Intermediate Input Prices and the Labor Share

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Abstract

We explore how the labor share relates to the price of materials in the economy. Under conditions of imperfect competition and complementarity between materials and primary inputs, a higher price of materials lowers the labor share and raises the profit share of income, without requiring a change in markups. We show that fluctuations in materials prices align with aggregate trends in the U.S. labor share, including a sharp decline during the 2000s commodity boom and stabilization in recent years; provide causal evidence for this effect across industries and across local labor markets; and quantify the importance of our mechanism using an input-output general equilibrium model of the U.S. economy. We conclude that absent our mechanism, the labor share's decline would have been smaller and smoother. We extend our framework to a multi-country setting and demonstrate, theoretically and empirically, how shocks to global commodities yield heterogeneous changes in the labor share across countries.

Keywords: Labor Share, Intermediate Inputs, Materials, Commodity Prices

JEL codes: E24, E25, F16, D2

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1 Introduction

The labor share of income in the United States has experienced significant changes in the past several decades. Despite bountiful research on the topic, the literature has struggled to explain some important patterns in the dynamics of the labor share. In particular, it is unclear why the labor share declined so sharply in the 2000s, why it stabilized (or even rebounded) in the past decade, and why the decline was absent from many service sectors. To shed light on these patterns, we propose a new mechanism that explains medium-term fluctuations in the labor share, focusing on the price of materials in the economy. Our study is motivated by a strong negative correlation between the price of raw materials and the labor share in the data. Figure 1 presents this relationship at the aggregate level for the United States in the past 50 years, in which sharp changes are observed in both series over the 2000s, with some stabilization in recent years. We argue that fluctuations in the price of materials can help to reconcile differences across sectors and countries, and introduce a "long-cycle" component in the labor share's dynamics, bridging the large literature that documents a long-term decline with the few papers that suggest a cyclical behaviour.[1]

We start by theoretically exploring under what conditions the price of materials affects the labor share.[2] This relationship is not obvious and absent from many standard settings, since the labor share is defined out of value added, excluding payments for intermediates. However, in a setting with imperfect competition, changes in the price of intermediates that increase their share in production costs, result in a higher share of profits in value added and a decline in the shares of labor and capital.[3] This effect is consistent with recent research that documents a fall in the capital share parallel to the labor share,[4] and does not rely on rising price-cost markups.

The share of intermediates in costs can increase when their relative price rises and they are complements to other inputs, or when their relative price falls and they are

[1]See Koh, Santaeulàlia-Llopis, and Zheng (2020) and Barro (2021) for this claim.

[2]Note that while we focus on the price of materials (a subgroup of intermediate inputs), our theory applies to all types of intermediates, which are typically divided into sourced services, materials, and energy. Throughout this paper, we include energy inputs in our definition of materials. Hereafter, we use the terms intermediate inputs and materials interchangeably unless otherwise noted.

[3]There is another channel that is present even with perfect competition, in which the price of intermediates can affect the labor share through a reallocation of costs between labor and capital when the production function is not separable between intermediates and primary inputs. In Section 2 we provide the exact conditions for this effect to take place, but we fail to find strong empirical support for this channel.

[4]See Barkai (2020).

substitutes to other inputs. This paper focuses on the empirically relevant case, in which materials and primary inputs are complements.[5] In particular, we argue that the commodity price boom of the 2000s was a major shock that increased the relative price of intermediates in industries that rely strongly on raw materials.

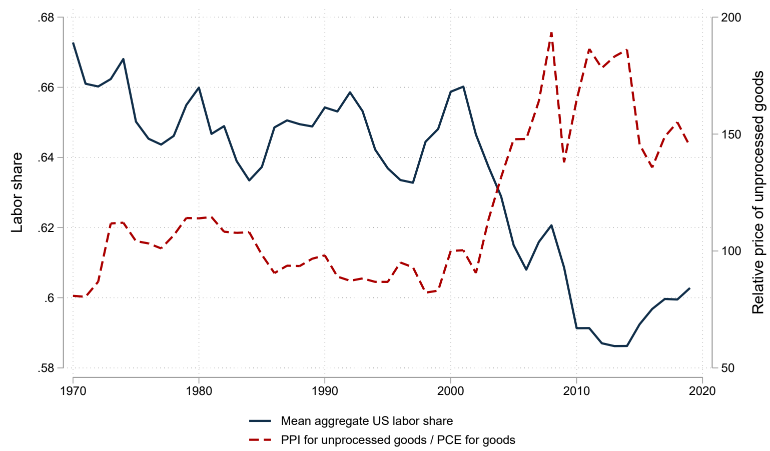


Figure 1: Trends in the Aggregate Labor Share and Relative Price of Materials. The solid line shows the mean of four measures for the U.S. aggregate labor share - see Section 3 for more details. The dashed line is the ratio of the Producer Price Index (PPI) for unprocessed goods (FRED series WPUID62) to the Personal Consumption Expenditures (PCE) index for goods (FRED series DGDSRC1).

We investigate the above mechanism using multiple sources of variation. First, we demonstrate a negative relationship between relative material prices and the labor share across broad U.S. sectors, and show that materials-intensive sectors experienced a sharp decline in their labor share during the 2000s. We then move to a more granular analysis of the U.S. manufacturing sector – in which the fall in the labor share was particularly strong – investigating the mechanism across narrowly defined industries and across commuting zones. To get exogenous variation in the price of materials, we rely on exposure to globally traded homogeneous commodities by constructing prices from international transactions. Weighting commodities by their usage in the U.S. input-output tables, we construct an instrumental variable capturing direct and indirect measures of exposure to these commodities in different industries and commuting zones. We find a robust negative relationship between materials prices and the labor share. We provide a structural interpretation of our estimates

[5]Note, however, that the second option in which some intermediates are substitutes and their price falls is likely to hold in the data as well. This is a plausible option in the case of purchased services, which are likely to be substitutes for in-house production. Both effects lead to a lower labor share out of value added through the higher share of intermediates in total costs.

through the lens of our theory, linking them to the degree of complementarity between materials and primary inputs, and to profit rates.

While we focus mainly on the 2000s in our empirical investigation, the 1970s also experienced large changes in commodity prices, specifically in energy goods. The increase in the real price of materials during this decade was dwarfed by the increment in the 2000s as can be seen Figure 1, in line with the rather moderate decline in the labor share over the 1970s. Nevertheless, it still provides a useful test of our mechanism, since we can leverage the exogenous nature of the oil shock in the 1970s as a second natural experiment. Accordingly, we construct a second instrument that relies on industry-level energy intensity, and use it to provide additional evidence of a negative causal relationship between materials prices and the labor share.

To quantify the relevance of our mechanism to aggregate changes in the labor share, we employ two approaches. First, we use our reduced-form estimates to construct counterfactual changes in the labor share that capture the role of rising material prices. Second, we develop and quantify a multi-sector input-output general equilibrium model of the U.S. economy. We use the model to compute counterfactual paths for the labor share that allow for our mechanism to take place while holding constant parameters that summarize competing narratives in the literature, such as changes in markups or changes in the split between payments to labor and capital (e.g. automation). We recover these parameters by inverting the equilibrium conditions of the model, matching key aspects of the data on U.S. sectors. This exercise also allows us to address a key concern in the literature on the labor share as raised recently by Grossman and Oberfield (2022), who highlight that many of the proposed explanations are not mutually exclusive. Since most existing theories are mediated through the division between labor and capital or through changes in markups, our model allows us to identify the separate role of our mechanism. In both exercises, we attribute around 30% of the overall decline in the labor share to changes in material intensity and conclude that the decline would have been smaller and smoother absent fluctuations in materials prices.

While the price of commodities has nominally increased across the globe since the 2000s, countries have experienced different trends in their labor share. Through the lens of our mechanism, this can occur if the prices of primary factors respond differently to a change in the price of materials across countries, thereby generating variation in the *relative* price of materials. To analyze differences across countries using this measure, we first develop a simple multi-country trade model with a global commodity market. In this framework, commodity prices can increase due to a negative shock to the global supply of raw materials, or due to higher demand following a productivity shock to some country.[6] Following either shock, countries experience different effects on their real price of materials, despite a common nominal price. As a result, the effect on the labor share is heterogeneous: countries with a higher increase in the real price of materials experience a greater decline in their labor share. We verify these predictions using data from the EU-KLEMS dataset. We show that the U.S. and Japan have experienced both a large increase in the relative price of materials and a larger decline in their labor share, with all trends reversing in recent years. By contrast, Europe has seen a stable labor share (on average), in line with a close-to-constant average relative price of materials. Extending the above analysis from U.S. manufacturing industries to manufacturing sectors across countries, we again find a negative relationship between the price of materials and the labor share.

Related Literature. Our main contribution is to the recent literature studying changes in the U.S. labor share. One strand of this literature has focused on neoclassical explanations, suggesting that the share of capital in value added has risen. Examples include Elsby, Hobijn, and Şahin (2013), Karabarbounis and Neiman (2014), Acemoglu and Restrepo (2018), Grossman, Helpman, Oberfield, and Sampson (2021), and Hubmer (2023). Our mechanism is most closely related to the one in Karabarbounis and Neiman (2014) and Hubmer (2023), in which a change in the relative price of inputs alters their mix in total costs. However, we do not require the capital share to rise. Moreover, the mechanism in these papers relies on the elasticity of substitution between capital and labor being greater than one – a contested finding in this literature.[7] By contrast, the theoretical restrictions that are required for our mechanism to take place (complementarities between materials and primary inputs) are consistent with available studies in this literature (e.g. Atalay 2017, Boehm, Flaaen, and Pandalai-Nayar 2019, Oberfield and Raval 2021, and Peter and Ruane 2022).

[6] These two comparative statics exercises capture the two common narratives for the reasons behind the significant increase in commodity prices during the 2000s.

[7] See Oberfield and Raval (2021) and Glover and Short (2020) for evidence that capital and labor are complements.

A second group of explanations suggests that broad technological changes have led to an increase in the share of income from rents, either through rising price-cost markups or labor market power. Examples include Barkai (2020), De Loecker, Eeckhout, and Unger (2020), Gouin-Bonenfant (2022), Aghion, Bergeaud, Boppart, Klenow, and Li (2023), and Autor, Dorn, Katz, Patterson, and Van Reenen (2020). We relate to this literature by suggesting a mechanism that leads to a higher share of profits in value added, without requiring a rise in firms' markups or markdowns. A final explanation, proposed by Philippon (2019), suggests that changes in the U.S. institutional environment have led to a rise in market power across U.S. industries, leading as a result to a lower labor share. This last explanation is related to the claim that the decline has been unique to the U.S., as proposed by Gutiérrez and Piton (2020), though the evidence for the cross-country comparison is mixed. As discussed in Section 5 of this paper, our mechanism offers an explanation for cross-country heterogeneity that does not rely on changes in institutional settings.

Some studies, including Autor et al. (2020) and Kehrig and Vincent (2021), have emphasized the importance of accounting for within-industry firm heterogeneity, and demonstrated that the downward trend in recent decades is much less pronounced for the median firm, occurring mostly at initially low labor share firms. While we focus on industry or regional outcomes in our empirical analysis, our theory suggests heterogeneous responses across firms that are amplified by their profit share, with ex-ante low labor share firms experiencing greater decline in their labor share following a change in the price of intermediate inputs. Empirically, our results are virtually unchanged when accounting for the dynamics in industry concentration.

Most of the above studies take the stance that there has been a long-term decline in the U.S. labor share. Some papers, notably Koh et al. (2020) and Barro (2021), claim that this long-run trend disappears after accounting correctly for investment and capitalization of intellectual property products in the national accounts, though significant medium-term fluctuations remain. In this paper, we also suggest that at least part of the long-term decline has a cyclical component, and relate the medium-term fluctuations to changes in the relative price of materials.

Finally, we also relate to the literature on aggregate elasticities of substitution across inputs in production, and in particular papers that consider the degree of substitution between materials and primary inputs. While this is not the focus of our study, we get results that align with Atalay (2017), Baqaee and Farhi (2019), Boehm et al. (2019), Oberfield and Raval (2021), and Peter and Ruane (2022), that suggest strong complementarities between materials and primary inputs in the manufacturing sector. In this context, we utilize booms in global commodity prices as our source of identification. Hassler, Krusell, and Olovsson (2021) focus exclusively on energy products and argue that there are substantial complementarities between energy and primary inputs in the short run, with a higher degree of substitutability in the long run due to innovation. While we abstract from this long-run innovation adjustment, it suggests another force that might contribute to a long-run stabilization of the labor share through the lens of our mechanism.

The rest of the paper is organized as follows. Section 2 investigates theoretically the link between materials prices and the labor share. Section 3 describes the identification strategy, the data, and the empirical results of our study of the relationship between the labor share and the price of materials across U.S. sectors, industries, and local labor markets. In Section 4 we construct an input-output general equilibrium model of the U.S. economy and use it to quantify the importance of our mechanism for aggregate changes in the labor share. Section 5 investigates our mechanism in a cross-country setting, both theoretically and empirically. Section 6 concludes.

2 Theoretical Framework

In this section, we provide theoretical conditions for a negative relationship between the price of materials and the labor share. We consider firms that produce using three factors - labor l, capital k, and materials m. Throughout the paper, we denote the labor share out of value added by λ, the expenditure on any factor i out of total costs by θ_i, and the ratio of expenditure on any factor i to total revenues by s_i. Detailed derivations of all results can be found in the Online Appendix.

2.1 Baseline setting

We begin with a standard setting that demonstrates our mechanism in the most straightforward way and then generalize it. We assume that the production function features a constant elasticity of substitution between materials and primary inputs, denoted by σ, and that firms charge an exogenous markup μ.[8] The production function is given by

$$y = A\left(\left(G\left(k,l\right)\right)^{\frac{\sigma-1}{\sigma}} + m^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where A is total factor productivity, and $G\left(k,l\right)$ is a flexible bundle that combines labor and capital under constant returns to scale. The labor share is given by

$$\lambda \equiv \frac{wl}{py - p_m m}, \tag{2}$$

where w is the cost of labor, p is the price of output, and p_m is the price of materials. Totally differentiating Equation 2 and incorporating the firm's optimal choice of inputs, we obtain the following result:

Proposition 1. *The elasticity of the labor share to the price of materials is given by*

$$\frac{d\log\lambda}{d\log p_m} = -\left(1-\sigma\right)\left(\mu-1\right)\frac{M}{Y}, \tag{3}$$

where σ is the elasticity of substitution between materials and primary inputs; μ is the price-cost markup; $M \equiv p_m m$ is total expenditure on materials; and $Y \equiv py - p_m m$ is total value added.

According to Proposition 1, an increase in the price of materials, other things equal, leads to a lower labor share if materials and primary inputs are complements ($\sigma < 1$) and markups are positive ($\mu > 1$). In addition, the transmission of higher material prices to the labor share is stronger under ex-ante higher markups and higher materials intensity M/Y. These features align with the concentration of the labor share's decline in materials-intensive sectors such as manufacturing. They also align with the key role of ex-ante high-markup firms, which therefore have a lower labor share, in this trend, as documented in Kehrig and Vincent (2021).

[8]For simplicity, we refer to the ratio of sales to costs (μ) as the price-cost markup throughout the paper. However, it can also be interpreted as the ratio of the markup over marginal cost and the scale elasticity in production, as discussed in Basu (2019). In this case, all of our analysis goes through, if returns to scale are exogenous. In the special case with constant returns-to-scale, μ is just the price cost markup. We also investigate the case with fixed costs in production below, in which case returns to scale are endogenous and increasing.

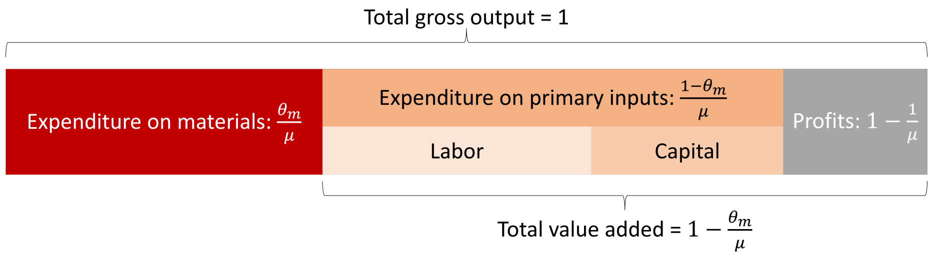


Figure 2: Distribution of Output and Value Added

2.2 Intuition

To provide further intuition for the relationship in Proposition 1, we examine how total revenues are distributed between profits, expenditure on materials, and expenditure on primary inputs, as illustrated in Figure 2. First, note that the share of profits in total revenues is given by $1 - 1/\mu$ and is independent of how costs are allocated between factors of production, since firms markup over their total costs, and not over the cost of primary inputs. More generally, the profit rate depends on the curvature of demand and/or the degree of returns to scale and is independent of the cost structure. Second, note that the share of primary inputs in total revenues, given by $(1 - \theta_m)/\mu$, is declining when the cost-share of materials θ_m increases. Combining these two observations, an increase in the price of materials, p_m, in the presence of complementarities reduces the revenue share of primary inputs but does not affect the revenue share of profits, leading to a higher profit share of value added. It is important to note that, under this mechanism, the absolute level of profits can decline, as long as the expenditure on primary inputs declines by a greater extent.

An extreme version of this mechanism is when $\theta_m \to 1$. In this case, the firm only purchases materials and resells them at a markup, without any expenditure on labor, and the labor share is zero. In other words, the firm becomes an intermediary. One can thus think about a world with high material prices as a world in which the role of firms as intermediaries is more prominent, and that the share of income generated by reselling materials is higher.

2.3 Generalizations

We now explore generalizations of the elasticity of the labor share to the price of materials derived in Proposition 1.

General production function. First, consider a general production function $F(k, l, m)$ rather than the CES production function in Equation 1.[9] The elasticity of the labor share to the price of materials is

$$\frac{d\log\lambda}{d\log p_m} = \left(1 - \left(\frac{\theta_l}{\theta_l + \theta_k}\sigma_{lm} + \frac{\theta_k}{\theta_l + \theta_k}\sigma_{km}\right)\right)(\mu - 1)\frac{M}{Y} + \frac{\theta_k}{\theta_l + \theta_k}\left(\sigma_{lm} - \sigma_{km}\right),$$

where σ_{im} is the *Morishima* elasticity of substitution between factor i and materials. This expression has two differences relative to our benchmark case in Proposition 1. First, since materials are no longer separable from labor and capital, σ is replaced with a weighted average of the Morishima elasticities of substitution between materials and capital and between materials and labor. Second, for the same reason, a higher price of materials can now also lower the labor share by shifting expenditure from labor to capital, if $\sigma_{lm} < \sigma_{km}$. Therefore, we get an additional term captured by $\frac{\theta_k}{\theta_l+\theta_k}\left(\sigma_{lm} - \sigma_{km}\right)$. Empirically, we find little evidence of this additional term, as we do not find an effect of the price of materials on capital-labor ratios. Therefore, in most of the paper, we focus on the case that $\sigma_{lm} = \sigma_{km}$, in which a higher price of materials leads to a higher profit share and does not raise the capital share.

Variable markups. Second, consider the case in which the markup μ is not constant. Suppose that the firm faces a general demand function $D(p)$ for its output, featuring a non-constant demand elasticity. The expression in Proposition 1 becomes

$$\frac{d\log\lambda}{d\log p_m} = \left(-(1-\sigma)(\mu - 1) + \xi\frac{\mu}{\epsilon - 1 + \xi}\right)\frac{M}{Y},$$

where $\epsilon \equiv \frac{d\log D(p)}{d\log p}$ is the elasticity of demand, $\xi \equiv \frac{d\log\epsilon}{d\log p}$ is the super-elasticity that governs how ϵ changes with the price, and the markup is given by $\mu = \epsilon/(\epsilon - 1)$. When the super-elasticity of demand ξ is zero, the above expression collapses to the one in Proposition 1. Otherwise, we get an additional term that multiplies the materials intensity, $\xi\frac{\mu}{\epsilon-1+\xi}$, which captures that a higher cost of production may lead the firm to adjust the markup μ, depending on how sensitive is the elasticity of demand to the price of output. For standard demand systems featuring Marshall's second law of demand, the super-elasticity, ξ, is positive, and we obtain a dampening effect: a

[9] We assume that F is a continuous, monotone, quasi-concave, and twice differentiable.

higher price of materials leads to a lower markup, contributing to a lower profit share.

Fixed costs. Finally, we consider a case with both fixed and variable costs. For simplicity, suppose that the fixed costs are paid in units of the composite of labor and capital $G(k,l)$ from Equation 1. The expression in Proposition 1 becomes

$$\frac{d\log\lambda}{d\log p_m} = \left(-\left(1-\sigma\right)\left(\mu-1\right) + \omega\frac{\left(\epsilon-\sigma\right)\left(\mu-\theta_m\right)}{1-\theta_m+\omega}\right)\frac{M}{Y},$$

where ω is the ratio of total fixed costs to total variable costs. Note that in this case, the ratio of sales to total costs is $\mu/(1+\omega)$, and $(1+\omega)$ can be thought of as the scale elasticity. When ω is zero (no fixed costs), the above expression collapses to the one in Proposition 1. Otherwise, we get an additional term that multiplies material intensity. When the price of materials rises and $\epsilon > \sigma$, variable costs go down relative to fixed costs, and the labor share increases. This acts as a dampening force on our mechanism. When $\epsilon < \sigma$, the converse occurs.

2.4 General equilibrium

We have outlined a partial equilibrium mechanism in which the wage and the price of materials are taken as given. To see how this effect manifests in general equilibrium, we consider three different stylized settings with different assumptions on the nature of sourced materials: a roundabout production economy, a two-sector vertical economy, and a small open economy. In each of them, the underlying shock that drives up the price of materials is different, but in all of them, the increase in the price of materials leads to a lower aggregate labor share through our suggested mechanism. To demonstrate this point in the simplest way, we abstract from capital, and consider a representative firm that uses labor and materials in production. In Section 4 below, we consider a quantitative multi-sector general equilibrium setting that combines elements from these three stylized environments.

A roundabout production economy. Consider an economy in which the aggregate production function takes the form of Equation 1, where for simplicity we impose $G(k,l) = A_L^{\frac{\sigma-1}{\sigma}} l$, i.e. the composite of capital and labor is linear in labor, adjusted by a labor-augmenting technological shifter A_L. In the roundabout production economy, firms source units of the final good to use as materials in production, combining them with labor. We assume that this process is subject to a sourcing friction, such that out of the total amount of the final good that is sourced by firms, only a fraction $1/\kappa$ can be used in production. This friction allows us to shock the relative price of materials in this roundabout production economy. The endowment of labor is given by L, and firms charge an exogenous price-cost markup μ in all transactions.

In this economy, the price of materials is given by κp. Normalizing the price of labor to one, this is also the expression for the relative price of materials, which can be shown to equal $p_m = A_L^{\frac{\sigma}{\sigma-1}} \left(\left(\frac{A}{\mu\kappa} \right)^{1-\sigma} - 1 \right)^{-\frac{1}{1-\sigma}}$. The relative price of materials is thus increasing when the sourcing friction κ rises relative to the TFP term A and materials are complements to labor ($\sigma < 1$).[10] Total labor income is given by L, and the only source for non-labor income is profits due to the existence of a positive markup μ. The labor share can be shown to equal

$$\lambda = \frac{1}{1 + \frac{\mu-1}{1-\left(\mu\frac{\kappa}{A}\right)^{1-\sigma}}}.$$

An increase in the sourcing friction κ relative to A thus leads to a lower labor share if $\sigma < 1$ and $\mu > 1$, in line with our partial equilibrium mechanism.

A two-sector economy. Consider an economy with two sectors - an extractive sector and a manufacturing sector. The extractive sector is endowed with the stock of raw materials in the economy, $\bar{m}$, and sells them to the manufacturing sector. The manufacturing sector combines materials with labor to produce the final good and sells it to consumers after charging an exogenous price-cost markup μ. The production function in the manufacturing sector takes the same form as in Equation 1, where for simplicity we impose $G(k,l) = A_L^{\frac{\sigma-1}{\sigma}} l$, i.e. the composite of capital and labor is linear in labor, adjusted by a labor-augmenting technological shifter A_L. The endowment of labor is given by L, and all of it is employed in the manufacturing sector.

In this economy, the price of materials p_m is given by $p_m = A_L \left(\frac{\bar{m}}{L}\right)^{-\frac{1}{\sigma}}$, where we have normalized the price of labor to unity. p_m is thus decreasing in the relative endowment of materials $\bar{m}/L$. Total labor compensation is just the endowment of labor L, and the manufacturing sector profits are given by a constant share of $1 - 1/\mu$ of manufacturing revenues. Consequentially, the manufacturing labor share in terms

[10] Note that the TFP shifter affects the relative price of materials in this model since it lowers the price of the final good relative to labor.

of primitives can be shown to be equal to

$$\lambda = \frac{1}{1 + (\mu - 1)\left(1 + A_L^{-1}\left(\frac{\bar{m}}{L}\right)^{-\frac{\sigma-1}{\sigma}}\right)}.$$

In line with our partial-equilibrium analysis, an exogenous decline in the relative supply of materials $\bar{m}/L$ raises their relative price p_m, which leads to a lower labor share when $\sigma < 1$ and $\mu > 1$. Note that when considering the aggregate labor share in this economy, one should also incorporate non-labor income in the extractive sector, given by rents for raw materials $p_m\bar{m}$. The aggregate labor share is thus given by $\lambda = \frac{1}{\mu\left(1+A_L^{-1}\left(\frac{\bar{m}}{L}\right)^{\frac{\sigma-1}{\sigma}}\right)}$. It is also decreasing in the relative supply of raw materials if $\sigma < 1$, though in this case, $\mu > 1$ is not required, since the rents to the endowment of materials ensure a positive profit share even under $\mu = 1$.

A small open economy. Finally, consider a small open economy that sources materials from the rest of the world at a given price p_m, and sells output to the rest of the world at a given price p. There is a single production sector with the same production function as before, $y = A\left[A_L l^{\frac{\sigma-1}{\sigma}} + m^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$, and which charges an exogenous markup μ over its marginal cost. Since nominal prices of materials and output are fixed, the price of materials relative to the unit cost of output is pinned down by local labor market clearing. The labor share in this setting is given by

$$\lambda = \frac{\left(\frac{\mu}{A}\frac{p_m}{p}\right)^{\sigma-1} - 1}{\mu\left(\frac{\mu}{A}\frac{p_m}{p}\right)^{\sigma-1} - 1}.$$

As before and in line with our partial-equilibrium analysis, an exogenous decline in the relative global price of materials p_m/p leads to a lower labor share when $\sigma < 1$ and $\mu > 1$.

These examples illustrate that the theoretical conditions for which an increase in the price of materials causes a decline in the labor share outlined in Section 2.1, are also sufficient in three different stylized general equilibrium settings. While the nature of sourced materials and the underlying shocks vary, in all of them an increase in the relative price of materials leads to a lower labor share under complementarities in production and positive markups.

3 Empirical evidence

3.1 Aggregate and sectoral evidence

We begin our empirical analysis with an exploration of aggregate trends in the U.S. labor share and the relative price of raw materials. We take as our baseline aggregate labor share a simple average of four popular series used in the literature.[11] Our baseline measure for the relative price of raw materials is the ratio between the Bureau of Labor Statistics (henceforth BLS) Producer Price Index (PPI) for unprocessed goods,[12] and the Bureau of Economic Analysis (BEA) Personal Consumption Expenditures (PCE) index for goods. Figure 1 shows these measures in the past fifty years. Both demonstrate relative stability during the 1980s and the 1990s. In the 2000s, the relative price of materials increased significantly, coinciding with a sharp drop in the labor share.[13] In recent years, the relative price of materials has declined, coinciding with a rebound of the labor share. Interestingly, despite the large increase in energy prices during the 1970s, the increase in the real price of materials is small, in line with the moderate decline in the labor share over this period. We discuss this period in greater detail in Section 3.7.

We now turn to explore trends at the sector level. To this end, we utilize the BEA's KLEMS accounts, which provide estimates of output and input prices and quantities for 59 broad sectors starting from 1987. First, we divide all U.S. sectors into two groups based on their materials intensity in the first year in this sample, such that each group represents half of total value-added in the economy. The materials-intensive group includes sectors in manufacturing, mining, construction, utilities, most of the transportation sector and some services sectors such as dining places. The other group includes most services and trade sectors. Panel (a) in Figure 3 demonstrates that

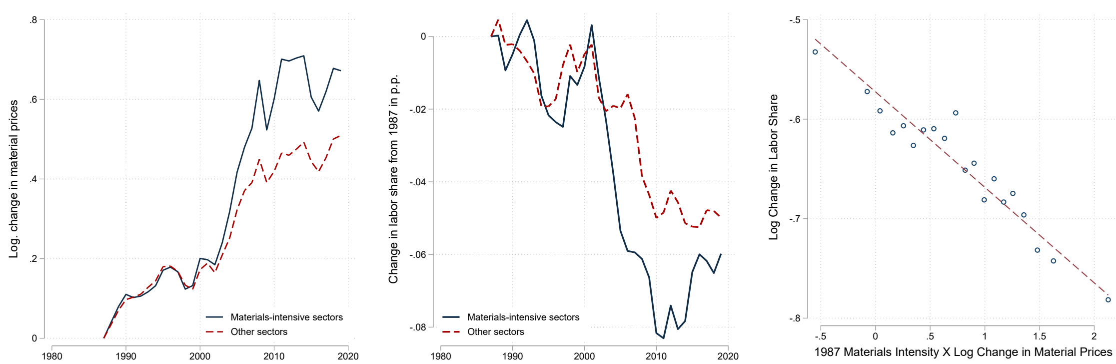
[11] We take an average of the following measures: (1) The main specification suggested in Gomme and Rupert (2004); (2) The labor share in U.S. non-financial corporations, constructed based on NIPA data; (3) The series computed by Fernald (2014); (4) The definition of the Bureau for Labor Statistics (BLS) for non-farm business-sector labor share, constructed from NIPA data.

[12] According to the BLS: "The price index for unprocessed goods for intermediate demand measures price change for goods that have undergone no fabrication and that are sold to businesses as inputs to production."

[13] Deflating the nominal price of unprocessed goods by the PCE for goods reflects the need to hold constant the prices of other inputs in production, as suggested by our theory. The PCE represents the final price of goods as reported by producers and retailers in the U.S.. One concern with this deflator (as with any price-based deflator) is that it captures changes in markups in addition to changes in costs. To the extent that markups have indeed increased over time as suggested by De Loecker et al. (2020), the actual unit cost is higher in earlier years and lower in later years. In this case, the rise in the relative price of unprocessed goods should be even larger during the 2000s and even more moderate during the 1970s.

while both groups experienced similar changes in the price index of material inputs over the 1990s, the materials-intensive group has seen a significantly greater increase over the 2000s, reflecting greater exposure to upstream materials and commodities. Accordingly, Panel (b) shows that the materials-intensive sectors have seen a greater decline in the labor share over the 2000s. A rough assessment of the gap between both groups suggests that the changes in material prices could explain roughly 30%-40% of the decline in labor share over these years, a similar magnitude to our more systematic analysis below.

Panel (c) in Figure 3 shows a binscatter plot of changes in sectoral log labor shares against exposure to the rise in material input prices, given by the product of ex-ante materials intensity (expenditure on materials over value-added) and the log-change in sectoral materials price index (reflecting the object $\frac{M}{Y} \times d \log p_m$ in the notation of Proposition 1). We control for time and sector fixed effects, and for the log price index of sectoral value-added, to account for changes in other factor prices. Evidently, sectors with high exposure to rising materials prices have seen the greatest decline in labor share.[14]



(a) Sectoral material prices **(b)** Sectoral labor shares **(c)** Sectoral exposure

Figure 3: Labor Shares and Material Price Shocks Across U.S. Sectors. Panel (a) shows the average change in the log price index of materials across two equally-sized groups of U.S. sectors (value-added weighted) according to their 1987 material intensity of output. The materials-intensive group includes sectors in manufacturing, mining, construction, utilities, most of the transportation sector and some services sectors such as dining places. The other group includes most services and trade sectors. Panel (b) shows the change in the aggregate labor share since 1987 for both groups. Panel (c) shows a binscatter plot of changes in the log labor share against a measure of exposure to the rise in material input prices (initial material intensity in 1987 × log-change in the sector material price index) across 59 BEA sectors, controlling for sector and time fixed effects and for the log price index of sector value added, and weighting sectors by their ex-ante value added.

[14]This negative relationship is robust to investigating separately goods-producing and services-producing sectors, and to different weighting schemes.

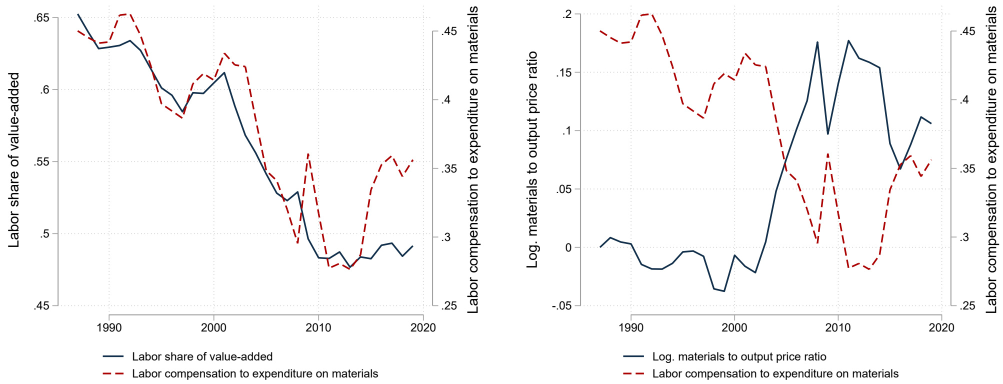
3.2 Evidence from the U.S. Manufacturing Sector

We now delve further into the U.S. manufacturing sector, a key driver of the aggregate changes in the labor share, where the decline in the labor share during the 2000s was especially pronounced. Before proceeding to our cross-sectional analysis, we first provide evidence for our mechanism for the manufacturing sector as a whole. First, we show that in line with our mechanism, the increase in the relative price of materials has resulted in a *reallocation of costs* between materials and primary inputs. Since the non-labor part of value-added includes both capital costs and profits, we focus on reallocation between materials and labor. Panel (a) in Figure 4 shows the ratio of labor compensation to expenditure on materials in the U.S. manufacturing sector over time, as well as the manufacturing labor share. A clear pattern of cost reallocation from labor to materials emerges, with a particularly sharp decline over the 2000s. Furthermore, both the trend and the overall magnitude align well with changes in the labor share of value added in this period, with the exception of a small divergence between the two series in the past few years. Still, even when taking this latter divergence into account, the figure suggests that a significant part of the fluctuation of the labor share in these years is related to changes in the composition of costs between materials and labor. Panel (b) plots the same series against the relative price of materials inputs. In line with our suggested mechanism, the reallocation between labor and materials aligns well in magnitude and timing with the rising price of materials.

It is worth mentioning that alternative explanations to changes in the labor share that operate through higher markups cannot explain this reallocation since other things equal, a higher markup keeps the distribution of costs between inputs unchanged.[15] While explanations that emphasize a higher capital share, such as capital deepening as described by Karabarbounis and Neiman (2014), could potentially generate this trend under specific assumptions about the substitution patterns between different inputs, the correlation with the relative price of materials—and its timing, which coincides with the global commodity boom—suggests a significant role for our

[15] Rising markups over time actually make our mechanism more plausible. The reason is that under cost minimization, the share of materials in *costs* must equal to a product of their share in *sales* and the price-cost markup. Since the share of materials in sales did not experience a decline, rising markups must lead to the conclusion that the cost share of materials has risen, leading to a lower labor share in the presence of markups. Therefore, any explanation that relies on rising markups must also imply an independent effect on the labor share through our suggested mechanism.

proposed mechanism.



(a) Cost-reallocation from labor to materials **(b)** Cost-reallocation and material prices

Figure 4: Cost reallocation from labor to materials. Panel (a) shows the ratio of labor compensation and expenditure on materials in the U.S. manufacturing sector over time (dashed red line) and the manufacturing labor share of value-added (solid line) from the KLEMS data. Panel (b) shows the same cost ratio against the output-weighted log. ratio of material prices to output prices.

We now turn to explore our mechanism across narrowly defined manufacturing industries, and later explore it across U.S. local labor markets. Our point of departure is Proposition 1 in the theoretical section. We are interested in the elasticity of the labor share to the price of materials, and we estimate the following regression specification:

$$\log \lambda_{jt} = \alpha + \beta \times \frac{M_{j,0}}{VA_{j,0}} \times \log p_{m,jt} + X_{jt}\gamma + \delta_j + \delta_t + \epsilon_{jt} \tag{4}$$

where j denotes an industry, t denotes time, λ_{jt} is the industry-level labor share, $\frac{M_{j,0}}{VA_{j,0}} \times \log p_{m,jt}$ is our regressor of interest that consists of the interaction between the price of materials for industry j in period t and the ex-ante materials intensity in an initial period. We control for other time-varying industry variables in X_{jt}, industry fixed-effects δ_j, and time fixed-effects δ_t, with an error term ϵ_{jt}.

The error term in this equation might contain the prices of other inputs - labor and capital - and terms that capture factor-specific technical changes that are not accounted for by the set of fixed effects. Whenever changes in the price of intermediates are correlated with changes in the technological parameters of the production function or with changes in other inputs, our estimates will be biased. In addition, the error term is likely to reflect measurement errors which are common for industry-specific price indices. To establish causality, we first control for other factor prices – namely, the wage level and the cost of capital, proxied by the price of investment goods – in addition to the set of fixed effects described above. Since factor-specific technical changes might not be fully captured by these controls, we develop an instrumental variable strategy that exploits variation in the prices of a particular subset of intermediate inputs: primary commodities that are globally traded. This instrument is valid as long as narrowly-defined U.S. manufacturing industries are price takers in the global commodity markets.

3.3 Data Sources

In order to estimate Equation 4, we rely on data from three main sources. We use the NBER-CES Manufacturing Industry Database (Becker, Gray, and Marvakov 2021) to obtain a yearly panel of detailed industry-level information on value added, revenues, employment, payroll, capital expenditure, energy and materials cost, and various industry-specific price indices. The database covers all 361 6-digit 2012 North American Industrial Classification System (NAICS) U.S. manufacturing industries. We construct the labor share as the ratio of payroll to value added. Note that some shortcomings of this data imply that the level of the labor share is too low and its decline is too fast relative to the U.S. national accounts.[16] However, despite this shortcoming in measuring the aggregate labor share, it is still useful for comparing trends across different industries.

We follow Fally and Sayre (2019) in defining a list of commodities that correspond to a significant share of the total global commodity trade, and obtain Trade Unit Values for the period between 1991-2016 from UN-COMTRADE.[17] We end this analysis in 2016 since the NBER manufacturing panel lacks some key variables for 2017-2018. We use these trade unit values as a proxy for the global prices of the commodities in this list. We construct this proxy by diving the total value of imports of each commodity by the total quantity imported in a given year by the U.S.. Finally, we use the 1997 BEA Input-Output table for the U.S. Economy to create measures of direct and indirect exposure to commodity prices at the industry level.[18]

[16] This is because the payroll variable captures a narrow definition of labor compensation, and the materials variable excludes some forms of intermediates. For further details, we refer readers to our Online Appendix, Section A.

[17] See `https://are.berkeley.edu/~fally/Data/commodity_names.xlsx` for the commodity list.

[18] Retrieved from `https://www.bea.gov/industry/input-output-accounts-data`. We choose this version of the

Finally, as part of our robustness assessments, we introduce other control variables in our regressions which are not in the NBER-CES dataset. We include a control for the industry-level import penetration ratio which is constructed as the ratio of industry imports over domestic absorption, defined as shipments minus net-exports. Industry level trade flows (exports and imports) are obtained from Peter Schott's trade data and from the Census Bureau U.S.A Trade Online portal.[19] In some specifications we include industry concentration controls, taken from the Concentration Subject Series of the U.S. Economic Census for the years 1997, 2002, 2007, 2012.

3.4 Constructing Commodity Intensity and Price Shocks

We start by computing the expenditure share of industry j on commodity k out of j's total cost of labor and intermediate inputs. Since we lack expenditure data at the specific commodity level, we proxy it by industry j's expenditure on the industry that produces commodity k in the input-output tables, assigning equal weights to different commodities produced by the same industry. Let $M_{jk,1997}$ be the expenditure of industry j on commodity k in 1997; $M_{j,1997}$ be industry j's total expenditure on intermediates in 1997; and $W_{j,1997}$ be industry j's total labor compensation in 1997. Then, the expenditure share of industry j on commodity k which we denote as $\omega_{jk,1997}$ corresponds to

$$\omega_{jk,1997} \equiv \frac{M_{jk,1997}}{M_{j,1997} + W_{j,1997}}. \tag{5}$$

Next, we define industry j's commodity intensity as its total expenditure on commodities out of its total cost of labor and intermediate inputs. We compute this measure by summing over $\omega_{jk,1997}$ across all the commodities considered:

$$\theta^{comm}_{j1997} \equiv \sum_k \omega_{jk,1997}. \tag{6}$$

This variable captures the potential exposure of each industry to changes in commodity prices, but does not utilize realized changes in the prices. To compute a measure of the commodity price shock, we now combine the weights in Equation 5 with the

Input-Output tables since its the first detailed NAICS-based table available. Additionally, it predates the large increase in the price of commodities which starts in the early 2000s, and offers straightforward concordances to the 2012 NAICS classifications.

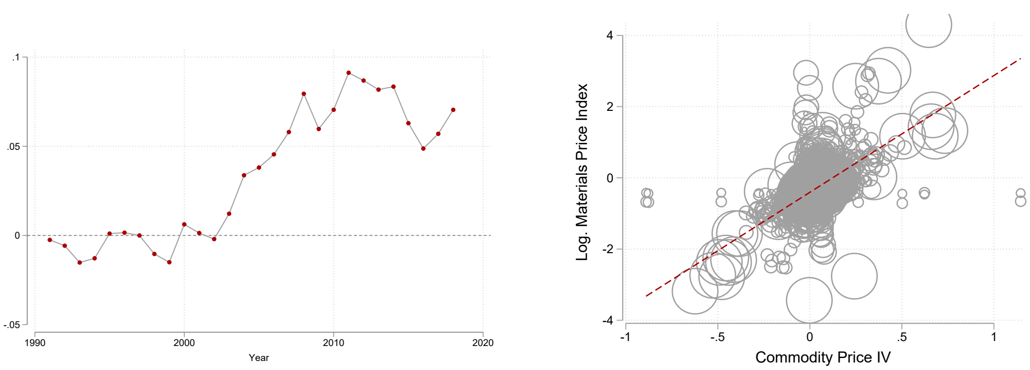
[19] See faculty.som.yale.edu/peterschott/sub_international.htm

commodity prices described above to the following "shift-share" instrument:

$$\log p_{jt}^{comm} \equiv \sum_{k} \omega_{jk,1997} \log \left(price_{k,t}\right) \tag{7}$$

The variable $\log p_{jt}^{comm}$ is a weighted average of the log. price of commodities, using the commodity cost shares of industry j as weights. In contrast to the exposure measure in Equation 6, this shift-share measure leverages both the heterogeneous changes in the price of commodities during our period of study and the differential exposure at baseline of each manufacturing industry to these commodities. We use $\log p_{jt}^{comm}$ as an instrument for the industry-level materials price index.

Figures 5a and 5b show that our measure of the industry-level commodity price shocks, $\log p_{jt}^{comm}$, exhibits a sensible behavior. The first figure plots the time series for the average commodity price shock computed according to Equation 7 and displays the same dynamics as the aggregate commodity and manufacturing intermediates prices, e.g., in Figure 1. The second figure shows the relationship between our measure of the commodity price shock at the industry level and the log. of the NBER-CES materials price index over the period 1991-2016, after controlling for industry and year fixed effects. As shown, there is a clear positive correlation between these variables.[20]



(a) Average Commodity Price Shock

(b) Commodity and Materials Prices

Figure 5: Commodity Cost Shock Measure. Panel (a) shows our commodity cost shock measure (Equation 7) over time, averaged across industries and weighting by value added in 1990. Panel (b) plots the log of the industry materials price index between 1991-2016 against our shift-share instrumental variable after controlling for industry and year fixed effects. Each circle is an industry-year pair, and the size indicates value added in 1990. The dashed line is a value added weighted linear fit.

[20]We provide additional information on our sample and treatment variable in our Online Appendix. In particular, Table D.1 reports the commodities with the largest price increases. Table D.2 reports the industries that experienced the largest change in $\log p_{jt}^{comm}$ in our years of study.

The rationale for our instrument is rooted in the main narrative for the 2000s commodities boom. While many factors have likely contributed to rising commodity prices over this period, it is widely believed that rising demand for materials from emerging economies, and in particular China, is the leading cause.[21] This view is supported by the repeated failures of analysts in forecasting the extent of China's growth over the 2000s, suggesting an interpretation that the global supply of commodities was slow to adjust to the sequence of unexpected demand shocks. This narrative raises the potential concern that the negative materials supply shock to U.S. industries might have been correlated with other implications of China's growth, such as import competition or rising demand in product markets. Therefore, we also control for these alternative trade exposure measures in X_{jt}. Moreover, in line with past literature, we find no evidence for a relationship between these alternative demand-side exposure measures to China's growth and the labor share. Finally, we find essentially no correlation between these alternative measures and our instrument.[22]

3.5 The Effect of Material Prices on the Labor Share

We now turn to study the relationship between exposure to rising materials prices and the labor share, starting with an investigation of the raw correlations in the data. The left panel in Figure 6 shows the relationship between the log labor share (y-axis) and the exposure to rising materials prices (x-axis) at the industry level between 1991 and 2016, after controlling for year and industry fixed effects. Exposure to rising materials prices is given by the product of ex-ante materials intensity and the log-change in the price index of materials. The right panel replaces the labor share with the ratio of expenditure on materials to the industry wage bill. In line with our theory and the prevalence of complementarities, industries with a larger exposure to the increase in the price of materials experience greater cost-reallocation from labor to materials and a larger decline in their labor share.

Next, we utilize the panel structure of the data to perform a non-parametric visual investigation of the relative magnitudes and timing of the effect. In this exercise, we

[21] Carter, Rausser, and Smith (2011), Baumeister and Kilian (2016), Stuermer (2018), Jacks and Stuermer (2020).

[22] In a regression of our instrument on industry-level import penetration from China, export exposure to China, industry and year fixed effects, and the same industry-level controls from our baseline specification, there is no statistically significant relationship between our instrument and import penetration from China (p-value of approximately 0.4) or export exposure to China (p-value of approximately 0.8). See also Autor et al. (2020) for the lack of relationship between the labor share and exposure to import penetration from China.

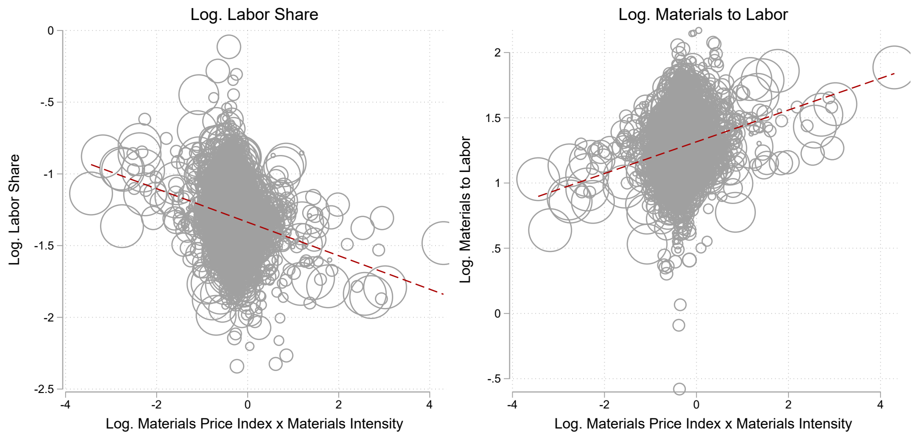


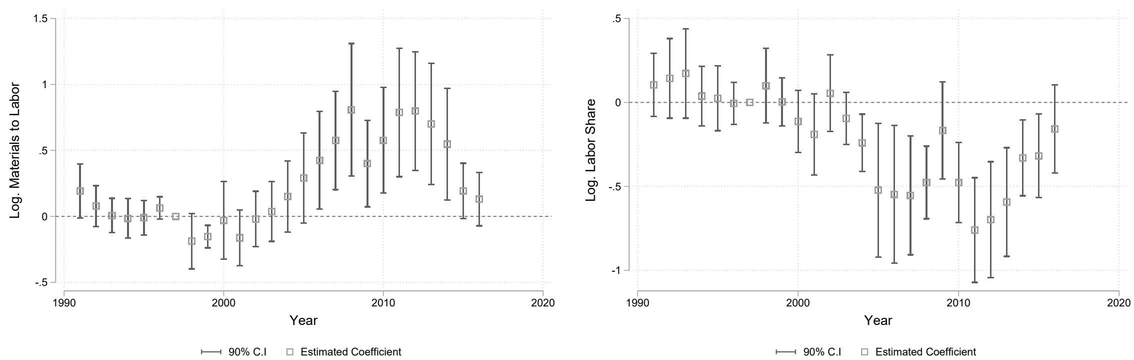
Figure 6: The Relationship Between Material Prices and Industry Outcomes. The left panel shows the relationship between the log labor share (y-axis) and the exposure to materials prices (x-axis) at the industry level between 1991 and 2016, after controlling for year and industry fixed effects. Exposure to materials prices is given by the product of ex-ante materials intensity and the log-change in the price index of materials. The right panel shows the ratio of expenditure on materials to the industry wage bill in the y-axis. Each circle is an industry-year pair, and the size indicates value added in 1990. The dashed line is a value added weighted linear fit.

do not rely on variation in prices, and demonstrate how variation in the commodity cost shares of an industry prior to the 2000s boom explains the path of its labor share and relative expenditure on materials. Specifically, we estimate the following specification akin to an event-study:

$$y_{jt} = \delta_t + \delta_j + \sum_{\ell=1991, \ell \neq 1997}^{2016} \beta_\ell \mathbf{1}\left[\ell = t\right] \times \theta_{j1997}^{comm} + \epsilon_{jt} \tag{8}$$

where θ_{j1997}^{comm} is the commodity cost share of industry j in the 1997 Input-Output Table defined in Equation 6. Our coefficients of interest are β_ℓ which flexibly estimate the effect of baseline industry commodity intensity on the outcome of interest in each year between 1991 and 2016 setting 1997 as the omitted year. This specification is informative on the dynamics as it provides information on the timing and the persistence of the effects. We again control for year and industry fixed effects.

Figure 7a shows the above specification for the case of expenditure on materials relative to expenditure on labor in logs. Industries with higher ex-ante exposure to commodities experienced an increase in the expenditure on materials relative to labor during the 2000s, coinciding with the timing of the rise in commodity prices. Recall that this specification does not use any information on prices, indicating that an industry's ex-ante reliance on commodities is a key characteristic for the path of its allocation of costs across inputs during the covered period. In addition, it provides further evidence for complementarities between labor and materials.



(a) Material-to-Labor Expenditure Ratio.

(b) Labor Share.

Figure 7: The Effect of Commodity Intensity on Materials-to-Labor Expenditure Ratio and on the Labor Share. Panel (a) plots the set of coefficients β_ℓ from the estimation of Equation 8, when the outcome variable is industry-level log expenditure on materials relative to expenditure on labor. Panel (b) plots the set of coefficients β_ℓ from the estimation of Equation 8, when the outcome variable is industry-level log labor share. The blue lines capture a 90% confidence interval.

Figure 7b shows the coefficients from estimating Equation 8 for the log labor share as the outcome. The plot shows that industries with higher ex-ante commodity intensity experienced a larger relative decline in their labor share. As before, this trend perfectly coincides with the timing of the large increase in commodity prices. The figure also shows that this decline was briefly overturned in 2009 during the Great Recession.

Taken together, Figures 7a and 7b indicate that during the 2000s, material- and commodity-intensive sectors experienced a set of manifestations consistent with the model outlined in Section 2. We should expect these patterns to occur following an increase in the price of materials when materials and primary inputs are complements, and there are positive markups.

We now turn to estimate the causal effect by relying on differential variation in material prices induced by changes in prices of specific commodities. To this end, we instrument the industry-level price index of materials with the measure defined in Equation 7, and estimate the regression specification in Equation 4. In all specifications, we cluster standard errors at the industry level. We focus on the years

1991-2016 in which all of the required data is available.

Table 1 presents results for regressing the yearly log labor share for each industry on the log of input prices multiplied with materials intensity using the identification strategy and the specification detailed in the previous subsections. Columns (1) and (2) present unweighted OLS results for regressions that include only our regressor of interest, and that control for other input prices (average wages and the price of investment goods), respectively. Columns (3) and (4) present unweighted 2SLS results for the same specifications. The coefficient on the log price of materials is negative and significant both statistically and economically in the four cases, and including controls for the prices of the other inputs does not change the estimate. In line with our earlier discussion, the OLS result is closer to 0, hinting towards an attenuation bias due to mismeasurements in the price index of materials. Columns (5) to (8) provide robustness checks, weighting by industry value added in 1990 and adding additional controls for the capital-labor ratio, the share of production workers, and changes in import penetration. Nevertheless, the coefficient remains remarkably stable at around -0.17 to -0.19. This estimate implies that a 1% increase in the price of materials, all else equal, reduces the manufacturing labor share by around 0.18%, for an industry with the average materials intensity.

3.6 Evidence from local labor markets

As an additional source of variation, we repeat our analysis for U.S. local labor markets. We construct a panel of 525 commuting zones. We combine county-level data from the BEA Regional Economic Accounts and the Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW). Using these data we construct regional manufacturing labor shares for each of the commuting zones in our sample. To construct commuting zone level materials price indices, we average the prices of different manufacturing industries according to their ex-ante weight in the regional economy. Similarly, we construct our commodity shock instrumental variable at the regional level by weighting the industry-level commodity shocks using the same region-industry weights. We run this analysis for the years 2001-2016, since 2001 is the first year with county-level GDP in the BEA data, and 2016 is the last year with investment prices in the NBER data.

Table 2 replicates Table 1 from the cross-industry analysis for this sample of

Table 1: The Effect of Material Prices on the Labor Share

Outcome: Industry Log Labor Share	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS	(8) 2SLS
Materials Intensity × Log. Materials Price	-0.132***	-0.135***	-0.218***	-0.227***	-0.176***	-0.190***	-0.191***	-0.189***
	(0.0212)	(0.0219)	(0.0405)	(0.0443)	(0.0216)	(0.0281)	(0.0245)	(0.0241)
Log. Average Wage		-0.0335		-0.0148		0.0603	0.0227	0.0284
		(0.0742)		(0.0753)		(0.149)	(0.145)	(0.135)
Log. Investment Price		0.0421		0.223		0.318*	0.492**	0.543**
		(0.115)		(0.145)		(0.184)	(0.191)	(0.219)
Log. Capital-Labor Ratio							0.0771*	0.0602
							(0.0413)	(0.0400)
Production Workers Share							-0.635**	-0.643**
							(0.259)	(0.269)
Import Penetration								0.0225
								(0.0502)
Import Penetration - China								0.172
								(0.134)
First-stage F-stat (KP-Wald)			17.20	16.21	55.50	40.78	37.80	37.20
N	9386	9386	9386	9386	9386	9386	9386	9386
Industry and Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weighted	No	No	No	No	Yes	Yes	Yes	Yes

Notes: This table reports results from the regression of industry-level log labor shares on the log of the price index of materials multiplied by the materials intensity in 1990. Observations correspond to industry-year pairs for the 361 NAICS industries in the NBER-CES dataset for the period between 1991 and 2016. All specifications control for industry and year fixed effects. Column (1) and (2) report OLS results. Columns (3) to (8) instrument the log. of the materials price index with the instrumental variable detailed in Expression 7. Columns (5) to (8) are weighted by the value added of the industry in year 1990. Column (7) adds a control for the log of the capital-labor ratio and the share of production workers in the industry, and Column (8) adds import penetration - from China and overall. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

local labor markets. Rather than controlling for industry-level characteristics, we now control in Columns (5) and (6) for additional standard regional characteristics, namely the log of total regional employment and the manufacturing share in regional value-added, though these additional controls have no statistically significant impact on the outcome. Similarly to Table 1, Column (6) controls for import penetration (both overall and from China specifically). The results are highly consistent with those from the cross-industry analysis. The estimated coefficient for the effect of higher exposure to rising materials prices on the labor share is around 0.16-0.17 in all specifications – very close to the obtained estimates in Table 1. This similarity also suggests that local general equilibrium forces do not play an important role relative to our partial equilibrium mechanism in the dynamics of the labor share.

Table 2: The Effect of Material Prices - Variation from Local Labor Markets

Outcome: Log Labor Share	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS
Materials Intensity × Log. Materials Price	-0.149**	-0.164***	-0.166***	-0.163***	-0.166***
	(0.0697)	(0.0401)	(0.0487)	(0.0483)	(0.0477)
First-stage F-stat (KP-Wald)		28.49	37.54	37.67	38.50
N	8400	8400	8400	8400	8400
Average Wage and Investment Price Controls	Yes	Yes	Yes	Yes	Yes
Controls for regional employment and manuf. share	No	No	No	Yes	Yes
Controls for import penetration	No	No	No	No	Yes
Region and Year FE	Yes	Yes	Yes	Yes	Yes
Weighted	No	No	Yes	Yes	Yes

Notes: This table reports results from the regression of the log manufacturing labor share at the commuting-zone level on the interaction of regional materials intensity and the log materials price index in that commuting-zone. Observations correspond to commuting-zone-year pairs for a balanced panel of 525 commuting zones between 2001 and 2016. All specifications control for the log of the average wage and the log of the price of investment, as well as commuting zone and year-fixed effects. Column 1 reports OLS results. Columns 2 to 5 instrument the log. of the materials price index with the instrumental variable detailed in the text. Columns 3 to 5 are weighted by the value added of the industry in the base year. Column 4 adds controls for the log of regional employment and for the share of manufacturing in regional GDP, and Column 5 adds import penetration - from China and overall. Standard errors clustered at the commuting-zone level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

3.7 The 1970s Oil Shocks

We now consider a different natural experiment that provides an alternative source of exogenous variation. In particular, we leverage the significant increase in the price of oil during the 1970s, following the 1973 oil embargo by the Organization of Arab Petroleum Exporting Countries (OAPEC) on the U.S. and Western countries, resulting in a threefold increase in the real price of oil.

To test our mechanism, we run similar regressions as in our baseline setting, but now consider a different instrument. Specifically, we interact the time series for the log of the oil price during this decade (common to all industries) with an industry-specific measure of energy intensity, the ratio of expenditure on energy to the total output in 1972, a year before the oil shock of 1973 took place.[23] The instrument for industry j is defined as

$$\log p^e_{jt} \equiv s_{ej,1972} \log \text{Oil Price}_t, \tag{9}$$

where $s_{ej,1972}$ is the revenue-share of expenditure on energy.

[23] Oil prices are taken from https://www.worldbank.org/en/research/commodity-markets. Energy intensity is constructed using the NBER-CES Dataset.

Table 3 presents results for the estimation of Equation 4 in 1970-1980, instrumenting the materials price index using the instrumental variable defined above. The first four columns replicate the corresponding columns in Table 1 under this new strategy. We continue to find negative and statistically significant effect of materials prices on the labor share, with a large overlap of the confidence intervals with the corresponding estimated effects, despite the different identification strategy. In columns (5) and (6) we control for the interaction of year and 3-digit NAICS sub-sectors fixed effects to utilize only variation within sub-sectors, and find even stronger results.[24]

The aggregate labor share in the 1970s. Despite the large change in oil prices, the aggregate labor share remained relatively stable in the 1970s. To understand this pattern, note that the relative price of the bundle of materials as a whole remained relatively stable in this period, with a much smaller increase than in the 2000s, as can be seen in Figure 1. Accordingly, through the lens of our mechanism, the impact on the labor share should have been small. There are two reasons for the limited pass-through of the 1970s oil shocks into real material prices. First, the commodity boom in this period focused mainly on energy goods, which constitute only 5% of total expenditure on materials in U.S. manufacturing. Second, other factors of production such as labor, experienced rapid price increases as part of the 1970s inflationary environment. While there was sufficient variation across industries in this period to identify our mechanism, the overall increase in the relative price of materials was small, suggesting small aggregate implications to the labor share.

3.8 Structural Interpretation and Aggregate Quantification

We now use our baseline estimates to evaluate the aggregate importance of our mechanism and to provide a structural interpretation for our reduced-form estimate of β from Equation 4.

We now relate the estimates in Table 1 to the structural parameters from Section 2 under our baseline specification for the production function. From Equation 3, β depends on the elasticity of substitution between materials and non-materials, σ, and

[24] We do not replicate Column (8) in Table 1 in the 1970s due to lacking trade data. Note that for the baseline exercise, we control for sub-sector specific trends in the robustness Section 3.9.

Table 3: The Effect of Material Prices on the Labor Share - 1970s Oil Shock

Outcome: Industry Log. Labor Share	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS
Materials Intensity × Log. Materials Price	-0.0384**	-0.219***	-0.167***	-0.168***	-0.233***	-0.234***
	(0.0183)	(0.0739)	(0.0551)	(0.0550)	(0.0784)	(0.0780)
First-stage F-stat (KP-Wald)		5.299	2.185	2.300	7.075	7.873
N	3971	3971	3971	3971	3971	3971
Average Wage and Investment Price Controls	Yes	Yes	Yes	Yes	Yes	Yes
Production Workers Share and K/L Ratio Controls	No	No	Yes	No	Yes	Yes
Industry and Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry and Year × Sector FE	No	No	No	No	Yes	Yes
Weighted	No	No	Yes	Yes	Yes	Yes

Notes: This table reports results from the regression of industry-level labor shares on the log. of the price index of materials multiplied by the materials intensity, the log. of the average wage and the log. of the price of investment goods. Observations correspond to industry-year pairs for the 364 NAICS industries in the NBER-CES dataset for the period between 1970 and 1980. Specifications in columns (1) to (4) control for industry and year fixed effects. Specifications in columns (5) and (6) control for industry fixed effects and the interaction of year and 3-digit NAICS sub-sectors fixed effects. Column (1) reports OLS results and Columns (2) to (6) instrument the log. of the materials price index with the instrumental variable detailed in Expression 9. All regressions are weighted by the value added in 1972. Columns (4) and (6) add a control for the log. of the capital-labor ratio and the share of production workers in the industry. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

the price-cost markup, μ, as follows

$$\beta \equiv \frac{d\log\lambda}{\frac{M}{Y}d\log p_m} = (\mu - 1)(\sigma - 1). \tag{10}$$

In Figure 8a, we plot the implied relationship between μ and σ, using the estimate for β in Column (8) of Table 1. We find that our estimate for β can be rationalized by multiple combinations of σ and μ. If manufacturing markups are in the range of 1.15 to 1.45, then through the lens of our estimates, the implied elasticity of substitution is in the range of 0.0 to 0.6. For comparison, the point estimate for σ in Peter and Ruane (2022) is around 0.6, whereas it is close to 0 in Boehm et al. (2019).

We now provide a calculation of the importance of our mechanism for the aggregate manufacturing sector. To this end, we construct a path for counterfactual changes in the labor share that shuts down our mechanism, by taking the difference between actual changes in the labor share and the changes that would be implied by our mechanism. We compute the latter as the product of our estimate for β, the baseline materials intensity M_0/Y_0, and the change in the log price of materials.[25] We deflate

[25] More specifically, we compute $d\log\lambda_t^{CF} = d\log\lambda_t - \hat{\beta} \times \frac{M_0}{Y_0} \times d\log p_{m,t}^{norm}$, where λ_t^{CF} is the counterfactual labor share in period t; λ_t is the actual labor share; β is our estimated coefficient from Equation 4; and $\log p_{m,t}^{norm}$ is the deflated price of materials.

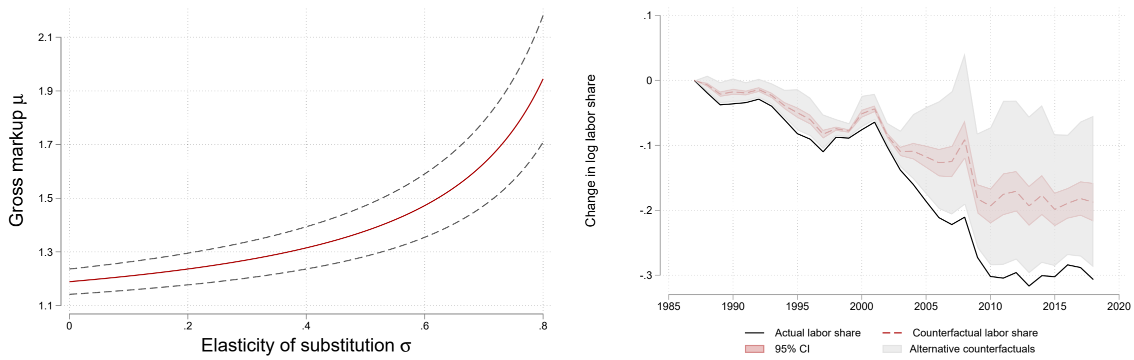
the price index of materials by the price index for value-added, to account for changes in prices of other factors and technology. We implement this exercise for the baseline manufacturing labor share in the BEA-KLEMS data, to be in line with the U.S. national accounts, and focus on all available years in the KLEMS data. Figure 8b plots these counterfactual changes in the log labor share against the factual labor share over time. The red-dashed line is the counterfactual based on our point estimate for β, and the red-shaded area captures the 95% confidence interval. While the counterfactual and the actual labor share are closely aligned before the 2000s, there is an apparent divergence between them in the period of the commodities boom. Overall, according to this quantification, the decline in the labor share is smoother absent our mechanism, and approximately 25%-30% smaller in the long run.

We also consider a range of alternative counterfactuals that replace our estimate with an evaluation of Equation 10 based on different values for σ and μ from the literature ($\sigma \in (0.0, 0.7)$ and $\mu \in (1.1, 1.4)$). This set of alternative counterfactuals is captured by the gray-shaded area. Evidently, when interpreting our reduced-form findings using Equation 10, the importance of our mechanism is sensitive to the exact chosen values for σ and μ. In the extreme case that implies the lowest elasticity of the labor share to the price of materials (low μ and high σ – the lowest edge of the gray-shaded area), it accounts for slightly above 5% of the long-term decline. However, given the robustness of our point estimate across multiple specifications and sources of variation, we view the red-shaded area as the most plausible counterfactual.

3.9 Extensions and Robustness Checks

We now turn to a series of robustness checks and extensions of our results. For brevity, we provide only the main highlights and refer readers to our Online Appendix for additional details.

Other Industry Outcomes. We explore the effect of materials prices for other industry outcomes on top of the labor share (Table D.3). In line with our mechanism, we find that a higher price of materials leads to an increase in the ratio of materials to value-added; and to an increase in expenditure on materials relative to the total cost of labor and relative to expenditure on capital (as proxied by the stock of capital after controlling for industry-specific investment prices). Moreover, the increase in expenditure on materials relative to labor and capital is higher than relative to value-



(a) Implied relationship between σ and μ

(b) Counterfactual labor share

Figure 8: Structural Interpretation and Counterfactual Labor Share. In Panel (a), we plot the estimated relationship between markups and the elasticity of substitution between materials and primary inputs according to $\hat{\beta} = -0.189$ from Column (8) of Table 1 (solid red line), with 95% confidence interval in-between the dashed gray lines. In Panel (b) we plot the actual change in the log manufacturing labor share relative to 1987 (solid-black line) and the counterfactual labor share that shuts down our mechanism as described in Section 3.8, using data on U.S. manufacturing from BEA-KLEMS. The dashed-red line captures our baseline value for this counterfactual as implied by our point estimate for β. The red-shaded area captures the 95% confidence interval. The gray-shaded area encompasses a range of alternative counterfactuals that evaluate Equation 10 based on values for $\sigma \in (0.0, 0.7)$ and $\mu \in (1.1, 1.4)$ that deviate from our estimates.

added, in line with the logic that it raises the profit share of value-added. These effects are consistent with the discussion in Section 2.2 and the implications of Figure 2. Finally, we find no effect of materials prices on capital-labor ratios, suggesting that the production function in Equation 1 is a good approximation for the data.

Sectoral Trends. In this robustness exercise, we restrict the source of variation further by considering only differential exposure to commodities within NAICS 3-digit sub-sectors (Table D.4). This allows us to alleviate concerns that despite our focus on homogeneous globally-traded commodities, our instrument is still correlated with sectoral factor-augmenting shocks. We add year fixed effects specific to each 3-digit sub-sector to our baseline specification and continue to find statistically significant and quantitatively similar results.

Heterogeneous effects. We allow for heterogeneous effects in our analysis across NAICS 3-digit subsectors by interacting our baseline treatment with an indicator variable for each subsector (Figure D.4). The negative effect of rising materials prices on the labor share is prevalent across most manufacturing subsectors.

BEA Data and Sourced Services. As discussed above, one limitation of the NBER-CES dataset is the low values of payroll relative to total labor compensation.

We consider a replication of our baseline results in Table 1 using more aggregate data from the BEA-KLEMS dataset (Table D.5). While providing significantly less granular data for only 19 manufacturing sub-sectors, this dataset includes superior estimates for total employment compensation and intermediate inputs including sourced services. The results remain very similar to our baseline specification.

The structure of the BEA-KLEMS dataset also allows us to control for the role of rising outsourcing of services as a confounding explanation, which might also increase the expenditure share on intermediates relative to labor and lead to a decline in the labor share. We add the share of outsourced services out of total intermediates and the price index of services as controls (Columns (6) and (7) in Table D.5). The effect of materials prices remains negative and statistically significant, and if anything becomes quantitatively stronger. Note that an alternative explanation based on greater outsourcing of goods (and not services) is not likely to play an important role in recent decades since it should imply a decline in the relative price of materials inputs, and not an increase as observed in the data.

Accounting for Input-Output Linkages. We augment our instrument to capture both the direct and indirect effect of commodity prices though input-output linkages, by constructing the shares ω_{jk} from the Leontief Inverse matrix (Table D.6). We continue to find very similar results to our main specification.

Utilizing only Variation in Prices. Following Borusyak, Hull, and Jaravel (2022) we consider only variation from shifts in prices, controlling for total reliance on commodities across industries. To this end, we divide the instrument by the total commodity cost share from Equation 6 (Table D.7). The estimate remains negative and quantitatively similar, though as expected, more noisy.

The Role of Industry Concentration. A prominent explanation for the decline of the labor share in the literature is rising industry concentration, e.g. in Autor et al. (2020). We add to our baseline analysis two industry concentration measures - the log of the HHI (Herfindahl-Hirschman index) for the top 50 firms and the sales-share of the top 4 firms in each industry (Table D.8). A negative relationship between concentration and the labor share emerges, in line with the existing literature. Nevertheless, the effect of material prices remains virtually unchanged. Moreover, multiplying the coefficient on industry measures by the average change in them over 1997-2012 suggests a smaller role for changes in concentration than for changes in material prices, largely due to the small change in concentration in the average manufacturing industry over this period.

A second insight from this literature is that the labor share did not decline for the median manufacturing establishment. While we lack data to investigate it directly, this pattern is completely consistent with our mechanism, in which an ex-ante higher profit-share (i.e., lower labor share) is required for a strong pass-through of material prices into the labor share. Since the typical establishment makes little or no profits, it should experience no change in its labor share following a shock to material prices, and the trend should be concentrated at establishments with ex-ante low labor shares.

4 General equilibrium multi-sector model

We now develop a quantitatively oriented, multi-sector, general equilibrium model and use it to assess the importance of spending on materials the aggregate changes in the U.S. labor share. This serves as a complementary approach to our reduced-form quantification in Section 3.8.

4.1 Setup

Preferences and endowments. Households consume goods of N sectors and maximize a Cobb-Douglas utility function

$$U = \prod_{i=1}^{N} c_i^{\beta_i}, \tag{11}$$

where β_i is the final-demand expenditure share on sector i. Households are endowed with L units of labor and K units of capital which they rent to producers, and they hold the claims to all profits.

Production. For each sector i, we assume a production function of the class given in Equation 1, taking the form

$$y_i = A_i \left(\left(l_i^{\alpha_i} k_i^{1-\alpha_i} \right)^{\frac{\sigma-1}{\sigma}} + \left(B_i m_i \right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{12}$$

where y_i is the output in sector i; σ is the elasticity of substitution between materials and primary inputs; A_i is total factor productivity; B_i is a technological shifter that captures exogenous changes in materials intensity; and α_i is the intensity of labor in the composite of primary inputs. We assume that the bundle of materials in each sector i combines inputs from all other sectors of the economy with the aggregator

$$m_i = \prod_{j=1}^{N} m_{ij}^{\gamma_{ij}}, \tag{13}$$

where m_{ij} is the amount of materials that sector i sources from sector j and γ_{ij} is the respective expenditure share of sector i on materials from sector j. In addition, we assume that the effective units of inputs that must be sourced from sector j in order to supply m_{ij} units to sector i is m_{ij}/τ_i, where τ_i serves as a wedge in the sourcing process of sector i, on which we elaborate further below.

Prices. We assume that firms in each sector i charge an exogenous markup μ_i over marginal costs. The price of sector i's output, p_i, is given by

$$p_i = \frac{\mu_i}{A_i}\left(\left(w^{\alpha_i} r^{1-\alpha_i}\right)^{1-\sigma} + B_i^{\sigma} p_{m,i}^{1-\sigma}\right)^{\frac{1}{1-\sigma}}, \quad p_{m,i} = \tau_i \prod_{j=1}^{N} p_j^{\gamma_{ij}} \tag{14}$$

where w and r are the prices of labor and capital, respectively. Note the appearance of τ_i in the formula for $p_{m,i}$, which allows us to match variation in materials prices for each sector that cannot be explained by the appropriately weighted average of output prices in all other sectors. As such, this wedge captures, in a reduced-form, frictions in the sourcing process for sector i, as well as the possibility of sector i to source materials from abroad.

Factor shares. We denote the share of materials in total costs for sector i by $\theta_{m,i}$, which is given by

$$\theta_{m,i} = \frac{B_i^{\sigma} p_{m,i}^{1-\sigma}}{\left(w^{\alpha_i} r^{1-\alpha_i}\right)^{1-\sigma} + B_i^{\sigma} p_{m,i}^{1-\sigma}}. \tag{15}$$

The shares of labor and capital in total costs are thus given by $(1-\theta_{m,i})\,\alpha_i$ and $(1-\theta_{m,i})\,(1-\alpha_i)$, respectively. Finally, the labor share of value added is given by

$$\lambda_i = \alpha_i \frac{1-\theta_{m,i}}{\mu_i - \theta_{m,i}}. \tag{16}$$

4.2 Equilibrium

The equilibrium conditions can be summarized by the following set of equations. First, market clearing for the local output of sector i is given by

$$x_i = \sum_{j=1}^{N} \left(\beta_i \left(1 - \frac{\theta_{m,j}}{\mu_j} \right) + \gamma_{ji} \frac{\theta_{m,j}}{\mu_j} \right) x_j \tag{17}$$

where x_i is total sales for sector i. Firms in every other sector j spend a share $\gamma_{ji}\frac{\theta_{m,j}}{\mu_j}$ of their total revenues x_j on materials from sector i. A share $1-\frac{\theta_{m,j}}{\mu_j}$ of sector j's revenues turns into local value added, out of which a share β_i is spent on sector i.

Second, labor market clearing is given by

$$\sum_{i=1}^{N} \alpha_i \left(1-\theta_{m,i}\right) \frac{x_i}{\mu_i} = wL, \tag{18}$$

indicating that labor income wL must equal expenditure on labor across all sectors, given by $\alpha_i \left(1-\theta_{m,i}\right) \frac{x_i}{\mu_i}$ for each sector i.

Third, capital market clearing is given by

$$\sum_{i=1}^{N} \left(1-\alpha_i\right)\left(1-\theta_{m,i}\right) \frac{x_i}{\mu_i} = rK, \tag{19}$$

indicating that capital income rK must equal expenditure on capital across all sectors, given by $\left(1-\alpha_i\right)\left(1-\theta_{m,i}\right) \frac{x_i}{\mu_i}$ for each sector i.

4.3 Mapping the Model to the Data

We map the model into 23 sectors of the U.S. economy: 19 manufacturing 3-digit NAICS sub-sectors, as well as aggregated sectors for mining, agriculture, services, and the U.S. government.[26] We recover the parameters of the model for each year between 1987-2019, in line with the availability of the KLEMS data. We take the

[26] Although there are 21 3-digit NAICS subsectors, in the Use Tables the BEA collapses subsectors 311 and 312 into a single subsector 311FT; and 313 and 314 into 313TT.

input-output coefficients γ_{ij} from the Annual Use Tables from the BEA Input-Output Accounts Data, setting the 1987-1997 coefficients to their level in 1997. We compute the final demand coefficients, β_j, as final use expenditure shares for each industry, and adjust them to ensure consistency with Equation 17 in our model.[27] We normalize the aggregate endowments of labor and capital to one, such that the prices of labor and capital capture total labor income and capital income, without taking a stance on their per-capital values or how are they distributed. We invert the materials cost wedge τ_i such that the relationship $p_{m,i} = \tau_i \prod_{j=1}^{N} p_j^{\gamma_{ij}}$ holds for each sector, given data on sectoral output prices and sectoral materials prices.

We are left to determine the elasticity of substitution σ and four vectors of sector-level fundamentals: the share of labor in the bundle of primary inputs α_i, sectoral gross markups μ_i, sectoral TFP A_i, and materials intensity B_i. We set the first year in the BEA-KLEMS data – 1987 – as our baseline year. For this baseline year, we recover these objects under assumptions that require us to take a stance on the value of the average markup in the economy and on σ. Then, for all other years, we use the structure of the model and sector-level empirical moments to recover changes in $\{\alpha_{it}, \mu_{it}, A_{it}, B_{it}\}_{i=1}^{N}$ relative to that baseline year.

For the baseline year, we invoke the following procedure. We assume that the differences between sectoral value added and sectoral wage bills are split between competitive rents to capital and profits by the same proportion across all sectors. We set this proportion such that the average markup in the aggregate economy is 1.25, and assume that $\sigma = 0.4$. Jointly, these values are in line with our reduced-form estimates from Table 1, and align with common values for markups and the elasticity of substitution from the literature. With these values at hand, we get sectoral markups $\mu_{i,0}$ from the implied profit rate of value-added in each sector. We can then recover sectoral fundamentals $\{\alpha_{i,0}, A_{i,0}, B_{i,0}\}_{i=1}^{N}$ from Equations 14, 15, 16, of the model, and using observed data on sectoral output and materials prices; sectoral labor shares; and sectoral materials intensity. Values for the rental rate r and the wage level w are pinned down from the equilibrium of the model.

For all consecutive years, we again rely on Equations 14, 15, and 16 from the model

[27] Note that for each sector, we observe in the data gross-output x_i, the input-output coefficients γ_{ij}, and the sales-shares of materials $s_{m,i} = \theta_{m,j}/\mu_j$. Therefore, we can adjust β_i to ensure that Equation 17 holds for all sectors in the quantified model.

and observed data on sectoral output and materials prices; sectoral labor shares; and sectoral materials intensity. We thus have $3 \times N$ equations and $4 \times N$ unknowns for every year. To identify all sectoral fundamentals, we take an intermediate scenario between two extremes: the first extreme scenario assumes that there is no change in the techonological shifters B_{it} relative to the baseline year, and the second extreme assumes that there is no change in the technological shifters α_{it}. In each of these extremes, we can fully identify all sectoral fundamentals using observed data and the model's equations. Our baseline scenario takes the midway between these two extremes, and we explore the sensitivity of our results to this assumption. We obtain all values for $\{\alpha_{it}, \mu_{it}, A_{it}, B_{it}\}_{i=1}^{N}$ for all years, with three main assumptions: a baseline value for the aggregate markup in 1987; a value for the elasticity of substitution σ and the weight that we put on changes in B_{it} relative to changes in α_{it}. In doing so, we make sure to exactly match changes in the relative price of materials, materials intensity, and the labor share in all sectors, as observed in the data.

4.4 Results

Transmission of sectoral shocks to the labor share. We first use the quantified model to demonstrate how specific shocks to raw materials can propagate and change the labor share throughout the whole economy. To this end, Figure 9 depicts the effect of a negative TFP shock to a single sector in the model economy on the labor share of value-added (red bars) and the materials share of costs (θ_m, gray bars) across all sectors. The left panel considers a negative TFP shock of 25% to the mining sector, raising the output price of that sector. Since mining is an upstream sector that is used either directly or indirectly (through input-output linkages) by all other sectors, it leads to an economy-wide increase in the price of intermediates and the cost-share of materials, and accordingly, to an economy-wide decline in the labor share. The effect is particularly strong for Petroleum and Coal Product Manufacturing since it has a high materials intensity (M/Y) and high exposure to the mining sector, resulting in a strong shock, $(M/Y) \times d\log p_{i,m}$. The middle panel considers a similar shock to Primary Metals Manufacturing, a major consumer of the mining sector. In this case, the shock to upstream sectors is mild, but it is strong for downstream manufacturing sectors such as Motor Vehicles Manufacturing. Finally, the same shock to a downstream sector such as Furniture Manufacturing (right panel) results in almost no change in the cost share of materials or in labor shares.

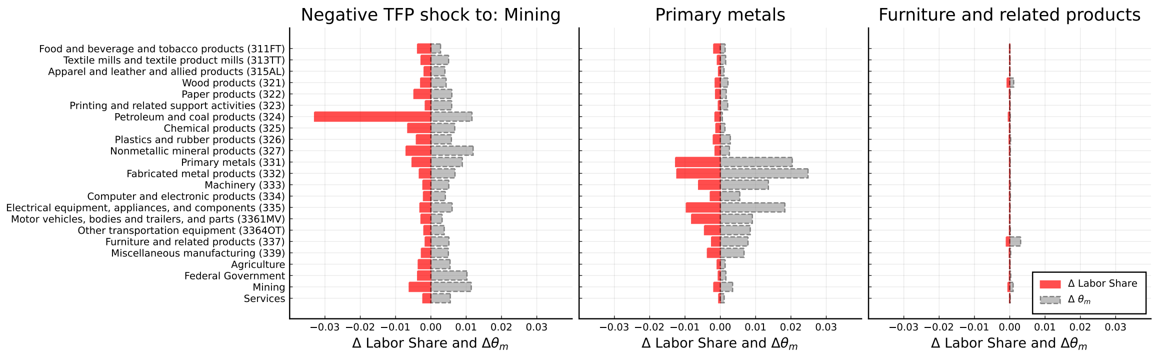
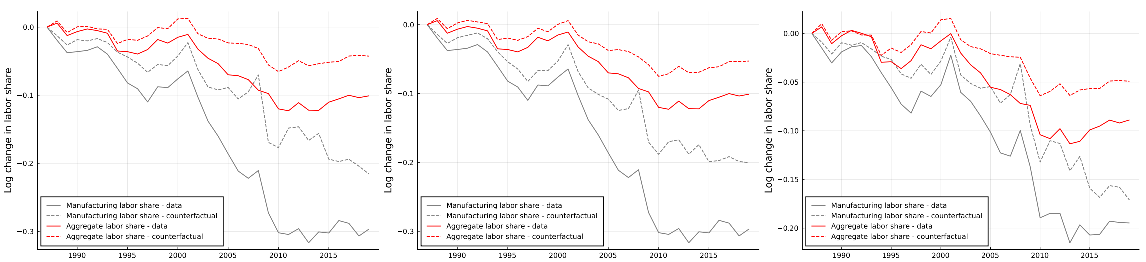


Figure 9: Transmission of sectoral shocks to labor shares. This figure shows how a negative TFP shock to a single sector in the model economy affects the labor share of value-added (red bars) and the materials share of costs (θ_m, gray bars) across all sectors. The left panel considers a negative TFP shock of 25% to the mining sector, keeping everything else constant. The middle panel repeats this exercise in the case of a shock to primary metals manufacturing. The right panel repeats it for furniture manufacturing.

Decomposition of changes in the labor share. We now use our quantified model to identify the importance of our mechanism relative to key alternative narratives from the literature. We consider counterfactual paths for the labor share when holding constant the labor share of primary inputs (α_i) and the markup (μ_i) at their 1987 level for all industries. These parameters capture common alternative explanations to changes in the labor share, such as automation and capital deepening (through changes in α_i), and rising market power and concentration (through changes in μ_i). These counterfactuals isolate the role of changes in the cost shares of materials $\theta_{m,i}$ in the evolution of sectoral labor shares. Through the lens of the model, these changes in $\theta_{m,i}$ result from shocks to the price wedges τ_i and the relative productivity terms A_i and B_i, in line with the stylized general equilibrium examples in Section 2.

We compare these counterfactual paths of the labor share to the data in Figure 10. Solid lines stand for log changes in the factual labor share in the data since 1987 (the first year of the BEA-KLEMS data), for the manufacturing sector as a whole (gray line) and for the aggregate economy (red line). Dashed lines represent the difference between these factual changes and our counterfactual paths of the labor shares that isolate the role of changes in $\theta_{m,i}$. As such, they capture changes in the labor share after eliminating the role of changes in the cost share of materials, $\theta_{m,i}$, while allowing α_i and μ_i to change.

The left panel shows these results for our baseline version, in which the aggregate markup in 1987 stands at 1.25, the elasticity of substitution between materials and primary inputs (σ) is 0.4, and the change in materials-augmenting technical change is halfway between remaining constant and fully rationalizing the data. Absent our mechanism, the decline in the labor share is smaller and smoother, with a milder drop during the 2000s. This residual decline reflects longer-term changes in α_i and μ_i, in line with the secular nature of these other mechanisms. Overall, in this benchmark case, our mechanism can account for around 30% of the decline in manufacturing and an even higher share of the aggregate decline. Moreover, the importance of our mechanism is largest around the peak of the commodity price boom around 2010.



(a) Baseline **(b)** Low markup **(c)** Constant weights

Figure 10: Actual and counterfactual changes in the labor share. This figure shows log changes in the labor share relative to 1987. Solid lines capture changes in the data, and dashed lines capture changes in a counterfactual labor share when isolating the role of variation in the cost share of materials, as described in detail in the text. Red lines show the aggregate labor share, and gray lines show it for the aggregate manufacturing sector. Panel (a) shows our baseline specification as described in the text. Panel (b) considers a more conservative specification with a lower baseline aggregate markup. Panel (c) repeats panel (a) but keeps the distribution of value-added across sectors constant at its 1987 level.

We also consider two alternative specifications as robustness checks. The middle panel considers a conservative scenario with a lower aggregate baseline aggregate markup of 1.1 in 1987. To maintain consistency with our reduced-form estimates which jointly capture the markup and the EoS σ, we set σ to 0.2. This value is on the lower end of the range of elasticities estimated in the literature (see e.g. the estimates in Boehm et al. 2019). Finally, in the right panel, we also consider a version in which the value-added weights used for aggregation are held constant at their 1987 level. This neutralizes any sectoral composition effects, both those that arise from our mechanism – due to reallocation to materials-intensive sectors – and those that are not related to our mechanism. In both of these exercises, the difference between the actual and the counterfactual labor shares are smaller relative to the benchmark, but are still substantial. In addition, in all of them, the counterfactual path of the labor share after isolating changes in the cost-share of materials is smoother and smaller, with a milder drop in the 2000s.

5 Cross-Country Investigation

We now turn to investigating the relationship between materials prices and the labor share in a multi-country setting. This will help to reconcile differences in the dynamics of the labor share across countries,[28] and provide another test of our suggested mechanism. We start by developing a simple multi-country trade model with a global market of materials that provides predictions for our mechanism in an international setting. We then provide evidence that its predictions hold in the data.

5.1 Multi-Country Model

We now present a simple multi-country trade model with a global market for commodities, featuring our mechanism. Detailed derivations can be found in our Online Appendix.

Setting. Consider a world with $N+1$ countries. N countries are industrial, producing output with endowments of labor and capital and with imported raw materials, and trading final goods. The remaining country, indexed by 0, is endowed with the global stock of raw materials and exports them to the rest of the world, lacking industrial capabilities. For simplicity, we assume that each country is endowed with an exogenous measure of F_i identical firms that engage in monopolistic competition.

Preferences. The preferences of the representative consumer in country n are given by a CES utility function across all available varieties:

$$U_n \equiv \left[\sum_{i=1}^{N} F_i {C_{ni}}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \tag{20}$$

where C_{ni} is the amount that country n consumes of the good produced by each firm in country i, and η is the elasticity of substitution across varieties.

Production. Each industrial country is endowed with L_n units of labor and K_n

[28] The literature that studied global trends in the labor share has not reached a conclusion to whether there was a common downward trend. While Karabarbounis and Neiman (2014) and Autor and Salomons (2018) document a decline in the aggregate labor share for a large set of countries - with a particular emphasis on the 2000s - Cette, Koehl, and Philippon (2019) and Gutiérrez and Piton (2020) claim that the existence of a common trend outside of the U.S. is not clear after corrections for income from self-employment and residential housing.

units of capital. Firms engage in monopolistic competition. We again consider our production function of from Section 2

$$y_i = z_i \left(\left(G_i \left(l_i, k_i \right) \right)^{\frac{\sigma-1}{\sigma}} + m_i^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{21}$$

where z_i is a country-specific productivity shock; k_i, l_i and m_i are the amounts of capital, labor and materials employed by country i, respectively; and $G_i \left(l_i, k_i \right)$ is a country-specific composite of capital and labor, taking the following form:

$$G_i \left(l_i, k_i \right) = \psi_i l_i^{\alpha} k_i^{1-\alpha}, \tag{22}$$

where α is the labor-elasticity in the non-materials composite input, and ψ_i is a factor augmenting technological shifter. We allow for trade costs that take the standard iceberg form, in which τ_{ni} units of output are required to ship a single unit of output from country i to country n. We assume that the global supply of materials is perfectly inelastic at $\bar{m}$; that the market for materials is perfectly competitive; and that there are no trade frictions in shipping materials.

Equilibrium in the materials market. Let p^m denote the global price of materials. The market clearing condition for materials can be written as

$$\bar{m} = \sum_i \frac{A_i^{\sigma-1}}{\alpha} L_i \left(\frac{w_i}{p^m} \right)^{\sigma}, \quad A_i \equiv \frac{1}{\psi_i} \left(\frac{1-\alpha}{\alpha} \frac{L_i}{K_i} \right)^{1-\alpha}, \tag{23}$$

where w_i is the wage level in country i. The global supply of materials must equal to a weighted power-mean of the wage to material price ratio in all countries.

The labor share. The labor share of income in country i can be expressed as

$$\lambda_i = \alpha \frac{\left(A_i w_i \right)^{1-\sigma}}{\frac{\eta}{\eta-1} \left(A_i w_i \right)^{1-\sigma} + \frac{1}{\eta-1} \left(p^m \right)^{1-\sigma}}. \tag{24}$$

Note that when the markups are eliminated ($\eta \to \infty$), the λ_i becomes the "neoclassical" labor share α, and when the elasticity of substitution σ equals to 1, λ_i becomes independent of the prices of materials. Otherwise, it depends on the ratio of material prices and the prices other inputs, captured here by the wage level w_i. Alternatively, it can be expressed in terms of the empirically-measurable domestic output price p_i:

$$\lambda_i = \alpha \frac{\eta - 1}{\eta + \left[\left(\frac{\eta}{\eta-1} \frac{1}{z_i} \frac{p^m}{p_i} \right)^{\sigma-1} + 1 \right]^{-1}}, \tag{25}$$

where p_i is given in the model by $p_i = \frac{\eta}{\eta-1} \frac{1}{z_i} \left((A_i w_i)^{1-\sigma} + (p^m)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$. Therefore, when $\sigma < 1$, the labor share in country i is negatively related to the relative price of materials in that country p^m/p_i, even when there is a global freely-traded commodity market and all countries face a similar price of materials.

Comparative statics. We consider two types of shocks to the above system, representing the common narratives for the 2000s commodity boom. For convenience, we set the price of materials p^m as the numéraire, so that wages are measured in terms of material inputs, and a higher wage w_i captures lower relative price of materials p^m/p_i. Using equations 23 and 24, we can rewrite the market clearing for materials in terms of the labor shares in all countries:

$$\bar{m} = \frac{1}{\alpha^{\alpha} (1-\alpha)^{1-\alpha}} \sum_i \frac{L_i^{\alpha} K_i^{1-\alpha}}{\psi_i} \left(\frac{1}{(\eta - 1)\, \alpha\, (\lambda_i)^{-1} - \eta} \right)^{\frac{\sigma}{1-\sigma}}. \tag{26}$$

Equation 26 reveals that the labor share remains constant if the global supply of materials $\bar{m}$ grows in the same rate as the composite of labor and capital in all countries. When the global supply of materials declines relative to these endowments, the global labor share shrinks on average. However, there is ambiguity with respect to patterns in specific countries, and in any case the decline is not homogeneous and depends on their initial labor share, endowments of L_i and K_i, and factor-bias ψ_i.

Next, consider a shock to productivity z_j in some country j. Since a higher z_j raises the marginal product of labor and L_j is constant, w_j must rise, and as a result, λ_j increases (see Equation 24). Finally, from Equation 26, we get that λ_ℓ must fall in at least one additional country ℓ, mediated through the relative price of materials in that country. We therefore get that asymmetric TFP growth maintains a constant (appropriately weighted) global labor share (Equation 26), but with heterogeneous effects across countries, with at least some countries experiencing a decline in their labor share. We summarize the above results in the following proposition:

Proposition 2. *In the multi-country model with a global commodities market, positive markups ($\eta \in (1, \infty)$) and complementarities in production ($\sigma < 1$): (a) The labor share of income in each country is negatively related to the relative price of materials in that country. (b) A negative shock to the global supply of materials $\bar{m}$ leads to a decline in an appropriately-weighted average of the global labor share, but with heterogeneous responses across countries. (c) A positive shock to total factor productivity z_j in some country j will increase the labor share in that country and necessarily decrease it in at least one other country, while the global average labor share remains unchanged.*

To conclude, the above model suggests that the response of the global labor share to a commodity boom depends on the nature of the shock. In addition, whether it is a demand or a supply shock, we should expect different adjustment of the labor share across countries, in line with differential trends in their relative price of materials.

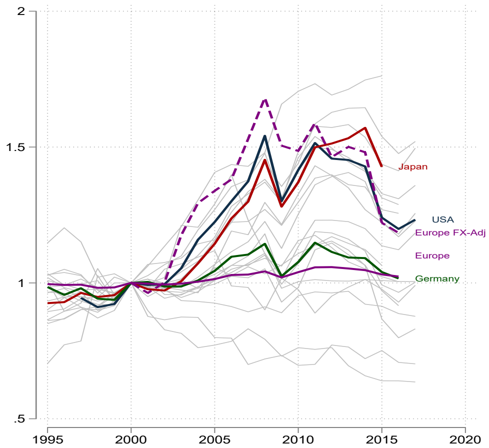
5.2 International Evidence

We now turn to investigate the model's predictions in cross-country data. We first demonstrate that trends in the relative price of materials were heterogeneous across major countries during the 2000s, corresponding to trends in the labor share. We then demonstrate a more systematic relation between the two in a panel of countries. We base our analysis on the latest (2019) release of EU-KLEMS, providing sectoral data on output, compensation and intermediates over 1995-2017.

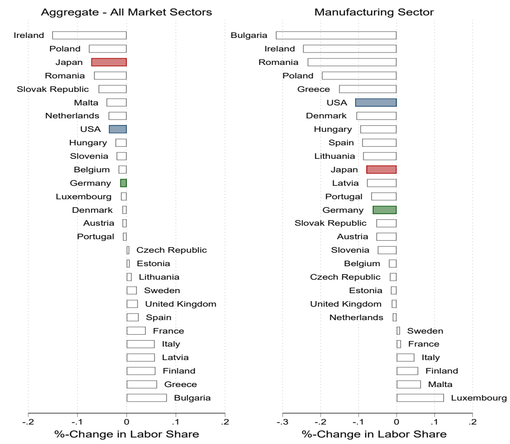
Figure 11a demonstrates that the trend in the relative price of intermediates varied greatly across countries.[29] Despite the global rise in commodity prices, the country-level trend exhibits vast heterogeneity. Moreover, the increase in the U.S. and Japan is greater than that of all European countries. The reason behind the more timid increase in the relative price of intermediates is that concurrently with the increase in the price of global raw materials, most European economies adopted the Euro which quickly appreciated. The strengthening of the Euro contributed to relatively lower raw material costs in comparison to the U.S. and Japan.[30]

[29] We divide the price index of intermediate inputs by the price index of value added that captures the costs of primary inputs for each manufacturing industry. We then take the value-added weighted mean across sectors to get a country-level measure. We normalize these measures such that relative prices are equal to unity in 2000 for all countries. The European average is an employment-weighted mean across all European countries.

[30] Note that a second reason for these heterogeneous effects across countries is variation in the transmission of price shocks. Recall from Section 2 that the effect of a shock to input prices on the labor share depends on the ex-ante cost share of intermediates in production; the ex-ante price-cost markup; and the degree of complementarity between



(a) Trends in the price of intermediates.



(b) Cross-country changes in the labor share.

Figure 11: Materials prices and the labor share across countries. Panel (a) shows the price ratio of materials to value added by country, normalized to unity at 2000. Ratios of industry price-indices are averaged across manufacturing industries in each country using value added. Each gray line is a separate country in the EU-KLEMS dataset. The thick purple line is an employment-weighted average of European countries. The dashed purple line corresponds to the employment-weighted average of European countries in the thick purple line multiplied by the U.S.D/EUR exchange rate from the BIS. Panel (b) shows changes in the labor share across different countries. The left panel shows changes in the aggregate market-industries labor share, as detailed in the main text. The right panel shows changes in the manufacturing labor share.

Figure 11b depicts changes in the labor share across countries in the EU-KLEMS dataset between 1997 and 2015.[31] The left panel shows the aggregate labor share for market sectors excluding housing,[32] and the right panel shows the manufacturing labor share. As claimed in Gutiérrez and Piton (2020), it is not clear if the median country has experienced a decline in its aggregate (i.e. market sectors excluding housing) labor share over this period. However, the manufacturing labor share has declined in most countries, suggestive of a common global factor that affected this sector. Moreover, the U.S.A and Japan have experienced a greater decline in their labor share relative to most European countries, in line with the above evidence of a greater increase in the relative price of intermediates.

Finally, we demonstrate a statistical relationship between the manufacturing labor share and the price of intermediates in the EU-KLEMS dataset. While price indices

materials and other inputs. All of these factors could potentially vary across countries, generating heterogeneous responses to common shocks.

[31] We focus on these years since 1997 is the first year that includes the U.S. in the 2019 vintage of EU-KLEMS; and 2015 is the last year that includes Japan.

[32] We exclude the following sectors: real estate activities; public administration and defence; compulsory social security; education; health and social work; activities of households as employers; activities of extraterritorial organizations and bodies.

for output and intermediates are included in the dataset, they have a mechanical correlation with gross output and expenditure on intermediates. Therefore, a spurious correlation between the raw relative price of intermediates and the labor share arises. To deal with this problem, we take the following approach. We set as our main regressor the relative price of intermediates for some industry j, and study its relationship with the aggregate manufacturing labor share, excluding industry j. The relative price index for industry j captures economy-wide forces that shape the relative price of inputs, but is not mechanically related to the aggregate price index. We set the food-products, beverages and tobacco sector (henceforth FBT) as the chosen industry, since it is responsive to global prices and does not account for a large part of GDP in most countries. However, other industries work as well. We then repeat specification 4, though lack of data prevents controlling for investment prices. We control for average manufacturing wages and for country and year fixed effects.

Table 4: Material Prices and the Labor Share Across EU-KLEMS Countries

Outcome: Log manufacturing labor share (Excluding FBT sector)	(1) OLS	(2) 2SLS	(3) 2SLS	(3) 2SLS
Materials intensity × Log materials price	-0.110**	-0.185***	-0.127***	-0.147***
	(0.0459)	(0.0599)	(0.0428)	(0.0475)
Log average wage	0.156***	0.208***	0.112	0.142*
	(0.0376)	(0.0570)	(0.0663)	(0.0703)
N	451	451	451	472
Country and year FE	Yes	Yes	Yes	Yes
Weighted	Yes	Yes	No	No
Including U.S.A	No	No	No	Yes

Notes: This table reports results from the regression of manufacturing sector labor share (excluding the FBT sector - food, beverages and tobacco) on price index of materials across countries in the EU-KLEMS dataset. All specifications control for average wage and for country and year fixed effects. Column 1 reports OLS results, weighted by value added and excluding the U.S.. Column 2 reports a similar specification when instrumenting the manufacturing materials price index (excluding FBT) with the FBT materials price index. Column 3 repeats Column 2 without weighting, and Column 4 repeats Column 2 with inclusion of the U.S.. Standard errors in parentheses, clustered at the country level. * p<0.1, ** p<0.05, *** p<0.01.

Table 4 presents the results for the cross-country estimation. Column 1 presents the OLS specification, demonstrating a negative relationship between intermediate prices and labor shares across countries (both of them excluding the FBT sector). Columns 2-4 present the results when we instrument the intermediates price index with the FBT price index, removing the spurious correlation discussed above. The results remain negative and significant, and are robust to the inclusion or exclusion of the U.S. in the estimation and to weighting by value added. Overall, the results suggest that the negative relationship between intermediate prices and the labor share exists in the cross-country panel, in line with our suggested mechanism.

6 Conclusion

We propose a mechanism that relates the labor share to the relative price of materials in the economy. We show that under complementarity between materials and primary inputs and imperfect competition, a higher price of materials lowers the labor share and raises the profit share of income without requiring a change in markups. Noting that the aggregate labor share mirrors the evolution of the relative price of materials in the U.S. economy, we provide causal evidence for this mechanism across broad sectors, narrowly defined U.S. manufacturing industries, U.S. commuting zones, and countries. In doing so, we utilize the 2000s global commodities boom and the 1970s oil crisis as exogenous sources of variation and consistently find a negative effect of rising material prices on the labor share. We quantify the aggregate importance of our mechanism by a back-of-the-envelope calculation from our reduced-form estimates and by quantifying a multi-sector input-output general equilibrium model of the U.S. economy. In both cases, we attribute around 30% of the labor share's decline to rising materials intensity and argue that this decline would have been smaller and smoother, absent fluctuations in relative materials prices.

We conclude by noting a few additional implications of our mechanism. First, it implies that part of the downward trend in the labor share has a medium-term cyclical component that varies with global commodity prices. Second, it suggests that aggregate profit shares may vary without any changes in firms' market power or conduct. Finally, it suggests caution when inferring markups from factor shares, highlighting the importance of accounting for fluctuations in the cost-share of intermediates.

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Online Appendices

A Data

A.1 Aggregate trends.

Aggregate labor share. Our baseline measure for the aggregate labor share is a simple average of four key measures used in the literature. The first measure is the main specification suggested in Gomme and Rupert (2004), constructed from BEA National Income and Product Accounts (henceforth NIPA). We divide aggregate compensation (NIPA series A033RC) by the sum of compensation, rental income (A048RC), corporate profits (A051RC) and net interest (W255RC), minus depreciation (A262RC). The second measure is the labor share of U.S. non-financial corporations, constructed as the ratio of NIPA series A460RC (compensation in non-financial corporations) to A455RC (gross value added of non-financial corporations). The third measure is the series computed by Fernald (2014), taken from `https://www.frbsf.org/economic-research/files/quarterly_tfp.xlsx`. The final measure is the definition of the BLS for non-farm business-sector labor share, taken from the FRED portal, series PRS85006173.

Aggregate relative price of materials. Our measure for the aggregate relative price of raw materials in Figure 1 is the ratio of the Producer Price Index (PPI) for unprocessed goods (FRED series WPUID62) to the Personal Consumption Expenditures (PCE) index for goods (FRED series DGDSRC1).

Sector-level outcomes. We rely on data from the BEA Integrated Industry-Level Production Account - the U.S. official KLEMS (capital, labour, energy, materials and service) accounts. See Garner, Harper, Howells, Russell, Samuels et al. (2018) for additional details. We define the labor share as the ratio of total labor compensation to the difference between gross output and compensation of intermediates. Additional measures of sector-level labor share are obtained from the BEA income accounts, dividing industry-level compensation (Table 6.2) by industry-level national income without capital consumption adjustment (Table 6.1). These measures can be seen in Figures D.3a-D.3c.

A.2 Industry-Level Outcomes in the Manufacturing Sector

NBER-CES Manufacturing Industry Database. Our main data source for the cross-industry analysis is the NBER-CES Manufacturing Industry Database (Becker et al. 2021). This database is a joint effort between the National Bureau of Economic Research (NBER) and U.S. Census Bureau's Center for Economic Studies (CES), containing annual industry-level data from 1958-2011. We use the NAICS version of the dataset with 364 6-digit 2012 NAICS industries.

Comparison of NBER-CES to BEA data. The raw time series for the ratio of wages to value added in the NBER-CES dataset results in a steady decline since the 1960s. This is in contrast to the path of manufacturing labor-share in other data sources. We have identified three reasons for this discrepancy.[33] First, the census data underestimates expenditure on intermediates (captured in the variable "matcost"), resulting in too high levels of value added, especially in the 1980s and 1990s. This is probably due to the exclusion of most purchased services from expenditures on materials. Note that the sales part of value added is very similar across both datasets. Secondly, the NBER-CES measure of payments to employees captures wages, but misses some other aspects of compensation that have grown in importance over time. Finally, the gap between the NBER-CES measure of wages to the BEA measure of wages and salaries (W&S) has grown over time as well. Figure A.1 shows these discrepancies over time.

Exposure to Global Commodity Prices. We instrument the industry-level price index of material from the NBER-CES panel using industry exposure to global commodity prices. We follow Fally and Sayre (2019) in defining a list of commodities[34] that correspond to a significant share of the total global commodity trade. We use trade unit values computed from transactions in UN COMTRADE. We construct this proxy by taking the average FOB trade unit value for each HS96 good and year.

To compute the weight of each commodity in the production process of each industry, we utilize the 1997 BEA Input-Output (henceforth I-O) table for the U.S. economy[35]. We first assign each commodity to the I-O industry that produces it,

[33] We have communicated on these findings with researchers in Census CES and BEA.

[34] See `https://are.berkeley.edu/~fally/Data/commodity_names.xlsx`.

[35] `https://www.bea.gov/industry/input-output-accounts-data`

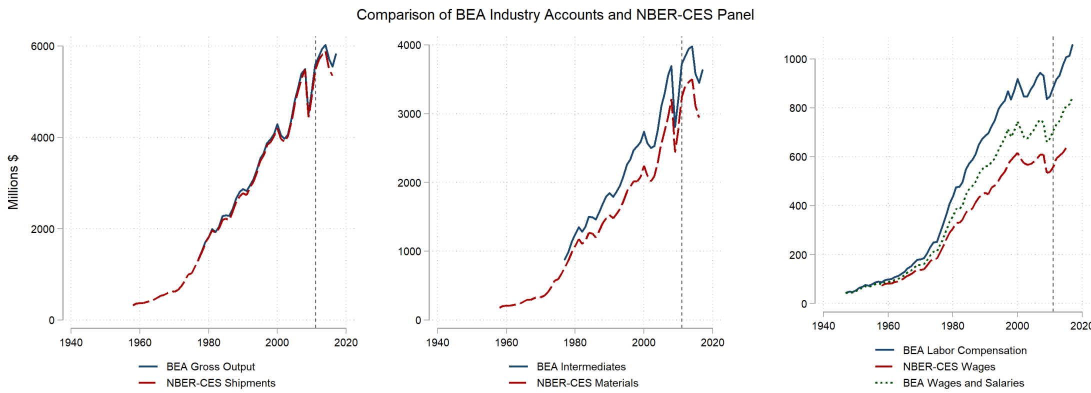


Figure A.1: Comparison of BEA and NBER-CES. This figure compares key aggregates for the manufacturing sector between the BEA industry accounts and the NBER-CES manufacturing panel. The vertical dashed line marks the year in which the NBER-CES data ends. All data from later years is taken from the Annual Survey of Manufacturers (ASM), upon which the NBER-CES panel is based. The left panel compares sales; the middle panel compares expenditure on intermediates in BEA to expenditure on materials (”matcost”) in Census data; and the right panel compares various measures of payments to employees.

using the concordance provided by the BEA[36]. Since each industry is associated with multiple commodities, we take an average of the changes in the different commodity prices within each industry. Finally, since the 1997 I-O classification of industries is a slight aggregation of 1997 NAICS industries, we assign the same measure of commodity prices to all NAICS industries within each I-O industry.

A.3 Regional Data

We obtain county-level manufacturing GDP and baseline county economic characteristics from the BEA regional economic accounts. We obtain county-level manufacturing labor compensation from the BLS Quarterly Census of Employment and Wages (QCEW). We aggregate counties to U.S. 1990 commuting zones according to the U.S. Census Bureau definitions.

A.4 International Data

EU KLEMS. We use the 2019 EU-KLEMS release, run by the Vienna Institute for International Economic Studies. This dataset includes measures of economic growth, productivity, employment, capital formation, and technological change at the

[36] https://apps.bea.gov/industry/zip/NDN0317.zip

industry level for all European Union member states, Japan, and the U.S. over the period 1995-2017.

B Additional Derivations

B.1 Elasticity of the labor share to the price of materials

We log. differentiate Equation 2 to get,

$$d\log\lambda = \frac{\theta_k}{\theta_l+\theta_k}\left(d\log\theta_l - d\log\theta_k\right) + \left[\frac{\mu}{\mu-\theta_m} - \frac{1}{1-\theta_m}\right] d\log\theta_m - \frac{\mu}{\mu-\theta_m} d\log\mu.$$

After some manipulations, this can be written as,

$$\frac{d\log\lambda}{d\log p_m} = \frac{\theta_k}{\theta_l+\theta_k}\left(\frac{d\log\frac{\theta_l}{\theta_m}}{d\log p_m} - \frac{d\log\frac{\theta_k}{\theta_m}}{d\log p_m}\right) + \left[\frac{\mu}{\mu-\theta_m} - \frac{1}{1-\theta_m}\right]\frac{d\log\theta_m}{d\log p_m} - \frac{\mu}{\mu-\theta_m}\frac{d\log\mu}{d\log p_m}.$$

Define the Morishima elasticity of substitution between materials and labor with respect to p_m as the % change in the ratio of labor to materials after a % change in their relative prices, p_m/w, when only p_m changes

$$\sigma_{lm}(p,y) \equiv -\frac{d\log\frac{m(\mathbf{p},y)}{l(\mathbf{p},y)}}{d\log\frac{p_m}{w}},$$

where $m(\mathbf{p},y)$ and $l(\mathbf{p},y)$ correspond to the conditional factor demands given an output level y and a vector of factor prices $\mathbf{p}$. Assuming that all the relative price changes come from changes in p_m, with w and p_k constant, we can reduce $\frac{d\log\frac{\theta_l}{\theta_m}}{d\log p_m}$ to

$$\frac{d\log\frac{\theta_l}{\theta_m}}{d\log p_m} - \frac{d\log\frac{p_m}{w} + d\log\frac{m(\mathbf{p},y)}{l(\mathbf{p},y)}}{\frac{w}{p_m}d\frac{p_m}{w}} = -1 - \frac{d\log\frac{m(\mathbf{p},y)}{l(\mathbf{p},y)}}{d\log\frac{p_m}{w}} = -1 + \sigma_{lm}(\mathbf{p},y).$$

In the above derivations, we used the assumption that w is constant.[37] Analogously,

[37]By Shephard's Lemma and homogeneity of degree one in prices of the cost function C(p,y), Blackorby and Russell (1989) show that the Morishima elasticity is equal to

$$\begin{aligned}\sigma_{lm}(\mathbf{p},y) &= \frac{p_m C_{lm}(\mathbf{p},y)}{C_l(\mathbf{p},y)} - \frac{p_m C_{mm}(\mathbf{p},y)}{C_m(\mathbf{p},y)}\\ &= \varepsilon_{lm}(\mathbf{p},y) - \varepsilon_{mm}(\mathbf{p},y)\end{aligned}$$

where $C_i(\mathbf{p},y) = \partial C(\mathbf{p},y)/\partial p_i$, $C_{ij}(\mathbf{p},y) = \partial^2 C(p,y)/\partial p_i \partial p_j$ and $\varepsilon_{ij}(\mathbf{p},y) = \partial C_i(\mathbf{p},y)/\partial p_j \times (p_j/C_i(\mathbf{p},y))$ corre-

$\frac{d \log \frac{\theta_k}{\theta_m}}{d \log p_m} = -1 + \sigma_{km}(\mathbf{p}, y)$.

The elasticity of the cost share of materials with respect to a change in p_m can be simplified as in terms of Morishima elasticities and cost shares:

$$\frac{d \log \theta_m}{d \log p_m} = -\theta_l \sigma_{lm}(\mathbf{p}, y) - \theta_k \sigma_{km}(\mathbf{p}, y) + 1 - \theta_m.$$

To derive the elasticity of the markup μ with respect to the price of materials. First, notice that we can write this elasticity in terms of the elasticity of demand ϵ as

$$\frac{d \log \mu}{d \log p_m} = -\frac{1}{\epsilon - 1} \frac{d \log \epsilon}{d \log p_m} = -\frac{1}{\epsilon - 1} \frac{d \log \epsilon}{d \log p} \frac{d \log p}{d \log c} \frac{d \log c}{d \log p_m}$$

where we define $\frac{d \log \epsilon}{d \log p}$ as ξ, the superelasticity of demand. Now, log-differentiating the optimal price equation, we can see that

$$d \log p = -\frac{1}{\epsilon - 1} d \log \epsilon + d \log c \implies \frac{d \log p}{d \log c} = \frac{\epsilon - 1}{\epsilon - 1 + \xi}$$

Also, notice that the last term of this differentiation corresponds to the cost-share of materials as $\frac{d \log c}{d \log p_m} = \theta_m$. Thus, $\frac{d \log \mu}{d \log p_m} = -\theta_m \frac{\xi}{\epsilon - 1 + \xi}$.

Finally, notice that $\frac{\theta_m}{\mu - \theta_m} = \frac{M}{Y}$. Plugging in the different elasticities into Equation B.1 and simplifying we get

$$\begin{aligned}
\frac{d \log \lambda}{d \log p_m} = & \underbrace{\frac{\theta_k}{\theta_l + \theta_k} \left(\sigma_{lm}(\mathbf{p}, y) - \sigma_{km}(\mathbf{p}, y) \right)}_{\text{Subst. between labor and capital}} \\
& + \underbrace{\frac{M}{Y} (\mu - 1) \left[\left(\frac{\theta_l}{\theta_l + \theta_k} \sigma_{lm}(\mathbf{p}, y) + \frac{\theta_k}{\theta_l + \theta_k} \sigma_{km}(\mathbf{p}, y) \right) - 1 \right]}_{\text{Subst. between non-materials and materials holding profit share constant}} \\
& + \underbrace{\frac{M}{Y} \frac{\xi \mu}{\epsilon - 1 + \xi}}_{\text{Adjustment of markups}} .
\end{aligned}$$

A particular case corresponds to the CES production function described in Equation 1, so that $\sigma = \sigma_{lm}(\mathbf{p}, y) = \sigma_{km}(\mathbf{p}, y)$. In that case, the first term disappears. The

sponds to the (constant-output) elasticity of demand of input i with respect to the price of j.

elasticity of the labor share to changes in the price of materials is

$$\frac{d\log\lambda}{d\log p_m}=\frac{M}{Y}\left[(\mu-1)(\sigma-1)+\mu\frac{\xi}{\epsilon-1+\xi}\right]$$

which nests, both our baseline elasticity (with $\xi=0$), and our expression with variable markups.

Next, we derive the elasticity of the labor share to the price of materials with fixed costs paid in a bundle of labor and capital. We start from the expression for the labor share,

$$\lambda=\frac{w^v l^v+w^f l^f}{R-M}=\frac{w^v l^v/C^v+w^f l^f/C^v}{R/C^v-M/C^v}=\frac{\theta_l+\omega}{\mu-\theta_m},\quad F\equiv w^f l^f,\quad \omega\equiv\frac{F}{C^v}$$

. Totally differentiating, and manipulating this expression, we get:

$$d\ln\lambda=-\frac{\theta_m}{1-\theta_m+\omega}d\ln\theta_m+\frac{\omega}{1-\theta_m+\omega}d\ln\omega+\frac{\theta_m}{\mu-\theta_m}d\ln\theta_m,$$

which can be written in terms of elasticities as

$$\begin{aligned}\frac{d\ln\lambda}{d\ln p_m}&=-\frac{\theta_m}{1-\theta_m+\omega}\left(1-\theta_m\right)\left(1-\sigma\right)+\frac{\theta_m}{\mu-\theta_m}\left(1-\theta_m\right)\left(1-\sigma\right)+\frac{\omega}{1-\theta_m+\omega}\left(\epsilon-1\right)\theta_m\\&=\left(1-\sigma\right)\left[\frac{\omega\frac{\epsilon-1}{1-\sigma}-\left(1-\theta_m\right)}{1-\theta_m+\omega}\left(\mu-\theta_m\right)+\left(1-\theta_m\right)\right]\frac{\theta_m}{\mu-\theta_m}\\&=\left(\sigma-1\right)\left[\left(\mu-1\right)-\left(\frac{\omega\frac{\epsilon-1}{1-\sigma}-\left(1-\theta_m\right)}{1-\theta_m+\omega}+1\right)\left(\mu-\theta_m\right)\right]\frac{\theta_m}{\mu-\theta_m}\\&=\left[\left(\sigma-1\right)\left(\mu-1\right)+\omega\frac{\left(\epsilon-\sigma\right)\left(\mu-\theta_m\right)}{1-\theta_m+\omega}\right]\frac{M}{Y}\end{aligned}$$

B.2 General equilibrium settings

B.2.1 A roundabout production economy

Consider an economy in which the aggregate production function takes the form of Equation 1, where for simplicity we impose $G(k,l)=A_L^{\frac{\sigma-1}{\sigma}}l$, i.e. the composite of capital and labor is linear in labor, adjusted by a labor-augmenting technological shifter A_L. In the roundabout production economy, firms source units of the final good to use as materials in production, combining them with labor. We assume that this process is subject to a sourcing friction, such that out of the total amount of the final good that is sourced by firms, only a fraction $1/\kappa$ can be used in production. The endowment of labor is given by L, and firms charge an exogenous price-cost markup μ in all transactions.

In the roundabout production economy, the price of materials is given by $p_m = \kappa p$. The price of a unit of output is given by

$$p = \frac{\mu}{A}\left[A_L^{-\sigma} w^{1-\sigma} + (\kappa p)^{1-\sigma}\right]^{\frac{1}{1-\sigma}},$$

where w is the price of labor. We thus obtain the following expression for p

$$p = \left[\frac{A_L^{-\sigma} w^{1-\sigma}}{\left(\frac{A}{\mu}\right)^{1-\sigma} - \kappa^{1-\sigma}}\right]^{\frac{1}{1-\sigma}}.$$

Normalizing $w = 1$, p_m equals to

$$p_m = \kappa p = \left(\frac{A_L^{-\sigma}}{\left(\frac{A}{\mu\kappa}\right)^{1-\sigma} - 1}\right)^{\frac{1}{1-\sigma}} = A_L^{\frac{\sigma}{\sigma-1}}\left(\left(\frac{A}{\mu\kappa}\right)^{1-\sigma} - 1\right)^{-\frac{1}{1-\sigma}}.$$

Denoting total profits by Π and total costs by C, the labor share in this economy is given by

$$\begin{aligned}\lambda = \frac{wL}{wL+\Pi} &= \frac{wL}{wL+(\mu-1)\,C} = \frac{1}{1+(\mu-1)\,\frac{C}{wL}}\\ &= \frac{1}{1+(\mu-1)\left(1+\frac{p_m m}{wL}\right)} = \frac{1}{1+\frac{\mu-1}{1-\left(\mu\frac{\kappa}{A}\right)^{1-\sigma}}}.\end{aligned}$$

where note that

$$\frac{p_m m}{wL} = \frac{\theta_m}{1-\theta_m} = \frac{(\kappa p)^{1-\sigma}}{A_L^{-\sigma} w^{1-\sigma}} = A_L^{\sigma}\kappa^{1-\sigma}p^{1-\sigma} = \frac{1}{\left(\frac{A}{\mu\kappa}\right)^{1-\sigma} - 1}.$$

Therefore

$$\lambda = \frac{1}{1 + \frac{\mu - 1}{1 - \left(\mu \frac{\kappa}{A}\right)^{1-\sigma}}},$$

and an increase in the sourcing friction κ relative to A leads to a lower labor share if $\sigma < 1$ and $\mu > 1$.

B.2.2 A two-sector economy

The economy consists of two sectors. The extractive sector is endowed with $\bar{m}$ units of materials and sells them to the manufacturing sector. The manufacturing sector buys materials from the extractive sector, and produces the final good using the same production function as in the above roundabout economy,

$$y = A\left[A_L l^{\frac{\sigma-1}{\sigma}} + m^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}.$$

We again denote the aggregate endowment of labor by L. In addition, we assume that the manufacturing sector charges an exogenous markup μ over its marginal cost. The labor share in the extractive sector is 0, and rents from selling materials to the manufacturing sector are given by $p_m \bar{m}$. The ratio of spending on materials relative to spending on labor in the manufacturing sector is given by

$$\frac{p_m m}{wl} = A_L^{-1}\left(\frac{\bar{m}}{L}\right)^{\frac{\sigma-1}{\sigma}} = A_L^{\sigma}\left(\frac{p_m}{w}\right)^{1-\sigma},$$

where p_m is the price of materials and w is the price of labor. In equilibrium, p_m is given by

$$p_m = A_L\left(\frac{\bar{m}}{L}\right)^{-\frac{1}{\sigma}},$$

where we have normalized $w = 1$.

The manufacturing labor share is given by

$$\lambda^{manuf} = \frac{1}{1 + (\mu - 1)\,\theta_m^{-1}} = \frac{1}{1 + (\mu - 1)\left(1 + A_L^{-1}\left(\frac{\bar{m}}{L}\right)^{-\frac{\sigma-1}{\sigma}}\right)},$$

where θ_m is the share of materials in costs. It increases in $\bar{m}/L$ when $\sigma < 1$ and

$\mu > 1$. The aggregate labor share in the economy is given by

$$
\begin{aligned}
\lambda &= \frac{wl}{wl + \Pi + p_m \bar{m}} \\
&= \frac{wl}{wl + (\mu - 1) C + p_m \bar{m}} \\
&= \frac{1}{1 + (\mu - 1)(1 + p_m \bar{m}/wl) + p_m \bar{m}/wl} \\
&= \frac{1}{\mu \left(1 + A_L^{-1} \left(\frac{\bar{m}}{L}\right)^{\frac{\sigma-1}{\sigma}}\right)}.
\end{aligned}
$$

where we denote total profits by Π and total costs in manufacturing by C. The aggregate labor share increases in $\bar{m}/L$ when $\sigma < 1$.

B.2.3 A small open economy

We continue to assume the same production function, but now materials are sourced from international markets, with a global price p_m. The global price of output is fixed at p, and the unit cost is given by p/μ. Output prices satisfy

$$
p = \frac{\mu}{A} \left[A_L^{\sigma} w^{1-\sigma} + p_m^{1-\sigma}\right]^{\frac{1}{1-\sigma}},
$$

which pins down the wage level in equilibrium. The labor share in equilibrium is given by

$$
\begin{aligned}
\lambda = \frac{wl}{wl + \Pi} &= \frac{\frac{A_L^{\sigma} w^{1-\sigma}}{A_L^{\sigma} w^{1-\sigma} + p_m^{1-\sigma}}}{\mu - \frac{p_m^{1-\sigma}}{A_L^{\sigma} w^{1-\sigma} + p_m^{1-\sigma}}} \\
&= \frac{\left(\frac{\mu}{A}\frac{p_m}{p}\right)^{\sigma-1} - 1}{\mu \left(\frac{\mu}{A}\frac{p_m}{p}\right)^{\sigma-1} - 1}.
\end{aligned}
$$

Since $\left(\frac{\mu}{A}\frac{p_m}{p}\right)^{\sigma-1} - 1 = \frac{A_L^{\sigma} w^{1-\sigma}}{p_m^{1-\sigma}}$. The labor share is thus decreasing in p_m/p when $\sigma < 1$ and $\mu > 1$.

B.3 Multi-country model

Setting. Consider a world that consists of $N+1$ countries. N countries are industrial, producing output with endowments of labor and capital and with imported raw materials. In addition, they export and import final goods. The remaining country, indexed by 0, is endowed with the global stock of raw materials and exports them to the rest of the world, lacking industrial capabilities. For simplicity, we assume that each country is endowed with an exogenous measure of F_i identical firms that engage in monopolistic competition. Together with the assumption of a CES demand system, it will ensure constant markups and that the profit share of revenues is constant. Note that since we consider a static model, introducing completely free entry would eliminate all profits, which we require to demonstrate the mechanism emphasized in previous sections. Since the goal of this section is to demonstrate the pass-through of material prices into the labor share, and not to study how frictions in entry arise, we make the extreme assumption of no entry. However, alternative assumptions on entry that allow profits to exist, or that pay entry costs with a composite of inputs that is more capital-intensive than the variable costs, would yield similar results.

Preferences. The preferences of the representative consumer in country n are characterized by a constant elasticity of substitution utility function across all available varieties in that country:

$$U_n \equiv \left[\sum_{i=1}^{N} F_i {C_{ni}}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \tag{27}$$

where C_{ni} is the amount that country n consumes of the good produced by each firm in country i, and η is the elasticity of substitution across varieties.

Production. Each industrial country is endowed with L_n units of labor and K_n units of capital. Firms engage in monopolistic competition. The production function has a nested-CES structure between materials and a composite input of capital and labor, where σ is the elasticity of substitution between materials and non-materials. The production function thus admits the following form:

$$y_i = z_i \left(\left(G_i \left(l_i, k_i\right)\right)^{\frac{\sigma-1}{\sigma}} + m_i^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{28}$$

where z_i is a neutral productivity shock; k_i, l_i and m_i are the amounts of capital, labor and materials employed by country i, respectively; $G_i(l_i, k_i)$ is a composite input of capital labor. To facilitate exposition, we assume that $G_i(k_i, l_i)$ takes a Cobb-Douglas form

$$G_i(l_i, k_i) = \psi_i l_i^{\alpha} k_i^{1-\alpha}, \tag{29}$$

where α is the labor-elasticity in the non-materials composite input, which also equals to the "neoclassical" labor share, and ψ_i is a factor augmenting technological shifter to the non-materials input. In addition, we assume the existence of trade costs that take the standard iceberg form, in which τ_{ni} units of output are required to ship a single unit of output from country i to country n. We assume that the global supply of materials is perfectly inelastic at $\bar{m}$; that the market for materials is perfectly competitive; and that there are no trade frictions in shipping materials.

Prices. Let p^m denote the price of materials faced by all industrial economies. The per-unit price paid by country n for a unit of output from country i is given by

$$p_{ni} = \frac{\eta}{\eta - 1} \frac{\tau_{ni}}{z_i} \left(\left(\frac{w_i^{\alpha} r_i^{1-\alpha}}{\psi_i} \right)^{1-\sigma} + (p^m)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}. \tag{30}$$

Due to the assumption on the non-materials composite in Equation 29, the ratio between expenditure on labor and expenditure on capital is constant and equal to

$$\frac{w_i l_i}{r_i k_i} = \frac{\alpha}{1-\alpha},$$

and the unit-cost of a composite of labor and capital can be written as

$$\frac{w_i^{\alpha} r_i^{1-\alpha}}{\psi_i} = \frac{1}{\psi_i} \left(\frac{1-\alpha}{\alpha} \frac{L_i}{K_i} \right)^{1-\alpha} w_i,$$

where we have already imposed that the firm-specific capital-labor ratio must equal to the economy-wide ratio since all firms in each market are identical. The output price can thus be written as

$$p_{ni} = \frac{\eta}{\eta - 1} \frac{\tau_{ni}}{z_i} \left((A_i w_i)^{1-\sigma} + (p^m)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}, \tag{31}$$

where

$$A_i \equiv \frac{1}{\psi_i}\left(\frac{1-\alpha}{\alpha}\frac{L_i}{K_i}\right)^{1-\alpha}.$$

Equilibrium in the materials market. From the above derivations, the ratio between the expenditure on materials by each firm and the expenditure on capital and labor by each firm equals to

$$\frac{p^m m_i}{r_i k_i + w_i l_i} = \left(\frac{p^m}{A_i w_i}\right)^{1-\sigma}.$$

Therefore, demand for materials by each firm in country i equals to

$$m_i = (p^m)^{-\sigma}(A_i w_i)^{\sigma-1}(r_i k_i + w_i l_i),$$

and demand for materials by all firms in country i is

$$F_i m_i = (p^m)^{-\sigma}(A_i w_i)^{\sigma-1}(r_i K_i + w_i L_i).$$

Recall that $r_i K_i + w_i L_i = \frac{w_i L_i}{\alpha}$. Equilibrium in the global materials market thus requires

$$\bar{m} = \frac{(p^m)^{-\sigma}}{\alpha}\sum_i A_i^{\sigma-1} L_i w_i^{\sigma}. \tag{32}$$

The labor share. The labor share of income in country i can be written as the product of the "neoclassical labor share" (payments to labor out of total payments to labor and capital), expenditure on labor and capital out of total costs, and the ratio of costs to value added VA_i:

$$\begin{aligned}
\lambda_i &= \left(\frac{w_i l_i}{r_i k_i + w_i l_i}\right) \times \left(\frac{r_i k_i + w_i l_i}{r_i k_i + w_i l_i + p^m m_i}\right) \times \left(\frac{r_i k_i + w_i l_i + p^m m_i}{VA_i}\right), \\
&= \alpha \times \frac{(A_i w_i)^{1-\sigma}}{(A_i w_i)^{1-\sigma} + (p^m)^{1-\sigma}} \times \frac{1}{\frac{sales_i}{costs_i} - \frac{p^m m_i}{costs_i}}, \\
&= \alpha \frac{(A_i w_i)^{1-\sigma}}{(A_i w_i)^{1-\sigma} + (p^m)^{1-\sigma}} \frac{1}{\frac{\eta}{\eta-1} - \frac{(p^m)^{1-\sigma}}{(A_i w_i)^{1-\sigma} + (p^m)^{1-\sigma}}}, \\
&= \alpha \frac{(A_i w_i)^{1-\sigma}}{\frac{\eta}{\eta-1}(A_i w_i)^{1-\sigma} + \frac{1}{\eta-1}(p^m)^{1-\sigma}}.
\end{aligned} \tag{33}$$

Note that when the markups are eliminated (η converges to infinity), the labor share becomes the "neoclassical" labor share α, and when the elasticity of substitution σ is equal to 1 the labor share becomes independent of the prices of materials. Otherwise, it depends on the ratio of material prices and the prices other inputs, captured here by the wage level w_i. Another way to express the labor share that relates more directly to some of our empirical exercises is in terms of the empirically-measurable domestic output price p_i: Otherwise, it depends on the ratio of material prices and the prices other inputs, captured here by the wage level w_i.

Another way to express the labor share that relates more directly to some of our empirical exercises is in terms of the domestic output price p_i which is measurable in the data and given in the model by

$$p_i = \frac{\eta}{\eta - 1} \frac{1}{z_i} \left((A_i w_i)^{1-\sigma} + (p^m)^{1-\sigma} \right)^{\frac{1}{1-\sigma}} . \tag{34}$$

Substituting $(A_i w_i)^{1-\sigma}$ for an expression that involves p_i and p^m based on this term yields

$$\lambda_i = \alpha \frac{\eta - 1}{\eta + \left[\left(\frac{\eta}{\eta-1} \frac{1}{z_i} \frac{p^m}{p_i} \right)^{\sigma - 1} + 1 \right]^{-1}} \tag{35}$$

i.e., when $\sigma < 1$, the labor share in country i is negatively related to the relative price of materials in that country p^m/p_i, even when there is a global freely-traded commodity market and all countries face a similar price of materials.

Equilibrium in output markets. Denote by S_{ni} the expenditure share of country n on output from country $i \in \{0, 1, ..., N\}$, given by

$$S_{ni} = \frac{F_i (p_{ni})^{1-\eta}}{\sum_{j=1}^{N} F_j (p_{nj})^{1-\eta}}. \tag{36}$$

Total revenues in each industrial country i equal to total expenditure on its output by all other countries. The expenditure level of country n on output from country i is given by

$$S_{ni} \times \frac{w_i L_i}{\lambda_i},$$

i.e., the expenditure share on country i by country n, multiplied by its total income, which is also given by the labor income divided by the labor share. Total expenditure for the materials exporter country is equivalently given by $S_{0i} p^m \bar{m}$. Total sales by country i can be written in terms of wages and the price of materials when expressed as

$$\frac{\eta}{\eta - 1} \frac{w_i L_i}{\theta_{l,i}},$$

i.e. the product of the price-cost markup and the total expenditure on labor divided by the cost-share of labor $\theta_{l,i}$, where the latter equals to

$$\theta_{l,i} = \alpha \frac{(A_i w_i)^{1-\sigma}}{(A_i w_i)^{1-\sigma} + (p^m)^{1-\sigma}}.$$

Combining all of these elements, goods market clearing is given by

$$\frac{\eta}{\eta - 1} \frac{w_i L_i}{\theta_{l,i}} = \sum_{n=1}^{N} S_{ni} \frac{w_i L_i}{\lambda_i} + S_{0i} p^m \bar{m} \tag{37}$$

General equilibrium. Recall that $\theta_{l,i}$, λ_i, S_{ni} are all functions of exogenous objects, the vector of wages $\{w_i\}_{i=1}^N$ and the price of materials p^m. Therefore, Equations 37 combined with the market clearing for materials in Equation 32 yield $N+1$ equations for the $N+1$ unknowns $\left(\{w_i\}_{i=1}^N, p^m\right)$, completely characterizing the global equilibrium.

Comparative statics. It will prove convenient to set the price of materials p^m as the numéraire. In this case, wages are measured in terms of units of material inputs, and a higher wage w_i is equivalent to lower relative price of mateials p^m/p_i (see Equation 34). Using Equations 32 and 33, we can rewrite the market clearing for materials in terms of the labor shares in all countries:

$$\bar{m} = \frac{1}{\alpha^\alpha (1-\alpha)^{1-\alpha}} \sum_i \frac{L_i^\alpha K_i^{1-\alpha}}{\psi_i} \left(\frac{1}{(\eta - 1)\alpha (\lambda_i)^{-1} - \eta} \right)^{\frac{\sigma}{1-\sigma}}. \tag{38}$$

Equation 38 reveals that the labor share remains constant in all countries if the global supply of materials $\bar{m}$ grows in the same rate as the composite of labor and capital in all countries $L_i^\alpha K_i^{1-\alpha}$ (adjusted to biases in technical change ψ_i). Furthermore, if the global supply of materials declines relative to these other endowments, the global labor share shrinks on average. However, there is ambiguity with respect to patterns in specific countries, and in any case the decline is not homogeneous across countries and depends on their initial labor share, endowments of L_i and K_i, and factor-bias ψ_i.

Next, consider a shock to productivity z_j in some country j. Since a higher z_j raises the marginal revenue product of labor in that country and the supply of labor is constant at L_j, w_j must rise. From Equation 33, we know that λ_j must rise as a consequence, recalling our normalization $p^m = 1$. Finally, from Equation 38, we get that λ_ℓ must fall in at least one additional country ℓ to maintain commodity market clearing, with the effect mediated through the relative price of materials in country ℓ. We therefore get that asymmetric TFP growth across countries maintains a constant (appropriately weighted) global labor share (Equation 38), but with heterogeneous effects across countries, with at least some countries experiencing a decline in their labor share.

C Analysis of Periods with no Variation in Prices

We have investigated our proposed mechanism in two periods that have witnessed significant changes in the prices of materials. In the 2000s, we relied on the broad change in commodity prices as an external source of variation. In the 1970s, we relied on the narrower event of the oil crisis. In other periods, our ability to test our mechanism is constrained by the lack of variation in materials' prices across industries. We present this pattern in Appendix Figure C.1 which depicts the variance of the growth of materials prices across manufacturing industries in the NBER-CES data. As can be seen in Figure C.1, the variance before the 1970s is essentially non-existent. This could result from the exchange-rate stability provided by the Bretton Woods system in these years, or just reflect issues with the measurement and construction of price indices. In either case, there is almost no variation in available measures of changes in materials prices for our proposed effect to be precisely identified. In Appendix Table C.1, we replicate our baseline OLS regression in different periods. Column (1) presents this relationship for the available years before the 1970s (1958-1970). In line with what one should expect when there is lack of variation in the treatment variable, we find negative but statistically insignificant relationship between materials prices and the labor share, with standard errors that are more than double their value in other periods.

The picture in the 1980s and early 1990s is more nuanced. In these years, we also find little variation in prices relative to the 1970s and the 2000s, but fail to find a negative (even if statistically insignificant) relationship between materials prices and the labor share, as can be seen in Column (3) of the same table. More strikingly, in Column (7), we even fail to find a relationship between materials prices and the expenditure on materials relative to labor, which is robust in all other periods. That is to say, we not only fail to find the pass-through into the labor share in the 1980s, but even the more basic evidence for complementarities between materials and non-materials that are well-documented in the literature and go beyond this paper. What can explain these patterns? One potential hypothesis is a stronger role for factor-biased technical change in these years.[38] Some evidence in favour of this explanation can be seen in Appendix Table C.2, which replicates Table C.1 for the various periods when controlling also for various measures of the industry technological capabilities, such as the log of total factor productivity. Indeed, once these variables are controlled for, both the positive relationship between materials prices and the relative expenditure on materials (Column 7), and the negative relationship between materials prices and the labor share (Column 3) are restored. In either case, the estimated relationship provides only correlational evidence, and no casual claim can be established.

[38]Recall that a technical change biased towards labor and capital relative to materials can lead to an increase in the expenditure on materials relative to other inputs without changes in relative prices.

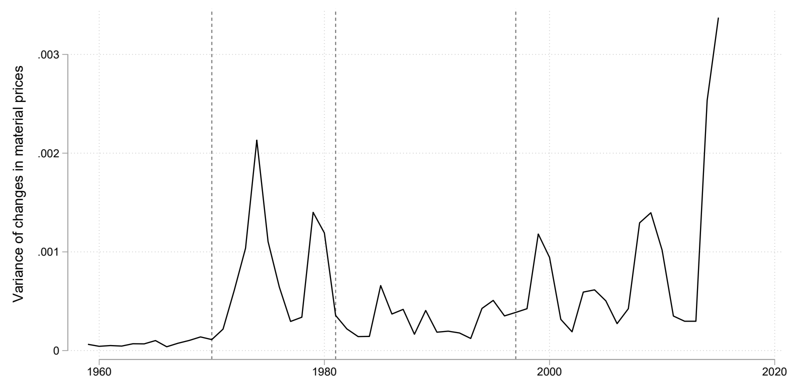


Figure C.1: Dispersion in the Growth of Residual Materials Prices. This figure plots the variance of the growth of materials prices across all 6-digit NAICS manufacturing industries after controlling for industry fixed effects, year fixed effects, the log of average wage and the log price of investment goods. Industries are weighted by value added. The vertical dashed lines correspond to the years 1970, 1981 and 1997.

Table C.1: The Effect of Material Prices - Different Periods (A)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Period:	1958-1970	1970-1980	1980-1997	1997-2016	1958-1970	1970-1980	1980-1997	1997-2016
Outcome:	Labor Share				Log. Materials to Wage-Bill			
Log. Materials Price	-0.0323	-0.0475**	0.0504	-0.0788***	0.638***	0.656***	0.394	0.456***
	(0.0455)	(0.0204)	(0.0416)	(0.0226)	(0.155)	(0.112)	(0.240)	(0.0802)
Log. Average Wage	0.00868	0.0846**	0.0483	0.0746	-0.305***	0.00580	-0.362***	-0.290*
	(0.0305)	(0.0360)	(0.0479)	(0.0457)	(0.107)	(0.142)	(0.115)	(0.149)
Log. Investment Price	-0.469***	0.261***	-0.00449	-0.0497	0.289	-0.679***	-1.200***	0.436
	(0.140)	(0.0533)	(0.0498)	(0.0751)	(0.498)	(0.240)	(0.284)	(0.274)
N	4693	3971	6498	7280	0.986	0.983	0.981	0.967
Industry and Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table reports results from the regression of industry-level outcomes on the log. of the price index of materials, the log. of the average wage and the log. of the price of investment, for different periods. Columns (1)-(4) report results for the labor share, and columns (5)-(8) report results for the log of expenditure on materials to wage bill ratio. Observations correspond to industry-year pairs for the 364 NAICS industries in the NBER-CES dataset. All specifications control for industry and year fixed effects and weight observations by value-added at the beginning of the corresponding period. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table C.2: The Effect of Material Prices - Different Periods (B)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Period:	1958-1970	1970-1980	1980-1997	1997-2016	1958-1970	1970-1980	1980-1997	1997-2016
Outcome:	Labor Share				Log. Materials to Wage-Bill			
Log. Materials Price	-0.0788	-0.0710***	-0.0442**	-0.0847***	0.723***	0.728***	0.601***	0.486***
	(0.0485)	(0.0230)	(0.0211)	(0.0245)	(0.155)	(0.107)	(0.189)	(0.0742)
Log. Average Wage	0.0314	0.0857**	0.0428	0.0811*	-0.331***	-0.0282	-0.353***	-0.312**
	(0.0274)	(0.0362)	(0.0482)	(0.0480)	(0.109)	(0.132)	(0.102)	(0.143)
Log. Investment Price	-0.498***	0.218***	-0.0462	-0.00617	0.362	-0.586**	-1.076***	0.395
	(0.144)	(0.0629)	(0.0498)	(0.0913)	(0.508)	(0.228)	(0.209)	(0.283)
Production Workers Share	-0.114**	-0.253***	-0.243**	0.000978	0.292	0.589**	1.142***	0.860***
	(0.0510)	(0.0715)	(0.104)	(0.0901)	(0.208)	(0.246)	(0.205)	(0.148)
Log. Capital-Labor Ratio	-0.0241***	-0.00496	-0.0364***	0.0338*	0.0225	0.0840	0.178***	-0.00562
	(0.00877)	(0.0122)	(0.0128)	(0.0187)	(0.0434)	(0.0621)	(0.0428)	(0.0606)
Log. TFP	-0.122***	-0.0679***	-0.119***	-0.0479	0.220***	0.181**	0.231***	0.0884
	(0.0200)	(0.0201)	(0.0183)	(0.0298)	(0.0819)	(0.0736)	(0.0781)	(0.0584)
N	4693	3971	6498	7280	4693	3971	6498	7280
Industry and Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table reports results from the regression of industry-level outcomes on the log. of the price index of materials, the log. of the average wage, the log. of the price of investment, the log of the capital-labor ratio, the share of production workers in total employment and the log of total factor productivity for different periods. Columns (1)-(4) report results for the labor share, and columns (5)-(8) report results for the log of expenditure on materials to wage bill ratio. Observations correspond to industry-year pairs for the 361 NAICS industries in the NBER-CES dataset. All specifications control for industry and year fixed effects and weight observations by value-added at the beginning of the corresponding period. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

D Additional Tables and Figures

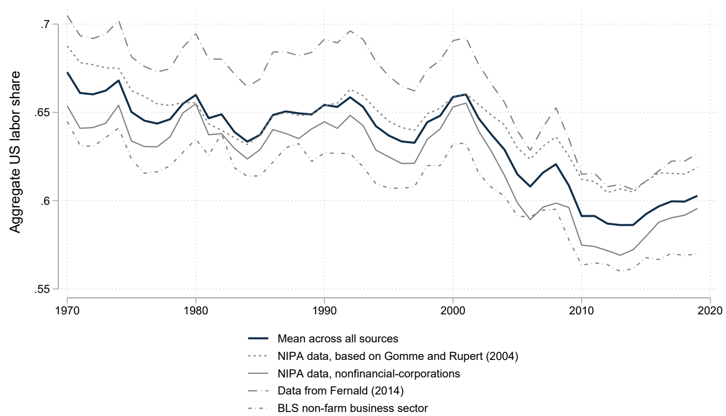


Figure D.1: U.S. aggregate labor share. This figure shows four different measures for the aggregate historical labor share out of income in the U.S.: (1) The main specification suggested in Gomme and Rupert (2004); (2) The labor share in U.S. non-financial corporations, constructed based on NIPA data; (3) The series computed by Fernald (2014); (4) The definition of the Bureau for Labor Statistics (BLS) for non-farm business-sector labor share, constructed from NIPA data.

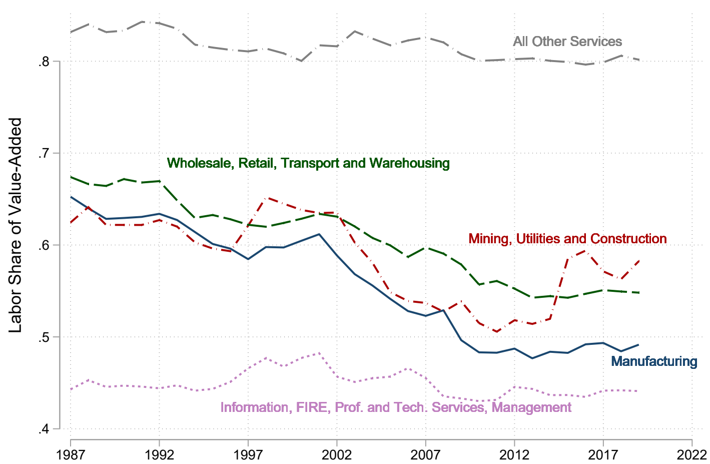
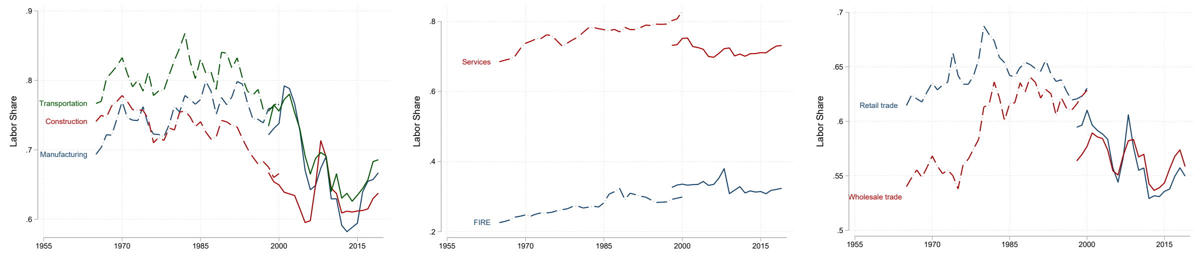


Figure D.2: The Labor Share Across U.S. Sectors - KLEMS Accounts. This figure plots the aggregate labor share for groups of U.S. sectors based on BEA's Integrated Industry-Level Production Account (KLEMS) estimates. The estimates are of highest quality after the change in industry classification from SIC to NAICS in 1997; and in years that are closest to an update of the input-output-table (1997, 2002, 2007, 2012).



(a) Transportation, Construction, Manufacturing

(b) Services, FIRE

(c) Retail, Wholesale

Figure D.3: The Labor Share Across U.S. Sectors - NIPA Accounts. This figure plots the aggregate labor share for different sectors based on BEA's National Income and Product Accounts (NIPA) accounts, defining the labor share as total employee compensation to total national income without capital consumption adjustment. Dashed lines represent the SIC definition for industries and solid lines represent the NAICS definition. Panel (a) plots the aggregate labor share for transportation, construction and manufacturing. Panel (b) plots the aggregate labor share for services and finance sectors. Panel (c) plots the aggregate labor share for the wholesale trade and retail trade sectors.

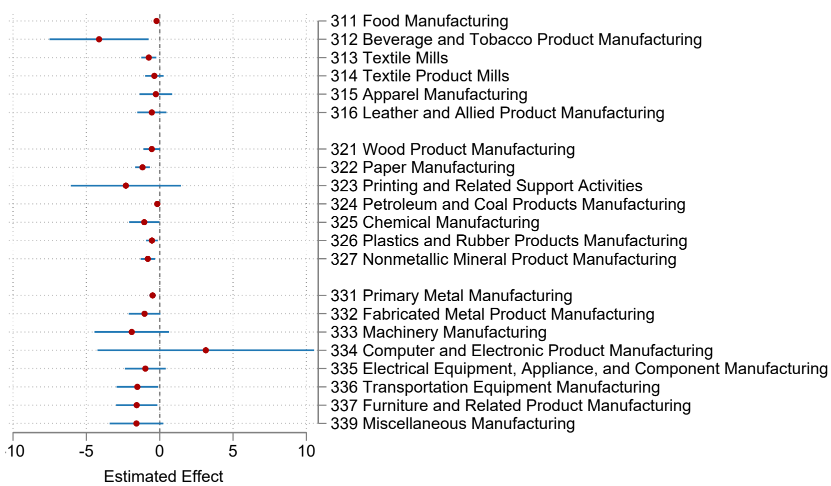


Figure D.4: Effect of Material Prices on the Labor Share by 3-digit NAICS Sectors. This figure plots the estimated coefficients for the effect of exposure to rising materials prices on the log of labor share from Section 3 for each 3-digit NAICS manufacturing subsector, with their corresponding 90% confidence intervals. We instrument the interaction between the 3-digit NAICS sectors dummy and the materials price index with the analogous interaction between these dummies and the shift-share instrument defined in Equation 7.

Table D.1: Commodities with Largest Price Increases.

HS96	Commodity	Δ Log. Price
811240	Vanadium	1847.8
280490	Selenium	1429.4
262050	Ash and Residues	1338.6
261390	Molybdenum	1167.7
811000	Antimony	1007.7
261610	Silver	847.2
261210	Uranium	790.4
722694	Zinc	766.6
741991	Copper	648
260700	Lead	636.7
284011	Borate	591.2

Table D.2: Industries with the Largest Increase in Commodity Prices.

Rank	NAICS Code	Description	Price Shock (00'-11')	Δ Labor Share (00'-11')	Commodity Intensity (1997)
1	324110	Petroleum Refineries	0.964	-0.051	0.641
2	331410	Nonferrous Metal Smelting and Refining	0.901	-0.186	0.645
3	311224	Soybean and Other Oilseed Processing	0.661	-0.108	0.685
4	331491	Nonferrous Metal Rolling, Drawing, Extruding	0.551	-0.109	0.493
5	311211	Flour Milling	0.511	-0.085	0.511
6	331210	Iron and Steel Pipe and Tube Manufacturing	0.506	-0.038	0.512
7	311212	Rice Milling	0.505	-0.113	0.505
8	311213	Malt Manufacturing	0.500	-0.131	0.499
9	331420	Copper Rolling, Drawing, Extruding, Alloying	0.495	-0.064	0.404
10	311911	Roasted Nuts and Peanut Butter Manufacturing	0.490	0.045	0.571
11	311221	Wet Corn Milling	0.484	-0.068	0.482
12	331318	Other Aluminum Rolling, Drawing, Extruding	0.482	-0.060	0.602
13	331221	Rolled Steel Shape Manufacturing	0.461	-0.155	0.476
14	331222	Steel Wire Drawing	0.455	-0.087	0.478
15	332114	Custom Roll Forming	0.411	-0.023	0.441

Table D.3: The Effect of the Price of Materials on Other Industry Outcomes.

	(1) Log M/Y	(2) Log Y/R	(3) Log M/W	(4) Log M/K	(5) Log K/Y	(6) Log K/L
Materials Intensity × Log. Materials Price	0.0713***	-0.263***	0.260***	0.277***	-0.206***	0.00593
	(0.0273)	(0.0279)	(0.0399)	(0.0373)	(0.0217)	(0.00378)
First-stage F-stat (KP-Wald)	37.20	37.20	37.20	37.20	37.20	37.20
N	9386	9386	9386	9386	9386	9386
Industry controls (see notes)	Yes	Yes	Yes	Yes	Yes	Yes
Industry and Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Weighted	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table reports results from the regression of selected industry outcomes on exposure to materials prices as in Table 1, using the same instrument, the same sample restrictions, and the same controls as in Column 9 of Table 1. Column 1 reports results for the log of expenditure on materials over value added; Column 2 for the log of value added over sales; Column 3 for the log of expenditure on materials over total payroll; Column 4 for the log of expenditure on materials over the real stock of capital; Column 5 for the log of the real stock of capital over value added; Column 6 for the log of the real stock of capital over the total number of employees. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table D.4: The Effect of Material Prices on the Labor Share - Three Digits NAICS - Year Fixed Effects

Outcome: Log Industry Labor Share	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS
Materials Intensity × Log. Materials Price	-0.135***	-0.220***	-0.193***	-0.211***	-0.211***
	(0.0278)	(0.0577)	(0.0533)	(0.05444)	(0.0543)
First-stage F-stat (KP-Wald)		11.13	30.71	29.81	29.62
N	9386	9386	9386	9386	9386
Average Wage and Investment Price Controls	Yes	Yes	Yes	Yes	Yes
Production Workers Share and K/L Ratio Controls	No	No	No	Yes	Yes
Import Penetration Controls	No	No	No	No	Yes
Industry and Year FE × NAICS-3 Sector FE	Yes	Yes	Yes	Yes	Yes
Weighted	No	No	Yes	Yes	Yes

Notes: This table is a replication of our baseline results Table 1 in Section 3, controlling also for Year × NAICS-3 sector fixed effects. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table D.5: The Effect of Material Prices on the Labor Share - BEA Subsectors

Outcome: Log Industry Labor Share	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
Materials Intensity × Log. Materials Price	-0.0957***	-0.103***	-0.0897***	-0.0935***	-0.0935***	-0.0936***	-0.0994***
	(0.0076)	(0.0126)	(0.0132)	(0.0113)	(0.0114)	(0.0116)	(0.0148)
Sourced Services Share						-0.125	-0.127
						(0.255)	(0.263)
Log. Services Price Index							0.403
							(0.679)
First-stage F-stat (KP-Wald)		118.7	90.38	96.78	92.46	93.19	81.17
N	494	494	494	494	494	494	494
Average Wage and Investment Price Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Production Workers Share and K/L Ratio Controls	No	No	No	Yes	Yes	Yes	Yes
Import Penetration Controls	No	No	No	No	Yes	Yes	Yes
BEA Subsector and Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weighted	No	No	Yes	Yes	Yes	Yes	Yes

Notes: This table is a replication of our baseline results Table 1 in Section 3 when aggregating the data to the 19 BEA (Bureau of Economic Analysis) manufacturing summary-level sub-sectors. Labor share is now defined as total labor compensation to value added in the BEA-KLEMS dataset, and the materials price index is taken from there as the ratio of total material compensation to material quantity. Column (6) extends the baseline analysis by controlling also for the share of sourced services compensation of total intermediates, and Column (7) adds the log price index of sourced services. Both variables are constructed from the BEA-KLEMS dataset. * p<0.1, ** p<0.05, *** p<0.01.

Table D.6: The Effect of Material Prices on the Labor Share - Leontief Inverse

Outcome: Log Industry Labor Share	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS
Materials Intensity × Log. Materials Price	-0.135***	-0.229***	-0.196***	-0.189***	-0.188***
	(0.0219)	(0.0468)	(0.0322)	(0.0256)	(0.0255)
First-stage F-stat (KP-Wald)		26.45	27.66	26.36	26.25
N	9386	9386	9386	9386	9386
Average Wage and Investment Price Controls	Yes	Yes	Yes	Yes	Yes
Production Workers Share and K/L Ratio Controls	No	No	No	Yes	Yes
Import Penetration Controls	No	No	No	No	Yes
Industry and Year FE	Yes	Yes	Yes	Yes	Yes
Weighted	No	No	Yes	Yes	Yes

Notes: This table is a replication of our baseline results Table 1 in Section 3, with an instrument constructed from the Leontief Inverse of the Input-Output table to account for exposure to changing commodity prices through input-output linkages, as described in Section 3.9. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table D.7: The Effect of Material Prices Using Only Variation in Prices

Outcome: Log Industry Labor Share	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS
Materials Intensity × Log. Materials Price	-0.135***	-0.338***	-0.194**	-0.161***	-0.161***
	(0.0219)	(0.0787)	(0.0437)	(0.0306)	(0.0304)
First-stage F-stat (KP-Wald)		14.42	3.65	3.36	3.36
N	9386	9386	9386	9386	9386
Average Wage and Investment Price Controls	Yes	Yes	Yes	Yes	Yes
Production Workers Share and K/L Ratio Controls	No	No	No	Yes	Yes
Import Penetration Controls	No	No	No	No	Yes
Industry and Year FE	Yes	Yes	Yes	Yes	Yes
Weighted	No	No	Yes	Yes	Yes

Notes: This table is a replication of our baseline results Table 1 in Section 3, with an instrument that utilizes only variation coming from changes in commodity prices, independently of overall exposure to commodities, as described in Section 3.9. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table D.8: Controlling for Industry Concentration

Outcome: Log Industry Labor Share	(1) OLS	(2) 2SLS	(3) 2SLS	(4) OLS	(5) 2SLS	(6) 2SLS
Materials Intensity × Log. Materials Price	-0.187***	-0.255***	-0.254***	-0.178***	-0.246***	-0.245***
	(0.0237)	(0.0265)	(0.0248)	(0.0222)	(0.0273)	(0.0243)
% Sales Top-4				-0.229	-0.163	-0.155
				(0.292)	(0.296)	(0.258)
Log. HHI-50				-0.0728	-0.0784*	-0.0771*
				(0.0446)	(0.0451)	(0.0420)
First-stage F-stat (KP-Wald)		80.90	77.06		86.02	80.77
N	1390	1390	1390	1390	1390	1390
Average Wage and Investment Price Controls	Yes	Yes	Yes	Yes	Yes	Yes
Production Workers Share and K/L Ratio Controls	No	No	Yes	No	No	Yes
Import Penetration Controls	No	No	Yes	No	No	Yes
Industry and Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table replicates our baseline specification with two industry concentration measures - the sales share of the largest 4 firms in each industry ("% Sales top 4") and the Log. Herfindahl–Hirschman index for the largest 50 firms ("Log. HHI-50"). Observations correspond to industry-year pairs for the 361 NAICS industries in the NBER-CES dataset for the years 1997, 2002, 2007 and 2012. All specifications control for industry and year fixed effects and are weighted by 1997 value-added. Columns 1-3 report OLS results and 2SLS results without industry concentration measures, and Columns 4-6 repeat these regressions with them. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.