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Market power, input substitution and the labor share

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Abstract

An increase in the aggregate markup induces substitution of primary inputs for intermediate inputs, and substitution of labor for capital. Both effects lower the labor share if the inputs are complements. A reasonable calibration shows that a 4% increase in the markup lowers U.S. labor share by 7.5 percentage points, with input substitution accounting for about one third of the total impact.

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1. Introduction

The decline of the labor share of income in recent decades has attracted much attention in the literature (Grossman and Oberfield, 2022). Recent studies argue that an increase in the price-cost markup might help explain the decline (De Loecker et al., 2020). This paper shows that a higher markup also induces input substitution through changing relative input prices, further lowering the labor share when the inputs are complements.

Section 2 presents a decomposition of the labor share in an environment with market power and intermediate input, which links the labor share to the cost shares of inputs. Both an increase in the cost share of intermediate inputs, and a decrease in the cost share of labor in primary inputs can decrease the labor share.

Section 3 show that a rise in the markup induces firms to substitute primary inputs for intermediate inputs, as the cost of primary inputs is suppressed relative to intermediate inputs. When the elasticity of substitution between primary and intermediate inputs is below 1, the substitution raises the cost share of intermediate inputs, and decreases the labor share.

Section 4 consider the impact of capital accumulation in a neoclassical growth model. A rise in the markup lowers the share of marginal product paid to the capital owners, and deters capital accumulation. This results in a lowered relative cost of labor, inducing a substitution of labor for capital. Such a substitution reduces the cost share of labor in primary inputs for the usual case of capital-labor complementarity, also decreasing the labor share.

Finally, Section 5 performs a simple calibration to gauge the quantitative importance of input substitution. I find that a small increase of the markup from 1.2 to 1.25 (a 4.2% increase) could induce a 7.5 percentage points reduction in the labor share, roughly the size of the observed decline since the 1950s. Input substitution accounts for about one third of the total decline. Capital-labor substitution plays a much larger role than intermediate input substitution.

This paper contributes to the understanding the impact of an increase in the markup on the labor share (De Loecker et al., 2020; Traina, 2018; Raval, 2023). The closest to this study is Basu (2019), who emphasizes that "double marginalization" could magnify the impact. This paper further shows the importance of input substitution in an equilibrium model. Kaplan and Zoch (2020) and Chu (2020) also examine the impact of an increase in the markup on aggregate labor share, but does not emphasize the input substitution channels discussed in this paper.

A few other studies have explored economic mechanisms presented in this paper. Giannoni and Mertens (2019) and Castro-Vincenzi and Kleinman (2022) study the effect of changes in the cost share of intermediate inputs on the labor share, focusing on outsourcing and input substitution due to a foreign demand shock respectively. This paper differs from them in studying an increase in the markup. Baqaee and Farhi (2020) point out the importance of input substitution following changing markups and study its impact on aggregate productivity. Different from them, this paper studies the impact on the labor share. Finally, Ball and Mankiw (2023) has explored the impact of an increase in the markup on capital accumulation and public policy. This paper points out that changes in capital accumulation also induces capital-labor substitution, changing the labor share. To the best of my knowledge, this point has not been raised in the literature.

2. A Decomposition of the Labor Share

This section presents a decomposition linking the labor share to the cost shares of inputs. Firms use capital (K), labor (L), and intermediate inputs to produce an output that is priced by a markup over costs. Aggregating over all firms, the value of gross output (Q) is,

$$Q = \mu(RK + WL + M),$$

where M is the value of intermediate inputs, R and W are the prices of capital and labor, and μ is markup. GDP is defined as total output minus the cost of the intermediate input,

$$Y = Q - M.$$

Combining the two equations, the labor share can be decomposed as,

$$\frac{WL}{Y} = \frac{\eta_L}{\mu + (\mu - 1)\frac{s_M}{1-s_M}}, \tag{1}$$

where $\eta_L = \frac{WL}{RK+WL}$ is the cost share of labor in primary inputs, and $s_M = \frac{M}{RK+WL+M}$ is the cost share of intermediate input. Clearly, the labor share is lower if labor costs decline relative to capital costs, or the cost share of intermediate inputs increases. The latter is because of a larger "double marginalization" effect (Rotemberg and Woodford, 1995; Basu, 2019): primary inputs are marked up more times during production, which increases the profit share.

With the decomposition in mind, the next two sections show that an increase in the markup induces input substitution which would changes the cost shares, and in turn changes the labor share.

3. Intermediate Input Substitution

In this section, I endogenize input choice in a model with a simple input-output structure and fixed primary input supply. To introduce market power, I use a standard monopolistic competition structure.[1] A final good is produced using a unit measure of varieties with a CES technology,

$$Q = \left(\int_0^1 q(i)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}.$$

The markup is pinned down by the elasticity of substitution, $\mu = \frac{\sigma}{\sigma-1}$. Each variety is produced by a monopoly using capital, labor, and an intermediate input with a nested CES

[1] Market structure does not matter for my analysis besides introducing a markup, as I take the markup as given.

production function,[2]

$$q(i) = f(g(k(i), l(i)), m(i)) = \left(\alpha^{\frac{1}{\nu}} g(k(i), l(i))^{\frac{\nu-1}{\nu}} + (1-\alpha)^{\frac{1}{\nu}} m(i)^{\frac{\nu-1}{\nu}}\right)^{\frac{\nu}{\nu-1}},$$

where

$$g(k(i), l(i)) = \left(\gamma^{\frac{1}{\rho}} k(i)^{\frac{\rho-1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} (Al(i))^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}},$$

where A is labor-augmenting productivity. The firms are symmetric, so that aggregate inputs equal each firm's inputs, $K = k(i), L = l(i), M = m(i), \forall i$. We can then write the aggregate production function as, $Q = f(g(K, L), M)$. The final output is used for consumption, investment, and as intermediate input.

Given the markup, producers minimize cost, leading to the following optimality conditions,

$$\frac{\partial Q}{\partial K} = \mu R, \qquad \frac{\partial Q}{\partial L} = \mu W, \qquad \frac{\partial Q}{\partial M} = \mu,$$

where I have made use of the fact that individual producers have the same production function as the aggregate economy, and the price of the intermediate input is the same as the final output, the numeraire. From these conditions, we can solve for the pricing equation,

$$1 = \mu(\alpha c(R, W)^{1-\nu} + (1-\alpha))^{\frac{1}{1-\nu}}, \tag{2}$$

where $c(R, W)$ is the cost of a unit of the capital-labor bundle $g(K, L)$,

$$c(R, W) = (\gamma R^{1-\rho} + (1-\gamma)(W/A)^{1-\rho})^{\frac{1}{1-\rho}}. \tag{3}$$

The cost share of intermediate input thus can be solved as,

$$s_M = \frac{1-\alpha}{\alpha c(R, W)^{1-\nu} + (1-\alpha)}, \tag{4}$$

which only depends on the price of the capital-labor bundle. From equation (2), it follows that an increase in μ decreases the price of the cost bundle.[3] If intermediate and primary inputs are complements as suggested by recent estimates in the literature (Peter and Ruane, 2023), equation (4) shows that the cost share of intermediate input increases. According to the decomposition in Section 2, the change in the costs shares lowers the labor share because the double marginalization effect would be larger. If the elasticity is larger than 1,

[2]The nested production functions are widely used in the literature. A few recent examples are Atalay (2017); Oberfield and Raval (2021); Castro-Vincenzi and Kleinman (2022); Peter and Ruane (2023). The nested structure allows us to characterize input substitution following an increase in the markup using two elasticities of substitution, and perfectly separate intermediate input substitution and capital-labor substitution.

[3]In the model, this could only come from a decrease in σ, which itself could result from anything that lowers competition in the market. Allowing for heterogeneous firms, increased competition could raise aggregate markup if resources reallocate from low markup firms to high markup firms (Autor et al., 2020). To study these possibilities, the markup and the market structure should be made endogenous. I will not delve into the exact source of the increase in the markup. Grossman and Oberfield (2022) argue that this is an important question for understanding what fundamental factors drive down the labor share.

the labor share increases in response to an increase in the markup. In the presence of market power, the substitution between primary and intermediate inputs changes the labor share. Otherwise, this effect vanishes as profit is always zero.

4. Capital-Labor Substitution

This section introduces capital accumulation by embedding the above production structure into a neoclassical growth model, while keeping labor supply exogenous, as in Ball and Mankiw (2023).[4]

A representative agent maximizes life-time utility, $\sum_0^\infty \beta^t U(C_t)$, where $U(C_t)$ is the instantaneous utility function and t indexes time. Technology and labor supply stays constant.[5] The representative agent's budget constraint is given by,

$$C_t + K_{t+1} = (R_t + 1 - \delta)K_t + W_t L_t + \Pi_t,$$

where Π_t represents profits, and δ is the depreciation rate.

Utility maximization leads to the Euler equation,

$$U'(C_t) = \beta U'(C_{t+1})(1 + R_{t+1} - \delta).$$

At the steady state, the Euler equation implies a constant rental rate of capital,

$$R = \frac{1}{\beta} - 1 + \delta.$$

From the cost minimization condition for capital, it follows an increase in μ increases the marginal product of capital. Capital accumulation is deterred by the increase in the markup, as an increased marginal product of capital implies a lower capital-labor ratio under decreasing marginal product of capital (Ball and Mankiw, 2023). Intuitively, this is because capital owners receive a smaller share of the marginal product of capital as the markup increases, which lowers the incentive to invest.

From equation (2), allowing for capital accumulation would not change $c(R, W)$, a fixed rental cost of capital results in a lowered wage. The relative cost of capital increases, inducing the firms to substitute labor for capital. From equation (3), the cost share of labor in primary inputs is,

$$\eta_L = \frac{(1-\gamma)(W/A)^{1-\rho}}{\gamma R^{1-\rho} + (1-\gamma)(W/A)^{1-\rho}}. \tag{5}$$

[4] I focus on the long run changes in the labor share as in the recent literature. In this case, it would not matter if we allow for endogenous labor supply or not. As can be seen below, the cost of the capital-labor bundle is pinned down by the markup, and the rental rate of capital is determined by preference parameters in the steady state. Wage in the steady state is thus pinned down in the demand side, so are the input shares. Allowing for endogenous labor supply only affects total labor supply in this economy, but will not change my analysis.

[5] Allowing for technical change and population growth would not change the results. But if technology changes we have to study the balanced growth path, which requires additional assumption on the utility function.

For the usual case of capital-labor complementarity, the cost share of labor in primary inputs is lowered. Capital-labor substitution induced by an increase in the markup also tends to lower the labor share. The opposite is true when the inputs are substitutes.

5. Quantitative Evaluation

This section performs a simple calibration to gauge the quantitative importance of input substitution. To reconcile the conflict between a large markup estimated in the literature and a small observed profit share in the data, I introduce an overhead labor ϕ as in Ball and Mankiw (2023). The capital-labor bundle now is given as,

$$g(K, L) = \left(\gamma^{\frac{1}{\rho}} K^{\frac{\rho-1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} (A(L-\phi))^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}}.$$

The overhead introduces an adjustment to the computation of the labor share, now given as,

$$\frac{WL}{Y} = \frac{L}{L-\phi} \frac{(1-\gamma)(W/A)^{1-\rho}}{\gamma R^{1-\rho} + (1-\gamma)(W/A)^{1-\rho}} \frac{1}{\mu + (\mu-1)\frac{1-\alpha}{\alpha c(R,W)^{1-\nu}}}. \tag{6}$$

The first term on the right-hand side is the adjustment factor. Following Ball and Mankiw (2023), I assume the ratio of the overhead to total labor supply is constant,[6] such that the adjustment factor is invariant to changes in the markup, and would not drive changes in the labor share.

Although the production function is specified at the firm level, the elasticities of substitution should be viewed as aggregate elasticities as our symmetric firm assumption does not allow for between-firm reallocation (Oberfield and Raval, 2021). I thus set the elasticity between capital and labor at $\rho = 0.6$, roughly in the middle of the range of estimates reported in Oberfield and Raval (2021) and consistent with existing estimates in the literature (Chirinko, 2008). Most estimates of the elasticity between primary and intermediate inputs however are at the firm or industry level, see, for example, those reported in Atalay (2017); Oberfield and Raval (2021); Castro-Vincenzi and Kleinman (2022); Peter and Ruane (2023). I set $\nu = 0.6$, which is in the range of the industry estimates reported in these studies. These estimates ignores between-industry reallocation, which is probably less important than within-industry reallocation as firm products within an industry are much more substitutable. Thus, the aggregate elasticity is probably not so much higher than these industry estimates. Nevertheless, I also report results for a higher elasticity, $\nu = 0.8$.

With the markup given, we are able to compute the labor share if we know the cost shares of inputs and the ratio of overhead over total labor employment, ϕ/L using equation (6). The nested production structure allows us to solve for these objects sequentially. First, from equation (2) we can solve for $c(R, W)$, which allows us to compute the cost share of intermediate input following equation (4), if we know α. The cost share of labor in primary inputs can then be solved from equation (3) if we know $\gamma R^{1-\rho}$, an object which is held constant in the analysis. I thus only have to calibrate three objects, ϕ/L, $\gamma R^{1-\rho}$, and α,

[6] This could be rationalized in a model where fixed cost is at the firm level, and the growth in labor supply is absorbed by more firms while firm size stays constant.

without worrying about the deeper parameters like β and γ. I call $\gamma R^{1-\rho}$ adjusted capital cost as it determines the cost share of labor in primary inputs.

I calibrate these objects to match three empirical moments: the profit share of GDP at 6%, the intermediate share of gross output at 50%, and the labor share of GDP at 65%. The link between the data moments and the the parameters is clear to see. Given the markup, the cost share of intermediate input can be pinned down by the intermediate input share of gross output. The cost share of labor and the ratio of overhead over total labor employment then jointly determine the profit share of GDP and the labor share. Table 1 summarizes the calibration strategy.

Table 1: Baseline Calibration Strategy

Parameter	Meaning	Value	Target/Source
ρ	EoS between K and L	0.6	Oberfield and Raval (2021)
ν	EoS between K-L and M	0.6	Oberfield and Raval (2021)
ϕ/L	Share of overhead in labor input	0.42	Profit share of GDP = 6%
$\gamma R^{1-\rho}$	Adjusted capital cost	0.37	Labor share of GDP = 65%
α	Weight on primary inputs	0.442	Intermediate share of GO = 50%

Note: EoS stands for elasticity of substitution. GO stands for gross output. I also experiment with $\nu = 0.8$, in which case the calibrated value of $\gamma R^{1-\rho}$ and α would change slightly.

Following Ball and Mankiw (2023), I set the baseline markup at 1.2, and compute the counterfactual labor share when the markup is raised to 1.25. Table 2 reports that such an increase in the markup leads to a 7.5 percentage point reduction in labor share, roughly consistent with the observed reduction of U.S. labor share since its peak in the 1950s.[7] The counterfactual markup amounts to a 4.2% increase, much smaller than the estimates of De Loecker et al. (2020) but consistent with evidence documented in Traina (2018) and Raval (2023). This paper is not about the measurement of markups. This finding however confirms a pointed raised by Basu (2019): a large increase in the markup could imply a much larger decline in the labor share than that observed in data. Without some counteracting forces that substantially increase the labor share, the labor share decline puts a constraint on the size of the increase in the markup. As estimating the markup is empirically very challenging (Bond et al., 2021), the indirect evidence from changes in the labor share should not be ignored.

Table 2 also reports the counterfactual labor share when I gradually allow for input substitution using the decomposition in Section 2. In particular, I compute the counterfactual labor share using $\mu = 1.25$ according to Equation (6), while using the cost shares at their baseline value in Column (1), using the counterfactual s_M and keeping η_L at its baseline value in Column (2), and using the counterfacutal s_M and η_L in Column (3). The percentage contribution of each effect is computed from these counterfactuals.[8] Input substitution

[7] Adjusting for measurement issues, the decline in the labor share could be even smaller (Grossman and Oberfield, 2022). In this case, the increase in the markup over-predicts the decline in the labor share.

[8] The percentage change is computed as the ratio the log change in the labor share when adding an effect to the log difference between the baseline and the counterfactual labor share.

Table 2: Rising Markup and Declining Labor Share

Baseline:$\mu = 1.2$	Counterfactual:$\mu = 1.25$		
	(1) no substitution	(2) M substitution	(3) KL substitution
Elasticity of Substitution between primary and intermediate inputs $\nu = 0.6$			
Counterfactual Labor Share	0.6	0.594	0.575
Additional Change	0.05	0.006	0.019
Percentage contribution	65.2%	7.9%	26.9%
Elasticity of Substitution between primary and intermediate inputs $\nu = 0.8$			
Counterfactual Labor Share	0.6	0.597	0.578
Additional Change	0.05	0.003	0.019
Percentage contribution	58.0%	4.1%	27.9%

Note: This table reports the decomposition of the labor share decrease when markup is raised up to 1.25. I compute the counterfactual labor share using $\mu = 1.25$ according to Equation (6) while switching on the substitution effects gradually. In particular, I keep the cost shares at their baseline value in Column (1), use the counterfactual s_M while keeping η_L at its baseline value in Column (2), and use the counterfacutal s_M and η_L in Column (3). In each case, I report the counterfactual labor share, additional change in the labor share due to the newly added effect, and the percentage contribution of the additional changes.

contributes to roughly a third of the total decline, with capital-labor substitution playing a much larger role than intermediate input substitution. These findings point to the importance of considering equilibrium effects in analysing the impact of an increase in the markup on the labor share.

Finally, Table 2 also shows that assuming a larger elasticity of substitution between primary and intermediate inputs leads to a slightly smaller reduction in the labor share following the increase in the markup. As expected, the most significant change is reduced contribution of the intermediate substitution effect, while the contribution of capital-labor substitution increases.

6. Conclusion

This paper explores the impact of induced input substitution following an increase in the aggregate markup on the labor share. With a simple calibration, I show that a 4% increase in the markup could explain the observed decline in the labor share in recent decades in full. Input substitution accounts for roughly one third of the total impact. The findings highlight the importance of induced input substitution in evaluating the impact of an increase in market power.

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