Intermediate Input Prices and the Labor Share

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Abstract

We argue that the relative price of materials is an important determinant of the labor share of income. When materials and primary inputs are complements and the profit share is positive, a higher price of materials lowers the labor share and raises the profit share of value added, without requiring markups or returns to scale to change. We show that materials-price fluctuations align with U.S. labor-share trends, provide causal evidence on this mechanism across industries and commuting zones, and quantify its importance in a dynamic quantitative model. Finally, we use our mechanism to rationalize differential labor-share trends across countries.

Keywords: Labor Share, Intermediate Inputs, Materials, Commodity Prices
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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 extensive 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 in the following 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 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, plotting the labor share alongside the relative prices of both unprocessed and processed intermediate goods. 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 behavior.[1]

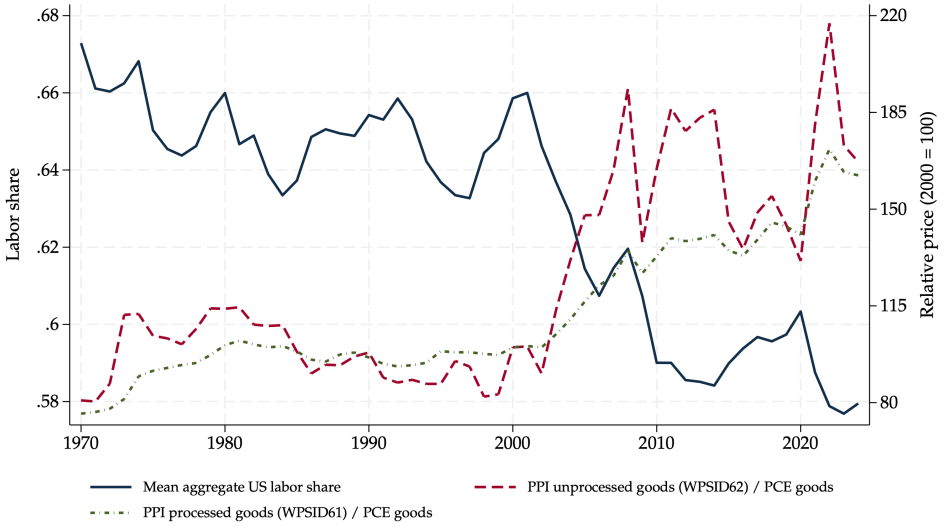
We begin by characterizing the conditions under which materials prices affect the labor share. The relationship is not immediate. Materials are often assumed to be separable from primary inputs – labor and capital – in the production function, and under zero profits, this implies that the shares of labor and capital in value added are independent of materials. With positive profits, however, value added exceeds payments to primary inputs, so factor shares in value added depend on how production costs are divided between materials and primary inputs. If materials and primary inputs are also complements, a higher relative price of materials raises their share of production costs and reduces labor and capital payments relative to value added. Both factor shares therefore decline even when the profit share of revenue remains constant. The mechanism thus requires neither rising markups nor changing returns to scale and is consistent with evidence that the capital share has declined alongside the labor share.[2]

We investigate the above mechanism using multiple sources of variation. We first

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

[2] See Barkai (2020).

Figure 1: Trends in the Aggregate Labor Share and Relative Price of Materials



Note: 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 PPI for unprocessed goods for intermediate demand (FRED series WPSID62) to the PCE index for goods. The dot-dashed line is the ratio of the PPI for processed goods for intermediate demand (FRED series WPSID61) to the PCE index for goods. Both relative price series are normalized to 100 in 2000.

demonstrate that materials-intensive U.S. sectors experienced both larger increases in material input prices and sharper declines in their labor share during the 2000s. We then focus on U.S. manufacturing – where the decline was particularly pronounced – and show that the ratio of labor compensation to materials expenditure fell in lockstep with rising materials prices, providing direct evidence of our proposed mechanism. To obtain exogenous variation, we construct a shift-share instrument based on industry exposure to globally traded commodities, using input-output tables to map commodity prices into industry-level shocks. Across narrowly defined manufacturing industries and commuting zones, we find a robust negative relationship between materials prices and the labor share. We provide a structural interpretation of these estimates through the lens of our theory, linking them to the degree of complementarity between materials and primary inputs and to profit rates. In a back-of-the-envelope calculation, we assess that changes in materials prices can account for around a third of the changes in the labor share in recent decades.

As a further validation, we exploit the 1970s oil shock as a second natural experiment, using industry-level energy intensity as an instrument, and obtain comparable

results. Although energy prices spiked during the 1970s, the increase in the relative price of the overall materials bundle was much smaller than in the 2000s (as can be seen in Figure 1), consistent with the more moderate decline in the labor share over that period; we discuss this in detail in Section 3.8. Finally, we also develop an alternative instrument based on natural disaster shocks in major commodity-exporting countries, which provides a fundamentally different source of exogenous variation and also yields similar estimates.

To quantify the importance of our mechanism, we assess it in the context of a dynamic model of the U.S. manufacturing sector with capital accumulation. To isolate the role of materials prices relative to alternative forces, we invert the model period by period to recover time-varying fundamentals – including markups, capital intensity, and productivity – from observed data on factor shares, investment, capital, and output. In counterfactual experiments, we hold materials prices fixed at their baseline level while allowing all other fundamentals to follow their observed paths. The results indicate that rising materials prices account for 23–35% of the decline in the manufacturing labor share during the 2000s. Importantly, this approach separates the role of materials prices from competing explanations such as rising markups or automation, addressing the concern raised by Grossman and Oberfield (2022) that many proposed explanations for changes in the labor share are not mutually exclusive.

While the price of commodities has nominally increased across the globe since the 2000s, countries have experienced different trends in their labor share. To study our mechanism across countries, we develop a simple multi-country trade model with a global commodity market in which countries experience different changes in their *relative* price of materials despite a common nominal price, leading to heterogeneous effects on the labor share. We verify these predictions using data from the EU-KLEMS dataset: the U.S. and Japan experienced both a large increase in the relative price of materials and a larger decline in their manufacturing labor share, while Europe saw a relatively stable labor share alongside a close-to-constant relative price of materials. Extending our analysis to a cross-country panel, we again find a negative relationship between the relative 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). Relatedly, Oberfield and Raval (2021) study labor-share movements through changes in the wage-rental ratio and a residual "bias of technical change" component.[3] 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.[4] By contrast, the complementarity between materials and primary inputs required for our mechanism is consistent with available estimates in this literature (e.g. Atalay 2017, Boehm, Flaaen, and Pandalai-Nayar 2019, Carvalho, Nirei, Saito, and Tahbaz-Salehi 2021, Oberfield and Raval 2021, and Peter and Ruane 2026).

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.[5] A related explanation, proposed by Philippon (2019) and Gutiérrez and Piton (2020), emphasizes changes in the U.S. institutional environment; as discussed in Section 5, our mechanism offers an alternative account of cross-country heterogeneity that does not rely on institutional changes.

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 Atkeson (2020), Koh et al. (2020),

[3]Specifically, Oberfield and Raval (2021) decompose labor share movements into a component driven by the wage-rental ratio and a residual "bias of technical change" component. In our framework, with a positive profit share, changes in materials prices are an additional source of labor-share variation even when the wage-rental ratio is unchanged and there is no factor-biased technical change.

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

[5]Some studies, including Autor et al. (2020) and Kehrig and Vincent (2021), have emphasized the importance of within-industry firm heterogeneity, showing that the downward trend is much less pronounced for the median firm. While we focus on industry or regional outcomes, our theory predicts heterogeneous responses amplified by the profit share, with ex-ante low labor share firms experiencing greater declines. Empirically, our results are virtually unchanged when controlling for industry concentration dynamics.

and Barro (2021), claim that this long-run trend is no longer clear after correctly accounting for intellectual property and intangible capital in the national accounts. Our paper is consistent with these corrected series, which still exhibit significant medium-term fluctuations (e.g. the 2000s drop and subsequent rebound) that our mechanism can explain.

Finally, we also relate to the literature on aggregate elasticities of substitution across inputs in production (Baqaee and Farhi, 2019), and in particular to papers that consider the degree of substitution between materials and primary inputs. While this is not the focus of our study, our estimates imply complementarity between materials and primary inputs and fall within the range reported in this literature. Several studies, particularly in manufacturing settings, likewise obtain point estimates below one (e.g. Bruno 1984, Rotemberg and Woodford 1996, Atalay 2017, Doraszelski and Jaumandreu 2018, Boehm et al. 2019, Carvalho et al. 2021, Oberfield and Raval 2021, and Peter and Ruane 2026). In this context, we utilize booms in global commodity prices as our main source of identification, and complement them with the 1970s oil shock and natural-disaster shocks in major commodity-exporting countries as alternative sources of exogenous variation.

Throughout the paper, we use the term "materials" to refer broadly to intermediate goods – both processed and unprocessed – and include energy goods in this definition. We refer to unprocessed goods or raw materials as a subcategory that drives much of the variation in the prices of the overall materials bundle, and rely on such variation as a source of identification, particularly when analyzing the global commodity boom in the 2000s. We mostly abstract from sourced services, although a similar mechanism can operate through this margin.[6]

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 develop a dynamic quantitative model with capital accumulation and use it to quantify the importance of our mechanism for the decline of the manufacturing labor share. Section 5 investigates our mechanism in a

[6]Sourced services are often thought of as being gross substitutes for in-house production. In this case, a decline in the relative cost of outsourcing can lead to a decline in the labor share through a similar mechanism.

cross-country setting, both theoretically and empirically. Section 6 concludes.

2 Theoretical Framework

In this section, we derive conditions under which an increase in the price of materials lowers the labor share. We deviate from standard macroeconomic frameworks in two ways. First, instead of a value-added production function, we consider a gross-output technology in which materials are an input. Second, we allow for profits – a wedge between revenues and costs.

2.1 Environment and notation

Technology. We consider a firm that produces output y using capital k, labor l, and materials m. The technology is *weakly separable* in primary inputs and materials:

$$y = F\big(G(k,l),\, m\big), \tag{1}$$

where $G(k,l)$ is a *primary-input bundle* combining capital and labor, and both F and G exhibit constant returns to scale.[7] Weak separability means that the marginal rate of technical substitution between capital and labor is independent of the level of materials. Appendix A.3 relaxes this assumption, allowing materials prices to shift expenditure between labor and capital directly.[8]

Prices. The firm takes the wage rate w, the rental rate of capital r, and the price of materials p_m as given. We denote the price of output by p.

Unit costs. The firm chooses inputs to minimize costs. Separability implies that cost minimization can be carried out in two stages: the firm first chooses the mix of capital and labor that minimizes the cost of the primary-input bundle, yielding unit cost $c_G(w,r)$, and then chooses the mix of that bundle and materials. We define the unit cost of the primary-input bundle as

$$c_G(w,r) \equiv \min_{k,l} \big\{ rk + wl :\ G(k,l) = 1 \big\}, \tag{2}$$

[7] We assume F and G are increasing, concave, and twice differentiable. We consider the case in which F features decreasing returns as a microfoundation for profits in Appendix A.1.

[8] Empirically, we find little evidence of non-separability, as we do not find an effect of the price of materials on capital-labor ratios, nor do our estimates for the transmission of materials prices to the labor share change when we control for capital-labor ratios. See Section 3 for more details.

and the unit cost of gross output as

$$c_F\big(c_G(w,r),\, p_m\big) \equiv \min_{G,m} \big\{ c_G(w,r)\, G + p_m m :\ \ F(G,m) = 1 \big\}. \tag{3}$$

Under constant returns to scale, the total cost of producing y is $C = c_F\big(c_G(w,r), p_m\big)\, y$, and payments to primary inputs equal the cost of the primary-input bundle: $rk + wl = c_G(w,r)\, G$.

Revenue, value added, and profits. We denote revenue by $R \equiv py$, value added by $V \equiv R - p_m m$, and profits by $\Pi \equiv R - C$, and we define the *profit share of revenues* as $\pi \equiv \Pi / R$. We remain agnostic about the source of $\pi > 0$ for most of the analysis; Appendix A.1 provides standard microfoundations based on markups, decreasing returns to scale, and fixed factors.

2.2 The labor share

The labor share is the ratio of labor payments to value added,

$$\lambda \equiv \frac{wl}{V} = \frac{wl}{wl + rk + \Pi}. \tag{4}$$

Multiplying and dividing by the cost of the primary-input bundle yields the decomposition

$$\lambda = \frac{wl}{c_G(w,r)\, G} \times \frac{c_G(w,r)\, G}{V}. \tag{5}$$

The labor share is thus the product of labor's share of primary-input costs and the ratio of primary-input costs to value added. We consider each term in turn.

The first term depends only on the relative price of primary inputs. By Shephard's lemma,

$$\frac{wl}{c_G(w,r)\, G} = \frac{\partial \log c_G(w,r)}{\partial \log w} \equiv \alpha(w,r), \tag{6}$$

which is homogeneous of degree zero in (w,r) – in particular, it is independent of the price and quantity of materials. This term is the margin on which existing neoclassical explanations of the decline in the labor share operate, through changes in relative primary-input prices or technologies that shift expenditure from labor to capital (e.g., Karabarbounis and Neiman, 2014; Oberfield and Raval, 2021).

The second term in Equation (5) is the ratio of primary-input costs to value

added. To understand it, note that value added equals payments to primary inputs plus profits, $V = c_G(w,r)\,G + \Pi$, and re-write it as

$$\frac{c_G(w,r)\,G}{V} = \left(1 + \frac{\pi}{1-\pi}\,\frac{c_F\big(c_G(w,r), p_m\big)\,y}{c_G(w,r)\,G}\right)^{-1}. \tag{7}$$

The second term thus depends on the profit share of revenues, π, and on the ratio of total costs to primary-input costs, which is a transformation of the materials cost share.

The labor share with materials and no profits. When $\pi = 0$, revenue equals total cost, the second term equals one, and value added coincides with payments to primary inputs: $V = c_G(w,r)\,G$. The economy then behaves as if value added were produced directly from capital and labor by the function G: real value added is the primary-input bundle $G(k,l)$, its price index is $c_G(w,r)$, and its marginal products, valued at c_G, equal their respective factor prices (Bruno, 1978). The labor share is then $\lambda = \alpha(w,r)$, and the price of materials does not affect it. In this case one can safely ignore materials prices in the analysis of changes in the labor share. Notably, this requires the separability of materials and primary inputs; without it, materials prices could shift expenditure between labor and capital directly, as discussed in Appendix A.3.

The labor share with materials and positive profits. With positive profits, payments to capital and labor no longer exhaust value added; part of it accrues as profits. The division of factor payments between labor and capital therefore no longer fully determines their shares of value added: those shares also depend on the fraction of value added accounted for by factor payments (Bruno, 1978; Hall, 1990; Basu and Fernald, 1997). The second term in Equation (5), the share of value added paid to primary inputs, is therefore strictly below one, so labor's share of value added is lower than its share of primary-input costs. Crucially, even holding the profit share of revenues fixed, this ratio can vary: it depends on the ratio of total costs to primary-input costs and therefore responds to the relative price of materials whenever that price changes the materials cost share. Combining Equations (5), (6), and (7), the

labor share can be written as

$$\lambda = \alpha(w,r)\left(1 + \frac{\pi}{1-\pi}\,\frac{1}{1-\theta_m\big(p_m/c_G(w,r)\big)}\right)^{-1}, \tag{8}$$

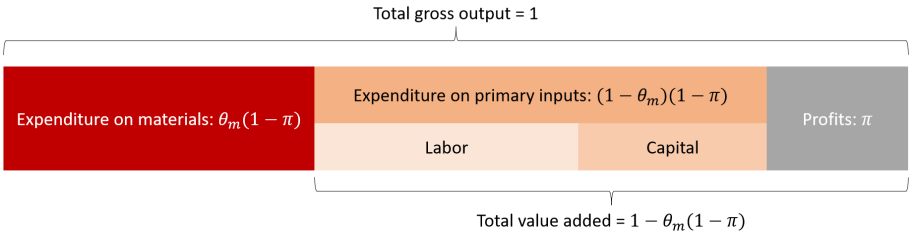
where $\theta_m \equiv p_m m/\big(c_F\big(c_G(w,r),p_m\big)\,y\big)$ denotes the materials cost share, which – under cost minimization – depends on the price of materials relative to the unit cost of the primary-input bundle, $p_m/c_G(w,r)$.

The share of value added paid to primary inputs also varies with the profit share of revenues, π – the margin emphasized in the literature on rising markups and economic profits (e.g., Barkai, 2020; De Loecker et al., 2020). Our focus is instead on the materials-share margin. Holding the profit share constant, a higher materials cost share reduces primary-input costs relative to value added and therefore lowers the labor share. If $F(\cdot)$ is Cobb-Douglas, the materials cost share is constant, so changes in the relative price of materials do not affect the labor share, even with positive profits. Under a more general production function, however, the materials cost share varies with the relative price $p_m/c_G(w,r)$. In particular, when materials and the primary-input bundle are gross complements, an increase in $p_m/c_G(w,r)$ raises the materials cost share, reduces primary-input costs relative to value added, and thereby lowers the labor share.

Figure 2 illustrates this mechanism by decomposing one unit of revenue. A share π of revenue accrues to profits, while the remaining share $1-\pi$ is divided between materials and primary inputs. When materials and the primary-input bundle are gross complements, a higher relative price of materials raises the materials cost share and shifts expenditure from primary inputs toward materials. Because materials payments are excluded from value added, profits then constitute a larger share of value added and primary inputs a smaller share, even though the profit share of revenue remains constant. Profits need not rise in levels: their share of value added can increase even if profits fall, provided primary-input payments fall proportionally more.

An extreme version of the mechanism arises as $\theta_m \to 1$ with positive profits. In that limit, materials absorb nearly all costs and payments to primary inputs vanish relative to revenue, so value added consists of profits alone and the labor share of value

Figure 2: Distribution of Output and Value Added



added approaches zero. Equivalently, the profit share of value added approaches one. A world with a high materials share is thus one in which a larger share of income is associated with the intermediary role of firms, leaving less for primary factors.

2.3 The transmission from materials prices to the labor share

We now characterize the transmission from changes in materials prices to the labor share by totally differentiating Equation (8), allowing materials prices to vary while holding constant other prices and the profit share.

Proposition 1. *Consider the production function in Equation (1) and a constant profit share of revenues π. The elasticity of the labor share of value added with respect to the price of materials, holding primary-input prices constant, is*

$$\frac{d\log\lambda}{d\log p_m} = -(1-\sigma)\frac{\pi}{1-\pi}\frac{M}{V}, \tag{9}$$

where $\sigma \equiv -\frac{\partial\log(m/G)}{\partial\log(p_m/c_G)}$ is the local elasticity of substitution between the primary-input bundle and materials; $M \equiv p_m m$ is total expenditure on materials; and $V \equiv py - p_m m$ is total value added.

Proof. See Appendix A.2. □

According to Proposition 1, an increase in the price of materials lowers the labor share if and only if two conditions hold: (i) materials and primary inputs are complements ($\sigma < 1$),[9] so that a higher price of materials raises their share in total cost; and (ii) the profit share is positive ($\pi > 0$), so the second term in Equation (8) is different from one and can be affected by input prices.

[9]By "complements" we mean gross complementarity: when $\sigma < 1$, an increase in the relative price of one input raises the expenditure share of that input, corresponding to an elasticity of substitution below one.

The magnitude of the effect is the product of two objects, corresponding to the two conditions. The first, $(1-\sigma)\theta_m$, where $\theta_m = M/C$ is the materials cost share, is the response of the ratio of total to primary-input costs to the price of materials: it measures how strongly a higher price of materials shifts expenditure toward materials, and it is positive only under complementarity. The second, the profit share of value added $\Pi/V = \frac{\pi}{1-\pi}\frac{C}{V}$, measures how strongly the ratio of primary-input costs to value added responds to this shift: it is zero without profits, in which case the shift in expenditure leaves the labor share unchanged. The effect is therefore stronger where profit shares and materials intensity M/V are higher. These predictions align with the concentration of the labor share's decline in materials-intensive sectors such as manufacturing. They may also help rationalize the central role of low-labor-share firms documented in Kehrig and Vincent (2021), insofar as these firms' low labor shares reflect high ex-ante profit shares.

CES production function. Proposition 1 holds for any weakly separable production function F, with σ evaluated at the current allocation. A useful special case for our analysis is the constant elasticity of substitution (CES) structure between the primary-input bundle and materials:

$$F\big(G(k,l),\, m\big) = \Big(G(k,l)^{\frac{\sigma-1}{\sigma}} + m^{\frac{\sigma-1}{\sigma}}\Big)^{\frac{\sigma}{\sigma-1}}, \tag{10}$$

in which case σ is a constant structural parameter.

Extensions and further discussion. Appendix A collects extensions and further discussion of these results. First, we describe standard microfoundations for the profit share of revenues π; a constant π can arise from a constant markup, decreasing returns, or a fixed factor entering in Cobb–Douglas form with the variable-input bundle (Appendix A.1). Second, we relax weak separability between materials and the primary-input bundle (Appendix A.3). Third, we generalize Proposition 1 to allow π to vary, whether through variable markups or through a fixed factor with a non-unitary elasticity of substitution with the variable-input bundle. Fourth, we allow for fixed costs of production. Finally, we show how the mechanism operates in three stylized general-equilibrium environments: a roundabout production economy, a two-sector economy, and a small open economy (Appendix A.4).

2.4 Total differential of the labor share

Proposition 1 isolates the response of the labor share to the price of materials while holding primary-input prices, technology, and the profit share constant. To motivate our empirical strategy and highlight the other forces beyond materials prices that must be accounted for in estimation, we now derive the full total differential of the labor share, allowing these objects to vary. To incorporate factor-augmenting technical change, we augment the weakly separable gross-output technology in Equation (1) as follows:

$$y = F\big(G(A_K k,\, A_L l),\, Bm\big), \tag{11}$$

where (A_K, A_L, B) are capital-, labor-, and materials-augmenting productivities.[10] The total differential can be written as[11]

$$\begin{aligned} d\log\lambda = &-\frac{\pi}{1-\pi}(1-\sigma)\frac{M}{V}\Big(d\log p_m - d\log B - d\log c_G(w/A_L,\, r/A_K)\Big) \\ &+\; d\log\alpha(w/A_L,\, r/A_K) \;-\; \frac{R}{V}\, d\log\left(\frac{1}{1-\pi}\right), \end{aligned} \tag{12}$$

where $c_G(w/A_L,\, r/A_K)$ is the unit cost of the primary-input bundle in efficiency units, $\alpha(w/A_L,\, r/A_K) = wl/(wl + rk)$ is labor's cost share within primary inputs, and σ is the local elasticity of substitution defined in Proposition 1, which is constant under the CES specification in Equation (10). Under separability, both c_G and α are independent of p_m and B. The first term captures our mechanism: when the price of materials rises relative to materials-augmenting productivity and the unit cost of primary inputs, the labor share falls when $\sigma < 1$ and $\pi > 0$, with the effect scaled by the profit share and materials intensity. The second term captures reallocation between labor and capital within the primary-input bundle, driven by changes in relative primary-input prices or factor-biased technical change. The third term captures changes in the profit share of revenues – whether due to markups, returns to scale, or other sources of rents. We take this equation to the data in Section 3.

[10] As emphasized by Diamond, McFadden, and Rodriguez (1978), factor-augmenting technical change creates an identification challenge, since factor-specific productivity shifts can be observationally similar to movements along an isoquant. This issue is relevant for our empirical strategy, and we return to it in Section 3.

[11] See Appendix A.2 for the derivation: Equation (12) is the special case of the total differential under a general (non-separable) production function (Equation (A.10)) when materials are weakly separable from the primary-input bundle.

2.5 A simple calibration

Before turning to the empirical analysis, we use a simple calibration to assess the quantitative plausibility of the mechanism. Consider the U.S. manufacturing sector between 2000 and 2010, a period covering the bulk of the decline in the labor share. In the BEA–KLEMS industry accounts, the labor share in U.S. manufacturing fell by 22 log points over this period, while the price of materials and energy relative to the price of value added rose by 38 log points (see the series underlying Figure 4). Consider $\sigma = 0.2$ and $\pi = 0.09$, the values from our full quantification in Section 4, and a materials intensity, M/V, of 1.8. In this case, Proposition 1 gives an elasticity of the labor share with respect to the price of materials of $-(1-0.2) \times \frac{0.09}{0.91} \times 1.8 \approx -0.14$. Applying this elasticity to the observed 38-log-point price increase implies a decline of approximately $0.14 \times 38 \approx 5$ log points – around one-quarter of the observed decline.

A few remarks are in order. First, this elasticity is naturally sensitive to the assumed values of σ and π, with scarce directly comparable estimates of the latter for U.S. manufacturing. As we discuss in Section 4, we find that a profit share of revenues of 9% is consistent with the high free cash flow ratios in U.S. manufacturing over our period of study. This value implies that gross operating surplus – value added net of labor compensation – is divided roughly equally between payments to measured capital and profits. Second, one can avoid taking a stance on the value of π altogether by directly measuring the pass-through from materials prices to the labor share, as we do in our empirical investigation in Section 3. As discussed there, the same measured pass-through can be consistent with lower values of π when the elasticity of substitution between materials and primary inputs is at the lower end of the values found in the literature.[12] Third, this calculation uses the elasticity in Proposition 1, which assumes that all inputs are freely adjustable. As we discuss in Section 4, the elasticity is larger in the short run, when capital has not yet adjusted, implying a stronger response of the labor share to materials prices at shorter horizons and a larger role for our mechanism than the above computation. We now turn to provide causal evidence for our mechanism and assess its quantitative importance.

[12] For instance, Boehm et al. (2019) estimate elasticities of substitution between materials and primary inputs close to zero.

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.[13] We compare the labor share to the relative prices of both unprocessed and processed intermediate goods, constructed as the ratios of the Bureau of Labor Statistics (henceforth BLS) Producer Price Indexes (PPI) for unprocessed and processed goods for intermediate demand to the Bureau of Economic Analysis (BEA) Personal Consumption Expenditures (PCE) index for goods.[14] Figure 1 shows these measures in the past fifty years. All series 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.[15] Interestingly, despite the large increase in energy prices during the 1970s, the increase in the real price of the overall materials bundle was small by comparison, in line with the moderate decline in the labor share over this period. We discuss this period in greater detail in Section 3.8.

We now turn to explore trends at the sector level. To this end, we utilize the BEA's Integrated Industry-Level Production Account (KLEMS), which provides estimates of output and input prices and quantities for 63 industries.[16] First, we divide all industries into two groups based on their ratio of materials and energy expenditure to value added in 1997, such that each group represents half of total value added in the economy. Panel (a) in Figure 3 shows a Törnqvist chain-type price index of

[13] 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 of Labor Statistics (BLS) for non-farm business-sector labor share, constructed from NIPA data.

[14] We focus on these PPI series because of their long time coverage. We present them separately rather than as a single aggregate because the BLS does not publish the expenditure weights needed to construct a combined index. In our disaggregated analysis in Section 3.3, we use industry-specific materials price indexes that capture the full bundle of intermediates for each industry.

[15] 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 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.

[16] We use a previous vintage of the BEA-BLS KLEMS data that covers 1987–2021. Following an update to the GDP-by-Industry accounts in September 2023, the current vintage available on the BEA website begins only in 1997. We exclude government, agriculture, and utilities sectors, leaving 58 industries in our sample.

materials and energy for each group. While both groups experienced similar changes in the price 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. The gap between both groups suggests that changes in material prices could account for 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 the log labor share against exposure to the rise in material input prices, given by the product of ex-ante materials intensity (expenditure on materials and energy over value-added) and the log-change in the sectoral materials price index (reflecting the object $\frac{M}{V} \times d \log p_m$ in the notation of Proposition 1). The materials price index is a Törnqvist chain-type aggregate of materials and energy prices at the industry level. We control for sector and time fixed effects, and for the log price index of sectoral value-added, to account for changes in other factor prices. Sectors with high exposure to rising materials prices have seen the greatest decline in labor share.[17]

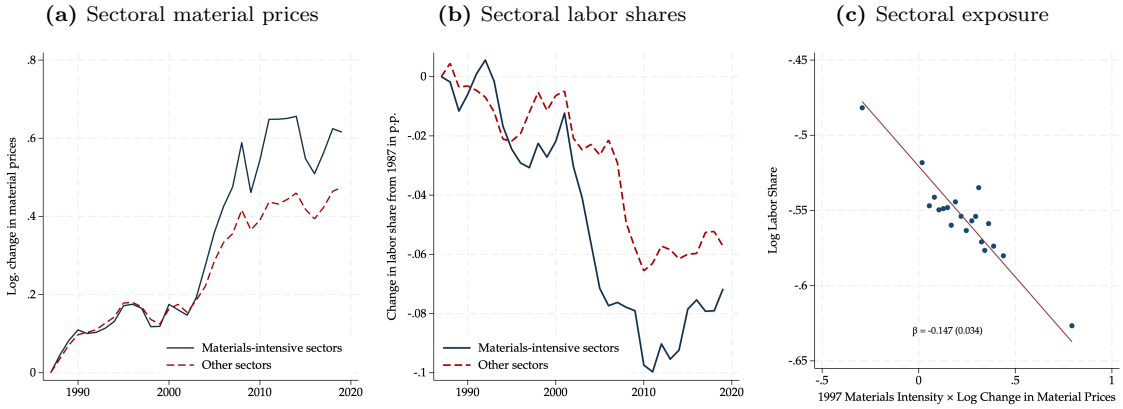
3.2 Evidence from the U.S. Manufacturing Sector

We now delve further into the U.S. manufacturing sector, a key driver of the aggregate changes in the labor share, where the decline during the 2000s was especially pronounced.

Trends for the overall manufacturing sector. Before proceeding to our cross-sectional analysis, we examine the aggregate evidence through the lens of the decomposition in Equation (5). Explanations that operate through its first term, labor's share of primary-input costs, should appear as a reallocation of expenditure from labor toward capital; our mechanism operates through the second term and instead predicts a *reallocation of costs* from primary inputs toward materials. 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 U.S. manufacturing over time,

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

Figure 3: Labor Shares and Material Price Shocks Across U.S. Sectors



Note: Panel (a) shows the change in a Törnqvist chain-type price index of materials and energy across two groups of U.S. industries split by their 1997 ratio of materials and energy expenditure to value added, with each group representing half of total value added. The materials-intensive group includes sectors in manufacturing, mining, construction, 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 the log labor share against a measure of exposure to the rise in material input prices (initial materials-to-value-added ratio in 1997 × log-change in the sector material price index) across 58 BEA-KLEMS industries, controlling for sector and time fixed effects and for the log price index of sector value added.

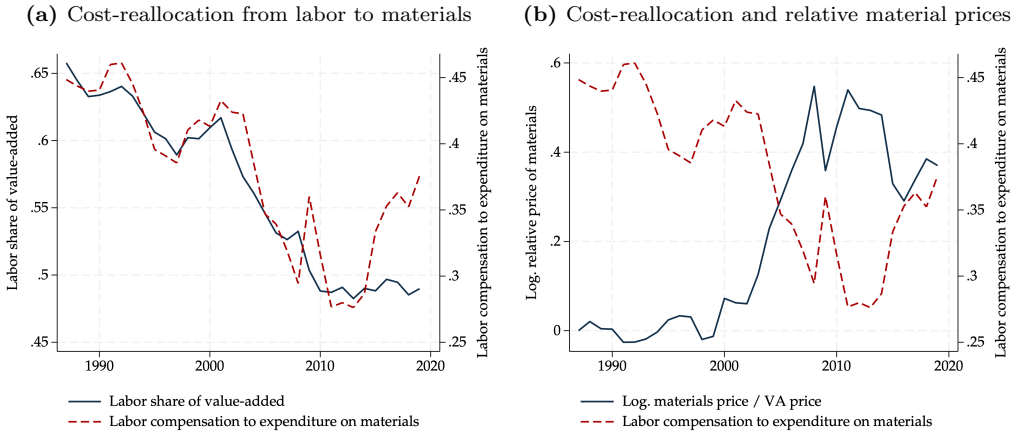
together with the manufacturing labor share: a clear reallocation from labor to materials emerges, particularly sharp over the 2000s.[18] Panel (b) plots the same series against the relative price of materials: the reallocation aligns in magnitude and timing with the rising price of materials. A higher profit share of revenues, π, cannot by itself explain this reallocation because, other things equal, it leaves the distribution of costs across inputs unchanged.[19]

Cross-section analysis. We now explore our mechanism across narrowly defined manufacturing industries and, later, across U.S. local labor markets. Motivated by the total differential in Equation (12), we isolate the materials-price channel from the

[18] Explanations operating through the first term of Equation (5) – a reallocation from labor toward capital, as under the capital-deepening mechanism of Karabarbounis and Neiman (2014) – could also lower the ratio of labor compensation to materials expenditure under specific assumptions about substitution between inputs. However, the correlation with the relative price of materials – and its timing, which coincides with the global commodity boom – suggests a significant role for our proposed mechanism.

[19] 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 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 through our mechanism. Therefore, any explanation that relies on rising markups must also imply an independent effect on the labor share through our suggested mechanism.

Figure 4: Cost reallocation from labor to materials



Note: Panel (a) shows the ratio of labor compensation to 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 BEA-KLEMS data. Panel (b) shows the same cost ratio against the log relative price of materials (materials price divided by value-added price), aggregated across manufacturing subsectors using Törnqvist weights.

other forces that shape the labor share by estimating:

$$\log \lambda_{jt} = \beta \times \frac{M_{j,0}}{V_{j,0}} \times \log p_{m,jt} + X'_{jt}\Gamma + \psi_j + \psi_t + \varepsilon_{jt} \tag{13}$$

where j indexes industries, t indexes years, λ_{jt} is the industry-level labor share, X_{jt} is a vector of controls, and ψ_j and ψ_t denote industry and year fixed effects. The regressor of interest interacts the materials price faced by industry j with its ex-ante materials intensity $M_{j,0}/V_{j,0}$ – the empirical counterpart of the exposure term $(M/V)\, d\log p_m$ in Equation (12). Baseline rather than contemporaneous intensity keeps exposure predetermined, so it does not respond to current materials prices.[20] Under the conditions of Proposition 1, with common and constant values of σ and π across industries, the coefficient is

$$\beta = -(1-\sigma)\frac{\pi}{1-\pi}.$$

[20] Equation (13) imposes the weak-separability restriction used in Proposition 1, under which materials-price changes affect the labor share through the materials cost share but do not induce within-primary reallocation between labor and capital. The more general expression in Appendix A.3 allows for non-separability ($\sigma_{lm} \neq \sigma_{km}$), which motivates the augmented regression in Appendix Table C.4. We focus on the separable specification because we find little evidence for non-separability: materials prices do not affect $\log(K/L)$ in Table C.3, controlling for $\log(K/L)$ does not change our estimates (Table 1, Column 7), and in Appendix Table C.4 the coefficient on the interaction remains stable when we include $\log p_{m,jt}$ separately.

Under weak separability, materials prices do not affect labor's share within primary-input costs, so with the remaining terms in Equation (12) absorbed by the controls and fixed effects, β captures, per unit of materials intensity, the labor-share response operating through the ratio of primary-input costs to value added – the second term in Equation (5). Given a positive profit share, a negative β is evidence of complementarity between materials and primary inputs ($\sigma < 1$). The regression identifies only this composite; in Section 3.10, we combine β with additional moments to recover σ and π separately.

As discussed in Section 2.4, other forces besides materials prices can shift the labor share, including changes in effective primary-input prices and factor-augmenting technical change, which operate through the unit cost of primary inputs, $c_G(w/A_L, r/A_K)$, and labor's cost share within primary inputs, $\alpha(w/A_L, r/A_K)$, as well as materials-augmenting technical change, B, and changes in the profit share of revenues. Industry and year fixed effects absorb time-invariant industry heterogeneity and common aggregate shocks, while our controls for wages and investment prices, and in some specifications for the capital-labor ratio and the production-worker share, address observable movements in the unit cost and composition of primary inputs, including labor's share within primary-input costs, the first term in Equation (5). The remaining industry-time variation in these channels enters the error term ε_{jt}, together with measurement error in industry-specific price indices. These residual components can bias OLS estimates in either direction, motivating an instrumental-variable strategy.

For identification, we develop an instrumental variable strategy that exploits variation in the prices of globally traded primary commodities, which is plausible insofar as narrowly defined U.S. manufacturing industries are price takers in these markets. The identifying assumption is that, conditional on controls and fixed effects, the global commodity-price movements entering our instrument are orthogonal to residual industry-level shocks to labor-, capital-, and materials-augmenting productivity and to residual changes in the profit share. We accommodate remaining concerns through a range of extensions, including flexible subsector×time fixed effects and industry-specific trends, which absorb industry- or sector-level slow-moving confounders, as well as controls for import penetration and industry concentration, which capture trade and market-structure forces that could affect the profit share.

3.3 Data Sources

We rely on three main data sources; additional details and a summary of data sources across all empirical exercises are provided in Appendix B (Table B.1). Full dataset citations are collected in the Data References at the end of the online appendix. Our primary source for industry-level outcomes is the NBER-CES Manufacturing Industry Database (Becker, Gray, and Marvakov, 2021a), which provides a yearly panel of value added, payroll, materials cost, and price indices for all 361 six-digit NAICS U.S. manufacturing industries. We construct the labor share as the ratio of payroll to value added.[21]

For commodity prices, we follow Fally and Sayre (2022) in defining a list of commodities that correspond to a significant share of total global commodity trade, and obtain Trade Unit Values for 1991–2016 from UN-COMTRADE.[22] We use the 1997 BEA Input-Output table to construct measures of industry-level exposure to commodity prices.[23] In most of the analysis, we focus on the years 1991–2016, in which all of the required data is available. In robustness specifications, we additionally control for import penetration (constructed from Peter Schott's trade data (Schott, 2019) and the Census Bureau) and industry concentration (from the U.S. Economic Census, U.S. Census Bureau 2026a).

3.4 Cross-Sectional Evidence

Before turning to causal estimation, we document the cross-industry relationship between exposure to materials prices and industry outcomes. Figure 5 presents this relationship for two outcomes: the log labor share (left) and the log ratio of materials expenditure to the industry wage bill (right). Panel A shows simple long-difference scatter plots for the period 2000–2010, during which the commodity boom was concentrated. Each point is an industry, and the x-axis measures the product of materials intensity and the log change in the materials price index over the decade. Panel B shows the analogous relationship in the full panel (1991–2016), using binscatter plots

[21] The payroll variable captures a narrow definition of labor compensation, and the materials variable excludes some forms of intermediates, implying that the level of the labor share is too low relative to the national accounts. Despite this limitation, the data remain useful for comparing trends across industries. See Appendix B for details.

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

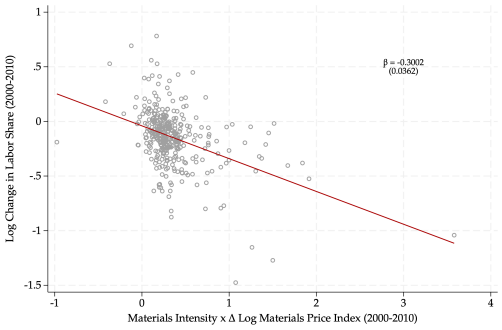
[23] We choose this version because it is the first detailed NAICS-based table available and predates the 2000s commodity boom.

that partial out industry and year fixed effects, weighted by value added. In both panels, industries with greater exposure to rising materials prices experienced a larger decline in the labor share and a larger increase in the materials-to-labor expenditure ratio, consistent with the predictions of Proposition 1. In Appendix C.2, we complement this evidence with a non-parametric event-study analysis that confirms these patterns using only cross-industry heterogeneity in ex-ante commodity intensity, without relying on price variation.

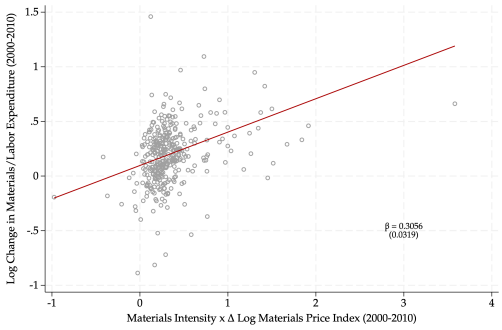
Figure 5: The Relationship Between Material Prices and Industry Outcomes

Panel A: Long-Difference Scatter (2000–2010)

(a) Labor Share

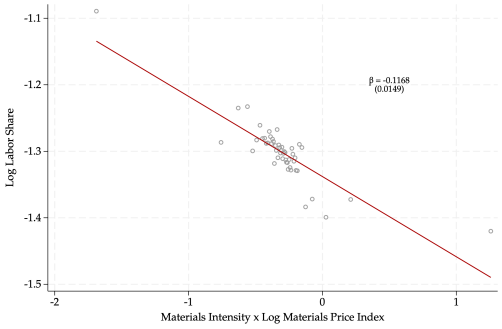


(b) Material-to-Labor Expenditure Ratio

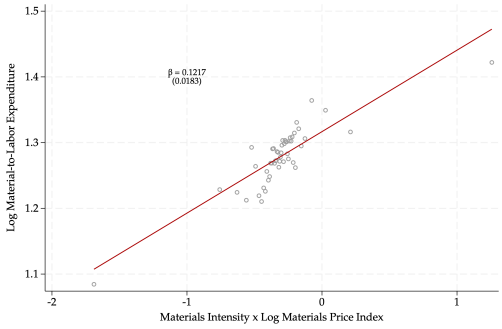


Panel B: Panel Binscatter (1991–2016)

(c) Labor Share



(d) Material-to-Labor Expenditure Ratio



Note: The top panel shows scatter plots of long-difference (2000–2010) industry outcomes against the product of materials intensity in 2000 and the change in the log price index of materials over the decade. Each circle is an industry, and the line is a value-added-weighted linear fit. The bottom panel shows binscatter plots of industry outcomes against the product of materials intensity in 1990 and the log price index of materials in the full panel (1991–2016), after residualizing industry and year fixed effects. Each circle represents the mean of a quantile bin, where observations are weighted by value added in 1990. The line is a linear fit. Reported coefficients and standard errors (in parentheses) are from value-added-weighted regressions; standard errors in the bottom panel are clustered by industry.

3.5 Constructing Commodity Intensity and Price Shocks

We construct a shift-share instrument for industry-level materials prices using predetermined input-output linkages and global commodity prices (see Appendix B for the full construction). Since we lack expenditure data at the specific commodity level, we proxy the expenditure share of industry j on commodity k using the input-output tables, weighting the different commodities produced by the same industry by their shares of U.S. imports in 1997. Let $M_{jk,1997}$ be the expenditure of industry j on commodity k; $M_{j,1997}$ be j's total expenditure on intermediates; and $W_{j,1997}$ be j's total labor compensation. The expenditure share of industry j on commodity k is

$$\omega_{jk,1997} \equiv \frac{M_{jk,1997}}{M_{j,1997} + W_{j,1997}}. \tag{14}$$

Industry j's commodity intensity is its total expenditure on commodities as a share of total costs:

$$\theta^{comm}_{j1997} \equiv \sum_k \omega_{jk,1997}. \tag{15}$$

This variable captures ex-ante exposure to commodity prices but does not utilize realized price changes. Our shift-share instrument combines these weights with realized commodity prices:

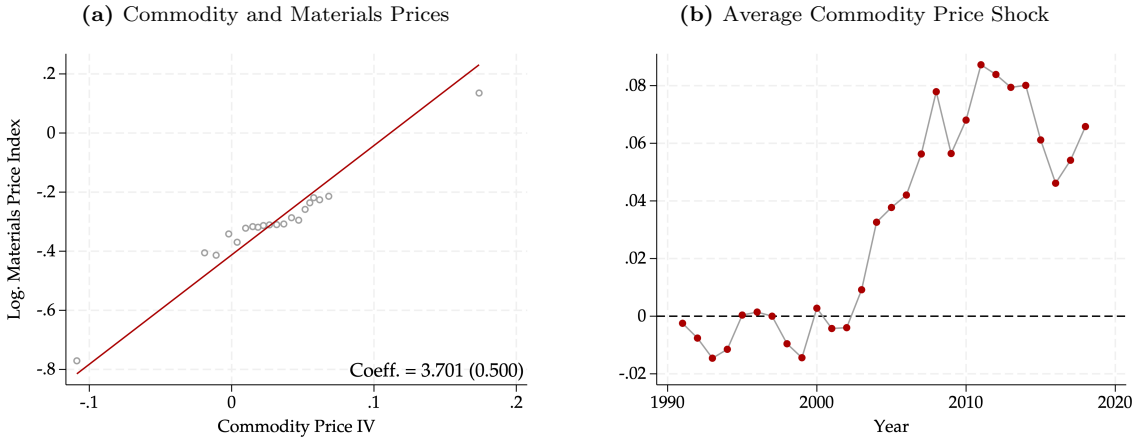
$$\log p^{comm}_{jt} \equiv \sum_k \omega_{jk,1997} \log\left(price_{k,t}\right). \tag{16}$$

This measure leverages both the heterogeneous changes in commodity prices and the differential baseline exposure of each manufacturing industry. We use $\log p^{comm}_{jt}$ as an instrument for the interaction between the industry-level materials price index and its ex-ante materials intensity. Figure 6b shows that the average commodity price shock tracks the aggregate dynamics in Figure 1, and Figure 6a confirms a strong positive correlation between the instrument and the NBER-CES materials price index at the industry level.[24]

The rationale for our instrument is rooted in the main narrative for the 2000s commodities boom: rising demand from emerging economies, and in particular China,

[24] Appendix B provides additional information about the data. We present the commodities with the largest price increases in Table C.1 and the most affected industries in Table C.2.

Figure 6: Commodity Cost Shock Measure



Note: Panel (a) is a binned scatter plot of the treatment variable (materials intensity × log materials price index) between 1991–2016 against our shift-share instrumental variable, after controlling for industry and year fixed effects and weighting by value added in 1990. Panel (b) shows our commodity cost shock measure (Equation 16) over time, averaged across industries weighted by value added in 1990.

is widely viewed as the leading cause of the price increase.[25] This raises the potential concern that the commodity price shock might be correlated with other implications of China's growth, such as import competition or rising demand in product markets. Therefore, we control for these alternative trade exposure measures in X_{jt}. In line with past literature, we find no evidence for a relationship between these demand-side exposure measures and the labor share, and essentially no correlation between them and our instrument.[26]

3.6 The Effect of Material Prices on the Labor Share

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 16, and estimate the regression specification in Equation 13. In all specifications, we cluster standard errors at the industry level.

Table 1 presents results for regressing the yearly log labor share for each industry

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

[26] In a regression of our instrument on import penetration from China, export exposure to China, and the full set of controls, neither is statistically significant (p-values of approximately 0.4 and 0.8, respectively). See also Autor et al. (2020).

on the log of materials prices multiplied by 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 stable at around -0.18 to -0.19 across weighted specifications. This estimate implies that a 1% increase in the price of materials, all else equal, reduces the manufacturing labor share by about 0.23% for an industry with the average baseline materials intensity (≈ 1.2). Column (9) further accommodates concerns about industry-specific factor-biased technical change or other slow-moving confounders by adding industry-specific linear time trends. While the coefficient remains negative and statistically significant, it is attenuated relative to the other columns. This is expected: industry trends absorb some of the low-frequency variation in relative materials prices across sectors that is central to identification, increasing the noise-to-signal ratio. It is therefore not clear whether the benchmark estimate should be Column (8) or Column (9); in the quantitative exercise below, we report counterfactuals using both.

3.7 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 528 commuting zones over 2001–2016 using county-level data from the BEA Regional Economic Accounts and the BLS Quarterly Census of Employment and Wages (see Appendix B for details). Regional materials price indices and the commodity shock instrument are constructed by weighting industry-level measures according to their share in the regional economy.

Table 2 replicates the cross-industry analysis for this sample of local labor mar-

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

	Log Industry Labor Share								
	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS	(8) 2SLS	(9) 2SLS
Materials Intensity × Log. Materials Price	-0.132***	-0.135***	-0.222***	-0.232***	-0.178***	-0.192***	-0.192***	-0.190***	-0.120***
	(0.0212)	(0.0219)	(0.0423)	(0.0464)	(0.0246)	(0.0317)	(0.0280)	(0.0275)	(0.0231)
Log. Average Wage		-0.0335		-0.0138		0.0611	0.0234	0.0291	0.00749
		(0.0742)		(0.0754)		(0.149)	(0.145)	(0.136)	(0.112)
Log. Investment Price		0.0421		0.232		0.322*	0.495**	0.546**	0.480
		(0.115)		(0.148)		(0.188)	(0.194)	(0.221)	(0.462)
Production Workers Share							-0.635**	-0.644**	-0.481
							(0.259)	(0.269)	(0.303)
Log. Capital-Labor Ratio							0.0767*	0.0599	-0.0150
							(0.0413)	(0.0400)	(0.0429)
Import Penetration								0.0225	-0.0218
								(0.0502)	(0.0471)
Import Penetration - China								0.171	0.405*
								(0.134)	(0.246)
First-stage F-stat (KP-Wald)			41.82	37.78	54.69	39.26	36.49	35.89	12.82
N	9386	9386	9386	9386	9386	9386	9386	9386	9386
Industry and Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weighted	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Industry-Specific Trends	No	No	No	No	No	No	No	No	Yes

Note: 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. Columns (1) and (2) report OLS results. Columns (3) to (9) instrument the log. of the materials price index with the instrumental variable detailed in Expression 16. Columns (5) to (9) 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. Column (9) further adds industry-specific linear time trends. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

kets. All specifications control for factor prices (regional wages and the price of investment goods) as well as commuting-zone and year fixed effects. Columns (4) and (5) add controls for log total regional employment, the manufacturing share of total regional employment, and import penetration. Column (6) further adds commuting-zone-specific linear time trends, paralleling Column (9) in Table 1. The estimated coefficient is around -0.17 across most specifications (ranging from -0.15 to -0.22), closely matching the industry-level estimates in Table 1. This consistency across different units of observation – industries and local labor markets – suggests that local general equilibrium forces do not substantially offset the partial equilibrium mechanism.

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

	Log Labor Share					
	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS
Materials Intensity × Log. Materials Price	-0.150**	-0.178***	-0.169***	-0.166***	-0.170***	-0.216***
	(0.0695)	(0.0422)	(0.0472)	(0.0466)	(0.0460)	(0.0614)
First-stage F-stat (KP-Wald)		34.62	43.12	43.39	44.38	196.2
N	8424	8424	8413	8413	8413	8413
Average Wage and Investment Price Controls	Yes	Yes	Yes	Yes	Yes	Yes
Controls for regional employment and manuf. share	No	No	No	Yes	Yes	Yes
Controls for import penetration	No	No	No	No	Yes	Yes
Region and Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Weighted	No	No	Yes	Yes	Yes	Yes
CZ-Specific Trends	No	No	No	No	No	Yes

Note: 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 528 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 6 instrument the log. of the materials price index with the instrumental variable detailed in the text. Columns 3 to 6 are weighted by total manufacturing GDP in the commuting zone in 2001. Column 4 adds controls for the log of regional employment and for the share of manufacturing in total regional employment, and Column 5 adds import penetration – from China and overall. Column 6 further adds commuting-zone-specific linear time trends. Standard errors clustered at the commuting-zone level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

3.8 The 1970s Oil Shocks

We now exploit a different source of exogenous variation: the 1970s oil shocks. The 1973 OAPEC embargo and subsequent disruptions resulted in a threefold increase in the real price of oil. We instrument the industry-level materials price index with the interaction of the log oil price (common across industries) and an industry-specific measure of energy intensity – the ratio of energy expenditure to value added in 1972, a year before the embargo:[27]

$$\log p^e_{jt} \equiv s_{ej,1972} \log \text{Oil Price}_t, \tag{17}$$

where $s_{ej,1972}$ denotes industry j's energy intensity in 1972, measured as the ratio of energy expenditure to value added.

Table 3 presents 2SLS results for 1970–1980. The estimated effect is negative and statistically significant, with confidence intervals that overlap with the baseline

[27] Oil prices are taken from the World Bank Pink Sheet (World Bank, 2025), https://www.worldbank.org/en/research/commodity-markets. Energy intensity is constructed using the NBER-CES Dataset.

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

	Log Industry Labor Share					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	2SLS	2SLS	2SLS	2SLS	2SLS
Materials Intensity × Log. Materials Price	-0.0384**	-0.219***	-0.167***	-0.166***	-0.233***	-0.230***
	(0.0183)	(0.0739)	(0.0551)	(0.0545)	(0.0784)	(0.0770)
First-stage F-stat (KP-Wald)		5.299	2.185	2.297	7.075	7.937
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	No	Yes	No	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

Note: 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 361 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 17. Columns (3) to (6) 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.

estimates in Table 1 despite the different identification strategy and historical period. Columns (5) and (6) replace year fixed effects with year×3-digit NAICS subsector fixed effects, exploiting only within-subsector variation, and find similar or stronger results.[28]

Despite the large oil price increase, the aggregate manufacturing labor share remained relatively stable in the 1970s. Through the lens of our mechanism, this is expected: energy goods account for only about 5% of total materials expenditure in manufacturing, and the 1970s boom was partly offset by rapid increases in other factor prices during that period's inflationary environment. While there was sufficient cross-industry variation to identify our mechanism, the overall increase in the relative price of the materials bundle was modest relative to the 2000s (as can also be seen in Figure 1), limiting the aggregate implications for the labor share.

3.9 Natural Disasters as an Alternative Source of Variation

As a further robustness exercise, we develop an alternative instrument that exploits supply disruptions caused by natural disasters in countries that are major

[28]We do not replicate Column (8) in Table 1 in the 1970s due to the lack of trade data. For the baseline exercise, we control for subsector-specific trends in the robustness Section 3.11.

exporters of specific commodities. For each HS4 product, we identify countries that account for a large share of global exports, and define the product-level shock as the share of 1997 world exports of the product supplied by such countries while they are experiencing a large disaster (as recorded in EM-DAT, the International Disaster Database). We then aggregate these product-level disaster shocks to the industry level using input-output linkages, analogously to our baseline instrument. Using the resulting instrument, the 2SLS estimates are consistent with our baseline results, with a point estimate of -0.212 (s.e. $= 0.056$) in the preferred specification, compared with -0.190 (s.e. $= 0.028$) in Table 1. The full construction and results are presented in Online Appendix D.

3.10 Structural Interpretation and Aggregate Quantification

We now relate the estimates in Table 1 to the structural parameters from Section 2 and evaluate the aggregate importance of our mechanism. From Proposition 1, β depends on the elasticity of substitution between materials and primary inputs, σ, and the profit share π:

$$\beta \equiv \frac{d \log \lambda}{\frac{M}{V} d \log p_m} = -\frac{\pi}{1-\pi}(1-\sigma). \tag{18}$$

This interpretation relies on the separability of materials from the capital-labor bundle in the production function (10), under which materials prices do not shift the capital-labor mix.[29] Since $\sigma < 1$ implies $\beta < 0$, the negative estimates in Table 1 are consistent with complementarities between materials and primary inputs. In Figure 7a, we plot the implied relationship between σ and π using the estimates for β in Columns (8) and (9) of Table 1. Each estimate defines a locus of (σ, π) combinations consistent with the estimated elasticity. To further discipline this relationship, we use in turn two related auxiliary implications of the mechanism: the elasticity of $\log(M/V)$ and the elasticity of $\log(V/R)$, both with respect to the price of materials.[30] Each auxiliary elasticity, estimated with and without industry-specific trends, yields one point estimate, for a total of four estimates in Figure 7a. Across them, the

[29] As discussed above, we find evidence consistent with this assumption: materials prices have no effect on capital-labor ratios (Table C.3), and controlling for capital-labor ratios does not change our estimates (Table 1, Column 7).

[30] Appendix A.2.3 derives the expressions for these elasticities and their mapping to (σ, π). Appendix Table C.5 reports the corresponding estimates.

implied elasticity of substitution is below one, ranging from about 0.04 to 0.33. For comparison, point estimates in the literature are close to zero in Boehm et al. (2019), around 0.3 in Peter and Ruane (2026), around 0.6 in Carvalho et al. (2021), between 0.6 and 1 in Oberfield and Raval (2021), and around 0.85 in Atalay (2017).

The implied profit share ranges from about 0.12 to 0.21. While these are high values that imply that a large share of gross operating surplus accrues to profits,[31] a few caveats are in order. First, they are a structural decomposition of the reduced-form coefficient rather than a direct measurement of profits: the estimated pass-through is converted into (σ, π) through the assumptions underlying Proposition 1 – weak separability, a constant profit share, and freely adjustable inputs – together with the auxiliary moment used. When one of these assumptions fails, the same pass-through maps into different parameter values, and a more general expression for the elasticity is needed, such as the extensions in Appendix A.3. In particular, in the next section, we consider how the pass-through of materials prices to the labor share behaves when capital adjusts only gradually. Second, when we instead recover the profit share from sectoral free cash flows and investment in Section 4, we obtain a lower π of about 0.09, with gross operating surplus split roughly equally between payments to capital and profits. While lower than the π implied by our point estimates in this section, it is compatible with the industry-trends confidence band in Figure 7a. Moreover, we obtain similar elasticities of the labor share with respect to materials prices, as further discussed in Section 4.

We next quantify the aggregate importance of our mechanism for the manufacturing labor share. We construct a counterfactual path that shuts down the materials price channel: $\Delta \log \lambda_t^{CF} = \Delta \log \lambda_t + |\hat{\beta}| \times (M/V)_{t-1} \times \Delta \log \tilde{p}_{m,t}$, where $\Delta \log \tilde{p}_{m,t}$ is the change in the deflated relative price of materials. We implement this exercise using BEA-KLEMS data for the manufacturing sector, which provides comprehen-

[31] The literature typically measures profit shares in one of two ways. One approach estimates markups from production data under cost minimization, following Hall (1988) and De Loecker et al. (2020); inferring π from markup estimates alone, without accounting for the wedge between average and marginal cost (e.g., due to fixed costs), typically yields much higher profit shares than our estimates. A second approach attributes part of income to capital using a required rate of return and recovers profits residually, as in Barkai (2020); these measures typically yield lower values, are usually economy-wide rather than specific to manufacturing, and are sensitive to the assumed rate of return, which is difficult to measure (Karabarbounis and Neiman, 2019). Relatedly, van Vlokhoven (2024) estimates the cost of capital from firms' input choices rather than assuming a rate of return. Our approach is complementary to these: it infers π either from the cross-sectional pass-through of materials prices to the labor share (when combined with auxiliary moments and the assumptions of Section 2), or from investment behavior and free cash flows, as in Section 4.

sive measures of compensation and value added consistent with the U.S. national accounts. The aggregate materials price index is constructed by Törnqvist chaining across materials and energy within each subsector, and then aggregating across subsectors using expenditure-share-weighted Törnqvist weights. To isolate relative price movements from general inflation, we regress the sector-level log materials price on the log value-added price deflator with sector and year fixed effects, weighting by base-year value added; the year fixed effects capture $\Delta \log \tilde{p}_{m,t}$.

As discussed above, it is not clear whether the preferred estimate is Column (8) or Column (9) of Table 1, since industry trends absorb some of the identifying variation along with potential confounders. We therefore report counterfactuals using both. Figure 7b plots the results. The counterfactual and actual labor shares are closely aligned before the 2000s, but diverge markedly during the commodities boom. To quantify this, we compute a cumulative contribution measure that captures how much of the labor share's total movement from its initial value is eliminated in the counterfactual.[32] Using the estimate from Column (8), the cumulative decline in the labor share would have been approximately 32% smaller; using Column (9), approximately 20% smaller. The two specifications bracket a range in which the decline would have been 20–32% smaller absent the rise in the relative price of materials.

3.11 Extensions and Robustness Checks

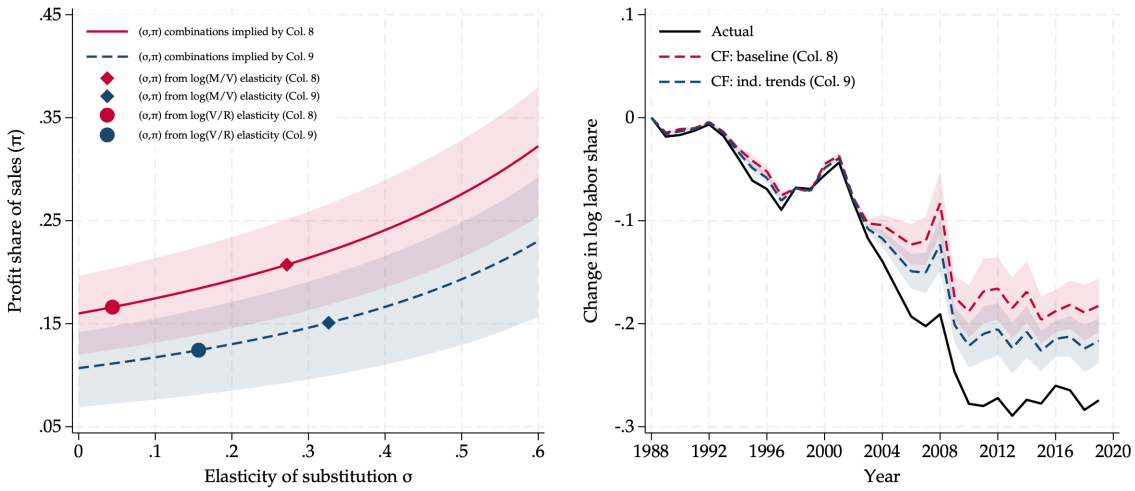
We now turn to a series of robustness checks and extensions of our results. For brevity, we provide only the main highlights and refer readers to our Online Appendix for additional details.

Other Industry Outcomes. We test auxiliary predictions of the theory by examining the effect of materials prices on other industry outcomes (Table C.3). In line with our mechanism, higher materials prices increase the ratio of materials expenditure to value added, and increase expenditure on materials relative to both labor costs and capital expenditure. Moreover, the increase relative to labor and capital exceeds the increase relative to value added, consistent with the prediction that the profit share of value added rises (Section 2.2, Figure 2). We find no effect of materials prices on capital-labor ratios, supporting the separability assumption

[32] Specifically, we compute $1 - \sum_t |\log \lambda_t^{CF} - \log \lambda_0| / \sum_t |\log \lambda_t - \log \lambda_0|$, where λ_0 is the labor share in 1988 and the sums run over all years. This measure aggregates deviations across the entire path rather than benchmarking to a single endpoint.

Figure 7: Structural Interpretation and Counterfactual Labor Share

(a) Implied relationship between σ and π **(b)** Counterfactual labor share



Note: In Panel (a), the solid cranberry line plots the combinations of σ and π implied by the estimate $\hat{\beta} = -0.190$ from Column (8) of Table 1, and the dashed navy line plots the combinations implied by $\hat{\beta} = -0.120$ from Column (9), which includes industry-specific trends. Diamonds denote the (σ, π) pairs obtained by combining the labor-share estimate with the auxiliary elasticity of $\log(M/V)$ with respect to the price of materials, and circles denote the corresponding pairs obtained using the auxiliary elasticity of $\log(V/R)$. In each case, cranberry corresponds to the baseline specification and navy to the industry-trends specification. In Panel (b) we plot the actual change in the log manufacturing labor share relative to 1988 (solid black line) and counterfactual labor shares that shut down our mechanism, using data on U.S. manufacturing from BEA-KLEMS. The cranberry dashed line uses the baseline estimate (Col. 8) and the navy dashed line uses the industry-trends estimate (Col. 9), with corresponding 95% CIs.

embedded in Equation (10).

Augmented Specification. To further test separability, we augment the baseline regression with a separate $\log p_{m,jt}$ term. Under the more general expression in Appendix A.3, such a term captures the direct effect of materials prices on the labor share when $\sigma_{lm} \neq \sigma_{km}$; under separability, materials prices should enter only through the interaction with baseline materials intensity (Appendix Table C.4). In the data, the interaction coefficient remains stable, while the coefficient on $\log p_{m,jt}$ is noisy and only marginally significant in some specifications, consistent with separability.

Sectoral Trends. We restrict the source of variation to differential exposure within NAICS 3-digit subsectors by adding year×3-digit subsector fixed effects (Table C.6). This alleviates concerns that the instrument is correlated with sectoral factor-augmenting shocks. The results remain statistically significant and quantitatively similar.

Heterogeneous Effects. We allow for heterogeneous effects across NAICS 3-digit subsectors by interacting our baseline treatment with subsector indicators (Figure C.4). The negative effect of rising materials prices on the labor share is prevalent across most manufacturing subsectors.

BEA Data and Sourced Services. We replicate our baseline results using more aggregate BEA-KLEMS data for 19 manufacturing subsectors, which provides superior measures of total compensation and includes sourced services (Table C.7). The results remain similar in sign and statistical significance, with somewhat smaller magnitudes, and controlling for the share and price of outsourced services does not weaken the effect – if anything, it becomes quantitatively stronger.

Accounting for Input-Output Linkages. We augment our instrument to capture both direct and indirect effects of commodity prices through input-output linkages, constructing the shares ω_{jk} from the Leontief Inverse matrix (Table C.8). The results are very similar.

Utilizing Only Variation in Prices. Following Borusyak, Hull, and Jaravel (2022), we isolate variation from price shifts by dividing the instrument by the total commodity cost share from Equation 15 (Table C.9). The estimate remains negative and quantitatively similar, though as expected, more noisy.

Industry Concentration. A prominent explanation for the decline of the labor share is rising industry concentration (Autor et al., 2020). We add two concentration measures – the log HHI for the top 50 firms and the sales share of the top 4 firms (Table C.10). While a negative relationship between concentration and the labor share emerges, the effect of materials prices remains virtually unchanged. Moreover, the implied contribution of changes in concentration to the decline of the manufacturing labor share is smaller than that of materials prices, largely because concentration changed little in the average manufacturing industry over this period. A related finding in this literature is that the labor share did not decline for the median manufacturing establishment (Kehrig and Vincent, 2021). This pattern is consistent with our mechanism: an ex-ante positive profit share is required for materials prices to affect the labor share (Proposition 1), so the effect should be concentrated at establishments with ex-ante low labor shares.

Energy vs. Non-energy Commodities. We decompose the shift-share instru-

ment into its energy and non-energy components and estimate separately with each (Table C.11). Energy commodities yield a very strong first stage and point estimates similar to the baseline. Non-energy commodities yield weaker first stages but, if anything, more negative point estimates.

4 A Dynamic Model with Capital Accumulation

In Section 2, we investigated our mechanism in a static framework to highlight the key forces governing the transmission of materials prices to the labor share. We now embed the mechanism in a dynamic structural model of the U.S. manufacturing sector, in which capital is accumulated through investment. In the long run, the elasticity of the labor share with respect to materials prices is the same as in the static model, but the dynamic model allows us to quantify the importance of our mechanism over the studied period when it takes time for capital to adjust. This quantification complements the reduced-form analysis in Section 3.10 in additional ways. First, it explicitly matches the paths of investment and the capital stock, thereby bringing alternative explanations based on capital deepening directly into the analysis. Second, by jointly matching factor payments, investment, capital accumulation, and output, the model disciplines the path of the profit share of sales – whether interpreted as reflecting markups or returns to scale – and also reproduces the observed path of free cash flow. Third, it generates counterfactual predictions for additional key moments beyond the labor share, including the investment rate and the ratio of free cash flow to value added. We implement the approach for aggregate manufacturing in the main text and for individual manufacturing subsectors in Appendix E.8.

4.1 Setup

Firms. We consider a sector populated by a unit measure of identical monopolistically competitive firms. Each firm takes as given the sequence of input prices $\{w_t, p_{m,t}, p_{i,t}\}_{t=0}^{\infty}$ (wages, materials prices, and investment goods prices, respectively), the sequence of sectoral expenditure $\{E_t\}_{t=0}^{\infty}$, and the path of exogenous time-varying fundamentals $\{\chi_t, A_t, B_t, \alpha_t, \mu_t\}_{t=0}^{\infty}$, detailed below.

Production Technology. Firms produce output q_t using a nested CES produc-

tion function F that combines a capital-labor bundle with materials:

$$q_t = F(k_t, l_t, m_t) = \left[\left(A_t l_t^{\alpha_t} k_t^{1-\alpha_t} \right)^{\frac{\sigma-1}{\sigma}} + (B_t m_t)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{19}$$

where l_t is labor, k_t is capital, m_t is materials, A_t is primary factor-augmenting productivity, B_t is materials-augmenting productivity, α_t is the labor share within the capital-labor bundle, and σ is the elasticity of substitution between the capital-labor bundle and materials.

Capital Accumulation. Following Lucas and Prescott (1971) and Eaton, Kortum, Neiman, and Romalis (2016), capital evolves according to

$$k_{t+1} = \chi_t i_t^{\gamma} k_t^{1-\gamma} + (1-\delta) k_t, \tag{20}$$

where i_t is investment, χ_t is investment efficiency, δ is the depreciation rate, and $\gamma \in (0, 1]$ governs adjustment frictions. In this formulation, $\gamma = 1$ corresponds to the benchmark without adjustment costs, whereas, when $\gamma = 0.5$, investment expenditure is quadratic in the amount added to the capital stock.

Demand. Firms operate under monopolistic competition with a CES demand aggregator. Letting E_t denote aggregate sectoral expenditure, P_t the sectoral price index, and $\eta_t > 1$ the time-varying elasticity of substitution across varieties, the firm's revenues are $R_t = E_t^{1/\eta_t} P_t^{(\eta_t-1)/\eta_t} q_t^{(\eta_t-1)/\eta_t}$, which equals E_t in symmetric equilibrium with a unit mass of identical firms. The associated gross markup is $\mu_t \equiv \eta_t/(\eta_t - 1)$. We treat the markup as a time-varying fundamental, although equivalently it can be viewed as a time-varying demand elasticity or time-varying return to scale. In all of these cases, it captures an exogenous time-varying wedge between firms' output price and their average unit cost.

Firm's Problem. The firm maximizes the present discounted value of profits:

$$\begin{aligned} \max_{\{l_t, m_t, i_t\}_{t=0}^{\infty}} \quad & \sum_{t=0}^{\infty} \beta^t \left\{ E_t^{\frac{1}{\eta_t}} P_t^{\frac{\eta_t-1}{\eta_t}} q_t^{\frac{\eta_t-1}{\eta_t}} - p_{m,t} m_t - w_t l_t - p_{i,t} i_t \right\} \\ \text{subject to:} \quad & q_t = F(k_t, l_t, m_t), \\ & k_{t+1} = \chi_t i_t^{\gamma} k_t^{1-\gamma} + (1-\delta) k_t, \\ & k_0 \text{ given.} \end{aligned} \tag{21}$$

4.2 Firm solutions

Define the output elasticities of materials and labor as:

$$\theta_{m,t} \equiv \frac{(B_t m_t)^{\frac{\sigma-1}{\sigma}}}{\left(A_t l_t^{\alpha_t} k_t^{1-\alpha_t}\right)^{\frac{\sigma-1}{\sigma}} + (B_t m_t)^{\frac{\sigma-1}{\sigma}}}, \quad \theta_{l,t} \equiv \frac{\alpha_t \left(A_t l_t^{\alpha_t} k_t^{1-\alpha_t}\right)^{\frac{\sigma-1}{\sigma}}}{\left(A_t l_t^{\alpha_t} k_t^{1-\alpha_t}\right)^{\frac{\sigma-1}{\sigma}} + (B_t m_t)^{\frac{\sigma-1}{\sigma}}}. \tag{22}$$

The output elasticities satisfy $\theta_{l,t} = \alpha_t(1-\theta_{m,t})$ and the capital output elasticity is $\theta_{k,t} = (1-\alpha_t)(1-\theta_{m,t})$, so that $\theta_{m,t} + \theta_{l,t} + \theta_{k,t} = 1$.

The static first-order conditions for labor and materials imply:

$$\frac{w_t l_t}{E_t} = \frac{\theta_{l,t}}{\mu_t}, \quad \frac{p_{m,t} m_t}{E_t} = \frac{\theta_{m,t}}{\mu_t}. \tag{23}$$

Factor payments as a share of revenues equal the corresponding output elasticity divided by the markup.

The dynamic first-order condition for investment yields:

$$s_{i,t} = \beta \dot{E}_{t+1} \left(\frac{\dot{k}_{t+1} - (1-\delta)}{\dot{k}_{t+1}}\right) \left\{\gamma \frac{1 - \theta_{m,t+1} - \theta_{l,t+1}}{\mu_{t+1}} + s_{i,t+1} \left(\frac{1-\delta}{\dot{k}_{t+2} - (1-\delta)} + (1-\gamma)\right)\right\}, \tag{24}$$

where $s_{i,t} \equiv p_{i,t} i_t / E_t$ is the investment share of revenues, $\dot{E}_{t+1} \equiv E_{t+1}/E_t$ is the gross growth rate of expenditure, and $\dot{k}_{t+1} \equiv k_{t+1}/k_t$ is the gross growth rate of capital.

The labor share of value added is:[33]

$$\lambda_t = \frac{s_{l,t}}{1 - s_{m,t}} = \frac{\theta_{l,t}/\mu_t}{1 - \theta_{m,t}/\mu_t} = \frac{\alpha_t(1-\theta_{m,t})}{\mu_t - \theta_{m,t}}, \tag{25}$$

where $s_{l,t} = w_t l_t / E_t$ and $s_{m,t} = p_{m,t} m_t / E_t$ are the labor and materials shares of revenues. The labor share depends on the endogenous materials output elasticity $\theta_{m,t}$, as well as the exogenous labor share parameter α_t in the capital-labor bundle, and the exogenous markup μ_t.[34]

[33] Notably, the total differential of the labor share in Equation (12) continues to hold in this environment when the market rental rate of capital is replaced by the firm's shadow rental rate of capital.

[34] Equation (25) implies that, once μ_t and α_t are recovered, any counterfactual path for the materials output elasticity $\theta_{m,t}^{CF}$ maps mechanically into a counterfactual labor share,

$$\lambda_t^{CF} = \frac{\alpha_t(1-\theta_{m,t}^{CF})}{\mu_t - \theta_{m,t}^{CF}}.$$

The transmission of materials prices to the labor share is governed by the same forces as in the static model, with the additional restriction that capital is predetermined and adjusts gradually. While in the long run the elasticity of the labor share with respect to the price of materials is the same as in Proposition 1, it is larger in the short run: the on-impact elasticity, when capital is fixed, equals the long-run elasticity multiplied by the factor $\left(1-(1-\sigma)(1-\alpha_t)\theta_{m,t}\right)^{-1} > 1$.[35] In practice, the difference between the two elasticities is modest: evaluated at the fundamentals we recover below, the amplification factor averages 1.2 over the sample period.

4.3 Mapping the Model to the Data

Data. We use annual data on U.S. manufacturing from 1998 to 2019 from the BEA industry accounts (see Appendix E for details). We apply an HP filter with a small smoothing parameter of 5 to all variables, which smooths out sharp year-to-year fluctuations while preserving the multi-year trends that are the focus of our analysis.

Model Inversion. We invert the model along a transition path to recover time-varying fundamentals from observed data.[36] We assume that total sectoral expenditure E_t and input prices (w_t, $p_{m,t}$, $p_{i,t}$) are taken as exogenously given. We then solve for the five time-varying structural residuals $\{\mu_t, \alpha_t, A_t, B_t, \chi_t\}$ by matching five endogenous moments in each period of the data: (i) the labor share of revenues ($s_{l,t}$), (ii) the materials share of revenues ($s_{m,t}$), (iii) the investment share of revenues ($s_{i,t}$), (iv) the capital stock (k_t), and (v) output (q_t).[37]

A useful way to think about the inversion is in three steps. First, the static first-order conditions map the observed labor and materials shares into the corre-

Thus, for counterfactuals stated directly in terms of $\theta_{m,t}$, only limited structure is needed. The fuller dynamic model is required to derive how counterfactual paths for prices and fundamentals map into $\theta_{m,t}$, investment, capital accumulation, and the other moments we study.

[35] Both results follow from log-differentiating the first-order conditions (23) and the production function (19), holding expenditure and fundamentals constant. When capital adjusts so that its marginal revenue product equals a constant user cost, $d\log\theta_{m,t}/d\log p_{m,t} = (1-\sigma)(1-\theta_{m,t})$, and Equation (25) delivers the elasticity in Proposition 1, $-(1-\sigma)\,\frac{\mu_t-1}{\mu_t-\theta_{m,t}}\,\theta_{m,t}$, where $\mu_t - 1 = \pi_t/(1-\pi_t)$ and $\theta_{m,t}/(\mu_t-\theta_{m,t}) = M_t/V_t$. When capital is fixed, output falls by less, so the response of $\theta_{m,t}$ – and hence of the labor share – is amplified by the factor in the text.

[36] We allow the model to be along a transition path across all periods of the data, but assume that after the last period of the data, there are no further expected changes in fundamentals, and that the model converges to the steady state implied by these fundamentals.

[37] These fundamentals are the model counterparts of the residual economic forces captured by ε_{jt} in Equation (13). Recall that, conditional on controls and fixed effects, our IV strategy requires the global commodity-price movements entering the instrument to be orthogonal to residual industry-level shocks to labor-, capital-, and materials-augmenting productivity and to the profit share. The dynamic model introduces investment efficiency, χ_t, as an additional residual. Because χ_t affects the labor share through capital accumulation, specifications that condition on the capital–labor ratio absorb this channel (Table 1, Column (7)).

sponding output elasticities relative to the markup. Second, the investment Euler equation recovers the capital output elasticity relative to the markup, $\theta_{k,t}/\mu_t$, from observed investment shares, capital growth, and expenditure growth. Third, once that component is known, the remaining portion of revenue net of labor and materials is attributed, through the model, to pure profits, which pins down the markup residual. Given the markup, the labor-share relationship recovers α_t, the capital accumulation equation recovers χ_t, the ratio of factor demands recovers the relative materials-productivity term B_t/A_t, and the production function pins down A_t to match output. Appendix E provides the full derivations and numerical details. We summarize these recovery steps in turn below.

Recovering $\theta_{k,t}/\mu_t$. The ratio of the capital output elasticity to the markup, $\theta_{k,t}/\mu_t$, is recovered directly from the investment Euler equation (24), using observed investment shares, capital growth rates, and expenditure growth.

Recovering markups. Given $\theta_{k,t}/\mu_t$, the gross markup follows from the first-order conditions (23) and the identity $\theta_{l,t} + \theta_{m,t} + \theta_{k,t} = 1$:

$$\mu_t = \frac{1}{\theta_{k,t}/\mu_t + s_{l,t} + s_{m,t}}. \tag{26}$$

Equivalently, revenue net of labor and materials is split between capital's marginal contribution to revenue, $\theta_{k,t}/\mu_t$, and a profit share of revenues, $1 - 1/\mu_t$. Since the investment Euler equation recovers the former, equation (26) recovers the latter residually through the lens of the model.

Recovering α_t. The labor share within the capital-labor bundle is recovered from

$$\alpha_t = \frac{\lambda_t \mu_t (1 - s_{m,t})}{1 - s_{m,t}\mu_t}, \tag{27}$$

which follows from combining Equation (25) with $\theta_{l,t} = \alpha_t(1 - \theta_{m,t})$.

Recovering productivity parameters. The ratio of factor demands recovers the relative materials-productivity term B_t/A_t, while primary factor-augmenting productivity A_t is pinned down to match observed output. Together these imply the path of B_t. Investment efficiency χ_t is recovered from the capital accumulation equation. Further details are provided in Appendix E.

Calibration. We calibrate the discount factor to yield an annual interest rate

of 3%. The depreciation rate is set to align with the average for the manufacturing sector as reported by BEA data (approximately 11% per year). The adjustment cost parameter is set to 0.75, positioned between the extremes of no adjustment costs and quadratic adjustment costs, which is consistent with the range of values found in the empirical literature. For the elasticity of substitution between the capital-labor bundle and materials, we set $\sigma = 0.20$, equal to the mean of the four point estimates for σ in Figure 7a.

Inversion results. We first present some key features that arise from our model inversion, before moving on to counterfactual analyses. Additional outcomes from the inversion are provided in Appendix E. We start with the gross markups implied by our inversion, which can be seen in Panel (a) of Figure 8. The markup increases gradually over the sample period, consistent with the evidence on rising market power documented in the literature. That said, the gross markup that we recover is quite low in both level and trend, ranging between around 1.06 in 1998 and 1.12 at the end of the sample. The increase in the markup suggests that through the lens of the model, the empirical path of free cash flows in U.S. manufacturing cannot be solely explained by investment patterns, and a structural residual to capture rising profit rates is needed. The recovered markups imply that the profit share of revenues rises from approximately 6% to 11% and averages about 9% over the sample.

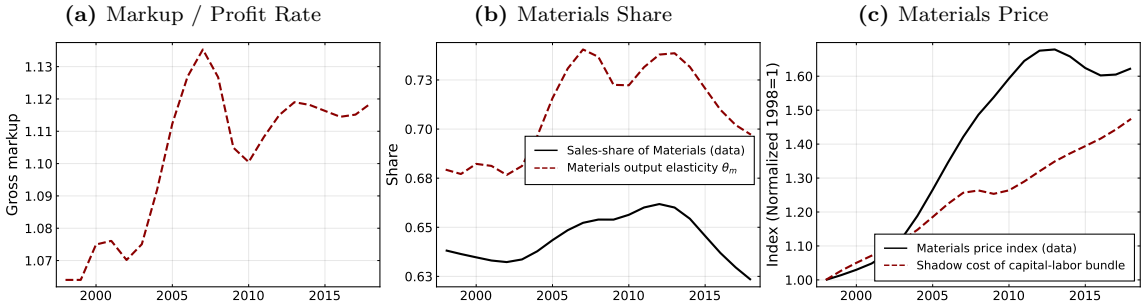
A second key outcome from the inversion is the output elasticity of materials, which can be seen in Panel (b) of Figure 8. The sales share of materials in the data increased in the early 2000s and then decreased in the 2010s. The recovered output elasticity of materials broadly follows this pattern, although given the recovered increase in markups, it remains persistently higher than at the beginning of the sample period.

Finally, Panel (c) shows the materials price index alongside the unit cost of the capital-labor bundle $\tilde{c}_G$.[38] In line with the empirical evidence, the inversion implies a large increase in the price of materials relative to the cost of other inputs of production.

The recovered fundamentals imply a long-run elasticity of the labor share with respect to the price of materials – the elasticity in Proposition 1 – that averages -0.15

[38] $\tilde{c}_{G,t}$ is the unit cost of the unaugmented capital-labor bundle, recovered from the ratio of the first-order conditions for materials and the capital-labor composite, as detailed in Appendix E.

Figure 8: Model Inversion Results



Note: This figure shows results from the model inversion in Section 4.3. Panel (a) shows the recovered gross markup μ_t. Panel (b) shows the materials share of revenues in the data (solid black) and the recovered materials output elasticity $\theta_{m,t}$ (dashed red). Panel (c) shows the materials price index from the data (solid black) and the recovered unit cost of the unaugmented capital-labor bundle $\tilde{c}_{G,t}$ (dashed red), both normalized to 1 in 1998. Data are from the BEA industry accounts for U.S. manufacturing, 1998–2019, HP-filtered with smoothing parameter 5.

over the sample period, and a slightly larger on-impact elasticity, with capital fixed, that averages -0.18 – both in line with the magnitudes of our reduced-form estimates in Section 3.

4.4 Counterfactual Analysis

Counterfactual Experiments. We conduct two counterfactual experiments to quantify the role of materials prices in shaping the dynamics of the labor share.

Counterfactual 1: Constant materials prices. We hold the materials price $p_{m,t}$ constant at its 1998 level while allowing all other fundamentals and prices to follow their historical paths, including the time-varying residuals α_t and μ_t. This experiment implies a counterfactual decline in the price of materials relative to the cost of labor and capital. Note that at least in the case of labor, for which the cost is measured well, this is a plausible scenario: historically, aside from short periods of booming materials prices, wages have increased at a faster rate than the price of materials.[39]

Counterfactual 2: Constant relative effective materials prices. We hold constant the effective relative price of materials, by adjusting the materials price in accordance with changes in the unit cost of the capital-labor bundle $\tilde{c}_G$, and by adjusting the materials-augmenting productivity B_t in accordance with changes in the primary factor-augmenting productivity A_t. This is a more restrictive counterfactual that

[39]This suggests that a constant materials-biased technical change is a desirable feature in the balanced growth path of an economy that features our production technology.

holds constant all the exogenous factors that might change the output elasticity of materials, although note that it can still change due to endogenous capital accumulation.

Counterfactual Results. Figure 9 presents results from the counterfactual experiments. Each panel shows an outcome of interest in the baseline equilibrium (solid black), which also equals the smoothed outcome in the data, and in the two counterfactual scenarios (dashed red for constant materials prices and dotted blue for constant effective materials prices).

Panel (a) shows our main outcome of interest, the labor share of value added. Holding materials prices constant and allowing everything else to change yields a smaller decline in the labor share than in the baseline. The difference picks up over the 2000s, during the period of the large increase in materials prices, with some gap remaining also at the end of the sample period. To quantify the contribution of materials prices to the changes in the labor share, we compute the cumulative change in the labor share in the counterfactual relative to the baseline:

$$\text{Contribution} = 1 - \frac{\sum_t |\lambda_t^{CF} - \lambda_0|}{\sum_t |\lambda_t^{Baseline} - \lambda_0|}, \tag{28}$$

where λ_0 denotes the labor share at the beginning of the sample (1998). This measure captures how much of the labor share's total cumulative movement from its initial value is eliminated when materials prices are held constant. Using this measure, we assess that the decline of the labor share would have been on average 23%–35% smaller if materials prices had been constant, depending on the counterfactual scenario – relatively similar to our reduced-form quantification in Section 3.

Notably, this counterfactual still allows for other key explanations for the decline in the labor share to operate, through changes in the markup residual (μ_t) and through changes in the capital intensity residual (α_t). In particular, our analysis suggests a non-trivial role for the increase in the markup residual. The model also allows us to decompose value added into labor, capital, and profit shares, since the inversion recovers μ_t. The capital share of value added, defined as the marginal revenue product of capital relative to value added, declines in the baseline but would have been higher absent materials price increases – mirroring the labor share results, with the difference absorbed by the profit share (see Appendix E.7, Figure E.2).

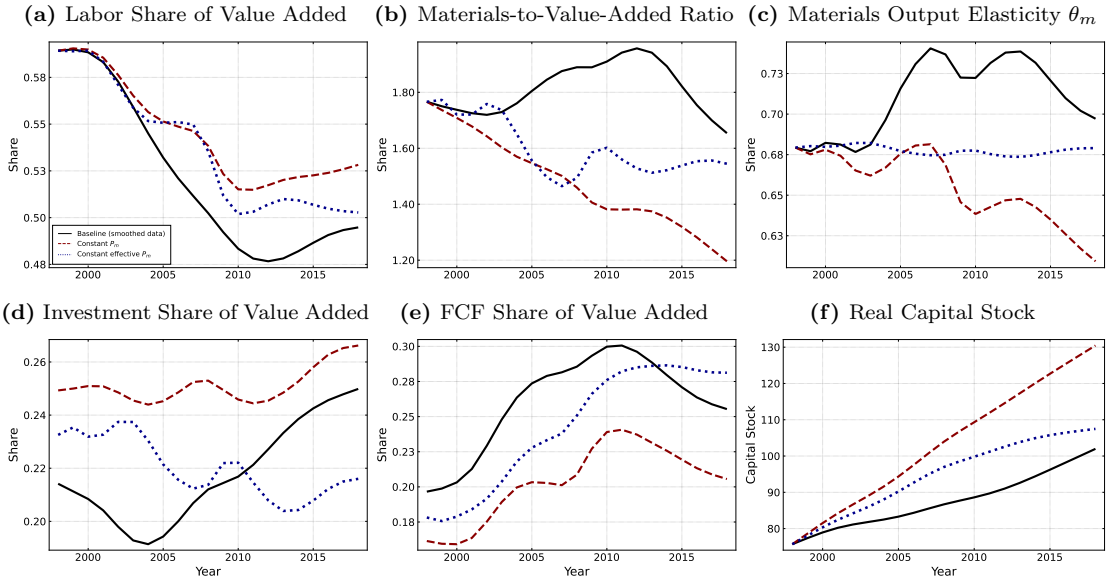
Panels (b)–(f) turn to additional outcomes: the materials-to-value-added ratio, the materials output elasticity, the investment-to-value-added ratio, the free-cash-flow-to-value-added ratio, and the real capital stock. Panels (b) and (c) show that both the materials-to-value-added ratio and the materials output elasticity are lower in the counterfactual scenarios than in the baseline, as the rise in materials prices is shut down. Indeed, absent the observed increase in materials prices, both objects would have trended downward over the sample period, reflecting both the lower relative cost of materials and, in part, the effect of rising markups.

The investment-to-value-added ratio is higher in the counterfactual scenarios, as a lower cost of materials raises the return to investment. Note that this measure jumps on impact relative to the baseline equilibrium, since investment is forward-looking. Accordingly, free cash flow ratios would have been lower in most years, because firms would have spent more on investment. This is distinct from the model's profit share: free cash flow combines capital's marginal contribution to revenue and pure profits and then subtracts current investment expenditure. Thus, while residual markups are still required to explain the rise in free cash flows through the lens of the model, free cash flow ratios would have been lower absent the rise in materials prices. Finally, since higher materials prices dampen firms' investment, the counterfactual scenarios imply a larger capital stock.[40] Similar to markups, the rise in materials prices over this time period acted as a dampening force on investment and capital accumulation, countering a push toward more investment from declining investment prices and from changes in the technological residuals.

Another insight from this analysis highlights the interplay between capital accumulation and our core mechanism. When there are complementarities in production, a higher capital stock – holding everything else constant – increases the materials output elasticity, which in turn lowers the labor share. Thus, while higher materials prices directly contribute to a lower labor share via a higher materials output elasticity, they also generate an offsetting effect: by dampening capital accumulation, they indirectly push the labor share upward.

[40] This follows from the investment Euler equation together with the envelope condition. The shadow value of capital satisfies $\partial \mathcal{V}_t/\partial k_t = \partial R_t/\partial k_t + \beta(\partial \mathcal{V}_{t+1}/\partial k_{t+1})(\partial k_{t+1}/\partial k_t)$, where $\partial R_t/\partial k_t = (\theta_{k,t}/\mu_t)(E_t/k_t)$ is the marginal revenue product of capital. With complementarity between materials and the capital-labor bundle, a higher materials price raises $\theta_{m,t}$ and lowers $\theta_{k,t} = (1-\alpha_t)(1-\theta_{m,t})$, thereby reducing the shadow value of capital and weakening the incentive to invest.

Figure 9: Counterfactual Sectoral Outcomes in the Quantitative Model



Note: This figure shows results from the counterfactual experiments in Section 4.4. Each panel compares the baseline equilibrium (solid black) with two counterfactual scenarios: constant materials prices $p_{m,t}$ (dashed red) and constant effective materials prices (dotted blue). Counterfactual 1 holds $p_{m,t}$ constant at its 1998 level. Counterfactual 2 holds the ratio $p_{m,t}/\tilde{c}_{G,t}$ constant at its 1998 level and keeps the ratio B_t/A_t constant at its 1998 level (see text for details).

5 Cross-Country Investigation

We now investigate the relationship between materials prices and the labor share in a multi-country setting. This serves two purposes: reconciling differences in the behavior of the labor share across countries, and providing an additional test of our mechanism using cross-country variation in relative materials prices.[41]

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 Appendix A.5.

Setting. Consider a world with $N+1$ countries. N countries are industrial, producing output with endowments of labor and capital and with imported raw ma-

[41] While Karabarbounis and Neiman (2014) and Autor and Salomons (2018) document a decline in the aggregate labor share for a large set of countries, Cette, Koehl, and Philippon (2020) and Gutiérrez and Piton (2020) argue that the existence of a common trend outside the U.S. is less clear after corrections for self-employment and residential housing.

terials, 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. 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:

$$U_n \equiv \left[\sum_{i=1}^{N} F_i {C_{ni}}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \tag{29}$$

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, charging a markup $\mu \equiv \eta/(\eta-1)$ over marginal cost. The production function takes our baseline nested-CES form:

$$y_i = \left(\left(A_i l_i^{\alpha} k_i^{1-\alpha} \right)^{\frac{\sigma-1}{\sigma}} + \left(B_i m_i \right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{30}$$

where A_i and B_i are country-specific primary-augmenting and materials-augmenting productivity, respectively; k_i, l_i and m_i are the amounts of capital, labor and materials employed by each firm in country i; and α is the labor elasticity within the primary input bundle. 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. Defining $\tilde{c}_{G,i} \equiv \frac{1}{A_i \alpha} \left(\frac{L_i}{K_i} \right)^{1-\alpha}$, so that $\tilde{c}_{G,i} w_i$ is the unit cost of the primary-input bundle in country i, the market clearing condition for materials can be written as

$$\bar{m} = \frac{1}{\alpha} \sum_i B_i^{\sigma-1} \tilde{c}_{G,i}^{\sigma-1} L_i \left(\frac{w_i}{p_m} \right)^{\sigma}. \tag{31}$$

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

$$\lambda_i = \alpha \frac{\left(\tilde{c}_{G,i}\, w_i\right)^{1-\sigma}}{\frac{\eta}{\eta-1}\left(\tilde{c}_{G,i}\, w_i\right)^{1-\sigma} + \frac{1}{\eta-1}\left(\frac{p_m}{B_i}\right)^{1-\sigma}}. \tag{32}$$

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

$$\lambda_i = \alpha \frac{\eta - 1}{\eta + \left[\left(\frac{\eta}{\eta-1}\frac{p_m}{B_i\, p_i}\right)^{\sigma-1} - 1\right]^{-1}}, \tag{33}$$

where p_i is given in the model by $p_i = \frac{\eta}{\eta-1}\left(\left(\tilde{c}_{G,i}\, w_i\right)^{1-\sigma} + \left(\frac{p_m}{B_i}\right)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$. 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 the same nominal 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 a lower relative price of materials p_m/p_i. Using equations (31) and (32), we can rewrite the market clearing for materials in terms of the labor shares in all countries:

$$\bar{m} = \sum_i \frac{A_i}{B_i} L_i^{\alpha} K_i^{1-\alpha} \left(\frac{1}{(\eta-1)\,\alpha\,(\lambda_i)^{-1} - \eta}\right)^{\frac{\sigma}{1-\sigma}}. \tag{34}$$

Equation (34) reveals that the labor share remains constant if the global supply of materials $\bar{m}$ grows at the same rate as the composite $\frac{A_i}{B_i} L_i^{\alpha} K_i^{1-\alpha}$ in all countries. When the global supply of materials declines relative to these endowments, at least one country's labor share must fall. More generally, the adjustment need not be homogeneous across countries, and depends on their initial labor shares, endowments

of L_i and K_i, and productivity parameters A_i and B_i. 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 the labor share in at least one country. (c) A small proportional increase in both primary-augmenting and materials-augmenting productivity (A_j, B_j) in some country j – equivalent to a Hicks-neutral productivity gain – raises the labor share in that country and lowers it in at least one other country.*

Proof. See Appendix A.5. □

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. A supply-driven boom lowers the labor share in at least some countries, while a demand-driven boom reflecting asymmetric productivity growth raises the labor share in the growing country at the expense of others. In both cases, we should expect heterogeneous adjustment of the labor share across countries, in line with differential trends in their relative price of materials.

5.2 International Evidence

The data confirm the model's key prediction: the relative price of materials displays substantial cross-country variation over the 2000s (Appendix Figure F.2). While the U.S. and Japan experienced large increases in relative materials prices, European countries saw more modest movements, in part because the concurrent appreciation of the Euro dampened the local-currency impact of the (dollar-denominated) commodity boom.

We base our analysis on the 2025 release of EU-KLEMS, supplemented with World KLEMS data for Canada and South Korea, covering 23 countries over 1995–2019 at the manufacturing-industry level (Appendix F). We construct a shift-share instrument paralleling the U.S. analysis: $\text{IV}_{c,j,t} = \sum_k s_{c,j,k} \, \Delta \log(p_{k,t} \, e_{c,t})$, where $s_{c,j,k}$ are country-specific input-output shares from the WIOD year-2000 tables, $\Delta \log p_{k,t}$ are global

commodity price shocks from ComTrade, and $e_{c,t}$ is the bilateral exchange rate vis-à-vis the U.S. dollar, so that commodity prices are expressed in local currency. We estimate the cross-country analog of specification (13), controlling for log wages and absorbing country×industry and year fixed effects.

Table 4: Material Prices and the Labor Share Across Countries

	Unweighted			Weighted		
	(1) OLS	(2) 2SLS	(3) 2SLS	(4) OLS	(5) 2SLS	(6) 2SLS
Materials Intensity × Log Materials Price	-0.0714***	-0.110***	-0.106***	-0.0759***	-0.131***	-0.132***
	(0.0128)	(0.0190)	(0.0201)	(0.0188)	(0.0322)	(0.0341)
First-stage F-stat (KP-Wald)		70.00	65.92		63.35	60.65
N	6318	6318	6018	6318	6318	6018
Country×Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Log Wage	Yes	Yes	Yes	Yes	Yes	Yes
Excl. US			Yes			Yes

Note: This table reports results from the regression of the log manufacturing labor share on materials intensity × log materials price across 23 countries. The instrument is a shift-share IV constructed from WIOD year-2000 IO shares and ComTrade commodity price shocks, adjusted for bilateral exchange rate movements. All specifications control for log wage and include country×industry and year fixed effects. Standard errors in parentheses, clustered at the country×industry 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 materials prices and the labor share. Columns 2–3 present the 2SLS results using the shift-share IV, with and without the U.S. Columns 4–6 repeat the same specifications weighted by baseline value-added shares. The results remain negative and significant across all specifications, robust to the inclusion or exclusion of the U.S. and to weighting. Overall, the results confirm that the negative relationship between intermediate prices and the labor share holds in the cross-country panel, in line with our suggested mechanism. Appendix F provides supplementary figures including the first-stage relationship, a binscatter of the OLS relationship, and trends in materials prices across countries.

6 Conclusion

We propose a mechanism linking the labor share to the relative price of materials. When materials and primary inputs are complements and the profit share is positive, an increase in the price of materials lowers the labor share and raises the profit share of value added, even without changes in markups or returns to scale. We provide empirical evidence for this mechanism in U.S. aggregate time series, across broad sectors, narrowly defined manufacturing industries, commuting zones, and countries. We estimate that rising materials prices account for roughly one-third of the decline in the labor share over recent decades and for much of its sharp drop in the 2000s.

We conclude with three further implications. First, part of the downward trend in the labor share reflects a medium-term cyclical component tied to global commodity prices. Second, aggregate profit shares can change without any corresponding change in firms' market power, conduct, or returns to scale. Finally, the mechanism highlights the importance of carefully accounting for fluctuations in the cost share of intermediate inputs when inferring markups from factor shares.

Data and Code Availability

Data and Code for this research are available at https://doi.org/10.7910/DVN/DJWFRB (Castro-Vincenzi and Kleinman, 2026). They were checked by the journal for their ability to reproduce the results presented in the paper.

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A Theory: Derivations and Extensions

This appendix collects the derivations and theoretical extensions of the framework in Section 2. Appendix A.1 provides standard microfoundations for the profit share of revenues π. Appendix A.2 derives the total differential of the labor share under a general production function, proves Proposition 1, derives the elasticities of the additional outcomes used in Section 3.10, and derives equation (12). Appendix A.3 generalizes Proposition 1 to non-separable production, variable markups, a fixed factor with a non-unitary elasticity of substitution, and fixed costs. Appendix A.4 shows that the mechanism operates in three stylized general-equilibrium environments. Appendix A.5 presents the multi-country model underlying Section 5 and proves Proposition 2.

A.1 Microfoundations for the profit share

Proposition 1 requires a positive profit share $\pi > 0$ but is agnostic about its source.

Markups. Suppose the firm charges a price-cost markup $\mu > 1$ (e.g. under monopolistic competition with isoelastic demand). Since revenues exceed costs by a factor of μ, we have $R = \mu C$ and the profit share is $\pi = 1 - 1/\mu$.[42]

Decreasing returns to scale. Suppose instead that markets are competitive but the firm operates a decreasing-returns technology, $y = F\big(G(k,l),m\big)^{\zeta}$ with $\zeta < 1$. Total factor payments equal a fraction ζ of revenue, so $C = \zeta R$ and $\pi = 1 - \zeta$. This case does not require imperfect competition. More generally, with both decreasing returns and a markup, $\pi = 1 - \zeta/\mu$.

A fixed factor. Decreasing returns can in turn be microfounded by a fixed factor. Suppose gross output is

$$y = F\big(G(k,l),m\big)^{\zeta}\,\bar{T}^{\,1-\zeta},$$

where $\bar{T}$ is a factor fixed at the firm level (e.g. land or organizational capital), so that production exhibits constant returns in $(k,l,m,\bar{T})$ jointly. Under competitive behavior in the variable inputs, payments to (k,l,m) equal ζR, and the residual

[42] If a fraction of gross profits is redistributed to workers (e.g. through profit-sharing or stock-based compensation), the result carries over to the measured labor share: if workers receive a share ϕ_l of profits, Proposition 1 holds exactly with $\pi/(1-\pi)$ replaced by $(\mu-1)(1-\phi_l/\lambda)$, where λ is the measured labor share inclusive of profit-sharing income.

$(1-\zeta)R$ accrues to the fixed factor and is measured as profit: $\pi = 1-\zeta$, constant and independent of the price of materials. The Cobb–Douglas form is exactly what makes π constant. If the fixed factor instead enters with a non-unitary elasticity of substitution with the variable-input bundle, its share of revenue – and hence π – responds to materials prices, contributing the $d\log\left(\frac{1}{1-\pi}\right)$ term in the total differential (12). We derive this case explicitly in Appendix A.3.

The profit share with fixed costs. Fixed costs are not themselves a source of profits, but they change what the profit share is for a given markup. Suppose the firm charges a markup μ over variable cost C and must also cover a fixed labor cost F_C. Net economic profit is $\Pi = R - C - F_C$, and letting $\omega \equiv F_C/C$ denote the ratio of fixed to variable costs, the profit share of revenues is

$$\pi = 1 - \frac{1+\omega}{\mu}.$$

A positive markup over variable cost alone is therefore not sufficient for $\pi > 0$: positive economic profits require $\mu > 1+\omega$.[43]

A.2 Total differential of the labor share

This section derives the total differential of the labor share under a general constant-returns technology $y = F(A_K k, A_L l, Bm)$, which allows for factor-augmenting productivity as in equation (11) but does not impose weak separability between primary inputs and materials. We then prove Proposition 1 and derive equation (12). The general expressions derived here also underlie the generalizations in Appendix A.3.

A.2.1 General case

We use the notation of Section 2: $\pi = (R-C)/R$ is the profit share of revenues, $M = p_m m$ is materials expenditure, $V = R - M$ is value added, $\theta_m = p_m m/C$ is the materials cost share, and $\alpha = wl/(wl+rk)$ is labor's share of primary-input costs. In addition, let $\theta_l \equiv wl/C$ and $\theta_k \equiv rk/C$ denote the labor and capital cost shares, so that $\alpha = \theta_l/(1-\theta_m)$. Since $wl = \theta_l C$, $R = C/(1-\pi)$, and hence $V = \left(\frac{1}{1-\pi} - \theta_m\right)C$, the labor share defined in equation (4) can be written as $\lambda = wl/V = (1-\pi)\theta_l/(1-(1-$

[43] A positive markup over variable cost can therefore coexist with zero economic profits when fixed costs drive a wedge between marginal and average cost (Rotemberg and Woodford, 1995).

$\pi)\theta_m$). Because technology is factor-augmenting and CRS, we can work in efficiency units: let $x_l \equiv A_L l$, $x_k \equiv A_K k$, and $x_m \equiv Bm$ denote effective inputs, with effective prices $\tilde{w} \equiv w/A_L$, $\tilde{r} \equiv r/A_K$, and $\tilde{p}_m \equiv p_m/B$. Expenditures are unchanged by this change of units ($\tilde{w}x_l = wl$, and so on), so $\theta_i = \tilde{p}_i x_i/C$, and cost shares depend on factor prices and technology only through the effective prices. Totally differentiating:

$$d\log\lambda = d\log\theta_l + \frac{M}{V}\, d\log\theta_m - \frac{R}{V}\, d\log\left(\frac{1}{1-\pi}\right), \tag{A.1}$$

where we used $(1-\pi)\theta_m/(1-(1-\pi)\theta_m) = M/V$ and $1 + M/V = R/V$.

Changes in cost shares are governed by the substitution structure of the production function. Let $\varepsilon_{ij} \equiv \partial \log x_i/\partial \log \tilde{p}_j$ denote constant-output demand elasticities. Totally differentiating $\theta_i = \tilde{p}_i x_i/C$ and using $d\log C = \sum_j \theta_j\, d\log\tilde{p}_j$:

$$d\log\theta_i = \sum_j H_{ij}\, d\log\tilde{p}_j, \qquad H_{ij} \equiv \mathbf{1}\{i=j\} + \varepsilon_{ij} - \theta_j. \tag{A.2}$$

Substituting into (A.1), define $a_j \equiv H_{lj} + \frac{M}{V} H_{mj}$, so that

$$d\log\lambda = a_l\, d\log(w/A_L) + a_k\, d\log(r/A_K) + a_m\, d\log(p_m/B) - \frac{R}{V}\, d\log\left(\frac{1}{1-\pi}\right). \tag{A.3}$$

By homogeneity ($\sum_j H_{ij} = 0$), we have $a_l + a_k + a_m = 0$: only relative effective price changes matter.

Morishima elasticities. Define the Morishima elasticity of input i for input j as $\sigma_{ij} \equiv \partial \log(x_i/x_j)/\partial \log \tilde{p}_j\big|_{y,\tilde{p}_{-j}}$ for $i \neq j$. Using $\varepsilon_{ij} = \sigma_{ij} + \varepsilon_{jj}$ and $\sum_i \theta_i \varepsilon_{ij} = 0$, the H matrix entries can be written as:

$$H_{ij} = \theta_j(\sigma_{ij} - 1) + \theta_n(\sigma_{ij} - \sigma_{nj}), \qquad i \neq j,\ n = \text{third factor}, \tag{A.4}$$

$$H_{jj} = (1-\theta_j)(1-\bar{\sigma}_j), \qquad \bar{\sigma}_j \equiv \frac{\sum_{i\neq j} \theta_i \sigma_{ij}}{1-\theta_j}. \tag{A.5}$$

Coefficients. The coefficient on the materials price admits a clean two-term

decomposition. Using (A.4)–(A.5) and the identity $\frac{M}{V}(1-\theta_m)-\theta_m = -\frac{\pi}{1-\pi}\frac{M}{V}$:[44]

$$a_m = \frac{\theta_k}{1-\theta_m}\big(\sigma_{lm}-\sigma_{km}\big) - (1-\bar{\sigma}_m)\frac{\pi}{1-\pi}\frac{M}{V}. \tag{A.6}$$

The first term captures differential substitution between labor and capital; the second is the profit-share-of-value-added channel from Proposition 1, generalized to a non-separable production function F. The remaining coefficients are:

$$a_l = (1-\theta_l)(1-\bar{\sigma}_l) + \frac{M}{V}\Big[\theta_l(\sigma_{ml}-1) + \theta_k(\sigma_{ml}-\sigma_{kl})\Big], \tag{A.7}$$

$$a_k = \Big[\theta_k(\sigma_{lk}-1) + \theta_m(\sigma_{lk}-\sigma_{mk})\Big] + \frac{M}{V}\Big[\theta_k(\sigma_{mk}-1) - \theta_l(\sigma_{lk}-\sigma_{mk})\Big], \tag{A.8}$$

with $a_l + a_k = -a_m$. In each, the first term captures the direct effect on θ_l and the second, scaled by M/V, the indirect effect through θ_m.

Summary. Combining (A.3) with (A.6)–(A.8), the full total differential of the labor share under a general production function F is:

$$\begin{aligned} d\log\lambda = &\left[\frac{\theta_k}{1-\theta_m}(\sigma_{lm}-\sigma_{km}) - (1-\bar{\sigma}_m)\frac{\pi}{1-\pi}\frac{M}{V}\right] d\log\frac{p_m}{B} \\ &+ \left[(1-\theta_l)(1-\bar{\sigma}_l) + \frac{M}{V}\big(\theta_l(\sigma_{ml}-1) + \theta_k(\sigma_{ml}-\sigma_{kl})\big)\right] d\log\frac{w}{A_L} \\ &+ \left[\theta_k(\sigma_{lk}-1) + \theta_m(\sigma_{lk}-\sigma_{mk}) + \frac{M}{V}\big(\theta_k(\sigma_{mk}-1) - \theta_l(\sigma_{lk}-\sigma_{mk})\big)\right] d\log\frac{r}{A_K} \\ &- \frac{R}{V}\, d\log\left(\frac{1}{1-\pi}\right). \end{aligned} \tag{A.9}$$

This expression depends only on cost shares $(\theta_l, \theta_k, \theta_m)$, Morishima elasticities (σ_{ij}), the profit share π, and materials intensity M/V, and it nests all the results in Section 2 as special cases.

An equivalent representation decomposes the change in the labor share into three channels: changes in the within-primary labor share α, changes in the relative price of materials versus primary inputs (scaled by the profit share), and changes in the

[44] Note that $\frac{M}{V} = \frac{(1-\pi)\theta_m}{1-(1-\pi)\theta_m}$, so $\frac{M}{V}(1-\theta_m) - \theta_m = \frac{-\pi\theta_m}{1-(1-\pi)\theta_m} = -\frac{\pi}{1-\pi}\frac{M}{V}$.

profit share itself:

$$
\begin{aligned}
d\log\lambda = d\log\alpha \;-\; \frac{\pi}{1-\pi}\frac{M}{V}\Bigg[&(1-\bar{\sigma}_m)\Big(d\log\frac{p_m}{B} - d\log c_G\Big) \\
&+ \frac{\theta_l(\sigma_{ml}-1)+\theta_k(\sigma_{ml}-\sigma_{kl})+\alpha(1-\theta_m)(1-\bar{\sigma}_m)}{1-\theta_m}\, d\log\frac{w}{A_L} \\
&+ \frac{\theta_k(\sigma_{mk}-1)+\theta_l(\sigma_{mk}-\sigma_{lk})+(1-\alpha)(1-\theta_m)(1-\bar{\sigma}_m)}{1-\theta_m}\, d\log\frac{r}{A_K}\Bigg] \\
&- \frac{R}{V}\, d\log\left(\frac{1}{1-\pi}\right), \qquad \text{(A.10)}
\end{aligned}
$$

where $d\log c_G \equiv \alpha\, d\log(w/A_L)+(1-\alpha)\, d\log(r/A_K)$ is the cost-share-weighted change in effective primary-input prices, and $\bar{\sigma}_m = (\theta_l\sigma_{lm} + \theta_k\sigma_{km})/(1-\theta_m)$. Under separability, $d\log c_G$ equals, by Shephard's lemma, the change in the unit cost of the primary-input bundle defined in equation (2), evaluated at effective prices. The second and third lines inside the bracket capture the effect of non-separability: when materials and the primary bundle are not separable, changes in within-primary prices $(w/A_L, r/A_K)$ also shift the materials cost share. Under separability ($\sigma_{lm} = \sigma_{km} = \sigma$), these terms vanish, $\bar{\sigma}_m = \sigma$, and the expression reduces to equation (12) in the main text.

A.2.2 Proof of Proposition 1

Proposition 1 considers a change in the price of materials holding primary-input prices, technology, and the profit share constant. Setting $d\log\tilde{w} = d\log\tilde{r} = d\log(1/(1-\pi)) = 0$ in (A.3) gives, using (A.6),

$$
\frac{d\log\lambda}{d\log p_m} = a_m = \frac{\theta_k}{1-\theta_m}\big(\sigma_{lm}-\sigma_{km}\big) - (1-\bar{\sigma}_m)\frac{\pi}{1-\pi}\frac{M}{V}.
$$

Under the weakly separable technology (1), the two Morishima elasticities coincide and equal the elasticity of substitution between the primary-input bundle and materials defined in Proposition 1. To see this, note that separability implies that the cost-minimizing ratios l/G and k/G depend only on (w,r), so the response of l/m

and k/m to the price of materials operates entirely through the bundle ratio G/m:

$$\sigma_{lm} = \sigma_{km} = -\frac{\partial \log(m/G)}{\partial \log(p_m/c_G)} \equiv \sigma.$$

The first term in a_m then vanishes, $\bar{\sigma}_m = \sigma$, and

$$\frac{d\log\lambda}{d\log p_m} = -(1-\sigma)\frac{\pi}{1-\pi}\frac{M}{V}. \qquad \square$$

A.2.3 Elasticities of other outcomes

The same argument yields the elasticities of the two additional outcomes used in Section 3.10. Continue to hold primary-input prices, technology, and the profit share of revenues fixed, and let $\tau \equiv M/V$ and $s_m \equiv M/R = \tau/(1+\tau)$. Under weak separability, cost minimization implies

$$\frac{d\log\theta_m}{d\log p_m} = (1-\sigma)(1-\theta_m), \tag{A.11}$$

because $\theta_m/(1-\theta_m) = p_m m/[c_G(w,r)G]$ and the elasticity of m/G with respect to $p_m/c_G(w,r)$ is $-\sigma$. Since $R = C/(1-\pi)$,

$$\frac{M}{V} = \frac{(1-\pi)\theta_m}{1-(1-\pi)\theta_m} \qquad \text{and} \qquad \frac{V}{R} = 1-(1-\pi)\theta_m.$$

Holding π constant and differentiating gives

$$\varepsilon_{MV} \equiv \frac{d\log(M/V)}{d\log p_m} = (1-\sigma)(1-\theta_m)\frac{R}{V} = (1-\sigma)+\beta\tau, \tag{A.12}$$

$$\varepsilon_{VR} \equiv \frac{d\log(V/R)}{d\log p_m} = -(1-\sigma)(1-\theta_m)\frac{M}{V} = -s_m\big[(1-\sigma)+\beta\tau\big], \tag{A.13}$$

where $\beta = -\frac{\pi}{1-\pi}(1-\sigma)$ is the labor-share coefficient in Equation (18). Thus, defining

$$A_{MV} \equiv \varepsilon_{MV} - \beta\tau \qquad \text{and} \qquad A_{VR} \equiv -\frac{\varepsilon_{VR}}{s_m} - \beta\tau,$$

either auxiliary elasticity implies $A_h = 1 - \sigma$ and, when combined with β, identifies

$$\sigma = 1 - A_h, \qquad \pi = \frac{-\beta}{A_h - \beta}, \qquad h \in \{MV, VR\}. \tag{A.14}$$

For Figure 7a, we evaluate τ at the value-added-weighted mean of baseline materials intensity in the estimation sample, $\tau = 1.21$, and set $s_m = \tau/(1+\tau)$. Because $V/R = 1/(1 + M/V)$, the two elasticities are linked at a common state; we use each in turn as an alternative auxiliary mapping rather than treating them as independent restrictions.

A.3 Generalizations of Proposition 1

We now generalize Proposition 1 in four directions, using the expressions derived in Appendix A.2: we relax weak separability between materials and primary inputs, allow the profit share to vary through endogenous markups, allow it to vary through a fixed factor with a non-unitary elasticity of substitution, and introduce fixed costs of production.

Non-separable production function. First, consider a general production function $F(k, l, m)$ that need not be weakly separable in primary inputs and materials.[45] In this case, the marginal rate of technical substitution between capital and labor may depend on the level of materials, so a change in the price of materials can shift expenditure between labor and capital directly. Setting $d\log\tilde{w} = d\log\tilde{r} = d\log(1/(1-\pi)) = 0$ in (A.3) gives $d\log\lambda/d\log p_m = a_m$, which by (A.6) and $\theta_l + \theta_k = 1 - \theta_m$ can be written as

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

where σ_{im} is the Morishima elasticity of substitution between factor i and materials, defined in Appendix A.2. This expression differs from Proposition 1 in two ways. First, since materials are no longer separable from labor and capital, σ is replaced with a cost-weighted average of the Morishima elasticities. Second, a higher price of materials can now also lower the labor share by shifting expenditure from labor to capital, if $\sigma_{lm} < \sigma_{km}$. As discussed in Section 2, we find little empirical evidence of this

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

second channel – materials prices do not affect capital-labor ratios, and controlling for them leaves our estimates unchanged – and we therefore focus on the case $\sigma_{lm} = \sigma_{km}$ in most of the paper.

Variable profit share. Second, suppose the firm faces a general demand function $D(p)$ with non-constant elasticity $\epsilon \equiv -\frac{d\log D(p)}{d\log p}$ and super-elasticity $\xi \equiv \frac{d\log \epsilon}{d\log p}$. The markup $\mu = \epsilon/(\epsilon-1)$ and the profit share now vary with the output price, so a change in the price of materials moves the labor share both through the materials cost share and through the profit share itself. The derivation proceeds in three steps. First, from the definition of Morishima elasticities and cost minimization, $d\log(\theta_i/\theta_m)/d\log p_m = -1+\sigma_{im}$. Second, combining this with $\sum_i \theta_i = 1$ gives $d\log\theta_m/d\log p_m = 1-\theta_l\sigma_{lm}-\theta_k\sigma_{km}-\theta_m$. Third, the profit share adjusts: from $\mu = \epsilon/(\epsilon-1)$ and $\pi = 1-1/\mu$, we obtain $d\log(1/(1-\pi))/d\log p_m = -\theta_m\xi/(\epsilon-1+\xi)$, because a higher materials price raises the output price, which under Marshall's second law ($\xi > 0$) raises the demand elasticity and lowers the markup. Substituting these into (A.1) yields

$$\frac{d\log\lambda}{d\log p_m} = \frac{\theta_k}{1-\theta_m}(\sigma_{lm}-\sigma_{km}) - (1-\bar{\sigma}_m)\frac{\pi}{1-\pi}\frac{M}{V} + \frac{M}{V}\frac{\xi}{(1-\pi)(\epsilon-1+\xi)}, \quad \text{(A.15)}$$

where the last term captures the endogenous markup adjustment. Under separability ($\sigma_{lm} = \sigma_{km} = \sigma$), and using $\mu = 1/(1-\pi)$, this becomes

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

When $\xi = 0$, this collapses to Proposition 1. For standard demand systems satisfying Marshall's second law ($\xi > 0$), a higher materials price lowers the markup, offsetting part of the baseline effect (or overturning it, if ξ is sufficiently large).

Variable profit share from a fixed factor. Third, the profit share can also vary through the technology rather than through demand. Consider the fixed-factor microfoundation of Appendix A.1, maintaining weak separability within the variable-input bundle, but suppose gross output is a CES aggregate of the variable-input bundle and the fixed factor,

$$y = \left[\zeta F\big(G(k,l),m\big)^{\frac{\nu-1}{\nu}} + (1-\zeta)\bar{T}^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu}{\nu-1}}, \qquad \zeta \in (0,1).$$

where ν is the elasticity of substitution between the two; the Cobb–Douglas case in Appendix A.1 corresponds to $\nu = 1$. Euler's theorem implies that payments to the variable inputs are $C = (1-\pi)R$ with $1-\pi = \zeta(F/y)^{\frac{\nu-1}{\nu}}$, so the fixed factor's revenue share – measured as profit – now responds to materials prices. The first-order condition for the variable-input bundle is $p\,\zeta(F/y)^{-1/\nu} = c_F$, where c_F is its unit cost. Holding the output price and primary-input prices fixed, these two conditions imply

$$d\log\left(\frac{1}{1-\pi}\right) = (\nu-1)\,d\log c_F = (\nu-1)\,\theta_m\,d\log p_m,$$

where the second equality uses Shephard's lemma. Substituting this expression into the total differential (12) and using $\frac{R}{V}\,\theta_m = \frac{1}{1-\pi}\frac{M}{V}$, the response of the labor share to the price of materials is

$$\frac{d\log\lambda}{d\log p_m} = \frac{M/V}{1-\pi}\Big[(1-\nu) - \pi(1-\sigma)\Big],$$

with all shares evaluated at the initial equilibrium. When $\nu = 1$, the profit share is constant and the expression reduces to the elasticity in Proposition 1. When $\nu > 1$, a higher materials price raises the unit cost of the variable-input bundle, expenditure shifts toward the fixed factor, and the resulting rise in π reinforces the decline in the labor share; when $\nu < 1$, the fixed factor's revenue share instead falls, dampening the mechanism – and overturning it when $\nu < 1 - \pi(1-\sigma)$.

Fixed costs. Fourth, consider a firm with variable costs C and a fixed cost F_C paid in labor, and let $\omega \equiv F_C/C$. Suppose the firm faces isoelastic demand with elasticity ϵ, so that $\mu = \epsilon/(\epsilon-1)$ is constant and the profit share is $\pi = 1-(1+\omega)/\mu$ (Appendix A.1). Since $d\log C/d\log p_m = (1-\epsilon)\theta_m$ and $d\log\omega/d\log p_m = (\epsilon-1)\theta_m$, the elasticity becomes

$$\frac{d\log\lambda}{d\log p_m} = \left[-(1-\sigma)\frac{\pi}{1-\pi} + \omega\left(\frac{(\epsilon-\sigma)(\mu-\theta_m)}{\theta_l+\omega} - \frac{1-\sigma}{1-\pi}\right)\right]\frac{M}{V}.$$

The first term is the baseline channel from Proposition 1, which this expression nests when $\omega = 0$; the second captures changes in the ratio of variable to fixed labor costs. When $\omega > 0$ and net profits are non-negative ($\mu \geq 1+\omega$), the second term is positive: using $1/(1-\pi) = \mu/(1+\omega)$, we have $(\mu-\theta_m)/(\theta_l+\omega) \geq \mu/(1+\omega)$ and, since $\epsilon > 1 > \sigma$,

$\epsilon - \sigma > 1 - \sigma$. The fixed-cost channel therefore dampens – and can overturn – the baseline effect: a higher materials price lowers output and hence variable costs, while the fixed labor payment F_C does not scale down, raising its share in value added. In particular, when $\pi = 0$ the baseline channel vanishes and the elasticity is positive: with zero net profits, a higher price of materials raises the labor share.

A.4 General equilibrium

The analysis in Section 2 is partial equilibrium, taking input prices as given. To show that the mechanism extends to general equilibrium, we consider three stylized settings – a roundabout production economy, a two-sector economy, and a small open economy – in which different shocks raise the price of materials and the labor share falls through the same logic. For simplicity, we abstract from capital and set $G(k, l) = l$, so the technology (11) with the CES aggregator (10) becomes

$$y = \left((A_L l)^{\frac{\sigma-1}{\sigma}} + (Bm)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}.$$

In each setting, firms have a profit share $\pi > 0$ and aggregate labor supply is fixed at L.

A roundabout production economy. Consider an economy in which firms source units of the final good as materials. A sourcing friction means that only a fraction $1/\kappa$ of sourced goods can be used in production, so the effective price of materials is $p_m = \kappa p$, where p is the price of the final good. The unit cost of output is

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

and the profit share implies $p = c/(1-\pi)$. We assume $(1-\pi)B > \kappa$, which for $\sigma < 1$ guarantees an equilibrium with a positive price of materials. Solving for the price of the final good yields

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

Normalizing the wage to one, the relative price of materials is

$$p_m = \frac{B}{A_L}\left[\left(\frac{(1-\pi)B}{\kappa}\right)^{1-\sigma} - 1\right]^{-\frac{1}{1-\sigma}},$$

which is increasing in the friction κ when $\sigma < 1$. Since value added is $wL + \Pi$, using $\Pi = \frac{\pi}{1-\pi}C$ and $p_m m/(wL) = 1/\left[\left(\frac{(1-\pi)B}{\kappa}\right)^{1-\sigma} - 1\right]$, the labor share is

$$\lambda = \frac{wL}{wL+\Pi} = \frac{1}{1 + \frac{\pi/(1-\pi)}{1-\left(\frac{\kappa}{(1-\pi)B}\right)^{1-\sigma}}}.$$

An increase in the sourcing friction κ relative to B thus raises the relative price of materials and lowers the labor share if $\sigma < 1$ and $\pi > 0$.

A two-sector economy. Consider an economy with an extractive sector endowed with $\bar{m}$ units of raw materials and a manufacturing sector that combines them with labor to produce the final good, with the same technology and profit share π as in the roundabout economy. Normalizing the wage to one, the market-clearing price of materials is

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

which is decreasing in the relative endowment $\bar{m}/L$. The manufacturing labor share is

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

which is increasing in $\bar{m}/L$ when $\sigma < 1$ and $\pi > 0$. The aggregate labor share, incorporating extractive-sector rents $p_m\bar{m}$, is

$$\lambda^{agg} = \frac{wL}{wL + \Pi^{manuf} + p_m\bar{m}} = \frac{1-\pi}{1 + \left(\frac{A_L}{B}\right)^{\frac{1-\sigma}{\sigma}} \left(\frac{\bar{m}}{L}\right)^{\frac{\sigma-1}{\sigma}}}.$$

An exogenous decline in $\bar{m}/L$ raises p_m and lowers both labor shares when $\sigma < 1$ (the manufacturing labor share provided also $\pi > 0$). Notably, the manufacturing profit share π need not be positive for the aggregate result: rents to the materials endowment drive a wedge between aggregate value added and labor payments, playing the role of profits in Proposition 1, and λ^{agg} is increasing in $\bar{m}/L$ when $\sigma < 1$ even

with $\pi = 0$.

A small open economy. Finally, consider a small open economy that sources materials at a given world price p_m and sells output at a given world price p. The pricing condition

$$p = \frac{1}{1-\pi}\left[\left(\frac{w}{A_L}\right)^{1-\sigma} + \left(\frac{p_m}{B}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$$

pins down the wage w. The materials cost share is

$$\theta_m = \left(\frac{p_m}{B(1-\pi)p}\right)^{1-\sigma}, \qquad \theta_l = 1 - \theta_m,$$

which is increasing in $p_m/(Bp)$ when $\sigma < 1$. The labor share is

$$\lambda = \frac{\theta_l}{\frac{1}{1-\pi} - \theta_m} = \frac{(1-\pi)(1-\theta_m)}{1-(1-\pi)\theta_m},$$

so that a higher relative price of materials p_m/p leads to a lower labor share when $\sigma < 1$ and $\pi > 0$.

These examples illustrate that the conditions of Proposition 1 – complementarities in production and a positive profit share, or rents playing its role – allow the mechanism to operate in general equilibrium, regardless of the nature of sourced materials or the underlying shock.

A.5 Multi-country model

Setting. Consider a world of $N + 1$ countries. N industrial countries produce output with endowments of labor and capital and with imported raw materials; they also export and import final goods. The remaining country (indexed by 0) is endowed with the global stock of raw materials and exports them, lacking industrial capabilities. Each country has an exogenous measure F_i of identical firms engaged in monopolistic competition with a CES demand system, ensuring a constant profit share $\pi = 1/\eta$ (where η is the demand elasticity). Since completely free entry in a static model would eliminate profits, we maintain the assumption of no entry.

Preferences. The representative consumer in country n has CES preferences:

$$U_n \equiv \left[\sum_{i=1}^{N} F_i C_{ni}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \tag{A.16}$$

where C_{ni} is consumption of country-i output 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. The production function has the nested-CES structure from Section 2:

$$y_i = \left(\left(A_i l_i^{\alpha} k_i^{1-\alpha} \right)^{\frac{\sigma-1}{\sigma}} + \left(B_i m_i \right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{A.17}$$

where A_i is primary-augmenting and B_i is materials-augmenting productivity. Standard iceberg trade costs τ_{ni} apply to final goods; materials trade freely at a global price p_m with perfectly inelastic supply $\bar{m}$.

Prices. Define $\tilde{c}_{G,i} \equiv \frac{1}{A_i \alpha} \left(\frac{L_i}{K_i} \right)^{1-\alpha}$, so that $\tilde{c}_{G,i} w_i$ is the unit cost of the primary-input bundle in country i. The delivered price from i to n is

$$p_{ni} = \frac{\eta}{\eta - 1} \tau_{ni} \left(\left(\tilde{c}_{G,i}\, w_i \right)^{1-\sigma} + \left(\frac{p_m}{B_i} \right)^{1-\sigma} \right)^{\frac{1}{1-\sigma}}, \tag{A.18}$$

where $\mu = \eta/(\eta-1)$ is the common markup (so that the profit share is $\pi = 1 - 1/\mu = 1/\eta$).

Materials market clearing.

$$\bar{m} = \frac{(p_m)^{-\sigma}}{\alpha} \sum_i B_i^{\sigma-1} \tilde{c}_{G,i}^{\sigma-1} L_i w_i^{\sigma}. \tag{A.19}$$

The labor share. In country i:

$$\begin{aligned} \lambda_i &= \alpha \times \frac{\left(\tilde{c}_{G,i}\, w_i \right)^{1-\sigma}}{\left(\tilde{c}_{G,i}\, w_i \right)^{1-\sigma} + \left(p_m / B_i \right)^{1-\sigma}} \times \frac{1}{\mu - \frac{\left(p_m / B_i \right)^{1-\sigma}}{\left(\tilde{c}_{G,i}\, w_i \right)^{1-\sigma} + \left(p_m / B_i \right)^{1-\sigma}}} \\ &= \alpha \frac{\left(\tilde{c}_{G,i}\, w_i \right)^{1-\sigma}}{\frac{\eta}{\eta-1} \left(\tilde{c}_{G,i}\, w_i \right)^{1-\sigma} + \frac{1}{\eta-1} \left(p_m / B_i \right)^{1-\sigma}}. \end{aligned} \tag{A.20}$$

When the profit share vanishes ($\pi \to 0$, i.e. $\eta \to \infty$), the labor share becomes

the "neoclassical" share α. In the Cobb–Douglas limit $\sigma \to 1$, the labor share is independent of the price of materials.

Equivalently, in terms of the domestic output price $p_i \equiv \frac{\eta}{\eta-1}\left(\left(\tilde{c}_{G,i}\, w_i\right)^{1-\sigma} + \left(\frac{p_m}{B_i}\right)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$ – the delivered price (A.18) without the trade cost:

$$\lambda_i = \alpha \frac{\eta - 1}{\eta + \left[\left(\frac{\eta}{\eta-1}\frac{p_m}{B_i p_i}\right)^{\sigma-1} - 1\right]^{-1}}. \tag{A.21}$$

Goods market clearing. Industrial-country expenditure on final goods equals value added, not gross revenue, since expenditures on materials are paid to country 0. Therefore

$$\frac{\eta}{\eta-1}\frac{w_i L_i}{\theta_{l,i}} = \sum_{n=1}^{N} S_{ni}\frac{w_n L_n}{\lambda_n} + S_{0i} p_m \bar{m}, \tag{A.22}$$

where $S_{ni} = F_i(p_{ni})^{1-\eta} / \sum_j F_j(p_{nj})^{1-\eta}$, $\theta_{l,i} = \alpha \frac{(\tilde{c}_{G,i}\, w_i)^{1-\sigma}}{(\tilde{c}_{G,i}\, w_i)^{1-\sigma} + (p_m/B_i)^{1-\sigma}}$, and $\lambda_n \equiv w_n L_n / V_n$ so that $V_n = w_n L_n / \lambda_n$ is value added in country n.

Together with (A.20), equations (A.22) and (A.19) yield $N+1$ equations in $N+1$ unknowns $(\{w_i\}_{i=1}^N, p_m)$, characterizing the equilibrium (by Walras' law, one equation is redundant, and prices are determined up to a normalization).

Comparative statics. Setting p_m as numéraire and using (A.19) and (A.20):

$$\bar{m} = \sum_i \frac{A_i}{B_i} L_i^{\alpha} K_i^{1-\alpha} \left(\frac{1}{(\eta-1)\alpha(\lambda_i)^{-1} - \eta}\right)^{\frac{\sigma}{1-\sigma}}. \tag{A.23}$$

The labor share remains constant in all countries if $\bar{m}$ grows at the same rate as the productivity-adjusted composite $A_i B_i^{-1} L_i^{\alpha} K_i^{1-\alpha}$. If $\bar{m}$ declines relative to these endowments, at least one country's labor share must fall.

A.5.1 Proof of Proposition 2

We prove each statement under the maintained assumptions $\eta \in (1, \infty)$ and $\sigma \in (0, 1)$, implying a positive profit share $\pi = 1/\eta \in (0, 1)$ and complementarities between materials and primary inputs with a strictly positive elasticity of substitution.

λ_i is negatively related to the relative price of materials.

From (A.20), dividing numerator and denominator by $(\tilde{c}_{G,i}\, w_i)^{1-\sigma}$:

$$\lambda_i = \frac{\alpha(\eta-1)}{\eta + \left(\frac{p_m}{B_i\, \tilde{c}_{G,i}\, w_i}\right)^{1-\sigma}}.$$

Since $\sigma < 1$, the exponent $1-\sigma > 0$, and the term $(p_m/(B_i\, \tilde{c}_{G,i}\, w_i))^{1-\sigma}$ is strictly increasing in the relative price of materials $p_m/(B_i\, \tilde{c}_{G,i}\, w_i)$. It appears in the denominator with a positive sign, so λ_i is strictly decreasing in $p_m/(B_i\, \tilde{c}_{G,i}\, w_i)$.

To express this in terms of the domestic output price p_i, note from the pricing equation (A.18) that

$$\frac{p_m}{p_i} = \frac{\eta-1}{\eta} \frac{p_m}{((\tilde{c}_{G,i}\, w_i)^{1-\sigma} + (p_m/B_i)^{1-\sigma})^{1/(1-\sigma)}},$$

which is strictly increasing in $p_m/(B_i\, \tilde{c}_{G,i}\, w_i)$ when $\sigma < 1$. Hence λ_i is also negatively related to p_m/p_i. □

A decrease in $\bar{m}$ lowers at least one country's labor share.

Setting p_m as numéraire and substituting the expression for w_i as a function of λ_i (obtained by inverting (A.20)) into the materials market clearing (A.19) yields (A.23):

$$\bar{m} = \sum_i \frac{A_i}{B_i} L_i^{\alpha} K_i^{1-\alpha}\, h(\lambda_i),$$

where

$$h(\lambda) \equiv \left(\frac{1}{(\eta-1)\alpha\lambda^{-1} - \eta}\right)^{\sigma/(1-\sigma)} = \left(\frac{\lambda}{(\eta-1)\alpha - \eta\lambda}\right)^{\sigma/(1-\sigma)}.$$

For any equilibrium labor share $\lambda_i \in (0, \alpha(\eta-1)/\eta)$, the argument of h is strictly positive. Since

$$h'(\lambda) = \frac{\sigma}{1-\sigma} \left(\frac{\lambda}{(\eta-1)\alpha - \eta\lambda}\right)^{\sigma/(1-\sigma)-1} \frac{(\eta-1)\alpha}{((\eta-1)\alpha - \eta\lambda)^2} > 0,$$

h is strictly increasing. The coefficients $c_i \equiv \frac{A_i}{B_i} L_i^{\alpha} K_i^{1-\alpha} > 0$ depend only on exogenous parameters.

If $\bar{m}$ decreases while all (L_i, K_i, A_i, B_i) remain fixed, then $\sum_i c_i h(\lambda_i)$ must decrease in the new equilibrium. Since h is strictly increasing, the labor shares $\{\lambda_i\}$ cannot all

weakly increase; at least one must decline.

The individual responses are in general heterogeneous, as the equilibrium adjustment of wages $\{w_i\}$ depends on country-specific characteristics through the goods market clearing conditions (A.22). □

A small proportional increase in (A_j, B_j) raises λ_j and lowers at least one other λ_i.

Consider a small proportional shock to country j such that

$$d\log A_j = d\log B_j > 0, \qquad d\log A_i = d\log B_i = 0 \text{ for all } i \neq j.$$

This is a Hicks-neutral productivity improvement in country j.

The coefficients in (A.23) *are unchanged.* Recall that

$$c_i \equiv \frac{A_i}{B_i} L_i^{\alpha} K_i^{1-\alpha}.$$

Since the shock is proportional, the ratio A_j/B_j is unchanged, so

$$d\log c_i = 0 \qquad \text{for all } i.$$

There is no direct effect on λ_j holding wages fixed. From (A.20), the labor share in country j depends on the relative price of materials

$$\frac{p_m}{B_j \tilde{c}_{G,j} w_j}.$$

Using the definition of $\tilde{c}_{G,j}$,

$$B_j \tilde{c}_{G,j} = \frac{B_j}{A_j \alpha} \left(\frac{L_j}{K_j}\right)^{1-\alpha},$$

which is unchanged under a proportional shock to (A_j, B_j). Hence, holding w_j fixed, the labor share λ_j is unchanged.

The wage in country j rises locally. A proportional increase in (A_j, B_j) lowers country j's unit cost proportionally and therefore lowers its delivered prices in all markets. For a small Hicks-neutral productivity shock, standard first-order comparative statics in constant-elasticity trade and economic-geography models imply that

this increase in competitiveness raises nominal income, and hence the wage, in the shocked country. Therefore,

$$d \log w_j > 0$$

when wages are measured relative to the materials numéraire.

λ_j rises. Since $d \log(B_j \tilde{c}_{G,j}) = 0$ and $d \log w_j > 0$, the relative price of materials in country j,

$$\frac{p_m}{B_j \tilde{c}_{G,j} w_j},$$

falls. Because (A.20) implies that λ_j is strictly decreasing in this relative price when $\sigma < 1$, it follows that

$$d\lambda_j > 0.$$

At least one other λ_i falls. Using (A.23),

$$\bar{m} = \sum_i c_i h(\lambda_i),$$

where $c_i > 0$ is unchanged by the shock and $h'(\lambda) > 0$. Since $\bar{m}$ is fixed and $c_j h(\lambda_j)$ rises when λ_j rises, it cannot be that all other $h(\lambda_i)$ weakly rise as well. Therefore at least one country $i \neq j$ must satisfy

$$d\lambda_i < 0.$$

This proves the claim locally. □

B Data

B.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 (Bureau of Economic Analysis, 2026a) (henceforth NIPA). We divide aggregate compensation (NIPA series A033RC) by the sum of compensation, rental income (A048RC), corporate profits (A051RC), net interest (W255RC), and 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 (Federal Reserve Bank of St. Louis, 2026), series PRS85006173.

Aggregate relative price of materials. Figure 1 plots two relative price series: the ratio of the PPI for unprocessed goods for intermediate demand (FRED series WPSID62) to the PCE price index for goods (FRED series DGDSRG3M086SBEA), and the ratio of the PPI for processed goods for intermediate demand (FRED series WPSID61) to the same PCE deflator.

Sector-level outcomes. We rely on data from the BEA Integrated Industry-Level Production Account – the U.S. official KLEMS (capital, labor, energy, materials and service) accounts (Bureau of Economic Analysis, 2023). 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 expenditure on intermediates. Additional measures of sector-level labor share are obtained from the BEA income accounts (Bureau of Economic Analysis, 2019a), dividing industry-level compensation (Table 6.2) by industry-level national income without capital consumption adjustment (Table 6.1).

B.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. 2021a). 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 1958–2018. We use the NAICS version of the dataset with 364 6-digit 2012 NAICS industries, of which 361 have the commodity exposure data needed for the shift-share instrumental variable in the 1991–2016 sample.

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.[46] 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 B.1 shows these discrepancies over time.

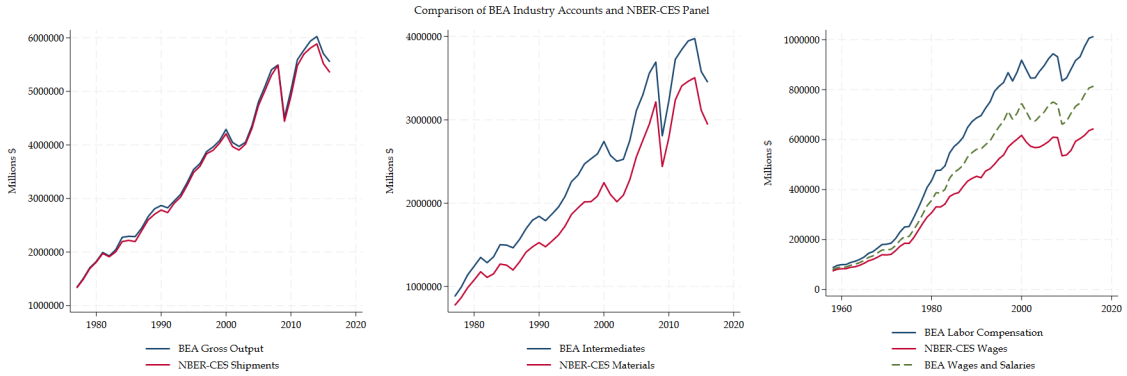
Exposure to Global Commodity Prices. We instrument the industry-level price index of material from the NBER-CES panel using industry exposure to global commodity prices. We follow Fally and Sayre (2022) in defining a list of commodities[47] that correspond to a significant share of the total global commodity trade.

We construct commodity-level price proxies from UN COMTRADE (United Nations, 2026) as FOB trade unit values at the HS6-year level. Following standard practice in the literature (e.g. Berthou and Emlinger 2011), we clean the raw series to address reporting-unit changes and obvious outliers rather than smooth genuine

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

[47] See https://fally.are.berkeley.edu/Data/Commodities/commodity_names.xlsx.

Figure B.1: Comparison of BEA and NBER-CES



Note: This figure compares key aggregates for the manufacturing sector between the BEA industry accounts and the NBER-CES manufacturing panel. 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.

price movements. We drop observations with missing or nonpositive quantities or trade values, remove very small flows, correct a set of known quantity-scale breaks, impose unit consistency for non-energy codes relative to their 1997 reporting unit, and screen out extreme year-to-year jumps in unit values for non-energy codes.

A very small number of series receive additional treatment. For crude oil and natural gas, we use kilogram-based net weights when available rather than reported quantities. For LNG (HS 271111) and gaseous natural gas (HS 271121), whose reporting units shift sharply over time, we replace the raw annual price path with official EIA import price series (U.S. Energy Information Administration, 2026), using the external data only for within-code time variation since each code is later normalized to its own 1997 level. Finally, for 11 residual problematic HS6 codes out of 4,281 codes surviving the standard filters, we keep the observed series through 1999 and, from 2000 onward, use median year-to-year growth from the CEPII Trade Unit Values Database, which starts in 2000, anchoring the resulting path to the observed 1999 level. Four of these residual series are subsequently dropped because, even after these corrections, they still imply implausibly large price increases in at least one observation.[48]

[48]The four dropped products are sugar beet (HS 121291), tin ores and concentrates (HS 260900), alloy pig iron (HS 720130), and cement copper (HS 740120). These series are quantitatively negligible as they account for less than 0.003% of global HS6 trade value in any 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 (Bureau of Economic Analysis, 2003a).[49] We first assign each commodity to the I-O industry that produces it, using the concordance provided by the BEA (Bureau of Economic Analysis, 2003b).[50] 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.

B.3 Regional Data

We obtain county-level manufacturing GDP and baseline county economic characteristics from the BEA regional economic accounts (Bureau of Economic Analysis, 2022). We obtain county-level manufacturing labor compensation from the BLS Quarterly Census of Employment and Wages (QCEW; Bureau of Labor Statistics, 2026). We aggregate counties to U.S. 1990 commuting zones following Dorn (2009).

B.4 International Data

EU KLEMS and World KLEMS. The cross-country analysis in Section 5 draws on two sources of industry-level data on gross output, intermediate inputs, value added, labor compensation, employment, and the corresponding price indices. The primary source is the 2025 release of EU-KLEMS (Bontadini, Corrado, Haskel, Iommi, and Jona-Lasinio, 2025), run by the Vienna Institute for International Economic Studies, which covers all European Union member states, Japan, and the U.S. over 1995–2019 at the NACE Rev. 2 classification level; we supplement it with the 2020 vintage (Vienna Institute for International Economic Studies, 2019) to fill gaps in price indices. The second source is the World KLEMS project (World KLEMS, 2015), from which we take industry-level data for Canada (2012 release, 1995–2008) and South Korea (2015 release, 1995–2012). See Appendix F for the harmonization of the two sources and the construction of the estimation sample.

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

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

B.5 Natural Disaster Data

We obtain records of natural disasters from EM-DAT, the International Disaster Database maintained by the Centre for Research on the Epidemiology of Disasters (CRED; Delforge, Wathelet, Below, Lanfredi Sofia, Tonnelier, van Loenhout, and Speybroek, 2024).[51] The database records the type, location, date, and human impact of disaster events worldwide. We retain events classified as natural disasters, excluding epidemics, infestations, and animal incidents, and use the country of occurrence, the start year, and the total death toll. Events with no reported fatalities are treated as zero-death events. We restrict attention to 1991–2016, so that the within-country severity threshold used in Appendix D to define a "large" disaster is computed only over events in the estimation window.

B.6 Bilateral Trade Data

We identify the major world suppliers of each traded product using BACI (Gaulier and Zignago, 2010), the CEPII database of harmonized bilateral trade flows.[52] We take the 1997 cross-section and aggregate bilateral export values from the HS6 to the HS4 level.

B.7 Summary of Data Sources and Samples

Table B.1 summarizes the data sources, materials price measures, and time periods used across the main empirical exercises in the paper.[53]

[51] We use version 2.0 of the official EM-DAT archive, released on 30 April 2026: https://doi.org/10.14428/DVN/IOLTPH.

[52] https://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=37. We use the HS92 release

[53] The construction additionally uses the BEA GDP-by-Industry accounts (Bureau of Economic Analysis, 2019b) and their SIC-basis historical counterpart (Bureau of Economic Analysis, 2010), the BEA NAICS-2012 to input-output concordance (Bureau of Economic Analysis, 2026b), the Census Bureau NAICS concordances and industry titles (U.S. Census Bureau, 2026b).

Table B.1: Summary of Data Sources Across Empirical Exercises

Exercise	Data source	Materials price measure	Period
Aggregate trends (Fig. 1)	NIPA, BLS	PPI (unproc. & proc.)	1970–2023
Sectoral evidence (Fig. 3)	BEA-KLEMS	Törnqvist of KLEMS prices (materials + energy)	1987–2019
Manufacturing trends (Fig. 4)	BEA-KLEMS	Törnqvist of KLEMS prices (materials + energy)	1987–2019
Baseline IV (Table 1, Figs. 5–6)	NBER-CES	Industry materials price index (materials + energy)	1991–2016
Local labor markets (Table 2)	BEA Regional, QCEW	Weighted industry prices	2001–2016
1970s oil shock (Table 3)	NBER-CES	Industry materials price index (materials + energy)	1970–1980
Counterfactual (Fig. 7)	BEA-KLEMS	Törnqvist of KLEMS prices (materials + energy)	1987–2019
Quantitative model (Sec. 4)	BEA GDP-by-Industry, NIPA, Fixed Assets	Intermediate inputs price index	1998–2019
Cross-country (Sec. 5)	EU-KLEMS 2025, World KLEMS	Intermediate inputs price index	1995–2019
Disaster IV (Tables D.2–D.3)	NBER-CES, EM-DAT, BACI	Industry materials price index (materials + energy)	1991–2016

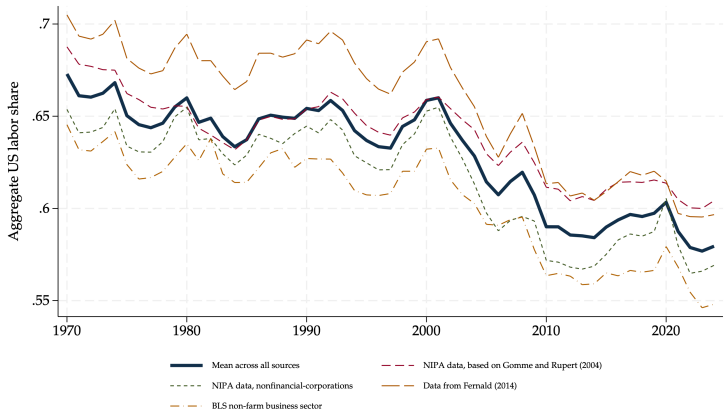
Note: This table summarizes the main data sources and materials price measures used across the empirical exercises in the paper. The NBER-CES industry materials price index (`pimat`) covers the full materials bundle inclusive of energy. KLEMS price indexes aggregate materials and energy prices using Törnqvist (expenditure-share) weights. See the text of this appendix for additional details on each data source.

C Additional Empirical Results

This appendix collects supplementary figures and tables referenced in the main text. We first present additional descriptive evidence on aggregate and sectoral trends, then report robustness checks for our baseline regression results.

C.1 Descriptive Evidence

Figure C.1: U.S. Aggregate Labor Share



Note: 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 of Labor Statistics (BLS) for non-farm business-sector labor share, constructed from NIPA data.

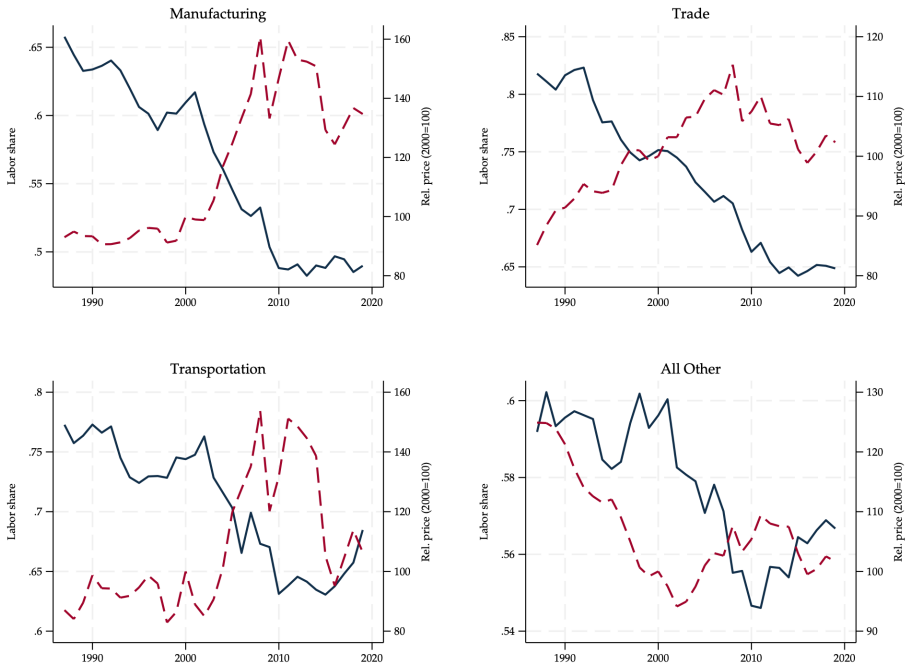
C.2 Dynamic Evidence

To investigate the timing and persistence of the effect, we estimate a non-parametric event-study specification that does not rely on variation in prices, and instead leverages only cross-industry heterogeneity in ex-ante commodity intensity:

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

where θ_{j1997}^{comm} is the commodity cost share of industry j in the 1997 Input-Output Table defined in Equation 15. The coefficients β_ℓ flexibly estimate the effect of baseline industry commodity intensity on the outcome of interest in each year, setting 1997 as the omitted year.

Figure C.2: Labor Share and Relative Price of Materials Across U.S. Sectors



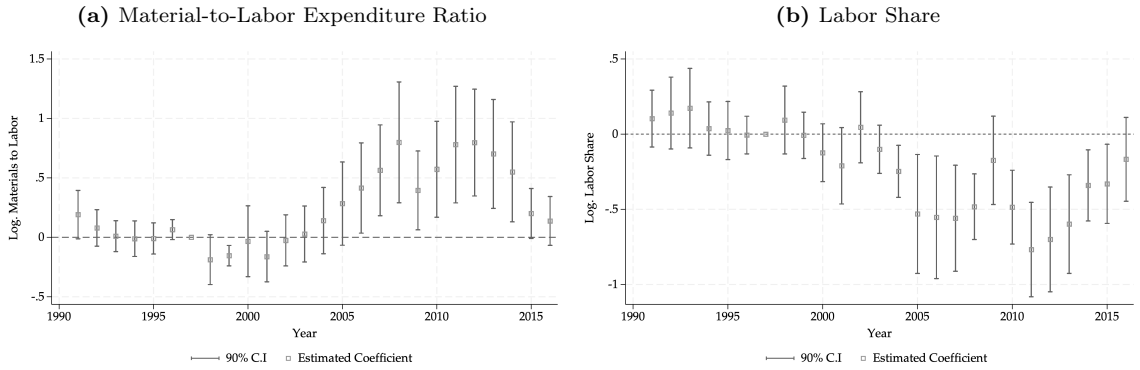
Solid (left axis): Labor share. Dashed (right axis): Relative price of M+E to VA (2000=100).

Note: Each panel plots the labor share (solid line, left axis) and the relative price of materials and energy inputs to value added (dashed line, right axis) for a broad sector of the U.S. economy between 1987 and 2019. Data are from BEA's Integrated Industry-Level Production Account (KLEMS). Manufacturing includes all 19 NAICS manufacturing subsectors. Trade includes wholesale and retail trade. Transportation includes air, rail, water, truck, transit, pipeline, other transportation, and warehousing. All Other includes mining, construction, information, finance, real estate, professional and business services, education, health care, arts, accommodation, food services, and other services (excluding government, agriculture, and utilities). Both the materials-and-energy and value added price indexes are Törnqvist chain-type indexes, aggregated across industries within each sector using time-varying nominal expenditure shares as weights. Each industry's implicit price is computed as nominal compensation divided by the corresponding quantity index. The relative price series are normalized to 100 in 2000. The labor share is computed as total labor compensation (college and non-college) divided by nominal value added within each sector.

Figure C.3a shows results 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. 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. Figure C.3b shows the corresponding results for the log labor share. Industries with higher ex-ante commodity intensity experienced a larger relative decline in their labor share, with the trend coinciding with the timing

of the commodity boom. The decline was briefly overturned in 2009 during the Great Recession.

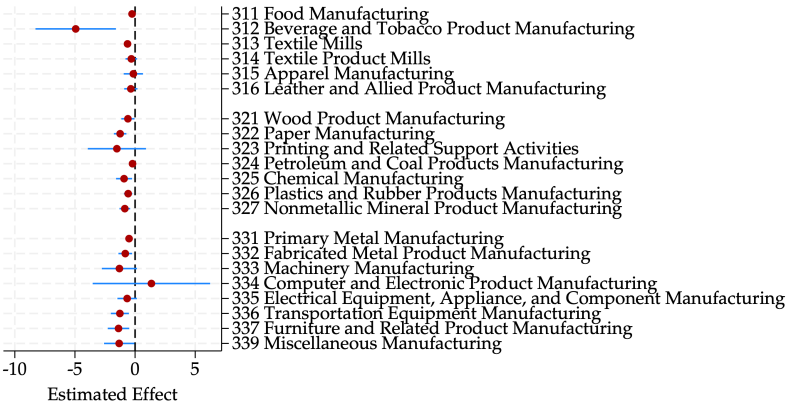
Figure C.3: The Effect of Commodity Intensity on Materials-to-Labor Expenditure Ratio and on the Labor Share



Note: Panel (a) plots the set of coefficients β_ℓ from the estimation of Equation C.1, 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 C.1, when the outcome variable is industry-level log labor share. The gray lines capture a 90% confidence interval.

C.3 Additional Figures

Figure C.4: Effect of Material Prices on the Labor Share by 3-digit NAICS Sectors



Note: 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 16.

C.4 Descriptive Tables

Table C.1 lists the individual commodities with the largest price increases between 2000 and 2010. Table C.2 reports the manufacturing industries most exposed to these price changes, along with the corresponding change in the labor share and baseline commodity intensity.

Table C.1: Commodities with Largest Price Increases

HS96	Commodity	% Δ Price (00'–10')
180200	Cocoa shells, husks, skins and other cocoa	2333.1
260300	Copper ores and concentrates	1889.9
520644	Combed cabled cotton yarn, with <85%	1072.8
741022	Foil, copper alloy, backed	867.1
740312	Wire bars, copper, unwrought	612.1
260111	Non-agglomerated iron ores and concentrates	598.2
740500	Master alloys of copper	491.5
120720	Cotton seeds	457.3
721129	Flat rolled prod, i/nas, hr, <600mm wide	439.8
721190	Flat rolled prod, i/nas, <600mm wide, not	426.8

C.5 Robustness and Extensions

The following tables present robustness checks for the baseline regression results reported in Section 3. Table C.3 examines the effect of materials prices on other industry-level outcomes. Table C.4 reports an augmented reduced form that includes both the non-interacted log materials price and its interaction with baseline materials intensity. Table C.5 reports auxiliary empirical moments used for structural identification in Section 3.10. Table C.6 adds 3-digit NAICS × year fixed effects. Table C.7 aggregates to the BEA subsector level. Tables C.8 and C.9 consider alternative instrument constructions. Table C.10 controls for industry concentration. Table C.11 decomposes the instrument into energy and non-energy components.

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

Rank	NAICS Code	Description	% Δ Commodity Price (00'–10')	Δ Labor Share (00'–10')	Commodity Intensity (00')
1	331410	Nonferrous Metal (except Aluminum)	96.3	-0.189	0.660
2	331420	Copper Rolling, Drawing, Extruding, and	93.4	-0.061	0.524
3	324110	Petroleum Refineries	87.5	-0.031	0.641
4	311224	Soybean and Other Oilseed Processing	59.1	-0.105	0.695
5	331491	Nonferrous Metal (except Copper and	50.0	-0.126	0.493
6	331210	Iron and Steel Pipe and Tube	44.2	-0.019	0.512
7	325314	Fertilizer (Mixing Only) Manufacturing	43.3	-0.110	0.323
8	331222	Steel Wire Drawing	38.4	-0.051	0.476
9	331221	Rolled Steel Shape Manufacturing	37.7	-0.112	0.474
10	332114	Custom Roll Forming	32.9	-0.044	0.441
11	331110	Iron and Steel Mills and Ferroalloy	32.0	-0.159	0.315
12	325311	Nitrogenous Fertilizer Manufacturing	30.4	-0.211	0.274
13	325312	Phosphatic Fertilizer Manufacturing	29.8	-0.155	0.326
14	311211	Flour Milling	29.4	-0.057	0.511
15	332112	Nonferrous Forging	29.2	-0.032	0.375

Note: Commodity price change is the percentage change in the shift-share commodity price index (Equation 16) between 2000 and 2010. Commodity intensity is total expenditure on commodities as a share of total costs in 2000 (Equation 15).

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

	(1) Log M/V	(2) Log V/R	(3) Log M/W	(4) Log M/K	(5) Log K/V	(6) Log K/L
Materials Intensity × Log. Materials Price	0.0963**	-0.0696***	0.216***	0.223***	-0.126***	-0.00224
	(0.0407)	(0.0183)	(0.0596)	(0.0598)	(0.0238)	(0.00382)
First-stage F-stat (KP-Wald)	12.82	12.82	12.82	12.82	12.82	12.82
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

Note: 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 C.4: The Effect of Material Prices on the Labor Share – Augmented Reduced Form

	Log Industry Labor Share						
	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS
Materials Intensity × Log. Materials Price	-0.119***	-0.119***	-0.278***	-0.275***	-0.202***	-0.211***	-0.185***
	(0.0281)	(0.0279)	(0.0764)	(0.0743)	(0.0360)	(0.0377)	(0.0569)
Log. Materials Price	-0.0494	-0.0640	0.189	0.156	0.122*	0.149	0.350*
	(0.0663)	(0.0657)	(0.115)	(0.105)	(0.0695)	(0.0922)	(0.197)
First-stage F-stat (KP-Wald)			15.23	16.64	28.60	30.30	19.70
N	9386	9386	9386	9386	9386	9386	9386
Industry and Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weighted	No	No	No	No	Yes	Yes	Yes
Industry-Specific Trends	No	No	No	No	No	No	Yes

Note: This table reports regressions of the industry-level log labor share on two terms: the non-interacted log materials price and its interaction with baseline materials intensity. 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 include industry and year fixed effects. Columns (1) and (2) report OLS results. Columns (3) to (7) instrument the interaction term with the shift-share commodity price instrument defined in Equation 16. Columns (5) to (7) are weighted by industry value added in 1990. Columns (2), (4), (6), and (7) control for the log of the average wage and the log of the investment price. Columns (6) and (7) additionally control for import penetration overall and from China. Column (7) further adds industry-specific linear time trends. We do not add controls such as $\log(K/L)$ or the production-worker share in this exercise, since those variables may mediate the independent effect of the non-interacted materials-price term. Standard errors clustered at the industry level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table C.5: The Effect of Material Prices on the Materials Intensity and the Value-Added Share

	(1) Log M/V	(2) Log M/V	(3) Log V/R	(4) Log V/R
Log. Materials Price	0.498***	0.529***	-0.397***	-0.382***
	(0.159)	(0.150)	(0.121)	(0.0491)
First-stage F-stat (KP-Wald)	29.76	72.54	29.76	72.54
N	9386	9386	9386	9386
Industry controls (see notes)	Yes	Yes	Yes	Yes
Industry and Year FE	Yes	Yes	Yes	Yes
Weighted	Yes	Yes	Yes	Yes

Note: This table reports results from the regression of additional industry outcomes on the log of the price index of materials, instrumented with the shift-share IV defined in Equation 16. Columns (1) and (2) use $\log(M/V)$ as the dependent variable, where M is materials expenditure and V is value added. Columns (3) and (4) use $\log(V/R)$, where R is gross output. Observations correspond to industry-year pairs for the 361 NAICS industries in the NBER-CES dataset between 1991 and 2016. All specifications control for industry and year fixed effects, the log of the average wage, the log of the price of investment, the share of production workers, the log of the capital-labor ratio, and import penetration overall and from China. All regressions are weighted by industry value added in 1990. Columns (2) and (4) additionally include industry-specific linear time trends. Standard errors clustered at the industry level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table C.6: The Effect of Material Prices on the Labor Share – Three Digits NAICS – Year Fixed Effects

	Log Industry Labor Share				
	(1)	(2)	(3)	(4)	(5)
	OLS	2SLS	2SLS	2SLS	2SLS
Materials Intensity × Log. Materials Price	-0.135***	-0.220***	-0.201***	-0.217***	-0.218***
	(0.0278)	(0.0562)	(0.0563)	(0.0572)	(0.0571)
First-stage F-stat (KP-Wald)		33.92	46.92	46.41	45.96
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

Note: 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 C.7: The Effect of Material Prices on the Labor Share – BEA Subsectors

	Log Industry Labor Share						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
Materials Intensity × Log. Materials Price	-0.0949***	-0.104***	-0.0908***	-0.0943***	-0.0942***	-0.0943***	-0.101***
	(0.00733)	(0.0138)	(0.0143)	(0.0127)	(0.0128)	(0.0130)	(0.0162)
Sourced Services Share						-0.134	-0.135
						(0.254)	(0.263)
Log. Services Price Index							0.427
							(0.685)
First-stage F-stat (KP-Wald)		79.96	60.03	64.40	61.64	62.11	54.36
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

Note: 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 C.8: The Effect of Material Prices on the Labor Share – Leontief Inverse

	Log Industry Labor Share				
	(1)	(2)	(3)	(4)	(5)
	OLS	2SLS	2SLS	2SLS	2SLS
Materials Intensity × Log. Materials Price	-0.135***	-0.228***	-0.197***	-0.189***	-0.188***
	(0.0219)	(0.0486)	(0.0344)	(0.0279)	(0.0278)
First-stage F-stat (KP-Wald)		37.89	22.53	21.60	21.51
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

Note: 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 3.11. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table C.9: The Effect of Material Prices Using Only Variation in Prices

	Log Industry Labor Share				
	(1)	(2)	(3)	(4)	(5)
	OLS	2SLS	2SLS	2SLS	2SLS
Materials Intensity × Log. Materials Price	-0.135***	-0.298***	-0.192***	-0.156***	-0.156***
	(0.0219)	(0.0598)	(0.0456)	(0.0317)	(0.0313)
First-stage F-stat (KP-Wald)		21.62	3.554	3.262	3.261
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

Note: 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 3.11. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table C.10: Controlling for Industry Concentration

	Log Industry Labor Share					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	2SLS	2SLS	OLS	2SLS	2SLS
Materials Intensity × Log. Materials Price	-0.187***	-0.261***	-0.260***	-0.174***	-0.248***	-0.247***
	(0.0237)	(0.0288)	(0.0270)	(0.0221)	(0.0291)	(0.0264)
Fraction of Sales Top-4				-0.577**	-0.469*	-0.376
				(0.234)	(0.239)	(0.234)
Log. HHI-50				-0.0140	-0.0251	-0.0372
				(0.0394)	(0.0391)	(0.0373)
First-stage F-stat (KP-Wald)		48.35	46.69		49.72	47.37
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
Weighted	Yes	Yes	Yes	Yes	Yes	Yes

Note: 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 1990 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.

Table C.11: The Effect of Material Prices on the Labor Share – Energy vs. Non-energy Instruments

	Energy IV				Non-energy IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
Materials Intensity × Log. Materials Price	-0.162***	-0.171***	-0.174***	-0.101***	-0.266**	-0.334**	-0.317*	-0.371*
	(0.00867)	(0.0123)	(0.0105)	(0.00561)	(0.104)	(0.153)	(0.164)	(0.193)
Log. Average Wage		0.0516	0.0203	0.00212		0.124	0.0952	0.0814
		(0.149)	(0.135)	(0.111)		(0.178)	(0.181)	(0.178)
Log. Investment Price		0.271	0.513**	0.473		0.667	0.791**	0.576
		(0.168)	(0.211)	(0.458)		(0.443)	(0.400)	(0.532)
Production Workers Share			-0.636**	-0.478			-0.701**	-0.531
			(0.268)	(0.303)			(0.293)	(0.334)
Log. Capital-Labor Ratio			0.0633	-0.0113			0.0345	-0.0657
			(0.0398)	(0.0424)			(0.0576)	(0.0939)
Import Penetration			0.0223	-0.0226			0.0241	-0.00957
			(0.0505)	(0.0470)			(0.0484)	(0.0529)
Import Penetration - China			0.180	0.408*			0.109	0.374
			(0.136)	(0.243)			(0.142)	(0.279)
First-stage F-stat (KP-Wald)	8466.6	4158.7	4878.0	17756.8	9.661	6.199	4.363	4.161
N	9386	9386	9386	9386	9386	9386	9386	9386
Industry and Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weighted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-Specific Trends	No	No	No	Yes	No	No	No	Yes

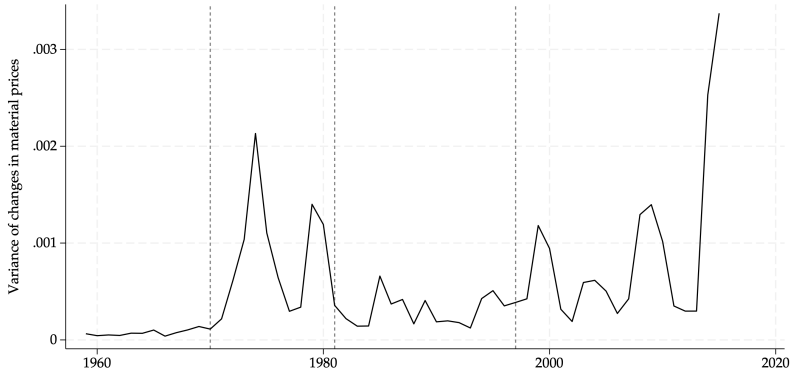
Note: All specifications include industry and year fixed effects and are weighted by value added in 1990. Standard errors clustered at the industry level are in parentheses. Columns (1)–(4) instrument with the energy component of the shift-share IV; columns (5)–(8) instrument with the non-energy component. Columns (4) and (8) further include industry-specific linear time trends. * p<0.1, ** p<0.05, *** p<0.01.

C.6 Analysis of Periods with no Variation in Prices

In the main text, we exploit the 2000s commodity boom and the 1970s oil shocks as sources of exogenous variation. In other periods, our ability to test the mechanism is constrained by limited cross-industry variation in materials prices. Appendix Figure C.5 shows the variance of materials price growth across manufacturing industries: it is negligible before the 1970s (possibly due to Bretton Woods exchange-rate stability or measurement issues) and modest in the 1980s and early 1990s.

Appendix Table C.12 replicates the OLS version of our baseline specification – the same controls as Column (7) of Table 1 – across four sub-periods. The coefficient on materials prices is negative in all periods: it is statistically significant in 1970–1980 and 1997–2016, marginally significant in 1958–1970, and small and imprecise in 1980–1997, where price variation is limited. The coefficients are smaller in magnitude in the earlier periods relative to the most recent period, consistent with both lower cross-industry price variation and lower profit rates in earlier decades (which, per Proposition 1, attenuate the transmission of materials prices to the labor share). The coefficient on the materials-to-labor expenditure ratio is positive and highly significant in all periods, confirming complementarity between materials and primary inputs across episodes. In all cases, the estimated relationship provides correlational evidence only.

Figure C.5: Dispersion in the Growth of Residual Materials Prices



Note: 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.12: The Effect of Material Prices – Different Periods

	Log. Labor Share				Log. Materials to Wage-Bill			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1958-1970	1970-1980	1980-1997	1997-2016	1958-1970	1970-1980	1980-1997	1997-2016
Materials Intensity × Log. Materials Price	-0.0552*	-0.0786***	-0.0125	-0.156***	0.157***	0.110***	0.136***	0.171***
	(0.0320)	(0.0274)	(0.0101)	(0.0229)	(0.0374)	(0.0335)	(0.00798)	(0.0301)
N	4693	3971	6498	7280	4693	3971	6498	7280
Industry and Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table reports OLS results from the regression of industry-level outcomes on materials intensity (materials expenditure over value added at the beginning of the period) interacted with the log materials price index, controlling for the log average wage, the log price of investment goods, the production-worker share, and the log capital-labor ratio (the same controls as Column 7 of Table 1). Import penetration controls are omitted because they are unavailable before 1991. Columns (1)–(4) report results for the log 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 NAICS industries in the NBER-CES dataset (361 industries in the first three periods and 364 in 1997–2016). 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 Alternative Instrument: Natural Disaster Shocks

In this appendix, we develop an alternative instrumental variable for changes in industry materials prices that exploits supply disruptions caused by natural disasters around the world. Intuitively, an industry is highly exposed to disasters in some period t if it heavily relies on inputs that tend to be exported by countries that experience disasters in that period. We describe the construction of this instrument and present results below.

D.1 Construction of the Disaster Instrument

The construction of the disaster-based instrument proceeds in four steps.

Step 1: Natural disaster data. We obtain data on natural disasters from EM-DAT, the International Disaster Database maintained by the Centre for Research on the Epidemiology of Disasters (CRED). The database provides comprehensive records of disasters worldwide, including information on the type of event (earthquake, flood, storm, extreme temperature, volcanic activity, wildfire, etc.), location, date, and human impact. We focus on natural disasters between 1991 and 2016, excluding epidemics, infestations, and animal incidents. For each country, we define a "large" disaster as one with a death toll at or above the 90th percentile of that country's distribution of positive-death disaster events. This country-specific threshold accounts for the fact that disaster severity varies substantially across countries due to differences in exposure, infrastructure, and population density. We then construct a dummy variable D_{kt} that equals one if country k experienced a large disaster in year t, $t-1$ or $t-2$, reflecting the potentially persistent effects of disasters on production and exports. This yields 201 countries with at least one qualifying disaster event during our sample period.

Step 2: Identifying products exposed to disasters. For each country that experiences large disasters, we use bilateral trade data from BACI (HS92 classification, 1997) to identify the products in which that country plays a central role in global trade. Specifically, we flag a product h as exposed to disasters in country k if two conditions are met: (i) country k accounts for at least 5% of global exports in product h, and (ii) product h constitutes at least 5% of country k's total exports.

The first condition ensures that the country is a sufficiently important supplier so that disruptions to its production capacity could plausibly affect world supply of that product. The second condition ensures that the product is economically important to the country, so that a major disaster is likely to disrupt its production. Across all disaster-affected countries, this yields 120 exposed country-product links spanning 75 products across 78 countries.

Step 3: Defining product-level disaster shocks. For each HS4 product h and year t, we define a product-level shock S_{ht} as the share of 1997 world exports of product h accounted for by major exporters that experienced a large disaster in year t, $t-1$ or $t-2$,

$$S_{ht} = \sum_{k} g_{kh}\, D_{kt},$$

where g_{kh} is country k's share of world exports of product h in 1997 and the sum runs over the major exporters of h identified in Step 2. The shock therefore lies between zero and one and measures how much of world supply of the product is disrupted.

Step 4: Constructing industry-level exposure to disasters. Finally, we construct each industry's exposure to the product-level disaster shocks defined in Step 3. For each NAICS industry j, we map each HS4 product to the input-output commodity it belongs to, using the BEA concordance between HS 1996 codes and IO commodities and then use the input-output shares from the 1997 BEA IO table to compute how much each upstream commodity matters for each downstream using industry. Industry j's disaster instrument in year t is then the exposure-weighted sum of the product-level shocks S_{ht}, where the weights reflect the importance of each product as an input to industry j. The resulting instrument is

$$Z_{jt}^{dis} = \sum_{c} \sum_{h \in c} \alpha_{cj} w_{hc} S_{ht}, \tag{D.1}$$

where α_{cj} is the input-output share of commodity c in industry j's input bundle, and w_{hc} is the share of commodity c's 1997 US import value accounted for by HS product h. An industry that relies heavily on inputs whose major exporters experienced disasters will thus have a higher value of Z_{jt}^{dis}. This structure is analogous to the baseline instrument in Equation 16, and uses the same input-output weights α_{cj} and

the same trade weights w_{hc}, but replaces the variation in commodity prices with variation in the share of world supply disrupted by natural disasters.

Table D.1: Examples of Major Disasters and Associated Export Products

Country	Disaster Example	Deaths	Major Export Product (HS4)	Global Share (%)	Export Share (%)
Indonesia	2004 Tsunami	165,708	Plywood (4412)	40.6	6.3
			Petroleum gases (2711)	8.6	9.0
Bangladesh	1991 Tropical cyclone	138,866	Men's shirts (6205)	7.7	12.9
Myanmar	2008 Tropical cyclone	138,366	Leguminous vegetables (0713)	6.6	17.5
Pakistan	2005 Earthquake	73,338	Cotton yarn (5205)	17.5	18.9
			Bed linen (6302)	8.9	8.0
			Leather apparel (4203)	6.8	5.5
			Cotton fabrics (5209)	5.0	5.2
Russia	2010 Heat wave	55,736	Petroleum gases (2711)	23.8	17.1
			Crude petroleum (2709)	7.4	20.7
			Refined petroleum (2710)	6.7	7.7
Sri Lanka	2004 Tsunami	35,399	Tea (0902)	11.9	7.7
Venezuela	1999 Flash flood	30,000	Refined petroleum (2710)	5.2	21.0
			Crude petroleum (2709)	5.0	49.6
Iran	2003 Earthquake	26,796	Crude petroleum (2709)	5.5	76.0
India	2001 Earthquake	20,005	Diamonds (7102)	10.6	10.2
Japan	2011 Tsunami	19,846	Motor vehicles (8703)	20.1	11.8
			Integrated circuits (8542)	16.4	6.0
France	2003 Heat wave	19,490	Aircraft (8802)	28.0	5.5
			Motor vehicles (8703)	7.3	6.7
Spain	2003 Heat wave	15,090	Motor vehicles (8703)	5.5	13.8
Germany	2003 Heat wave	9,355	Motor vehicles (8703)	19.8	10.5
Nepal	2015 Earthquake	8,831	Carpets (5701)	8.3	36.6
Philippines	2013 Tropical cyclone	7,354	Integrated circuits (8542)	5.5	27.6
Vietnam	1997 Tropical cyclone	3,682	Rice (1006)	7.8	6.3
			Textile footwear (6404)	6.7	5.1
Portugal	2003 Heat wave	2,696	Leather footwear (6403)	5.8	7.0
Algeria	2003 Earthquake	2,266	Petroleum gases (2711)	9.3	39.7
Guatemala	2005 Tropical cyclone	1,513	Coffee (0901)	5.1	22.5
Colombia	1999 Earthquake	1,186	Coffee (0901)	14.2	18.4
			Bananas (0803)	11.1	5.9

Note: This table shows the 20 deadliest qualifying natural disasters (from EM-DAT, 1991–2016, excluding epidemics, infestations, and animal incidents) among countries used in the construction of the disaster instrumental variable, showing one disaster per country (the deadliest). For each country, the table lists the products for which it is a major global exporter. A disaster qualifies as "large" if its death toll is at or above the 90th percentile of the country's positive-death disaster distribution. The instrument is activated in the disaster year and the two following years. Products listed are those for which the country has a global export share $\geq 5\%$ and a product share of country exports $\geq 5\%$ (BACI HS92, 1997). The full set of 201 countries with qualifying disasters is available in the replication materials.

Table D.1 provides illustrative examples of the types of variation exploited by this instrument. The table lists selected countries alongside their major export products and examples of qualifying disaster events. As can be seen, the instrument leverages a wide variety of disaster types - earthquakes, tsunamis, tropical cyclones, floods, and heat waves - across diverse geographies and commodity categories, ranging from primary commodities (crude and refined petroleum, petroleum gases) to agricultural

Table D.2: The Effect of Material Prices on the Labor Share – Disaster IV

	Log Industry Labor Share							
	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS	(8) 2SLS
Mat. Int. × Log Mat. Price	-0.132***	-0.135***	-0.194**	-0.215**	-0.190***	-0.216***	-0.219***	-0.212***
	(0.0212)	(0.0219)	(0.0860)	(0.107)	(0.0365)	(0.0590)	(0.0613)	(0.0561)
Log. Average Wage		-0.0335		-0.0172		0.0716	0.0377	0.0403
		(0.0742)		(0.0790)		(0.151)	(0.148)	(0.140)
Log. Investment Price		0.0421		0.199		0.380	0.550**	0.587**
		(0.115)		(0.234)		(0.255)	(0.259)	(0.273)
Log. Capital-Labor Ratio							0.0703*	0.0556
							(0.0404)	(0.0407)
Production Workers Share							-0.648**	-0.654**
							(0.264)	(0.272)
Import Penetration								0.0228
								(0.0498)
Import Penetration - China								0.161
								(0.126)
First-stage F-stat (KP-Wald)			8.84	5.86	26.93	13.92	13.86	12.71
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

Note: This table replicates Table 1 using the disaster-based instrumental variable defined in Equation D.1 in place of the commodity price instrument defined in Equation 16. The dependent variable is the industry-level log labor share. 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. Columns (1) and (2) report OLS results. Columns (3) to (8) instrument the materials price regressor with the disaster instrument. Columns (5) to (8) are weighted by the value added of the industry in 1990. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

products (coffee, tea, rice, bananas) and manufactures (motor vehicles, integrated circuits, textiles and footwear).

D.2 Results

We use the disaster instrument Z_{jt}^{dis} to instrument for the interaction of materials intensity and the log materials price index, following the same regression specification as in our baseline analysis. Table D.2 replicates Table 1 using this alternative instrument. The structure of the table is identical to the baseline: Columns (1) and (2) report OLS results, Columns (3) and (4) report unweighted 2SLS results, and Columns (5) to (8) report weighted 2SLS results with progressively richer controls.

The OLS results in Columns (1) and (2) are mechanically identical to Table 1, as they do not depend on the choice of instrument. The 2SLS estimates using the disaster instrument are negative and statistically significant across all specifications, with point estimates ranging from -0.19 to -0.22. These estimates are broadly con-

sistent with the baseline results in Table 1, where the corresponding 2SLS coefficients (Columns 3 to 8) range from −0.18 to −0.23. In the preferred weighted specification with the full set of controls (Column 8), the disaster IV estimate is −0.212 (s.e. = 0.056), compared to −0.190 (s.e. = 0.028) in the corresponding column of Table 1. The larger standard errors are expected given that the disaster instrument leverages a coarser source of variation than the continuous commodity price instrument.

The first-stage Kleibergen-Paap Wald F-statistics range from 5.9 to 26.9 across specifications. In the weighted specifications that constitute our preferred estimates (Columns 5 to 8) they lie between 12.7 and 26.9, above conventional thresholds for weak instruments. Table D.3 reports the first-stage results. The disaster instrument enters positively and significantly in all specifications: a disruption to major exporters of a commodity used as an input by industry j is associated with higher materials prices in that industry, consistent with a supply disruption channel.

Table D.3: First Stage – Disaster IV

	Materials Intensity × Log. Materials Price					
	(1) 2SLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS
Disaster IV	5.987***	4.823**	11.16***	9.528***	9.475***	9.341***
	(2.014)	(1.993)	(2.151)	(2.554)	(2.545)	(2.620)
F-stat (KP-Wald)	8.84	5.86	26.93	13.92	13.86	12.71
N	9386	9386	9386	9386	9386	9386
Controls	No	Yes	No	Yes	Yes	Yes
Weighted	No	No	Yes	Yes	Yes	Yes

Note: This table reports the first-stage regressions; Columns (1) to (6) correspond to the 2SLS specifications in Columns (3) to (8) of Table D.2. The dependent variable is the interaction of materials intensity and the log of the materials price index. The excluded instrument is the disaster-based shift-share variable defined in Equation D.1. All specifications control for industry and year fixed effects. Standard errors clustered at the industry-level are in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

The similarity of the estimated effects across two fundamentally different sources of identifying variation - global commodity price movements and natural disaster shocks - provides further reassurance that our baseline estimates reflect the causal effect of materials prices on the labor share, rather than confounding factors specific to either identification strategy.

E Quantitative Model Details

This appendix provides detailed derivations for the quantitative model presented in Section 4. We begin by restating the environment, then derive the first-order conditions, characterize the transition path, and finally present the model inversion procedure.

E.1 Environment

Production technology. Firms produce output q_t using a nested CES production function F:

$$q_t = F(k_t, l_t, m_t) = \left[\left(A_t l_t^{\alpha_t} k_t^{1-\alpha_t} \right)^{\frac{\sigma-1}{\sigma}} + \left(B_t m_t \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{E.1}$$

where l_t is labor, k_t is capital, m_t is materials, A_t is primary factor-augmenting productivity, B_t is materials-augmenting productivity, $\alpha_t \in (0,1)$ is the labor share within the capital-labor bundle, and $\sigma > 0$ is the elasticity of substitution between the capital-labor bundle and materials.

Capital accumulation. Capital evolves according to:

$$k_{t+1} = \chi_t i_t^{\gamma} k_t^{1-\gamma} + (1-\delta) k_t, \tag{E.2}$$

where i_t is investment expenditure, χ_t is investment efficiency, $\gamma \in (0,1]$ governs adjustment frictions (with $\gamma = 1$ corresponding to no adjustment costs), and $\delta \in (0,1)$ is the depreciation rate.

Demand. Firms operate under monopolistic competition with a CES demand aggregator. Letting E_t denote aggregate sectoral expenditure, P_t the sectoral price index, and $\eta_t > 1$ the time-varying demand elasticity, the firm's revenues are:

$$R_t = E_t^{\frac{1}{\eta_t}} P_t^{\frac{\eta_t - 1}{\eta_t}} q_t^{\frac{\eta_t - 1}{\eta_t}}, \tag{E.3}$$

where the associated gross markup is $\mu_t \equiv \eta_t/(\eta_t - 1)$. The markup captures a time-varying wedge between firms' price of output and their average unit cost, and can equivalently be viewed as a time-varying demand elasticity or return to scale. In a symmetric equilibrium with a unit mass of identical firms, $R_t = E_t$.

Firm's problem. The firm maximizes the present discounted value of profits:

$$\begin{aligned} \max_{\{l_t, m_t, i_t\}_{t=0}^{\infty}} \quad & \sum_{t=0}^{\infty} \beta^t \left\{ E_t^{\frac{1}{\eta_t}} P_t^{\frac{\eta_t - 1}{\eta_t}} q_t^{\frac{\eta_t - 1}{\eta_t}} - w_t l_t - p_{m,t} m_t - p_{i,t} i_t \right\} \\ \text{subject to:} \quad & q_t = F(k_t, l_t, m_t), \\ & k_{t+1} = \chi_t i_t^{\gamma} k_t^{1-\gamma} + (1-\delta) k_t, \\ & k_0 \text{ given}, \end{aligned} \tag{E.4}$$

where $\beta \in (0,1)$ is the discount factor, w_t is the wage, $p_{m,t}$ is the materials price, and $p_{i,t}$ is the investment goods price.

E.2 Derivation of First-Order Conditions

Output elasticities. Define the output elasticities as:

$$\theta_{x,t} \equiv \frac{\partial \ln q_t}{\partial \ln x_t} = \frac{\partial \ln F}{\partial \ln x_t}, \quad x \in \{l, k, m\}. \tag{E.5}$$

For the CES production function (E.1), we can compute these elasticities. Let $\Phi_t \equiv A_t l_t^{\alpha_t} k_t^{1-\alpha_t}$ denote the capital-labor composite. Then:

$$q_t = \left[\Phi_t^{\frac{\sigma-1}{\sigma}} + (B_t m_t)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}. \tag{E.6}$$

Taking the derivative with respect to m_t:

$$\frac{\partial q_t}{\partial m_t} = \frac{\sigma}{\sigma - 1} \left[\Phi_t^{\frac{\sigma-1}{\sigma}} + (B_t m_t)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}-1} \frac{\sigma - 1}{\sigma} (B_t m_t)^{\frac{\sigma-1}{\sigma}-1} B_t \tag{E.7}$$

$$= q_t^{\frac{1}{\sigma}} (B_t m_t)^{-\frac{1}{\sigma}} B_t = \frac{q_t}{m_t} \left(\frac{B_t m_t}{q_t} \right)^{\frac{\sigma-1}{\sigma}}. \tag{E.8}$$

Therefore, the materials output elasticity is:

$$\theta_{m,t} = \frac{\partial \ln q_t}{\partial \ln m_t} = \frac{m_t}{q_t} \frac{\partial q_t}{\partial m_t} = \left(\frac{B_t m_t}{q_t} \right)^{\frac{\sigma-1}{\sigma}}. \tag{E.9}$$

Similarly, the labor output elasticity is:

$$\theta_{l,t} = \alpha_t \left(\frac{\Phi_t}{q_t}\right)^{\frac{\sigma-1}{\sigma}} = \alpha_t \left(\frac{A_t l_t^{\alpha_t} k_t^{1-\alpha_t}}{q_t}\right)^{\frac{\sigma-1}{\sigma}}, \tag{E.10}$$

and the capital output elasticity is:

$$\theta_{k,t} = (1-\alpha_t) \left(\frac{\Phi_t}{q_t}\right)^{\frac{\sigma-1}{\sigma}} = (1-\alpha_t) \left(\frac{A_t l_t^{\alpha_t} k_t^{1-\alpha_t}}{q_t}\right)^{\frac{\sigma-1}{\sigma}}. \tag{E.11}$$

Note that $\Phi_t^{(\sigma-1)/\sigma} + (B_t m_t)^{(\sigma-1)/\sigma} = q_t^{(\sigma-1)/\sigma}$, so:

$$\left(\frac{\Phi_t}{q_t}\right)^{\frac{\sigma-1}{\sigma}} + \left(\frac{B_t m_t}{q_t}\right)^{\frac{\sigma-1}{\sigma}} = 1 \implies (1-\theta_{m,t}) = \left(\frac{\Phi_t}{q_t}\right)^{\frac{\sigma-1}{\sigma}}. \tag{E.12}$$

This yields the key relationships:

$$\theta_{l,t} = \alpha_t(1-\theta_{m,t}), \tag{E.13}$$

$$\theta_{k,t} = (1-\alpha_t)(1-\theta_{m,t}), \tag{E.14}$$

$$\theta_{l,t} + \theta_{k,t} + \theta_{m,t} = 1. \tag{E.15}$$

Static first-order conditions. Consider the firm's first-order condition for labor. Using $R_t = E_t^{1/\eta_t} P_t^{(\eta_t-1)/\eta_t} q_t^{(\eta_t-1)/\eta_t}$, the first-order condition is:

$$\frac{\partial R_t}{\partial l_t} = w_t. \tag{E.16}$$

Computing the derivative:

$$\frac{\partial R_t}{\partial l_t} = E_t^{\frac{1}{\eta_t}} P_t^{\frac{\eta_t-1}{\eta_t}} \frac{\eta_t - 1}{\eta_t} q_t^{\frac{\eta_t-1}{\eta_t}-1} \frac{\partial q_t}{\partial l_t} = \frac{\eta_t - 1}{\eta_t} \frac{R_t}{q_t} \frac{\partial q_t}{\partial l_t} = \frac{1}{\mu_t} R_t \frac{\theta_{l,t}}{l_t}, \tag{E.17}$$

where $\mu_t \equiv \eta_t/(\eta_t - 1) > 1$ is the gross markup. In equilibrium, $R_t = E_t$, so:

$$w_t l_t = \frac{\theta_{l,t}}{\mu_t} E_t \implies s_{l,t} \equiv \frac{w_t l_t}{E_t} = \frac{\theta_{l,t}}{\mu_t}. \tag{E.18}$$

Analogously, the first-order condition for materials yields:

$$p_{m,t}m_t = \frac{\theta_{m,t}}{\mu_t}E_t \implies s_{m,t} \equiv \frac{p_{m,t}m_t}{E_t} = \frac{\theta_{m,t}}{\mu_t}. \tag{E.19}$$

Dynamic first-order condition for investment. The firm's problem can be written recursively. Define the value function:

$$\mathcal{V}_t(k_t) = \max_{l_t,m_t,i_t} \left\{R_t - w_t l_t - p_{m,t}m_t - p_{i,t}i_t + \beta\mathcal{V}_{t+1}(k_{t+1})\right\}, \tag{E.20}$$

subject to (E.2). The first-order condition for investment is:

$$p_{i,t} = \beta\frac{\partial\mathcal{V}_{t+1}}{\partial k_{t+1}}\frac{\partial k_{t+1}}{\partial i_t}. \tag{E.21}$$

From (E.2):

$$\frac{\partial k_{t+1}}{\partial i_t} = \gamma\chi_t i_t^{\gamma-1}k_t^{1-\gamma} = \gamma\frac{k_{t+1}-(1-\delta)k_t}{i_t}. \tag{E.22}$$

By the envelope theorem:

$$\frac{\partial\mathcal{V}_t}{\partial k_t} = \frac{\partial R_t}{\partial k_t} + \beta\frac{\partial\mathcal{V}_{t+1}}{\partial k_{t+1}}\frac{\partial k_{t+1}}{\partial k_t}. \tag{E.23}$$

Since $\partial R_t/\partial k_t = (\theta_{k,t}/\mu_t)(E_t/k_t)$ and $\partial k_{t+1}/\partial k_t = (1-\gamma)(k_{t+1}-(1-\delta)k_t)/k_t + (1-\delta)$:

$$\frac{\partial\mathcal{V}_t}{\partial k_t} = \frac{\theta_{k,t}}{\mu_t}\frac{E_t}{k_t} + \beta\frac{\partial\mathcal{V}_{t+1}}{\partial k_{t+1}}\left[(1-\gamma)\frac{k_{t+1}-(1-\delta)k_t}{k_t} + (1-\delta)\right]. \tag{E.24}$$

Define $\dot{k}_{t+1} \equiv k_{t+1}/k_t$ as the gross growth rate of capital. Substituting and rearranging, we can express the investment share $s_{i,t} \equiv p_{i,t}i_t/E_t$ recursively. After some algebra:

$$s_{i,t} = \beta\frac{E_{t+1}}{E_t}\left(\frac{\dot{k}_{t+1}-(1-\delta)}{\dot{k}_{t+1}}\right)\left\{\gamma\frac{\theta_{k,t+1}}{\mu_{t+1}} + s_{i,t+1}\left(\frac{1-\delta}{\dot{k}_{t+2}-(1-\delta)} + (1-\gamma)\right)\right\} \tag{E.25}$$

Using $\theta_{k,t} = (1-\alpha_t)(1-\theta_{m,t}) = 1-\theta_{m,t}-\theta_{l,t}$, this becomes equation (24) in the main text.

Labor share of value added. Value added is defined as revenues minus materials

expenditure: $V_t = E_t - p_{m,t}m_t = E_t(1 - s_{m,t})$. The labor share of value added is:

$$\lambda_t \equiv \frac{w_t l_t}{V_t} = \frac{s_{l,t}}{1 - s_{m,t}} = \frac{\theta_{l,t}/\mu_t}{1 - \theta_{m,t}/\mu_t} = \frac{\theta_{l,t}}{\mu_t - \theta_{m,t}}. \tag{E.26}$$

Using $\theta_{l,t} = \alpha_t(1 - \theta_{m,t})$:

$$\lambda_t = \frac{\alpha_t(1 - \theta_{m,t})}{\mu_t - \theta_{m,t}}. \tag{E.27}$$

E.3 Solving the Transition Path

Given paths of fundamentals $\{A_t, B_t, \alpha_t, \chi_t, \mu_t, E_t\}_{t=0}^T$ and prices $\{w_t, p_{m,t}, p_{i,t}\}_{t=0}^T$, we solve for the equilibrium path of allocations. The key state variable is capital k_t.

Factor demands given capital. Given the capital stock k_t, we can express factor demands as functions of $\theta_{m,t}$. From the first-order conditions:

$$l_t = \frac{\theta_{l,t}}{\mu_t}\frac{E_t}{w_t} = \frac{\alpha_t(1 - \theta_{m,t})}{\mu_t}\frac{E_t}{w_t}, \tag{E.28}$$

$$m_t = \frac{\theta_{m,t}}{\mu_t}\frac{E_t}{p_{m,t}}. \tag{E.29}$$

However, $\theta_{m,t}$ itself depends on factor demands through equation (E.9). This creates a fixed-point problem: given k_t, we solve for $\theta_{m,t}$ such that:

$$\theta_{m,t} = \left(\frac{B_t m_t(\theta_{m,t})}{F(k_t, l_t(\theta_{m,t}), m_t(\theta_{m,t}))}\right)^{\frac{\sigma-1}{\sigma}}, \tag{E.30}$$

where $l_t(\theta_{m,t})$ and $m_t(\theta_{m,t})$ are given by (E.28)–(E.29). We solve this fixed-point problem numerically (by bisection) for each period t.

Capital dynamics. Given the investment share $s_{i,t}$, investment is:

$$i_t = s_{i,t}\frac{E_t}{p_{i,t}}. \tag{E.31}$$

The capital accumulation equation (E.2) can be written as:

$$k_{t+1} = (1 - \delta)k_t + \chi_t \left(s_{i,t}\frac{E_t}{p_{i,t}}\right)^{\gamma} k_t^{1-\gamma}. \tag{E.32}$$

Define $\bar{\chi}_t \equiv \chi_t (E_t/p_{i,t})^\gamma$. Then:

$$k_{t+1} = (1-\delta)k_t + \bar{\chi}_t s_{i,t}^\gamma k_t^{1-\gamma}. \tag{E.33}$$

Steady state. In steady state, $k_{t+1} = k_t = k^{SS}$, $\dot{k} = 1$, and all fundamentals are constant. From (E.33):

$$k^{SS} = (1-\delta)k^{SS} + \bar{\chi}(s_i^{SS})^\gamma (k^{SS})^{1-\gamma} \implies \delta k^{SS} = \bar{\chi}(s_i^{SS})^\gamma (k^{SS})^{1-\gamma}. \tag{E.34}$$

This yields:

$$(k^{SS})^\gamma = \frac{\bar{\chi}}{\delta}(s_i^{SS})^\gamma \implies k^{SS} = \left(\frac{\chi}{\delta}\right)^{\frac{1}{\gamma}} \frac{E}{p_i} s_i^{SS} = \left(\frac{\chi}{\delta}\right)^{\frac{1}{\gamma}} i^{SS}. \tag{E.35}$$

From the Euler equation (E.25) in steady state with $\dot{k} = 1$:

$$s_i^{SS} = \beta\delta \left\{ \gamma \frac{\theta_k}{\mu} + s_i^{SS} \left(\frac{1-\delta}{\delta} + (1-\gamma) \right) \right\}. \tag{E.36}$$

Solving for s_i^{SS}:

$$s_i^{SS} \left[1 - \beta\delta \left(\frac{1-\delta}{\delta} + 1 - \gamma \right) \right] = \beta\delta\gamma \frac{\theta_k}{\mu}. \tag{E.37}$$

The term in brackets simplifies to $1 - \beta(1-\delta\gamma)$, so:

$$s_i^{SS} = \bar{\beta}\frac{\theta_k}{\mu} = \bar{\beta}\frac{1-\theta_m-\theta_l}{\mu}, \quad \text{where} \quad \bar{\beta} \equiv \frac{\beta\delta\gamma}{1-\beta(1-\delta\gamma)} \tag{E.38}$$

Transition path algorithm. We solve for the transition path using the following algorithm:

1. **Compute steady state**: Given terminal fundamentals and prices, compute θ_m^{SS} from the fixed-point problem, then s_i^{SS} from (E.38), and k^{SS}.
2. **Initialize**: Guess a path $\{k_t\}_{t=1}^T$ interpolating from k_0 to k^{SS}.
3. **Iterate**:
   (a) For each t, solve the fixed-point problem (E.30) to obtain $\theta_{m,t}$ given k_t.

(b) Compute $\theta_{k,t}/\mu_t = (1 - \theta_{m,t} - \alpha_t(1 - \theta_{m,t}))/\mu_t$ for each t.

(c) Solve backwards for $s_{i,t}$ using (E.25), starting from $s_{i,T} = s_i^{SS}$.

(d) Update the capital path forward using (E.33), starting from k_0.

(e) Apply dampening: $k_t^{new} = \rho\, k_t^{old} + (1 - \rho)\, k_t^{update}$.

4. **Check convergence**: If $\max_t |k_t^{new} - k_t^{old}| < \epsilon$, stop. Otherwise, return to step 3.

E.4 Model Inversion

The inversion procedure recovers the time-varying fundamentals $\{\mu_t, \alpha_t, A_t, B_t, \chi_t\}$ from observed data. We observe: revenue shares $\{s_{l,t}, s_{m,t}, s_{i,t}\}$, capital stock $\{k_t\}$, output $\{q_t\}$, prices $\{w_t, p_{m,t}, p_{i,t}\}$, and revenues $\{E_t\}$.

Recovering $\theta_{k,t}/\mu_t$ from the Euler equation. Rearranging (E.25):

$$\frac{\theta_{k,t+1}}{\mu_{t+1}} = \frac{1}{\gamma}\left[\frac{s_{i,t}}{\beta(E_{t+1}/E_t)\,(\dot{k}_{t+1} - (1-\delta))/\dot{k}_{t+1}} - s_{i,t+1}\left(\frac{1-\delta}{\dot{k}_{t+2} - (1-\delta)} + (1-\gamma)\right)\right]. \tag{E.39}$$

This allows us to recover $\theta_{k,t}/\mu_t$ from observed investment shares and capital growth rates.

Recovering markups μ_t. From the first-order conditions, factor payments satisfy:

$$s_{l,t} + s_{m,t} + \frac{\theta_{k,t}}{\mu_t} = \frac{\theta_{l,t} + \theta_{m,t} + \theta_{k,t}}{\mu_t} = \frac{1}{\mu_t}. \tag{E.40}$$

Therefore:

$$\mu_t = \frac{1}{s_{l,t} + s_{m,t} + \theta_{k,t}/\mu_t} \tag{E.41}$$

where $\theta_{k,t}/\mu_t$ is obtained from (E.39).

Rearranging the same identity,

$$1 - s_{l,t} - s_{m,t} = \frac{\theta_{k,t}}{\mu_t} + \left(1 - \frac{1}{\mu_t}\right). \tag{E.42}$$

Thus, revenue net of labor and materials is split between the capital output elasticity relative to the markup, $\theta_{k,t}/\mu_t$, and a profit share of revenues, $1 - 1/\mu_t$. Since (E.39)

recovers the former from the investment Euler equation, (E.41) then recovers the latter residually through the lens of the model.

Equivalently, free cash flow as a share of revenue,

$$\frac{FCF_t}{E_t} \equiv 1 - s_{i,t} - s_{l,t} - s_{m,t}, \tag{E.43}$$

satisfies

$$1 - s_{i,t} - s_{l,t} - s_{m,t} = \frac{\theta_{k,t}}{\mu_t} + \left(1 - \frac{1}{\mu_t}\right) - s_{i,t}. \tag{E.44}$$

Hence, free cash flow is informative about the markup only jointly with the model-implied capital-income component.

Recovering α_t. From the labor share of value added (E.26):

$$\lambda_t = \frac{s_{l,t}}{1 - s_{m,t}} = \frac{\alpha_t(1 - \theta_{m,t})}{\mu_t - \theta_{m,t}}. \tag{E.45}$$

Note that $\theta_{m,t} = s_{m,t}\mu_t$. Substituting:

$$\lambda_t = \frac{\alpha_t(1 - s_{m,t}\mu_t)}{\mu_t - s_{m,t}\mu_t} = \frac{\alpha_t(1 - s_{m,t}\mu_t)}{\mu_t(1 - s_{m,t})}. \tag{E.46}$$

Solving for α_t:

$$\alpha_t = \frac{\lambda_t \mu_t (1 - s_{m,t})}{1 - s_{m,t}\mu_t} \tag{E.47}$$

Recovering B_t. From the ratio of first-order conditions for labor and materials:

$$\frac{w_t l_t}{p_{m,t} m_t} = \frac{\theta_{l,t}}{\theta_{m,t}} = \frac{\alpha_t(1 - \theta_{m,t})}{\theta_{m,t}}. \tag{E.48}$$

Using (E.9) and (E.10):

$$\frac{s_{l,t}}{s_{m,t}} = \alpha_t \left(\frac{\Phi_t}{B_t m_t}\right)^{\frac{\sigma-1}{\sigma}}, \tag{E.49}$$

where $\Phi_t = A_t l_t^{\alpha_t} k_t^{1-\alpha_t}$. Taking powers and rearranging:

$$\left(\frac{s_{l,t}}{s_{m,t}\alpha_t}\right)^{\frac{\sigma}{\sigma-1}} = \frac{\Phi_t}{B_t m_t}. \tag{E.50}$$

Using $l_t = s_{l,t}E_t/w_t$ and $m_t = s_{m,t}E_t/p_{m,t}$:

$$B_t = \frac{A_t(s_{l,t}E_t/w_t)^{\alpha_t}k_t^{1-\alpha_t}}{(s_{m,t}E_t/p_{m,t})}\left(\frac{s_{m,t}\alpha_t}{s_{l,t}}\right)^{\frac{\sigma}{\sigma-1}}. \tag{E.51}$$

Simplifying:

$$B_t = A_t\left(\frac{1}{\alpha_t}\right)^{\frac{\sigma}{1-\sigma}}\left(\frac{s_{l,t}}{s_{m,t}}\right)^{\frac{1}{1-\sigma}}\frac{p_{m,t}}{w_t\left(\frac{s_{l,t}E_t}{w_t k_t}\right)^{1-\alpha_t}} \tag{E.52}$$

Recovering χ_t. From the capital accumulation equation (E.2):

$$k_{t+1} - (1-\delta)k_t = \chi_t i_t^{\gamma}k_t^{1-\gamma}. \tag{E.53}$$

Using $i_t = s_{i,t}E_t/p_{i,t}$:

$$\chi_t = \frac{k_{t+1} - (1-\delta)k_t}{(s_{i,t}E_t/p_{i,t})^{\gamma}k_t^{1-\gamma}}. \tag{E.54}$$

This can be written as:

$$\chi_t = \left(\frac{E_t}{p_{i,t}}\right)^{-\gamma}\frac{k_{t+1} - (1-\delta)k_t}{s_{i,t}^{\gamma}k_t^{1-\gamma}} \tag{E.55}$$

Recovering A_t. We normalize A_t to match observed output. Given l_t, k_t, m_t, and B_t:

$$A_t = \frac{q_t}{\left[\left(l_t^{\alpha_t}k_t^{1-\alpha_t}\right)^{\frac{\sigma-1}{\sigma}} + \left(\frac{B_t}{A_t}m_t\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}} \tag{E.56}$$

Note that A_t appears on both sides of this expression. In practice, we substitute the expression for B_t/A_t from (E.52) (which does not depend on A_t).

Inversion algorithm. The full inversion algorithm iterates on the capital path:

1. **Initialize**: Set $k_t = k_t^{data}$ for $t \leq T_{data}$. Guess continuation path for $t > T_{data}$.
2. **Iterate**:
   (a) Compute $\theta_{k,t}/\mu_t$ from (E.39) for all t.
   (b) Recover μ_t from (E.41).

(c) Recover α_t from (E.47).

(d) Recover B_t from (E.52).

(e) Recover χ_t from (E.55).

(f) Recover A_t from (E.56).

(g) For $t > T_{data}$: set fundamentals to terminal values and update capital path using (E.33).

(h) Apply dampening and check convergence.

Recovery of $\tilde{c}_{G,t}$. Given the recovered output elasticity of materials $\theta_{m,t}$ and materials-augmenting productivity B_t, the unit cost of the *unaugmented* primary-input bundle $(l_t^{\alpha_t} k_t^{1-\alpha_t})$ can be recovered from CES duality:

$$\tilde{c}_{G,t} = A_t \left(\frac{\theta_{m,t}}{1-\theta_{m,t}} \right)^{-\frac{1}{1-\sigma}} \frac{p_{m,t}}{B_t}. \tag{E.57}$$

This is the unit cost of the unaugmented bundle, related to the augmented unit cost c_G in Section 2 by $\tilde{c}_{G,t} = A_t \, c_G$.

E.5 Data Sources and Construction

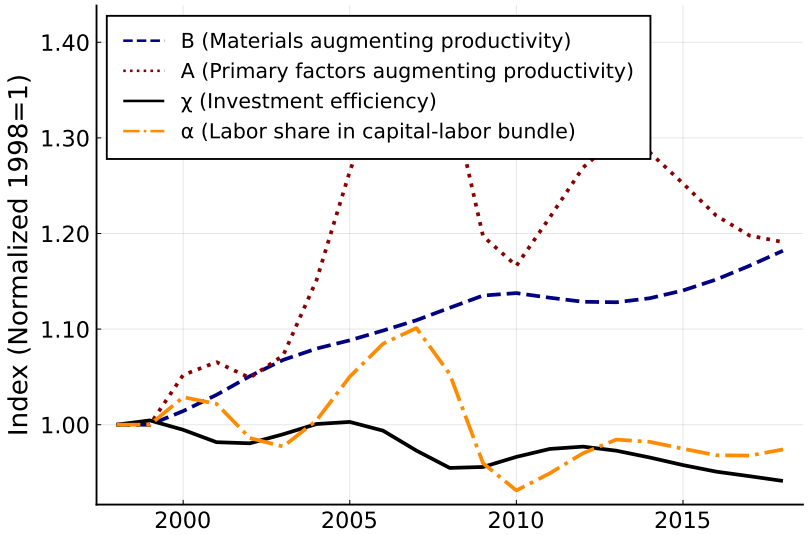
Our data come from the Bureau of Economic Analysis (BEA) industry accounts (Bureau of Economic Analysis, 2025a,b,c). We use compensation of employees (wages and salaries plus supplements) as our measure of labor costs; intermediate inputs expenditure as materials; gross private domestic investment in the manufacturing sector as investment; the real capital stock computed using the perpetual inventory method; and gross output by industry. Prices include wages and salaries per full-time equivalent employee (wages), the intermediate inputs price index (materials price), and the investment goods price index. All nominal variables are converted to real terms using appropriate deflators. The sample period is 1998–2019, with data smoothed using an HP filter (with smoothing parameter equal to 5) to focus on medium-run trends.

E.6 Additional Inversion Results

Figure E.1 shows the recovered productivity parameters and the labor share parameter from the model inversion. Materials-augmenting productivity B_t increased

steadily over the sample period. Primary factor-augmenting productivity A_t rose sharply through the mid-2000s before partially reverting, ending the sample at a similar cumulative growth rate as B_t. Investment efficiency χ_t declined modestly over the period. The labor share within the capital-labor bundle α_t rose in the mid-2000s before falling back, ending somewhat below its initial level.

Figure E.1: Recovered Fundamentals



Note: Materials-augmenting productivity B_t (dashed blue), primary factor-augmenting productivity A_t (dotted red), investment efficiency χ_t (solid black), and labor share in the capital-labor bundle α_t (dash-dotted orange). All series normalized to 1 in 1998.

E.7 Capital Share of Value Added

The model allows us to decompose value added into three components: a labor share λ_t, a capital share κ_t, and a profit share. Specifically, defining the capital share as the marginal revenue product of capital relative to value added:

$$\kappa_t = \frac{(1-\alpha_t)(1-\theta_{m,t})}{\mu_t - \theta_{m,t}}, \tag{E.58}$$

the three shares satisfy $\lambda_t + \kappa_t + (\mu_t - 1)/(\mu_t - \theta_{m,t}) = 1$. In the data, only $1 - \lambda_t$ is directly measurable, combining the capital share and profits. The model's inversion of μ_t allows us to separate them.

It is useful to distinguish this decomposition from the free-cash-flow ratio plotted

in Panel (e) of Figure 9. Free cash flow as a share of value added is given by

$$\frac{FCF_t}{V_t} = \kappa_t + \frac{\mu_t - 1}{\mu_t - \theta_{m,t}} - \frac{s_{i,t}}{1 - s_{m,t}}, \tag{E.59}$$

where $FCF_t \equiv E_t - w_t l_t - p_{m,t} m_t - p_{i,t} i_t$. Thus, free cash flow is not the same as the model's profit share: it combines capital's marginal contribution to revenue and pure profits, and then subtracts current investment expenditure.

Figure E.2 plots all three components under the baseline (solid) and the constant-$p_{m,t}$ counterfactual (dashed). Both the labor and capital shares decline in the baseline, with the difference absorbed by a rising profit share. In the counterfactual, the labor and capital shares are higher, while the profit share is lower – indicating that the rise in materials prices contributed to an increase in profits at the expense of both labor and capital.

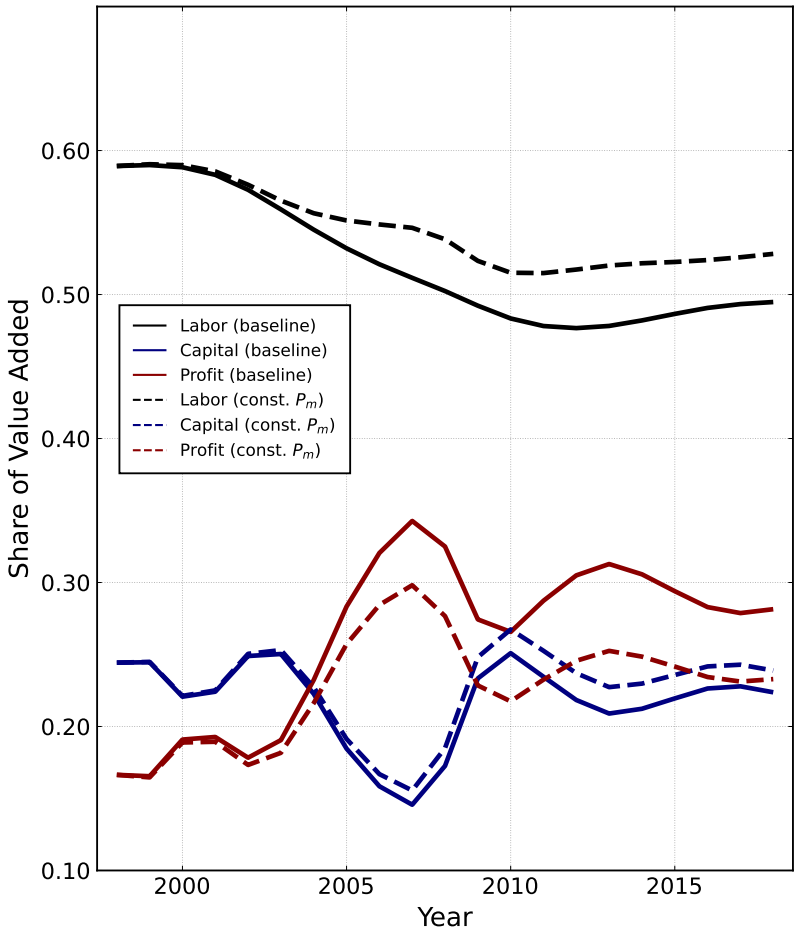
E.8 Subsector Counterfactuals

We repeat the counterfactual analysis for each manufacturing subsector individually. Figure E.3 displays the labor share of value added under the baseline equilibrium and the two counterfactual scenarios for each of the 19 manufacturing subsectors. The analysis applies the same inversion procedure, calibration, and counterfactual experiments described in Section 4 to subsector-specific data from the BEA industry accounts. Counterfactual 1 holds the materials price $p_{m,t}$ constant at its 1998 level, while Counterfactual 2 holds constant the effective relative price of materials $p_{m,t}/\tilde{c}_{G,t}$ and the ratio B_t/A_t.

The results show that the contribution of materials prices to the labor share dynamics varies substantially across subsectors. In most subsectors, holding materials prices constant (dashed red) or holding effective materials prices constant (dotted blue) attenuates the decline in the labor share relative to the baseline (solid black). However, the magnitude of this attenuation differs considerably, reflecting heterogeneity in the initial materials intensity, the recovered markups, and the extent of materials price changes across industries.

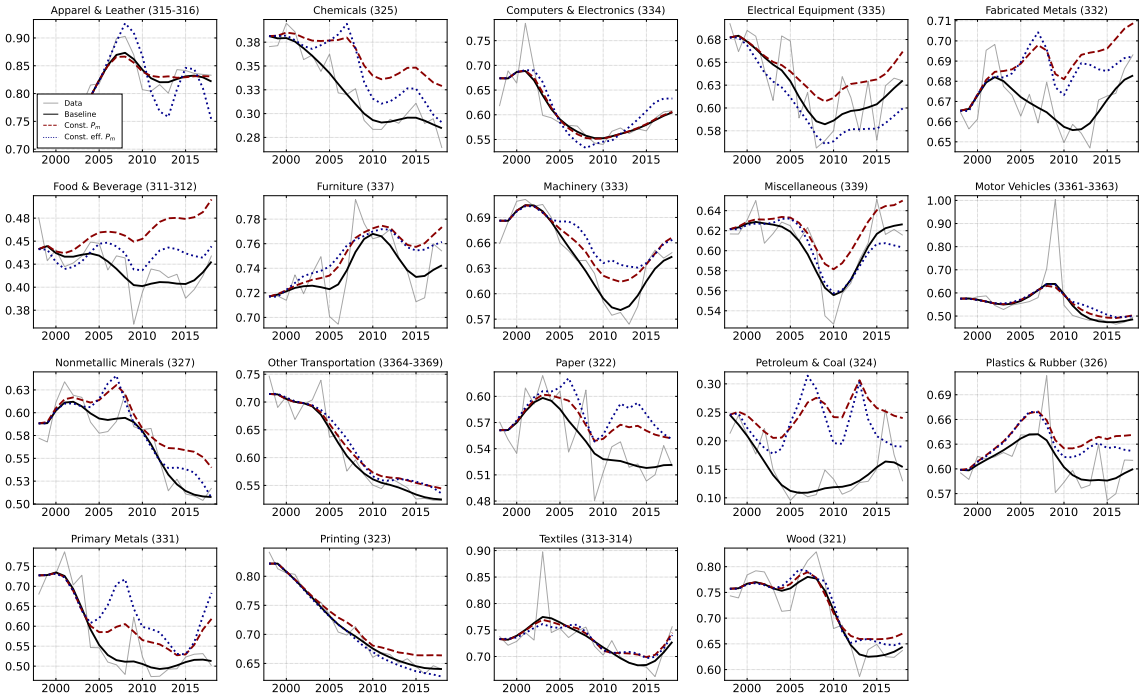
Table E.1 reports the effect of materials prices on the labor share for each subsector. For each subsector, the table shows the total change in the labor share in the data alongside the change attributable to materials price changes and effective

Figure E.2: Decomposition of Value Added



Note: Labor share $\lambda_t = \alpha_t(1-\theta_{m,t})/(\mu_t - \theta_{m,t})$, capital share $\kappa_t = (1-\alpha_t)(1-\theta_{m,t})/(\mu_t - \theta_{m,t})$, and profit share $(\mu_t - 1)/(\mu_t - \theta_{m,t})$. Solid lines: baseline. Dashed lines: counterfactual with constant $p_{m,t}$.

Figure E.3: Subsector Counterfactual Results – Labor Share of Value Added



Note: Each panel shows results for one of 19 manufacturing subsectors (NAICS codes in parentheses). Gray line: raw (unsmoothed) data. Solid black line: baseline equilibrium (HP-filtered data). Dashed red line: counterfactual with constant materials prices $p_{m,t}$. Dotted blue line: counterfactual with constant effective materials prices $p_{m,t}/\tilde{c}_{G,t}$. Data are from the BEA industry accounts, 1998–2019.

materials price changes. These are reported both for the end period (comparing the last sample year to the first) and on average across all sample years. Subsectors are ranked by the average effect of materials prices (column 3), from largest to smallest.

Table E.1: Effect of Materials Prices on Subsector Labor Shares

Subsector (NAICS)	VA Share	Average			End Period		
		$\Delta\lambda$ Data	Due to ΔP_m	Due to Δ Eff. P_m	$\Delta\lambda$ Data	Due to ΔP_m	Due to Δ Eff. P_m
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Petroleum & Coal (324)	6.3	-9.7	-9.9	-7.9	-9.2	-8.6	-3.6
Primary Metals (331)	3.1	-15.5	-4.0	-6.8	-21.5	-10.6	-17.1
Food & Beverage (311-312)	11.7	-2.1	-3.9	-1.4	-1.4	-6.8	-1.7
Chemicals (325)	15.2	-5.6	-3.6	-2.3	-9.7	-4.4	-0.6
Plastics & Rubber (326)	3.7	1.0	-2.6	-2.0	0.1	-4.1	-2.2
Paper (322)	3.1	-1.0	-2.1	-3.0	-4.0	-3.0	-2.9
Nonmetallic Minerals (327)	2.6	-1.9	-2.0	-1.0	-8.1	-3.2	0.1
Fabricated Metals (332)	7.1	0.4	-1.9	-1.5	1.7	-2.6	-0.9
Electrical Equipment (335)	2.8	-5.4	-1.8	1.8	-4.7	-3.2	3.0
Miscellaneous (339)	4.1	-1.6	-1.7	0.1	0.5	-2.4	2.3
Machinery (333)	7.2	-4.2	-1.5	-2.2	-4.2	-2.3	-2.0
Furniture (337)	1.6	2.1	-1.2	-1.2	2.5	-3.1	-1.9
Wood (321)	1.6	-4.3	-1.1	-1.1	-11.3	-2.6	-0.8
Other Transportation (3364-3369)	6.2	-10.5	-1.1	-1.2	-19.0	-2.0	-1.0
Printing (323)	2.3	-11.0	-1.0	0.5	-18.1	-2.4	1.3
Motor Vehicles (3361-3363)	7.1	-2.7	-0.6	-1.2	-8.9	-1.8	-1.4
Textiles (313-314)	1.1	-0.4	-0.4	-0.3	-0.5	-1.7	-1.3
Apparel & Leather (315-316)	0.7	7.2	-0.1	0.5	8.6	-0.9	7.0
Computers & Electronics (334)	12.2	-7.1	-0.0	-0.6	-6.9	-0.1	-2.8

Note: All values are in percentage points. Columns (2) and (5) report the change in the labor share in the data. Columns (3)–(4) and (6)–(7) report the change in the labor share attributable to changes in materials prices and effective materials prices, respectively. "Average" averages across all sample years; "End period" compares the last sample year to the first. Subsectors are ranked by column (3).

F Cross-Country Empirical Analysis

This appendix provides additional details on the data sources, sample construction, and instrumental variable strategy for the cross-country analysis of Section 5.

F.1 Data

EU-KLEMS. Our primary data source for the cross-country analysis is the 2025 release of EU-KLEMS, run by the Vienna Institute for International Economic Studies. This dataset provides industry-level measures of gross output, intermediate inputs, value added, compensation, employment, hours worked, and price indices for all European Union member states, Japan, and the U.S. at the NACE Rev. 2 classification level. We use data over the period 1995–2019. Where the 2025 vintage has gaps in price indices – particularly for newer member states – we splice with the 2020 EU-KLEMS vintage. Where the two vintages overlap, we compute a splice ratio at the country×industry level and apply it to fill gaps; for country-sector pairs with very sparse 2025 coverage (≤ 3 non-missing observations), we replace entirely with the 2020 vintage. Level variables (compensation, hours) are filled directly from the 2020 vintage where the 2025 vintage is missing.

World KLEMS. We supplement the EU-KLEMS data with industry-level data for Canada and South Korea from the World KLEMS project. For Canada, we use the 2012 release covering 1995–2008, which reports data at the ISIC Rev. 3 level. We map sectors to NACE Rev. 2 manufacturing industries, aggregating sub-sectors as needed (e.g., wood and paper products into C16–C18) using value-added-weighted price indices and summing level variables. For South Korea, we use the 2015 release covering 1995–2012. Since the Korean data are reported at a finer sub-industry level than EU-KLEMS, we compute implicit price deflators from nominal and real series (normalized to 2000) and aggregate to NACE Rev. 2 sectors. In both cases, we drop sectors for which the ISIC classification does not permit a clean separation into EU-KLEMS industries (e.g., C21 and C27 for Canada).

Sample construction. We restrict the sample to 13 manufacturing sectors at the NACE Rev. 2 level (C10–C12 through C31–C33). We drop Luxembourg and Slovakia, which exhibit extreme price outliers driven by small manufacturing sectors and vintage-splicing artifacts. We further drop observations where compensation

exceeds value added; intermediate inputs exceed gross output; the materials-to-value-added ratio exceeds 10 (mostly petroleum refining with volatile margins); or the labor share falls below 0.05 or above 0.95. Country-sector pairs with fewer than 5 observations are also excluded. The resulting estimation sample contains 6,318 observations across 23 countries: 19 EU member states (Austria, Belgium, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, the Netherlands, Poland, Portugal, Romania, Slovenia, and Sweden), Japan, and the U.S. from EU-KLEMS, and Canada and South Korea from World KLEMS.

F.2 Instrumental Variable

We construct a shift-share instrument for industry-level materials prices at the country level, following a strategy that parallels the instrument used in the U.S. analysis (Section 3). The construction proceeds in three steps.

Step 1: Input-output shares. For each country c and using sector j, we extract the share of supplying sector k in j's intermediate input bundle from the year-2000 national input-output table in the WIOD (World Input-Output Database). Specifically,

$$s_{c,j,k} = \frac{\text{flow}_c(k \to j)}{\sum_{k'} \text{flow}_c(k' \to j)},$$

where flows sum both domestic and imported intermediates. We use the year-2000 table so that shares are predetermined with respect to subsequent price changes. The WIOD (Timmer, Dietzenbacher, Los, Stehrer, and de Vries, 2015) covers 43 countries at a 56-sector level, providing country-specific input structures that reflect heterogeneity in production technologies across economies.

Step 2: Commodity price shocks. We measure global commodity price shocks using trade unit values from UN ComTrade at the HS6 product level, following the same source used in our U.S. analysis. To aggregate HS-level prices to WIOD sectors, we construct a chained concordance from HS92 to HS96 (using the correspondence in our commodity dataset), from HS96 to ISIC Rev. 3 4-digit (using the WITS concordance, World Integrated Trade Solution 2026), and from ISIC Rev. 3 to WIOD sectors via a 2-digit mapping, with a 4-digit carve-out for pharmaceuticals (ISIC3 2423 $\to$ C21). We collapse to simple averages within each WIOD sector-year cell and

interpolate linearly to fill gaps. This yields price series for 9 WIOD sectors over 30 years.

Step 3: Shift-share instrument. The instrument for country c, sector j, year t is

$$Z_{c,j,t} = \sum_k s_{c,j,k} \log\left(\frac{p_{k,t}}{p_{k,\text{base}}}\right),$$

where $s_{c,j,k}$ are IO expenditure shares, constructed analogously to Equation 14: the expenditure of sector j on inputs from sector k, divided by sector j's total costs (intermediate inputs plus labor compensation), using WIOD year-2000 values and KLEMS compensation data. Since commodity prices are only available for a subset of supplying sectors, the shares sum to less than one, capturing both the composition and overall intensity of each industry's commodity exposure. The instrument is analogous to Equation 16.

Exchange rate adjustment. For countries outside the U.S., changes in the bilateral exchange rate affect the transmission of dollar-denominated commodity price shocks to domestic materials costs. We convert commodity prices to local currency before applying the IO weights:

$$Z^{fx}_{c,j,t} = \sum_k s_{c,j,k} \log\left(\frac{p_{k,t}\, e_{c,t}}{p_{k,\text{base}}\, e_{c,\text{base}}}\right),$$

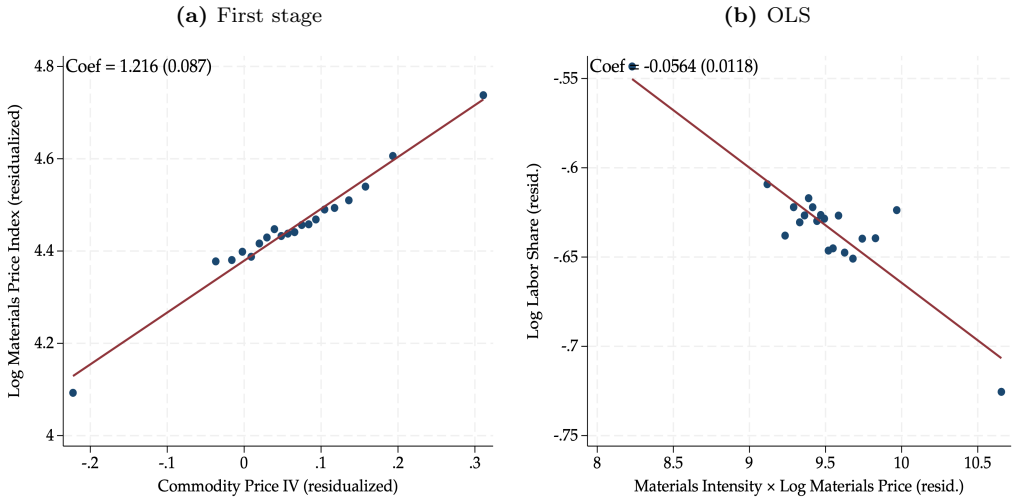
where $e_{c,t}$ is the bilateral exchange rate vis-à-vis the U.S. dollar from the BIS (Bank for International Settlements, 2023) (units of local currency per dollar). A country whose currency appreciated relative to the dollar will have experienced a smaller increase in domestic materials costs than the raw commodity price movement would suggest.

F.3 Supplementary Figures

Figure F.1 presents binned scatter plots for the cross-country panel, analogous to the binscatter evidence shown for the U.S. in the main text. Panel (a) plots the first-stage relationship between the FX-adjusted shift-share instrument and the log materials price index. The positive and significant relationship confirms that the instrument has predictive power for materials prices in the cross-country setting. Panel

(b) plots the OLS relationship between the treatment variable (baseline materials intensity × log materials price) and the log labor share. The negative slope is consistent with the results in Table 4 and with the U.S. evidence.

Figure F.1: Cross-Country Binscatter

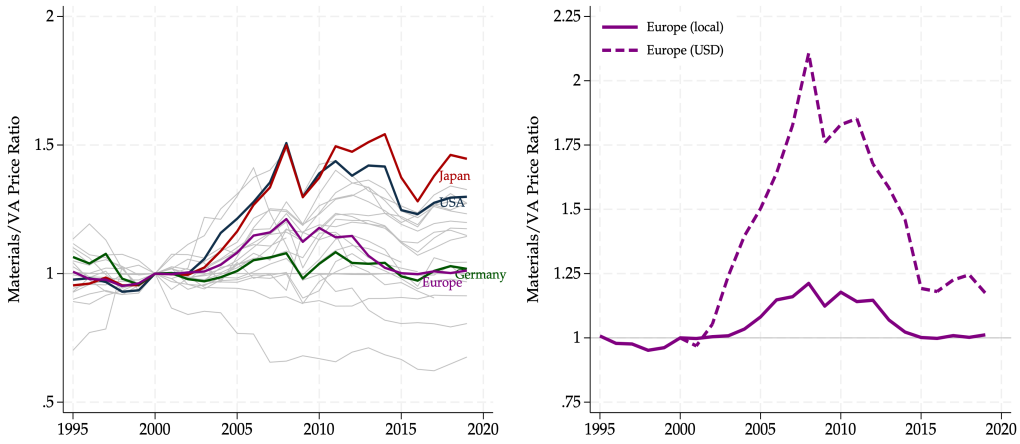


Note: Both panels show binned scatter plots with 20 quantile bins, residualized with respect to country×industry and year fixed effects, weighted by baseline value-added shares. Panel (a) shows the first-stage relationship between the FX-adjusted shift-share IV and the log materials price index. Panel (b) shows the OLS relationship between materials intensity × log materials price and the log labor share. Regression coefficients and standard errors are reported in each panel.

Figure F.2 documents the heterogeneous trends in the relative price of intermediates across countries. Panel (a) plots the ratio of materials to value-added price indices by country, normalized to unity at 2000. Each country's index is computed as a Törnqvist chain across manufacturing sectors, weighted by materials expenditure. Despite the global rise in commodity prices during the 2000s, the country-level trend exhibits vast heterogeneity. Moreover, the increase in the U.S. and Japan is greater than in all European countries. One reason behind this more timid European increase is that concurrently with the rise in global raw material prices, most European economies adopted the Euro, which quickly appreciated against the dollar. Panel (b) confirms this mechanism: the European aggregate in local currency (solid line) is essentially flat, while the same aggregate adjusted to U.S. dollars (dashed line) exhibits a substantially larger increase that is more comparable to the U.S. and Japanese experience.

Figure F.2: Materials Prices Across Countries

(a) All countries **(b)** Europe: local currency vs. USD



Note: Panel (a) shows the ratio of materials to value-added price indices by country, normalized to unity at 2000. Each gray line is a separate country. Bold lines highlight the U.S. (navy), Japan (red), Germany (green), and a Törnqvist-weighted European aggregate (purple). Panel (b) shows the European aggregate in local currency (solid) and adjusted to U.S. dollars using bilateral exchange rates from the BIS (dashed).

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