OUTSOURCING, MARKUPS AND THE LABOR SHARE*

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March 20, 2019

We show that an important reason labor shares are falling in many US industries is the rise in domestic labor outsourcing, which matters little for the aggregate labor share because of offsets in the labor services sector. Using cross-sectional variation in labor shares to study the sources of aggregate labor share losses in the US requires attention to the changing use of intermediate labor services. Labor outsourcing also induces spurious trends in estimates of industry markups based on inverse labor or intermediate input shares. We estimate industry markups in ways that are robust to outsourcing trends, and use them in structural decompositions of the aggregate labor share loss between 1997 and 2016 that account for varying production networks. Rising markups do not contribute meaningfully to aggregate labor share trends before 2009, which are primarily driven by decreases in labor intensity. However, higher markups in a few large US industries are potentially important in depressing the labor share during the recovery from the Great Recession.

*The views in this paper are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Dallas or the Federal Reserve System. We are grateful to Tyler Atkinson, Vasco Carvalho, Ayşegül Sahin, and participants at various seminars for comments and suggestions. All errors are ours.

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The share of total income paid as labor compensation in the US has fallen considerably since the late 1990s. Economists are not sure why. Setting aside issues of measurement, the fall in the labor share must reflect a process of capital deepening, shifts in the distribution of rents, or some combination of both. Decompositions into contributions from changes in the industry composition of value added and from changes in within-industry labor shares in value added consistently show the latter dominating, see Elsby, Hobijn and Sahin (2013) or Karabarbounis and Neiman (2014). This observation goes against explanations based on a compositional shift towards more capital-intensive industries, for instance driven by globalization and trade specialization. Successful theories of the aggregate labor share loss must be consistent with labor share declines *within* a large number of goods- and services-producing industries. The two main contenders are rising market power and automation, i.e. the substitution of labor with capital.

In this paper, we show that a key reason labor shares are falling within many US industries is that establishments are contracting out more and more labor-intensive activities to external providers. We present several pieces of evidence for the importance of labor outsourcing for labor share trends *at the industry level*:

First, growth in the professional and business services (PBS) sector has outpaced the aggregate economy for decades and is largely outsourcing-related, see Dey, Houseman and Polivka (2010), Berlingueri (2014) and Dorn et al. (2018). A shift-share decomposition reveals that the recent growth in the PBS employment share between 2002 and 2017 is driven entirely by changes in the share of PBS employees within occupations. In other words, PBS employment is growing faster, not because there are relatively more janitors, security guards, accountants or technicians, but because relatively more of them are employed externally rather than in-house.

The second piece of evidence is based on a comparison of trends in labor and intermediate shares in industry output. If rising industry markups are the main driver of falling industry labor shares, then intermediate spending shares should also be falling. If the main reason is that many industries are replacing workers with machines or software, we show in a stylized model that intermediate spending on labor services should also be falling. Trends in industry labor and intermediate input shares are instead negatively correlated in the data, which can be explained by the rise in labor outsourcing.

Third, we use industry input-output data to decompose aggregate labor share changes into contributions from changes in final expenditure shares and from changes in the total labor shares in final expenditures. Similar to Baqaee (2013), we further decompose the total labor shares in final output into direct and indirect components. The direct labor share is the compensation paid directly by the industry at the final stage of production. The indirect share is the compensation paid indirectly at all earlier stages of production through purchases of intermediate inputs. Theory predicts that rising markups or automation generate a positive relationship between direct and indirect labor shares, while labor outsourcing generates a negative relationship. We show that the relationship in the US data is negative, which is consistent with labor outsourcing. In an open economy extension, we show that the negative relationship is driven by domestic rather than international outsourcing.

At the same time, we argue that labor outsourcing is unlikely to be an important driver of the labor share *at the aggregate level*:

First, outsourcing-related declines in industry labor shares are generally offset by the gains from the growth of the intermediate suppliers of labor services. If there are markups on intermediate labor services, increased outsourcing can theoretically lower the aggregate labor share by effectively increasing the exercise of market power even when markups are constant. However, we estimate these effects to be relatively small.

Second, in a value added decomposition of the aggregate labor share change, the reallocation of value added towards the PBS industry generates a large positive contribution to the aggregate labor share. The total contribution from compositional changes is however slightly negative, which means that labor outsourcing alone cannot explain the aggregate labor share loss.

Finally, the strong relative growth in the PBS industry and the pickup in outsourcing long precedes any reasonable dating of the beginning of aggregate labor share decline in the US.

Our finding that labor outsourcing is an important driver of industry labor shares, but not of the aggregate labor share, means that empirical validations of theories of aggregate labor share losses based on patterns in cross-sectional labor shares must be mindful of changes in production networks, and particularly of trends in labor outsourcing. Successful explanations of the aggregate decline do not need to account for industry-level declines that have offsets elsewhere in the production network. Since outsourcing is widespread, aggregate losses that are driven by markup increases or automation in a select number of industries can be consistent with labor share declines across a much broader range of industries.

We analyze the sources of the aggregate labor share loss in the US between 1997 and 2016 in structural decompositions that separately account for changes in production networks. These decompositions isolate the contributions from industry-level changes in (1) final expenditure shares, (2) labor input elasticities of production, (3) intermediate input elasticities of production and (4) markups. While we view none of these as exogenous primitives, the decompositions are nevertheless informative about the various channels through which the underlying causes are operative.

The decompositions of the aggregate labor share loss require estimates of industry markups as inputs. We show that outsourcing induces spurious trends in industry markups estimated from inverse labor or intermediate input shares. Instead, we either use the approach in Hall (1986, 1988), which amounts to assuming that markups are constant, or a novel alternative approach based on the combined labor & intermediates share, which amounts to assuming constant capital intensities. These two different approaches allow us to study the structural decompositions under each of the two main competing hypotheses for the aggregate labor share loss: rising markups and greater capital intensities of production.

The main finding is that there is no single driver of the aggregate labor share loss that dominates over the entire 1997-2016 period. Before the Great Recession, within-industry decreases in labor intensity unrelated to outsourcing to the PBS industry are the most important factor. According to our markup estimates based on the combined labor & intermediates share, which are robust to outsourcing trends, there is little evidence for an aggregate trend in markups before 2009. As result, we find no evidence that markups are responsible for the aggregate labor share losses prior to 2009.

After the Great Recession, reallocation becomes more important and explains about 30 percent of the labor share decline, mainly driven by the construction, housing, and oil and gas industries. The main contributor to the labor share loss after 2009, however, depends critically on assumptions about markups. According to our time-varying estimates, markups jump up in the Great Recession and remain higher throughout the recovery period. In the decomposition with constant capital elasticities, the higher markups since 2009 explain the bulk (82 percent) of the lower aggregate labor share in the recent recovery, with large depressing effects that are concentrated in a small number of industries, predominantly in the finance and tech sectors. In the decomposition with constant markups, on the other hand, within-industry decreases in labor intensity (unrelated to outsourcing) continue to be important in explaining the lower aggregate labor share relative to 1997. However, capital deepening through changes in production networks becomes the most important contributor, explaining roughly 45 percent of the aggregate labor share loss.

One key aspect of our findings is that much of the observed declines in labor intensity at the industry level is not the result of substitution of labor with capital, but of substitution with intermediate labor purchased from the PBS industry. In the decomposition that assumes constant capital intensities, expanding the definition of labor intensity to include outsourced labor essentially eliminates declines in labor intensity as a significant driver of the aggregate labor share decline over the entire sample period. In the specification with constant markups but unrestricted capital intensities, the contribution of declining labor intensities to the aggregate labor share loss from 1997 to 2016 is reduced substantially after including intermediate labor inputs supplied by PBS. The flip side of the adjustment for labor outsourcing is that capital deepening through changes in production networks becomes important in contributing to the aggregate labor share loss. With the PBS industry included, supply chain changes between 1997 and 2016 are either neutral or contribute positively to the aggregate labor share depending on markup assumptions. Once the PBS industry is excluded, however, it becomes clear that the rest of the US production network has evolved in ways that disadvantage labor.

We also consider an open economy version of the decomposition to verify the role of offshoring on the aggregate labor share. A rising share of intermediate imports leads to leakage of labor compensation as well as value added. Because intermediate imports are relatively capital intensive, leakage of value added dominates leakage of compensation, and as a result the immediate effect of offshoring is a modest increase in the US labor share.

1 The Declining Labor Share in the US

1.1 Evidence and Potential Explanations

The black line in Figure 1 shows the labor share for the total US economy constructed using data from the Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics (BLS). For some of the major underlying sectors, measuring the labor share is inherently difficult. Government output is in practice measured mostly by labor compensation alone, such that labor share in the private sector (blue line in Figure 1) is considerably below the total. The measured labor share in the household/nonprofit sector is very small because of the dominant role of imputed income from owner-occupied housing. For this reason, the labor share in the private business sector (red line in Figure 1) is larger than in the private sector as a whole. Within the private business sector, a well-known difficulty is the lack of data on self-employment compensation.[1] The measures shown in Figure 1 rely on procedures by the BLS to impute proprietors' labor income, which are not without criticism.[2] Many studies focus therefore on the labor share in the corporate private sector (yellow line in Figure 1), which excludes most self-employment income. By removing the influence of time trends in the weights of the government, household/non-profit and sole proprietorship sectors, the evolution of the private corporate labor share presents some of the best evidence that the overall decline is not merely an artifact of mismeasurement in the non-corporate sectors.

According to Figure 1, the corporate labor share was fairly stable at around 63 percent between 1947 and the late 1990s, before dropping off by 6 to 8 percentage points in the 2000s.[3] There are, however, several reasons why measurement problems still play a role in the corporate sector. Smith, Yagan, Zidar and Zwick (2017), for instance, argue that gross operating surplus for many S-corporations is largely active labor income of owners, and that for this reason the corporate labor share decline is overstated by 16 percent. Bridgeman (2017) shows that the drop in compensation as a share of corporate *net* value added, i.e. after deducting depreciation, is less pronounced. Guvenen et al. (2018), on the other hand, find that the decline in the corporate labor share in the 2000s is a percentage point larger after correcting value added to account for offshore profit shifting. While these and other measurement problems undoubtedly affect the precise magnitude, there exists nevertheless a broad consensus among economists that aggregate labor share loss in recent decades is real (Armenter, 2015).

The first possible explanation is that the labor share decline reflects a process of capital deepening because of compositional effects and/or because production is becoming more capital intensive.

[1] See Kravis (1962) or Gollin (2002).

[2] See for instance Gomme and Rupert (2004), Elsby, Hobijn and Sahin (2013) or Giandrea and Sprague (2017). The BLS produces two different measures of labor share. Figure 1 is based on the 'labor approach' measure in the Major Sector Productivity and Costs release, which imputes proprietors' labor income by multiplying proprietor hours with business employee compensation per hour. The labor share measure in BLS's Multifactor Productivity release uses a combination of the labor approach and the 'asset approach', in which capital income is measured first and then subtracted from total income.

[3] Whether there was a downward trend much before the 2000s is far less clear. The online appendix discusses the evidence from a number of alternative measures of the aggregate labor share.

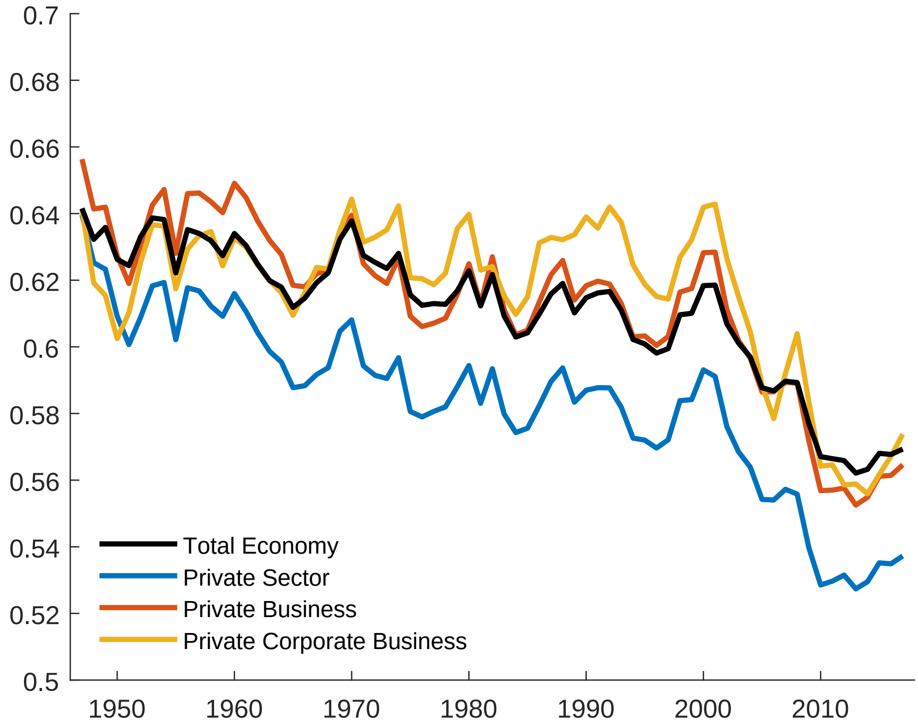

Figure 1 The Labor Share in GDP, 1947 to 2017

Notes: Based on data from BEA NIPA and the BLS (Major Sector Productivity & Costs), see the data appendix for details. The private business sector includes private corporate business as well as sole proprietors, parternships, government enterprises and other private business. The private sector additionally includes households and non-profits.

One reason why production could be increasingly capital intensive is technological innovation. Karabarbounis and Neiman (2014) argue that substitution of labor with capital in response to investment-specific technological progress can explain roughly half of the labor share decline. Koh, Santaeulàlia-Llopis and Zheng (2016) emphasize in particular the growing importance build-up of intellectual property capital. One potential problem with this hypothesis, however, is timing: the observed decline in the relative price of investment started well before the 1990s and, if anything, has decelerated since 2000. Another problem is that standard growth models require an elasticity of substitution between capital and labor that exceeds unity to generate a falling labor share, whereas most empirical studies find values below one.[4] Elsby, Hobijn and Sahin (2013) discuss other explanations involving changes in the skill composition of the labor force, but similarly question their relevance on the basis of timing. Acemoglu and Restrepo (2018) present a model in which automation of labor tasks leads to a decrease in the labor share. However, in their framework the effects of automation are offset by the creation of new technologies and labor tasks, such that continuous replacement of workers by machines and software can remain consistent with a stable labor share in the longer run.

Another possible driver of increased capital intensity in US production is globalization and, in particular, the possibility that relatively labor intensive stages of production in many industries have

[4] Alvarez-Cuadrado et al. (2017) and Grossman et al. (2017) formulate growth models in which elasticities of substitution between capital and labor below one are consistent with a declining labor share.

relocated to countries with lower wage costs. Offshoring is particularly prevalent in manufacturing industries, see Boehm, Flaaen and Pandalai-Nayar (2018), which also experienced some of the largest declines in the labor share. Elsby et al. (2013) show that labor share changes and import exposure are indeed generally positively correlated across US industries. Autor, Dorn, Katz, Patterson and Van Reenen (2017), on the other hand, find no relationship between labor shares losses and exposure to exogenous trade shocks, and point out that labor shares have also declined in largely non-traded industries such as retail trade and utilities.

Capital deepening could also be mainly the result of changes in industrial composition. Shift-share decompositions, however, consistently find little role for reallocation of value added towards more capital intensive sectors, see Elsby et al. (2013) or Karabarbounis and Neiman (2014). Interestingly, Rognlie (2016) and Gutiérrez (2017) show that relative growth of the real estate sector can account almost fully for observed aggregate labor share losses in most countries. This is not the case, however, for the US. In statistical decompositions using establishment-level data, Kehrig and Vincent (2017) find that one third of the decline in the manufacturing labor share is driven by reallocation of production from high- to low-labor share establishments, while another 50 percent is driven by establishments that grow very fast and simultaneously experience a falling labor share. Autor et al. (2017) reach similar conclusions using a variety of firm- and establishment level datasets with broader industry coverage for the US as well as for other countries. The aggregate labor share decline, according to their evidence, reflects to an important extent the increased concentration of production in large and less labor intensive 'superstar' firms.

The other main explanation for the labor share loss is that changes in market power are shifting factor payments towards capital. In other words, it is not necessarily the mix of production factors that is changing, but how rents are distributed between them. This hypothesis seems ex ante plausible in light of the well documented rise in industry concentration.[5]

One possibility is that workers' bargaining power is decreasing, for instance because of a growing number of larger firms with more monopsony power. Blanchard (1997) and Blanchard and Giavazzi (2003) cite declining union power and labor market deregulations as causal factors for rising capital shares in Continental Europe during 1980s, but these seem less relevant explanations for the US during the 2000s. The rise of alternative work arrangements, see Katz and Krueger (2016), and the growth in outsourcing of jobs instead seem more plausible potential contributors. There is, for instance, much evidence suggesting considerable wage penalties from outsourcing due to losses of firm specific rents, see e.g. Dube and Kaplan (2010), Goldschmidt and Schmieder (2017) and Dorn, Schmieder and Spletzer (2018). Eckert (2019) argues the rise in intermediate labor services is associated with greater spatial fragmentation of high- and low skilled labor and contributes to the rise in wage inequality. Glover and Short (2018) argue that labor market rents of workers deteriorate with age, and consequently that the ageing of the workforce can account for a large fraction of the aggre-

[5] See for instance Barkai (2016), Gutiérrez (2017), Gutiérrez and Philippon (2017) and Autor et al. (2017).

gate labor share decline.

Greater concentration and market power may also mean that markups of price over marginal costs in product markets have risen. Even when labor costs are a constant fraction of total costs, higher product markups decrease the labor share of revenues. Nekarda and Ramey (2013) were first to find a pronounced upward trend in their measures of aggregate markups that accelerated in the 2000s. Based on a number of different methodologies, several recent studies find that markups have increased in the US in a way that can potentially explain the labor share decline, see for instance Barkai (2016), De Loecker, Eeckhout and Unger (2018), Gutiérrez (2017), or Eggertson, Robbins and Wold (2018). The estimates by De Loecker, Eeckhout and Unger (2018), which show a total increase in average markups of around 30 percentage points between 1980 and 2016, have drawn particular attention. Measuring aggregate markups, however, is difficult, and the finding of broad-based increase in pricing power remains controversial.[6]

1.2 Value Added Decomposition of Aggregate Labor Share Dynamics

One well-established fact is that the decline in the aggregate labor share is attributable to within-industry changes rather than to changes in the industrial composition of value added, see e.g. Karabarbounis and Neiman (2014). We begin with a value added decomposition of aggregate labor share dynamics for the 1997 to 2016 period using data from the BEA's Industry Economic Accounts at the 3-digit NAICS level. The measures of private industry labor shares are from the BLS Combined Sectors and Industry KLEMS Multifactor Productivity Tables (BLS-KLEMS).[7] The appendix provides full details on data sources and construction.

The aggregate labor share in GDP, denoted by λ, equals the value-added weighted sum of the labor shares in different industries:

$$\lambda = \sum_i w_i \lambda_i \tag{1}$$

where w_i is the share of industry i's value added in total GDP and λ_i is industry i's labor share in value added. We decompose annual changes $\Delta\lambda$ into two components:

$$\Delta\lambda = \underbrace{\sum_i (\bar{\lambda}_i - \bar{\lambda})\Delta w_i}_{\substack{\text{value added}\\ \text{reallocation}}} + \underbrace{\sum_i \bar{w}_i \Delta\lambda_i}_{\substack{\text{within-industry}\\ \text{change in labor share}}} \tag{2}$$

A bar above a variable denotes the average of the current and last observation, i.e. $\bar{x}_t = (x_t + x_{t-1})/2$. The first term in (2) represents the reallocation effect – in an accounting sense – that arises because

[6] See for instance Karabarbounis and Neiman (2018), Basu (2018), Ramey (2018) and Syverson (2019).

[7] Note that BLS-KLEMS uses a slightly different methodology to impute proprietor's income than the BLS measure used to construct the labor shares shown in Figure 1. To our knowledge, separate KLEMS data for the corporate sector is unfortunately not available.

some industries grow faster than others. An industry that is growing relatively fast, $\Delta w_i > 0$, makes a positive contribution if its labor share is higher than the aggregate, $\bar{\lambda}_i - \bar{\lambda} > 0$, and a negative contribution otherwise. Conversely, an industry with declining weight, $\Delta w_i < 0$, makes a negative (positive) contribution if its labor share is above (below) the average, $\bar{\lambda}_i - \bar{\lambda} > 0$. The second term in (2) captures the contribution of labor shares within an industry changing over time.

Table A.I in the appendix provides the results of the decomposition in (2) for 66 non-overlapping NAICS 3-digit private industries as well as selected aggregates. The first four columns provide the industry weights and the labor shares in the first and last year of the sample. The last three columns of Table A.I show the reallocation and within-industry components for each industry in the decomposition, as well as the industry's total contribution to the aggregate labor share change between 1997 and 2016. The industry contributions are the sums of annual observations of the respective terms in (2) over the sample period. The aggregates shown are sums of the contributions of the subindustries.

In 2016, the aggregate labor share was 3.79 percentage points lower than in 1997. The first row in Table A.I shows that, according to the value added decomposition in (2), shifts in economic activity from high to low labor share industries account for 0.76 percentage points of the total drop. Manufacturing makes the largest negative contribution (−61 basis points) in this regard, mostly because of declines in subindustries that are relatively labor intensive such as the motor vehicles industry. Growth in certain capital intensive manufacturing industries, such as petroleum refining and chemicals, also contribute negatively. Among the other goods-producing industries, growth in capital intensive mining, mostly oil and gas extraction, makes a substantial negative reallocation contribution (−22 basis points). The adverse composition effects in the goods sector are not offset by the rise of services, which make little contribution on net (+3 basis points). The negligible total contribution of services, however, masks substantial heterogeneity within the various subsectors within services. Some service sectors make substantial positive contributions: fast-growing, labor intensive industries, such as professional and business services (+62 basis points), but also capital intensive industries with declining weight, such as utilities (+15 basis points). Other service sectors contribute negatively: some because they are fast-growing and capital intensive, such as parts of the financial industry (funds and trusts: −10 basis points), others because they are declining in weight and labor intensive, for example retail trade (−5 basis points). Consistent with Rognlie (2016) and Gutiérrez (2017), growth in real estate makes a substantial negative reallocation contribution (−62 basis points), but this contribution is not sufficient to explain the aggregate decline.

While changes in the industrial composition of value added play a role, the results in Table A.I confirm that the dominant contribution to the aggregate labor share decline is from within-industry labor share changes. The first row in Table A.I shows that within-industry declines account for 3.04 of the total 3.79 percentage points drop. Labor share losses are widespread across sectors: in about half of all private 3-digit NAICS industries, the share in 2016 is lower by at least 5 percentage points compared to 1997. Losses occur both in relatively fast-growing sectors, such as health care (−27 basis points), as well as in industries with declining weights, such as motor vehicles (-7 basis points). The decomposition attributes 1.03 percentage points of the total decline to losses within the goods sector, with the construction (-21 basis points), chemical products (-28 basis points) and food-producing industries (-13 basis points) making the largest negative contributions. The contribution of labor share losses in services, however, is more than twice as a large (-2.22 percentage points). The largest contributors within services are the retail and wholesale trade sectors (-49 basis points and -48 basis points, respectively). Labor share losses in the trade sectors, which combined roughly have the same GDP weight as manufacturing in 2016, contribute more than manufacturing and almost as much as the entire goods-producing sector. Labor share losses within the information industries (-37 basis points), professional and business services (-31 basis points), and hospital and nursing (-23 basis points) also make substantial negative contributions.

The results in Table A.I are comparable to similar decompositions in the literature, such as by Elsby et al. (2013), Karabarbounis and Neiman (2014) or Alvarez-Cuadrado et al. (2017). For the US, the role of changes in the industrial composition of value added is consistently found to be small compared to the role of within-industry changes in labor shares. Moreover, a wide array of goods and service industries seem to contribute through labor share losses. These patterns are often used to discriminate between competing explanations. For instance, Karabarbounis and Neiman (2014) dismiss globalization and trade integration as a major explanation, because these would show up primarily in the reallocation component. Another conclusion is that the aggregate decline requires a (common) explanation for within-industry declines applicable for a broad set of industries. A typical approach in the literature is to investigate the relationship between industry labor share changes and indicators of possible causal factors, such as measures of exposure to trade or market concentration, e.g. Elsby et al. (2013), Barkai (2016) or Autor et al. (2017).

Value added decompositions of the aggregate labor share, however, can be misleading when intermediate input linkages across industries are changing over time, a point also made in Baqaee (2013). In this paper, we argue that labor outsourcing trends are an important source of such changes.

2 Outsourcing and Labor Shares

Several existing studies provide evidence for the rise in domestic outsourcing in the US dating back at least several decades. Based on special questions in BLS surveys, Abraham and Taylor (1996) find that manufacturing firms report increasing percentages of services contracted out during the 1980s. Dey, Houseman and Polivka (2010) report growth in outsourcing for a range of occupations in the BLS Occupational Employment Statistics from 1987 to 2001, while Dube and Kaplan (2010) document the rise in contracting out of janitors and security guards during the 1980s and 1990s. More recently, Berlingueri (2014) and Dorn, Schmieder and Spletzer (2018) provide longer time series evidence based on decennial occupational Census data, which shows outsourcing taking off in 1970. Berlingueri (2014) also studies outsourcing in US input-output data and finds that it explains 36 percent of the rise in services employment and 25 percent of the fall in manufacturing employment between 1948 and 2002. Bloom, Guo and Lucking (2018) document the rising concentration of occupations within establishments between 1999 and 2016 and argue this is driven by the rise of outsourcing. The next section presents a stylized model that will help us illustrate various empirical implications of labor outsourcing trends.

2.1 A Stylized Model of Domestic Outsourcing of Labor Intensive Tasks

Consider an economy with a single upstream and downstream industry. The upstream industry produces intermediate business services using labor as the only input. The downstream industry produces a single final good. Firms in the final industry operate capital and employ workers to perform production tasks, but they can alternatively purchase intermediate services to accomplish some of these tasks.

The upstream technology for producing intermediate services M is

$$M = A_m L_m \tag{3}$$

where A_m is productivity and labor L_m is the industry's labor input. The industry-wide markup μ_m of price over marginal cost is defined as

$$\mu_m = \frac{P_m}{W_m/A_m} \tag{4}$$

where P_m is the price of intermediate services, W_m is the industry wage, and W_m/A_m is marginal cost. The labor share in the intermediate industry is

$$\lambda_m = \frac{W_m L_m}{P_m M} = \frac{1}{\mu_m} \tag{5}$$

Note that (4) and (5) are merely definitions.

The representative downstream firm produces a final good Y in the economy, using

$$Y = \left(\frac{K}{1-\alpha}\right)^{1-\alpha}\left(\frac{X}{\alpha}\right)^{\alpha} \quad , \quad 0 < \alpha < 1 \tag{6}$$

where K is capital input and X is an index of production tasks, given by

$$\ln(X) = \int_0^1 \ln\left(x(i)\right) d(i) \quad , \quad x(i) = \begin{cases} z(i)l(i) + m(i) & \text{if } i \leq I \\ z(i)l(i) & \text{if } i > I \end{cases} \tag{7}$$

In the expression above, $l(i)$ is labor assigned to task i and $m(i)$ is the input of intermediate purchases to accomplish task i. The term $z(i)$ determines labor productivity in task i. We assume that $z(i)$ is strictly increasing in $i \in [0,1]$. Tasks $i \leq I$ can be outsourced to the intermediate services industry, whereas tasks $i > I$ can only be performed in-house. The task-based framework to the outsourcing decision is analogous to the approach in Acemoglu and Restrepo (2018) for modeling the automation decision.

Define the threshold i^* as the task for which

$$P_m = W_y/z(i^*) \tag{8}$$

where W_y is the wage in the final goods industry. For all tasks $i > i^*$, $W_y/z(i) < P_m$ such that it is cheaper for the firm to hire labor and perform them in-house. For all tasks $i \leq i^*$ that are offered by the intermediate industry $i \leq I$, it is cheaper to outsource. The cost-minimizing decision is therefore to retain all tasks $i > \theta$ within the firm, and outsource all tasks $i \leq \theta$ to the intermediate service industry, where $\theta \equiv \min(i^*, I)$. The task-specific demand functions for labor and intermediate services are

$$l(i) = \begin{cases} P_x X/W_y & \text{if } i > \theta \\ 0 & \text{if } i \leq \theta \end{cases} \quad , \quad m(i) = \begin{cases} 0 & \text{if } i > \theta \\ P_x X/P_m & \text{if } i \leq \theta \end{cases} \tag{9}$$

where

$$\ln(P_x) = \theta \ln(P_m) + (1-\theta)\ln(W_y) - \int_\theta^1 \ln(z(i))di \tag{10}$$

Aggregating (9) across tasks leads to

$$L_y = \int_\theta^1 l(i)di = (1-\theta)P_x X/W_y \quad , \quad M_y = \int_0^\theta m(i)di = \theta P_x X/P_m \tag{11}$$

Substituting (11) into (10), rearranging and taking exponents yields

$$X = e^{\int_\theta^1 \ln(z(i))di} \left(\frac{M_y}{\theta}\right)^\theta \left(\frac{L_y}{1-\theta}\right)^{1-\theta} \tag{12}$$

Finally, substituting (12) into the production function (6),

$$Y = e^{\alpha\int_\theta^1 \ln(z(i))di} \left(\frac{K}{1-\alpha}\right)^{1-\alpha} \left(\frac{M_y}{\alpha\theta}\right)^{\alpha\theta} \left(\frac{L_y}{\alpha(1-\theta)}\right)^{\alpha(1-\theta)} \quad , \quad 0 \leq \alpha, \theta \leq 1 \tag{13}$$

We can rewrite (11) as

$$W_y L_y = \alpha(1-\theta)P_x \left((1-\alpha)\frac{Y}{K}\right)^{\frac{1-\alpha}{\alpha}} Y \quad , \quad P_m M_y = \alpha\theta P_x \left((1-\alpha)\frac{Y}{K}\right)^{\frac{1-\alpha}{\alpha}} Y \tag{14}$$

The cost-minimizing choice of K satisfies

$$R = MC_y(1-\alpha)Y/K \tag{15}$$

where $MC_y = R^{1-\alpha}P_x^\alpha$ is marginal cost and R is the rental rate of capital. Substituting this condition into (14) yields,

$$W_yL_y = \alpha(1-\theta)MC_yY \quad , \quad P_mM_y = \alpha\theta MC_yY \tag{16}$$

The markup in the final goods industry is defined as

$$\mu_y = P_y/MC_y \tag{17}$$

Using (16) and (17), we can express the industry labor share in value added as

$$\lambda_y = \frac{W_yL_y}{P_yY - P_mM_y} = \frac{1}{w_y}\frac{\alpha(1-\theta)}{\mu_y} \tag{18}$$

where $w_y = (P_yY - P_mM_y)/P_yY$ is the final industry weight in total value added.

Using (16) and (17) and imposing market clearing in intermediate services $M = M_y$, the intermediate input share in industry output, denoted by ω_y, is

$$\omega_y = \frac{P_mM}{P_yY} = 1 - w_y = \frac{\alpha\theta}{\mu_y} \tag{19}$$

Although (19) implies that w_y is decreasing in θ, the labor share in value added in the final industry λ_y is unambiguously decreasing in the degree of outsourcing θ.

Our focus is on the empirical implications of trends in θ on industry and aggregate labor shares. For this purpose, no additional assumptions beyond the specification of technologies, cost minimizing behavior by firms in the final goods industry, and clearing in the market for intermediate services are required. Determining industry wages, markups, etc. requires additional structure that is beyond the scope of our analysis. We briefly list, however, the possible determinants of the degree of outsourcing θ in a fully specified general equilibrium model. One possibility is that outsourcing is constrained by the services available in the market: $\theta = I$, where I can be affected by technological innovation, either exogenously or endogenously determined by a choice to allocate resources to research and development. The other possibility is that outsourcing decisions are at an interior $\theta = i^*$ and

$$z(i^*) = \frac{W_y}{P_m} = \frac{W_y}{W_m}\frac{A_m}{\mu_m}$$

In this case outsourcing θ is increasing in productivity A_m and the industry wage gap W_y/W_m, and decreasing in the markup μ_m in the intermediate service industry.

The aggregate labor share in the model is

$$\lambda = w_y\lambda_y + (1-w_y)\lambda_m = \frac{\alpha}{\mu_y}\left(1 - \theta\left(1 - \frac{1}{\mu_m}\right)\right) \tag{20}$$

This expression shows that outsourcing $\theta > 0$ does not affect the aggregate labor share whenever $\mu_m = 1$, i.e. when there is perfect competition for intermediate services. In this case, outsourcing affects industry-level labor and intermediate input shares, see (18) and (19), but in the aggregate these effects cancel out perfectly and regardless of industry wage differentials. This example illustrates more broadly how supply chain changes can induce trends in industry-level labor shares that have nothing to do with the determinants of aggregate labor share dynamics.

An additional insight from (20) is that, whenever there is imperfect competition in the intermediate industry, outsourcing does affect the aggregate labor share. More specifically, if $\mu_m > 1$ an increase in outsourcing θ leads to a lower aggregate labor share λ. The reason is the greater exercise of market power along the vertical layer of the supply chain. Even when industry-level markups μ_m and μ_y are constant, the greater extent of double marginalization means that market power distortions effectively go up in the aggregate when θ rises. Equation (20) therefore suggests that the rise in labor outsourcing potentially contributes to the decline in the aggregate labor share. Although this mechanism requires that intermediate firms have market power, it differs from standard market power explanations because it does not require any changes in market power at the industry level. In our model industry wage differences do not directly affect the aggregate labor share in the model. However lower wages in outsourced jobs, as documented by Dube and Kaplan (2010), Goldschmidt and Schmieder (2017) and Dorn et al. (2018), of course can still matter indirectly by inducing more outsourcing.

2.2 Labor Shares and Outsourcing in the Data

2.2.1 Labor Outsourcing and the Value Added Decomposition

We begin by studying the implications of the theory for the reallocation and within-industry contributions across industries in the value added decomposition of Section 1.2. In the context of the stylized model, performing this decomposition yields

$$(21) \qquad \Delta\lambda = \underbrace{(\bar{\lambda}_y - \bar{\lambda})(-\Delta\omega_y)}_{\substack{\text{value added} \\ \text{reallocation} \\ \text{final industry}}} + \underbrace{(\bar{\lambda}_m - \bar{\lambda})\Delta\omega_y}_{\substack{\text{value added} \\ \text{reallocation} \\ \text{intermediate industry}}} + \underbrace{(1-\bar{\omega}_y)\Delta\lambda_y}_{\substack{\text{change in labor share} \\ \text{final industry}}} + \underbrace{\bar{\omega}_y\Delta\lambda_m}_{\substack{\text{change in labor share} \\ \text{intermediate industry}}}$$

The first and second term represent the effects of value added reallocation in the final and intermediate industries, respectively. The last two terms are the within-industry contributions of changes in labor shares in value added. Ceteris paribus, increased outsourcing (higher θ) leads to a larger intermediate input share in output ω_y, which in the model example also determines the industry value added weights. When the intermediate industry has the larger labor share on average, $\bar{\lambda}_y < \bar{\lambda} < \bar{\lambda}_m$, outsourcing leads to a positive reallocation contribution in both industries. The within-industry contribution of the final sector is unambiguously negative because its labor share λ_y is always decreasing in θ. Absent changes in intermediate sector markups, $\Delta\lambda_m = 0$, the within-industry contribution of the intermediate sector is zero. If the intermediates market is perfectly competitive, $\mu_m = 1$, the sum of the different contributions always cancel exactly, and $\Delta\lambda = 0$. When $\mu_m > 1$, the positive value added reallocation effects in each industry do not fully offset the negative within contribution of the industry that is outsourcing jobs.

The two-sector model makes predictions for the value added decomposition in (2) that shed light on the potential role of labor outsourcing. While the model is highly stylized, these predictions are largely a matter of accounting and will hold also in more complicated settings.

The first prediction is that, ceteris paribus, labor outsourcing leads to negative within-industry contributions in all industries that are engaging in more outsourcing of the labor-intensive parts of production. In practice, the associated within-industry labor share declines are likely to be widespread, since many of the underlying reasons for outsourcing jobs can be expected to be common across industries. As discussed in Section 1.2 and in many previous studies, this is indeed the case in the data.

A second prediction of the model is that the value added share of upstream service industries should increase. Because of the relatively high labor shares in these industries, they should also make a positive reallocation contribution. Under the NAICS system, the main providers of intermediate business services are classified in the professional and business services (PBS) category. We describe the PBS industries and its activities in detail below, but note here that the sector's labor share in value added is very high (around 90 percent on average, see Table A.I). The value added share of the PBS industry in GDP did increase substantially from 9.8 in 1997 to 12.1 percent in 2016, surpassing the share of manufacturing. Consistent with the model prediction, the PBS sector makes a large positive reallocation contribution (62 basis points).

The third prediction regards the value added reallocation effects in the industries outsourcing labor to external providers. Although an individual industry's reallocation contribution can be positive or negative depending on how its labor share compares to the aggregate, for all outsourcing industries the combined reallocation component should be positive. Table A.I instead shows that, for the economy as a whole, the reallocation contribution is substantially negative, and it remains negative even after subtracting the contribution of the real estate sector. The third model prediction is therefore not supported by the data.

The fact that the combined reallocation component in the value added decomposition is negative is evidence that domestic outsourcing is not likely to be a main driver of the aggregate labor share decline. However, we will show that outsourcing is an important influence on the within components of the decomposition in Table A.I. For this reason, outsourcing trends complicate the interpretation of the value added decomposition. Labor outsourcing generates movements in the reallocation and within components of (2) that are not independent. Not accounting for these joint movements leads one to overstate the aggregate role of within-industry labor share declines, while the negative contribution of reallocation effects are understated.

2.2.2 Outsourcing to the Professional and Business Services Industry

Much (though not all) of the evidence for labor outsourcing effects that we present in this paper relies on the professional and business services (PBS) industry being the primary supplier of labor-intensive intermediate services. The NAICS system defines three subsectors within PBS:[8]

1. The *Professional, Scientific, and Technical Services* sector comprises establishments that specialize in performing professional, scientific, and technical activities for others. The establishments in this sector specialize according to expertise and provide these services to clients in a variety of industries and, in some cases, to households.[9] The sector accounts for around 60 percent of value added and 43 percent of employment in PBS.

2. The *Management of Companies and Enterprises* sector comprises (1) establishments that hold the securities of (or other equity interests in) companies and enterprises for the purpose of owning a controlling interest or influencing management decisions or (2) establishments (except government establishments) that administer, oversee, and manage establishments of the company or enterprise and that normally undertake the strategic or organizational planning and decision making role of the company or enterprise. The sector accounts for roughly 15 percent of value added and 11 percent of employment in PBS.

3. The *Administrative and Support Services and Waste Management and Remediation Services* sector comprises establishments performing routine support activities for the day-to-day operations of other organizations. These essential activities are often undertaken in-house by establishments in many sectors of the economy. The establishments in this sector specialize in one or more of these support activities and provide these services to clients in a variety of industries and, in some cases, to households.[10] The sector accounts for 25 percent of value added and 46 percent of employment in PBS.

Production in the PBS subsectors is labor intensive – as mentioned earlier the labor share in value added on average exceeds 90 percent – and is mostly for intermediate use.[11] In terms of the model above, we think of the PBS industry as the equivalent of the intermediate industry. One feature of NAICS is that the system classifies establishments, and not firms. This means that intermediate purchases from the PBS industry not necessarily only reflect transactions between firms, but potentially also the consolidation at one establishment of services provided to establishments of the same firm in other industries. We include such consolidation in our definition of outsourcing because the implications for NAICS industry-level measures of labor shares are the same. The theoretical model

[8] NAICS codes 54, 55 and 56, see https://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2012.

[9] Activities performed include: legal advice and representation; accounting, bookkeeping, and payroll services; architectural, engineering, and specialized design services; computer services; consulting services; research services; advertising services; photographic services; translation and interpretation services; veterinary services; and other professional, scientific, and technical services.

[10] Activities performed include: office administration, hiring and placing of personnel, document preparation and similar clerical services, solicitation, collection, security and surveillance services, cleaning, and waste disposal services.

[11] The PBS share of value added is 9.8 percent of GDP in 1997 and 12 percent in 2016, whereas the share in final expenditures is 4.3 percent in 1997 and 4.9 percent in 2016, see Tables A.I and A.II.

can also easily be reinterpreted as one of outsourcing between establishments of the same firm. The only substantive difference is that there is no double marginalization ($\mu_m = 1$) between establishments of a single profit-maximizing firm.

Figure 2a provides a breakdown of the major occupation groups active within the PBS industry according to the BLS Occupational Employment Statistics available for NAICS industries from 2002 to 2017. The table shows that the PBS sector employs workers with all skill levels, from janitors and security guards to computer programmers and engineers. Almost a quarter of PBS employees are office and administrative support workers. Roughly 20 percent of PBS employment is in routine jobs providing various cleaning (10 percent), transportation (6.2 percent) and protective services (4.1 percent). Another 10 percent or so are employed in sales (5.3 percent) and production work (4.9 percent). A substantial fraction of employment within administrative and support services is in 'temporary help services'. This NAICS category contains all workers employed by agencies engaged in supplying workers for limited periods of time to other industries, a large number of which are in transportation, production and administrative support occupations.

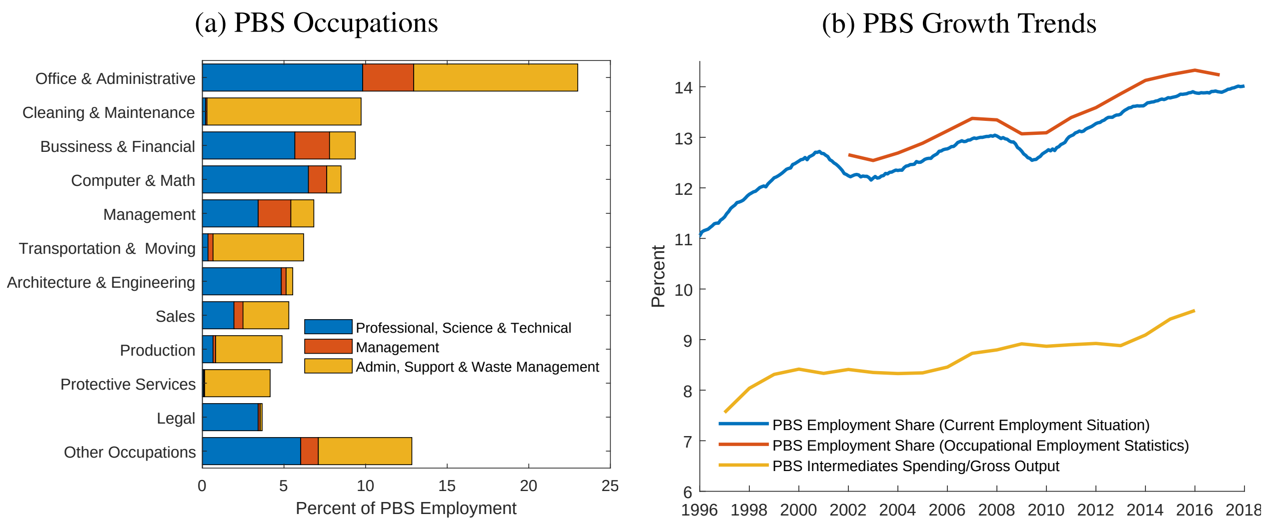

Figure 2 PBS Occupations and Growth Trends

Notes: *Panel a*: Numbers are average shares of occupational employment in total PBS employment from 2002 to 2017. The figure shows the 11 largest of the 22 major occupation categories in the Occupational Employment Statistics. The remaining 11 are combined in 'Other Occupations'. *Panel b*: See appendix for data sources.

Table A.I – discussed above – shows the rising PBS share in value added. Figure 2b shows some additional measures of the industry's growth. The blue and red lines depict the PBS share in total nonfarm employment according to the monthly BLS Current Employment Situation (CES) report and the annual BLS Occupational Employment Statistics (OES). Both show increases in the fraction of full and part-time workers employed in PBS establishments. In the CES, PBS employment rose from 11 percent of total employment in 1996, to 14 percent in 2018. To verify the growth of the industry as an upstream producer, the yellow line in Figure 2b depicts the total spending by all industries on intermediate PBS services as a share of total gross output. The figure shows that aggregate spending on PBS intermediates rose from 7.6 percent of gross output in 1997 to 9.6 percent in 2016.

The relative growth in PBS value added, employment and output by itself does not necessarily indicate a rise in labor outsourcing but could also be entirely compositional, for instance because of relatively stronger growth in industries using intermediate PBS services, or in the types of occupations that are overrepresented in the PBS sector. However, occupational decompositions of the PBS employment share indicate that much of the rise of PBS activity is due to increased labor outsourcing, see for instance Dey et al. (2010) Berlingueri (2014), Dorn et al. (2018). Consider for instance the following decomposition of the change in PBS employment E^{PBS} to total employment E:

$$\Delta(E^{PBS}/E) = \underbrace{\sum_j \left(\overline{E_j^{PBS}/E_j} - \overline{E^{PBS}/E}\right)\Delta(E_j/E)}_{\text{occupational reallocation}} + \underbrace{\sum_j (\overline{E_j/E})\Delta(E_j^{PBS}/E_j)}_{\substack{\text{within-occupation} \\ \text{change in PBS share}}} \tag{22}$$

where E_j is the economy wide employment in occupation j and E_j^{PBS} is employment in occupation j within the PBS industry. As before, a bar above a variable denotes the average of the observations in the current and last year. The first term in (22) captures the effect of aggregate changes in the occupational composition of the workforce. For instance, if the share of security guards in employment increases economy wide, $\Delta(E_j/E) > 0$, and the PBS sector on average employs a greater share of security guards, $\overline{E_j^{PBS}/E_j} > \overline{E^{PBS}/E}$, then aggregate growth in the employment of security guards makes a positive reallocation contribution to the change in the PBS employment share. The second term in (22) represents the contribution of changes in the occupation shares of the PBS sector. If there is, for example, no aggregate change in the share of security guards in employment, $\Delta(E_j/E) = 0$, but there is an increase in the share of security guards employed in the PBS industry, $\Delta(E_j^{PBS}/E_j) > 0$, then security guards make a positive within-occupation contribution to the change in the total PBS employment share. If the outsourcing of jobs previously done in-house by establishments in other industries is the primary reason for the relative growth of PBS employment, then contributions of within-occupation changes should dominate.

Table I presents the results of the decomposition based on OES data available for NAICS industry from 2002 to 2017. For brevity, we focus on the broadest classification into 22 major occupations. The table reports the sums of annual observations of the respective terms in (22) over the sample period, and the first line in Table I shows the sums across occupations. According to the OES data, the PBS employment share across all occupations rose by 1.58 percentage points between 2002 and 2017. The first row in Table I shows that the decomposition attributes the entire increase to changes in within-occupation PBS employment shares (column [2]). Increases in the share of PBS employment in 17 of 22 occupations contribute positively. The largest contribution is within the business and financial operations category (31 basis points), which consists mainly of accountants, analysts, marketing specialists and tax preparers. Other important occupations moving into PBS are in cleaning and maintenance (27 basis points), management (24 basis points), computer and math (18 points), production (16 basis points) and administrative support (12 basis points). The net contribution of aggregate changes in occupational composition is close to zero (less than 0.3 basis points). Aggregate growth in business/financial and computer/math occupations is almost entirely offset by declining occupations prevalent in PBS, e.g. administrative support, or by growing occupations under-represented in PBS, e.g. food preparation or personal care.

TABLE I
CHANGE IN THE PBS EMPLOYMENT SHARE BY OCCUPATION, 2002-2017

	Share in Total Employment		*Share in PBS Employment*		*Occupation Reallocation*	*Change in PBS Share*	
	2002	2017	2002	2017	[1]	[2]	Total
All Occupations	100.0	100.0	12.7	14.2	0.00	1.57	1.58
Management	5.6	5.1	16.0	21.1	−0.00	0.24	0.24
Business and Financial Operations	3.7	5.2	23.3	30.0	0.20	0.31	0.51
Computer and Mathematical	2.2	3.0	40.1	47.3	0.25	0.18	0.43
Architecture and Engineering	1.9	1.8	37.4	42.5	−0.03	0.09	0.07
Life, Physical, and Social Science	0.8	0.8	29.4	32.0	−0.01	0.02	0.02
Community and Social Service	1.2	1.5	2.7	2.4	−0.03	−0.00	−0.03
Legal	0.7	0.8	62.4	65.3	0.02	0.02	0.04
Education, Training, and Library	6.1	6.1	0.7	1.1	−0.00	0.03	0.03
Arts, Design, Entertainment, Sports, and Media	1.2	1.3	22.6	23.8	0.02	0.02	0.03
Healthcare Practitioners and Technical	4.8	6.0	4.9	4.8	−0.10	−0.01	−0.11
Healthcare Support	2.5	2.9	5.5	4.7	−0.03	−0.02	−0.05
Protective Service	2.3	2.4	22.4	24.4	0.01	0.05	0.05
Food Preparation and Serving Related	7.9	9.3	1.1	0.9	−0.17	−0.01	−0.18
Building and Grounds Cleaning and Maintenance	3.3	3.1	35.9	44.1	−0.06	0.27	0.21
Personal Care and Service	2.2	3.6	3.5	2.6	−0.15	−0.03	−0.17
Sales and Related	10.5	10.2	6.6	7.0	0.02	0.04	0.07
Office and Administrative Support	17.8	15.4	18.0	18.8	−0.12	0.12	0.00
Farming, Fishing, and Forestry	0.3	0.3	7.7	4.7	0.00	−0.01	−0.01
Construction and Extraction	4.8	4.0	5.6	5.7	0.06	0.00	0.06
Installation, Maintenance, and Repair	4.1	3.9	5.2	6.6	0.01	0.05	0.07
Production	8.4	6.3	8.3	10.8	0.09	0.16	0.25
Transportation and Material Moving	7.4	7.0	12.1	12.8	0.01	0.04	0.05

Notes: Numbers are percentage points. PBS is professional and business services. Based on data from the BLS Occupational Employment Statistics for 2002 to 2017. The table reports the sums of annual observations of the respective terms in (22) over the sample period. The first line shows the sums across all occupations. *Share in total employment* is total employment in the occupation over total employment across all occupations. *Share in PBS employment* is employment in the occupation within PBS over employment in the occupation across all industries.

The decomposition by occupations strongly suggests that the growth in the PBS employment share between 2002 and 2017 is predominantly due to labor outsourcing. This is consistent with Bloom et al. (2018), who show in the underlying OES microdata for 1999 to 2016 that the mean number of occupations within establishments has fallen since 2000.

The rise in the PBS employment share long pre-dates the 2000s. CES data shows a steady increase in the PBS employment share since at least the early 1960s, rising by roughly 10 basis points every year with no sign of acceleration around 2000.[12] NAICS-based OES data is not available before 2002, but there is much evidence that labor outsourcing accounts for much of the growth in earlier years. Dey et al. (2010) find evidence for labor outsourcing in the 1987-2001 SIC-based OES data. Berlingueri (2014) and Dorn et al. (2018) conduct similar occupational decompositions using decennial census data from 1950 to 2010, and find evidence of labor outsourcing since 1960 and a pickup from 1970 onwards. The evidence for outsourcing trends in the 1970s and earlier suggests that labor outsourcing is not a key explanation for the unprecedented labor share losses observed in the 2000s.

2.2.3 Labor Outsourcing and Labor Shares in Industry Output

Next, we provide direct evidence that outsourcing trends are important drivers of within-industry labor shares. We first consider a basic implication of the theory that helps distinguish labor outsourcing effects from other potential drivers of industry labor shares – increases in capital intensity and rising markups. In the model of Section 2.1, cost minimization leads to the following expressions for spending on intermediate inputs and labor as share of industry output:

$$\omega_y = \frac{\theta\alpha}{\mu_y} \quad , \quad \lambda_y^g = \frac{\alpha(1-\theta)}{\mu_y} \tag{23}$$

Note that the superscript g in λ_y^g denotes the labor share in gross output, which is different from λ_y, the labor share in industry valued added. According to (23), an increase in the downstream markup μ_y lowers both the labor share λ_y^g and the intermediate input share ω_y. Increases in capital intensity – a decrease in α in the model – similarly lead to decreases in both labor and intermediate input shares. Increased outsourcing (higher θ), in contrast, decreases the labor share but leads to an increase in the intermediate input share. Therefore, one way to verify the relative importance of outsourcing trends is to look at the comovement of trends in labor and intermediate input shares in industry output. A negative comovement is evidence that outsourcing is the key determinant of labor share trends, while a positive comovement calls for explanations based on rising markups or increases in capital intensities.

For each industry, we estimate time trends by regressing labor and intermediate input shares in industry output on a linear time trend for the 1997-2016 sample, and we calculate the implied trend change over that period from the regression coefficient. Figure 3a shows the relationship between estimated trends in both share variables, obtained from the BEA's input-output tables. The line shown in the figure is the regression line from a value added-weighted OLS regression that includes all industries with a labor share trend that is statistically significantly different from zero at the 1 percent level. The conclusion from Figure 3a is that labor and intermediate shares are moving mostly in opposite directions.

In practice, not all intermediate spending is of course for purchases of labor-intensive services.

[12] The PBS industry contained 7 percent of all payroll employment at the start of the 1960s, compared to 14 percent in 2018.

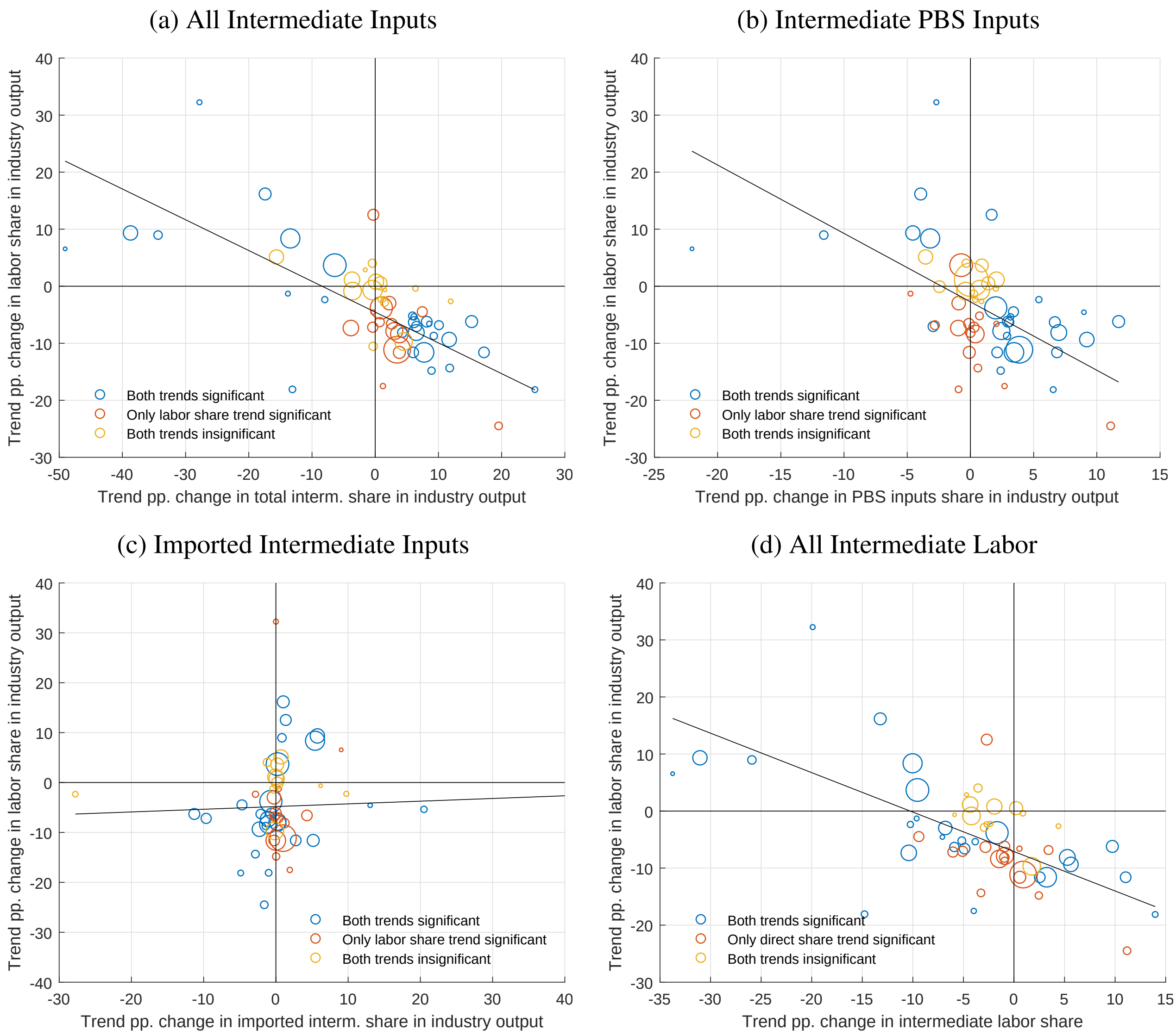

Figure 3 Trend changes in labor and intermediate shares in industry output, 1997-2016.

Notes: Based on data from BLS-KLEMS and the BEA Input-Output Accounts, see appendix. Circles represent 3-digit NAICS private industries. Circle size reflects industry value added weight. Trend changes are estimated by OLS regression of shares on a linear time trend. Blue circles represent industries for which both trend coefficients are statistically significant at the 1 percent level. Red circles represent industries for which only the labor share trend is significant. Yellow circles represent industries for which neither trend is significant. Intermediate labor shares in Panel d are calculated as in (27) using the input matrix with all intermediate spending (domestic and imported).

For the market power hypothesis, this is less relevant since rising markups should decrease the share of all intermediates, see Bils, Klenow and Malin (2018) or Kim (2017). The implications of automation for total intermediate spending shares are less immediate, as more capital intensive production could in principle require a larger materials or energy share. Automation could also involve greater use of capital-intensive intermediate goods rather than within-industry capital. For this reason, Figure 3b reports the relationship between trends in industry labor shares in output and in the share of services purchased from the PBS industry.[13] The relationship between the trends remains predominantly negative. In fact, the figure shows how the vast majority of industries with significant labor share losses saw simultaneous increases in the share of purchases of labor-intensive PBS intermediates.

[13]Using intermediate purchases from all services-producing industries leads to the same conclusions.

Labor shares could also be falling in many industries because labor intensive stages of production are increasingly relocated abroad. To verify the role of international outsourcing, Figure 3c shows the relationship between trends in industry labor shares and the share of imported intermediates. The figure shows there is no immediate relationship between industry labor share trends and trends in spending on foreign intermediates.

We conclude from Figures 3a-3c that industry-level labor share losses appear more strongly related to increased domestic labor outsourcing than to factor substitution, increases in markups or offshoring. To the extent outsourcing is more prevalent at larger firms, outsourcing may help explain the correlation between labor share declines and industry concentration (Barkai, 2016) and the fact that much of the declines occur though within industry reallocation towards larger establishments (Autor et al., 2017; Kehrig and Vincent, 2017).

2.2.4 Labor Outsourcing and the Final Use Decomposition

The observed trends in industry labor shares likely reflect changes in domestic and global supply chains that are more complex than in our stylized two sector model. If so, analyzing the role of labor outsourcing requires information on the full production network and not just on direct spending on PBS or imported intermediates. Therefore, we next study the relationship between the compensation paid directly by an industry and the compensation paid by all industries in earlier stages of production. Large parts of the methodology in this section are similar to Baqaee (2013).

To start, we restate the aggregate labor share in GDP as the Domar-weighted sum of industry labor shares in gross output:

$$\lambda = \lambda_g' \mathbf{w}_d \tag{24}$$

where λ_g is the vector of industry labor shares in industry output and $\mathbf{w}_d$ is the vector of Domar weights, i.e. industry gross output as a ratio of total value added. Let $\mathbf{y}$ and $\mathbf{x}$ denote the vector of industry output and final industry demand. As a matter of accounting, both are linked through

$$\mathbf{y} = (I - \Omega)^{-1} \mathbf{x} \tag{25}$$

where Ω is the industry input matrix. The ij-th element of the industry input matrix specifies the output of industry i used directly as an intermediate input for producing output in industry j, as share of output in industry j. Dividing both sides of (25) by total GDP and substituting into (24) yields

$$\lambda = \lambda_x' \mathbf{w}_x \tag{26}$$

where $\lambda_x = (I - \Omega')^{-1} \lambda_g$ is the vector containing the total labor share in the final use of industry output, see also Valentinyi and Herrendorf (2008), and $\mathbf{w}_x$ is the vector of final expenditure shares by industry. The total labor share in final use has two components:

$$\lambda_x = \underbrace{\lambda_g}_{\text{direct labor share}} + \underbrace{(I-\Omega')^{-1}\Omega'\lambda_g}_{\text{intermediate labor share}} \tag{27}$$

The first component is the direct labor share, which measures the compensation paid by an industry for every dollar in final sales and simply equals the industry's labor share in gross output. The second component is the intermediate labor share, which measures the total share of compensation paid in the production of intermediate inputs at all earlier stages. The intermediate labor share therefore captures the total labor costs incurred along the supply chain to bring a unit of industry output to its final use.

In the example of the two sector model of Section 2.1, the vector of labor shares in final use is

$$\lambda_x = \underbrace{\begin{bmatrix}(1-\theta)\alpha/\mu_y \\ 1/\mu_m\end{bmatrix}}_{\text{direct labor share}} + \underbrace{\begin{bmatrix}\alpha\theta/\mu_y/\mu_m \\ 0\end{bmatrix}}_{\text{intermediate labor share}} = \begin{bmatrix}\lambda \\ 0\end{bmatrix} \tag{28}$$

In the model, the labor share in final use of the final industry simply equals λ, the aggregate labor share in value added, since it is the only industry producing final goods. The final industry's intermediate labor share is the intermediate sector's labor share $1/\mu_m$ times the intermediate input share $\alpha\theta/\mu_y$ of the final sector. The intermediate labor share of the intermediate sector is zero, since it does not use any intermediate inputs.

Figure 3d shows the relationship between trends in the direct and intermediate labor shares calculated from BLS-KLEMS compensation data and the BEA Input-Output tables. The intermediate labor share is constructed using the industry input matrix that includes both domestic and imported intermediates. It therefore measures the intermediate labor costs assuming all intermediates are produced domestically, or equivalently that the intermediate labor costs of imported and domestic intermediates are identical. Figure 3d shows that trends in direct and intermediate labor costs are negatively related, which confirms that the labor-intensive parts of production are more generally moving along the supply chain. Note that the regression line in Figure 3d is shifted to the southwest direction relative to those for the intermediate input share trends in the previous figures. This reflects the fact that labor share losses are pervasive not only at the final stage, but also at upstream stages of production.

If outsourcing is a quantitatively important driver of industry labor share trends, then we should observe that opposite changes in intermediate labor shares are offsetting most of the direct accounting impact of these trends on the aggregate labor share. Using (26) and (27), we can investigate this formally in the following final use decomposition of aggregate labor share dynamics:

$$\Delta\lambda = \underbrace{\sum_i (\bar{\lambda}_i^x - \bar{\lambda})\Delta w_i^x}_{\substack{\text{final use}\\ \text{reallocation}\\ \text{contribution}}} + \underbrace{\sum_i \bar{w}_i^x \Delta\lambda_i^{x,direct}}_{\substack{\text{direct}\\ \text{labor share}\\ \text{contribution}}} + \underbrace{\sum_i \bar{w}_i^x \Delta\lambda_i^{x,interm}}_{\substack{\text{intermediate}\\ \text{labor share}\\ \text{contribution}}} \tag{29}$$

As before, a bar above a variable denotes the average of the current and last observation. The first term in this decomposition represents the reallocation effects on λ from changes in final expenditure shares. These final use reallocation effects differ from the value added reallocation effects in (2). The reason is that, whereas labor outsourcing directly shifts value added across industries, it does not lead to immediate shifts in final expenditure shares. The second term in (29) captures the contribution of changes in direct labor shares – the labor shares in industry output – on $\Delta\lambda$. Finally, the last term in (29) captures the contributions of changes in intermediate labor shares, i.e. the labor share implied by an industry's use of intermediates in the supply chain. The final use decomposition in (29) is also derived by Baqaee (2013).

To gain intuition for the final use decomposition, Table II provides the different components in the context of the model example in Section 2.1. With a single final and a single intermediate industry, all terms of the decomposition are zero apart from the direct and intermediate labor share contributions of the final industry. The direct labor share contribution is a function of changes in the labor elasticity of production, $\Delta(\alpha(1-\theta))$ and markup changes $\Delta(1/\mu_y)$. The intermediate labor share contribution is a function of changes in the intermediate input elasticity of production, $\Delta(\alpha\theta)$ and markup changes in both industries, $\Delta(1/\mu_y)$ and $\Delta(1/\mu_m)$.

TABLE II
FINAL USE DECOMPOSITION OF $\Delta\lambda$ IN THE MODEL EXAMPLE

	Final Use Reallocation	*Direct Labor Share Change*	*Intermediate Labor Share Change*
	[1]	[2]	[3]
Final industry	0	$\overline{1/\mu_y}\Delta(\alpha(1-\theta))+\overline{\alpha(1-\theta)}\Delta(1/\mu_y)$	$\overline{1/\mu_m}\;\overline{1/\mu_y}\Delta(\alpha\theta)+\left(\overline{1/\mu_m}\;\overline{\alpha\theta}\right)\Delta(1/\mu_y)$ $+\overline{\alpha\theta/\mu_y}\Delta(1/\mu_m)$
Intermediate industry	0	0	0

If there are no distortions at intermediary stages of production, $\mu_m = 1$, then – ceteris paribus – increases in θ generate negative direct labor share contributions and positive intermediate labor share contributions that cancel exactly. With distortions ($\mu_m > 1$), the within contributions do not cancel exactly, and the negative direct contributions exceed the positive intermediate labor share contribution. Falling labor intensities $\Delta\alpha < 0$ and markup increases $\Delta(1/\mu_y) < 0$ each lead to negative contributions in both the direct and intermediate labor share components. Markup increases in the intermediate industry, $\Delta(1/\mu_m) < 0$ lead to a negative contribution of intermediate labor share changes.

Table A.II lists the components of the final use decomposition in (29) – summed over the 1997-2016 period – for all industries and selected aggregates, together with final expenditure shares and

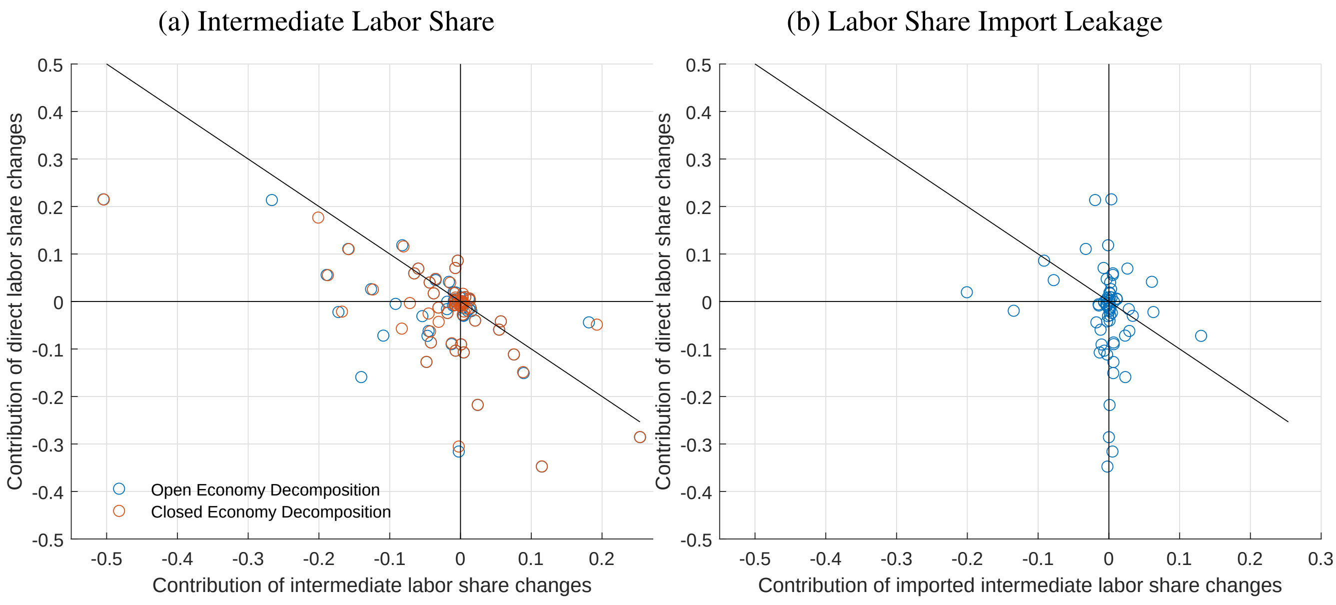

Figure 4 Aggregate contributions of direct and intermediate labor shares changes, 1997-2016.

Notes: Based on data from BLS-KLEMS and the BEA Input-Output Accounts, see appendix. Circles represent 3-digit NAICS private industries and reflect the percentage points contributions of the direct and intermediate industry labor shares to the aggregate labor share change in the final use decomposition. The straight lines in both panels are the negative 45 degree line. The red circles are based on the closed economy decomposition in (29) using the input matrix with all intermediate spending (domestic and imported). The blue circles in both panels are based on the open economy decomposition in (30) using the domestic input matrix.

final use labor shares in the first and last year of the sample. Columns [2] and [3] contain the direct and intermediate labor contributions in (29). The results shown in the table are based on the industry input matrix that does not distinguish between domestic and imported intermediates. We refer to the resulting decomposition as the closed economy final use decomposition. Final expenditures $\mathbf{x}$ in this case are defined as in the national accounts, i.e. net of imported intermediates. The open economy decomposition is discussed below.

Figure 4a shows the scatter plot of the contributions of changes in direct and intermediate labor shares to the aggregate labor share over the sample periods in the closed economy decomposition (red circles). The line shown in the figure is the negative 45 degree line through the origin. If outsourcing is the only source of variation in industry labor shares and without intermediary markup distortions, a generalization of the theory to multiple industries predicts industry contributions that lie perfectly on the negative 45 degree line. With intermediary markup distortions, the industry contributions fall on a line that is somewhat flatter. If instead markup trends or changes in capital intensity are the dominant source of variation in industry labor shares, there should be a positive relation between direct and intermediate labor shares.

Figure 4a shows a clear negative relationship between the direct and intermediate labor share contributions, which is consistent with labor shifting across NAICS industry boundaries. The negative relationships means that, at least in the industries that matter in the aggregate, labor outsourcing is a more important driver of industry labor shares than markups or automation. In practice, the points do of course not line up exactly, and most lie to the southwest of the negative 45 degree line. This is because changes in capital intensity and/or variation in industry markups also play a role. The main takeaway from Figure 4a, however, is that the aggregate impact of industry labor share trends is to an important extent offset by opposite changes in intermediate labor shares.

Column [1] in Table A.II shows the contributions of changes in the industrial composition of final demand. We discuss the effects of the compositional changes in final use in greater detail below, because they are also part of the structural decompositions in Section 3.2. Here, we verify one additional model prediction: Relative to the effects of value added reallocation in Table A.I, the combined final use reallocation effects in Table A.II ceteris paribus should be smaller – or in other words explain a larger share of the aggregate labor share loss. Moreover, the positive value added reallocation contribution of industries providing intermediate labor-intensive services should largely disappear in the final use reallocation contributions of these industries. Table A.II confirms both of these predictions: the first row shows that reallocation in final demand subtracts 1.12 percentage points of the labor share relative to 1997, explaining roughly 30 percent of the total 3.79 percentage points drop. This is more than the reduction by 0.76 percentage points attributed to value added reallocation in Table A.I. Finally, the contribution of the shift towards final use of PBS output (15 basis points) is considerably smaller than the contribution of the shift towards PBS valued added (62 basis points, see Table A.I), which is consistent with increased outsourcing to the labor intensive PBS industry in particular.

The intermediate labor shares reported so far include compensation embedded in intermediate inputs imported from abroad. To the extent foreign labor shares are comparable to their domestic equivalents, including these imports captures labor movements along the entire supply chain, both domestic and global. However, wages paid abroad do not contribute to domestic wage income, and any offshoring at intermediate stages of production leads to an overstatement of the intermediate labor share contributions to the numerator of the aggregate labor share. In appendix, we derive an open economy final use decomposition that separately accounts for the leakage of labor income through imported intermediates, which is of the form:

$$\text{(30)} \qquad \Delta\lambda = \underbrace{\sum_i \tilde{w}_i^x \Delta\lambda_i^{x,direct}}_{\substack{\text{direct}\\ \text{labor share}\\ \text{contribution}}} + \underbrace{\sum_i \tilde{w}_i^x \Delta\lambda_i^{x,interm}}_{\substack{\text{intermediate}\\ \text{labor share}\\ \text{contribution}}} + \underbrace{\left(-\sum_i \tilde{w}_i^x \Delta\lambda_i^{x,imports}\right)}_{\substack{\text{compensation}\\ \text{import leakage}}} + \text{other terms}$$

The weights $\tilde{w}_i^x$ in the open economy decomposition differ from those in (29), and their sum exceeds one if there are imported intermediates. The new term in (30) contains the contributions of changes in the labor share embedded in imported intermediates, as measured by their domestic equivalents. Increased offshoring and more spending on intermediate imports leads to $\Delta\lambda_i^{x,imports} > 0$ and more leakage of compensation. The relationship between the direct labor share and compensation import leakage contributions sheds further light on whether it is domestic or international labor outsourcing that explains the negative relationship between direct and intermediate labor/spending shares. Note that the overall effect of offshoring on the aggregate labor share is generally ambiguous because there is also leakage of value added that reduces the denominator in the aggregate labor share. The net effect of changes in global supply chains depends on the labor intensity of imported intermediates, and is studied later in Section 3.2.

The blue circles in Figure 4a show the relationship between the direct and intermediate labor share contributions in the open economy decomposition. The main finding is that the negative relationship between the direct and intermediate labor share contributions is preserved, and it remains regardless of whether the compensation leakage term is included or not. Figure 4b shows the relationship between the direct labor share contributions and the import leakage contributions for each industry. In most industries the import leakage contribution is relatively small, which is the main reason offshoring cannot be the main driver of the negative relationship in Figure 4a. A few industries have larger contributions, but there is no obvious relationship with direct labor share contributions. Overall, it is quite clear that the negative relationship between industry labor share losses and intermediate spending on labor predominantly reflects changes in domestic production networks rather than the rise of global supply chains.

3 The Sources of the Decline in the Aggregate Labor Share

Labor outsourcing trends make it difficult to infer the sources of aggregate labor share losses from disaggregated labor shares without tracking changes in intermediate input linkages. By accounting for such changes, the final use decompositions reveal that much of the within-industry variation in labor shares is offset by changes in the indirect use of labor in earlier stages of production. The final use decomposition, however, does not identify the main drivers of the aggregate labor share. In this section, we present structural decompositions that isolate the contributions of trends in technologies and production networks, industry markups and final expenditure shares. To accomplish these decompositions, we first obtain estimates of time-varying markups at the industry level under a number of different assumptions. Our methodology for estimating these markups is discussed next.

3.1 Estimating Industry Level Markups

There exist several ways to measure markups at the macro level.[14] A first approach is to use measures of the return to capital to distinguish normal capital costs from non-competitive profits. Recent examples of this approach are Barkai (2016), Gutiérrez (2017) and Eggertson, Robbins and Wold (2018). A second approach is to rely on direct measures of marginal cost. An early example is Domowitz, Hubbard and Petersen (1986), who use average variable costs (measured as the sum of payroll and materials) in a panel of manufacturing industries to construct time series of price cost margins. More recently Anderson, Rebelo and Wong (2018) use product level data on the replacement cost from a large retailer, as well as average costs of goods sold for the retail sector as a whole, as

[14]See Syverson (2019) for an overview of the recent literature.

measures of marginal cost. A third approach is to obtain markups from an estimated structural equilibrium model. Many New Keynesian models, for instance, follow this approach, but very few allow for low frequency trends in markups.[15] A fourth approach relies on assumptions about production functions and cost minimizing behavior by firms. Under a Cobb-Douglas technology, as in the model of Section 2.1, markups are inversely proportional to the labor share. A large number of studies use various labor share measures to infer the cyclicality of markups and test theories of business cycle fluctuations, e.g. Bils (1987), Rotemberg and Woodford (1999) or Nekarda and Ramey (2013). More recently, Kim (2017) and Bils, Klenow and Malin (2018) apply the same idea but use the intermediate input share instead. Finally, a fifth approach builds on Hall (1986, 1988)'s generalization of Solow growth accounting. While Hall (1988) only permits the estimation of an average industry markup, a recent extension in Hall (2018) allows for a deterministic time trend in markups. De Loecker, Eeckhout and Unger (2018) extend Hall (1988)'s approach and use variable input spending shares to infer time varying markups at the firm level. Crouzet and Eberly (2018) similarly combine Hall (1988)'s approach and the variable input approach.

We consider markups estimated under the Hall (1988) approach as well as extensions that combine Hall (1988) with the variable input approaches to infer markups dynamics. Using either the labor or intermediate input margin, however, is problematic if outsourcing trends are important. Most existing studies using the variable input approach remove trends in spending shares and focus on cyclical dynamics. Our interest, however, is precisely in the trend component of industry markups. Motivated by the model in Section 2.1 and the evidence on labor outsourcing above, we also consider a combination of labor and intermediate input margins to infer the dynamics of industry markups. This approach allows for time-varying markups but is robust to the presence of outsourcing trends.

We start from a decomposition of industry output growth into the contributions of growth in factor inputs, intermediate inputs and total factor productivity (TFP) :

$$d\ln Y = \sum_j \varepsilon_Y^j d\ln j + dz \ , \ j = K,L,M \tag{31}$$

where Y denotes industry output, j indexes the inputs into production (capital K, labor L, intermediates M) and dz denotes the contribution of growth in TFP. The ε_Y^j parameters denote the elasticities of the production function with respect to the inputs $j = K,L,M$

Denoting the industry markup by μ, we assume that cost minimization leads to

$$\mu = \varepsilon_Y^j / s_j \quad j = K,L,M \tag{32}$$

where s_j are the costs associated with input j as a ratio of the value of production.

[15] One recent exception is Farhi and Gourio (2018).

Substituting (32) into (31) yields

$$d \ln Y = \mu \sum s_j d \ln j + dz \tag{33}$$

Equation (33) motivates industry level regressions as in Hall (1988) for estimating the markup μ, using demand-side instruments to account for endogeneity.[16]

The industry data required for the Hall (1988) regressions are the same as in Solow residual calculations. In datasets such as KLEMS, the Solow residual SR is constructed as

$$SR = d \ln Y - \sum s_j d \ln j = (\mu - 1) \sum s_j d \ln j + dz \tag{34}$$

with the capital revenue share obtained residually, i.e. $s_K = (1 - s_L - s_M)$. Unless there is perfect competition and $\mu = 1$, the Solow residual does not measure TFP growth. Hall (1988) generalizes Solow residual accounting by allowing for imperfect competition, $\mu \neq 1$. Assuming constant returns to scale, the regression in (33) is equivalent to

$$d \ln Y/K = \mu (d \ln(Y/K) - SR) + dz \tag{35}$$

The Hall (1988) approach estimates markups as constant regression coefficients. To allow for secular trends in markups, Hall (2018) allows μ to be a linear function of time by introducing an interaction term in (33) involving a deterministic time trend.[17] In this paper, we instead modify the Hall (1988) regression by substituting (32) into (35):

$$d \ln Y/K = \varepsilon_Y^j (d \ln Y/K - SR)/s_j + dz \tag{36}$$

where the input elasticity ε_Y^j can be estimated using the same instrumental variables as in the original approach. Subsequently, time-varying markups can be obtained from (32) using the IV estimates of ε_Y^j and revenue shares s_j. The difference with Hall (1988) is that the output elasticities to input j, rather than markups, are assumed to be constant over the sample.[18]

The remaining question is which revenue share s_j to use in practice. We consider four different options, listed in Table III. The first option is to set $s_j = 1$, which imposes that markups are constant and corresponds directly to Hall (1988). The second option is to use the labor share $s_j = s_L$, which

[16] Hall (1988) and Domowitz, Hubbard and Petersen (1988) use aggregate GNP as instruments for regressions at the industry level. Subsequent papers typically use changes in military spending, oil prices, or measures of monetary policy shocks as instruments.

[17] Another closely related specification is in terms of the Lerner index $\gamma = 1 - 1/\mu$ instead of the markup:

$$SR = \gamma d \ln Y/K + (1 - \gamma) dz$$

obtained after multiply both sides of (35) by $1 - \gamma$ and rearranging. The latest version of Hall (2018) adopts a specification in terms of γ, allowing for a deterministic time trend in γ instead of μ.

[18] Our approach is very similar to Crouzet and Eberly (2018), who scale inverse cost-of-goods-sold shares to the average markups estimated in Hall (1988, 2018)'s industry level regressions.

amounts to inferring markup dynamics from inverse labor shares as in much of the New Keynesian literature. The regression step in (36) simply produces in addition an estimate of the overall level of the markup. Using the labor share s_L requires the assumption that output elasticities with respect to labor ε_L are constant. The third option is to use the intermediate input margin $s_j = s_M$. In this case, our approach is conceptually the same as in Bils, Klenow and Malin (2018), with the regression step to obtain markup levels. This choice imposes that output elasticities with respect to intermediate inputs ε_M are constant.

In the presence of labor outsourcing trends, however, neither of the last two options produces the correct markups. Our theoretical model in Section 2.1 illustrates why. In the model, the labor and intermediate factor shares for the final goods industry are

$$s_L = \frac{(1-\theta)\alpha}{\mu_y} \quad , \quad s_M = \frac{\theta\alpha}{\mu_y} \tag{37}$$

Each of these are poor indicators of markup trends for industries in which θ is changing over time such that both the output elasticities with respect to labor and intermediates are not constant. In that case, outsourcing induces trends in output elasticities $\varepsilon_L = \alpha(1-\theta)$ and $\varepsilon_M = \alpha\theta$ that are unrelated to variations in markups. Since we showed that these trends are highly relevant empirically, we consider a fourth option that uses the sum of labor and intermediate input shares:

$$s_L + s_M = \frac{WL_y + P_m M}{P_y Y} \quad = \quad \frac{\alpha}{\mu_y} \tag{38}$$

which does not depend on θ. Under the assumption that $\varepsilon_L + \varepsilon_M = \alpha$ is constant over the sample, using the combined labor and intermediate input share yields estimates that correctly reflect secular trends in industry markups regardless of the presence of outsourcing trends.

The BLS-KLEMS data we use for the regressions separate real intermediate inputs into energy, materials and purchased business services. However, we use total intermediate spending to construct s_M, and not intermediate spending on any of the subcomponents. The main reason is that the breakdown between different types of intermediate inputs is not available before 1997, which would shorten the sample size considerably. The other reason is that using total intermediate spending and setting $s_j = s_L + s_M$ implements the assumption that capital intensities ε_K are constant. To see why, recall that the combined labor & intermediates-based approach imposes that $\varepsilon_M + \varepsilon_L$ is constant. Because of the assumption of constant returns to scale, $\varepsilon_K + \varepsilon_M + \varepsilon_L = 1$, this means that implicitly ε_K is assumed to be constant. For the purpose of evaluating the drivers of the aggregate labor share decline, assuming constant capital intensities is the natural alternative to assuming that markups are constant.

Table III summarizes the four different options for estimating markups, specifying in each case which parameter is assumed constant and which parameters are unrestricted. Only the first (constant markups), and fourth (constant capital intensity) options are valid in the presence of outsourcing trends. The first option produces a structural decomposition under the hypothesis that markups are constant, but capital intensities vary freely, while the fourth option produces the one under the hypothesis that capital intensities are constant, but markups vary freely.

TABLE III
ALTERNATIVE ASSUMPTIONS UNDERLYING MARKUP ESTIMATES

		s_j	*Constant*	*Unrestricted*
1.	Constant markups	1	μ	$\varepsilon_L, \varepsilon_M, \varepsilon_K$
2.	Labor-based markups	s_L	ε_L	$\mu, \varepsilon_M, \varepsilon_K$
3.	Intermediates-based markups	s_M	ε_M	$\mu, \varepsilon_L, \varepsilon_K$
4.	Labor & intermediates-based markups	$s_M + s_L$	ε_K	$\mu, \varepsilon_L, \varepsilon_M$

Notes: All cases assume $\varepsilon_K + \varepsilon_M + \varepsilon_L = 1$.

In all other aspects of the markup estimation, we closely follow Hall (2018). This includes the use of the same BLS-KLEMS data for 60 non-overlapping NAICS 3-digit private industries for the 1987 to 2016 period, and the same five instrumental variables. These include the log differences of (1) military purchases of equipment, (2) ships, and (3) software, (4) military expenditure on research and development, and (5) the market price of West Texas Intermediate Crude. Precise data definitions and sources are given in the data appendix. Also following Hall (2018), the estimates we report are based on the inverse regressions, i.e. $(d\ln Y/K - SR)/s_j$ on $d\ln Y/K$.

As discussed extensively in Hall (2018), there is substantial sampling error in the estimated industry specific regression coefficients. This leads to implausible markup estimates in some industries/years, such as values below unity. Unless mentioned explicitly, we do not take any steps to mitigate this sampling error and simply take the markup estimates at face value.

Figure 5 shows aggregate markups for the nonfarm private sector obtained under each of the different assumptions in Table III. In each case, the aggregate markup is the revenue-weighted sum of the estimated industry markups. For illustrative purposes, the broken lines in Figure 5 show aggregate markups based on the corresponding inverse aggregate share variables, i.e. ignoring industry heterogeneity. The blue lines in all three panels show the aggregate markup under the assumption that markups are constant at the industry level (option 1 in Table III). The resulting aggregate markup averages 1.47, and shows a gradual rise from 1.46 in 1987 to 1.50 in 2016 due to changing industry weights. Viewing the estimates as averages of industry markups over the sample period, the results are remarkably consistent with the benchmark estimates in De Loecker et al. (2018), both in terms of the average value of the aggregate markup over the same period, and in terms of the limited role of changes in industry composition.[19]

Figure 5a shows the aggregate markup based on industry labor shares in gross output (option 2 in Table III). When estimated from industry labor shares, the aggregate markup shows a clear upward

[19] We refer to the PF1 measure in Figure 1 of De Loecker et al. (2018).

trend, rising from 1.36 in 1987 to 1.58 in 2016. The rise is somewhat smaller than De Loecker et al. (2018), who find an increase from 1.31 in 1986 to 1.61 in 2016, but it is nevertheless substantial. The broken line is an aggregate markup obtained from the inverse aggregate labor share in GDP, as in Nekarda and Ramey (2013). This measure indicates a smaller rise in markups –from 1.43 in 1987 to 1.54 in 2016 – that occurs entirely after 2000.

Figure 5b depicts aggregate markups based on intermediate input shares (option 3 in Table III). In this case, the weighted average aggregate markup shows a declining trend over most of the sample, falling from 1.57 in 1987 to 1.41 in 2008, and fluctuating around a value of 1.50 afterwards. The broken line shows the aggregate markup based on the inverse aggregate intermediate input share, which shows little evidence for any up- or downward trend. As pointed out by Bils, Klenow and Malin (2018), the dynamics of intermediate input shares are clearly not consistent with the sharp rise in markups found by De Loecker et al. (2018).

Finally, Figure 5c shows the aggregate markup based on combined labor and intermediate input shares (option 4 in Table III). Even though in this case industry markups are not restricted from trending, the resulting aggregate markup is roughly similar to the one obtained under the assumption of constant markups. In particular, there is no indication of any aggregate trend from 1987 to 2008, with an estimated value of 1.45 in both 1987 and 2008 and only relatively minor variation in between. The aggregate markup jumps by 5 percentage points in 2009, remains elevated compared to the years before, and rises further to 1.54 in the last two years of the sample. Unlike in Figures 5a and 5b, the aggregate markup based on the inverse aggregate labor and intermediate input share (broken line) is very close to the weighted average series. Overall, the combination of labor and intermediate input shares produces results that clearly do not support the type of upward trend in markups since the 1980s that De Loecker et al. (2018) estimate. Interestingly, one similarity with their estimates is the sharp and persistent increase in markups in the Great Recession.

(a) Labor-Based (b) Intermediates-Based (c) Labor & Intermediates-Based

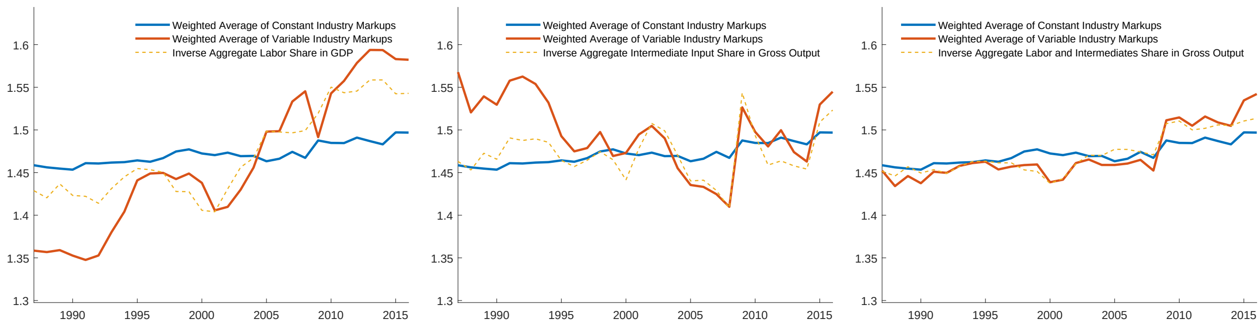

Figure 5 Estimates of Aggregate Markups in the Nonfarm Private Sector, 1987-2016

Notes: Aggregates of industry markups are weighted by the value of production. Industry markups are estimated from IV regressions of $(d\ln Y/K - SR)/s_j$ on $d\ln Y/K$ where $s_j = 1$ (blue line in all panels), $s_j = s_L$ (panel a), $s_j = s_M$ (panel b) or $s_j = s_L + s_M$ (panel c), using on BLS-KLEMS data. See the data appendix for sources and construction. Markups series based on inverses of aggregate shares (broken lines) are based on BLS-KLEMS data and are scaled to have the same mean as the weighted average of constant industry markups (blue lines).

The stark differences in the estimated markup trends in Figure 5 are consistent with the rise in labor outsourcing. The downward trend in labor shares in many industries induced by outsourcing translates into an upward trend in industry markups if one wrongly assumes constant output elasticities with respect to labor input. Conversely, the upward trend in intermediate shares induced by outsourcing results in a downward trend in industry markups if one incorrectly assumes that output elasticities with respect to intermediates are constant. The weighted average industry markups in Figures 5a and 5b reflect these trends. In addition, the changing input-output structure exaggerates these spurious trends in the weighted averages of industry markups relative to the simple inverse aggregate ratios. The approach that combines labor and intermediate shares, in contrast, is robust to the presence of outsourcing trends and yields an aggregate markup without any upward or downward trend before 2009 and smaller differences with the markups based on the aggregate ratio.

The analysis in De Loecker et al. (2018) is mostly based on Compustat firms and without separate information on labor and intermediate costs, which makes it difficult to reconcile their findings with ours. Various authors have pointed to various shortcomings of their proxy for variable input spending, which is cost of goods sold – a combination of direct labor and intermediate input costs differing from industry to industry according to accounting conventions – see for instance Karabarbounis and Neiman (2018) and Syverson (2019). Traina (2018) shows that broadening the cost category to include all operating expenses leads to aggregate markups that have not increased meaningfully since the 1980s. Karabarbounis and Neiman (2018) suggest outsourcing as one possible reason for the relative stability of the share of operating expenses versus cost of goods sold. The similarity between Traina (2018) and our findings, both of which are based on broadening the measure of costs, suggest there is merit to this explanation. However, a deeper investigation into how outsourcing affects the various accounting items in Compustat is beyond our scope.

In any case, it is premature to conclude from Figure 5c that markups do not play a role in explaining the decline in the aggregate labor share. First, the quantitative implications of the average rise in markups by about 5 points since 2009 are not ex ante clear. Second, the stylized model in Section 2.1 illustrates that changing intermediate input linkages between industries can effectively change aggregate market power even when industry markups are constant. In addition, changes in markups in industries with a central position in supply networks may still have important aggregate implications. In order to evaluate the role of market power for the aggregate labor share decline, observing markups at the aggregate or industry level is not sufficient. It is also necessary to account for intermediate input linkages across firms or industries as well as for possible changes in these linkages. The next section describes our methodology for doing so.

3.2 A Structural Decomposition of Aggregate Labor Share Dynamics

The derivation of the structural decomposition of aggregate labor share dynamics begins with the following expression for changes in the total labor shares in final use, defined earlier as $\lambda_x' =$

$\lambda_g'(I-\Omega)^{-1}$:

$$\Delta\lambda_x' = \Delta\lambda_g'\bar{\Gamma} + \bar{\lambda}_g'\Delta\Gamma \tag{39}$$

The matrix $\Gamma = (I-\Omega)^{-1}$ is the industry inverse input matrix, and as before a bar above a variable denotes the average of the current and last observation. Equation (39) states that changes in the total final use labor shares are driven by variation in both industry labor shares in output, $\Delta\lambda_g$ and in input-output linkages across industries, $\Delta\Gamma$. Both $\Delta\lambda_g$ and $\Delta\Gamma$ in turn depend on changes in industry markups and on changes in input elasticities.

For notational convenience, we use Lerner indices rather than markups in the derivations. Define the diagonal matrix $\mathcal{L} = I - \text{diag}(\mu)^{-1}$ with industry Lerner indices along the diagonal. By assumption, cost minimization in all industries leads to the following decomposition for the industry labor shares and the input matrix:

$$\lambda_g = (I-\mathcal{L})E_L \quad , \quad \Omega = E_M(I-\mathcal{L}) \tag{40}$$

where the vector E_L and the matrix E_M contain the output elasticities with respect to labor and intermediate inputs, respectively. Annual changes in the input shares and the industry input inverse matrix are given by[20]

$$\Delta\lambda_g' = \Delta E_L'(I-\bar{\mathcal{L}}) - \bar{E}_L'\Delta\mathcal{L} \tag{41}$$

$$\Delta\Omega = \Delta E_M(I-\bar{\mathcal{L}}) - \bar{E}_M\Delta\mathcal{L} \tag{42}$$

$$\Delta\Gamma = (I-\bar{\Omega})^{-1}\Delta\Omega\bar{\Gamma} \tag{43}$$

Substituting (41)-(43) into (39) yields

$$\Delta\lambda_x' = \bar{\lambda}_g'(I-\bar{\Omega})^{-1}\Delta E_M(I-\bar{\mathcal{L}})\bar{\Gamma} + \Delta E_L'(I-\bar{\mathcal{L}})\bar{\Gamma} - \left(\bar{\lambda}_g'(I-\bar{\Omega})^{-1}\bar{E}_M + \bar{E}_L'\right)\Delta\mathcal{L}\bar{\Gamma} \tag{44}$$

where the first term represents the contribution of changes in the intermediate input elasticities ΔE_M, the second term the contributions of changes in the labor input elasticities ΔE_L, and the last term the contributions of variation in market power as measured by changes in the Lerner indices $\Delta\mathcal{L}$. Equation (44) leads to the following decomposition of the dynamics of the aggregate labor share:

$$\Delta\lambda = \underbrace{(\bar{\lambda}_x - \bar{\lambda})'\Delta\mathbf{w}_x}_{\substack{\text{final use}\\ \text{reallocation}}} + \underbrace{\bar{\lambda}_g'(I-\bar{\Omega})^{-1}\Delta E_M(I-\bar{\mathcal{L}})\bar{\Gamma}\bar{\mathbf{w}}_x}_{\text{use of intermediates}} + \underbrace{\Delta E_L'(I-\bar{\mathcal{L}})\bar{\Gamma}\bar{\mathbf{w}}_x}_{\substack{\text{net labor}\\ \text{intensity}}} + \underbrace{\left(-\bar{\lambda}_g'(I-\bar{\Omega})^{-1}\bar{E}_M - \bar{E}_L'\right)\Delta\mathcal{L}\bar{\Gamma}\bar{\mathbf{w}}_x}_{\text{markups}} \tag{45}$$

The first term in this decomposition contains the same reallocation effects as in the final use de-

[20]To derive (43), use $\Gamma = I + \Omega\Gamma$, take differences and solve for $\Delta\Gamma$.

composition of Section 2.2. The reallocation contributions by industry are given by the elements of $(\bar{\lambda}_x - \bar{\lambda}) \circ \Delta \mathbf{w}_x$, where $\circ$ denotes element-wise multiplication. The second term in (45) contains the contribution of the use of intermediates in the production network. The total contribution of changes in intermediate use also equals the sum of all elements of the following industry-by-industry matrix:

$$\text{diag}(\lambda_g)(I - \bar{\Omega})^{-1} \Delta E_M (I - \bar{\mathcal{L}}) \Gamma \text{diag}(\bar{\mathbf{w}}_x) \tag{46}$$

The ij-th element of (46) contains the contribution of changes in industry j's use in final production of intermediate inputs produced by industry i. A row sum of (46) summarizes the corresponding industry's contribution that results from changes in the economy-wide use of that industry's intermediates. The third component in (45) reflects changes in the net labor intensity of production, given for each industry by the elements of $\Delta E_L \circ (I - \bar{\mathcal{L}}) \bar{\Gamma} \bar{\mathbf{w}}_x$. We use the term 'net' labor intensity, because below we also consider the contribution of labor intensity changes before removing outsourced labor. The final term in (45) represents the impact of changes in markups on the aggregate labor share. The markup contributions in the individual industries are given by $\left(-\bar{\lambda}_g'(I - \bar{\Omega})^{-1} \bar{E}_M - \bar{E}_L'\right)' \circ \Delta \mathcal{L} \bar{\Gamma} \bar{\mathbf{w}}_x$.

To gain some intuition for the components of the decomposition in (45), Table IV shows the various terms for the stylized model in Section 2.1. In the model, there is a single final good that is produced only in the final industry. This means that the final use reallocation contribution of both sectors (column [1] in Table IV) and the contribution of net labor intensity changes in the intermediate sector (second row of the column with label $[2]-[3]$) are all always zero. The final industry produces no intermediates, which means that the contribution of the aggregate use of its intermediates (first row of column [4]) is also always zero. Changes in the labor elasticity of production, $\Delta\alpha(1-\theta)$, contribute to aggregate labor share dynamics through the net labor intensity term of the final industry (first row of the column with label $[2]-[3]$). Changes in the intermediate input elasticity of production, $\Delta\alpha\theta$, show up in the use of industry intermediates contribution of the intermediate industry (second row of column [4] in Table IV). Finally, both industries contribute through markup changes (column [5]).

TABLE IV
STRUCTURAL DECOMPOSITION OF $\Delta\lambda$ IN THE MODEL EXAMPLE

	Final Use Reallocation	*Labor Intensity*	*Labor Outsourcing*	*Net Labor Intensity*	*Use of Industry Intermediates*	*Markup*
	[1]	[2]	[3]	$[2]-[3]$	[4]	[5]
Final industry	0	$\overline{1/\mu_y}\Delta\alpha$	$\overline{1/\mu_y}\Delta(\alpha\theta)$	$\overline{1/\mu_y}\Delta(\alpha(1-\theta))$	0	$\overline{\alpha(1-\theta)}\Delta(1/\mu_y)$ $+\overline{1/\mu_m}\,\overline{\alpha\theta}\Delta(1/\mu_y)$
Intermediate industry	0	0	0	0	$\overline{1/\mu_m}\Delta(\alpha\theta)\,\overline{1/\mu_y}$	$\overline{\alpha\theta/\mu_y}\Delta(1/\mu_m)$

Notes: The total contribution of an industry to the aggregate labor share in GDP is equal to $[1]+[2]-[3]+[4]+[5]$.

The final industry's net labor intensity contribution is the difference between its labor intensity contribution (before outsourcing) and the effect of labor outsourcing:

(47)
$$\underbrace{\overline{1/\mu_y}\Delta(\alpha(1-\theta))}_{\substack{\text{net labor}\\ \text{intensity}}} = \underbrace{\overline{1/\mu_y}\Delta\alpha}_{\substack{\text{labor}\\ \text{intensity}}} - \underbrace{\overline{1/\mu_y}\Delta(\alpha\theta)}_{\substack{\text{labor}\\ \text{outsourcing}}}$$

In the model example, the contribution of labor outsourcing in the final sector can be identified from the use of industry intermediates contribution of the intermediate sector, after adjusting for the markup on intermediates $\overline{1/\mu_m}$. Under perfect competition, $\overline{1/\mu_m} = 1$, the outsourcing effect is canceled exactly by the use of intermediates contribution of the intermediate industry. Under imperfect competition, $\overline{1/\mu_m} < 1$, the outsourcing effect does not cancel exactly and makes a negative contribution to the aggregate labor share. In the actual US data, we can similarly calculate the labor intensity and labor outsourcing components by taking the use of intermediates contributions of the PBS sector to each industry (the elements of the column in (46) corresponding to the PBS industry) and adjust it by the estimated value of $\overline{1/\mu}$ in the PBS industry.

To asses the role of changes in domestic versus global supply networks, we also consider the following open economy extension of the structural decomposition:

(48)
$$\begin{aligned}\Delta\lambda \ = \ & \underbrace{(\tilde{\lambda}_x' - \tilde{\lambda})\Delta\mathbf{w}_{x_d}}_{\substack{\text{dom. final use}\\ \text{reallocation}}} + \underbrace{\Delta E_L'(I-\bar{\mathcal{L}})\bar{\Gamma}_d\tilde{\mathbf{w}}_x}_{\substack{\text{net labor}\\ \text{intensity}}} \underbrace{- \left(\tilde{\lambda}_g'(I-\bar{\Omega}_d)^{-1}\bar{E}_{M_d} + \bar{E}_L' + \delta\bar{E}_{M_i}^{*\prime}\right)\Delta\mathcal{L}\bar{\Gamma}_d\tilde{\mathbf{w}}_x}_{\text{markups}} \\ & \underbrace{+\tilde{\lambda}_g'(I-\bar{\Omega}_d)^{-1}\Delta E_{M_d}(I-\bar{\mathcal{L}})\bar{\Gamma}_d\tilde{\mathbf{w}}_x + \delta\Delta E_{M_i}^{*\prime}(I-\bar{\mathcal{L}})\bar{\Gamma}_d\tilde{\mathbf{w}}_x}_{\text{use of intermediates}}\end{aligned}$$

The open economy version has the same basic components as (45), but separately accounts for the domestic and global parts of the production network. The first term now captures reallocation in the final use of domestic output ($\mathbf{x}_d$, or final spending by residents plus all exports). The industry input matrix Ω_d is now based on the use of domestic intermediates only, and so is the inverse Γ_d. The use of intermediates term in (48) distinguishes between changes in the production elasticities in domestic and imported intermediates, represented by the industry-by-industry matrices E_{M_d} and E_{M_i} respectively. The vector $E_{M_i}^*$ is the joint elasticity with respect to all imported intermediates (the column sum of E_{M_i}), and $\delta > 0$ is a positive scalar. The appendix contains the derivation of (48) and defines all the parameters.

The main purpose of the open economy decomposition is to differentiate between changes in domestic and global production networks. To do so, we further decompose the use of intermediates contribution in (48) as follows:

$$(49)\quad \underbrace{\tilde{\lambda}_g'(I-\bar{\Omega}_d)^{-1}\Delta E_{M_d}(I-\bar{\mathcal{L}})\bar{\Gamma}_d\tilde{\mathbf{w}}_x+\delta\Delta E_{M_i}^{*\prime}(I-\bar{\mathcal{L}})\bar{\Gamma}_d\tilde{\mathbf{w}}_x}_{\text{use of intermediates}}=\underbrace{\lambda_g'(I-\bar{\Omega})^{-1}\Delta E_M(I-\bar{\mathcal{L}})\bar{\Gamma}\tilde{\mathbf{w}}_x}_{\text{use of domestic intermediates}}$$
$$\underbrace{\underbrace{-\left(\lambda_g'(I-\bar{\Omega})^{-1}\Delta E_M(I-\bar{\mathcal{L}})\bar{\Gamma}\tilde{\mathbf{w}}_x-\tilde{\lambda}_g'(I-\bar{\Omega}_d)^{-1}\Delta E_{M_d}(I-\bar{\mathcal{L}})\bar{\Gamma}_d\tilde{\mathbf{w}}_x\right)}_{\text{compensation import leakage}}+\underbrace{\delta\Delta E_{M_i}^{*\prime}(I-\bar{\mathcal{L}})\bar{\Gamma}_d\tilde{\mathbf{w}}_x}_{\text{value added import leakage}}}_{\text{net contribution of supply chain globalization}}$$

The first term in (49) contains the (hypothetical) use of intermediates contribution that would occur if all intermediates were produced domestically. The second term captures the compensation import leakage effects, defined as the difference between the actual contribution to domestic compensation from changes in the domestic production network and the hypothetical domestic contribution. Increases in intermediate imports resulting from a rise in global supply chains lead to negative contributions in this term as labor compensation shifts abroad. The final term in (49) captures the leakage of value added in the global production network. Increased offshoring of intermediate production shifts value added abroad, which reduces the denominator in the ratio of aggregate compensation to GDP. The net contribution of internationalization of production networks is the difference between the compensation and value added leakage effects. Depending on the labor intensity of the production stages that are relocated abroad, the net effect of the rise in global supply chains on the aggregate labor share can be positive or negative.

As before, we use data on industry labor shares, output, value added, final expenditures and industry input matrices are from BLS-KLEMS and the BEA Input-Output Accounts, see the appendix for full details. The methodology for estimating markups described in the previous section yields time series of markups in each private industry included in BLS-KLEMS. To be able to map the industries in BLS-KLEMS to those reported in the BEA Input-Output Accounts, we make a few additional assumptions. First, gross markups in all government sectors are always set to one. Second, markups in subsectors disaggregated in the Input-Output Accounts but not in BLS-KLEMS are equated to the estimate at the next available level of aggregation.[21] Third, the estimates of the gross markups for the oil and gas extraction industry are highly erratic in the sense that they are less than zero in all years and for all assumptions in Table III. We replace them with a value of one in all cases. Finally, as the measure of the PBS markup used to adjust the net labor intensity for outsourcing and obtain the labor intensity that includes outsourced labor inputs, we use the average of the estimates for the 6 PBS subsectors after leaving out the estimate with highest and lowest mean value to reduce the effect of sampling error.[22]

[21]Specifically, for the BEA sectors (1) motor vehicle and parts dealers, (2) food and beverage stores, (3) general merchandise stores and (4) other retail, we use the markup estimated for retail trade in BLS-KLEMS; for the BEA sectors (1) motor vehicles, bodies and trailers, and parts and (2) other transportation equipment, we use the markup estimated for transportation equipment in BLS-KLEMS; for the BEA sectors (1) housing and (2) other real estate, we use the markup estimated for real estate in BLS-KLEMS; and for the BEA sectors (1) hospitals and (2) nursing and residential care facilities, we use the markup estimated for hospitals and nursing and residential care facilities in BLS-KLEMS.

[22]The resulting markup for the PBS industry is 1.22 in the constant markup specification. Under the labor & intermediates approach, the PBS markup is relatively stable around this value: the estimated value is around 1.19 before 2000,

3.3 Structural Decomposition Results

We now describe the results of the structural decompositions of the aggregate labor share change between 1997 and 2016. In this section, we only discuss the decompositions based on markups estimated under assumptions that are robust to outsourcing trends, i.e. assuming either that industry markups or capital intensities are constant.[23] Table A.III and A.IV in appendix provide the full results with the contributions for every 3-digit NAICS industry under the assumption of constant capital intensities and constant industry markups, respectively. Unless mentioned otherwise, we focus on the results for the closed economy decomposition in (45). The main conclusions from the open economy version are similar and full results are available in the online appendix.

TABLE V
STRUCTURAL DECOMPOSITIONS OF THE AGGREGATE LABOR SHARE CHANGE, 1997-2016
OVERVIEW OF RESULTS

	Assuming Constant Capital Intensities			*Assuming Constant Markups*		
	1997-2008	2009-2016	1997-2016	1997-2009	2009-2016	1997-2016
1. Final Use Reallocation	**−0.28**	**−0.83**	**−1.12**	**−0.28**	**−0.83**	**−1.12**
2. Changes in Interm. Use (excl. PBS)	**−0.29**	**−0.40**	**−0.70**	**−0.09**	**−1.61**	**−1.71**
a) Changes in Interm. Use (Total)	1.02	0.35	1.37	1.28	−1.31	−0.03
b) less: Labor Outsourcing to PBS	1.31	0.76	2.07	1.38	0.31	1.68
3. Changes in Labor Intensities	**−1.79**	**3.41**	**1.61**	**−1.81**	**1.21**	**−0.60**
a) Net Labor Intensities	−3.39	2.48	−0.91	−3.49	0.83	−2.65
b) plus: Labor Outsourcing to PBS	1.59	0.93	2.52	1.68	0.37	2.06
4. Labor Outsourcing Net Effect	**−0.28**	**−0.17**	**−0.45**	**−0.30**	**−0.07**	**−0.37**
5. Markup Changes	**0.16**	**−3.30**	**−3.14**	**−0.00**	**−0.00**	**−0.00**
Total Change in Aggr. Labor Share	**−2.49**	**−1.31**	**−3.79**	**−2.49**	**−1.31**	**−3.79**

Notes: All numbers are percentage points. Based on data from BLS-KLEMS and the BEA Input-Output Accounts and estimated industry markups, see data appendix and Section 3.1. The table reports the sums of annual observations of the respective terms in (45) over the sample period. Aggregates are sums of the contributions of the subindustries.

As a summary of the main findings, Table V presents the key elements in the decompositions aggregated across industries. These components are the contribution of (1) final use reallocation, (2) changes in intermediate use, (3) changes in labor intensities, (4) the net effect of labor outsourcing and (5) markup changes. To demonstrate the importance of domestic labor outsourcing trends, items

rises gradually to 1.23 until 2010 and drops off to 1.22 afterwards.

[23]The results based on markups estimated using labor or intermediate input shares – which are problematic in the presence of outsourcing trends – are discussed in the online appendix.

(2) and (3) in Table V show the contributions both with and without including the effects of outsourcing to the PBS industry. To highlight some important differences before and after 2009, Table V also reports the totals for the 1997 to 2008 and 2009 to 2016 subperiods.

The main conclusion from Table V is that there is no single dominating factor that explains the aggregate labor share losses over the entire sample period. Before 2009, there is little difference between the results for constant or variable markups. In both cases, within-industry decreases in labor intensity that are unrelated to outsourcing to the PBS industry are the most important contributor prior to aggregate labor share losses. After the Great Recession, final use reallocation becomes more important. Assuming constant capital intensities, there is a reversal in the contribution of labor intensities, and instead rises in markups since 2009 become the dominant reason for the aggregate labor share loss relative to 1997. In the specification that assumes constant markups, there is a partial reversal in the contribution of labor intensities, and changes in the use of intermediate (outside of outsourcing to PBS) becomes the largest factor. Next, we discuss each of the contributions in more detail.

3.3.1 Role of Reallocation in Final Expenditures

The first item in Table V provides the contribution of final use reallocation to the change in the aggregate labor share. As can be seen in (45), this contribution does not depend on $\mathcal{L}$, and is therefore the same regardless of the assumptions made to estimate industry markups. According to Table V, the cumulative impact of final use reallocation between 1997 and 2016 is -1.12 percentage points, or 30 percent of the total aggregate labor share decline between 1997 and 2016. Compositional capital deepening – shifts in expenditures towards more capital intensive final goods and services – therefore plays a nontrivial role in explaining the aggregate labor share loss over the sample period.

Table V shows that most of the depressing effect of final use reallocation on the labor share occurs after 2008. Figure 6 shows the full time series of the contribution of final use reallocation. While changes in final expenditure shares contribute negatively in most years since 2000, there is a particularly large drop of 0.70 percentage points – or 60 percent of the total labor share decline attributable to reallocation – in the recession year of 2009. To better understand the origins of these negative reallocation effects, column [1] in Tables A.III and A.IV provides the industry breakdown. It turns out that three individual industries are key drivers of the aggregate reallocation effects, and in particular of the shift in 2009: housing, construction, and oil and gas extraction. The other lines in Figure 6 shows the annual reallocation contributions for each of these industries.

As pointed out in earlier studies. e.g. Rognlie (2016) and Gutiérrez (2017), housing plays a nontrivial role in determining the aggregate labor share. The housing share in final expenditures rose from 9.8 percent in 1997 to a peak of 10.9 percent in 2009, before falling to 10.3 percent in 2014 and recovering to 10.7 percent in 2016. With a very low total labor share in final use of around 15 percent, these changes in housing weights result in substantial reallocation effects that cumulate to -0.46 percentage points over the sample period, or about 40 percent of the total contribution of final

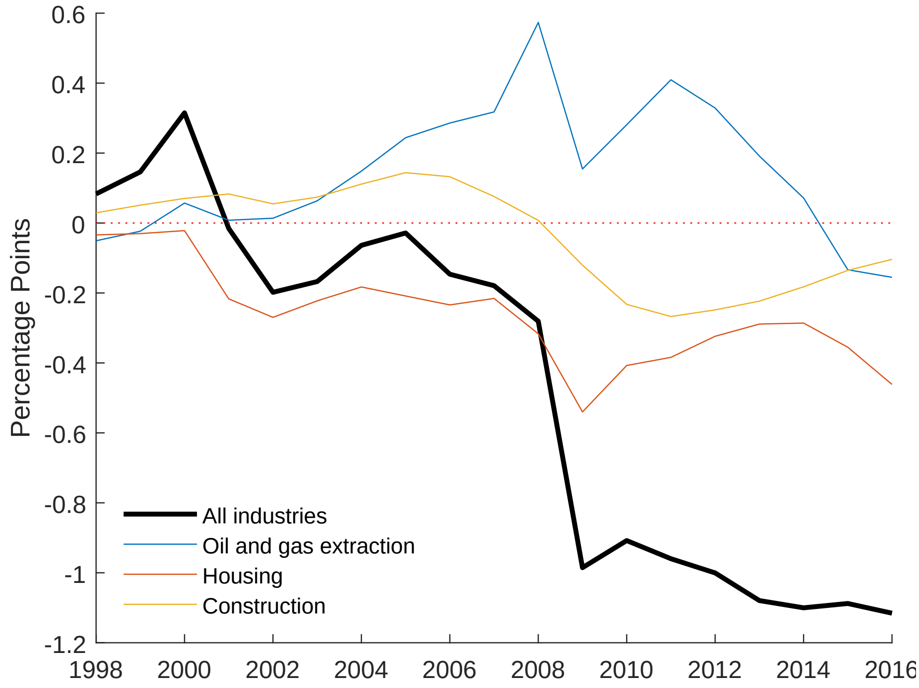

Figure 6 Role of Reallocation in Final Expenditures, 1997-2016

use reallocation over the sample. The peak in the housing share in 2009 alone makes a negative contribution of 22 basis points.

The second influential industry is construction, which has a relatively high total labor share in final use (about 75 percent). The weight of the construction sector in final demand rose from 7.2 percent to 8.4 percent in 2005, before falling sharply to 5.1 percent in 2011 and recovering only partially to 6.3 percent in 2016, see Figure 6. As a result, the reallocation impact of construction switched from 14 basis points at the peak of the boom to -27 basis points in 2011. The drop in the construction share in 2009 subtracts 13 basis points from the aggregate labor share. In 2016, the cumulative reallocation contribution of construction since 1997 remains negative at -10 basis points.

The third industry that is critical for understanding reallocation effects before and after 2009 is oil and gas extraction. The impact of the oil and gas industry on the reallocation contribution is complicated by several factors. First, the US is a net importer of crude oil and gas over the entire sample period. Even though the oil and gas extraction industry produces largely intermediate goods, imports and exports include intermediates in final expenditures. Net imports of crude oil are therefore (negative) final demand for the industry. In addition, the final expenditure share of the oil and gas industry varies greatly over the sample period. One reason is the high volatility in energy prices. Because of large increases in oil prices and increased expenditures on net oil imports, the final expenditure share decreased from -0.6 percent in 1997 to -2.2 percent in 2008. Because the industry is very capital intensive (the total labor share in final use is around 25 percent), this decline results in a large positive reallocation contribution, see Figure 6. In 2009, the sector's contribution falls sharply because of the collapse in oil prices during the Global Financial Crisis. After 2009, the recovery in oil prices initially reverses some of the effect. However, the strong expansion of domestic production driven by the development of hydraulic fracturing technology as well as lower oil prices after 2014 increase the industry's weight to -0.3 percent by 2016, resulting in reallocation effects that depress the aggregate labor share. Cumulating over the entire sample period, the large positive contribution prior to 2009 and subsequent negative contribution roughly cancel to a net contribution of -16 basis points.

Together, the housing, construction and oil and gas industries account for the entire 70 basis points drop in the reallocation contribution in 2009. Besides the shale revolution and greatly diminished construction activity, there are several other industries that contribute meaningfully to the negative final use reallocation contribution since 2009. Some because they are relatively labor intensive and have a decreasing final expenditure share, such as motor vehicles (-9 basis points), others because they are capital intensive and are growing in share, e.g. petroleum and chemical products (-20 basis points combined).

3.3.2 Role of Changes in the Use of Intermediates

The second item in Table V reports the contribution of changes in production networks to aggregate labor share dynamics. To highlight the importance of domestic labor outsourcing, Table V shows the aggregate contribution both with and without the PBS industry included. Changes in the total use of intermediates make either a positive (1.37 percentage points under constant capital intensities) or net zero (-0.03 percentage points under constant markups) contribution between 1997 and 2016. The totals therefore suggest that supply chain changes are either neutral or partially counteract the aggregate labor share loss. However, these total contributions contain large positive contributions from the PBS industry because of labor outsourcing. Once we remove the contribution of the PBS industry, it becomes evident that capital deepening through changes in production networks actually depresses the aggregate labor share in both subperiods, regardless of the measure of markups used. Between 1997 and 2016, all these other supply chain changes together lower the aggregate labor share by -0.70 percentage points, or 18 percent of the total drop, when assuming constant capital intensities. In the decomposition with constant markups, changes in production networks are the dominant source of labor share losses, subtracting 1.71 percentage points from the aggregate labor share or 45 percent of the total decline.

Figures 7a and 7b show the time series of the aggregate use of intermediates contributions for each of the markup assumptions. The yellow lines show the gradual and roughly acyclical contribution of the growth in the use of PBS intermediates. The figures further illustrate how – within the total contributions (red lines) – labor outsourcing trends are offsetting the capital deepening that occurs through other changes in supply chains (blue lines). The combined impact of all intermediate use changes is procyclical in both figures, with the size of the contributions being the main difference between the decompositions.[24]

[24] That intermediate input use relative to gross output is procyclical is also documented by Basu (1995).

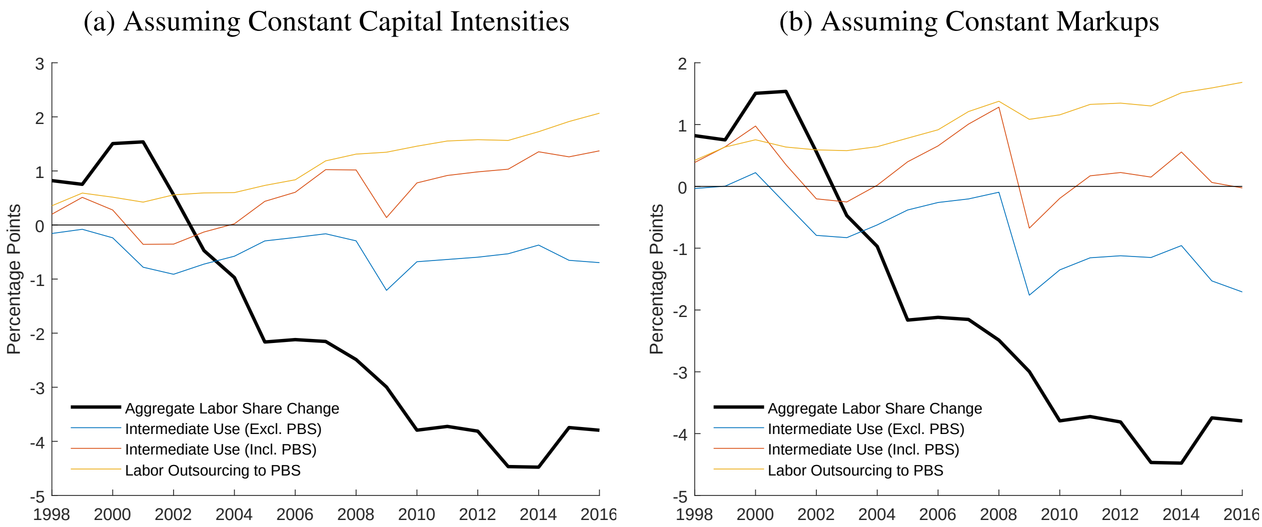

Figure 7 Role of Changes in the Use of Intermediates, 1997-2016

We can gain more insight into the causes of capital deepening through changes in the use of intermediates by studying the contributions of individual industries, which are shown in column [4] in Tables A.III-A.IV. Recall that these numbers measure the contribution that results from changes in the intensity with which the economy as a whole is using the industry's output as intermediate inputs. In general, industries with declining (rising) shares in production of intermediates make negative (positive) contributions.

From Tables A.III and A.IV, it is clear that declines in the use of intermediates produced by the manufacturing industries dominate quantitatively. In the decomposition with constant capital intensities, the decline of manufacturing in intermediate production in total reduces the aggregate labor share by 1.26 percentage points. In the decomposition with constant markups, this number rises to 1.53 percentage points. In both tables, all but two industries within manufacturing show negative contributions (petroleum refining and other transportation equipment are the exceptions).

The manufacturing industries with the largest negative contributions are computer and electronic products (-22 and -27 basis points), chemical products and plastics (-15 and -21 basis points combined), primary and fabricated metal products (-11 and -15 basis points combined) and textiles (-10 and -11 basis points). While there likely are a number of different technological and compositional drivers, one noticeable trend in Table A.III is the digitalization of the economy, which can be seen from the negative contributions of paper products and printing (-35 and -37 basis points combined) or broadcasting and telecommunications (-13 and -14 basis points), and the positive contribution of data processing & internet (14 basis points in both cases).

Outside of the PBS industry, a few other sectors make positive use of intermediates contributions to the aggregate labor share, including the insurance industry (66 and 49 basis points), warehousing and other transportation (29 and 25 basis points jointly), and construction (17 and 13 basis points). However, these positive contributions fall far short of offsetting the consequences of the diminishing role of manufacturing in the US supply chain.

To verify the extent to which the rise of global supply chains accounts for the negative impact of supply chain changes on the labor share, Figure 8 shows the separate contributions of changes in domestic and global supply networks in the open economy version of the structural decomposition, see (48). The blue lines show the domestic production network component, which is essentially identical to the use of intermediates contribution in the closed economy decomposition. The blue lines show the compensation leakage effects that result from increased offshoring, while the yellow lines show the contribution of value added leakage. The importance of supply chain globalization is immediately evident from the trends in these leakage contributions. Regardless of markup assumptions, the increase in imports of intermediates reduces domestic compensation by around 1.5 percentage points of GDP. However, the reduction in domestic value added associated with the increase in offshoring more than offsets the compensation losses, and the net contribution of increased supply chain globalization on the US labor share (purple lines) is mildly positive. The positive aggregate labor share effect of offshoring is explained by the fact that imported intermediates are in fact relatively capital intensive. The conclusion is that the losses in manufacturing jobs resulting from the relocation of intermediate stages of production overseas is not directly contributing to the decline in the US labor share since the late 1990s.

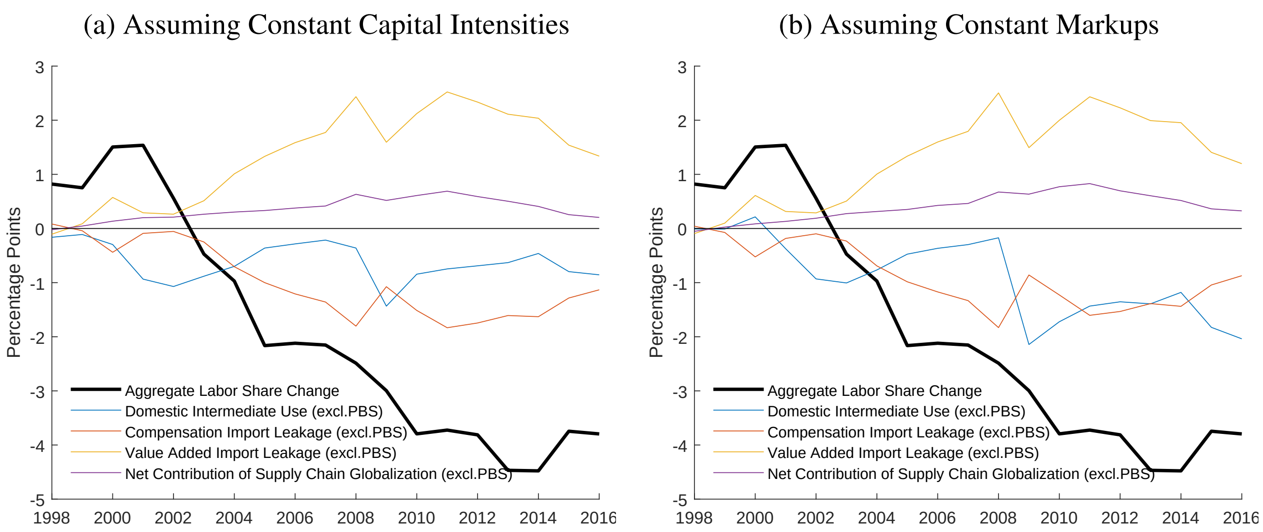

Figure 8 Role of Supply Chain Globalization

The substantial positive intermediate use contributions of the PBS sector in Figure 7 do not mean that the rise of labor outsourcing is raising the US labor share because it reflects primarily the substitution of downstream labor with upstream labor. As such, the growth in labor outsourcing entails an offsetting negative effect on the aggregate labor share through the impact on net labor intensities, which are discussed next.

3.3.3 Role of Falling Labor Intensities and Labor Outsourcing

The third item in Table V quantifies the role of changes in the labor intensity of production for explaining the aggregate labor share decline. The table reports the aggregate contribution of changes in net labor intensities, the component attributable to changes in labor outsourcing to the PBS industry, and finally the contribution of the 'total' labor intensities. The latter are the net labor intensities after incorporating the effects of labor outsourcing, which we see as a much better measure of the true labor intensity. Figure 9 shows the full time series of each these contributions for each of the markup assumptions. The labor outsourcing contributions (blue lines) are the negative of the outsourcing contributions reported in columns [3] in Tables IV, A.III and A.IV. The latter are obtained as the 'use of intermediates' contribution of the PBS industry adjusted for the PBS markup, as discussed above. The contribution of changes in labor intensities (red lines) is obtained by adding the labor outsourcing component to the contribution of changes in net labor intensities (yellow lines).

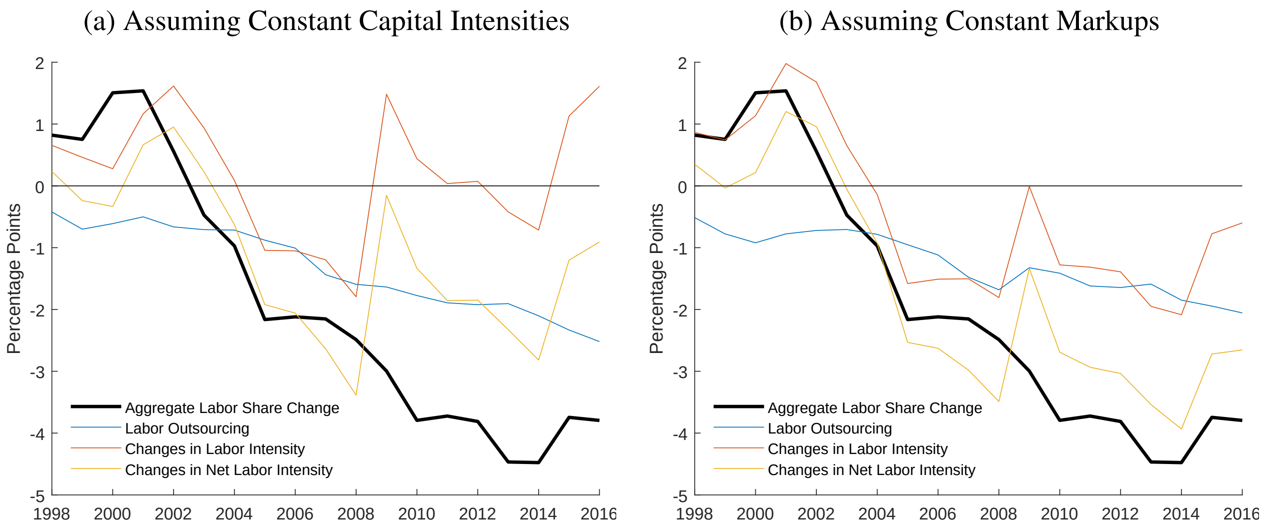

Figure 9 Role of Changes in Labor Intensities of Production, 1997-2016

Assuming Constant Capital Intensities We first discuss the results based on labor & intermediates-based markups. Table V shows that decreases in net labor intensities in the aggregate account for −0.91 percentage points of the total labor share decline between 1997 and 2016. The yellow line in Figure 9a shows that the negative contribution occurs mostly between 2001 and 2009 and is relatively persistent afterwards. Direct substitution of labor with capital does not explain the negative impact, since in this case constant capital intensities are imposed. The fact that declining labor elasticities of production still play a role in driving aggregate labor share losses must be because of changes in the use of intermediates. The rise in outsourcing to the PBS industry fully explains the negative contribution of declining labor elasticities over the entire sample period, see the blue line in Figure 9a. After accounting for labor outsourcing, there is no longer any role for declining labor intensities in explaining persistent aggregate labor share losses. However, declining labor intensities do remain the largest contributor to the aggregate labor share loss between 1997 and 2008. The labor intensity component is clearly countercyclical, lifting the labor share in the 2001 recession, the 2009 recession, and the 2015-2016 mini-recession, which could be the consequence of labor hoarding. Between 1997 and 2016, the contribution to the aggregate labor share ranges from 1.60 percentage points in 2002 following the recession in the early 2000s, to -1.79 percentage points in 2008. It is therefore not clear to what extent the contribution of labor elasticities over this period is due to purely cyclical factors. A key takeaway, however, is that declines in labor intensity do not make persistently negative contributions after accounting for outsourcing effects. In fact, labor intensity changes make a positive contribution of 1.61 percentage points to the aggregate labor share by the end of sample. Figure 9a again demonstrates the importance of labor outsourcing, which explains the declines in industry labor input elasticities that remain even after imposing constant capital intensities and allowing for variable markups.

Through its impact on net labor intensities in a wide number of industries, labor outsourcing cumulatively subtracts 2.52 percentage points from the aggregate labor share, see Table V. This is the negative effect that is offsetting the positive use of intermediates contribution of the PBS industry discussed above. The net contribution of labor outsourcing over the sample period is -0.45 percentage points, see item 4 in Table V. This net negative aggregate effect on the aggregate labor share arises because of increased double marginalization along the vertical layers of the supply chain, since the estimated gross markups in the PBS industry exceed one.[25]

The second to fourth columns in Table A.III provide insight into the role of changes in labor intensities by industry. Between 1997 and 2016, a small majority of private industries (38 out of 66) contribute negatively to the aggregate labor share through decreases in net labor intensities. The most significant of these are all in services, and specifically in retail (-67 basis points after aggregating 3-digit subindustries), wholesale trade (-35 basis points), other services (-33 basis points) and hospitals (-29 basis points). At the same time, increases in net labor intensities in several industries contribute positively to the aggregate labor share, for instance computers and electronics (63 basis points), credit intermediation (43 basis points) and construction (40 basis points). A large majority of private industries (52 out of 66) show negative contributions through net labor intensities caused by increased labor outsourcing, which shows that outsourcing to the domestic PBS industry is widespread across industries. In terms of the private industries engaging in outsourcing, the largest contributors are in retail trade (28 basis points combined), hospitals (22 basis points) and food services (19 basis points). Finally, labor outsourcing occurs not only in the private sector, but is also quantitatively important in the government sector (43 basis points).[26]

The labor intensity contributions that account for labor outsourcing, reported in column [2] of Table A.III, are much more heterogenous across industries. Almost half (32 out of 66) of all private industries contribute negatively because of falling labor intensities. Among the industries in which declines in labor intensity have substantial depressing effects on the aggregate labor share even after

[25]The PBS markups is 1.22 on average see footnote 22.

[26]The government labor outsourcing contribution is the difference between the first and second rows of column [3] in Table A.III.

adjusting for outsourcing are: retail trade (-38 basis points), other services (-23 basis points) and broadcasting and telecom (-21 basis points). In some industries (e.g. computers and electronics, credit intermediation and construction), production is now more labor intensive compared to the late 1990s.

Assuming Constant Markups If increases in capital intensity rather than rising markups are the key driver of the aggregate labor share loss, this should be evident in the labor intensity contributions derived under the assumption of constant markups. According to Figure 9b, falling labor intensities – without incorporating labor outsourcing effects– indeed appear to account for a virtually all of the labor share loss that is not attributable to changes in final expenditure shares. Table V reports that the contribution of net labor intensity changes is -2.65 percentage points, or 70 percent of the total labor share decline between 1997 and 2016.

However, outsourcing contributes 2.06 percentage points to the total 2.65 percentage points effect. Most of the net labor intensity contribution therefore does not represent the replacement of workers with machines and software, but domestic labor outsourcing. As a result, the negative effect on the aggregate labor share is to a large extent offset by the positive intermediate use contribution of the PBS industry (1.68 percentage points). Changes in industry labor intensities really explain just 0.60 percentage points of the aggregate labor share decline between 1997 and 2016, or about 17 percent of the total. At the same time, Figure 9b shows that the total cumulative contribution between 1997 and 2016 masks a more important role for falling labor intensities in the early 2000s. Between 2002 and 2004, a drop in labor intensities is in fact the dominant source of the labor share decline, with a contribution that decreases from 1.97 percentage points in 2001 to -1.60 percentage points in 2005. Apart from a temporary cyclical increase in 2009, variation in labor intensities does not generate any major movements in the aggregate labor share between 2004 and 2014. In 2015 and 2016, increases in labor intensities limit the total cumulative contribution since 1997 to -0.60 percentage points, which is considerable smaller the contribution of supply chain changes. The countercyclicality in the labor intensity contribution, likely the result of labor hoarding, make it difficult to discern the true longer run contribution of declines in labor intensity. However, the results suggest that capital deepening through changes in production networks may be more important than capital deepening through falling labor intensities.

As in the decomposition with constant capital intensities, we conclude that it is essential to incorporate outsourcing effects to assess the role of industry labor intensity changes for labor share dynamics. Table V reports that the net contribution of labor outsourcing to the labor share change over the sample period is -0.38 percentage points. As explained before, this net negative effect arises because of increased double marginalization.

The second to fourth columns in Table A.IV list the contributions of changing labor intensities by industry. Not surprisingly, the constant markup assumption generates larger contributions of falling labor intensities than the decomposition with constant capital intensities. Between 1997 and 2016, 41 out of 66 private industries contribute negatively to the aggregate labor share through decreases in net labor intensities. The largest contributors remain selected service-producing sectors: retail (−76 basis points), wholesale trade (−53 basis points), other services (−32 basis points) and hospitals (−29 basis points). The same industries contribute positively, but to a smaller extent: e.g. computers and electronics (44 basis points), credit intermediation (29 basis points) and construction (25 basis points). Again, in most (52 out of 66) industries, incorporating labor outsourcing effects reduces the contribution of labor intensity changes, and outsourcing effects are particularly important in the government sector (43 basis points), retail trade (25 basis points), hospitals (22 basis points) and food services (18 basis points).

3.3.4 Role of Rising Industry Markups

Finally, item 5 in Table V shows the contributions of changes in industry markups. If markups are the key driver of the aggregate labor share loss, this will off course only be apparent in the decomposition with labor & intermediates-based markups, since the other decomposition assumes that markups are constant. With instead capital intensities assumed constant, markups are indeed an important determinant of aggregate labor share dynamics in the structural decomposition. Between 1997 and 2016, Table V shows that rising markups account for 3.14 percentage points of the labor share loss.

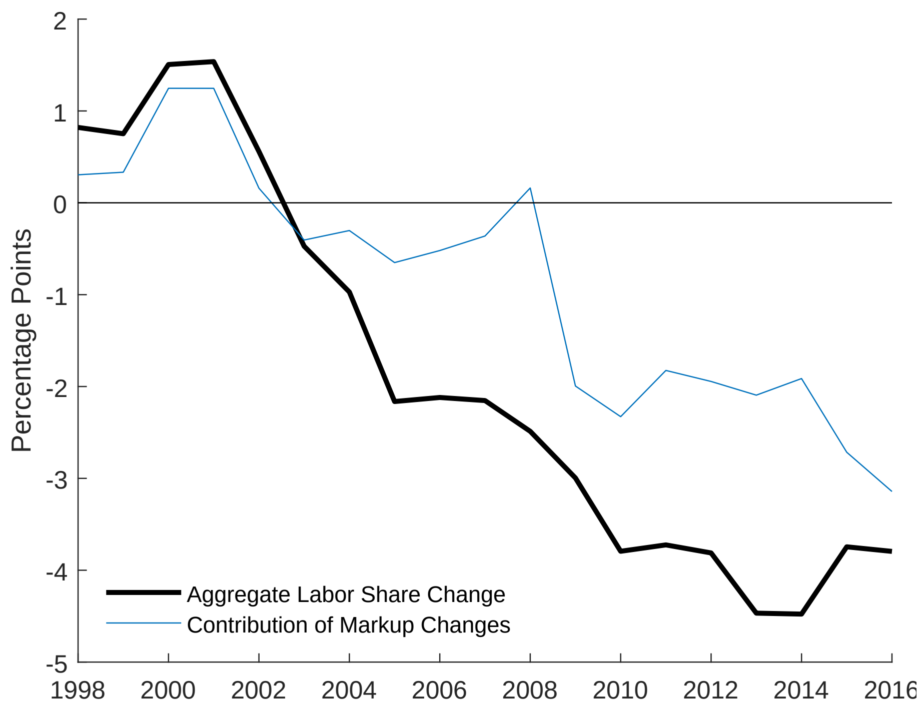

Figure 10 Role of Markup Changes, 1997-2016

The contribution of markups, however, does not occur evenly across years. Figure 10 shows the time series for the aggregate contribution of changes in industry markups (blue line) to the aggregate labor share change (black line) in the decomposition. Prior to 2009, the impact of markup changes on the labor share is limited to mostly transitory cyclical markup fluctuations, with little net cumulative effect on the aggregate labor share between 1997 and 2008 (0.16 percentage points). It is instead increases in markups in 2009 that generate a large negative contribution of -2.00 percentage points that persists until 2014. In the last two years of the sample, further rises in markups subtract an additional 1.14 percentage points from the labor share. The estimated markups are countercyclical and bring down the labor share in the 2001 and 2009 recessions. The additional drop at the end of the sample is potentially transitory as a result of the 2015-2016 mini-recession. What the decomposition with constant capital intensities suggests, however, is that a key reason for the persistently low labor share since the Great Recession is that during the recovery markups did not return to prior lower levels.

The markup contributions to the labor share decline are not evenly distributed across industries. Column [5] in Table A.III shows the contribution of markup changes by industry. Between 1997 and 2016, rising markups in 38 out of 66 private industries contribute negatively to the aggregate labor share. However, the 10 largest of these account for 2.76 percentage points, or 88 percent of the total labor share loss that is attributable to markups. The implication is that markup explanations of the recent labor share decline require a focus on relative small number of industries. The most important of these are in the financial sector, and specifically in credit intermediation (-28 basis points) and insurance (-53 basis points). Within manufacturing, computers and electronics (-29 basis points) and chemicals (-26 basis points) are quantitatively important. Other industries with large negative markup contributions are located within the information sector (-46 basis points combined), in the PBS industry (-30 basis points combined), wholesale trade (-27 basis points), and in construction (-26 basis points). Industries with lower markups in 2016 relative to 1997 make only small positive contributions, the largest of which are in securities, commodity contracts and investments (12 basis points), and rental and leasing services (10 basis points).

4 Concluding Remarks

Our analysis shows that trends in labor outsourcing are an important driver of labor shares at the industry level. This is important because labor outsourcing has little impact on the aggregate labor share: the effects of the associated within-industry labor share declines are largely offset by growth in the employment services sector. Empirical tests of the various explanations of the aggregate decline in the US labor share that rely on cross-sectional patterns in labor shares should take labor outsourcing trends into account. Outsourcing also matters for assessments of markup trends that are based on inverse labor or intermediate input shares at the disaggregated level. Relying on some combination of labor and intermediate input margins is necessary in the presence of outsourcing, and in industry-level data produces little evidence for a long run upward trend in aggregate markups before 2009.

Decompositions that isolate the contributions of trends in labor intensities, production networks, industry markups and final expenditure shares show that no single factor explains the aggregate labor share losses over between 1997 and 2016. Before 2009, within-industry decreases in labor intensity are the most important contributor prior to aggregate labor share losses. Imposing constant capital intensities, rises in markups in a select number of sector sectors are the dominant reason for the aggregate labor share loss after 2009. If we impose that markups are constant, changes in the use of intermediate (outside of outsourcing to PBS) rather than changes in labor intensities are the largest factor.

There are several interesting avenues for future research. First, in light of the evidence of the importance of within-industry reallocation, e.g. Kehrig and Vincent (2017) and Autor et al. (2017), it would be interesting to verify to what extent labor shares within industries vary with firm size because of different outsourcing behaviors. Second, it would be useful to conduct a more detailed analysis of the role of outsourcing in the estimation of markups on the basis of data from company financial reports, as in De Loecker et al. (2018). Finally, it would be interesting to investigate the effects of outsourcing trends on aggregate productivity as well as on the transmission of macroeconomic shocks as in Baqaee and Farhi (2018).

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TABLE A.I

VALUE ADDED DECOMPOSITION OF THE AGGREGATE LABOR SHARE CHANGE: 1997-2016

	Weight in Value Added		*Labor Share in Value Added*		*Value Added Realloc-ation*	*Change in Labor Share*	
	1997	2016	1997	2016	[1]	[2]	Total
All industries	100.0	100.0	63.3	59.6	−0.76	−3.04	−3.79
Private industries	86.7	87.2	61.2	56.7	−0.68	−3.25	−3.93
Agriculture, forestry, fishing, and hunting	1.3	1.0	43.8	43.3	0.08	−0.03	0.05
Farms	1.0	0.7	37.6	29.7	0.08	−0.07	0.01
Forestry, fishing, and related activities	0.2	0.2	70.6	88.9	0.00	0.04	0.04
Mining	1.1	1.4	41.6	31.6	−0.22	−0.00	−0.22
Oil and gas extraction	0.6	0.9	25.1	24.4	−0.18	0.07	−0.11
Mining, except oil and gas	0.3	0.3	64.5	29.4	−0.01	−0.11	−0.12
Support activities for mining	0.2	0.2	64.5	66.7	−0.03	0.03	0.00
Utilities	2.0	1.5	26.3	30.5	0.15	0.07	0.23
Construction	4.0	4.2	86.2	80.7	0.03	−0.21	−0.18
Manufacturing	16.2	11.8	63.1	51.2	−0.61	−0.79	−1.39
Durable goods	9.7	6.4	68.7	61.8	−0.39	−0.23	−0.62
Wood products	0.3	0.2	82.9	83.1	−0.05	0.02	−0.03
Nonmetallic mineral products	0.5	0.3	60.5	57.1	−0.01	0.00	−0.01
Primary metals	0.7	0.4	65.1	52.7	−0.00	−0.05	−0.05
Fabricated metal products	1.3	0.8	69.3	70.6	−0.05	0.03	−0.02
Machinery	1.2	0.8	74.7	66.8	−0.04	−0.07	−0.11
Computer and electronic products	2.3	1.5	61.7	52.5	−0.08	−0.05	−0.12
Electrical equipment	0.5	0.3	59.9	63.0	−0.01	0.02	0.02
Motor vehicles	1.3	0.9	86.4	74.4	−0.13	−0.07	−0.20
Other transportation equipment	0.7	0.7	56.4	44.8	0.00	−0.08	−0.08
Furniture and related products	0.3	0.2	75.8	74.2	−0.03	0.00	−0.02
Miscellaneous manufacturing	0.6	0.4	65.6	68.7	−0.01	0.01	0.01
Nondurable goods	6.6	5.4	54.8	38.7	−0.22	−0.56	−0.78
Food and beverage and tobacco products	1.6	1.5	53.3	44.7	0.01	−0.13	−0.12
Textile mills and textile product mills	0.3	0.1	84.8	71.0	−0.04	−0.02	−0.06
Apparel and leather and allied products	0.3	0.1	77.8	83.2	−0.04	0.01	−0.03
Paper products	0.7	0.3	68.2	60.0	−0.02	−0.03	−0.05
Printing and related support activities	0.4	0.2	86.0	69.0	−0.03	−0.06	−0.09
Petroleum and coal products	0.6	0.7	23.2	16.6	−0.07	−0.03	−0.10
Chemical products	2.0	2.1	43.0	28.6	−0.03	−0.28	−0.30
Plastics and rubber products	0.7	0.4	62.5	57.4	−0.01	−0.01	−0.02
Wholesale trade	6.1	5.9	67.7	59.2	−0.01	−0.49	−0.50
Retail trade	6.8	5.9	72.8	65.4	−0.05	−0.48	−0.53
Motor vehicle and parts dealers	1.5	1.1	67.8	58.6	−0.01	−0.11	−0.12
Food and beverage stores	1.0	0.9	72.1	60.9	−0.01	−0.11	−0.11
General merchandise stores	1.0	0.8	66.4	62.0	−0.01	−0.04	−0.05
Other retail	3.3	3.1	77.2	69.9	−0.02	−0.23	−0.26
Transportation and warehousing	3.1	3.1	70.0	68.4	−0.02	−0.02	−0.04
Air transportation	0.7	0.6	49.4	49.0	−0.01	0.03	0.02
Rail transportation	0.2	0.2	74.6	52.2	−0.00	−0.05	−0.05
Water transportation	0.1	0.1	34.6	35.8	−0.00	0.00	0.00
Truck transportation	0.9	0.8	81.1	77.5	−0.01	−0.03	−0.04
Transit and ground passenger transportation	0.2	0.2	74.9	85.5	0.00	0.02	0.02
Pipeline transportation	0.1	0.1	47.8	25.8	−0.01	−0.03	−0.04
Other transportation and support activities	0.7	0.7	78.2	82.2	0.00	0.03	0.03
Warehousing and storage	0.2	0.3	84.3	87.4	0.02	0.01	0.03
Information	4.7	4.9	48.0	41.5	0.02	−0.37	−0.35
Publishing industries, except internet	1.1	1.3	62.0	54.2	−0.01	−0.09	−0.10
Motion picture and sound recording industries	0.5	0.7	53.1	39.3	−0.03	−0.08	−0.11
Broadcasting and telecommunications	2.7	2.3	37.8	32.7	0.07	−0.09	−0.02
Data processing, internet publishing, and other	0.4	0.7	75.5	50.7	−0.01	−0.11	−0.12

Finance, insurance and real estate	18.8	20.9	36.0	34.7	−0.59	−0.22	−0.82
Finance and insurance	6.8	7.7	77.0	71.1	−0.04	−0.28	−0.32
Credit intermediation	2.7	2.9	54.1	53.2	−0.06	0.00	−0.06
Securities and investments	1.5	1.4	95.7	97.7	−0.04	0.04	0.00
Insurance carriers and related activities	2.5	3.1	93.1	81.3	0.16	−0.31	−0.15
Funds, trusts, and other financial vehicles	0.1	0.3	11.4	3.3	−0.10	−0.01	−0.11
Real estate and rental and leasing	12.0	13.2	13.0	13.7	−0.55	0.06	−0.50
Real estate	10.8	12.1	11.8	13.3	−0.62	0.13	−0.49
Housing	9.0	9.8	9.8	10.6	−0.46	0.09	−0.37
Other real estate	1.8	2.3	21.5	24.5	−0.16	0.04	−0.12
Rental and leasing services	1.2	1.1	23.8	18.2	0.06	−0.07	−0.01
Professional and business services	9.8	12.0	91.8	88.8	0.62	−0.31	0.31
Professional, scientific, and technical	5.8	7.1	95.0	90.7	0.36	−0.25	0.11
Legal	1.2	1.3	94.9	89.1	0.01	−0.08	−0.06
Computer systems design and related	0.9	1.5	89.6	91.4	0.17	0.04	0.20
Miscellaneous	3.7	4.3	96.3	91.0	0.18	−0.21	−0.03
Management of companies and enterprises	1.5	1.9	83.4	84.8	0.10	0.02	0.12
Administrative and waste management	2.5	3.0	89.4	87.0	0.16	−0.08	0.08
Administrative and support	2.2	2.8	91.4	88.1	0.16	−0.09	0.07
Waste management and remediation	0.2	0.2	69.8	73.0	−0.00	0.01	0.01
Education and health care	6.7	8.3	61.7	58.9	−0.06	−0.18	−0.24
Educational services	0.8	1.1	28.9	38.3	−0.08	0.09	0.01
Health care and social assistance	5.9	7.2	66.4	62.0	0.01	−0.27	−0.26
Ambulatory health care services	2.9	3.5	85.0	82.5	0.12	−0.07	0.05
Hospitals and nursing	2.5	3.0	45.8	37.7	−0.10	−0.23	−0.33
Hospitals	1.8	2.3	47.0	39.5	−0.08	−0.15	−0.24
Nursing and residential care facilities	0.7	0.8	42.5	32.4	−0.02	−0.08	−0.10
Social assistance	0.5	0.7	61.5	66.3	0.00	0.03	0.03
Entertainment, accommodation and food	3.5	4.0	64.8	65.0	0.04	−0.01	0.03
Arts, entertainment, and recreation	0.9	1.0	49.4	51.0	−0.02	0.02	0.01
Performing arts, sports, museums, ...	0.4	0.6	47.5	55.2	−0.01	0.04	0.02
Amusements, gambling, and recreation	0.5	0.5	50.9	46.1	−0.00	−0.01	−0.02
Accommodation and food services	2.6	3.0	70.3	69.8	0.05	−0.03	0.02
Accommodation	0.8	0.8	60.1	54.3	−0.00	−0.04	−0.05
Food services and drinking places	1.7	2.1	75.2	75.9	0.06	0.01	0.07
Other services, except government	2.7	2.3	83.3	74.7	−0.06	−0.21	−0.27
Addenda:							
Private goods-producing industries [a]	22.6	18.4	65.0	56.1	−0.71	−1.03	−1.74
Private services-producing industries [b]	64.1	68.8	59.9	56.8	0.03	−2.22	−2.19

Notes: Numbers are percentage points. Based on data from BLS-KLEMS and the BEA Input-Output Accounts, see appendix. The table reports the sums of annual observations of the respective terms in (2) over the sample period. Aggregates are sums of the contributions of the subindustries. [a] Consists of agriculture, forestry, fishing, and hunting; mining; construction; and manufacturing. [b] Consists of utilities; wholesale trade; retail trade; transportation and warehousing; information; finance, insurance, real estate, rental, and leasing; professional and business services; educational services, health care, and social assistance; arts, entertainment, recreation, accommodation, and food services; and other services, except government.

TABLE A.II
FINAL USE DECOMPOSITION OF THE AGGREGATE LABOR SHARE CHANGE: 1997-2016

	Weight in Final Demand		*Final Use Labor share*		*Final Use Realloc-ation*	*Direct Labor Share Change*	*Indirect Labor Share Change*	
	1997	2016	1997	2016	[1]	[2]	[3]	Total
All industries	100.0	100.0			−1.12	−1.50	−1.18	−3.79
Private industries	82.8	82.5			−1.13	−1.39	−1.21	−3.72
Agriculture, forestry, fishing, and hunting	0.6	0.4			0.01	−0.03	0.01	−0.00
Farms	0.6	0.4	50.1	46.4	0.01	−0.02	0.00	−0.00
Forestry, fishing, and related activities	0.0	−0.0	68.3	85.0	0.00	−0.01	0.00	−0.00
Mining	−0.3	−0.0			−0.19	−0.02	0.17	−0.04
Oil and gas extraction	−0.6	−0.3	36.8	31.0	−0.16	−0.05	0.19	−0.01
Mining, except oil and gas	0.1	0.1	64.7	39.6	−0.01	−0.01	−0.01	−0.03
Support activities for mining	0.2	0.2	65.9	65.5	−0.03	0.04	−0.01	−0.00
Utilities	1.4	1.1	35.8	35.8	0.08	0.06	−0.07	0.07
Construction	7.2	6.3	76.0	72.0	−0.10	0.21	−0.50	−0.39
Manufacturing	16.2	11.2			−0.47	−0.01	−0.58	−1.06
Durable goods	9.4	5.2			−0.26	0.06	−0.32	−0.52
Wood products	0.0	−0.0	73.4	73.6	−0.01	0.00	0.00	−0.00
Nonmetallic mineral products	−0.0	0.0	62.7	57.2	0.00	−0.00	−0.00	0.00
Primary metals	−0.2	−0.2	65.6	56.0	−0.00	0.02	0.00	0.02
Fabricated metal products	0.2	0.1	67.6	65.1	−0.01	−0.00	0.00	−0.01
Machinery	1.8	1.0	70.3	64.2	−0.05	−0.03	−0.05	−0.12
Computer and electronic products	2.2	0.4	64.5	54.9	−0.06	0.18	−0.20	−0.08
Electrical equipment	0.4	0.1	63.3	61.5	−0.01	0.01	−0.01	−0.01
Motor vehicles	2.7	2.1	73.9	66.9	−0.09	−0.06	−0.04	−0.20
Other transportation equipment	1.1	0.9	61.8	53.8	−0.00	−0.04	−0.03	−0.07
Furniture and related products	0.5	0.2	71.3	68.0	−0.03	−0.01	0.01	−0.03
Miscellaneous manufacturing	0.6	0.4	65.9	66.0	−0.00	0.00	−0.01	−0.01
Nondurable goods	6.8	6.0			−0.22	−0.07	−0.26	−0.55
Food and beverage and tobacco products	3.6	2.9	58.3	52.4	0.05	−0.02	−0.17	−0.14
Textile mills and textile product mills	0.2	0.1	70.0	62.8	−0.00	−0.00	−0.01	−0.01
Apparel and leather and allied products	0.7	0.1	72.7	72.0	−0.06	0.02	−0.01	−0.05
Paper products	0.1	0.2	66.8	60.6	−0.00	−0.01	0.00	−0.01
Printing and related support activities	0.2	0.1	73.7	65.5	−0.01	0.00	−0.01	−0.01
Petroleum and coal products	0.6	0.9	36.2	31.8	−0.13	0.01	0.01	−0.11
Chemical products	1.2	1.6	53.0	41.8	−0.07	−0.06	−0.08	−0.21
Plastics and rubber products	0.2	0.2	61.9	56.0	−0.00	−0.00	−0.00	−0.01
Wholesale trade	4.4	4.7	68.3	61.8	0.02	−0.31	−0.00	−0.29
Retail trade	8.5	7.9			−0.02	−0.67	0.19	−0.50
Motor vehicle and parts dealers	1.7	1.2	68.2	60.3	−0.01	−0.10	−0.01	−0.12
Food and beverage stores	1.4	1.2	69.7	61.7	−0.01	−0.11	0.00	−0.11
General merchandise stores	1.3	1.2	66.7	64.0	−0.00	−0.11	0.08	−0.04
Other retail	4.2	4.3	73.4	67.7	0.00	−0.35	0.11	−0.23
Transportation and warehousing	2.3	2.0			0.01	0.00	−0.06	−0.04
Air transportation	0.8	0.6	54.2	50.6	0.01	0.04	−0.04	0.00
Rail transportation	0.1	0.1	69.6	56.0	−0.00	−0.01	−0.01	−0.02
Water transportation	0.2	0.2	54.1	55.3	0.00	−0.00	0.00	0.00
Truck transportation	0.8	0.8	74.3	69.1	−0.00	−0.02	−0.02	−0.04
Transit and ground passenger transportation	0.1	0.2	71.0	77.4	0.00	0.01	0.00	0.01
Pipeline transportation	0.0	0.0	56.6	31.5	0.00	0.00	−0.01	−0.01
Other transportation and support activities	0.2	0.2	75.5	75.7	0.00	−0.01	0.01	0.00
Warehousing and storage	0.0	0.0	80.4	78.8	0.00	−0.00	0.00	0.00
Information	4.2	4.5			−0.04	−0.10	−0.22	−0.35
Publishing industries, except internet	1.4	1.2	66.0	56.8	0.01	0.06	−0.19	−0.12
Motion picture and sound recording industries	0.6	0.4	60.1	42.5	0.02	0.03	−0.12	−0.08
Broadcasting and telecommunications	2.1	2.5	46.6	44.2	−0.07	−0.15	0.09	−0.13
Data processing, internet publishing, and other	0.1	0.4	72.6	57.7	0.00	−0.03	0.00	−0.02

Finance, insurance and real estate	16.4	17.9			−0.48	−0.03	−0.16	−0.67
Finance and insurance	5.3	5.8			0.00	−0.08	−0.22	−0.30
Credit intermediation	1.8	2.0	61.3	58.6	−0.01	0.11	−0.16	−0.05
Securities and investments	0.9	1.1	86.0	84.9	0.05	−0.06	0.05	0.04
Insurance carriers and related activities	2.0	1.8	89.0	80.0	−0.03	−0.13	−0.05	−0.21
Funds, trusts, and other financial vehicles	0.6	0.8	69.9	57.6	−0.01	−0.00	−0.07	−0.08
Real estate and rental and leasing	11.1	12.1			−0.48	0.05	0.07	−0.37
Real estate	10.4	11.5			−0.48	0.09	0.01	−0.38
Housing	9.8	10.7	14.6	15.3	−0.46	0.09	−0.00	−0.38
Other real estate	0.7	0.7	46.6	47.9	−0.02	0.00	0.01	−0.00
Rental and leasing services	0.6	0.7	35.7	38.6	−0.00	−0.04	0.06	0.01
Professional and business services	4.3	4.9			0.12	0.03	−0.13	0.02
Professional, scientific, and technical	3.8	4.4			0.11	0.05	−0.13	0.03
Legal	0.8	0.7	85.4	83.3	−0.02	0.02	−0.04	−0.04
Computer systems design and related	0.8	1.1	81.6	85.2	0.05	0.12	−0.08	0.09
Miscellaneous	2.2	2.6	85.9	81.3	0.08	−0.09	−0.01	−0.02
Management of companies and enterprises	0.0	0.1	78.1	76.5	0.00	−0.00	0.00	0.00
Administrative and waste management	0.4	0.5			0.01	−0.01	0.00	−0.00
Administrative and support	0.3	0.4	82.7	80.0	0.01	−0.01	−0.00	−0.00
Waste management and remediation	0.1	0.1	68.4	68.6	−0.00	−0.00	0.00	−0.00
Education and health care	10.2	13.5			−0.09	−0.34	0.17	−0.26
Educational services	1.1	1.5	40.4	45.4	−0.08	0.07	−0.01	−0.01
Health care and social assistance	9.1	11.9			−0.01	−0.41	0.18	−0.25
Ambulatory health care services	4.3	5.2	78.8	75.8	0.13	−0.09	−0.04	0.01
Hospitals and nursing	4.2	5.7			−0.15	−0.38	0.25	−0.27
Hospitals	3.1	4.5	54.4	53.2	−0.12	−0.29	0.25	−0.15
Nursing and residential care facilities	1.1	1.2	50.8	43.1	−0.03	−0.09	0.00	−0.12
Social assistance	0.7	1.0	63.2	64.6	0.00	0.05	−0.04	0.01
Entertainment, accommodation and food	4.8	5.4			0.02	0.03	−0.06	−0.02
Arts, entertainment, and recreation	1.1	1.2			−0.01	−0.03	0.03	−0.02
Performing arts, sports, museums, ...	0.3	0.5	54.6	58.7	−0.01	0.01	0.01	0.01
Amusements, gambling, and recreation	0.7	0.7	56.1	52.7	−0.00	−0.04	0.02	−0.02
Accommodation and food services	3.8	4.2			0.03	0.06	−0.09	−0.00
Accommodation	1.0	1.0	63.0	58.4	−0.00	−0.01	−0.03	−0.05
Food services and drinking places	2.8	3.2	68.9	69.2	0.03	0.07	−0.06	0.04
Other services, except government	2.6	2.7	77.2	70.1	0.01	−0.22	0.02	−0.18
Addenda:								
Private goods-producing industries [a]	23.6	17.9			−0.76	0.16	−0.90	−1.50
Private services-producing industries [b]	59.1	64.6			−0.37	−1.55	−0.31	−2.22

Notes: Numbers are percentage points. Based on data from BLS-KLEMS and the BEA Input-Output Accounts, see appendix. The table reports the sums of annual observations of the respective terms in (29) over the sample period. Aggregates are sums of the contributions of the subindustries.[a] Consists of agriculture, forestry, fishing, and hunting; mining; construction; and manufacturing. [b] Consists of utilities; wholesale trade; retail trade; transportation and warehousing; information; finance, insurance, real estate, rental, and leasing; professional and business services; educational services, health care, and social assistance; arts, entertainment, recreation, accommodation, and food services; and other services, except government.

TABLE A.III

STRUCTURAL DECOMPOSITION OF THE AGGREGATE LABOR CHANGE: 1997-2016
CONSTANT CAPITAL INTENSITIES

	Final Use Realloc-ation	*Labor Inten-sity*	*Labor Out-sourcing*	*Net Labor Inten-sity*	*Use of Industry Inter-mediates*	*Markup*	
	[1]	[2]	[3]	[2] – [3]	[4]	[5]	Total
All industries	−1.12	1.61	2.52	−0.91	1.37	−3.14	−3.79
Private industries	−1.13	1.30	2.09	−0.79	1.48	−3.14	−3.58
Agriculture, forestry, fishing, and hunting	0.01	0.02	0.01	0.01	−0.06	0.01	−0.02
Farms	0.01	−0.07	0.01	−0.08	−0.01	−0.02	−0.09
Forestry, fishing, and related activities	0.00	0.09	0.00	0.09	−0.05	0.03	0.07
Mining	−0.19	0.19	0.05	0.14	−0.11	−0.09	−0.25
Oil and gas extraction	−0.16	0.18	0.05	0.13	−0.10	−0.00	−0.13
Mining, except oil and gas	−0.01	−0.02	0.00	−0.02	−0.01	−0.10	−0.14
Support activities for mining	−0.03	0.03	−0.00	0.04	0.00	0.01	0.02
Utilities	0.08	0.12	−0.01	0.14	−0.09	0.03	0.15
Construction	−0.10	0.51	0.10	0.40	0.17	−0.26	0.21
Manufacturing	−0.47	0.61	0.52	0.09	−1.26	−0.92	−2.57
Durable goods	−0.26	0.58	0.30	0.28	−0.65	−0.40	−1.02
Wood products	−0.01	0.00	−0.00	0.00	−0.08	0.01	−0.07
Nonmetallic mineral products	0.00	−0.03	−0.00	−0.03	−0.06	0.01	−0.08
Primary metals	−0.00	−0.09	−0.01	−0.08	−0.06	−0.00	−0.15
Fabricated metal products	−0.01	−0.09	0.01	−0.10	−0.05	0.06	−0.10
Machinery	−0.05	0.01	0.04	−0.02	−0.02	−0.05	−0.14
Computer and electronic products	−0.06	0.62	−0.01	0.63	−0.22	−0.29	0.07
Electrical equipment	−0.01	0.04	0.00	0.04	−0.05	0.01	−0.01
Motor vehicles	−0.09	0.09	0.17	−0.08	−0.04	−0.13	−0.35
Other transportation equipment	−0.00	0.00	0.05	−0.05	0.02	−0.05	−0.08
Furniture and related products	−0.03	−0.01	0.02	−0.03	−0.01	0.01	−0.05
Miscellaneous manufacturing	−0.00	0.03	0.03	0.00	−0.07	0.01	−0.06
Nondurable goods	−0.22	0.03	0.22	−0.19	−0.61	−0.52	−1.54
Food and beverage and tobacco products	0.05	0.08	0.07	0.01	−0.00	−0.19	−0.13
Textile mills and textile product mills	−0.00	−0.01	0.01	−0.01	−0.10	−0.00	−0.12
Apparel and leather and allied products	−0.06	0.04	0.02	0.02	−0.03	0.01	−0.06
Paper products	−0.00	−0.08	0.01	−0.09	−0.15	0.02	−0.22
Printing and related support activities	−0.01	0.04	0.01	0.03	−0.20	−0.06	−0.23
Petroleum and coal products	−0.13	0.01	0.03	−0.01	0.01	−0.03	−0.16
Chemical products	−0.07	−0.03	0.07	−0.11	−0.08	−0.26	−0.51
Plastics and rubber products	−0.00	−0.02	0.01	−0.03	−0.07	−0.01	−0.10
Wholesale trade	0.02	−0.19	0.16	−0.35	0.03	−0.27	−0.57
Retail trade	−0.02	−0.38	0.28	−0.67	0.02	−0.13	−0.80
Motor vehicle and parts dealers	−0.01	−0.10	0.01	−0.11	−0.02	−0.02	−0.16
Food and beverage stores	−0.01	−0.06	0.03	−0.10	0.00	−0.02	−0.12
General merchandise stores	−0.00	−0.03	0.07	−0.10	−0.00	−0.02	−0.13
Other retail	0.00	−0.20	0.16	−0.36	0.04	−0.08	−0.39
Transportation and warehousing	0.01	−0.05	0.01	−0.06	0.28	−0.09	0.14
Air transportation	0.01	0.05	−0.02	0.07	−0.02	0.01	0.06
Rail transportation	−0.00	0.00	0.00	−0.00	−0.00	−0.05	−0.05
Water transportation	0.00	0.01	0.01	0.00	0.01	−0.01	0.01
Truck transportation	−0.00	−0.04	0.01	−0.05	0.02	−0.01	−0.04
Transit and ground passenger transportation	0.00	0.00	0.00	0.00	0.01	0.02	0.03
Pipeline transportation	0.00	0.05	−0.00	0.05	−0.01	−0.07	−0.03
Other transportation and support activities	0.00	−0.09	0.00	−0.10	0.16	0.01	0.07
Warehousing and storage	0.00	−0.03	0.00	−0.04	0.13	0.02	0.11
Information	−0.04	−0.04	−0.01	−0.03	0.01	−0.46	−0.51
Publishing industries, except internet	0.01	0.10	−0.07	0.18	−0.03	−0.19	−0.04
Motion picture and sound recording industries	0.02	0.17	−0.02	0.19	0.02	−0.25	−0.03
Broadcasting and telecommunications	−0.07	−0.21	0.07	−0.28	−0.13	0.06	−0.41

Data processing, internet publishing, and other	0.00	−0.10	0.01	−0.11	0.14	−0.07	−0.03
Finance, insurance and real estate	−0.48	0.32	0.08	0.24	0.58	−0.68	−0.34
Finance and insurance	0.00	0.23	−0.03	0.26	0.43	−0.78	−0.09
Credit intermediation	−0.01	0.41	−0.02	0.43	−0.27	−0.28	−0.13
Securities and investments	0.05	−0.20	0.04	−0.25	0.03	0.12	−0.05
Insurance carriers and related activities	−0.03	0.03	−0.05	0.07	0.66	−0.53	0.18
Funds, trusts, and other financial vehicles	−0.01	−0.01	−0.01	−0.00	0.00	−0.09	−0.10
Real estate and rental and leasing	−0.48	0.09	0.11	−0.02	0.15	0.10	−0.25
Real estate	−0.48	0.20	0.07	0.13	0.12	0.00	−0.23
Housing	−0.46	0.12	0.03	0.10	−0.00	−0.01	−0.37
Other real estate	−0.02	0.08	0.04	0.04	0.12	0.01	0.14
Rental and leasing services	−0.00	−0.11	0.05	−0.16	0.04	0.10	−0.02
Professional and business services	0.12	0.01	0.09	−0.09	2.07	−0.30	1.80
Professional, scientific, and technical	0.11	0.29	0.08	0.21	0.69	−0.30	0.71
Legal	−0.02	0.09	0.01	0.09	0.04	−0.06	0.04
Computer systems design and related	0.05	0.20	−0.01	0.21	0.22	0.01	0.49
Miscellaneous	0.08	−0.00	0.08	−0.08	0.43	−0.25	0.18
Management of companies and enterprises	0.00	−0.21	0.00	−0.21	0.78	0.04	0.62
Administrative and waste management	0.01	−0.07	0.01	−0.09	0.60	−0.04	0.48
Administrative and support	0.01	−0.06	0.01	−0.07	0.57	−0.06	0.45
Waste management and remediation	−0.00	−0.02	0.00	−0.02	0.02	0.02	0.02
Education and health care	−0.09	0.10	0.43	−0.32	0.00	−0.02	−0.43
Educational services	−0.08	0.11	0.04	0.08	0.02	0.01	0.03
Health care and social assistance	−0.01	−0.01	0.39	−0.40	−0.02	−0.03	−0.46
Ambulatory health care services	0.13	0.04	0.11	−0.07	−0.02	−0.03	0.01
Hospitals and nursing	−0.15	−0.12	0.26	−0.38	0.01	0.01	−0.51
Hospitals	−0.12	−0.07	0.22	−0.29	0.00	0.01	−0.40
Nursing and residential care facilities	−0.03	−0.05	0.04	−0.09	0.00	−0.00	−0.12
Social assistance	0.00	0.07	0.01	0.05	−0.01	−0.01	0.04
Entertainment, accommodation and food	0.02	0.31	0.27	0.04	0.09	0.01	0.16
Arts, entertainment, and recreation	−0.01	−0.04	0.04	−0.07	0.04	0.08	0.03
Performing arts, sports, museums, ...	−0.01	−0.00	0.01	−0.01	0.03	0.05	0.06
Amusements, gambling, and recreation	−0.00	−0.03	0.03	−0.06	0.01	0.03	−0.03
Accommodation and food services	0.03	0.35	0.24	0.11	0.06	−0.06	0.13
Accommodation	−0.00	0.06	0.05	0.01	−0.02	−0.04	−0.06
Food services and drinking places	0.03	0.29	0.19	0.10	0.08	−0.02	0.19
Other services, except government	0.01	−0.23	0.10	−0.33	−0.25	0.02	−0.55
Addenda:							
Private goods-producing industries [a]	−0.76	1.32	0.68	0.64	−1.26	−1.26	−2.63
Private services-producing industries [b]	−0.37	−0.02	1.41	−1.43	2.73	−1.88	−0.95

Notes: All numbers are percentage points. Based on data from BLS-KLEMS and the BEA Input-Output Accounts and estimated industry markups, see data appendix and Section 3.1. The table reports the sums of annual observations of the respective terms in (45) over the sample period. Aggregates are sums of the contributions of the subindustries. The total in the last column equals $[1]+[2]-[3]+[4]+[5]$. See appendix for data description and sources. [a] Consists of agriculture, forestry, fishing, and hunting; mining; construction; and manufacturing. [b] Consists of utilities; wholesale trade; retail trade; transportation and warehousing; information; finance, insurance, real estate, rental, and leasing; professional and business services; educational services, health care, and social assistance; arts, entertainment, recreation, accommodation, and food services; and other services, except government.

TABLE A.IV

STRUCTURAL DECOMPOSITION OF THE AGGREGATE LABOR CHANGE: 1997-2016

CONSTANT MARKUPS

	Final Use Realloc- ation [1]	*Labor Inten- sity* [2]	*Labor Out- sourcing* [3]	*Net Labor Inten- sity* [2] − [3]	*Use of Industry Inter- mediates* [4]	*Markup* [5]	Total
All industries	−1.12	−0.60	2.06	−2.65	−0.03	−0.00	−3.79
Private industries	−1.13	−0.87	1.66	−2.53	0.13	−0.00	−3.53
Agriculture, forestry, fishing, and hunting	0.01	0.02	0.01	0.01	−0.08	−0.00	−0.06
Farms	0.01	−0.08	0.01	−0.09	−0.03	−0.00	−0.10
Forestry, fishing, and related activities	0.00	0.10	0.00	0.10	−0.06	−0.00	0.05
Mining	−0.19	0.15	0.05	0.11	−0.14	−0.00	−0.23
Oil and gas extraction	−0.16	0.18	0.05	0.13	−0.12	−0.00	−0.15
Mining, except oil and gas	−0.01	−0.06	0.00	−0.07	−0.02	−0.00	−0.10
Support activities for mining	−0.03	0.04	−0.00	0.04	−0.00	−0.00	0.02
Utilities	0.08	0.10	−0.01	0.12	−0.10	−0.00	0.09
Construction	−0.10	0.32	0.07	0.25	0.13	−0.00	0.28
Manufacturing	−0.47	0.10	0.39	−0.29	−1.53	−0.00	−2.29
Durable goods	−0.26	0.30	0.24	0.06	−0.80	−0.00	−1.00
Wood products	−0.01	0.01	−0.00	0.01	−0.09	−0.00	−0.09
Nonmetallic mineral products	0.00	−0.03	−0.00	−0.03	−0.07	−0.00	−0.10
Primary metals	−0.00	−0.09	−0.01	−0.08	−0.07	−0.00	−0.16
Fabricated metal products	−0.01	−0.06	0.01	−0.07	−0.08	−0.00	−0.16
Machinery	−0.05	−0.01	0.03	−0.04	−0.03	−0.00	−0.13
Computer and electronic products	−0.06	0.41	−0.03	0.44	−0.27	−0.00	0.12
Electrical equipment	−0.01	0.05	0.00	0.04	−0.06	−0.00	−0.03
Motor vehicles	−0.09	0.03	0.15	−0.12	−0.06	−0.00	−0.27
Other transportation equipment	−0.00	−0.03	0.04	−0.07	0.01	−0.00	−0.06
Furniture and related products	−0.03	−0.00	0.02	−0.02	−0.01	−0.00	−0.06
Miscellaneous manufacturing	−0.00	0.04	0.03	0.01	−0.07	−0.00	−0.07
Nondurable goods	−0.22	−0.20	0.15	−0.35	−0.72	−0.00	−1.29
Food and beverage and tobacco products	0.05	0.00	0.04	−0.03	−0.02	−0.00	−0.00
Textile mills and textile product mills	−0.00	−0.01	0.01	−0.02	−0.11	−0.00	−0.12
Apparel and leather and allied products	−0.06	0.05	0.02	0.03	−0.03	−0.00	−0.06
Paper products	−0.00	−0.08	0.01	−0.09	−0.16	−0.00	−0.25
Printing and related support activities	−0.01	0.01	0.01	0.00	−0.21	−0.00	−0.22
Petroleum and coal products	−0.13	−0.00	0.02	−0.02	0.01	−0.00	−0.14
Chemical products	−0.07	−0.15	0.04	−0.19	−0.13	−0.00	−0.39
Plastics and rubber products	−0.00	−0.03	0.01	−0.03	−0.08	−0.00	−0.12
Wholesale trade	0.02	−0.41	0.12	−0.53	−0.06	−0.00	−0.57
Retail trade	−0.02	−0.51	0.25	−0.76	−0.00	−0.00	−0.78
Motor vehicle and parts dealers	−0.01	−0.11	0.01	−0.12	−0.03	−0.00	−0.16
Food and beverage stores	−0.01	−0.08	0.03	−0.11	0.00	−0.00	−0.12
General merchandise stores	−0.00	−0.05	0.07	−0.12	−0.00	−0.00	−0.12
Other retail	0.00	−0.27	0.14	−0.41	0.02	−0.00	−0.38
Transportation and warehousing	0.01	−0.10	0.01	−0.10	0.20	−0.00	0.11
Air transportation	0.01	0.05	−0.02	0.07	−0.03	−0.00	0.04
Rail transportation	−0.00	−0.03	0.00	−0.03	−0.01	−0.00	−0.04
Water transportation	0.00	0.01	0.01	−0.00	0.01	−0.00	0.01
Truck transportation	−0.00	−0.05	0.01	−0.05	−0.00	−0.00	−0.06
Transit and ground passenger transportation	0.00	0.02	0.00	0.02	0.01	−0.00	0.02
Pipeline transportation	0.00	0.01	−0.00	0.02	−0.01	−0.00	0.00
Other transportation and support activities	0.00	−0.09	0.00	−0.09	0.13	−0.00	0.04
Warehousing and storage	0.00	−0.03	0.00	−0.03	0.12	−0.00	0.09
Information	−0.04	−0.36	−0.08	−0.28	−0.05	−0.00	−0.37
Publishing industries, except internet	0.01	−0.02	−0.10	0.08	−0.05	−0.00	0.05
Motion picture and sound recording industries	0.02	0.00	−0.05	0.05	−0.00	−0.00	0.07
Broadcasting and telecommunications	−0.07	−0.20	0.06	−0.26	−0.14	−0.00	−0.47

Data processing, internet publishing, and other	0.00	−0.14	0.01	−0.15	0.14	−0.00	−0.02
Finance, insurance and real estate	−0.48	−0.10	0.04	−0.14	0.27	−0.00	−0.34
Finance and insurance	0.00	−0.22	−0.09	−0.13	0.14	−0.00	0.01
Credit intermediation	−0.01	0.24	−0.05	0.29	−0.31	−0.00	−0.03
Securities and investments	0.05	−0.13	0.05	−0.18	−0.04	−0.00	−0.17
Insurance carriers and related activities	−0.03	−0.31	−0.07	−0.24	0.49	−0.00	0.22
Funds, trusts, and other financial vehicles	−0.01	−0.03	−0.02	−0.00	0.00	−0.00	−0.01
Real estate and rental and leasing	−0.48	0.12	0.13	−0.00	0.13	−0.00	−0.36
Real estate	−0.48	0.19	0.07	0.12	0.10	−0.00	−0.26
Housing	−0.46	0.11	0.02	0.09	−0.00	−0.00	−0.38
Other real estate	−0.02	0.08	0.05	0.03	0.10	−0.00	0.11
Rental and leasing services	−0.00	−0.06	0.06	−0.12	0.03	−0.00	−0.09
Professional and business services	0.12	−0.23	0.07	−0.30	1.68	−0.00	1.50
Professional, scientific, and technical	0.11	0.06	0.05	0.01	0.52	−0.00	0.64
Legal	−0.02	0.04	0.00	0.04	−0.00	−0.00	0.01
Computer systems design and related	0.05	0.21	−0.01	0.22	0.21	−0.00	0.48
Miscellaneous	0.08	−0.19	0.06	−0.25	0.31	−0.00	0.14
Management of companies and enterprises	0.00	−0.18	0.00	−0.18	0.68	−0.00	0.50
Administrative and waste management	0.01	−0.11	0.01	−0.12	0.48	−0.00	0.37
Administrative and support	0.01	−0.11	0.01	−0.11	0.47	−0.00	0.36
Waste management and remediation	−0.00	−0.00	0.01	−0.01	0.02	−0.00	0.01
Education and health care	−0.09	0.05	0.39	−0.34	−0.00	−0.00	−0.44
Educational services	−0.08	0.11	0.03	0.08	0.02	−0.00	0.02
Health care and social assistance	−0.01	−0.06	0.36	−0.42	−0.02	−0.00	−0.46
Ambulatory health care services	0.13	0.00	0.09	−0.09	−0.02	−0.00	0.02
Hospitals and nursing	−0.15	−0.13	0.26	−0.38	0.01	−0.00	−0.52
Hospitals	−0.12	−0.07	0.22	−0.29	0.00	−0.00	−0.41
Nursing and residential care facilities	−0.03	−0.06	0.03	−0.09	0.00	−0.00	−0.12
Social assistance	0.00	0.06	0.01	0.05	−0.01	−0.00	0.04
Entertainment, accommodation and food	0.02	0.30	0.26	0.04	0.07	−0.00	0.13
Arts, entertainment, and recreation	−0.01	0.01	0.04	−0.03	0.03	−0.00	−0.01
Performing arts, sports, museums, ...	−0.01	0.03	0.01	0.02	0.02	−0.00	0.03
Amusements, gambling, and recreation	−0.00	−0.02	0.03	−0.05	0.01	−0.00	−0.04
Accommodation and food services	0.03	0.29	0.22	0.07	0.04	−0.00	0.14
Accommodation	−0.00	0.02	0.04	−0.02	−0.03	−0.00	−0.05
Food services and drinking places	0.03	0.27	0.18	0.09	0.07	−0.00	0.19
Other services, except government	0.01	−0.22	0.09	−0.32	−0.26	−0.00	−0.56
Addenda:							
Private goods-producing industries [a]	−0.76	0.59	0.52	0.07	−1.62	−0.00	−2.30
Private services-producing industries [b]	−0.37	−1.47	1.14	−2.61	1.74	−0.00	−1.23

Notes: All numbers are percentage points. Based on data from BLS-KLEMS and the BEA Input-Output Accounts and estimated industry markups, see data appendix and Section 3.1. The table reports the sums of annual observations of the respective terms in (45) over the sample period. Aggregates are sums of the contributions of the subindustries. The total in the last column equals $[1]+[2]-[3]+[4]+[5]$. See appendix for data description and sources. [a] Consists of agriculture, forestry, fishing, and hunting; mining; construction; and manufacturing. [b] Consists of utilities; wholesale trade; retail trade; transportation and warehousing; information; finance, insurance, real estate, rental, and leasing; professional and business services; educational services, health care, and social assistance; arts, entertainment, recreation, accommodation, and food services; and other services, except government.

Data Appendix

The main data sources are:

- BEA NIPA Tables released on July 27, 2018.
  https://www.bea.gov/data/economic-accounts/national
- BLS Major Sector Productivity and Costs released on August 15, 2018.
  https://www.bls.gov/lpc/data.htm
- BLS-KLEMS (Combined Sectors and Industry KLEMS Multifactor Productivity Tables), downloaded August 22, 2018
  https://www.bls.gov/mfp/special_requests/klemscombinedbymeasure.xlsx
- BEA Industry Economic Accounts: Input-Output Accounts, released on November 2, 2017 .
  https://www.bea.gov/data/economic-accounts/industry
- BLS Occupational Employment Statistics https://www.bls.gov/oes/, downloaded January 31, 2019.

The Labor Share in GDP (Figure 1)

The **total labor share** is the ratio of total compensation to GDP (NIPA Table 1.3.5 line 1). **Total compensation** is the sum of compensation in the government sector (NIPA Table 3.10.5 line 4), in government enterprises (NIPA Series A4081C and B4086C, obtained from FRED, NIPA Table unknown), and in the private sector. **Compensation in the private sector** is the sum of compensation the household/non-profit sector (NIPA Table RfHhInstComp line 1) and in the private business sector. **Compensation in the private business sector** is compensation in the business sector less compensation in government enterprises. **Compensation in the business sector** is obtained as the product of the sector's labor share from the BLS Productivity and Costs Release and business sector GDP (NIPA Table 1.3.5 line 10).

The **private sector labor share** is compensation in the private sector divided by **private sector GDP**, which is total GDP less gross value added in the government sector (NIPA Table 1.3.5 line 8) and less gross value added of government enterprises (BEA Industry Economic Accounts, Value Added By Industry, sum of lines 95 and 98).

The **private business labor share** is compensation in the private business sector divided by **private business sector GDP**, which is gross value added in the business sector (NIPA Table 1.3.5 line 10) less gross value added of government enterprises (BEA Industry Economic Accounts, Value Added By Industry, sum of lines 95 and 98).

The **private corporate business labor share** is compensation in the corporate business sector (NIPA Table 1.14 line 4) divided by gross value added in the sector (NIPA Table 1.14 line 1).

Industry/Occupation-Level Data (Figure 2 and Table I)

Occupation counts in Figure 2 and Table I are based on 22 'major occupations' as defined in the BLS Occupational Employment Statistics. The PBS Employment Share according to the Current Employment Situation is the ratio of FRED series USPBS to PAYEMS, where USPBS are Professional and Business Services Employees and PAYEMS is Total Nonfarm Payroll Employees (https://fred.stlouisfed.org/). Total spending on PBS intermediates and gross output are from the BEA Input-Output Accounts, constructed as explained below.

Industry-Level Data Definitions and Construction

There are Z commodities and N industries. Define

$$\begin{aligned} \mathbf{y}: &\quad N \times 1 \text{ industry gross output vector} \\ \mathbf{x}: &\quad N \times 1 \text{ final industry demand vector} \\ \mathbf{z}: &\quad Z \times 1 \text{ commodity output vector} \\ \mathbf{q}: &\quad Z \times 1 \text{ final commodity demand vector} \\ \mathbf{v}: &\quad N \times 1 \text{ industry value added vector} \end{aligned}$$

Industry and commodity output are related by

$$\mathbf{y} = B\mathbf{z} \tag{A.1}$$

where B is the $N \times Z$ Industry-by-Commodity Make matrix. The ij-th element of the Make matrix specifies industry i's share in the total dollar value of good j produced. Next,

$$\mathbf{z} = D\mathbf{y} + \mathbf{q} \tag{A.2}$$

where D is the $Z \times N$ Commodity-by-Industry Use matrix. The ij-th element of the Use matrix specifies the dollar value of commodity i used in production by industry, per dollar of total industry output. Substituting (A.2) into (A.1) yields

$$\mathbf{y} = \Omega\mathbf{y} + \mathbf{x} \tag{A.3}$$

where $\Omega = BD$ is **industry input matrix** (or the Industry-by-Industry Direct Requirements Matrix) and $\mathbf{x} = B\mathbf{q}$ is final industry demand. Rearranging,

$$\mathbf{y} = (I - \Omega)^{-1}\mathbf{x} \tag{A.4}$$

where $(I - \Omega)^{-1}$ is the **industry input inverse** matrix. Value added is

$$\mathbf{v} = (I - \Omega_o)^{-1}\mathbf{y} \tag{A.5}$$

where $\Omega_o = \text{diag}(\mathbf{y})\Omega'\text{diag}(\mathbf{y})^{-1}$ is the **industry output matrix**: The ij-th element of Ω_o specifies the intermediate inputs of industry j sold for use in production of industry i, as a share of total output of industry i.

The use matrix D includes not only commodities produced domestically, but also commodities that are imported. Let D_d denote the use matrix that only records domestically produced commodities. The corresponding **industry domestic input matrix** (or Domestic Direct Requirements Matrix) is $\Omega_d = BD_d$. Imported intermediates are given by

$$\mathbf{i} = (I - \Omega_d)\mathbf{y} - \mathbf{x} \tag{A.6}$$

Rearranging,

$$\mathbf{y} = (I - \Omega_d)^{-1}\mathbf{x}_d \tag{A.7}$$

where $(I - \Omega_d)^{-1}$ is the **industry domestic input inverse** matrix and $\mathbf{x}_d = \mathbf{i} + \mathbf{x}$ is final expenditures on domestic production (final spending by US residents and all exports).

We derive all objects above from the Make and Use matrices (in current dollars) provided in the Input-Output Accounts in the BEA Industry Economic Accounts. Specifically, we use the summary-level Make and Use tables before redefinitions data (producer's prices). The online appendix shows that using the Make/Use tables after redefinitions – in which some secondary products and their inputs are reassigned – makes little difference for our results. The redefinitions make little difference.m The domestic Use table is obtained by subtracting the Import Matrix from the Use table.

The summary level tables provide data for 71 non-overlapping NAICS industries, including 66 in the private sector. The industry commodity vector is the column total of the Make matrix, while the **industry output** vector is the row total of the Make matrix. **Industry final expenditures** and **industry value added** are obtained through (A.3) and (A.5), respectively, after calculating industry input and output matrices from the (scaled) Make and Use matrices.

Industry output derived as above is consistent with, but differs from the industry output measures reported in the BEA Industry Economic Account as Gross Output by Industry. The latter include two additional items: (1) scrap, used and secondhand goods and (2) noncomparable imports and a rest-of-the-world adjustment, that are omitted from our measures. Similarly, the value added measures we use differ from those reported in the BEA Industry Economic Account as Industry Value Added because they omit both the output and the intermediate use of these items.

The **labor shares in gross output for private industries** are from the BLS-KLEMS data, calculated as Cost of Labor divided by the Value of Production. The BLS-KLEMS dataset combines certain sectors that are reported separately in the BEA's Industry Economic Accounts. In these cases, we use the labor shares at the next level of aggregation. Specifically, for (1) motor vehicle and parts dealers, (2) food and beverage stores, (3) general merchandise stores and (4) other retail, we use the retail trade labor share in BLS-KLEMS; for (1) motor vehicles, bodies and trailers, and parts and (2) other transportation equipment, we use the transportation equipment labor share in BLS-KLEMS; for (1) housing and (2) other real estate, we use the real estate labor share in BLS-KLEMS; and for (1) hospitals and (2) nursing and residential care facilities, we use the hospitals and nursing and residential care facilities in BLS-KLEMS. The **labor shares in gross output for the government sectors** are obtained from the BEA Industry Accounts as the ratio of Compensation of Employees to Gross Output.

Estimation of Industry Markups

The industry markup regressions make use of the following BLS-KLEMS data: $\ln(Y/K)$ is the log of Real Sectoral Output to Capital Services; SR is the log first difference of Multifactor Productivity; s_L is Cost of Labor divided by the Value of Production; s_M is Cost of Intermediate Inputs divided by the Value of Production. The instrumental variables are the same as Hall (2018): real military expenditure on equipment, ships, and software, and research and development are from NIPA Table 3.11.3 (lines 31,34, 39 and 40). The market price of West Texas Intermediate Crude is series ACOILWTICO from FRED `https://fred.stlouisfed.org/`.

Appendix with Derivations

Derivation of the Open Economy Final Use Decomposition in Equation (30)

Let Ω_d denote the domestic input matrix, and x_d final expenditures on domestic production (final spending by residents plus all exports). Analogous to (27), the total labor share in the final use of domestic output is

$$\text{(A.8)} \qquad \lambda_{x_d} = (I-\Omega_d')^{-1}\lambda_g = \lambda_g + (I-\Omega_d')^{-1}\Omega_d'\lambda_g$$

The aggregate labor share in GDP λ can be expressed as

$$\text{(A.9)} \qquad \lambda = (1+\rho)\lambda_{x_d}'\mathbf{w}_{x_d}$$

where ρ is the ratio of total spending on imported intermediates to GDP and $\mathbf{w}_{x_d}$ are the weights of final expenditures on domestic production. Taking first differences

$$\text{(A.10)} \qquad \Delta\lambda = (1+\bar{\rho})\Delta(\lambda/(1+\rho)) + \overline{\lambda/(1+\rho)}\Delta\rho$$

where bars denote averages of current and last period values. Substituting

$$\text{(A.11)} \qquad \Delta(\lambda/(1+\rho)) = \sum_i \left(\bar{\lambda}_i^{x_d} - \bar{\lambda}\right)\Delta w_i^{x_d} + \sum_i \bar{w}_i^{x_d}\Delta\lambda_i^{x_d,direct} + \sum_i \bar{w}_i^{x_d}\Delta\lambda_i^{x_d,interm}$$

into (A.10) yields

$$\text{(A.12)} \qquad \Delta\lambda = \overline{\lambda/(1+\rho)}\Delta\rho + (1+\bar{\rho})\sum_i \left(\bar{\lambda}_i^{x_d} - \bar{\lambda}\right)\Delta w_i^{x_d} + (1+\bar{\rho})\sum_i \bar{w}_i^{x_d}\Delta\lambda_i^{x_d,direct} + (1+\bar{\rho})\sum_i \bar{w}_i^{x_d}\Delta\lambda_i^{x_d,interm}$$

Using $\lambda_i^{x_d,direct} = \lambda_i^{x,direct}$ and adding/subtracting terms involving $\Delta\lambda_i^{x,interm}$ yields

$$\text{(A.13)} \qquad \Delta\lambda = \overline{\lambda/(1+\rho)}\Delta\rho + (1+\bar{\rho})\sum_i \left(\bar{\lambda}_i^{x_d} - \bar{\lambda}\right)\Delta w_i^{x_d} + (1+\bar{\rho})\sum_i \bar{w}_i^{x_d}\Delta\lambda_i^{x,direct} + (1+\bar{\rho})\sum_i \bar{w}_i^{x_d}\Delta\lambda_i^{x,interm} - (1+\bar{\rho})\sum_i \bar{w}_i^{x_d}(\Delta\lambda_i^{x,interm} - \Delta\lambda_i^{x_d,interm})$$

which, after defining $\Delta\lambda_i^{x,imports} = (\Delta\lambda_i^{x,interm} - \Delta\lambda_i^{x_d,interm})$ and $\tilde{w}_i^x = (1+\bar{\rho})\bar{w}_i^{x_d}$, yields equation (30) in the main text.

Derivation of the Open Economy Structural Decomposition in Equation (48)

Let Ω_d denote the domestic input matrix, x_d final expenditures on domestic production (final spending by residents plus all exports), and ρ_g the vector of imported intermediate spending shares in industry gross output. Analogous to (A.8), the total intermediate import share in the final use of domestic output is

$$\text{(A.14)} \qquad \rho_{x_d} = (I-\Omega_d')^{-1}\rho_g$$

Defining $\Gamma_d = (I-\Omega_d)^{-1}$ and taking first differences of (A.8) and (A.14) yields

$$\text{(A.15)} \qquad \Delta\lambda_{x_d}' = \Delta\lambda_g'\bar{\Gamma}_d + \bar{\lambda}_g'\Delta\Gamma_d$$

$$\text{(A.16)} \qquad \Delta\rho_{x_d}' = \Delta\rho_g'\bar{\Gamma}_d + \bar{\rho}_g'\Delta\Gamma_d$$

Assuming cost minimization,

$$\text{(A.17)} \qquad \lambda_g = (I - \mathcal{L})E_L \quad , \quad \Omega_d = E_{M_d}(I - \mathcal{L}) \quad , \quad \rho_g = (I - \mathcal{L})E^*_{M_i}$$

where E_L is the vector of labor input elasticies, E_{M_d} and E_{M_i} are matrices containing the output elasticities with respect to domestic intermediate inputs and imported intermediate inputs respectively, and $E^*_{M_i}$ is the column vector containing the column sums of E_{M_i}. Taking first differences:

$$\begin{aligned}
&\text{(A.18)} & \Delta\lambda'_g &= \Delta E'_L(I - \bar{\mathcal{L}}) - \bar{E}'_L \Delta\mathcal{L} \\
&\text{(A.19)} & \Delta\rho'_g &= \Delta E^{*\prime}_{M_i}(I - \bar{\mathcal{L}}) - \bar{E}^{*\prime}_{M_i}\Delta\mathcal{L} \\
&\text{(A.20)} & \Delta\Omega_d &= \Delta E_{M_d}(I - \bar{\mathcal{L}}) - \bar{E}_{M_d}\Delta\mathcal{L} \\
&\text{(A.21)} & \Delta\Gamma_d &= (I - \bar{\Omega}_d)^{-1}\Delta\Omega_d\bar{\Gamma}_d
\end{aligned}$$

Substituting into (A.15) and (A.16),

$$\begin{aligned}
&\text{(A.22)} & \Delta\lambda'_{x_d} &= \bar{\lambda}'_g(I - \bar{\Omega}_d)^{-1}\Delta E_{M_d}(I - \bar{\mathcal{L}})\bar{\Gamma}_d + \Delta E'_L(I - \bar{\mathcal{L}})\bar{\Gamma}_d \\
& & &\quad - \left(\bar{\lambda}'_g(I - \bar{\Omega}_d)^{-1}\bar{E}_{M_d} + \bar{E}'_L\right)\Delta\mathcal{L}\bar{\Gamma}_d \\
&\text{(A.23)} & \Delta\rho'_{x_d} &= \bar{\rho}'_g(I - \bar{\Omega}_d)^{-1}\Delta E_{M_d}(I - \bar{\mathcal{L}})\bar{\Gamma}_d + \Delta E^{*\prime}_{M_i}(I - \bar{\mathcal{L}})\bar{\Gamma}_d \\
& & &\quad - \left(\bar{\rho}'_g(I - \bar{\Omega}_d)^{-1}\bar{E}_{M_d} + \bar{E}^{*\prime}_{M_i}\right)\Delta\mathcal{L}\bar{\Gamma}_d
\end{aligned}$$

Changes in the aggregate labor share in GDP can be expressed as

$$\text{(A.24)} \qquad \Delta\lambda = (1+\bar{\rho})\Delta(\lambda/(1+\rho)) + (1+\bar{\rho})\delta\Delta(\rho/(1+\rho))$$

where $\delta \equiv (\overline{\lambda/(1+\rho)})/(1 - \overline{\rho/(1+\rho)})$. Since

$$\begin{aligned}
&\text{(A.25)} & \Delta(\lambda/(1+\rho)) &= \left(\bar{\lambda}'_{x_d} - \bar{\lambda}\right)\Delta\mathbf{w}_{x_d} + \Delta\lambda'_{x_d}\bar{\mathbf{w}}_{x_d} \\
&\text{(A.26)} & \Delta(\rho/(1+\rho)) &= \left(\bar{\rho}'_{x_d} - \bar{\rho}\right)\Delta\mathbf{w}_{x_d} + \Delta\rho'_{x_d}\bar{\mathbf{w}}_{x_d}
\end{aligned}$$

Substituting into (A.24)

$$\begin{aligned}
\Delta\lambda &= \left[\left(\bar{\lambda}'_{x_d} - \bar{\lambda}\right) + \delta\left(\bar{\rho}'_{x_d} - \bar{\rho}\right)\right](1+\bar{\rho})\Delta\mathbf{w}_{x_d} + \Delta E'_L(I - \bar{\mathcal{L}})\bar{\Gamma}_d(1+\bar{\rho})\bar{\mathbf{w}}_{x_d} \\
&\quad + \left[\bar{\lambda}_g + \delta\bar{\rho}_g\right]'(I - \bar{\Omega}_d)^{-1}\Delta E_{M_d}(I - \bar{\mathcal{L}})\bar{\Gamma}_d(1+\bar{\rho})\bar{\mathbf{w}}_{x_d} + \delta\Delta E^{*\prime}_{M_i}(I - \bar{\mathcal{L}})\bar{\Gamma}_d(1+\bar{\rho})\bar{\mathbf{w}}_{x_d} \\
&\quad - \left(\left[\bar{\lambda}_g + \delta\bar{\rho}_g\right]'(I - \bar{\Omega}_d)^{-1}\bar{E}_{M_d} + \bar{E}'_L + \delta\bar{E}^{*\prime}_{M_i}\right)\Delta\mathcal{L}\bar{\Gamma}_d(1+\bar{\rho})\bar{\mathbf{w}}_{x_d}
\end{aligned}$$

which, after defining $\tilde{\mathbf{w}}_x = (1+\bar{\rho})\bar{\mathbf{w}}_{x_d}$, $\tilde{\lambda}_x = (1+\bar{\rho})(\bar{\lambda}_{x_d} + \delta\bar{\rho}_g)$, $\tilde{\lambda} = (1+\bar{\rho})(\bar{\lambda} + \delta\bar{\rho})$, $\tilde{\lambda}_g = \bar{\lambda}_g + \delta\bar{\rho}_g$, yields equation (48) in the main text.