percentage points. This decomposition points to the importance of the within-sub-industry component in the divergent evolution of compensation shares. For non-services, it accounts for almost all of the decline, and for services it accounts for more than two-thirds of the increase. The rest is accounted for by the between-sub-industry component, which accounts for around 2.5 percentage points of the increase in the compensation share, of which 1.5 percentage points occurred since the 2000s.

Consistent with previous evidence, this decomposition points to the importance of both differences in the evolution of the compensation share within sub-industries and compositional changes for understanding the distinct evolution of the compensation

Figure 7: Decomposition of the Industry's Compensation Share



Notes: This figure plots the decomposition of the compensation share for non-services (left panel) and services (right panel) industries from 1987 to 2015. The black solid line is the average compensation share within each industry. The red circles line is the shift component and the dashed blue line is the share component as defined in the text.

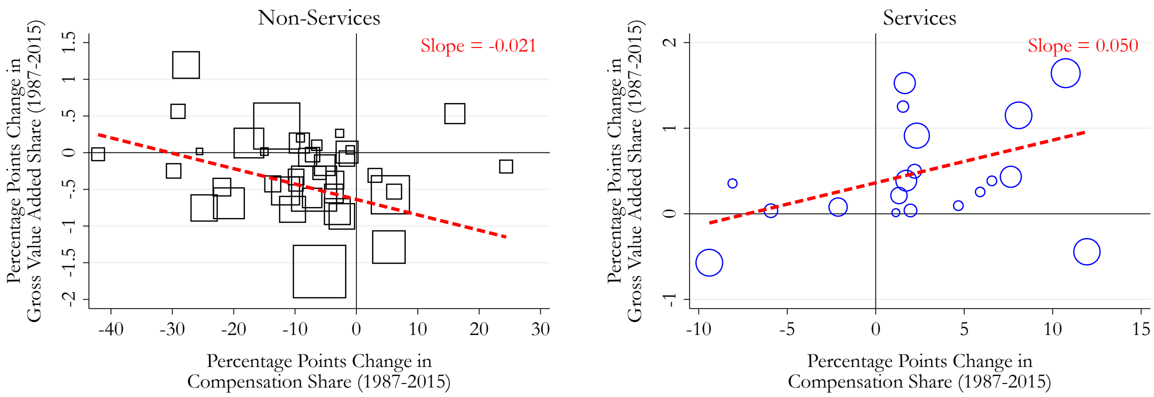
share for services industries. Nevertheless, it remains true that most of the effect is within sub-industries.

Finally, I explore how changes within sub-industries are related to changes across sub-industries. Figure 8 plots each sub-industry's change in gross value added against the change in compensation share between 1987 and 2015 separately for non-services and services industries. This figure contains a great deal of information, and summarizes well the main conclusions of this section.

First, Figure 8 shows that most sub-industries in non-services have shrunk, whereas most sub-industries in services have expanded. Most non-services sub-industries (black squares) are below zero, while most services sub-industries (blue circles) are above zero. This is consistent with the steady transformation of the U.S. economy into a service economy.

Second, it shows that the majority of sub-industries in non-services have experienced a decrease in their compensation share, whereas the majority of sub-industries in services have experienced an increase in their compensation share. Most non-services sub-industries (black squares) are to the left of zero, while most services sub-industries (blue circles) are to the right of zero. This is both consistent with the divergent path of the aggregate compensation share between these two sets of industries and in line with the conclusion of the shift-share analysis that most of the action in compensation

Figure 8: Change in Gross Value Added Share and Compensation Share, 1987-2015



Notes: This figure plots the change in gross value added share against the change in compensation share from 1987 to 2015 using industry-level NIPA data. Each black square (non-services) and blue circle (services) represents a NIPA sub-industry, with its size reflecting the sub-industry's gross value added share in 1987. The dotted red line shows the best-fit line, using the 1987 gross value added share as the sub-industry weight. The difference between the slopes is statistically different at a 10% level of significance. Figure 29 plots these correlations using more disaggregated industry-level BLS data.

shares is occurring within sub-industries.

Lastly, the correlation between the change in the gross value added share and the change in the compensation share shows that sub-industries that grew more were those with the largest increase in the compensation share within services and those with the largest decline in the compensation share within non-services.[18]

To further understand the differences between non-services and services industries, the next section examines the changes in labor intensity within industries.

Changes in labor intensity

Figure 9 plots the compensation share in 1987 against the change in the compensation share between 1987 and 2015 for 60 sub-industries within services and non-services industries. I estimate OLS regressions separately for each set of sub-industries of the form:

$$\Delta S_{i,t} = \beta_0 + \beta_1 S_{i,t} + \epsilon_{i,t} \tag{3}$$

[18] Oberfield and Raval (2014) also find a negative correlation when only looking at manufacturing industries.

where $S_{i,t}$ is the compensation share of sub-industry i at time t. The coefficients that result from the estimation of Equation 3 are also plotted.

It is clear that they have the exact opposite pattern. Within non-services, sub-industries that had a high compensation share in 1987 experienced a larger decrease in the compensation share between 1987 and 2015. For example, a 10 percentage points higher compensation share in 1987 is associated with a 2.3 percentage points higher decrease in the compensation share between 1987 and 2015. However, within services, sub-industries that had a high compensation share in 1987 experienced a larger increase in the compensation share. For example, a 10 percentage points higher compensation share in 1987 is associated with a 1.5 percentage points higher increase in the compensation share between 1987 and 2015. This pattern is especially surprising in services, given that the initial values were already high and compensation shares cannot be higher than 100%.

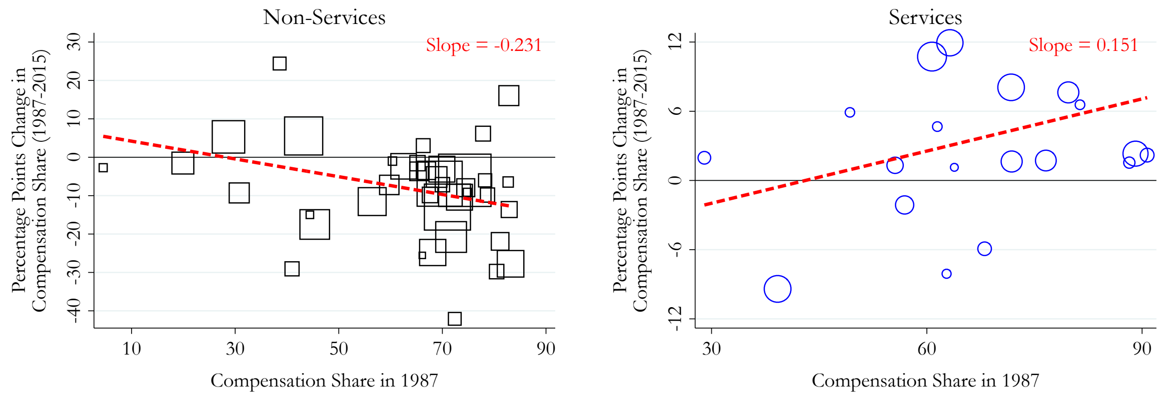
As we have shown before, 2000 was a turning point: The compensation share started falling faster, and the divergence between non-services and services industries widened. To explore whether the effect was different from 2000 on, I separately estimate Equation 3 from 1987 to 2000 and from 2000 to 2015. The results are reported in Figure 10. Consistent with the idea that the dynamics of the compensation share changed around the 2000s, Figure 10 shows that most of the effect between 1987 and 2015 is explained by changes in labor intensity during the 2000-2015 period.

All of these patterns are striking, and call for an explanation that can reconcile the different evolution of the compensation share in services and non-services industries. The key insight from this section is that the divergent pattern is mainly a within-sub-industry phenomenon. The next section lays out a two-sector model that is consistent with the general divergence between industries and the aggregate fall in the labor share.

5 Model

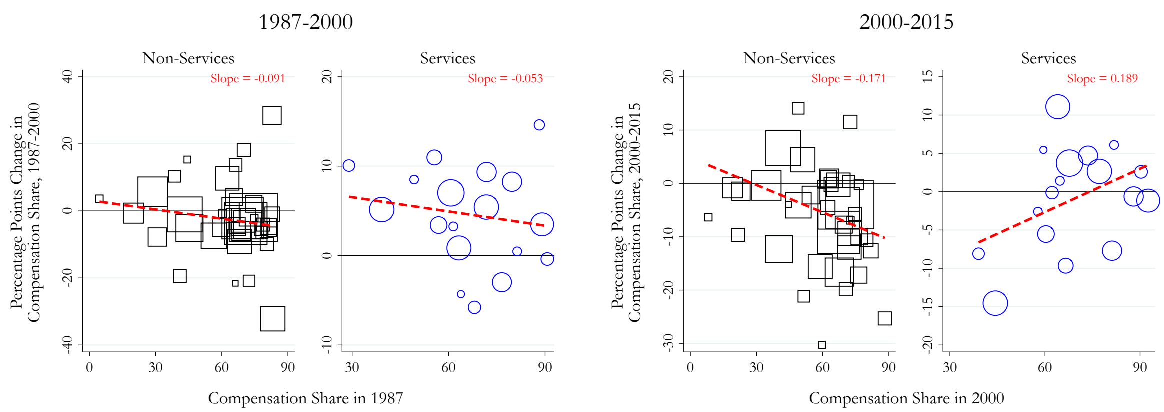
This section develops a model for studying the impact of the declining relative price of investment on the divergence in the compensation share between non-services and ser-

Figure 9: Change in the Compensation Share, 1987-2015



Notes: This figure plots the compensation share in 1987 against the change in the compensation share from 1987 to 2015 using industry-level NIPA data. Each black square (non-services) and blue circle (services) represents a NIPA sub-industry, with its size reflecting the sub-industry's gross value added share in 1987. The dotted red line shows the best-fit line, using the 1987 gross value added share as the sub-industry weight. The difference between the slopes is statistically different at a 5% level of significance.

Figure 10: Decomposition of the Change in the Compensation Share, 1987-2015



Notes: The left figure plots the compensation share in 1987 against the change in the compensation share from 1987 to 2000. The right figure plots the compensation share in 2000 against the change in the compensation share between 2000 and 2015. Each black square (non-services) and blue circle (services) represents a NIPA sub-industry, with its size reflecting the sub-industry's gross value added share in 1987. The dotted red line shows the best-fit line, using the 1987 gross value added share as sub-industry weight. The difference between the slopes is statistically different at a 5% level of significance for the period 2000-2015. Figure 30 plots these correlations using more disaggregated industry-level BLS data.

vices industries. It builds on Karabarbounis and Neiman (2014) and Alvarez-Cuadrado, Long, and Poschke (2015). After presenting the model, this section describes the competitive equilibrium of the model. The last part of the section derives the exact expression for the compensation share in non-services and services industries.

I consider a representative agent model in which both non-services and services final goods are produced. Time is discrete. There is no uncertainty, and all economic agents have perfect foresight. There are three sectors in the economy. (i) A non-services goods producer competitively aggregates capital and labor to produce non-services goods. (ii) A services goods producer competitively aggregates capital and labor to produce services goods. (iii) Investment goods are produced competitively using the non-service goods as an input.

In what follows, the description of the model starts with the problem of the three sectors and the characterization of their optimal demand for labor and capital. I then describe the household problem and market clearing conditions. Throughout this section, the subscript m denotes non-services goods and s denotes services goods.

Non-services Goods Producer

The non-service goods producer uses a CES technology to produce the non-service goods,

$$Y_{m,t} = F(K_{m,t}, L_{m,t}) = \left(\alpha_m (B_{m,t} K_{m,t})^{\frac{\sigma_m - 1}{\sigma_m}} + (1 - \alpha_m)(A_{m,t} L_{m,t})^{\frac{\sigma_m - 1}{\sigma_m}}\right)^{\frac{\sigma_m}{\sigma_m - 1}}$$

where σ_m denotes the elasticity of substitution between capital and labor in production, α_m is a distribution parameter, and $A_{m,t}$ and $B_{m,t}$ denote labor-augmenting and capital-augmenting technology, respectively.

The non-service goods producer solves the following problem:

$$\max_{K_{m,t}, L_{m,t}} \quad Y_{m,t} - w_t L_{m,t} - R_t K_{m,t}$$

where w_t denotes the wage rate and R_t denotes the rental rate of capital. Competitive markets and cost minimization imply:

$$R_t = \alpha_m B_{m,t}^{\frac{\sigma_m - 1}{\sigma_m}} \left(\frac{Y_{m,t}}{K_{m,t}} \right)^{\frac{1}{\sigma_m}}$$

$$w_t = (1 - \alpha_m) A_{m,t}^{\frac{\sigma_m - 1}{\sigma_m}} \left(\frac{Y_{m,t}}{L_{m,t}} \right)^{\frac{1}{\sigma_m}}$$

Services Goods Producer

The services producer uses a CES technology to produce the service goods,

$$Y_{s,t} = F(K_{s,t}, L_{s,t}) = \left(\alpha_s (B_{s,t} K_{s,t})^{\frac{\sigma_s - 1}{\sigma_s}} + (1 - \alpha_s)(A_{s,t} L_{s,t})^{\frac{\sigma_s - 1}{\sigma_s}} \right)^{\frac{\sigma_s}{\sigma_s - 1}}$$

where σ_s denotes the elasticity of substitution between capital and labor in production, α_s is a distribution parameter, and $A_{s,t}$ and $B_{s,t}$ denote labor-augmenting and capital-augmenting technology, respectively.

The services producer solves a problem similar to the non-services goods producer which implies:

$$R_t = \alpha_s B_{s,t}^{\frac{\sigma_s - 1}{\sigma_s}} \left(\frac{Y_{s,t}}{K_{s,t}} \right)^{\frac{1}{\sigma_s}}$$

$$w_t = (1 - \alpha_s) A_{s,t}^{\frac{\sigma_s - 1}{\sigma_s}} \left(\frac{Y_{s,t}}{L_{s,t}} \right)^{\frac{1}{\sigma_s}}$$

Investment Goods Producer

Let q_t denote the price of one unit of the investment goods. The investment goods producer uses a linear technology that turns one unit of the non-services goods into $A_{x,t}$ units of the investment goods X_t. Therefore, it solves:

$$\max_{Y_{m,t}^x} . \quad X_t q_t - Y_{m,t}^x$$

$$\text{s.t.} \quad X_t = Y_{m,t}^x A_{x,t}$$

Hence $q_t = 1/A_{x,t}$. This modeling strategy implies that the relative price of investment goods is driven entirely by investment-specific production efficiency. In the study of transitional dynamics, $A_{x,t}$ changes exogenously. It also implies that capital is only produced by the non-services goods producer, and therefore services goods are nondurable and fully consumed at every period. This is the main difference between non-services and services goods, along with technology and preferences.

Household Problem

The economy is populated by an infinitely lived representative household. The household derives utility from non-services and services goods. The household uses the investment goods, X_t, to augment the capital stock, and rents capital to the non-services goods producer and the services goods producer at the rental rate R_t. It supplies inelastically one unit of labor to the non-services and services goods producers at the wage rate w_t. Capital depreciates at rate δ, and the discounted factor is denoted by β. Therefore, the representative household solves the following problem:

$$\begin{aligned} \max_{C_{s,t}, C_{m,t}, K_{t+1}, L_t} \quad & \sum_{t=0}^{\infty} \beta^t u(C_{s,t}, C_{m,t}) \\ \text{s.t.} \quad & C_{m,t} + p_{s,t} C_{s,t} + q_t X_t \leq R_t K_t + w_t L_t \\ & X_t = K_{t+1} - (1-\delta) K_t \\ & K_0 \text{ given} \end{aligned}$$

with $K_t \geq 0$, $C_{m,t}, C_{s,t} \geq 0$, and $p_{s,t}$ denoting the prices of services goods in terms of non-services goods.

Market Clearing

All markets clear —the market for the non-services consumption good and investment good,

$$\begin{aligned} Y_{m,t} &= C_{m,t} + Y_{m,t}^x \\ &= C_{m,t} + \frac{X_t}{A_{x,t}} \end{aligned}$$

the labor market,

$$L_{s,t} + L_{m,t} = 1$$

the capital market,

$$K_{s,t} + K_{m,t} = K_t$$

and the services good market,

$$Y_{s,t} = C_{s,t}$$

Equilibrium

A *competitive equilibrium* for this economy is:

a) exogenous sequences $\{A_{x,t}, A_{m,t}, B_{m,t}, A_{s,t}, B_{s,t}\}$,

b) a sequence of prices $\{p_{s,t}, R_t, w_t, q_t\}$, and

c) a sequence of quantities $\{C_{m,t}, C_{s,t}, K_{t+1}, K_{m,t}, K_{s,t}, L_{m,t}, L_{s,t}, Y_{m,t}, Y_{s,t}\}$

that satisfy the following conditions:

i) given prices, $\{C_{m,t}, C_{s,t}, K_{t+1}\}$ solve the household problem.

ii) given prices, $\{K_{m,t}, L_{m,t}, Y_{m,t}\}$ minimize the cost of the non-services good producer.

iii) given prices, $\{K_{s,t}, L_{s,t}, Y_{s,t}\}$ minimize the cost of the services good producer.

iv) given prices, $\{Y^x_{m,t}\}$ minimize the cost of the investment good producer.

v) markets for the non-services and services consumption good, investments good, labor and capital clear at every date.

A *steady-state equilibrium* is a competitive equilibrium in which all variables are constant over time.

The Labor Share

This section derives an expression for the labor share in the non-services and services sectors. Using the first-order conditions from the producers' problems, I obtain an expression that relates the labor share to the rental rate of capital, R_t, capital augmenting technology, $B_{i,t}$, and the price of services, $p_{s,t}$, given the elasticity of substitution between labor and capital, σ_i, and the distributional parameter, α_i:

$$\begin{aligned} S_{L,m,t} &= \frac{w_t L_{m,t}}{R_t K_{m,t} + w_t L_{m,t}} \\ &= 1 - \alpha_m^{\sigma_m} \left(\frac{B_{m,t}}{R_t} \right)^{\sigma_m - 1} \end{aligned} \tag{4}$$

$$\begin{aligned} S_{L,s,t} &= \frac{w_t L_{s,t}}{R_t K_{s,t} + w_t L_{s,t}} \\ &= 1 - \alpha_s^{\sigma_s} \left(\frac{p_{s,t} B_{s,t}}{R_t} \right)^{\sigma_s - 1} \end{aligned} \tag{5}$$

Notice that if σ_i equals 1, the CES technology boils down to a Cobb-Douglas technology, and the labor share in each sector equals $1 - \alpha_i$ and its constant over time. Finally, the aggregate labor share can be written as

$$S_{L,t} = S_{L,m,t} \left(\frac{Y_{m,t}}{Y_{m,t} + p_{s,t} Y_{s,t}} \right) + S_{L,s,t} \left(\frac{p_{s,t} Y_{s,t}}{Y_{m,t} + p_{s,t} Y_{s,t}} \right),$$

the sum of the sector's labor share weighted by its value added.

6 Quantitative Results

This section calibrates the model and presents the main quantitative results of the paper. The objective of this quantitative exercise is to study the different impact of the decline in the relative price of investment on non-services and services industries as a mechanism to explain the divergence in the labor share between the two sectors, as documented in Section 3. First, I explore differences in the degree of substitutability between capital and labor in production. After that, I examine differences in technical change across industries.

To carry this out, the model is calibrated to its steady-state equilibrium so that it matches the sectoral compensation shares of the U.S. economy in 1980. Then the declining trend in the relative price of investment—shown in Figure 31—is fed into the model. As the economy responds to the decline in the relative price of investment goods, differences in technology parameters in the non-services and service sector imply differences in the evolution of the labor share for each industry.

I find that when I allow for differences in the degree of substitutability between factors, the model can account for 45% of the decrease in the labor share in non-services industries and 93% of the increase in services industries observed over the last 35 years in the United States. When I only consider differences in technical change and capital and labor are complements in production in both sectors, the model can explain 74% of the decrease in non-services industries, and half of the increase in services industries.

6.1 Calibration

This section shows the calibration of the model. Each period in the model corresponds to one year. Table 1 reports the parameters of the model that are calibrated independently, whereas Table 2 reports the parameters that are jointly calibrated to match the moments reported in Table 3.

Preferences

The utility function is assumed to be Cobb-Douglas in non-services and services goods:

$$u(C_s, C_m) = C_m^{\gamma} C_s^{1-\gamma}$$

The parameter γ equals 0.37 to match the average consumption share of non-services goods in the United States from 1980 and 2015, as reported by Boppart (2014). The discount rate β is calibrated to generate a capital-over-output ratio of 3 in the initial steady-state equilibrium. The calibrated value for β is 0.93.

Production Technology and Capital Depreciation

Let us assume a capital depreciation rate δ of 0.05. The two sectors have a CES production technology that is characterized by two parameters —α_i, the distributional parameter, and σ_i, the elasticity of substitution between capital and labor —and two exogenous sequences, $A_{i,t}$ and $B_{i,t}$, which represent labor- and capital-augmenting technology, respectively. To the best of my knowledge, there are no estimates of the elasticity of substitution between capital and labor, and labor- and capital-augmenting technology for the exact split of the economy used in this paper. I therefore explore two different calibrations of the model.

First, I set σ_m and σ_s equal to 1.25 and 0.75, respectively. These values correspond to the benchmark estimate for the aggregate elasticity of substitution in Karabarbounis and Neiman (2014), and to the estimate of the elasticity of substitution for services industries in Herrendorf, Herrington, and Valentinyi (2013).[19] The distributional parameters are calibrated to match the initial value for the compensation share for each industry in 1980. The calibrated values for α_m and α_s are 0.34 and 0.46, respectively.

However, although the range of estimates is wide, the bulk of the empirical literature suggests an elasticity below one for most industries. Oberfield and Raval (2014) and Lawrence (2015) have proposed that with limited substitution possibilities between capital and labor, the fall in the labor share can be explained by changes in the pace of technical change. The second experiment considers an alternative calibration of the benchmark model that uses direct estimates from Herrendorf, Herrington, and Valentinyi (2013) (HHV).[20] They find that σ_m equals 0.8, and σ_s equals 0.75. I recalibrate the model in 1980 to match the sectoral compensation shares and find that α_m and α_s are 0.59 and 0.50, respectively.

6.2 Differences in Substitutability between Capital and Labor

This section shows the main quantitative results for the first calibration of the model. In 1980, it is assumed that the economy is in a steady-state equilibrium. The representative

[19] Their definition of services industries includes all sectors apart from agriculture and manufacturing.

[20] Their split of the economy is between agriculture, manufacturing and services. I assume that non-services industries correspond to manufacturing.

Table 1: Parameters Calibrated Independently

Parameters		$\sigma_m > 1, \sigma_s < 1$ Value	HHV Value
Capital Depreciation	δ	0.05	0.05
Share of Non-Services Goods	γ	0.37	0.37
Elasticity of Substitution (Non-Services Sector)	σ_m	1.25	0.8
Elasticity of Substitution (Services Sector)	σ_s	0.75	0.75

This table shows the parameters of the benchmark model that are calibrated independently.

Table 2: Parameters Calibrated Jointly in Equilibrium

Parameters		$\sigma_m > 1, \sigma_s < 1$ Value	HHV Value
Discount Factor	β	0.93	0.93
Distributional Parameter (Non-Services Sector)	α_m	0.34	0.59
Distributional Parameter (Services Sector)	α_s	0.46	0.50

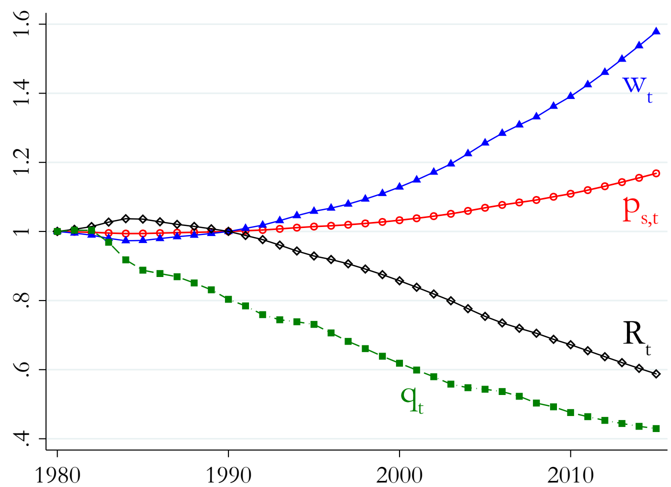
This table shows the parameters of the benchmark model that are calibrated jointly to match the initial steady-state equilibrium for the moments reported in Table 3.

Table 3: Data and Model Moments

Targets	Data	$\sigma_m > 1, \sigma_s < 1$	HHV
Capital to Output Ratio	3	3.00	3.00
Compensation Share (Non-Services)	0.57	0.57	0.57
Compensation Share (Services)	0.66	0.66	0.66

This table summarizes the joint calibration exercise. The data column reports the targets of the calibration, whereas the model columns report the moments of the calibrated model. The calibrated parameters that generate the model moments are reported in Table 2.

Figure 11: Prices, 1980-2015 ($\sigma_m > 1, \sigma_s < 1$)



Notes: This figure plots prices over the transition. The time series for the price of investment, q_t, is fed into the model, whereas the wage rate, w_t, the rental rate, R_t, and the price of services goods, $p_{s,t}$, are the result of general equilibrium.

agent then learns about the future decreasing path of the relative price of investment goods. In the benchmark exercise, the price of investment declines by 57% from 1980 to 2015, as shown in Figure 31, and remains constant after that for the rest of the transition. Figure 11 shows the evolution of prices. As investment goods become cheaper, the wage rate, w_t, and the price of services, $p_{s,t}$, increase, whereas the rental rate of capital, R_t, decreases.

Table 4 shows the change in the aggregate and industry compensation shares between 1980 and 2015, comparing the output of the model with NIPA data. The model can account for one-third of the fall in the aggregate compensation share, half of the decline in the non-services compensation share, and most of the increase in the services compensation share. Figure 12 plots the time series for the compensation shares in services and non-services, comparing the model transition with data from NIPA industry accounts.

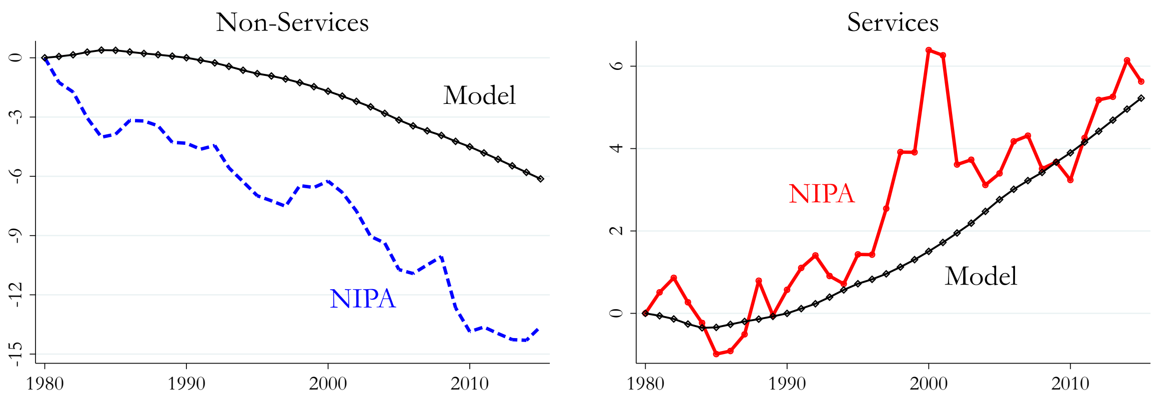
In Equation 4 and Equation 5, the only non-constant variables that affect the evolution of the sectoral compensation shares are the price of services, $p_{s,t}$, and the rental rate of capital, R_t. As shown in Figure 11, prices take some time to respond, and this explains why sectoral compensation shares are flat during the first 10 years of the transition. The rental rate of capital then starts falling, and the diverging path for sectoral

Table 4: Compensation Share: Change from 1980 to 2015 ($\sigma_m > 1, \sigma_s < 1$)

	Data	$\sigma_m > 1, \sigma_s < 1$
Aggregate	-5.4 pp	-1.51 pp
Non-Services	-13.61 pp	-6.13 pp
Services	5.63 pp	5.22 pp

Notes: This table compares the data generated by the model with industry-level NIPA data. Results are displayed in percentage points (pp) differences. The 1980 calibration that generates this output is reported in Table 1, Table 2, and Table 3. Figure 12 plots the time series for these changes.

Figure 12: Compensation Share: Data and Model, 1980-2015 ($\sigma_m > 1, \sigma_s < 1$)



Notes: This figure compares the data generated by the model with industry-level NIPA data. The left panel shows the non-services sector, and the right panel shows the services sector. The 1980 calibration that generates this output is reported in Table 1, Table 2, and Table 3. Table 4 shows a direct comparison of the change in the compensation shares from 1980 to 2015, and Figure 36 plots the aggregate compensation share.

compensation shares unfolds. For services, the rise in the relative price of services goods further increases the labor share in this sector. The different magnitude of the response across sectors is a consequence of differences in the values for σ and α.

The key parameters that govern the distinct evolution of compensation shares are the elasticities of substitution between capital and labor, σ_m and σ_s. For this calibration, they are set equal to 1.25 and 0.75, respectively. This implies that capital and labor are substitutes in production in the non-services sector and complements in the services sector. In this economy, as the rental rate of capital decreases, both producers increase their capital-to-labor ratio. However, the increase for the non-services producer is much steeper. In fact, the differences are large enough to entail a decrease in the compensation share in non-services and an increase in services.

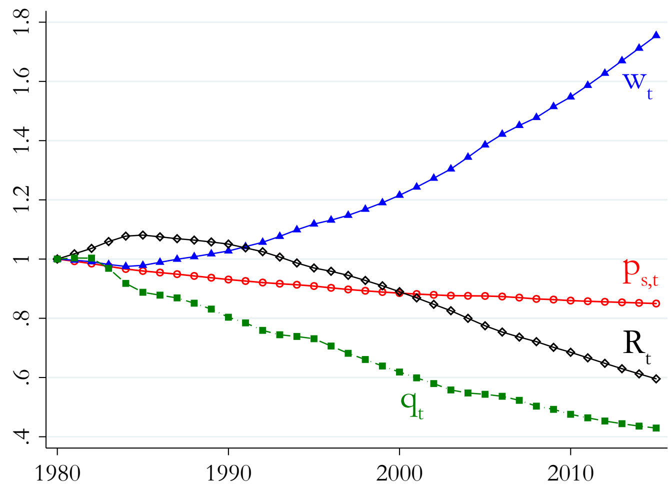
6.3 Differences in Technical Change

This section considers an alternative calibration of the benchmark model that uses direct estimates from Herrendorf, Herrington, and Valentinyi (2013). They find that σ_m equals 0.8, and σ_s equals 0.75. They also find differences in capital- and labor-augmenting technological progress between manufacturing and services. Growth rates for labor-augmenting technology were 4.4% per year in manufacturing, but only 1.6% for services. For capital-augmenting technology, growth rates were -4.5% in manufacturing and flat for services. In this experiment, I therefore assume that all A_m, A_s, B_m, and B_s are equal to one in 1980, and feed into the model the series for the price of investment goods, as well as exogenous series for $A_{m,t}$ $A_{s,t}$, and $B_{m,t}$. In the benchmark calibration, the exogenous series for technical change grows at a constant rate from 1980 to 2015, and remain constant after that for the rest of the transition. Figure 13 shows the evolution of prices. As investment goods become cheaper, the wage rate, w_t, increases, whereas the price of services, $p_{s,t}$, and the rental rate of capital, R_t, decrease.

Table 5 shows the change in the aggregate and industry compensation shares between 1980 and 2015, comparing the output of the model with NIPA data. The model can account for 80% of the fall in the aggregate compensation share, three-quarters of the decline in the non-services compensation share, and half of the increase in the services compensation share. Figure 14 plots the time series for the compensation shares in services and non-services, comparing the model transition with data from NIPA industry accounts.

From Equation 4 and Equation 5 we can see that sectoral labor shares only depend on the price of services, $p_{s,t}$, the rental rate of capital, R_t, and the evolution of capital-augmenting technology in each sector ($B_{m,t}$ and $B_{s,t}$). As shown in Figure 13 and discussed in the previous section, prices take some time to respond. This explains why the labor share in services is flat at the beginning of the transition and only starts increasing when the rental rate starts falling in 1990. In this experiment, the magnitude of the increase in services is lower. The main reason for this is the general equilibrium response of the price of services: It also decreases during the transition, and dampens

Figure 13: Prices, 1980-2015 (HHV)



Notes: This figure plots prices over the transition. The time series for the price of investment, q_t, is fed into the model, whereas the wage rate, w_t, the rental rate, R_t, and the price of services goods, $p_{s,t}$, are the result of general equilibrium.

the increase in the compensation share in the services sector. However, for the non-services sector, the labor share starts falling immediately. This is the result of both the exogenous decrease in $B_{m,t}$ and the initial increase in the rental rate of capital during the first years. Then, it starts decreasing at a lower rate as the rental rate of capital starts declining.

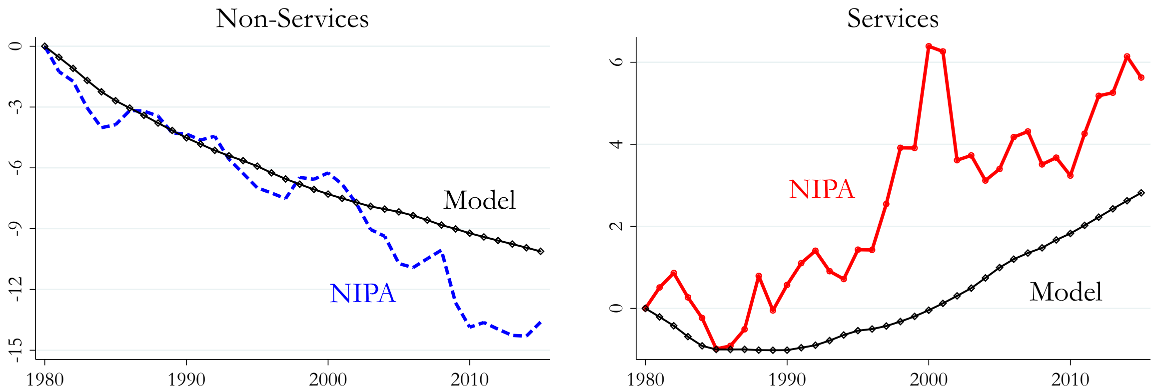
In this experiment, the key input that explains the result is the decrease in capital-augmenting technology in the non-services sector. In the model, capital in the non-services sector is getting progressively less productive over the transition. The non-services producer efficiently decides to use more capital to make up for the negative technical progress. As a result, even if both producers increase their capital-to-labor ratio, as capital is getting relatively cheaper, the increase in the non-services producer is much steeper. Similar to the previous experiment, the differences are large enough to entail a decrease in the compensation share in the non-services sector and an increase in the services sector.

Table 5: Compensation Share: Change from 1980 to 2015 (HHV)

	Data	HHV
Aggregate	-5.4 pp	-4.63 pp
Non-Services	-13.61 pp	-10.12 pp
Services	5.63 pp	2.82 pp

Notes: This table compares the data generated by the model with industry-level NIPA data. Results are displayed in percentage points (pp) differences. The 1980 calibration that generates this output is reported in Table 1, Table 2, and Table 3. Figure 14 plots the time series for these changes.

Figure 14: Compensation Share: Data and Model, 1980-2015 (HHV)



Notes: This figure compares the data generated by the model with industry-level NIPA data. The left panel shows the non-services sector, and the right panel shows the services sector. The 1980 calibration that generates this output is reported in Table 1, Table 2, and Table 3. Table 5 shows a direct comparison of the change in compensation shares from 1980 to 2015, and Figure 36 plots the aggregate compensation share.

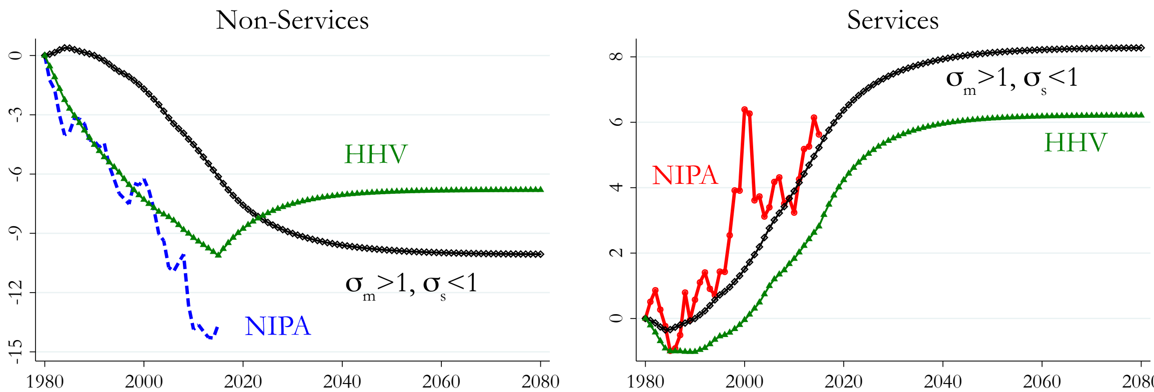
6.4 Compensation Share in the Long Run

This section considers the model's long-run predictions for the compensation share. The relation between the price of investment goods, q_t, and the rental rate of capital, R_t, plays an important role in these predictions. For this reason, I begin by considering the relation between q_t and R_t in a steady-state equilibrium of the model:

$$\frac{q_t}{R_t} = \frac{\beta}{1 - \beta(1 - \delta)} \tag{6}$$

Equation 6 implies that, in equilibrium, the rental rate of capital and the price of investment goods have a constant relation. As a consequence, R_t and q_t must decrease by the same percentage during the transition from the initial to the new long-run steady-

Figure 15: Compensation Share: Data and Model, Long Run



Notes: This figure presents the output from the benchmark model in the long run and the compensation shares from industry-level NIPA data. The left panel shows the evolution of the compensation share in non-services industries, and the right panel shows the evolution of the compensation share in services industries. Figure 37 plots the aggregate compensation share.

state equilibrium. Therefore, R_t also decreases by 57% over the transition between the two equilibria.

Figure 15 illustrates the compensation shares in NIPA and those generated by the model under the two different calibrations over a time horizon of 100 periods. The long-run implications of these two experiments are very different. Under the assumption that investment-specific technological progress stops in the 2010s, the model with differences in substitutability between factors (black line) further predicts that the divergence will continue for a few more decades. Under the additional assumption that differences in labor- and capital-augmenting technology will stop across sectors and that capital and labor are complements, the model predicts a reversion in the trend in the non-services sector and a slight convergence between industries (green line).

7 Robustness

This section examines the robustness of the results of the benchmark model to departures from the baseline calibration and assumptions.

7.1 Myopic Agent

This section considers the evolution of the compensation shares in the model when the representative agent does not have perfect foresight. In the benchmark model, in 1980 the representative agent acquires knowledge of the future path for all exogenous variables (q_t, $A_{m,t}$, $A_{ms,t}$, ,$B_{m,t}$, or $B_{ms,t}$). To bound the effect between the two extreme cases, let us consider the opposite perfect foresight—that is, a perfectly myopic agent.

In this version of the model, the agent learns about the contemporaneous change in the price of investment and the changes in labor- and capital-augmenting technology for each period from 1980 to 2015, but does not anticipate future paths for these variables. In response to each surprising change, the agent optimally chooses new consumption and capital plans.

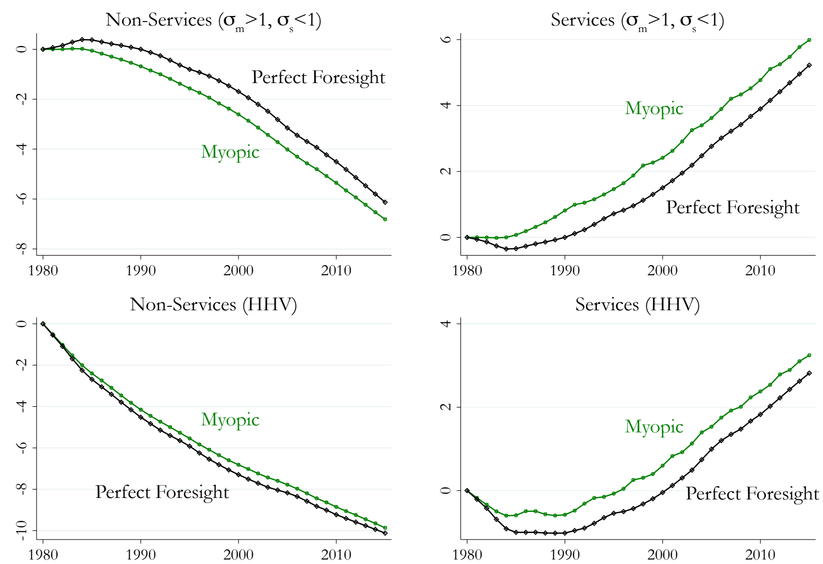
Figure 16 shows the evolution of compensation shares over the transition, under the assumption that the agent is perfectly myopic. To facilitate the comparison with the benchmark model, the time series of the perfect foresight case are also represented in the graph. The figure shows that the evolution of the compensation shares is very similar under both assumptions, although the model with a myopic agent predicts a slightly larger increase in the compensation share in the services sector. In conclusion, assuming a perfectly myopic agent does not affect the qualitative or quantitative findings of the benchmark model.

7.2 Smooth Transition

How would the results change under an alternative assumption about the evolution of the exogenous variables after 2015? To answer this question, this section considers an alternative transition in which the relative price of investment goods and labor- and capital-augmenting technology mantain a constant growth rate equal to the average growth rate observed during the period 2005-2015. I assume the growth rate of each trend declines geometrically to reach 0 growth in 2035.

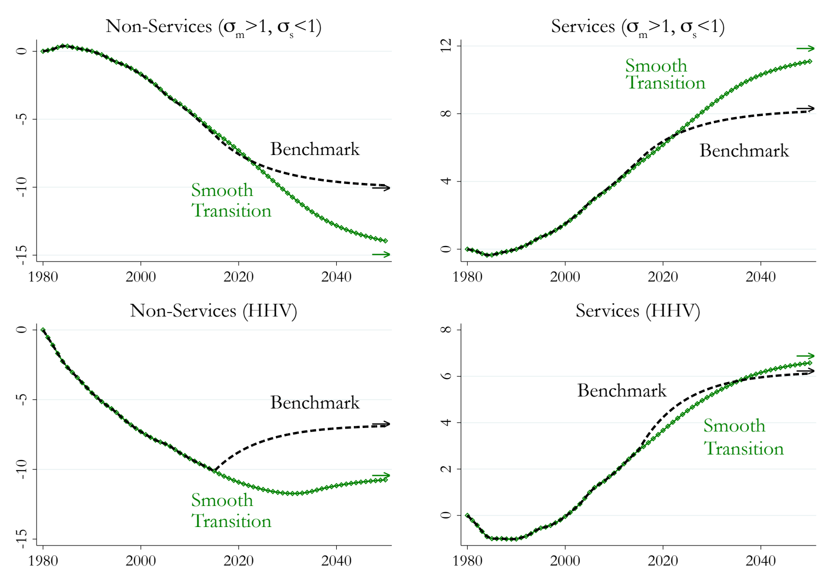
Figure 17 shows that the compensation shares implied by this alternative assumption are almost equal to the results under the benchmark calibration between 1980 and 2015. The only noticeable changes refer to the long-run predictions of the model.

Figure 16: Myopic Agent



Notes: The left panels plot the results for the non-services sector and the right panels the results for the services sector. The graphs compare the output from the benchmark model with the time series generated by a model in which the representative agent is perfectly myopic.

Figure 17: Smooth Transition



Notes: The left panels plot the results for the non-services sector and the right panels the results for the services sector. The graphs compare the output from the benchmark model with the time series generated by a model in which there is a smooth transition for the exogenous variables. The right arrow on the right of each panel indicates the value of the compensation shares at the final steady-state equilibrium.

8 Conclusion

This paper discusses a general divergence in the labor share between services and non-services industries in the United States over recent decades. Several European countries experience a similar diverging pattern. Why have services industries experienced a steady increase in the labor share over recent decades, at a time of global decline in the aggregate labor share? What drives this increase? By exploiting industry-level data, I show that this phenomenon occurs in most sub-industries within both services and non-services, and is related to changes in labor intensity across industries.

I then propose a standard quantitative two-sector model that can account for the observed patterns in the data. The decrease in the price of investment goods affects the optimal capital-labor mix differently in non-services and services industries. As a consequence, the labor share increases in services industries and decreases in non-services industries. I show that this can be rationalized by differences in the degree of substitutability between capital and labor and differences in technical change across industries. However the long-run implications of the two calibrations differ. Under the assumption that investment-specific technological progress stops in the 2010s, the model with differences in substitutability between factors further predicts that the divergence will continue. Under the additional assumption that differences in labor- and capital-augmenting technology will stop across sectors, the model implies a slight convergence between sectors.

This paper is a first attempt to understand the different evolution of the labor share in services and non-services industries over recent decades. I show that one of the mechanisms already explored in the literature—the decrease in the price of investment goods—is consistent not only with the aggregate fall but also with the observed sectoral divergence. In future work, I would like to incorporate other important features in the model and explore other differences across industries, such as markups, levels of outsourcing, or skill composition that may be related to the evolution of the sectoral labor shares.

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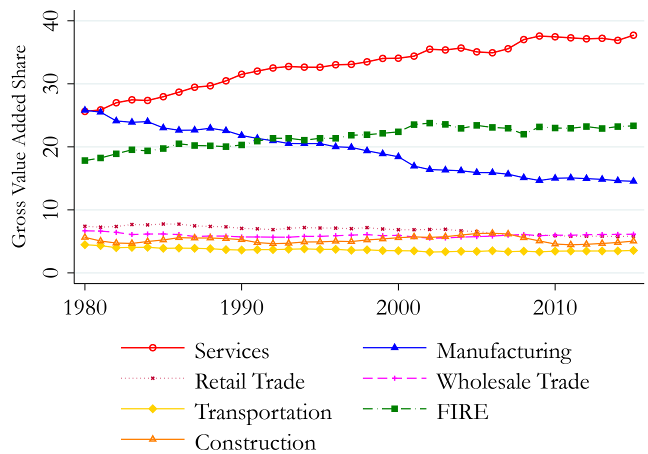
APPENDIX

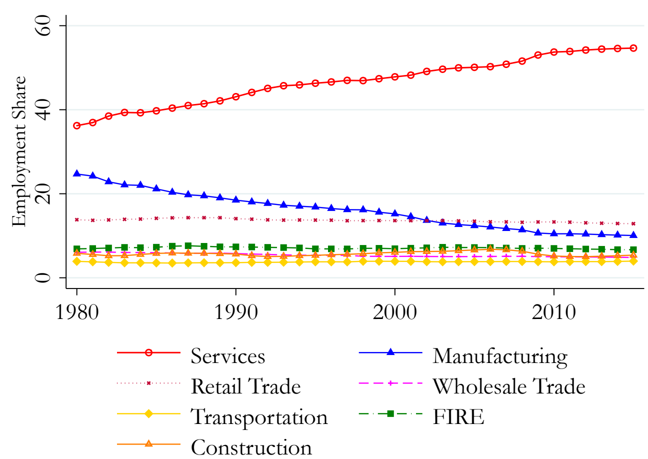
A1 Figures and Tables

Figure 18: Gross Value Added Share, 1980-2015



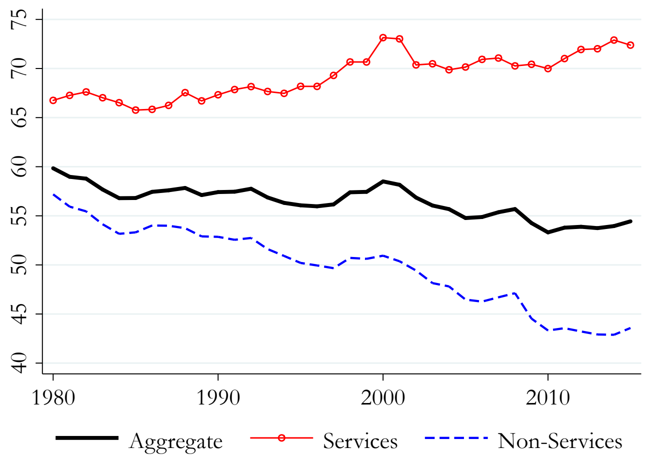
Notes: The figure plots the gross value added share for services and the largest non-services industries from 1980 to 2015 using industry-level NIPA data.

Figure 19: Employment Share, 1980-2015



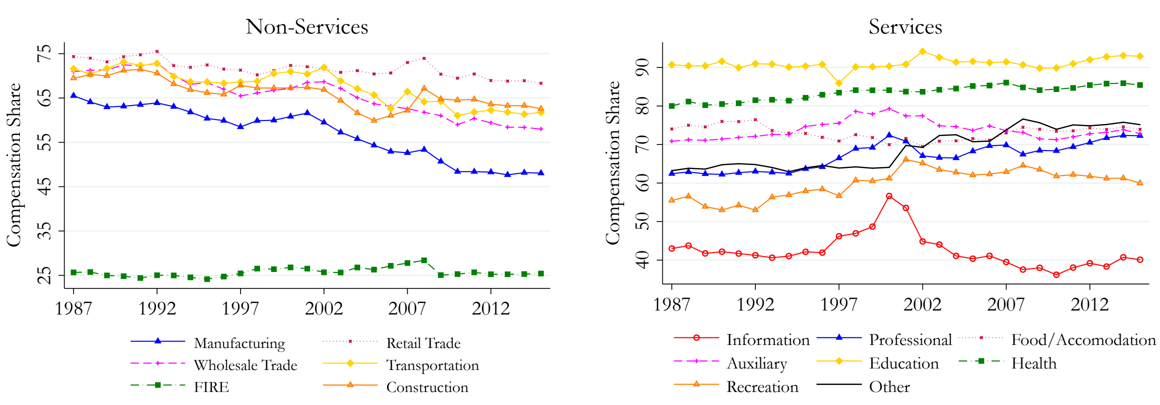
Notes: The figure plots the employment share for services and the largest non-services industries from 1980 to 2015 using industry-level NIPA data.

Figure 20: Compensation Share, 1980-2015



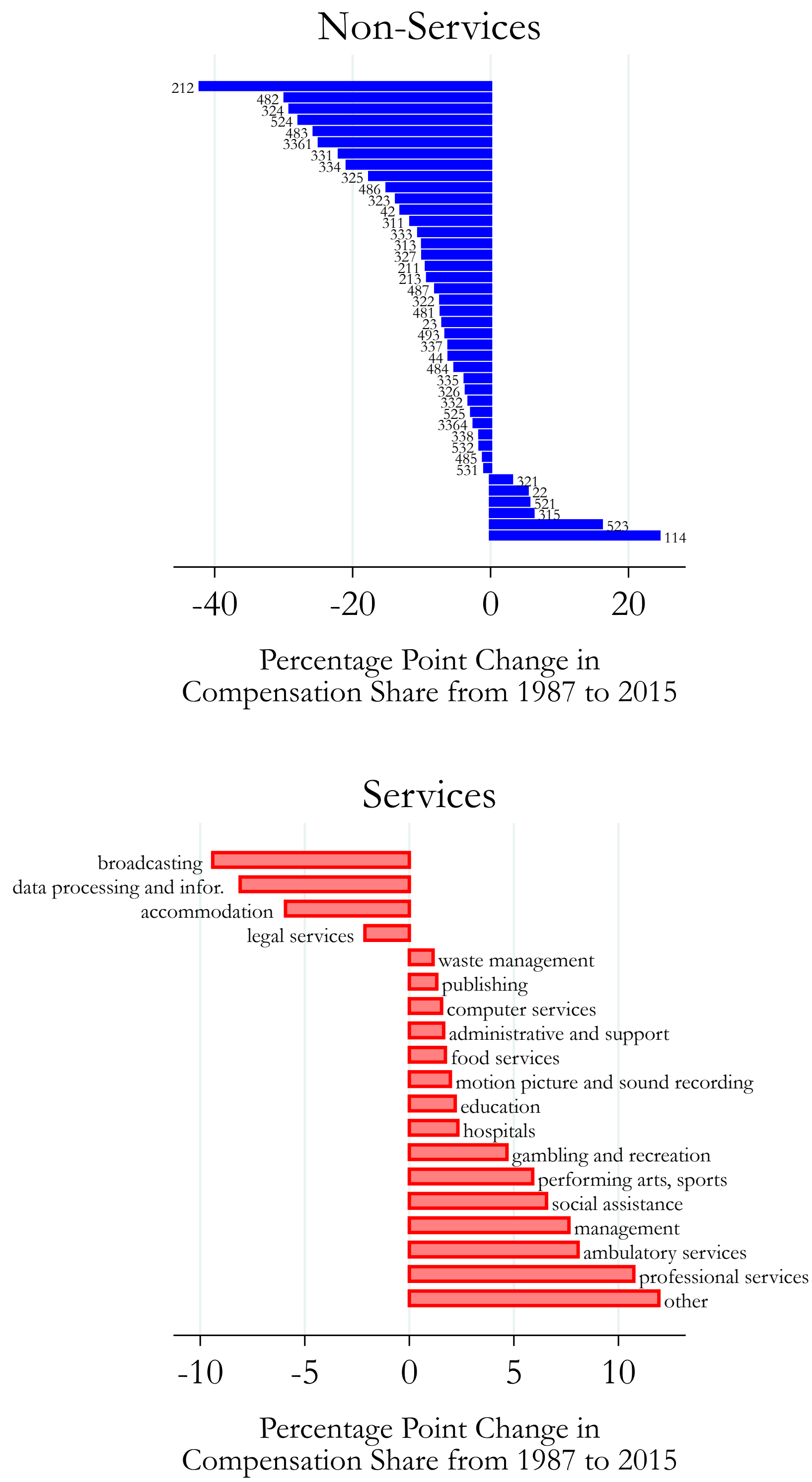
Notes: This figure plots the aggregate compensation share (black line) for the U.S. nonfarm business sector from 1980 to 2015 using industry-level NIPA data. Red circles show the compensation share for services industries. Dashed blue line shows the compensation share for non-services industries.

Figure 21: Industry Compensation Shares, 1987-2015



Notes: This figure plots the change in the compensation share for some selected industries from 1980 to 2015 using industry-level NIPA data.

Figure 22: Change in Compensation Shares, 1987-2015



Notes: This figure plots the change in the compensation share for all sub-industries from 1987 to 2015 using industry-level NIPA data. The numbers next to the blue bars represent the NAICS codes for each sub-industry.

Table 6: Change in the Compensation Share by Industry (1987-2015)

Industry	Emp. Sh. 1987	Emp. Sh. 2015	Diff. Emp. Sh.	Gva. Sh. 1987	Gva. Sh. 2015	Diff. Gva. Sh.	Comp. Sh. 1987	Comp. Sh. 2015	Diff. Comp. Sh.
health care services	8.14	12.23	4.09	5.88	7.98	2.1	79.9	85.19	5.29
food services and drinking places	6.5	8.99	2.49	1.9	2.3	0.4	76.59	78.32	1.73
administrative and support services	4.39	6.86	2.47	1.95	3.49	1.53	71.83	73.47	1.64
social assistance	1.16	2.89	1.73	0.41	0.79	0.39	81.35	87.91	6.56
computer systems design and related services	0.41	1.55	1.14	0.56	1.8	1.25	88.22	89.77	1.54
professional, scientific, and technical services	3.57	4.58	1.01	3.67	5.33	1.66	60.73	71.46	10.74
educational services	1.86	2.85	0.99	0.84	1.34	0.5	90.71	92.9	2.2
amusements, gambling, and recreation industries	0.83	1.27	0.44	0.41	0.5	0.1	61.47	66.14	4.67
TRANSPORTATION	3.51	3.94	0.43	3.83	3.52	-0.3	71.57	61.75	-9.82
management of companies and enterprises	1.41	1.78	0.37	1.95	2.39	0.45	79.72	87.36	7.63
performing arts, spectator sports, museums	0.38	0.5	0.12	0.39	0.65	0.26	49.29	55.19	5.9
data processing, internet publishing, and other	0.27	0.33	0.06	0.36	0.72	0.35	62.76	54.67	-8.09
waste management and remediation services	0.26	0.32	0.06	0.27	0.29	0.01	63.84	64.98	1.14
motion picture and sound recording industries	0.28	0.33	0.05	0.7	0.75	0.04	29	30.97	1.97
accommodation	1.57	1.56	-0.01	0.81	0.85	0.04	68.06	62.13	-5.92
MINING	0.74	0.61	-0.14	1.67	1.99	0.32	46.01	31.51	-14.5
publishing industries, except internet	0.91	0.7	-0.22	1.17	1.39	0.22	55.58	56.89	1.31
other services, except government	6.03	5.74	-0.29	3.04	2.63	-0.41	63.22	75.15	11.94
legal services	1.22	0.92	-0.3	1.46	1.55	0.09	56.91	54.78	-2.12
UTILITIES	0.81	0.45	-0.36	2.81	1.56	-1.25	28.71	34.01	5.3
CONSTRUCTION	5.79	5.35	-0.43	5.43	5	-0.43	69.48	62.58	-6.9
AGRICULTURE	1.58	1.14	-0.44	2.31	1.19	-1.13	17.86	30.65	12.78
broadcasting and telecommunications	1.36	0.88	-0.47	3.15	2.61	-0.54	39.21	29.8	-9.4
FIRE	7.54	6.64	-0.9	19.83	23.12	3.29	25.66	25.4	-0.26
WHOLESALE TRADE	5.78	4.79	-0.99	5.67	6.08	0.41	70.98	58	-12.98
RETAIL TRADE	14.15	12.79	-1.36	7.32	5.78	-1.54	74.33	68.33	-6
MANUFACTURING	19.54	9.99	-9.55	22.23	14.4	-7.83	65.51	48.05	-17.46
SERVICES INDUSTRIES	40.56	54.3	13.74	28.90	37.36	8.45	66.24	72.38	6.14
NON-SERVICES INDUSTRIES	59.44	45.7	-13.74	71.10	62.64	-8.45	52.90	43.25	-9.65

Notes: This table reports the change on employment share, gross value added share and compensation share for all the industries in the industry-level NIPA data from 1987 to 2015. Services sub-industries (lower case letters) are reported more dissaggregated than non-services industries (upper case letters). They are ordered by the increase in the employment share from 1987 to 2015.

A2 Data

A2.1 NIPA/BEA

This section describes in greater detail the Gross Domestic Product by Industry Data of the National Income and Product Accounts (NIPA) produced by the Bureau of Economic Analysis (BEA). It explains which sub-industries are included in each major industry, the exact data used in the analysis, and the construction of the continuous time series for the sectoral compensation shares between 1950 and 2015.

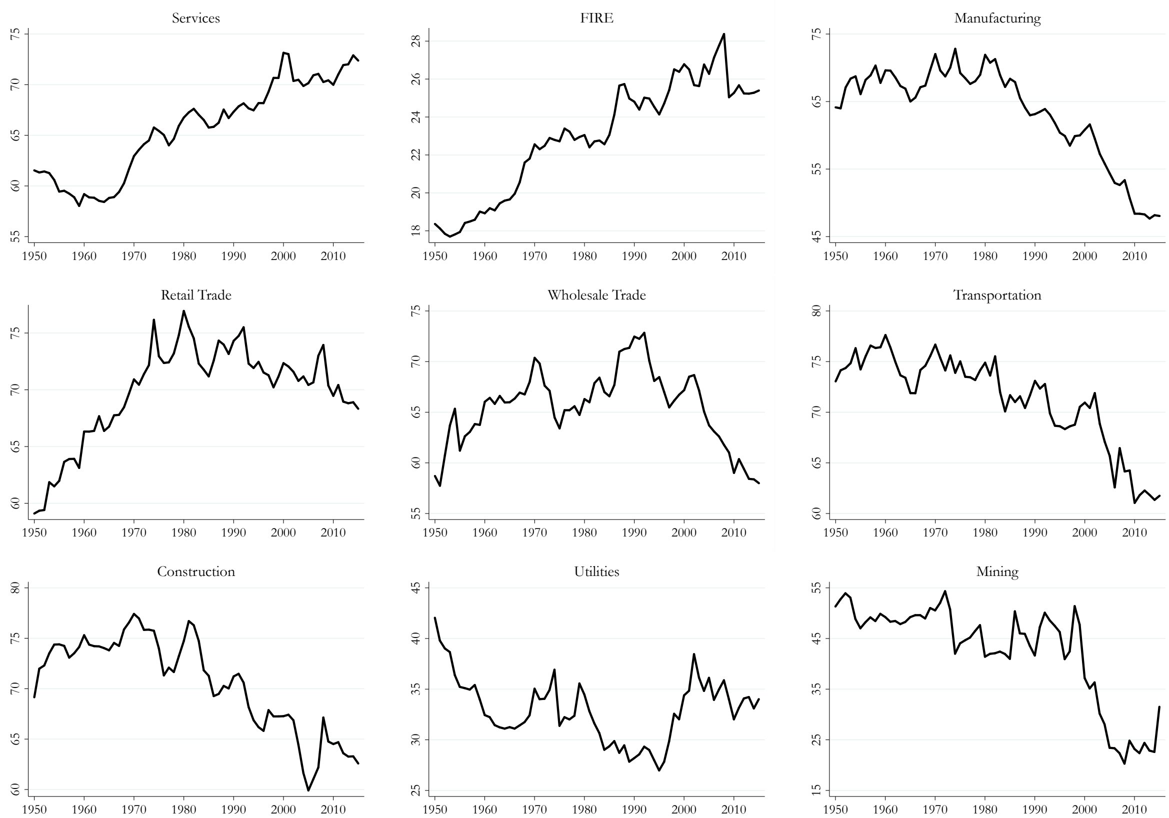
In NIPA, industries are classified according to the North American Industrial Classification System (NAICS). However, data on wages and salaries, total compensation, and taxes are only available on the basis of NAICS codes from 1998 and 1987, respectively. Previous data for wages and salaries, total compensation, and taxes are on the basis of Standard Industrial Classification (SIC) codes. Given this data limitation, I only use the 10-industry level of detailed data when studying the compensation share before 1987.

In order to group industries in 10 major sectors, I follow a classification of industries similar to the one used by Autor, Dorn, Katz, Patterson, and van Reenen (2017b). Industries are grouped as agriculture (SIC: 07-09 and NAICS: 113); mining (SIC: 10-14 and NAICS: 21); construction (SIC: 15-17 and NAICS: 23); manufacturing (SIC: 20-39 and NAICS: 31-33); transportation (SIC: 40-42 and 44-47 and NAICS: 48-49); utilities (SIC: 49 and NAICS: 22); wholesale trade (SIC: 50-51 and NAICS: 42); retail trade (SIC: 52-59 and NAICS: 44-45); FIRE (SIC: 60-67 and NAICS: 52-53); and services (SIC: 48 and 70-89 and NAICS: 51, 54-56, 61-62, 71-72, and 81). Services industries therefore include information, professional and business services, education, health, arts and entertainment, accomodation, and food services.

Construction of continuous time series

For 10 years, from 1987 to 1997, gross value added and total compensation are available under NAICS and SIC codes. To construct consistent series of the compensation share by industry, I do as follows. First, I compute the ratio of total compensation

Figure 23: The Compensation Share by Industry



Notes: The figure plots consistent sectorial compensation shares from 1950 to 2015 using industry-level NIPA data.

and gross value added using SIC codes and NAICS codes at the most disaggregated level between 1987 and 1997. Then, I compute the average deviation between these two series. Finally, I scale total compensation and gross value added under the SIC series by the discrepancy. This result in a continuous series, which I then use to calculate compensation shares.[21] This effectively shifts the earlier values of the overall U.S. aggregate compensation share in the nonfarm business sector down by about 1.72 percentage points.[22] In Figure 23, I report the time series for each industry. To construct

[21]An alternative strategy is to compute compensation shares by industry using SIC codes from 1950 to 1997 and NAICS codes from 1987 to 2015, then match the 1987 values at the most disaggregated level and scale SIC values by the discrepancy. This strategy provides similar results. There are some differences in the levels, especially for FIRE, retail trade, and wholesale trade, but the time series have a remarkably similar trend between 1987 and 1997.

[22]This shift is similar in magnitude (1.17 percentage points) to the overall average shift in the aggregate compensation share when using pre- and post-2013 revision data from NIPA over the 1987-2011 period. I also compare the gross value added share time series with the value added share time series already available in NIPA on the NAICS basis from 1950. As is the case for the sectoral

the series for total employment, I use directly data on the NAICS basis from 1950 to 2015.

The exact data I use are:

- Historical series under the SIC system: GDPbyInd_VA_SIC: `https://www.bea.gov/industry/io_histannual.htm`. This has information on *value added, total compensation, wages and salaries, and taxes*. This series is based on the 1972 and 1987 Standard Industrial Classification (SIC) systems. These data are not consistent with the 2010 comprehensive revision of the annual industry accounts or 2013 comprehensive revision of the NIPAs.[23]
- Valued Added / "1947-2016: up to 71 industries." Data on *value added (from 1947 to 2015), and total compensation and taxes (from 1987 to 2015)*: `https://www.bea.gov/industry/gdpbyind_data.htm`
- COMP, TXPIXS, GOS / "1998-2015: up to 65 industries." Data on *wages and salaries (from 1998 to 2015)*: `https://www.bea.gov/industry/more.htm`
- Employment / "1948-1997: up 65 industries" and NIPA Table 6.4D. Data on *full-time and part-time employees (from 1948 to 2015)*: `https://www.bea.gov/industry/more.htm`

For the analysis in Section 4, I exclude Real Estate, since it has a very low compensation share due to the value of assets in the sector, which does not reflect the share of labor in the production function of the sector. Acemoglu and Guerrieri (2008) also follow this assumption. I also exclude all the sub-industries with a compensation share higher than 100% in 2000 in Figure 6 and Figure 9. These extraordinarily high compensation shares are only related to the dot-com bubble and do not reflect the normal share of labor in the sector's production. I therefore exclude "514: Data processing, internet publishing, and other information services," "523: Securities, commodity contracts, and investments," and "5415: Computer systems design and related services,"

compensation shares, the trends are remarkably similar and there are only minor differences in the levels for services, retail, and wholesale trade.

[23]Data on wages and salaries, and total compensation consistent with the 2013 comprehensive revision of the NIPAs is in Tables 6.2B and 6.2C on the BEA website. However, I do not use this data because it does not exist in a post-revision version of gross value added by industry under the SIC system.

with compensation shares equal to 179%, 111%, and 103%, respectively.

A2.2 KLEMS

This section describes the September 2017 release of EU KLEMS Growth and Productivity Accounts. The dataset covers all European Union (EU-28) countries and the United States. Consistent data are available from 1995-2015 for most of the countries.[24] Most of the raw series are taken from the national accounts of all individual countries, and they are consistent with the official statistics available in Eurostat and NIPA. At the lowest level of aggregation, data were collected for 34 industries. The industries are classified according to the ISIC Rev. 4 (NACE Rev. 2) industry classification. I drop public administration and postal services in order to be as consistent as possible with the definition of the non-farm business sector used for the United States.

Compensation Share vs. Labor Share in the United States

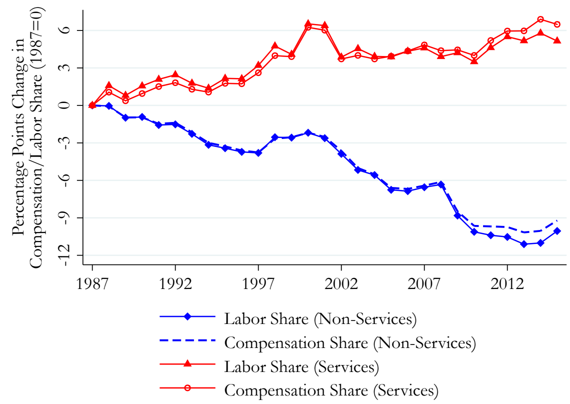
KLEMS provides an estimate of labor compensation that includes the self-employed. This is calculated by applying the ratio of hours worked by total persons engaged to hours worked by employees to total compensation, assuming that the self-employed receive the same hourly wages as employees. I can therefore compute the evolution of both the labor share and compensation share in the United States from 1987 to 2015. Figure 24 plots these time series and shows that the evolution of the labor share and the compensation share were remarkably similar during this time. This provides some evidence that the compensation share is an informative measure of the divergence between services and non-services industries.

Divergence of the Compensation Share in Europe

I construct a series for the compensation share in services and non-services industries between 1995 and 2015. I have data for all countries since 1995 except for Bulgaria,

[24] Data for Denmark are available from 1975, France from 1978, Finland from 1980, Sweden from 1993, and the United States from 1987.

Figure 24: Compensation vs. Labor Share (United States), 1987-2015



Notes: This figure plots the percentage points change in the compensation share for services (red-circles line), and non-services (blue-dash line) industries from 1987 to 2015 using industry-level KLEMS data. It also plots the labor share for services (red-triangles line), and non-services (blue-diamond line) industries. All series are normalized to zero in 1987.

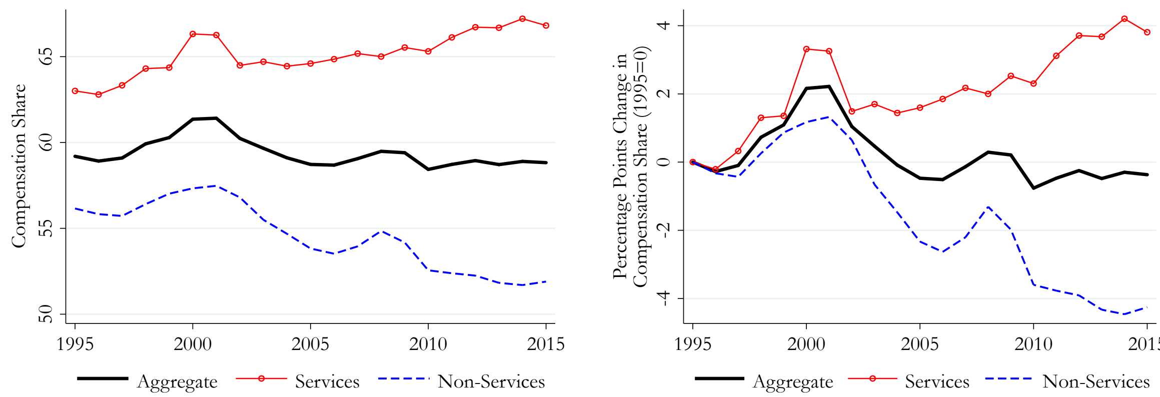
Croatia, and Poland, which start in 1999, 2000, and 2003, respectively.[25] Figure 25 shows the evolution of the aggregate (solid black line), services (red circles) and non-services (dashed-blue line) compensation share in KLEMS by plotting year fixed effects from a least-squares regression of the compensation shares on country and year fixed effects. Each observation is weighted by gross value added measured in U.S. dollars at market exchange rates. Fixed effects are normalized such that the compensation share equals the average level for each statistic in 1995.

During the sample period, the aggregate compensation share is remarkably constant, at around 59%. This contrasts with the evolution of the compensation share when we split industries between services and non-services. On the one hand, services' compensation share exhibits a positive upward trend, and it increases from 63% in 1995 to about 67% at the end of the sample. On the other hand, non-services' compensation share exhibits a steady downward trend, and it decreases from 56% in 1995 to around 52% in 2015. In the right-hand panel of Figure 25, we can see that most of the divergence started around 2000.

Figure 26 plots the percentage-points change in the difference between services' and non-services' industries compensation shares between 1995 and 2015. It shows that

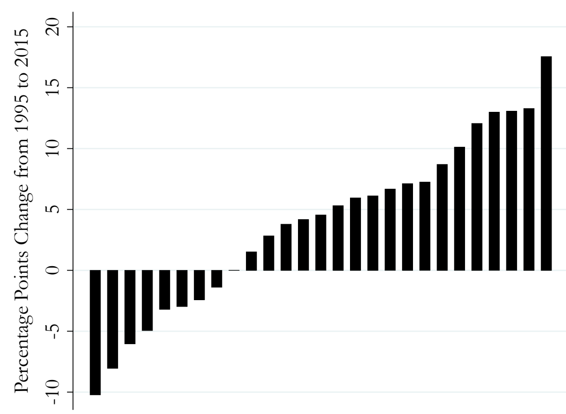
[25] I drop Malta from the sample, which has an implausible evolution of the compensation share over this period.

Figure 25: Divergence of the Compensation Share, 1995-2015



Notes: The figure on the left shows year fixed effects from a regression of aggregate, services and non-services compensation share that also include country fixed effects. The regression is weighted by gross value added measured in U.S. dollars at market exchange rates. The fixed effects are normalized to equal the average level of the compensation share in 1995. The figure on the right shows the same graph normalized at zero in 1995.

Figure 26: Divergence of the Compensation Share (EU-28), 1995-2015

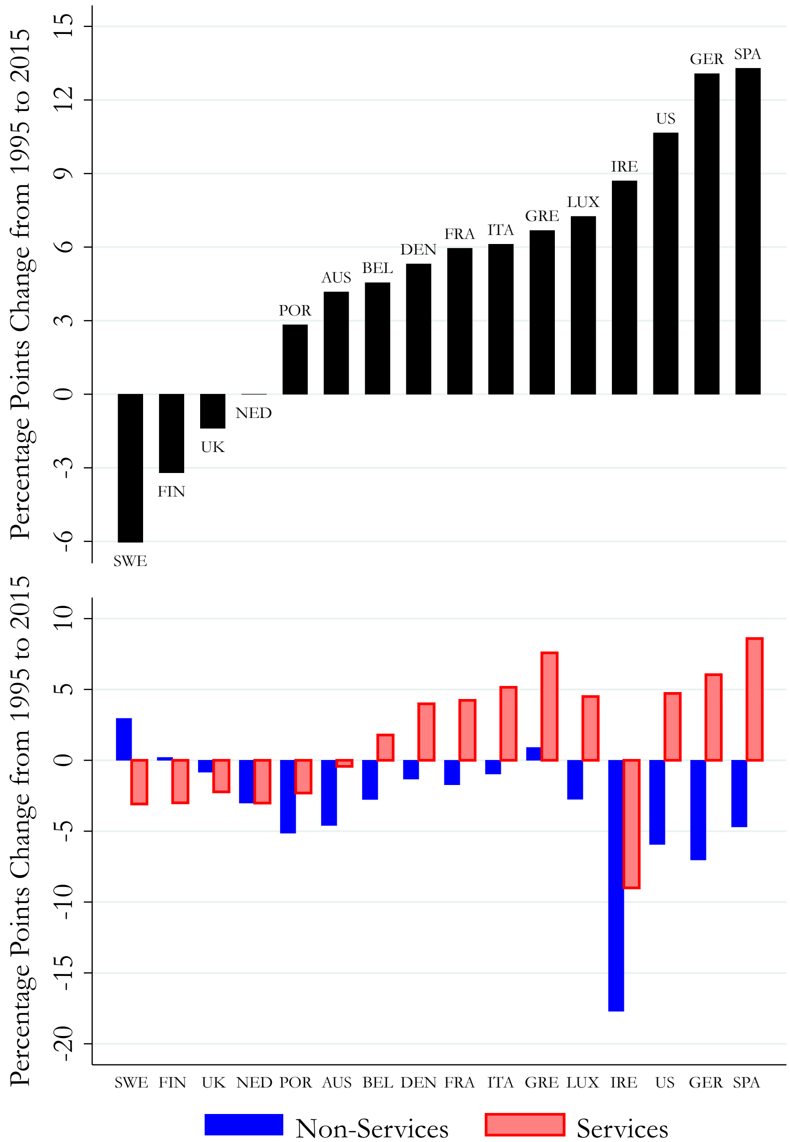


Notes: This figure plots the percentage point change on the difference between the compensation share in services and non-services industries from 1995 to 2015 for the EU-28 countries.

most of the countries in Europe experienced a similar divergence in the evolution of the compensation share. Nineteen countries experienced a divergence in the compensation share, compared to eight that did not.

Figure 27 plots the same statistic for the EU-15 countries and also shows that, consistent with the pooled regression and the evidence for the United States, the divergence was predominantly the result of a decrease in the compensation share in non-services industries and an increase in the compensation share in services industries.

Figure 27: Divergence of the Compensation Share (EU-15), 1995-2015



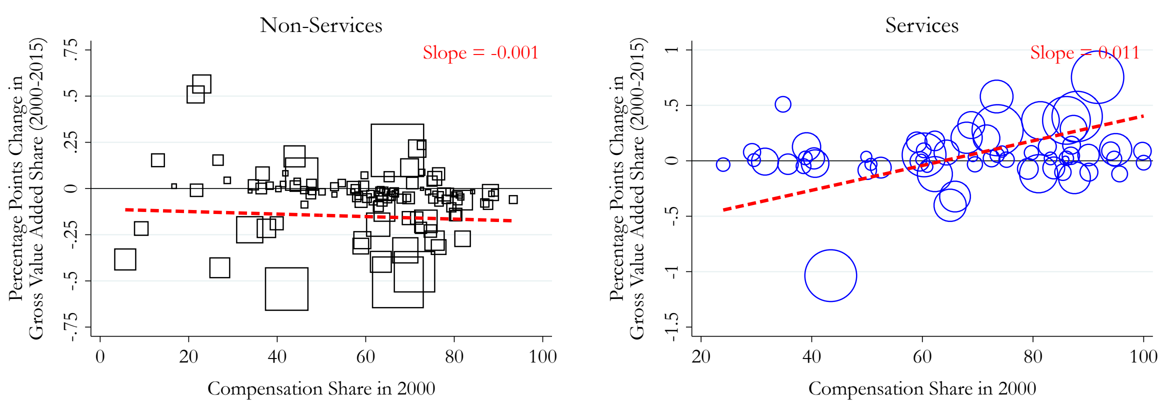
Notes: The top figure shows the percentage point change in the difference between the compensation share in services and non-services industries from 1995 to 2015 for the EU-15 countries and the United States. The bottom figures shows the percentage point change in the compensation share for non-services (blue-bar) and services (red-bar) industries from 1995 to 2015.

A2.3 BLS

This section describes the Input/Output data for the U.S. economy for the historical years 1997-2016 produced by the Bureau of Labor Statistics (BLS).[26] It is based on the 2012 North American Industrial Classification System (NAICS), the U.S. Department of Commerce's Bureau of Economic Analysis (BEA) 1997, 2002, and 2007 benchmark input-output tables, and the BEA Annual input-output tables for 1997-2015.

The main advantage when compared with NIPA data is that it is much more disaggregated. However, it only spans 1997-2015. I use this data as a robustness check for some of the statistics I study in the paper. Following the same criteria explained in Section A2.1, I exclude the following sub-industries: Real Estate, "514: Data processing, internet publishing, and other information services," "523: Securities, commodity contracts, and investments," and "5415: Computer systems design and related services."

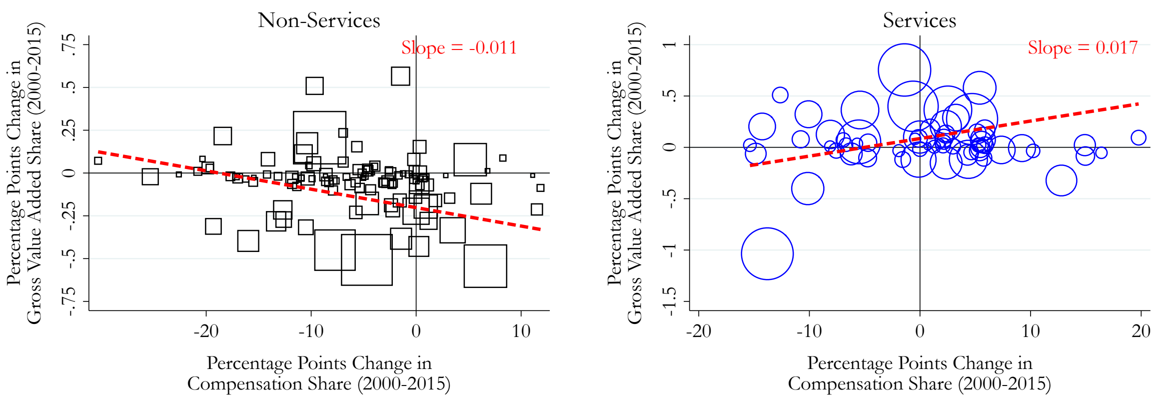
Figure 28: Change in Gross Value Added Share, 2000-2015



Notes: This figure plots the compensation share in 2000 against the change in gross value added share from 2000 to 2015 using input-output BLS data. The left panel shows the results for non-services sub-industries. The right panel shows the results for services sub-industries. Each blue-circle (services) and black-square (non-services) represents a BLS industry, with its size reflecting the sub-industry's gross value added share in 2000. The red-dotted line shows the best-fit line, using the 2000 gross value added share as the sub-industry weight. The difference between the slope coefficient for non-services and services sub-industries is statistically different at a 5% level of significance.

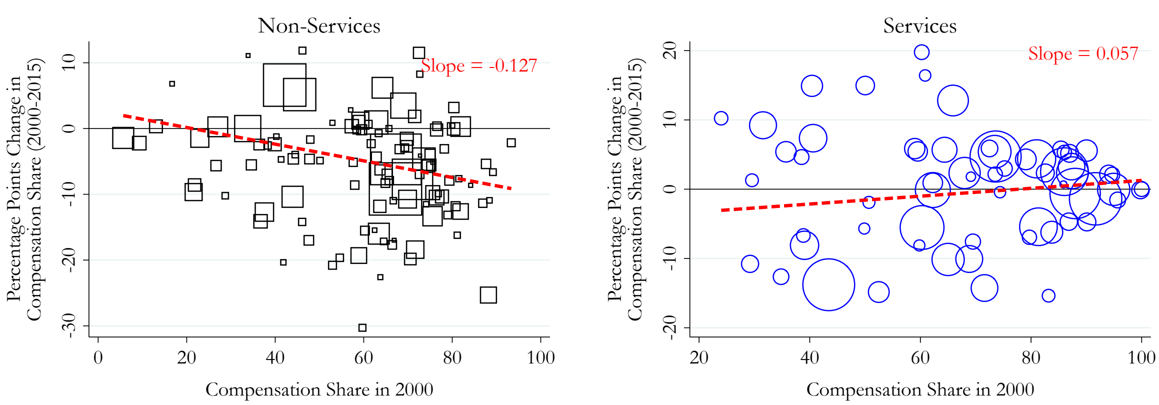
[26]Data are available at `https://www.bls.gov/emp/ep_data_input_output_matrix.htm`.

Figure 29: Change in Gross Value Added Share and Compensation Share, 2000-2015



Notes: This figure plots the change in gross value added share against the change in compensation share from 2000 to 2015 using input-output BLS data. The left panel shows the results for non-services sub-industries. The right panel shows the results for services sub-industries. Each blue-circle (services) and black-square (non-services) represents a BLS industry, with its size reflecting the sub-industry's gross value added share in 2000. The red-dotted line shows the best-fit line, using the 2000 gross value added share as the sub-industry weight. The difference between the slope coefficient for non-services and services sub-industries is statistically different at a 10% level of significance.

Figure 30: Change in the Compensation Share, 1987-2015

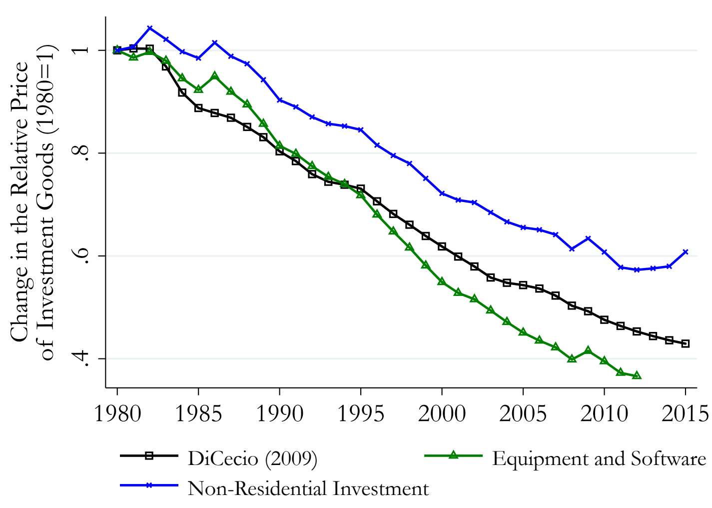


Notes: This figure plots the compensation share in 2000 against the change in the compensation share from 2000 to 2015 using input-output BLS data. The left panel shows the results for non-services sub-industries. The right panel shows the results for services sub-industries. Each black-square (non-services) and blue-circle (services) represents a NIPA industry, with its size reflecting the sub-industry's gross value added share in 1987. The red-dotted line shows the best-fit line, using the 1987 gross value added share as the sub-industry weight. The difference between the slope coefficient for no services and services sub-industries is statistically different at a 5% level of significance.

A2.4 The Relative Price of Investment Goods

I use the time series of the relative price of investment goods available on the Federal Reserve Bank of St. Louis website (FRED time series PIRIC), which are based on the estimates of DiCecio (2009). One alternative would be to calculate the relative price of investment goods as the ratio between the price index of non residential investment, as reported by the BEA (FRED time series A008RD3Q086SBEA), divided by the price index of non durable consumption (FRED series CUUR0000SAN). Another option would be to compute this statistic as the ratio between a measure of investment that only considers equipment and software (FRED time series A010RD3A086NBEA) and the price index of non durable consumption. Figure 31 shows the time series of the three measures normalized to one in 1980. All display a similar declining trend, but differ on the magnitude of the fall. Relative to 1980, the statistic that only includes equipment and software decreased by 65%, the one that considers all investment goods fell by 40%, and the time series that follows DiCecio (2009) fell by 57%. I use the series produced by DiCecio (2009), which lies in the middle of the other two estimates.

Figure 31: The Relative Price of Investment Goods, 1980-2015



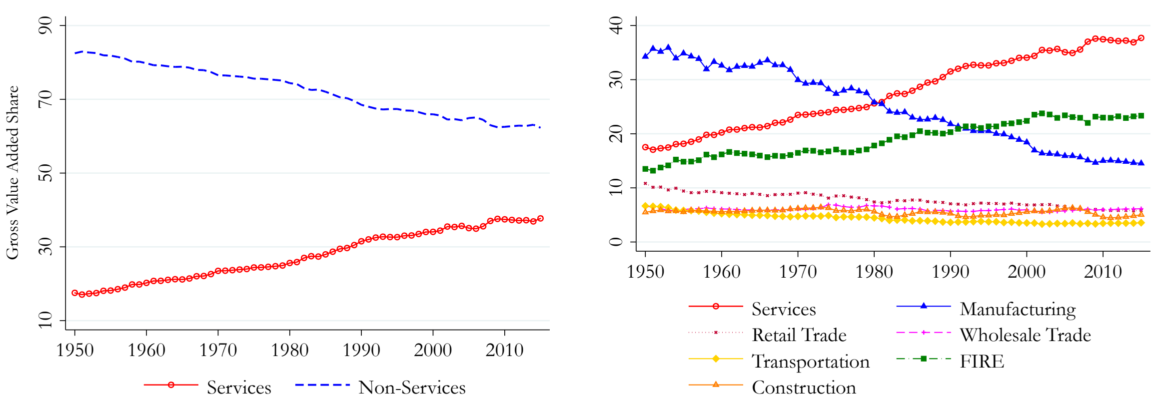
Notes: This figure shows the price of investment relative to the price of consumption. The blue-x line is obtained as the ratio between the price index of non-residential investment and the price index of non-durable consumption. The green-triangle line is obtained as the ratio between the price index of equipment and software and the price index of non-durable consumption. The black-square line is computed by DiCecio (2009), extrapolating the quality-adjusted series of Gordon (1990). All series are normalized to one in 1980.

A3 Long-run Analysis of the Compensation Share for the United States, 1950-2015

This section studies the evolution of the compensation share within services and non-services industries in the United States from 1950 to 2015.

There are two reasons the main analysis starts in 1980. First, 1980 is a major turning point in the sample: It is both the year when the aggregate compensation share starts its declining trend and the moment when the divergent trend between services and non-services industries begins. Second, as the sample goes back in time, there is increasing worry that the composition of the services industries today may not be comparable to services industries in the 1950s.[27] Nevertheless, this section studies the long-rung evolution of the compensation share, and extends the sample back to 1950. Results are consistent with the long-run analysis of Elsby, Hobijn, and Sahin (2013).

Figure 32: The Evolution of the Gross Value Added Share, 1950-2015

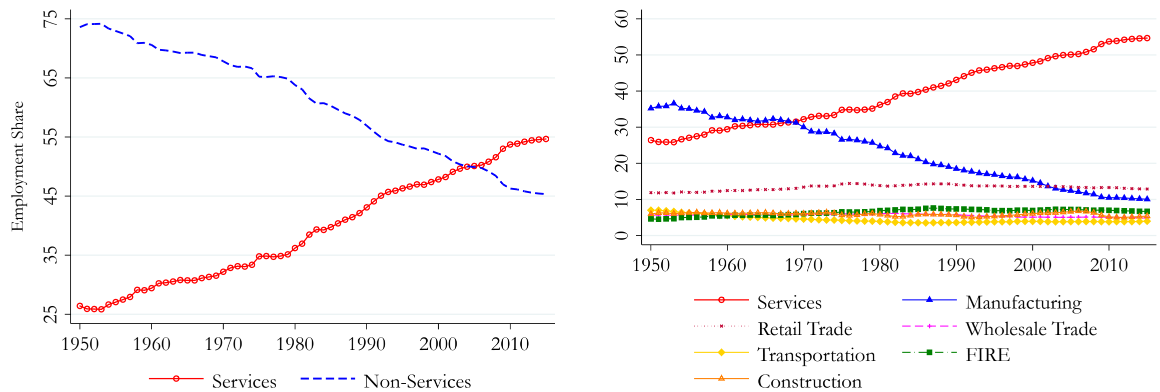


Notes: The left figure plots the gross value added share for services (red circles) and non-services industries (dashed blue line) from 1950 to 2015 using industry-level NIPA data. The right figure plots the gross value added share for some selected non-services industries. For comparison, the gross value added share for services is also plotted.

Figure 32 and Figure 33 plot the evolution of the gross value added share and the employment share from 1950 to 2015. As discussed in the main text, they illustrate well the transition of the United States from a manufacturing/trade economy to a service economy.

[27] Potential reasons are the advances in information technology and the computer age, which have substantially disrupted services industries over recent decades.

Figure 33: The Evolution of the Employment Share, 1950-2015

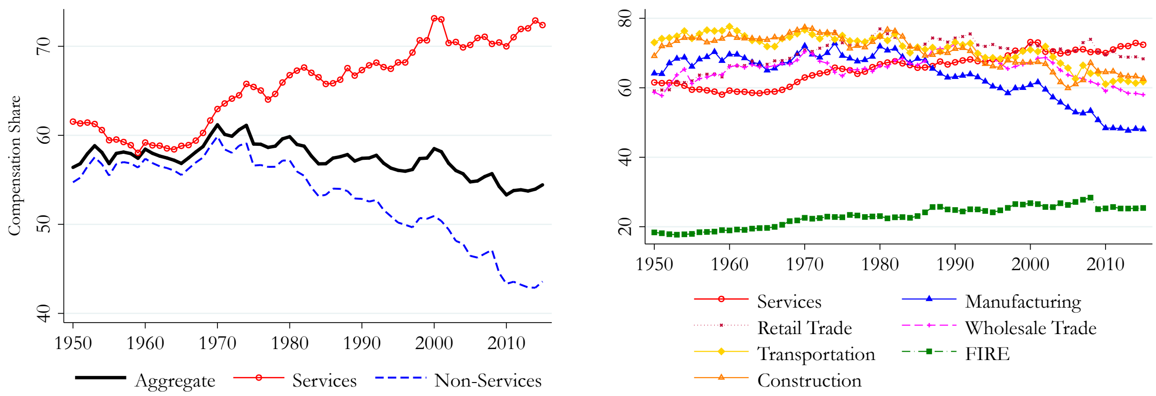


Notes: The left figure plots the employment share for services (red-circle line) and non-services industries (blue-dash line) from 1950 to 2015 using industry-level NIPA data. The right figure plots the employment share for some selected non-services industries. For comparison, the employment share for services is also plotted. Employment refers to all full-time and part-time workers.

The black line in Figure 34 and Figure 35 plots the aggregate compensation share from 1950 to 2015. As is well documented, three main periods can be identified. First, from 1950 to the early 1980s, the aggregate compensation share was remarkably constant, without an obvious trend. Second, in the early 1980s, a trend decline started. Finally, this decline accelerated from 2000. As a result, from the early 1980s to 2015, the aggregate compensation share decreased by around 6 percentage points.

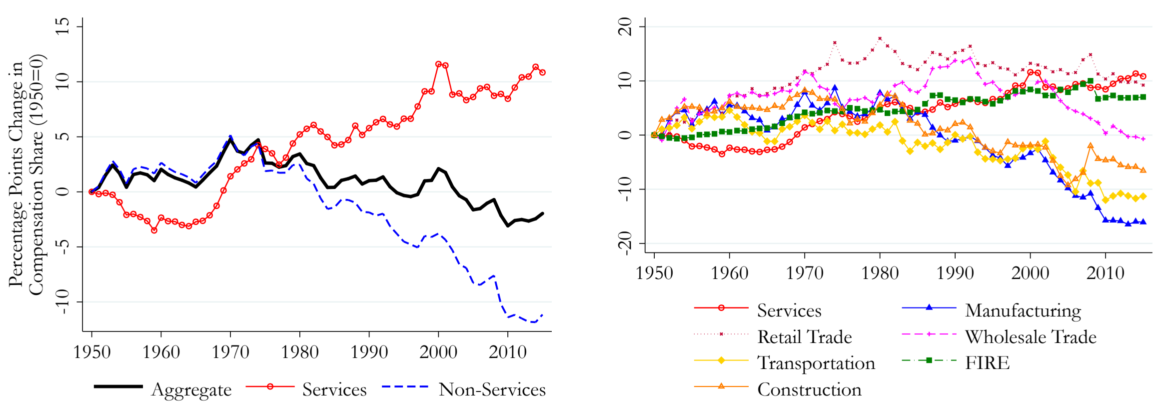
Figure 34 and Figure 35 also plot the industry's compensation shares since 1950. Consistent with the work of Elsby, Hobijn, and Sahin (2013), two main episodes can be identified. First, up to the early 1980s, all industries seem to move together. All of the sectors exhibited a positive trend at a time when the aggregate measure did not have a distinct trend. This is explained by a contemporaneous reshuffling in the U.S. economy: Activity moved from high-compensation-share industries, such as manufacturing and transportation, to relatively low-compensation-share industries, such as services. Since 1980, discussed at length in the main text, a general divergence in the evolution of the compensation share unfolds.

Figure 34: The Evolution of the Compensation Share, 1950-2015



Notes: The figure on the left plots the evolution of the aggregate compensation share (black line) for the U.S. nonfarm business sector from 1950 to 2015 using industry-level NIPA data. Red-circles line shows the compensation share for services industries. Lastly, the blue-dash line shows the same statistic for all non-services industries together. The figure on the right plots the industry compensation shares for some selected industries from industry-level NIPA data.

Figure 35: Change in the Compensation Share, 1950-2015



Notes: The left figure plots the percentage points change in the aggregate compensation share (black line) for the U.S. nonfarm business sector from 1950 to 2015 using industry-level NIPA data. Red-circles line shows the compensation share for services industries. Lastly, the blue-dash line shows the same statistic for all non-services industries together. The right figure plots the industry compensation shares for some selected industries from industry-level NIPA data. All series are normalized to zero in 1950.

A4 Model Appendix

This appendix describes the computational strategy used to solve the benchmark model, and includes some additional figures from the model.

A4.1 Computational Appendix

The solution of the model implies calculating an initial and final steady state, and the complete transition path of quantities and prices, given the exogenous sequences of q_t, $A_{m,t}$, $A_{s,t}$, $B_{m,t}$, and $B_{s,t}$.

Compute the Steady-state Equilibrium

I assume that the economy is in a steady-state equilibrium in $t = 0$: All the exogenous variables equal 1 and the representative agent expects this vector of exogenous variables to remain constant forever. The algorithm to find the steady-state equilibrium is as follows,

1. Guess a value function, V_0.
2. Guess a value for the consumption of non-services goods, $C_{m,0}$. Then, given $C_{m,0}$, solve the following system of non linear equations, which pin down the optimal values for $K_{m,t}, K_s, L_m, L_s$, and C_s:

$$\begin{aligned}
\frac{\partial Y_m}{\partial K_m} &= p_s \frac{\partial Y_s}{\partial K_s} \\
\frac{\partial Y_m}{\partial L_m} &= p_s \frac{\partial Y_s}{\partial L_s} \\
u_m &= \frac{u_s}{p_s} \\
L_s + L_m &= 1 \\
K_s + K_m &= K \\
Y_s &= C_s
\end{aligned}$$

3. The accumulation of capital no longer depends on s, and we can solve for the

optimal K', given the guess for $C_{m,0}$. K' implies a value for $C_{m,1}$.

$$\begin{aligned} V(K) = & \max_{C_m, K'} && u(C_s, C_m) + \beta V(K') \\ & \text{s.t.} && C_m + q(K' - (1-\delta)K) \leq Y_m \\ & && C_m, K' \geq 0 \end{aligned}$$

I use value function iteration and search continuously over the capital space using cubic spline interpolation.

4. Repeat (2)-(3) until $C_{m,0} = C_{m,1}$.
5. Repeat (2)-(4) until $|V_0 - V_1| < tol$.

Compute the Transition

To calculate the transition path of the economy between an initial and final steady state requires taking a stand of what the representative agent knows about the evolution of the economy from period 0 to the infinite future. Here I consider two extremes cases. First, I assume that the representative agent has perfect foresight about all the exogenous variables of the model. Second, I assume the representative agent is myopic and learns about the contemporaneous change in the price of investment and changes in labor- and capital-augmenting technology for each period, and perceives that such variables will remain fixed forever. I now describe both algorithms in detail.

a) Perfect Foresight

Given a sequence of exogenous variables $\Theta_t = \{q_t, A_{m,t}, A_{s,t}, B_{m,t}, B_{s,t}\}_{t=0}^{T}$ and a fixed value of the vector after T periods, $\Theta_T = \{q_T, A_{m,T}, A_{s,T}, B_{m,T}, B_{s,T}\}$ for all $t > T$, I proceed as follows,

1. Take $\Theta_t = \Theta_0$ and $\Theta_t = \Theta_T$ and calculate the corresponding steady-state equilibriums saving the equilibrium quantities, prices and value functions, V_0^s and V_T^s.

2. Starting in period $T-1$, solve for the optimal policy function associated with the continuation value, V_T^s and Θ_{T-1}. Record the value function as, V_{T-1}^s.

3. Go to period $T-2$, take V_{T-1}^s and Θ_{T-2} as given, and solve the policy function in $T-2$ recording the continuation value. Continue until $t = 1$. This generates a path of value functions for each point in the state space.

4. Given the sequence of value functions, and starting with the $K_{0,ss}$ and Θ_0, go forward and compute the optimal quantities and prices. I then use these to compute the compensation shares over the transition.

b) Myopic

The representative household is surprised every period by the change in the exogenous process Θ_t and thinks that is going to remain fixed for the infinite future. To solve for the transition under this assumption I proceed as follows,

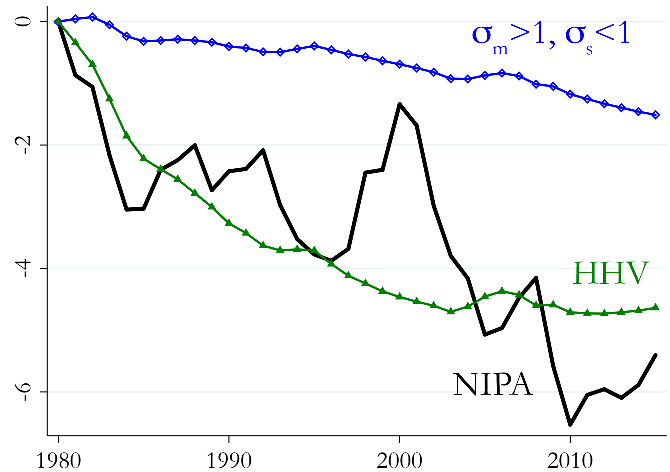
1. Solve the initial steady-state equilibrium of the economy with $\Theta_t = \Theta_0$.

2. Go to period $t = 1$ with Θ_1 and assume the representative agent thinks that $\Theta_t = \Theta_1$ for all t. Solve the equilibrium and use the policy function for capital to determine capital in the next period.

3. Go to period $t = 2$ and start again in [2.], and proceed until the entire transition path is completed. This generates a new path for quantities and prices that I then use to compute the compensation shares.

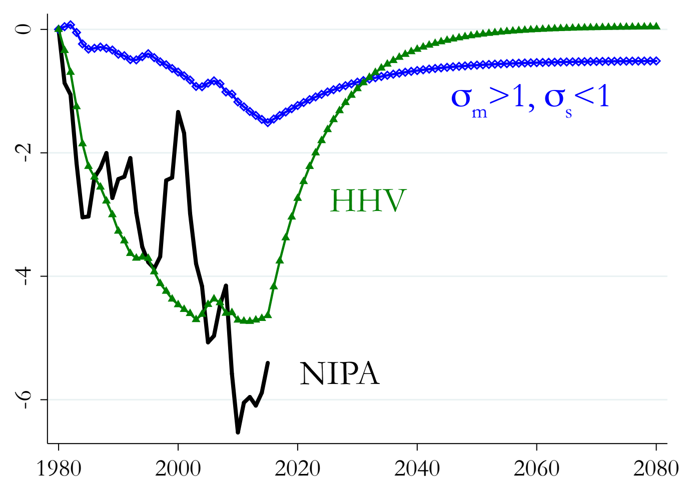
A4.2 Figures

FIGURE 36: AGGREGATE COMPENSATION SHARE: DATA AND MODEL, 1980-2015



Notes: This figure compares the aggregate compensation share generated by the model with industry-level NIPA data.

FIGURE 37: AGGREGATE COMPENSATION SHARE: DATA AND MODEL, LONG RUN



Notes: This figure compares the aggregate compensation share generated by the model with industry-level NIPA data in the long run.

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