Market Power and Labor Market Trends *

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Abstract

Market power has been rising while wage polarization and wage growth have both slowed down in the United States since 2000. Over the same time period, routine labor share has continued downward trend whereas non-routine labor share has turned to decline from the previous rise, which results in the dramatic decline of aggregate labor share. I develop a general equilibrium model which incorporates the job polarization mechanism into monopolistic competition to explore the role of market power on these labor market trends. Comparative static analysis suggests rising market power qualitatively contributes to these trends. The calibrated model can quantitatively account for the trends with the magnitude of increase in markups close to the higher end of range in the literature. Empirically, I find that increases in industry concentration are associated with declines in aggregate labor share, declines in labor share across non-routine and routine occupations, and stagnation of growth in wages per efficiency unit of labor across both occupational groups.

Keywords: Market Power, Wage Polarization, Labor Share, Skill Price

JEL Codes: D4, E24, E25, J31

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1 Introduction

Thriving competition is an essential component of a well-functioning market economy and changes in the degree of competition have vital implications for resource allocation. Empirical investigations have found a broad-based secular rise in market power in the United States at least as far back as 2000 (Barkai (2016), De Loecker and Eeckhout (2017), Hall (2018), Covarrubias et al. (2019), and others). In this paper, I develop a general equilibrium model to demonstrate how a set of post-2000 labor market trends in the United States, including the stagnation of wage growth, the slowdown of wage polarization, the decline of aggregate labor share and the distinct labor share trends across routine and non-routine occupations, can be both qualitatively and quantitatively accounted for by the rising market power. Exploiting cross-industry variation, I find suggestive evidence supporting most of the testable hypotheses.

I start by presenting a set of post-2000 labor market trends in the United States. Using micro-level data collected from Annual Social and Economic Supplement (ASEC) of the Current Population Survey (CPS) I show that wage polarization-the comparatively high growth of wage in non-routine occupations relative to routine occupations-has slowed down and wage growth across both occupational groups has stagnated since 2000, even after controlling for the education level and demographic composition. Meanwhile, routine labor share has continued downward trend whereas non-routine labor share has turned to decline from the previous rise, which results in the dramatic post-2000 decline of aggregate labor share.

I then develop a general equilibrium model that relates the set of labor market trends to the rising market power. Monopolistically competitive firms differentiate an intermediate input into a continuum of final goods and sell them at a constant markup over marginal cost. A perfectly competitive intermediate good sector produces the intermediate input with capital, non-routine task labor and routine task labor using a constant elasticity of substitution (CES) technology and, following the job polarization literature, the technology features non-routine task labor being more complementary to capital than routine task labor (capital-task complementarity, henceforth).

Increases in markups of the final goods producing firms reduce the real price (in units of the final goods composites) of the intermediate input, and thus impose downward adjustment pressure on both the output and demand for all factors of production in the intermediate good sector. Drop in demand, in particular, slows down the accumulation of capital, reducing the capital-labor ratio. The reduced capital-labor ratio decreases the marginal product of labor and, together with the drop in the real price of intermediate good, reduces the real wage for both tasks. Moreover, the lower capital-labor ratio disproportionately hurts the non-routine task labor through the capital-task complementarity effect, thus slows down the wage polarization and induces more labor to work in the routine task, reducing the wage-bill ratio of non-routine to routine task. Changes in capital-labor ratio and non-routine to routine labor ratio affect the shares of each factor in business costs for nonunitary elasticities of substitution. Additionally, rises in markups increase the profit share and reduce the business cost relative to income, which tends to reduce the labor share of income across both tasks.

To quantitatively evaluate the model performance of the variables of interest for the post-2000 period, I calibrate the initial steady state of the model to match the level of variables of interest measured at the start of the sample period (1996-2000). Then I compare variables of interest measured at the end of sample period (2011-2015) with those generated at a new steady state that differs from the initial one due to the observed changes in the exogenous variables, including markups, the investment-specific technology and real risk-free interest rate, which are used to capture the changes of the macroeconomic environment. Counterfactual analysis are used to quantify separately the role of each individual exogenous variable.

The model generates a decline in routine labor share, increases in non-routine wage premium and relative labor share between non-routine and routine occupations by magnitudes close to the observed changes in the data. It over predicts the skill prices a bit and doesn't generate enough decline in aggregate labor share and non-routine labor share, which suggests other channels not incorporated in this model may be at work and/or the estimated increase in markups could be downward biased. Given the large range of magnitude of increase in markups estimated in the literature, I then ask what would be the end value of markups that could fully account for the observed decline of the aggregate labor share and under this value how well this model could capture the changes of other variables of interest. It turns out the required magnitude of increase in markups would be 19 percentage points, which is close to the upper end of range estimated in the literature. Under this higher end value of markups, the model produces changes in most variables of interest by magnitudes very close to those observed in the data. Moreover, the counterfactual analysis indicates that the increase in markups has a quantitatively large effect on most of the variables of interest.

Lastly, I exploit the cross-industry variation in market power and variables of interest and find suggestive evidence for several testable hypotheses derived from the model. Supported by the findings in Covarrubias et al. (2019), I use the change in market concentration as a proxy to the change in market power at the industry level for the post-2000 period. The results show that increases in industry concentration are associated with declines in aggregate labor share, declines in labor share across non-routine and routine occupations, and stagnation of growth in wages per efficiency unit of labor across both occupational groups.

2 Related Literature

There is a growing literature documenting a broad-based secular rise in market power as reviewed in Basu (2019), and it triggers a round of research discussing the macroeconomic implications of the rising market power. Barkai (2016) ties the decline in competition and increase in markups to the decline in aggregate labor share. De Loecker and Eeckhout (2017) discusses the implications of rising market power on the decrease in labor market dynamism as well as the declining aggregate labor and capital share. Gutiérrez and Philippon (2017) relates the decreasing competition to the post-2000 weak investment relative to fundamentals. Farhi and Gourio (2018) links rising market power to the stability of the return to private capital despite of the decreasing risk-free rate, the moderate increase in stock market valuation ratios and weak investment. In a similar spirit, Eggertsson et al. (2018) also ties rising market power, along with the decline of real interest rate, to a set of macro-finance trends, which include the decline of aggregate labor share, the increase in financial wealth-to-output ratio, the increase in measured Tobin's Q and a divergence between the marginal and the average return on capital. My work, which provides a unified explanation based on rising market power for a set of post-2000 labor market trends, naturally contributes to this strand of literature.

My work also relates to the large job polarization literature (Autor et al. (2003), Autor et al. (2006), Autor et al. (2008), Autor and Dorn (2013), and others), which studies the comparatively high growth in employment and wages for non-routine (low and high skilled) occupations relative to routine (middle skilled) occupations. Much discussion of the job polarization literature has centered around the role of technological change (or automation). Autor et al. (2003) and subsequent papers in this literature suggest that the progress in automation reduces the price of machines capable of performing routine tasks and substitutes for labor in such occupations. While labor in non-routine occupations is more complementary to machines in production, the reduced price of machines raises the demand for the non-routine labor. However, very recent studies which examine the quantitative effect of the technological change on the job polarization process find it unsatisfactory to account for the dynamics over time. vom Lehn (2019) finds the observed investment-specific technology growth can not simultaneously reconcile the rapid polarization in the 1980s and 1990s with the much slower polarization since the 2000s. Cortes et al. (2017) also points out that the observed technological change can only account for a relatively small portion of the decline of the routine employment and the associated rise in non-routine manual employment and non-employment. My work relates the rising market power to the post-2000 slowdown of the wage polarization, potentially enriching the understanding of the driving forces of the dynamics of job polarization.

Finally, my paper relates to the expanding literature on the decline in the labor share of income (Elsby et al. (2013),Karabarbounis and Neiman (2014), Rognlie (2016), Autor et al. (2017), Acemoglu and Restrepo (2018), Eden and Gaggl (2018), and others). As already discussed, Barkai (2016), De Loecker and Eeckhout (2017) and Eggertsson et al. (2018) have tied the increase in markups to the decline in aggregate labor share, but none of them has looked into how market power may have differential effect on the labor shares across different occupations. My results show that the rising market power could reduce the relative labor share of non-routine occupations to routine occupations.

3 Empirical Facts

This section presents the macroeconomic trends of interest in this study. I focus on the corporate sector in the United States to exclude the role of housing and avoid the issue with the imputation of proprietor's income. These trends are summarised as four facts.

Fact 1: Market power has been rising. I follow the methodology used in Barkai (2016) to construct the economic profit share using macro-level data and impute markups from it under the assumption of constant return to scale of production.[1]

Figure 1(a) shows the factor shares trends. Labor share exhibits a decline after 2000. Capital share is stable or has decreased moderately since 1980. Profit share shows a mild increase since 1980 and a sharp rise after 2000. The imputed markups mirrors the trend of the profit share and shows a dramatic increase right after 2000 as shown in Figure 1(b).

De Loecker and Eeckhout (2017) and Hall (2018) use micro-level data and different methodologies to estimate markups and also find an upward trend, though the start of the trend and magnitude of increase differ in general. The sharp rise of markups after 2000 shown here is consistent with the findings in Covarrubias et al. (2019), which studies the

[1] See Appendix A for the details of data source and data constructions.

joint evolution of productivity, prices, markups and market concentration and concludes that the year 2000 is the turning point where the decline in competition and the rise in market power started.

Fact 2: Wage polarization has slowed down. The job polarization literature (e.g. Autor et al. (2003), Autor et al. (2006), Autor et al. (2008), Autor and Dorn (2013)) has well documented the wage polarization-the comparatively high growth of wage in non-routine occupations relative to routine occupations-since the 1980s in the United States.[2] The sample period in the literature usually covers up to the early 2000. To look at the recent wage polarization trend, I collect micro-level data to include the sample up to the year 2015 from ASEC of the CPS available through IPUMS (Flood et al. (2015)).[3] I construct the consistent occupation codes using crosswalk files provided by Autor and Dorn (2013) and vom Lehn (2018) and group all occupations into routine and non-routine occupations based on Autor and Dorn (2013).[4] Farm sector, government sector and private household sector are removed from the CPS sample for the comparability with the corporate sector.

Figure 2 shows the non-routine raw average wage premium (i.e. the ratio of the average real wage of non-routine occupations to routine occupations). There is a clear upward trend since the early 1980s which reflects the wage polarization, but the rise slows down after 2000. Both changes in the education level and demographic composition and changes in the skill prices (i.e. wages per efficiency unit of labor) could contribute to the trend change in raw average wage premium. To isolate out the changes in the relative skill price, similar to vom Lehn (2019), I run a Mincerian regression each year, t, to control for the education and

[2]The non-routine occupations include both non-routine abstract occupations which require intuition, judgement and creativity, and non-routine manual occupations which involve physical exertion or interpersonal skills. Routine occupations typically follows strict, pre-specified procedure and are highly repetitive. By the very nature of the routine occupations, these jobs are more susceptible to automation.

[3]To adjust the top-coded wage and salary income in the CPS, I follow vom Lehn (2018) to use the cell means procedure of Larrimore et al. (2008) and fit a Pareto distribution to the upper tail of the income distribution to correct for the internal top coding of the CPS.

[4]Autor and Dorn (2013) does not provide time-consistent coverage for the most recent Census occupational code revision which is implemented in the CPS in 2010. vom Lehn (2018) uses crosswalks provided by the Census and generates a consistent mapping for the years after the most recent revision.

demographic factors' changes:

$$lnw_{i,t} = \beta_{0,t} + \beta_{1,t} NR_{i,t} + \beta_{2,t} X_{i,t} + \epsilon_{i,t} \quad for\ t \in \{1979, 2015\} \tag{1}$$

where $lnw_{i,t}$ is the log wage for individual i in year t. $NR_{i,t}$ is a dummy variable indicating that individual i works in a non-routine occupation in year t. $X_{i,t}$ includes age, age square, indicators for sex, race, education and interaction of indicator for education and age. Regression is weighted by sampling weights. The skill prices for routine and non-routine occupations in year t are constructed as $w_{rt} = exp(\hat{\beta}_{0,t})$ and $w_{nt} = exp(\hat{\beta}_{0,t} + \hat{\beta}_{1,t})$ respectively. The non-routine wage premium (i.e. the relative skill price, $\frac{w_{nt}}{w_{rt}}$) is thus $exp(\hat{\beta}_{1,t})$.

Figure 3 plots the 5-year moving average of non-routine wage premium. The slowdown of the growth is less obvious than that of the raw average wage premium, indicating changes in education level and demographic factors partially account for the trend change. Nevertheless, the post-2000 increase in non-routine wage premium is still slower than the pre-2000 period-it increases by 9.04 percentage points over the period 1984-1999 and only by 5.25 percentage points over the period 2000-2015.[5]

Fact 3: Wage growth has slowed down. Figure 4 shows the raw average wage and skill prices by routine and non-routine occupations. There is a visible slowdown of wage growth around 2000 across both occupational groups and in terms of both raw average wage and skill prices. Eden and Gaggl (2018) also constructs the skill prices by non-routine and routine occupations with the same data source but uses a different methodology-they decomposes the sample into demographic cells and use Fisher's ideal formula to construct chained quantity index of labor, then construct the implicit price deflator as the skill price. Their results also show an apparent slowdown of the growth in skill prices right after 2000.[6]

Fact 4: Labor shares across occupations exhibit distinct trends. The aggregate labor

[5]As mentioned in the section of Related Literature, the slowdown of job polarization since the 2000s is also noted by vom Lehn (2019).

[6]See Panel B1 and B2 of Fig. F.16 in Eden and Gaggl (2018) for their results. The non-routine wage premium constructed using the relative implicit price deflator in their paper also shows a slowdown of increase after 2000.

share of income of the corporate sector in the United States started to decline since 2000, as depicted in Figure 5. I further decompose the aggregate labor share into routine labor share and non-routine labor share based on the earnings ratio of the two occupational groups at each year using data on wage and salary income from the ASEC of CPS.[7] The pre-2000 stability of the aggregate labor share masks the underlying different labor share trends across routine and non-routine occupations-routine labor share has been declining since the start of the sample period and this is offset by the rise in non-routine labor share, leading to the stability on aggregate until 2000. While there is no trend change in the routine labor share, the non-routine labor share turns to decline from the previous rise after 2000. The sharp trend change in non-routine labor share breaks the stability on aggregate and results in the dramatic post-2000 decline in aggregate labor share.[8] The distinct labor share trends by occupations are also confirmed by the empirical findings in vom Lehn (2018) and Eden and Gaggl (2018).[9]

4 Model

In this section, I develop a general equilibrium model that relates the labor market trends documented above to the market power measured by markups as well as to other macroeconomic variables, such as the relative price of investment goods and real risk-free interest rate. The model features the elements that have been traditionally considered by the job polarization literature, which includes the CES aggregate production function with non-routine task

[7]Wage and salary income in the ASEC of CPS data indicates each respondent's total pre-tax wage and salary income-that is, money received as an employee and amounts are expressed as they were reported to the interviewer. It excludes supplements to wage and salary income, while in NIPA the compensation of employees includes wage and salary income, whether paid in cash or in kind, and supplements to wage and salary income. See Chapter 10 of the NIPA Handbook: https://www.bea.gov/sites/default/files/methodologies/nipa-handbook-all-chapters.pdf for the definition of compensation of employees in the national account.

[8]The fact that the post-2000 decline in labor share is driven by the sharp trend change in non-routine labor share is an evidence against the explanation for the decline in labor share since 2000 based on automation; by the very nature of the non-routine occupations, these are the kind of jobs less prone to being automated comparing with routine occupations.

[9]See Fig.2 in vom Lehn (2018) and Panel A of Fig.1 in Eden and Gaggl (2018) for their results.

labor more complementary to capital than routine task labor and endogenous task choice of labor. The difference is that I incorporate these elements into a monopolistic competition (instead of perfect competition) framework. This allows me to study the *implications* of the variation of market power on the labor market.

The horizon is infinite and there is no uncertainty. All agents in the economy have perfect foresight about the evolution of all exogenous driving forces. The setup of the market structure is similar to that in Eggertsson et al. (2018) with the final goods sector being monopolistically competitive and the intermediate good sector being perfectly competitive.

4.1 Final Goods Sector

There is a unit measure of monopolistically competitive final goods firms, indexed by $i \in [0,1]$, that differentiate an intermediate good and sell it to the household. The final goods composite Y_t, assembled by the households and used for both consumption and investment, is a CES aggregate of these differentiated final goods $y_t^f(i)$:

$$Y_t = [\int_0^1 y_t^f(i)^{\frac{\Lambda_t - 1}{\Lambda_t}} di]^{\frac{\Lambda_t}{\Lambda_t - 1}} \tag{2}$$

where $\Lambda_t > 1$ denotes the elasticity of substitution between final goods varieties.

Denote the price of final good variety i as $p_t(i)$. Cost minimization of the households implies the nominal price index of the final goods composite is:

$$P_t = [\int_0^1 p_t(i)^{1-\Lambda_t} di]^{\frac{1}{1-\Lambda_t}} \tag{3}$$

and the demand for final good variety i is:

$$y_t^f(i) = Y_t(\frac{p_t(i)}{P_t})^{-\Lambda_t} \tag{4}$$

Each final goods producer purchases the intermediate good y_t^m from perfectly competitive intermediate good firms and differentiate it according to a linear production technology: $y_t^f = y_t^m$. Final goods firm i takes the intermediate good price p_t^{int}, the the price index of the final goods composite P_t and the aggregate demand for the final goods composite Y_t as given, but chooses price $p_t(i)$ and output $y_t^f(i)$ to maximize profits, subject to the production technology and demand constraints:

$$\max_{\{p_t(i), y_t^f(i)\}} p_t(i) y_t^f(i) - p_t^{int} y_t^f(i)$$

$$s.t. \;\; y_t^f(i) = Y_t (\frac{p_t(i)}{P_t})^{-\Lambda_t}$$

The optimality condition implies that:

$$p_t(i) = \frac{\Lambda_t}{\Lambda_t - 1} p_t^{int} = \mu_t p_t^{int} \tag{5}$$

where $\mu_t \equiv \frac{\Lambda_t}{\Lambda_t - 1}$ is the optimal markup of firm i. Equation (3) and (5) imply $p_t(i) = P_t$ and $p_t^{int} = \frac{1}{\mu_t} P_t$. Equation (4) further indicates $y_t^f(i) = Y_t$. The aggregate profits of final goods firms are thus given by:

$$\Pi_t = \int_0^1 [p_t^f(i) y_t^f(i) - p_t^{int} y_t^f(i)] di = \frac{\mu_t - 1}{\mu_t} P_t Y_t \tag{6}$$

Profits earned by the final goods firms are distributed to the shareholders in the form of dividends:

$$d_t^f = \Pi_t \tag{7}$$

For simplicity of the notation, normalize $P_t = 1$, which implies that the numeraire is the final goods composite.

4.2 Intermediate Good Sector

Intermediate good sector is perfectly competitive. The representative firm produces intermediate good Y_t^m that is used by the final goods firms as input. Intermediate output is produced by a constant return to scale technology in three factors of input - capital, routine task labor and non-routine task labor, according to the following aggregate production function (which takes similar form to that in Krusell et al. (2000)):

$$Y_t^m = [\Phi_1[\Phi_2 K_t^\rho + (1-\Phi_2)L_{nt}^\rho]^{\frac{1}{\rho}\sigma} + (1-\Phi_1){L_{rt}}^\sigma]^{\frac{1}{\sigma}} \tag{8}$$

where L_{jt} is the amount of labor in efficiency unit employed in task j, $j \in \{r, n\}$ with r denoted as routine task and n denoted as non-routine task, and K_t is capital in efficiency unit. σ and ρ ($\sigma, \rho < 1$) govern the elasticity of substitution between capital and labor in different tasks. In particular, $\gamma_n \equiv \frac{1}{1-\rho}$ is the elasticity of substitution between capital and non-routine labor and $\gamma_r \equiv \frac{1}{1-\sigma}$ is the elasticity of substitution between routine labor and the composite product of capital and non-routine labor. I follow the standard hypothesis in the job polarization literature to assume that non-routine labor is more complementary with capital than is routine labor (i.e. $\gamma_n < \gamma_r$ or $\sigma > \rho$).

The representative intermediate good firm rents capital at rate r_t and rents labor doing task j at skill price w_{jt} from the household, and sells its output at price $p_t^{int} = \frac{1}{\mu_t}$ to the final goods firms. The profit maximization problem of the representative firm is:

$$\max_{\{K_t, L_{rt}, L_{nt}\}} \frac{1}{\mu_t} Y_t^m - W_{rt}L_{rt} - W_{nt}L_{nt} - r_t K_t$$

The first-order conditions for the representative firm's problem are:

$$W_{nt} = \frac{1}{\mu_t}\frac{\partial Y_t^m}{\partial L_{nt}} = \frac{1}{\mu_t}\Phi_1(1-\Phi_2)(Y_t^m)^{1-\sigma}(\Phi_2 K_t^\rho + (1-\Phi_2)L_{nt}^\rho)^{\frac{\sigma-\rho}{\rho}} L_{nt}^{\rho-1} \tag{9}$$

$$W_{rt} = \frac{1}{\mu_t}\frac{\partial Y_t^m}{\partial L_{rt}} = \frac{1}{\mu_t}(1-\Phi_1)(Y_t^m)^{1-\sigma}L_{rt}^{\sigma-1} \tag{10}$$

$$r_t = \frac{1}{\mu_t}\frac{\partial Y_t^m}{\partial K_t} = \frac{1}{\mu_t}\Phi_1\Phi_2(Y_t^m)^{1-\sigma}(\Phi_2 K_t^\rho + (1-\Phi_2)L_{nt}^\rho)^{\frac{\sigma-\rho}{\rho}}K_t^{\rho-1} \tag{11}$$

The factors' prices are equal to their marginal revenue product (i.e. the marginal product times the price of the intermediate good, $\frac{1}{\mu_t}$).

The first-order conditions of the representative intermediate good firm's problem give some intuitions about how changes in factor quantities affect the non-routine wage premium, $\frac{W_{nt}}{W_{rt}}$. To see this, dividing equation (9) by equation (10), I obtain the following expression for the non-routine wage premium:

$$\frac{W_{nt}}{W_{rt}} = \frac{\Phi_1(1-\Phi_2)}{1-\Phi_1} \underbrace{(\Phi_2(\frac{K_t}{L_{nt}})^\rho + (1-\Phi_2))^{\frac{\sigma-\rho}{\rho}}}_{\text{capital-task complementarity effect}} \overbrace{(\frac{L_{rt}}{L_{nt}})^{1-\sigma}}^{\text{relative quantity effect}}$$

where there are two components that affect the non-routine wage premium. The first component is the capital-task complementarity effect, $(\Phi_2(\frac{K_t}{L_{nt}})^\rho + (1-\Phi_2))^{\frac{\sigma-\rho}{\rho}}$. Under the assumption that non-routine task labor is more complementary with capital than is routine task labor (i.e. $\sigma > \rho$), an increase in capital tends to increase the non-routine wage premium, as it drives up the relative demand for non-routine task labor. The second component is the relative quantity effect, $(\frac{L_{rt}}{L_{nt}})^{1-\sigma}$. An increase in the routine task labor in efficiency units relative to non-routine task labor in efficiency units tends to increase the non-routine wage premium as $\sigma < 1$.

4.3 Household

A representative household has a unit measure of members, indexed by identifier $\tau \in [0,1]$, with the vector of efficiencies $(h(\tau), \xi)$ for non-routine task and routine task respectively. It is convenient to choose a functional form for $h(\tau)$ to permit analytic solutions; following Beaudry et al. (2016), I assume $h(\tau) = \tau^{-\frac{1}{2}}$. The household purchases final goods from the final goods firms and assembles them into final goods composite which are used for both consumption and investment. One unit of the consumption good is identical to one unit of the final goods composite. The household has free access to an investment specific technology which converts one unit of final goods composite into q_t efficiency units of investment good. Arbitrage thus implies that $\frac{1}{q_t}$ is the relative price of investment good to consumption good. Increase in q_t reflects improvement in the investment-specific technology which lowers the relative price of investment good. Investment good is used to augment capital stock which is rented to the intermediate good firm at r_t. Members of the household are allocated to non-routine task and routine task at skill prices W_{nt} and W_{rt} respectively. The household owns all shares of the portfolio of the securities of the final goods firms, which gives the rights to all future dividends d_t^f of these firms.

The representative household's problem is:

$$\max_{\{C_t, I_t, K_{t+1}, \bar{\tau}_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \log(C_t)$$

$$s.t.\ C_t + \frac{1}{q_t} I_t \leq W_{nt} \int_0^{\bar{\tau}_t} h(\tau) d\tau + W_{rt} \int_{\bar{\tau}_t}^1 \xi d\tau + r_t K_t + d_t^f$$

$$K_{t+1} = I_t + (1-\delta) K_t \tag{12}$$

K_0 is given. $\bar{\tau}_t$ is the cut-off value of the identifier: members with an identifier below $\bar{\tau}_t$ (ranked as relatively more efficent in terms of doing non-routine task) will be assigned to the non-routine task; those with an identifier above $\bar{\tau}_t$ will be assigned to the routine task.

The first-order condition with respect to $\bar{\tau}_t$ is:

$$W_{nt} h(\bar{\tau}_t) - W_{rt} \xi = 0 \Rightarrow \frac{W_{nt}}{W_{rt}} = \frac{\xi}{\bar{\tau}_t^{-\frac{1}{2}}} = \xi (\bar{\tau}_t)^{\frac{1}{2}} \tag{13}$$

Equation (13) relates the the cut-off value identifier, $\bar{\tau}_t$, to the non-routine wage premium, $\frac{W_{nt}}{W_{rt}}$. In particular, an increase in the non-routine wage premium induces more members to be assigned in the non-routine task and less in the routine task, as reflected by a higher $\bar{\tau}_t$.

The first-order condition with respect to capital is:

$$r_{t+1} = \frac{1}{q_t}(\frac{C_{t+1}}{C_t\beta} - \frac{1-\delta}{\frac{q_{t+1}}{q_t}}) \tag{14}$$

This condition expresses rental rate of capital, r_{t+1}, as a function of the relative price of investment good, $\frac{1}{q_t}$, the inverse of the consumption based discount factor (or, equivalently the gross real interest rate of a riskless bond denominated in units of consumption good), $\frac{C_{t+1}}{C_t\beta}$, and capital gains from undepreciated capital, $\frac{1-\delta}{\frac{q_{t+1}}{q_t}}$. This equation can be interpreted as the no arbitrage condition of the household between investing in a riskless bond and physical capital. An increase in investment-specific technology, reflected by an increase in q_t, reduces the amount of consumption good needed to give up in order to invest in one unit of investment good, thus reducing the required rate of return of capital.[10] Arbitrage also implies that a decrease in the gross real interest rate of a riskless bond, $\frac{C_{t+1}}{C_t\beta}$, reduces the rental rate of capital. An increase in the depreciation rate, δ, requires a higher rate of return to invest in capital.

4.4 Equilibrium

Given a sequence of exogenous variables, I define an equilibrium for this economy as a sequence of prices:

$$\{W_{nt}, W_{rt}, r_t, p_t(i), p_t^{int}, P_t\}$$

and a sequence of quantities:

$$\{C_t, K_t, I_t, L_{nt}, L_{rt}, Y_t, \bar{\tau}_t, Y_t^m, y_t^f(i), \Pi_t, d_t^f\}$$

[10]However, an increase in the rate of technology change, $\frac{q_{t+1}}{q_t}$, decreases the capital gain from holding capital, requiring a higher rate of return in order to make the household indifferent between capital and bond, and thus attenuates the decline of the rental rate.

such that:

1. Given $\{W_{nt}, W_{rt}, r_t, d_t^f\}$, $\{C_t, K_{t+1}, I_t, \bar{\tau}_t\}$ solves the representative household's problem.

2. Given $\{Y_t, P_t, p_t^{int}\}$, $\{p_t(i), y_t^f(i)\}$ solves the final goods firm i's problem.

3. Given $\{W_{nt}, W_{rt}, r_t\}$, $\{L_{nt}, L_{rt}, K_t, Y_t^m\}$ solves the representative intermediate good firm's problem.

4. Y_t satisfies (2), P_t satisfies (3) and is normalized to be 1, Π_t satisfies (6), d_t^f satisfies (7) and Y_t^m satisfies (8).

5. Markets for final goods, non-routine task labor, routine task labor and capital need to clear at each period. Final goods market clearing:

$$Y_t = C_t + \frac{I_t}{q_t} \tag{15}$$

Labor market clearing:

$$L_{nt} = \int_0^{\bar{\tau}_t} h(\tau) d\tau \tag{16}$$

$$L_{rt} = \int_{\bar{\tau}_t}^1 \xi d\tau \tag{17}$$

As both the demand and the supply of physical capital at period t are denoted as K_t, it implicitly implies capital market clearing.

4.5 Steady State

For a sequence of constant exogenous variables, I define a steady state solution of the model as all endogenous variables being constant, and denoted as $\{W_n, W_r, r, p(i), p^{int}, P\}$ and $\{C, K, I, L_n, L_r, Y, \bar{\tau}, Y^m, y^f(i), \Pi, d^f\}$. Imposing this steady state condition, I obtain the following conditions to characterize the steady state values of the endogenous variables:

$$\frac{W_n}{W_r} = \xi(\bar{\tau})^{\frac{1}{2}} \tag{18}$$

$$\beta(r + \frac{1-\delta}{q}) = \frac{1}{q} \tag{19}$$

$$I = \delta K \tag{20}$$

$$Y = C + \frac{I}{q} \tag{21}$$

$$L_n = 2\bar{\tau}^{\frac{1}{2}} \tag{22}$$

$$L_r = (1-\bar{\tau})\xi \tag{23}$$

$$W_n = \frac{1}{\mu}\Phi_1(1-\Phi_2)Y^{1-\sigma}(\Phi_2 K^\rho + (1-\Phi_2)L_n^\rho)^{\frac{\sigma-\rho}{\rho}} L_n^{\rho-1} \tag{24}$$

$$W_r = \frac{1}{\mu}(1-\Phi_1)Y^{1-\sigma}L_r^{\sigma-1} \tag{25}$$

$$r = \frac{1}{\mu}\Phi_1\Phi_2 Y^{1-\sigma}(\Phi_2 K^\rho + (1-\Phi_2)L_n^\rho)^{\frac{\sigma-\rho}{\rho}} K^{\rho-1} \tag{26}$$

$$Y = [\Phi_1(\Phi_2 K^\rho + (1-\Phi_2)L_n^\rho)^{\frac{\sigma}{\rho}} + (1-\Phi_1)L_r^\sigma]^{\frac{1}{\sigma}} \tag{27}$$

$$Y = Y^m = y^f(i) \tag{28}$$

$$d^f = \Pi = \frac{\mu - 1}{\mu}Y \tag{29}$$

$$p(i) = P = 1 \tag{30}$$

$$p^{int} = \frac{1}{\mu}P = \frac{1}{\mu} \tag{31}$$

Equations (18)-(31) pins down the steady state values of the endogenous variables.

5 Comparative Static Analysis

The qualitative results from the comparative static analysis support the hypothesis that the rise in markups contributes to the post-2000 slowdown of the wage polarization, the wage stagnation of both routine and non-routine occupations, the decline of aggregate labor share and, under a certain range of the elasticities of substitution in the production function, the distinct labor share trend changes across the two occupational groups. These results are summarized by the following propositions.

Proposition 5.1 *The following comparative static results hold:*

1. $\frac{\partial K}{\partial \mu} < 0$. *An increase in steady state markups decreases capital stock.*

2. $\frac{\partial W_n}{\partial \mu} < 0$ *and* $\frac{\partial W_r}{\partial \mu} < 0$. *An increase in steady state markups decreases the skill prices of both non-routine task and routine task.*

3. $\frac{\partial \frac{W_n}{W_r}}{\partial \mu} < 0$. *An increase in steady state markups decreases the non-routine wage premium.*

4. $\frac{\partial \bar{\tau}}{\partial \mu} < 0$. *An increase in steady state markups decreases (increases) the employment of workers in non-routine task (routine task).*

Proof. See Appendix C. ■

When the market power of the final goods firms increases, they set a higher price over the marginal cost which is the price of the intermediate good. This decreases the real price of the intermediate good (i.e. the price in units of the final goods composites), imposing downward adjustment pressure on both the output and the demand for all factors of production. In particular, it slows down the accumulation of capital and tends to decrease the capital-labor ratio, thus reducing the marginal product of labor and, together with the drop in the real price of the intermediate good, decreasing the skill prices of both tasks. Trough the capital-task complementarity effect, the reduced capital-labor ratio tends disproportionately hurt the non-routine labor, decreasing the non-routine wage premium. A reduced non-routine wage premium induces less worker to be employed in the non-routine task and more in the routine task, thus also reducing the wage-bill ratio of non-routine to routine task, $\frac{W_n L_n}{W_r L_r}$.[11]

The aggregate labor share LS_t, routine labor share RLS_t, non-routine labor share NLS_t, capital share CS_t, profit share PS_t and business cost BC_t are defined by the following equations:

$$LS_t \equiv \frac{W_{nt}L_{nt} + W_{rt}L_{rt}}{Y_t}$$

$$RLS_t \equiv \frac{W_{rt}L_{rt}}{Y_t}$$

$$NLS_t \equiv \frac{W_{nt}L_{nt}}{Y_t}$$

$$CS_t \equiv \frac{r_t K_t}{Y_t}$$

$$PS_t \equiv \frac{\Pi_t}{Y_t}$$

$$BC_t \equiv W_{nt}L_{nt} + W_{rt}L_{rt} + r_t K_t$$

Denote the ratio of aggregate labor income $(W_{nt}L_{nt} + W_{rt}L_{rt})$ to business cost as LC_t, the ratio of routine labor income $(W_{rt}L_{rt})$ to business cost as RLC_t and the ratio of non-routine labor income $(W_{nt}L_{nt})$ to business cost as NLC_t. The definitions of labor share directly imply that labor share can be expressed as the product of the ratio of labor income to business cost and the ratio of business cost to output:

$$LS_t = LC_t(\frac{BC_t}{Y_t}) = LC_t(1 - PS_t)$$

$$RLS_t = RLC_t(\frac{BC_t}{Y_t}) = RLC_t(1 - PS_t)$$

[11] It is easy to see from equations (22) and (23) that $\frac{\partial \bar{\tau}}{\partial \mu} < 0$ directly implies $\frac{\partial L_n}{\partial \mu} < 0$ and $\frac{\partial L_r}{\partial \mu} > 0$. This, together with $\frac{\partial \frac{W_n}{W_r}}{\partial \mu} < 0$, leads to $\frac{\partial \frac{W_n L_n}{W_r L_r}}{\partial \mu} < 0$.

$$NLS_t = NLC_t(\frac{BC_t}{Y_t}) = NLC_t(1 - PS_t)$$

where the second steps reflect the fact that output is the sum of business cost and profit.

Markups affect labor share through affecting these two components. First, an increase in markups unambiguously increases the profit share. This can be seen directly by equation (29) and the definition of profit share. An increase in profit share implies a decrease of business cost relative to output which tends to decrease the labor share in aggregate and across both tasks. Second, an increase in markups changes the labor income relative to business cost through affecting the relative factor quantities-it reduces the capital-labor ratio by slowing down the accumulation of capital and further decreases non-routine to routine labor ratio due to the capital-task complementarity effect. The exact effect on labor income relative to business cost hinges on the range of the elasticities of substitution between capital and labor in different tasks. Under the assumption that non-routine task labor is more complementary with capital than is routine task labor (i.e. $\gamma_n < \gamma_r$), there are three cases to consider regarding the range of γ_n and γ_r: $\gamma_n \geq 1$, $\gamma_r \leq 1$ and $\gamma_n < 1 < \gamma_r$. The effects of these two channels are summarized by the following proposition.

Proposition 5.2 *The following comparative static results hold:*

1. $\frac{\partial PS}{\partial \mu} > 0$. *An increase in steady state markups increases the profit share.*

2. $\frac{\partial LC}{\partial \mu} > 0$ *and* $\frac{\partial RLC}{\partial \mu} > 0$ *if* $\gamma_n \geq 1$. *An increase in steady state markups increases both aggregate labor income relative to business cost and routine labor income relative to business cost if* $\gamma_n \geq 1$.

3. $\frac{\partial LC}{\partial \mu} < 0$, $\frac{\partial RLC}{\partial \mu} \leq 0$ *(equal to* 0 *only if* $\gamma_r = 1$*) and* $\frac{\partial NLC}{\partial \mu} < 0$ *if* $\gamma_r \leq 1$. *An increase in steady state markups (weakly) decreases aggregate labor income relative to business cost, routine labor income relative to business cost and non-routine labor income relative to business cost if* $\gamma_r \leq 1$.

4. $\frac{\partial RLC}{\partial \mu} > 0$ *and* $\frac{\partial NLC}{\partial \mu} < 0$ *if* $\gamma_n < 1 < \gamma_r$. *An increase in steady state markups increases*

routine labor income relative to business cost and decreases non-routine labor income relative to business cost if $\gamma_n < 1 < \gamma_r$*.*

Proof. See Appendix C. ■

Under the last case where $\gamma_n < 1 < \gamma_r$, $\frac{\partial RLC}{\partial \mu} > 0$ which tends to mitigate the decline in the routine labor share due to the increase in profit share, while $\frac{\partial NLC}{\partial \mu} < 0$ which tends to contribute to the decline in the non-routine labor share jointly with the increase in profit share. The distinct effects of markups on labor share across the two tasks under this case is consistent with the observed post-2000 trend *changes* in labor share across occupations-non-routine labor share turns to decline from the previous rise while there is very limited change in the routine labor share's downward trend.

In Appendix B I show that the investment specific technology tends to increase the non-routine wage premium, skill prices for both tasks, and also has opposite effect to markups for the labor income relative to business cost.

These results support the hypothesis that the investment specific technology drives the long-run trends of non-routine wage premium, skill prices and labor shares, but the rise in markups contributes to the trend *changes* around 2000.

6 Quantitative Analysis

Given the focus of this study on the long-term trend changes starting at around 2000, I calibrate the initial steady state of the model to match the level of variables of interest measured at the start of the sample period (1996-2000).[12] Then I compare variables of interest measured at the end of sample period (2011-2015) with those generated at a new steady state that differs from the initial one due to the observed changes in the (smoothed) exogenous variables which are used to capture the changes of the macroeconomic environment. Counterfactual exercises are used to quantify separately the role of each individual exogenous

[12]Following Karabarbounis and Neiman (2014), I use steady states of the model to represent the simulated trend component of the variables of interest.

variable.[13]

6.1 Measurement of the Exogenous Variables

There are four exogenous variables that I consider to capture the changes of the macroeconomic environment that is potentially of quantitative relevance to the variables of interest; these are the investment-specific technology (q_t), markups (μ_t), depreciation rate (δ_t) and discount factor (β_t) (which is used as a shortcut to reflect the changes in the real interest rate of the riskless bond).

The measurement of the investment-specific technology, or the inverse of the relative price of investment goods to consumption goods, is directly obtained from Federal Reserve Economic Data (FRED).[14] I normalize the 5-year moving average of the relative price of the investment goods at the beginning of the sample (1996-2000) to be one .

Depreciation rate is constructed as the ratio of current-cost depreciation to the sum of current-cost depreciation and current-cost net stock of capital using BEA's Fixed Asset Table 4.1 and 4.4.

Real interest rate of the riskless bond is constructed as the Moody's Aaa corporate bond yield minus the expected inflation rate. I use the three-year moving average of the realized inflation rate to proxy the expected inflation rate. Personal Consumption Expenditures Price Index (PCEPI), obtained via FRED, is used to construct the realized inflation rate.

In steady state $\frac{1}{\beta}$ is equal to the gross real interest rate of a riskless bond.[15] Based on this condition, I vary the discount factor as a short cut to account for the variation in the real interest rate.

The five-year moving average of the exogenous variables at the start and end of the sample is shown in Table 1.

[13]The quantitative analysis strategy used here is similar to Chen et al. (2017).

[14]Specifically, the measurement of the investment-specific technology is the inverse of the series of PIRIC, which is calculated as investment deflator divided by consumption deflator. (DiCecio (2009))

[15]This condition holds in general with log utility, though for simplicity I don't explicitly introduce the riskless bond in the model.

6.2 Calibration

The parameters left to calibrate are efficiency for routine occupation (ξ), weight parameters (ϕ_1, ϕ_2) and elasticities of substitution (γ_n, γ_r) in the production function. The elasticities of substitution would be ideally estimated using micro-level data, but to the best of my knowledge, no reliable micro estimates have been generated in the literature. I instead use the elasticities of substitution estimated using time-series macro-level data by Krusell et al. (2000). The estimates in Krusell et al. (2000) are between skilled, unskilled labor and equipment, which does not exactly match the conceptual framework of this study. However, judging from the skill composition of non-routine and routine occupations and the relative substitutability between labor with different skill level and different types of capital, I treat their estimates as a useful benchmark for this quantitative exercise.[16] Thus, I set $\gamma_n = 0.67$ and $\gamma_r = 1.67$. I then calibrate ϕ_1, ϕ_2 and ξ simultaneously to match the initial level (average between 1996-2000) of routine, non-routine labor share and non-routine wage premium. This gives $\phi_1 = 0.74$, $\phi_2 = 0.54$ and $\xi = 1.36$.

6.3 Simulation

Table 2 summarizes the results. Row 1 shows values for the agggregate labor share LS, the non-routine labor share NLS, the routine labor share RLS, the non-routine wage premium $\frac{W_n}{W_r}$, the relative labor share (or wage-bill ratio) of non-routine to routine occupations $\frac{NLS}{RLS}$,

[16] It is plausible to assume the skilled and unskilled labor defined in Krusell et al. (2000) using college graduation as the criteria as a combination of high skilled and middle skilled and a combination of middle skilled and low skilled respectively. As indicated by the job polarization literature, routine occupation is mostly associated with middle skilled while non-routine is associated with both high skilled and low skilled. In addition, the job polarisation literature also suggests the substitutability between equipment and labor with different skill level is the strongest for middle skilled, then low skilled and the weakest for high skilled. Thus the elasticity of substitution between routine occupation and equipment should be greater than that between unskilled and equipment. The elasticity of substitution between routine occupation and aggregate capital (which also includes structure), however, should be smaller than that between routine occupation and equipment, as the substitutability effect is weaker for structure than equipment. So I use the estimate of the elasticity of substitution between unskilled and equipment in Krusell et al. (2000) as the benchmark for that between routine occupation and aggregate capital. Similar argument applies for using the estimate of the elasticity of substitution between skilled and equipment for that between non-routine occupation and aggregate capital.

the non-routine skill price W_n, and the routine skill price W_r at the start of the sample (five-year moving average between 1996 and 2000).[17] Row 2 shows the corresponding values generated by the initial steady state of the model. By the calibration procedure, the model matches exactly the data at the start of the sample.

Row 3 lists the observed changes of the variables between the start (1996-2000) and the end (2011-2015) of the sample period. Aggregate labor share in the corporate sector of the United States declined by almost 6.4 percentage points, which was accounted for by a 2.5 percentage point decline of non-routine labor share and a almost 3.9 percentage point decline of routine labor share. Non-routine wage premium increased by close to 5.2 percentage points. The relative labor share of non-routine to routine occupations rose by 85.6 percentage points. Skill prices for non-routine and routine occupations increased by a factor of around 1.17 and 1.11 respectively.

Row 4 has the key results of the analysis. It shows the model-generated changes in the corresponding variables, which are calculated as the difference between the initial and final steady states driven by the observed changes in the exogenous variables, as discussed in Section 6.1. The model generates a decline in routine labor share, an increase in non-routine wage premium and relative labor share of non-routine to routine occupations by magnitudes close to the observed changes in the data. It over predicts the skill prices a bit and doesn't generate enough decline in aggregate labor share and non-routine labor share, which suggests other channels not incorporated in this model may be at work and/or the estimated increase in markups could be downward biased.

In the counterfactual analysis, I turn off the effect of each exogenous variable one at a time by reverting it to its initial value while keeping the rest at their end values. Through comparing the results with (row 4) and without (row 5-8) the change of each exogenous variable, it highlights the quantitative role played by each separately.

In row 5, I turn off the channel of investment specific technology. Without the decline in

[17] As mentioned, Skill price is estimated using the Mincerian regression (1). Its value is thus an index number and there is no point in matching the level of this index at the start of the sample.

the relative price of investment goods, the aggregate labor share and non-routine labor share would have declined even much more. This contradicts with the claim in Karabarbounis and Neiman (2014) that the decline in the relative price of investment goods reduces the labor share. Their result critically hinges on the condition that the elasticity of substitution between capital and (aggregate) labor is greater than one[18]. While in this quantitative exercise, the elasticity of substitution between capital and non-routine labor is less than one, which drives the effect of investment specific technology on labor share to the opposite direction. This result is consistent with the preponderant evidence that suggests the elasticity of substitution between capital and labor is less than one. The decline of the relative price of investment goods also has a large effect on lowering the routine labor share, increasing the non-routine wage premium, wage-bill ratio and skill prices.

By comparing row 6 with row 4, it shows the increase in markups plays a significant role in the decline of aggregate labor share and non-routine labor share, while a relatively smaller role in the decline of routine labor share. As shown by proposition 5.2, under $\gamma_n < 1 < \gamma_r$, the increase in markups reduces non-routine labor income relative to business cost and raises profit share, both of which tend to reduce non-routine labor share. While routine labor income relative to business cost is raised by rising markups, which tends to offset the effect of rising profit share on driving the decline of routine labor share. The increase in markups also significantly suppresses the growth of skill prices across both occupations, reduces the non-routine labor share relative to routine labor share, slows down the increase of non-routine wage premium. All these results are consistent with the qualitative analysis.

In row 7, I remove the decline in the real interest rate. This leads to significant changes on all variables of interest. Qualitatively, these effects are the same with those of the investment specific technology, as both the decline in the real interest rate and the decline in the relative price of investment goods affect the variables of interest through lowering the rental cost of

[18] Karabarbounis and Neiman (2014) estimates the elasticity of substitution between capital and labor using cross-country variation in trends in the rental rates and labor shares. Their baseline estimated value is 1.25.

capital.

The depreciation rate doesn't change by much over the sample period. Removing this change in row 8 has no large effect on the variables of interest.

As discussed in the qualitative analysis, the increase in markups affects labor income relative to business cost, non-routine wage premium and skill prices through slowing down the accumulation of capital. I evaluate the model performance of investment, capital stock and investment rate in Table 3. The variables I, K, Y, I/q and $(I/q)/Y$ denote investment in efficiency unit, capital stock in efficiency unit, output in units of consumption goods, investment in units of consumption goods and investment rate. The model produces a 20 percent investment rate which is very close to the 19 percent observed investment rate at the start of sample. The model-generated changes in investment and investment rate are a bit higher than the observed changes in the data. Comparing row 6 with row 4, it nevertheless shows the quantitatively significant role played by the rising markups in slowing down the accumulation of capital, reducing the investment and investment rate.

Given the large range of magnitude of increase in markups estimated in the literature, in the following exercise, I ask what would be the end value of markups that could fully account for the observed decline of the aggregate labor share and under this value how well this model could capture the changes of other variables of interest.

The simulation shows it requires the end value of markups to be 1.23 and this implies a 19 percentage points increase in markups over the sample period. The magnitude of increase would be close to the upper end of range estimated in the literature.[19] Table 4 summarises the results. As shown by row 4, by construction, the model-generated change in aggregate labor share matches exactly the observed change. The magnitudes of changes in non-routine labor share, routine labor share, non-routine wage premium, and relative labor share are all very close to those observed in the data. Under this higher end value of markups the model

[19] In Hall (2018), the estimated markups increase by 14.4 percentage points on average in 15 years. In De Loecker and Eeckhout (2017), the increase is approximately 20 percentage points (1.4 to 1.6) from 1998 to 2013.

over suppresses the growth in the skill prices. Given the potential measurement issues of skill prices, however, the model-generated growth of skill prices may still fall in a reasonable range. As already mentioned, the estimates of skill prices in Eden and Gaggl (2018) exhibits almost no growth after 2000; the model-generate changes in the skill prices are close to their estimates.

The model performance of investment, capital stock and investment rate is summarized in Table 5. With the higher end value of markups, the model-generated changes in investment and investment rate are a bit lower than the observed changes but still close. The accumulation of capital stock is under predicted.

It is a plausible scenario that the magnitude of increase in markups lies between those implied by the two end values shown in the analysis, so the model could account for a bulk of the observed trend changes of the variables of interest. Factors other than markups may also contribute to the trend changes. Nevertheless, even with the lower end value of markups, the counterfactual analysis still indicates that the increase in markups has a quantitatively large effect on most of the variables of interest.

7 Empirical Evidence

In this section, I exploit the cross-industry variation in market power and variables of interest to present correlational evidence for several testable hypothesis derived from the model. In particular, assuming labor mobility is imperfect across industries, the model predicts industries with larger increase in (average) markups will experience smaller increase in non-routine wage premium, smaller increase in skill prices across both routine and non-routine occupations, (tend to experience) larger decrease in labor share in aggregate and across both occupations, smaller increase in the wage-bill ratio of non-routine to routine occupations.

I use the change in market concentration-share of sales by the 4, 8, 20 and 50 largest firms-as a proxy to the change in market power at the industry level. This proxy in general may not be valid, as both a decrease and an increase in competition could lead to an increase in market concentration, as argued in Syverson (2019). However, for the post-2000 period, which is the focus of this study, Covarrubias et al. (2019) shows the increase in concentration is associated with a rise in markups (decline in competition).

I obtain payrolls, sales and concentration by industry at 6-digit NAICS level for year 2002, 2007 and 2012 from US Economic Census' Concentration accounts. Following Barkai (2016), I construct aggregate labor share by industry as the payroll labor share of sales and restrict the samples from Census data to the industries that are consistently defined overtime. I then merge CPS data and Census data based on crosswalk between NAICS and Census industry code provided by Soltas (2019).[20] Table 6 reports descriptive statistics of the concentration ratios and variables of interest of the matched sample.

The empirical specification is a reduced form regression in log differences assessing the cross-sectional correlation across industries between change in concentration and change in variables of interest:

$$\Delta_5 log(Z_{j,t}) = \beta \Delta_5 log(CR^n_{j,t}) + \gamma_t + \epsilon_{j,t} \tag{32}$$

where j and t are the indexes for industry and year respectively, Δ_5 denotes a 5-year change, $Z_{j,t}$ is the variable of interest, $CR^n_{j,t}$ is the share of sales by the n largest firms ($n = 4, 8, 20, 50$) and γ_t is the year fixed effect. The two separate time windows are 2002-2007 and 2007-2012. Standard errors are clustered at the industry level.

Table 7 summarises the results for n=20. The regression coefficients are negative and statistically significant at conventional levels for the regressions of aggregate labor share (2), labor share across both occupations (3,4) and skill prices across both occupations (5,6) on concentration ratios. It indicates rising concentration is associated with the decline in aggregate labor share and labor share across both occupations, the slowdown in the growth of skill prices across both occupations, providing suggestive evidence for the corresponding testable

[20]Within the consistently defined 6-digit NAICS industries, each is mapped into one Census industry. I aggregate the concentration ratios and labor shares to Census industries by taking a sales-weighted average.

hypotheses. However, the coefficients for the regressions of non-routine wage premium (1) and wage-bill ratio (7) are statistically insignificant at conventional levels. The regressions using n=4,8,50 show similar results.[21]

The results that the industries experiencing larger increase in concentration are associated with a larger decline in skill prices supports the claim that the post-2000 increase in concentration is an inefficient outcome due to decline in competition and rise in market power, which is consistent with the conclusions in Covarrubias et al. (2019), but contradicts with the argument in Autor et al. (2017). Autor et al. (2017) argues that if globalization or technological changes drive the expansion of the most productive firms in each industry, product market concentration will rise and aggregate labor share will decline as industries become increasingly dominated by superstar firms, which have a low labor share of value-added. Since more productive firms tend to have a higher marginal product of labor, the argument should imply rising concentration is associated with a higher growth of skill price, which is at odds with the results here.

8 Conclusion

In this paper, I develop a general equilibrium model to provide a unified explanation based on the rising market power for a set of post-2000 labor market trends, including the stagnation of wage growth, the slowdown of wage polarization, the decline of aggregate labor share and the distinct labor share trends across routine and non-routine occupations. The calibrated model can quantitatively account for the trends with the magnitude of increase in markups close to the higher end of range in the literature. Using cross-industry variation, I find suggestive evidence supporting most of the testable hypotheses.

As the quantitative effect of market power hinges on the elasticities of substitution between capital and labor in routine and non-routine tasks, one potential path for future research is to get more precise estimates of these parameters. The cross-industry correlation

[21] See Appendix D for the results for n=4,8,50.

examined in the paper does not suggest tight associations between market power and the non-routine wage premium and the wage-bill ratio of non-routine to routine occupations; designing better empirical strategy to identify the causal effects of market power on the variables of interest is left for future research.

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Tables

Table 1: **5-year Moving Average of the Exogenous Variables**
The table summarizes the values of the 5-year moving average of the exogenous variables of the model at the beginning (1996-2000) and at the end (2011-2015) of the sample. The variables q, μ, β and δ denote investment-specific technology, markups, discount factor and depreciation rate. Investment-specific technology is taken from FRED and is normalized to be one at the beginning of the sample. Markups are imputed from the profit share under the assumption of constant return to scale of production. Discount factor is used as a short cut to account for the variation in the real interest rate of the riskless bond which is constructed as the Moody's Aaa corporate bond yield minus the expected inflation rate. The three-year moving average of the realized inflation rate is used to proxy the expected inflation rate. Personal consumption expenditures index (PCEPI), obtained via FRED, is used to construct the realized inflation rate. Depreciation rate is constructed as the ratio of current-cost depreciation to the sum of current-cost depreciation and current-cost net stock of capital using BEA's Fixed Asset Table 4.1 and 4.4.

	1996-2000	2011-2015
$\frac{1}{q}$	1.0000	0.6462
μ	1.0377	1.1234
$\frac{1}{\beta}$	1.0548	1.0263
δ	0.0824	0.0820

Table 2: **Model Results on Labor Market Trends with μ_1=1.123**

The table summarizes the model results on labor market trends with the end value of markups, μ_1, as 1.123. Row 1 shows the values of the variables of interest at the start of the sample (1996-2000). Row 2 shows the corresponding values generated by the initial steady state of the model which, by the calibration procedure, matches the data exactly. Row 3 lists the observed changes of the variables between the start (1996-2000) and the end (2011-2015) of the sample. Row 4 shows the model-generated changes. Row 5 to 8 show the counterfactual changes with one of the exogenous variables reverted to its initial value. Row 3 to 8 show the changes of W_n and W_r in factors, and the changes of the rest variables of interest in levels. μ_0 and μ_1 denote the value of markups at the start and at the end of the sample, respectively.

μ_0=1.038, μ_1=1.123							
Start of sample (1996-2000)	LS	NLS	RLS	Wn/Wr	NLS/RLS	Wn	Wr
1.Data	0.6294	0.4774	0.1520	1.0637	3.1413	index	index
2.Model	0.6294	0.4774	0.1520	1.0637	3.1413	index	index
End of sample (2011-2015; Δ)	LS	NLS	RLS	Wn/Wr	NLS/RLS	Wn(fac.)	Wr(fac.)
3.Data	-0.0639	-0.0250	-0.0388	0.0517	0.8563	1.1659	1.1116
4.Model	-0.0037	0.0288	-0.0325	0.0579	1.0946	1.2388	1.1749
Counterfactuals (Δ)	LS	NLS	RLS	Wn/Wr	NLS/RLS	Wn(fac.)	Wr(fac.)
5.No q	-0.0361	-0.0182	-0.0179	0.0175	0.2829	1.0055	0.9892
6.No μ	0.0541	0.0792	-0.0251	0.0641	1.2443	1.3874	1.3086
7.No β	-0.0208	0.0044	-0.0252	0.0377	0.6575	1.1133	1.0752
8.No δ	-0.0039	0.0284	-0.0324	0.0576	1.0879	1.2369	1.1734

Table 3: **Model Results on Investment with μ_1=1.123**

The table summarizes the model results on investment, capital stock and investment rate with the end value of markups, μ_1, as 1.123. Row 1 shows the values of the variables of interest at the start of the sample (1996-2000). Row 2 shows the corresponding values generated by the initial steady state of the model. Row 3 lists the observed changes of the variables between the start (1996-2000) and the end (2011-2015) of the sample. Row 4 shows the model-generated changes. Row 5 to 8 show the counterfactual changes with one of the exogenous variables reverted to its initial value. Investment and capital stock are restricted to non-residential. Investment in efficiency unit, I, and capital stock in efficiency unit, K, are constructed as the ratio of the nominal values to the investment deflator (INVDEF, from FRED). Output in units of consumption goods, Y, is the ratio of nominal output to consumption deflator (CONSDEF, from FRED). Row 3 to 8 show the changes of I and K in factors, and the changes of $\frac{(I/q)}{Y}$ in levels. μ_0 and μ_1 denote the value of markups at the start and at the end of the sample, respectively.

μ_0=1.038, μ_1=1.123			
Start of sample (1996-2000)	I	K	(I/q)/Y
1.Data	index	index	0.1903
2.Model	index	index	0.2008
End of sample (2011-2015; Δ)	I(fac.)	K(fac.)	(I/q)/Y
3.Data	1.8112	2.1555	-0.0046
4.Model	1.9013	1.9104	-0.0005
Counterfactuals (Δ)	I(fac.)	K(fac.)	(I/q)/Y
5.No q	1.1894	1.1951	0.0240
6.No μ	2.0626	2.0724	0.0113
7.No β	1.4867	1.4938	-0.0320
8.No δ	1.9033	1.9033	-0.0001

Table 4: **Model Results on Labor Market Trends with μ_1=1.23**
The table summarizes the model results on labor market trends with the end value of markups, μ_1, as 1.23. Row 1 shows the values of the variables of interest at the start of the sample (1996-2000). Row 2 shows the corresponding values generated by the initial steady state of the model which, by the calibration procedure, matches the data exactly. Row 3 lists the observed changes of the variables between the start (1996-2000) and the end (2011-2015) of the sample. Row 4 shows the model-generated changes. Row 5 to 8 show the counterfactual changes with one of the exogenous variables reverted to its initial value. Row 3 to 8 show the changes of W_n and W_r in factors, and the changes of the rest variables of interest in levels. μ_0 and μ_1 denote the value of markups at the start and at the end of the sample, respectively.

μ_0=1.038, μ_1=1.23							
Start of sample (1996-2000)	LS	NLS	RLS	Wn/Wr	NLS/RLS	Wn	Wr
1.Data	0.6294	0.4774	0.1520	1.0637	3.1413	index	index
2.Model	0.6294	0.4774	0.1520	1.0637	3.1413	index	index
End of sample (2011-2015; Δ)	LS	NLS	RLS	Wn/Wr	NLS/RLS	Wn(fac.)	Wr(fac.)
3.Data	-0.0639	-0.0250	-0.0388	0.0517	0.8563	1.1659	1.1116
4.Model	-0.0639	-0.0236	-0.0403	0.0504	0.9240	1.0867	1.0376
Counterfactuals (Δ)	LS	NLS	RLS	Wn/Wr	NLS/RLS	Wn(fac.)	Wr(fac.)
5.No q	-0.0938	-0.0675	-0.0262	0.0076	0.1186	0.8750	0.8688
6.No μ	0.0541	0.0792	-0.0251	0.0641	1.2443	1.3874	1.3086
7.No β	-0.0798	-0.0465	-0.0333	0.0290	0.4895	0.9727	0.9468
8.No δ	-0.0642	-0.0239	-0.0402	0.0501	0.9173	1.0850	1.0362

Table 5: **Model Results on Investment with μ_1=1.23**

The table summarizes the model results on investment, capital stock and investment rate with the end value of markups, μ_1, as 1.23. Row 1 shows the values of the variables of interest at the start of the sample (1996-2000). Row 2 shows the corresponding values generated by the initial steady state of the model. Row 3 lists the observed changes of the variables between the start (1996-2000) and the end (2011-2015) of the sample. Row 4 shows the model-generated changes. Row 5 to 8 show the counterfactual changes with one of the exogenous variables reverted to its initial value. Investment and capital stock are restricted to non-residential. Investment in efficiency unit, I, and capital stock in efficiency unit, K, are constructed as the ratio of the nominal values to the investment deflator (INVDEF, from FRED). Output in units of consumption goods, Y, is the ratio of nominal output to consumption deflator (CONSDEF, from FRED). Row 3 to 8 show the changes of I and K in factors, and the changes of $\frac{(I/q)}{Y}$ in levels. μ_0 and μ_1 denote the value of markups at the start and at the end of the sample, respectively.

μ_0=1.038, μ_1=1.23			
Start of sample (1996-2000)	I	K	(I/q)/Y
1.Data	index	index	0.1903
2.Model	index	index	0.2008
End of sample (2011-2015; Δ)	I(fac.)	K(fac.)	(I/q)/Y
3.Data	1.8112	2.1555	-0.0046
4.Model	1.7299	1.7382	-0.0133
Counterfactuals (Δ)	I(fac.)	K(fac.)	(I/q)/Y
5.No q	1.0737	1.0788	0.0092
6.No μ	2.0626	2.0724	0.0113
7.No β	1.3473	1.3537	-0.0429
8.No δ	1.7316	1.7316	-0.0129

Table 6: **Descriptive Statistics**
The table shows descriptive statistics of the matched sample. The unit of observation is a Census industry. All numbers for the value and change in value are in units of percentage points. Skill prices are constructed as index numbers, so only the log-change in value of them is economically meaningful and shown here.

	N	Mean	Median	S.D.	Min	Max
Value in 2002						
Sales Share of 4 Largest Firms	174	33.15	30.20	19.57	0.80	92.98
Sales Share of 8 Largest Firms	174	42.25	40.81	22.48	1.40	98.35
Sales Share of 20 Largest Firms	174	52.85	54.42	24.79	2.20	99.82
Sales Share of 50 Largest Firms	174	62.16	64.42	26.10	3.40	100.00
Non-routine Wage Premium	174	114.76	112.01	24.86	38.84	204.99
Aggregate Labor Share	113	24.26	18.02	20.21	1.34	153.78
Non-routine Labor Share	113	19.03	13.74	17.78	1.15	135.62
Routine Labor Share	113	5.24	4.08	4.83	0.19	37.39
Wage-bill ratio	174	481.22	187.31	1419.94	13.59	18086.21
Value in 2012						
Sales Share of 4 Largest Firms	173	34.92	32.30	19.62	0.80	91.26
Sales Share of 8 Largest Firms	173	44.24	42.56	22.47	1.10	100.00
Sales Share of 20 Largest Firms	174	55.33	58.12	24.83	1.80	100.00
Sales Share of 50 Largest Firms	174	64.60	69.90	25.87	3.10	100.00
Non-routine Wage Premium	174	115.00	113.80	27.59	25.29	235.94
Aggregate Labor Share	113	22.86	18.44	16.07	0.51	98.82
Non-routine Labor Share	113	18.33	14.87	14.28	0.40	60.28
Routine Labor Share	113	4.53	3.55	4.33	0.06	38.53
Wage-bill ratio	174	933.03	195.35	6212.60	4.68	81629.09
Change in Value (2002-2012)						
Sales Share of 4 Largest Firms	173	1.92	1.42	6.84	-40.38	25.01
Sales Share of 8 Largest Firms	173	2.10	2.00	6.72	-38.45	27.62
Sales Share of 20 Largest Firms	174	2.49	2.37	5.88	-36.01	23.08
Sales Share of 50 Largest Firms	174	2.44	2.15	5.33	-33.34	15.40
Non-routine Wage Premium	174	0.23	1.53	34.19	-120.14	112.70
Aggregate Labor Share	113	-1.40	-0.71	10.32	-107.43	9.99
Non-routine Labor Share	113	-0.70	-0.24	9.32	-93.93	13.90
Routine Labor Share	113	-0.71	-0.28	2.74	-18.73	4.95
Wage-bill ratio	174	451.81	15.59	4870.41	-2137.58	63542.88
Log-Change in Value (2002-2012)						
Sales Share of 4 Largest Firms	173	0.08	0.07	0.25	-1.69	0.72
Sales Share of 8 Largest Firms	173	0.07	0.06	0.21	-1.37	0.63
Sales Share of 20 Largest Firms	174	0.06	0.04	0.17	-1.09	0.58
Sales Share of 50 Largest Firms	174	0.05	0.04	0.14	-0.88	0.53
Non-routine Wage Premium	174	-0.01	0.01	0.31	-1.67	1.36
Aggregate Labor Share	113	-0.06	-0.03	0.20	-1.20	0.45
Non-routine Labor Share	113	-0.03	-0.01	0.30	-1.18	1.08
Routine Labor Share	113	-0.17	-0.10	0.52	-2.40	1.37
Wage-bill ratio	174	0.11	0.07	0.66	-1.81	2.89
Non-routine Skill Price	174	0.02	0.30	3.12	-31.28	7.13
Routine Skill Price	174	0.02	0.30	3.11	-30.71	7.18

Table 7: **Wage Premium, Labor Share, Skill Prices and Wage-bill Ratio on Industry Concentration**

The table reports results of industry-level regressions of contemporaneous 5-year log-changes in non-routine wage premium, aggregate labor share, non-routine labor share, routine labor share, skill price of routine occupation, skill price of non-routine occupation and wage-bill ratio of non-routine to routine occupation on 5-year log-changes in industry concentration. The unit of observation is a Census industry. CR^{20} denotes the share of sales by the 20 largest firms within a industry. Standard errors are clustered at industry level.

	(1) $\Delta_5 \log(\frac{W_n}{W_r}(\%))$	(2) $\Delta_5 \log(LS)$	(3) $\Delta_5 \log(NLS)$	(4) $\Delta_5 \log(RLS)$	(5) $\Delta_5 \log(W_r)$	(6) $\Delta_5 \log(W_n)$	(7) $\Delta_5 \log(\frac{W_n L_n}{W_r L_r})$
$\Delta_5 log(CR^{20})$	0.050	-0.262***	-0.252***	-0.389***	-1.632**	-1.582**	0.167
	(0.091)	(0.086)	(0.093)	(0.146)	(0.752)	(0.743)	(0.146)
Year FE	Y	Y	Y	Y	Y	Y	Y
R^2	.017	.077	.028	.017	.0071	.0078	.0028
Observations	348	226	224	224	348	348	346

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figures

Figure 1: **Factor Shares and Markups**
The figure shows factor shares and 5-year moving average of markups for the US corporate sector. Factor shares include labor share, capital share, profit share and tax share. Markups are imputed from the profit share under the assumption of constant return to scale of production.

(a) Factor Shares

(b) 5-year Moving Average of Markups

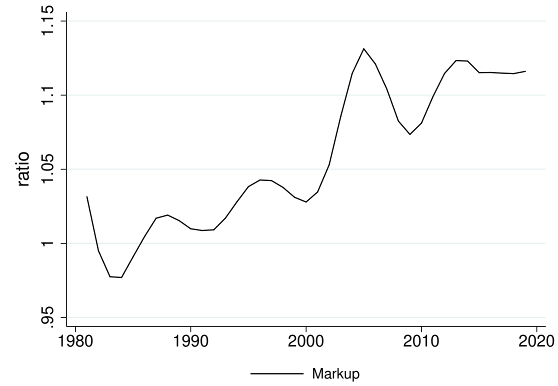


Figure 2: **Non-routine Raw Average Wage Premium**
The figure shows the non-routine raw average wage premium, i.e. the ratio of the average real wage in units of dollars per hour worked of non-routine occupations to routine occupations.

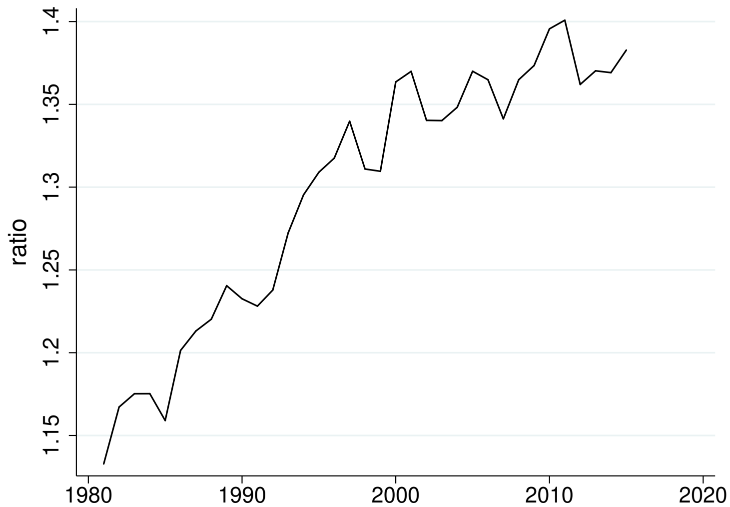


Figure 3: **5-year Moving Average of Non-routine Wage Premium**
The figure shows the 5-year moving average of non-routine wage premium, i.e. the ratio of the average skill price (real wage per efficiency unit of labor) of non-routine occupations to routine occupations. Skill prices are constructed using the Mincerian regression (1) to control for the education and demographic factors. The regression is weighted by sampling weights.

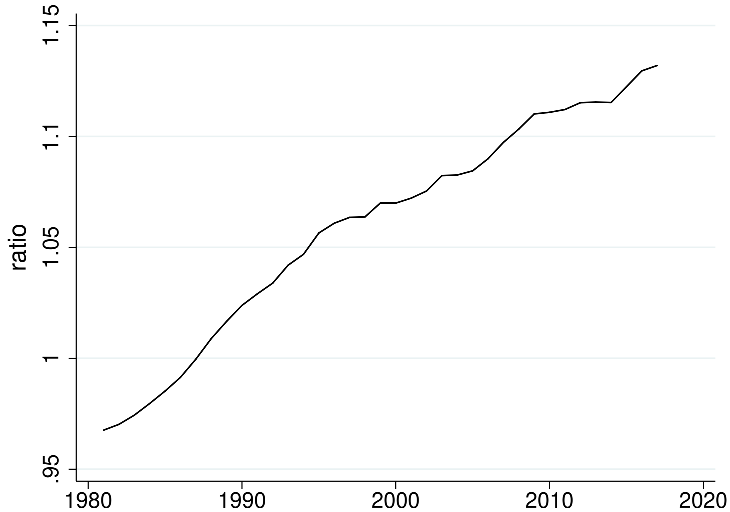


Figure 4: **Wages by Occupations**

The figure shows the wages by routine and non-routine occupations. Panel (a) shows the raw average wages, i.e. the real wages per hour worked by occupations. Panel (b) shows the 5-year moving average of skill prices, i.e. real wages per efficiency unit of labor. Skill prices are constructed using the Mincerian regression (1) to control for the education and demographic factors. The regression is weighted by sampling weights.

(a) Raw Average Wage

(b) 5-year Moving Average of Skill Prices

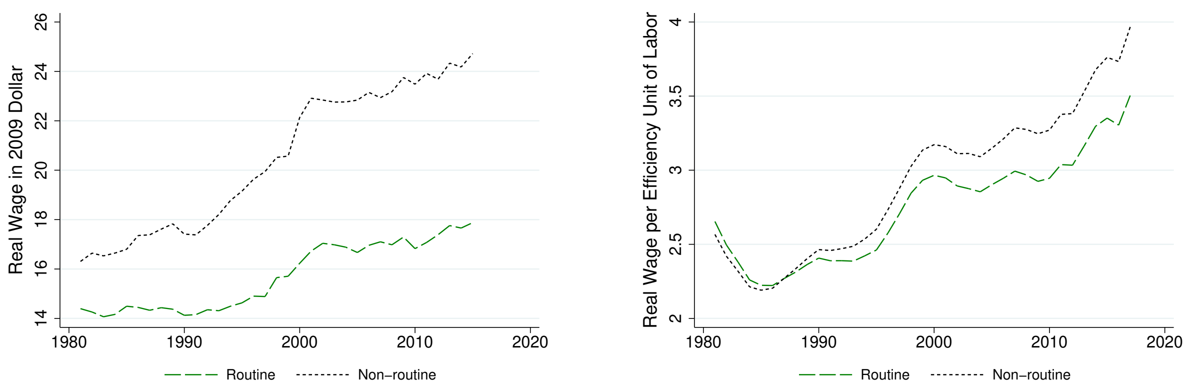
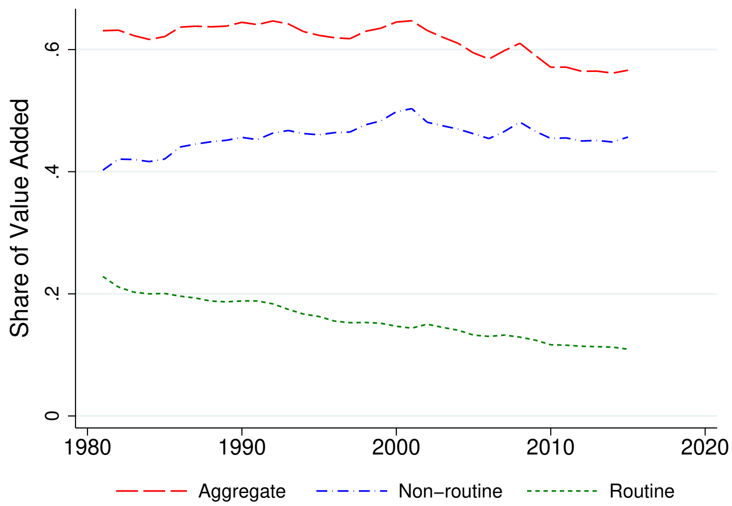


Figure 5: **Labor Share by Occupations**
The figure shows aggregate labor share and labor share by routine and non-routine occupations for the US corporate sector. Aggregate labor share is decomposed into routine labor share and non-routine labor share based on the earnings ratio of the two occupation groups at each year using data on wage and salary income from the ASEC of CPS.



Appendices

A Measurement of Markups

I follow the methodology used in Barkai (2016) to measure markups.[22] In particular, equation (6) implies the markup levels are directly tied with the profit share[23], I thus compute the series of profit share and then use it to back out the series of markups. To construct profit share, the key is to distinguish profit from cost of capital in the total capital income which is equal to the gross value added minus the labor income, both of which can be directly obtained from Bureau of Economic Analysis (BEA)'s National Income and Product Account (NIPA). Following Hall and Jorgenson (1967), also consistent with the model, the cost of capital is equal to the product of the required rate of return on capital and the value of the capital stock, where the required rate of return r is determined by equation (14). To express r in terms of the variables which can be directly obtained from the data, I do the following transformation of equation (14)[24]:

$$r_{t+1} = \frac{1}{q_t}\left(\frac{C_{t+1}}{C_t\beta} - \frac{1-\delta_{t+1}}{\frac{q_{t+1}}{q_t}}\right) \tag{33}$$

$$\frac{P_t}{P_{t+1}}P_{t+1}r_{t+1} = P_t\frac{1}{q_t}\left(1+\tilde{r}_{t+1} - (1-\delta_{t+1})\frac{\frac{P_{t+1}}{q_{t+1}}}{\frac{P_t}{q_t}}\frac{P_t}{P_{t+1}}\right) \tag{34}$$

$$(1+\pi_{t+1})^{-1}P_{t+1}r_{t+1} = \xi_t\left(1+\tilde{r}_{t+1} - (1-\delta_{t+1})\frac{\xi_{t+1}}{\xi_t}(1+\pi_{t+1})^{-1}\right) \tag{35}$$

$$(1+\pi_{t+1})^{-1}P_{t+1}r_{t+1} = \xi_t\left(1+\tilde{r}_{t+1} - (1-\delta_{t+1})(1+\pi_{K,t+1})(1+\pi_{t+1})^{-1}\right) \tag{36}$$

$$(1+\pi_{t+1})^{-1}\frac{P_{t+1}r_{t+1}}{\xi_{t+1}} = \frac{\xi_t}{\xi_{t+1}}\left(1+\tilde{r}_{t+1} - (1-\delta_{t+1})(1+\pi_{K,t+1})(1+\pi_{t+1})^{-1}\right) \tag{37}$$

$$(1+\pi_{t+1})^{-1}\tilde{R}_{t+1} = (1+\pi_{K,t+1})^{-1}\left(1+\tilde{r}_{t+1} - (1-\delta_{t+1})(1+\pi_{K,t+1})(1+\pi_{t+1})^{-1}\right) \tag{38}$$

$$\tilde{R}_{t+1} \approx \tilde{r}_{t+1} + \delta_{t+1} - \pi_{K,t+1} + \pi_{t+1} \tag{39}$$

$$\tilde{R}_{t+1} \approx i^D_{t+1} + \delta_{t+1} - \pi_{K,t+1} \tag{40}$$

$$\tilde{R}_{t+1} \approx i^D_{t+1} + \delta_{t+1} - E_t[\pi_{K,t+1}] \tag{41}$$

where equation (41) is the stochastic version of equation (40). r_{t+1} is the required rate of return of capital in units of consumption goods per efficiency unit of investment goods

[22]See Basu (2019) for a discussion of the issues with different methodologies used in the literature to measure markups.

[23]Equation(6) hinges on the assumption that the production exhibits constant return to scale.

[24]I add time subscript to the depreciation rate δ here to explicitly allow for time variation.

(capital), $\frac{1}{q_t}$ is the relative price of investment goods in units of consumption goods per efficiency unit of investment goods, $1+\tilde{r}_{t+1} \equiv \frac{C_{t+1}}{C_t \beta}$ is the gross real interest rate of a riskless bond denominated in units of consumption goods, P_t is the nominal price of consumption goods, $\pi_{t+1} \equiv \frac{P_{t+1}}{P_t} - 1$ is the inflation rate of consumption goods, $\xi_t \equiv \frac{P_t}{q_t}$ is the nominal price of investment goods in units of dollars per efficiency unit of investment goods, $\pi_{K,t+1} \equiv \frac{\xi_{t+1}}{\xi_t} - 1$ is the inflation rate of investment goods, $\tilde{R}_{t+1} \equiv \frac{P_{t+1} r_{t+1}}{\xi_{t+1}}$ is the nominal required rate of return of capital in units of dollars per dollar of capital, i^D_{t+1} is the net nominal interest rate of a riskless bond denominated in dollars, which measures the debt cost of capital.

To account for both debt and equity financing, following Barkai (2016), I rewrite equation (41) as:

$$\tilde{R}_{t+1} \approx \left(\frac{D_t}{D_t + E_t} i^D_{t+1} + \frac{E_t}{D_t + E_t} i^E_{t+1}\right) + \delta_{t+1} - E_t[\pi_{K,t+1}] \tag{42}$$

where D_t is the market value of debt, E_t is the market value of equity, i^E_{t+1} is the equity cost of capital.

Most of the variables on the right-hand side of equation (42) can be either directly obtained or easily constructed from the data. The market value of debt and equity are obtained from Integrated Macroeconomic Accounts for the United States.[25] I use Moody's Aaa corporate bond yield, which is available through FRED, to measure the debt cost of capital. Equity cost of capital is not directly observed in the data. I follow Barkai (2016)'s main specification to construct equity cost of capital as the sum of the debt cost of capitals and a 5% equity risk premium. Data on the depreciation rate and inflation rate of capital are taken from BEA's Fixed Asset Table (FAT). Depreciation rate equals the ratio of current-cost depreciation to the sum of current-cost depreciation and current-cost net stock of capital. To construct the inflation rate of capital, I first construct the implicit price deflator of capital as the ratio of the current-cost net stock of capital to the chain-type quantity index for net stock of capital. Realized inflation rate of capital equals the growth rate of the implicit price deflator. I then construct the expected inflation rate of capital as the 3-year moving average of the realized inflation rate of capital. Plugging in the variables constructed above into equation (42), this gives me a series of the required rate of return of capital, $\tilde{R}$.

Denote the nominal value of capital stock as $\tilde{K}_t \equiv \xi_t K_t$. Then capital share can be expressed as:

$$CS_t \equiv \frac{r_t K_t}{Y_t} = \frac{P_t r_t K_t}{P_t Y_t} = \frac{(\frac{P_t r_t}{\xi_t})(\xi_t K_t)}{P_t Y_t} = \frac{\tilde{R}_t \tilde{K}_t}{P_t Y_t}$$

where $\tilde{R}_t \tilde{K}_t$ is the nominal value of the capital cost and $P_t Y_t$ is the nominal value of gross

[25] I construct the market value of debt as the sum of debt securities and loans and the market value of equity as the corporate equity of the non-financial corporate sector.

value added. For the corporate sector, data on $\tilde{K}_t$ is taken from the FAT Table 4.1 (line 17) as current-cost net stock of capital, and data on $P_t Y_t$ is taken from the NIPA Table 1.14 (line 1) as gross value added in current dollars.

In NIPA Table 1.14, gross value added (line 1) equals the sum of compensation of employees (line 4), gross operating surplus (line 2 + line 8) and taxes on production and imports less subsidies (line 7). Decomposing gross operating surplus into capital cost and profit, I get the expression for the profit share:

$$PS_t = 1 - LS_t - CS_t - TS_t$$

where LS_t is the labor share, i.e. the ratio of compensation of employees to gross value added, TS_t is the tax share, i.e. the ratio of taxes on production and imports less subsidies to gross value added.[26] Given also the capital share, CS_t, constructed earlier, I obtain a series of profit share, PS_t.

Lastly, equation (6) implies

$$\mu_t = \frac{1}{1 - PS_t}$$

which allows me to construct the series of markups, μ_t, from the series of profit share.

B Additional Qualitative Results

The following propositions summarize the qualitative effect of investment-specific technology on wage polarization, wage growth and labor share.

Proposition B.1 *The following comparative static results hold:*

1. $\frac{\partial r}{\partial q} < 0$. *An increase in steady state q decreases the rental rate of capital.*
2. $\frac{\partial K}{\partial q} > 0$. *An increase in steady state q increases capital stock.*
3. $\frac{\partial W_n}{\partial q} > 0$ *and* $\frac{\partial W_r}{\partial q} > 0$. *An increase in steady state q increases both the skill price of non-routine task and routine task.*
4. $\frac{\partial \frac{W_n}{W_r}}{\partial q} > 0$. *An increase in steady state q increases the non-routine wage premium.*
5. $\frac{\partial \bar{\tau}}{\partial q} > 0$. *An increase in steady state q increases (decreases) the employment of workers in non-routine task (routine task).*

Proof. See Appendix C. ■

[26]Taxes on production and imports do not include taxes on income, and thus it is unclear how to attribute it to factors of production and profits. See Chapter2 of the NIPA handbook for the definition of taxes on production and imports: https://www.bea.gov/sites/default/files/methodologies/nipa-handbook-all-chapters.pdf.

The investment-specific technology growth drives the changes of the model's endogenous variables by reducing the rental rate of capital. As the price of capital becomes lower, firms tend to demand more capital, leading to more capital stock in steady state.

As capital being favored more by the firm due to the reduced rental price, it tends to increase the capital-labor ratio and thus the marginal product of labor in both routine and non-routine tasks, raising the skill prices. Through the capital-task complementarity effect, the increase in capital increases the non-routine wage premium. The increase in the non-routine wage premium further induces more workers to be employed in the non-routine task and less in the routine task.

The effect of investment-specific technology on the labor share is shown by the following proposition.

Proposition B.2 *The following comparative static results hold:*

1. $\frac{\partial LS}{\partial q} < 0$ *and* $\frac{\partial RLS}{\partial q} < 0$ *if* $\gamma_n \geq 1$*. An increase in steady state* q *decreases aggregate labor share share and routine labor share if* $\gamma_n \geq 1$*.*

2. $\frac{\partial LS}{\partial q} > 0$, $\frac{\partial RLS}{\partial q} \geq 0$ *(equal to* 0 *only if* $\gamma_r = 1$*) and* $\frac{\partial NLS}{\partial q} > 0$ *if* $\gamma_r \leq 1$*. An increase in steady state* q *(weakly) increases aggregate labor share, routine labor share and non-routine labor share if* $\gamma_r \leq 1$*.*

3. $\frac{\partial RLS}{\partial q} < 0$ *and* $\frac{\partial NLS}{\partial q} > 0$ *if* $\gamma_n < 1 < \gamma_r$*. An increase in steady state* q *decreases routine labor share and increases non-routine labor share if* $\gamma_n < 1 < \gamma_r$*.*

Proof. See Appendix C. ■

When $1 \leq \gamma_n < \gamma_r$, both routine labor and non-routine labor are gross substitutes with capital. Then a decrease in the rental rate of capital implied by the investment-specific technology growth leads to a decrease in aggregate labor share. On the other hand, if $\gamma_n < \gamma_r \leq 1$, both routine labor and non-routine labor are gross complements with capital, implying that a decrease in the rental rate of capital leads to an increase in aggregate labor share. Under the condition that $\gamma_n < 1 < \gamma_r$ it indicates the investment-specific technology growth will drive up the non-routine labor share and reduce the routine labor share, which is consistent with the observed long-term trends of labor share by the two groups of occupations. However, the partial effect of q on the aggregate labor share can't be unambiguously signed in this case.

The effect of q on labor income relative to business cost is qualitatively the same with that on labor share shown in Proposition B.2, because μ is held constant, which implies the profit share is constant, when calculating the partial effect of q. Thus q affects the labor share only through affecting the labor income relative to business cost. By comparing these results with Proposition 5.2, it is easy to see that an increase in markups has the exact opposite effect on labor income relative to business cost to an increase in investment-specific technology. However, on top of affecting labor income relative to business cost, an increase in markups also increases the profit share, which tends to reduce the labor share.

C Proofs

C.1 Proof of Proposition 5.1

Dividing equation (24) by equation (25), I get the following expression for $\frac{W_n}{W_r}$:

$$\frac{W_n}{W_r} = \frac{\Phi_1(1-\Phi_2)}{1-\Phi_1}(\Phi_2(\frac{K}{L_n})^\rho + (1-\Phi_2))^{\frac{\sigma-\rho}{\rho}}(\frac{L_r}{L_n})^{1-\sigma} \tag{43}$$

Combining equation (43) with equations (18), (22) and (23), it gives:

$$\xi(\bar{\tau}^{\frac{1}{2}}) = \frac{\Phi_1(1-\Phi_2)}{1-\Phi_1}(\Phi_2(\frac{K}{2\bar{\tau}^{\frac{1}{2}}})^\rho + (1-\Phi_2))^{\frac{\sigma-\rho}{\rho}}(\frac{(1-\bar{\tau})\xi}{2\bar{\tau}^{\frac{1}{2}}})^{1-\sigma} \tag{44}$$

This equation relates $\bar{\tau}$ with K. Taking total derivative with respect to $\bar{\tau}$ and K of it, I obtain:

$$\begin{aligned}
&[\frac{(1-\bar{\tau})+(1-\sigma)(1+\bar{\tau})}{2\bar{\tau}(1-\bar{\tau})} + \frac{(\sigma-\rho)\Phi_2(\frac{K}{2\bar{\tau}^{\frac{1}{2}}})^{\rho-1}\frac{\bar{\tau}^{-\frac{1}{2}}K}{4\bar{\tau}}}{\Phi_2(\frac{K}{2\bar{\tau}^{\frac{1}{2}}})^\rho + (1-\Phi_2)}]d\tau \\
&= (\sigma-\rho)\frac{\Phi_2(\frac{K}{2\bar{\tau}^{\frac{1}{2}}})^{\rho-1}\frac{1}{2\bar{\tau}^{\frac{1}{2}}}}{\Phi_2(\frac{K}{2\bar{\tau}^{\frac{1}{2}}})^\rho + (1-\Phi_2)}dK
\end{aligned}$$

Under the assumption of capital non-routine task complementarity, i.e. $\sigma > \rho$, it is easy to see that $\frac{dK}{d\bar{\tau}} > 0$.

Equation (44) can be also written as:

$$\xi(\bar{\tau}^{\frac{1}{2}}) = \frac{\Phi_1(1-\Phi_2)}{1-\Phi_1}(\Phi_2(\frac{K}{L_n})^\rho + (1-\Phi_2))^{\frac{\sigma-\rho}{\rho}}(\frac{(1-\bar{\tau})\xi}{2\bar{\tau}^{\frac{1}{2}}})^{1-\sigma} \tag{45}$$

Taking total derivative with respect to $\bar{\tau}$ and $\frac{K}{L_n}$ of equation (45), it gives:

$$\frac{(1-\bar{\tau})+(1-\sigma)(1+\bar{\tau})}{2\bar{\tau}(1-\bar{\tau})}d\bar{\tau} = (\sigma-\rho)\frac{\Phi_2(\frac{K}{2\bar{\tau}^{\frac{1}{2}}})^{\rho-1}}{\Phi_2(\frac{K}{2\bar{\tau}^{\frac{1}{2}}})^\rho + (1-\Phi_2)}d(\frac{K}{L_n}) \tag{46}$$

which implies $\frac{d\frac{K}{L_n}}{d\bar{\tau}} > 0$.

Equation (23) directly implies $\frac{dL_r}{d\bar{\tau}} < 0$. $\frac{dK}{d\bar{\tau}} > 0$ and $\frac{dL_r}{d\bar{\tau}} < 0$ lead to $\frac{d(\frac{K}{L_r})}{d\bar{\tau}} > 0$.

Combining equations (26) and (27), I obtain:

$$r\mu = \Phi_1\Phi_2[\Phi_1(\Phi_2 + (1-\Phi_2)(\frac{L_n}{K})^\rho)^{\frac{\sigma}{\rho}} + (1-\Phi_1)(\frac{L_r}{K})^\sigma]^{\frac{1-\sigma}{\sigma}}(\Phi_2 + (1-\Phi_2)(\frac{L_n}{K})^\rho)^{\frac{\sigma-\rho}{\rho}} \tag{47}$$

Taking log on both sides and then taking total derivative of equation (47) with respect to r, μ, $\frac{K}{L_n}$ and $\frac{K}{L_r}$, it gives:

$$\begin{aligned}\frac{dr}{r} + \frac{d\mu}{\mu} =& \frac{1-\sigma}{\sigma}\cdot\frac{\frac{\sigma}{\rho}\Phi_1(\Phi_2+(1-\Phi_2)(\frac{L_n}{K})^\rho)^{\frac{\sigma-\rho}{\rho}}(1-\Phi_2)(-\rho)(\frac{L_n}{K})^{\rho+1}}{\Phi_1(\Phi_2+(1-\Phi_2)(\frac{L_n}{K})^\rho)^{\frac{\sigma}{\rho}}+(1-\Phi_1)(\frac{L_r}{K})^\sigma}d(\frac{K}{L_n})\\ &+\frac{1-\sigma}{\sigma}\cdot\frac{(-\sigma)(1-\Phi_1)(\frac{L_r}{K})^{\sigma+1}}{\Phi_1(\Phi_2+(1-\Phi_2)(\frac{L_n}{K})^\rho)^{\frac{\sigma}{\rho}}+(1-\Phi_1)(\frac{L_r}{K})^\sigma}d(\frac{K}{L_r})\\ &+\frac{\sigma-\rho}{\rho}\cdot\frac{(1-\Phi_2)(-\rho)(\frac{L_n}{K})^{\rho+1}}{\Phi_2+(1-\Phi_2)(\frac{L_n}{K})^\rho}d(\frac{K}{L_n})\end{aligned}$$

Dividing both sides of the above equation by $d\bar{\tau}$, it gets:

$$\begin{aligned}\frac{dr}{dq}\frac{dq}{d\bar{\tau}}\frac{1}{r} + \frac{1}{\mu}\frac{d\mu}{d\bar{\tau}} =& \frac{1-\sigma}{\sigma}\cdot\frac{\frac{\sigma}{\rho}\Phi_1(\Phi_2+(1-\Phi_2)(\frac{L_n}{K})^\rho)^{\frac{\sigma-\rho}{\rho}}(1-\Phi_2)(-\rho)(\frac{L_n}{K})^{\rho+1}}{\Phi_1(\Phi_2+(1-\Phi_2)(\frac{L_n}{K})^\rho)^{\frac{\sigma}{\rho}}+(1-\Phi_1)(\frac{L_r}{K})^\sigma}\cdot\frac{d(\frac{K}{L_n})}{d\bar{\tau}}\\ &+\frac{1-\sigma}{\sigma}\cdot\frac{(-\sigma)(1-\Phi_1)(\frac{L_r}{K})^{\sigma+1}}{\Phi_1(\Phi_2+(1-\Phi_2)(\frac{L_n}{K})^\rho)^{\frac{\sigma}{\rho}}+(1-\Phi_1)(\frac{L_r}{K})^\sigma}\cdot\frac{d(\frac{K}{L_r})}{d\bar{\tau}}\\ &+\frac{\sigma-\rho}{\rho}\cdot\frac{(1-\Phi_2)(-\rho)(\frac{L_n}{K})^{\rho+1}}{\Phi_2+(1-\Phi_2)(\frac{L_n}{K})^\rho}\cdot\frac{d(\frac{K}{L_n})}{d\bar{\tau}}\end{aligned}$$

The right-hand side of the above equation is negative, as $\frac{d(\frac{K}{L_n})}{d\bar{\tau}} > 0$, $\frac{d(\frac{K}{L_r})}{d\bar{\tau}} > 0$ and the coefficients on $\frac{d(\frac{K}{L_n})}{d\bar{\tau}}$ and $\frac{d(\frac{K}{L_r})}{d\bar{\tau}}$ are all negative. Equation (19) directly implies $\frac{dr}{dq} < 0$. Thus, it results in $\frac{\partial\bar{\tau}}{\partial q} > 0$ and $\frac{\partial\bar{\tau}}{\partial\mu} < 0$.

$\frac{\partial\bar{\tau}}{\partial\mu} < 0$, together with $\frac{dK}{d\bar{\tau}} > 0$, $\frac{d(\frac{K}{L_n})}{d\bar{\tau}} > 0$ and $\frac{d(\frac{K}{L_r})}{d\bar{\tau}} > 0$, implies $\frac{\partial K}{\partial\mu} < 0$, $\frac{\partial(\frac{K}{L_n})}{\partial\mu} < 0$ and $\frac{\partial(\frac{K}{L_r})}{\partial\mu} < 0$ respectively. Equation (18) directly leads to $\frac{d(\frac{W_n}{W_r})}{d\bar{\tau}} > 0$, which further implies $\frac{\partial(\frac{W_n}{W_r})}{\partial\mu} < 0$.

Combining equation (25) and equation (27), I get the following expression for W_r:

$$W_r = \frac{1}{\mu}(1-\Phi_1)[\Phi_1(\Phi_2(\frac{K}{L_r})^\rho + (1-\Phi_2)(\frac{L_n}{L_r})^\rho)^{\frac{\sigma}{\rho}} + (1-\Phi_1)]^{\frac{1-\sigma}{\sigma}} \tag{48}$$

It is easy to see from equations (22) and (23) that $\frac{d(\frac{L_n}{L_r})}{d\bar{\tau}} > 0$, and thus $\frac{\partial(\frac{L_n}{L_r})}{\partial\mu} < 0$. Together with $\frac{\partial(\frac{K}{L_r})}{\partial\mu} < 0$, which is proved earlier, it implies $\frac{\partial W_r}{\partial\mu} < 0$. $\frac{\partial W_r}{\partial\mu} < 0$ and $\frac{\partial(\frac{W_n}{W_r})}{\partial\mu} < 0$ further leads to $\frac{\partial W_n}{\partial\mu} < 0$. This concludes the proof of Proposition 5.1.

C.2 Proof of Proposition B.1

The proof in this subsection makes use of the results proved in subsection C.1.

$\frac{\partial\bar{\tau}}{\partial q} > 0$, together with $\frac{dK}{d\bar{\tau}} > 0$, $\frac{d(\frac{K}{L_n})}{d\bar{\tau}} > 0$, $\frac{d(\frac{K}{L_r})}{d\bar{\tau}} > 0$, $\frac{d(\frac{W_n}{W_r})}{d\bar{\tau}} > 0$ and $\frac{d(\frac{L_n}{L_r})}{d\bar{\tau}} > 0$, implies $\frac{\partial K}{\partial q} > 0$, $\frac{\partial(\frac{K}{L_n})}{\partial q} > 0$, $\frac{\partial(\frac{K}{L_r})}{\partial q} > 0$, $\frac{\partial(\frac{W_n}{W_r})}{\partial q} > 0$ and $\frac{\partial(\frac{L_n}{L_r})}{\partial q} > 0$ respectively. Taking into account of $\frac{d(\frac{K}{L_r})}{d\bar{\tau}} > 0$, $\frac{d(\frac{L_n}{L_r})}{d\bar{\tau}} > 0$ and $\frac{\partial\bar{\tau}}{\partial q} > 0$, equation (48) implies $\frac{\partial W_r}{\partial q} > 0$. $\frac{\partial W_r}{\partial q} > 0$ and $\frac{\partial(\frac{W_n}{W_r})}{\partial q} > 0$ further results in $\frac{\partial W_n}{\partial q} > 0$. This concludes the proof of Proposition B.1.

C.3 Proof of Proposition 5.2

Equation (29) directly implies $\frac{\partial PS}{\partial\mu} > 0$.

By definition, aggregate labor share relative to business cost, LC, can be written as:

$$
\begin{aligned}
LC &= \frac{W_nL_n + W_rL_r}{W_nL_n + W_rL_r + rK} \\
&= \frac{1}{1 + \frac{rK}{W_nL_n + W_rL_r}} \\
&= \frac{1}{1 + \frac{\frac{rK}{W_nL_n}}{1 + \frac{W_rL_r}{W_nL_n}}}
\end{aligned}
$$

which implies

$$
\frac{\partial LC}{\partial\mu} = -LC^2 \frac{\partial(\frac{\frac{rK}{W_nL_n}}{1+\frac{W_rL_r}{W_nL_n}})}{\partial\mu} \tag{49}
$$

where $\frac{rK}{W_nL_n}$, based on equations (24) and (26), can be derived as:

$$
\frac{rK}{W_nL_n} = \frac{\Phi_2}{1-\Phi_2}(\frac{K}{L_n})^{\rho} \tag{50}
$$

Non-routine labor share relative to business cost, NLC, can be written as:

$$
\begin{aligned}
NLC &= \frac{W_nL_n}{W_nL_n + W_rL_r + rK} \\
&= \frac{1}{1 + \frac{W_rL_r}{W_nL_n} + \frac{rK}{W_nL_n}}
\end{aligned}
$$

which implies

$$\frac{\partial NLC}{\partial \mu} = -NLC^2 \frac{\partial(\frac{W_r L_r}{W_n L_n} + \frac{rK}{W_n L_n})}{\partial \mu} \tag{51}$$

Due to the constant return to scale of the production function, $W_n L_n + W_r L_r + rK = \frac{1}{\mu} Y$. Thus, routine labor share relative to business cost, RLC, can be written as:

$$\begin{aligned} RLC &= \frac{W_r L_r}{W_n L_n + W_r L_r + rK} \\ &= \frac{W_r L_r}{\frac{1}{\mu} Y} \end{aligned}$$

which, together with equations (25) and (27), implies:

$$RLC = (1 - \Phi_1)[\Phi_1(\Phi_2(\frac{K}{L_r})^\rho + (1 - \Phi_2)(\frac{L_n}{L_r})^\rho)^{\frac{\sigma}{\rho}} + (1 - \Phi_1)]^{-1} \tag{52}$$

Under the case where $\gamma_n \geq 1$ (i.e. $0 \leq \rho < \sigma < 1$), equation (50) implies $\frac{\partial(\frac{rK}{W_n L_n})}{\partial \mu} \leq 0$ as $\frac{\partial(\frac{K}{L_n})}{\partial \mu} < 0$ holds.[27] $\frac{\partial(\frac{W_n}{W_r})}{\partial \mu} < 0$ and $\frac{\partial(\frac{L_n}{L_r})}{\partial \mu} < 0$ leads to $\frac{\partial(\frac{W_n L_n}{W_r L_r})}{\partial \mu} < 0$, which further implies $\frac{\partial(\frac{W_r L_r}{W_n L_n})}{\partial \mu} > 0$. Combining that with $\frac{\partial(\frac{rK}{W_n L_n})}{\partial \mu} \leq 0$, equation (49) results in $\frac{\partial LC}{\partial \mu} > 0$. As $\frac{\partial(\frac{K}{L_n})}{\partial \mu} < 0$ and $\frac{\partial(\frac{L_n}{L_r})}{\partial \mu} < 0$, equation (52) implies $\frac{\partial RLC}{\partial \mu} > 0$.

Under the case where $\gamma_r \leq 1$ (i.e. $\rho < \sigma \leq 0$), equation (52) implies $\frac{\partial RLC}{\partial \mu} \leq 0$ ((equal to 0 only if $\gamma_r = 1$)).[28] Equation (50) implies $\frac{\partial(\frac{rK}{W_n L_n})}{\partial \mu} > 0$. Combining that with $\frac{\partial(\frac{W_r L_r}{W_n L_n})}{\partial \mu} > 0$, equation (51) implies $\frac{\partial NLC}{\partial \mu} < 0$. $\frac{\partial NLC}{\partial \mu} < 0$ and $\frac{\partial RLC}{\partial \mu} \leq 0$ lead to $\frac{\partial LC}{\partial \mu} < 0$.

Under the case where $\gamma_n < 1 < \gamma_r$ (i.e. $\rho < 0 < \sigma < 1$), equation (52) implies $\frac{\partial RLC}{\partial \mu} > 0$. Equation (50) implies $\frac{\partial(\frac{rK}{W_n L_n})}{\partial \mu} > 0$. Combining that with $\frac{\partial(\frac{W_r L_r}{W_n L_n})}{\partial \mu} > 0$, equation (51) implies $\frac{\partial NLC}{\partial \mu} < 0$.

This concludes the proof of Proposition 5.2.

[27] when $\gamma_n = 1$ (i.e. $\rho = 0$), the production function becomes $Y = [\Phi_1(K^{\Phi_2} L_n^{(1-\Phi_2)})^\sigma + (1 - \Phi_1) L_r^\sigma]^{\frac{1}{\sigma}}$.

[28] when $\gamma_r = 1$ (i.e. $\sigma = 0$), the production function becomes $Y = (\Phi_2 K^\rho + (1 - \Phi_2) L_n^\rho)^{\frac{\Phi_1}{\rho}} L_r^{(1-\Phi_1)}$.

C.4 Proof of Proposition B.2

By definition, aggregate labor share, LS, can be written as:

$$\begin{aligned} LS &= \frac{W_n L_n + W_r L_r}{Y} \\ &= \frac{1}{\mu}\frac{W_n L_n + W_r L_r}{\frac{1}{\mu}Y} \\ &= \frac{1}{\mu}\frac{W_n L_n + W_r L_r}{W_n L_n + W_r L_r + rK} \\ &= \frac{1}{\mu}LC \end{aligned}$$

which implies

$$\frac{\partial LS}{\partial q} = \frac{1}{\mu}\frac{\partial LC}{\partial q} \tag{53}$$

The above result uses the fact that μ is held constant when taking partial derivative with respect to q, as both μ and q are exogenous variables in the model.

Non-routine labor share, NLS, can be written as:

$$\begin{aligned} NLS &= \frac{W_n L_n}{Y} \\ &= \frac{1}{\mu}\frac{W_n L_n}{\frac{1}{\mu}Y} \\ &= \frac{1}{\mu}\frac{W_n L_n}{W_n L_n + W_r L_r + rK} \\ &= \frac{1}{\mu}NLC \end{aligned}$$

which implies

$$\frac{\partial NLS}{\partial q} = \frac{1}{\mu}\frac{\partial NLC}{\partial q} \tag{54}$$

Routine labor share, RLS, can be written as:

$$\begin{aligned} RLS &= \frac{W_r L_r}{Y} \\ &= \frac{1}{\mu}\frac{W_r L_r}{\frac{1}{\mu}Y} \\ &= \frac{1}{\mu}\frac{W_r L_r}{W_n L_n + W_r L_r + rK} \\ &= \frac{1}{\mu}RLC \end{aligned}$$

which implies

$$\frac{\partial RLS}{\partial q} = \frac{1}{\mu}\frac{\partial RLC}{\partial q} \tag{55}$$

I first derive the effects of q on labor income relative to business cost and then use equations (53), (54) and (55) to relate those to the effects of q on labor share.

Under the case where $\gamma_n \geq 1$ (i.e. $0 \leq \rho < \sigma < 1$), equation (50) implies $\frac{\partial(\frac{rK}{W_n L_n})}{\partial q} \geq 0$ as $\frac{\partial(\frac{K}{L_n})}{\partial q} > 0$ holds. $\frac{\partial(\frac{W_n}{W_r})}{\partial q} > 0$ and $\frac{\partial(\frac{L_n}{L_r})}{\partial q} > 0$ leads to $\frac{\partial(\frac{W_n L_n}{W_r L_r})}{\partial q} > 0$, which further implies $\frac{\partial(\frac{W_r L_r}{W_n L_n})}{\partial q} < 0$. Combining that with $\frac{\partial(\frac{rK}{W_n L_n})}{\partial q} \geq 0$, equation (49) results in $\frac{\partial LC}{\partial q} < 0$. Equation (53) further leads to $\frac{\partial LS}{\partial q} < 0$. As $\frac{\partial(\frac{K}{L_n})}{\partial q} > 0$ and $\frac{\partial(\frac{L_n}{L_r})}{\partial q} > 0$, equation (52) implies $\frac{\partial RLC}{\partial q} < 0$. Equation (55) further leads to $\frac{\partial RLS}{\partial q} < 0$.

Under the case where $\gamma_r \leq 1$ (i.e. $\rho < \sigma \leq 0$), equation (52) implies $\frac{\partial RLC}{\partial q} \geq 0$ (equal to 0 only if $\gamma_r = 1$). Equation (55) further leads to $\frac{\partial RLS}{\partial q} \geq 0$ (equal to 0 only if $\gamma_r = 1$). Equation (50) implies $\frac{\partial(\frac{rK}{W_n L_n})}{\partial q} < 0$. Combining that with $\frac{\partial(\frac{W_r L_r}{W_n L_n})}{\partial q} < 0$, equation (51) implies $\frac{\partial NLC}{\partial q} > 0$. $\frac{\partial NLC}{\partial q} > 0$ and $\frac{\partial RLC}{\partial q} \geq 0$ lead to $\frac{\partial LC}{\partial q} > 0$. Equation (53) further implies $\frac{\partial LS}{\partial q} > 0$.

Under the case where $\gamma_n < 1 < \gamma_r$ (i.e. $\rho < 0 < \sigma < 1$), equation (52) implies $\frac{\partial RLC}{\partial q} < 0$. Equation (55) further leads to $\frac{\partial RLS}{\partial q} < 0$. Equation (50) implies $\frac{\partial(\frac{rK}{W_n L_n})}{\partial q} < 0$. Combining that with $\frac{\partial(\frac{W_r L_r}{W_n L_n})}{\partial q} < 0$, equation (51) implies $\frac{\partial NLC}{\partial q} > 0$. Equation (54) further leads to $\frac{\partial NLS}{\partial q} > 0$.

This concludes the proof of Proposition B.2.

D Additional Empirical Results

Table 8: **Wage Premium, Labor Share, Skill Prices and Wage-bill Ratio on Industry Concentration**

The table reports results of industry-level regressions of contemporaneous 5-year log-changes in non-routine wage premium, aggregate labor share, non-routine labor share, routine labor share, skill price of routine occupation, skill price of non-routine occupation and wage-bill ratio of non-routine to routine occupation on 5-year log-changes in industry concentration. The unit of observation is a Census industry. CR^{50}, CR^{8}, CR^{4} denote the share of sales by the 50, 8, and 4 largest firms within a industry respectively. Standard errors are clustered at industry level.

	(1) $\Delta_5 \log(\frac{W_n}{W_r}(\%))$	(2) $\Delta_5 \log(LS)$	(3) $\Delta_5 \log(NLS)$	(4) $\Delta_5 \log(RLS)$	(5) $\Delta_5 \log(W_r)$	(6) $\Delta_5 \log(W_n)$	(7) $\Delta_5 \log(\frac{W_n L_n}{W_r L_r})$
$\Delta_5 log(CR^{50})$	0.050	-0.341***	-0.319***	-0.495***	-2.180**	-2.130**	0.178
	(0.109)	(0.103)	(0.113)	(0.173)	(0.868)	(0.854)	(0.175)
Year FE	Y	Y	Y	Y	Y	Y	Y
R^2	.017	.084	.03	.019	.0081	.0087	.0024
Observations	348	226	224	224	348	348	346

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

	(1) $\Delta_5 \log(\frac{W_n}{W_r}(\%))$	(2) $\Delta_5 \log(LS)$	(3) $\Delta_5 \log(NLS)$	(4) $\Delta_5 \log(RLS)$	(5) $\Delta_5 \log(W_r)$	(6) $\Delta_5 \log(W_n)$	(7) $\Delta_5 \log(\frac{W_n L_n}{W_r L_r})$
$\Delta_5 log(CR^{8})$	0.042	-0.200**	-0.195**	-0.357***	-1.236*	-1.194*	0.177
	(0.079)	(0.077)	(0.084)	(0.135)	(0.631)	(0.618)	(0.135)
Year FE	Y	Y	Y	Y	Y	Y	Y
R^2	.017	.068	.025	.021	.0069	.0076	.0035
Observations	347	225	223	223	347	347	345

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

	(1) $\Delta_5 \log(\frac{W_n}{W_r}(\%))$	(2) $\Delta_5 \log(LS)$	(3) $\Delta_5 \log(NLS)$	(4) $\Delta_5 \log(RLS)$	(5) $\Delta_5 \log(W_r)$	(6) $\Delta_5 \log(W_n)$	(7) $\Delta_5 \log(\frac{W_n L_n}{W_r L_r})$
$\Delta_5 log(CR^{4})$	0.050	-0.149**	-0.131	-0.315**	-0.812	-0.762	0.158
	(0.066)	(0.074)	(0.086)	(0.126)	(0.575)	(0.564)	(0.123)
Year FE	Y	Y	Y	Y	Y	Y	Y
R^2	.017	.056	.017	.021	.005	.0058	.0038
Observations	347	225	223	223	347	347	345

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$