

Business Cycle Implications of Firm Market Power in Labor and Product Markets*

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Abstract

In this paper, we analyze the business cycle implications of firms having *oligopsony* power in labor markets, as well as *oligopoly* power in product markets, within the context of a New Keynesian dynamic stochastic general equilibrium model with firm entry and exit. Relative to the standard setup with monopolistic competition in both goods and labor markets, the strategic interaction between intermediate goods firms in the current setup results in larger price markups as well as wage markdowns, while the slopes of the aggregate price and wage Phillips curves become flatter. These effects are strengthened in a strongly non-linear fashion as the number of firms in each sector decline. Oligopsonistic labor markets also render wage shocks expansionary, unlike in the standard setup. Results indicate that a secular increase in industry concentration would not only reduce the labor share of income, but also weaken the pass-through from firms' marginal costs to prices and from productivity increases to real wages.

Keywords: Market power, oligopoly, oligopsony, New Keynesian DSGE model, entry-exit.

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1 Introduction

Recent decades in the U.S. economy have been characterized by a decline in the share of aggregate income that has accrued to labor, a slowdown in the pass-through from productivity growth to labor compensation, and a flattening of the price and wage Phillips curves. There are likely many different factors behind each of these developments, but this paper argues that a rise in industry concentration in product and labor markets can provide a potential explanation that can weave across them and help account for them simultaneously.¹

In order to analyze the implications of industry concentration on the aforementioned developments, we build a New Keynesian dynamic stochastic general equilibrium (DSGE) model where firms have oligopsony power in labor markets as well as oligopoly power in product markets. The model features a continuum of sectors, each of which has a finite number of firms that engage in Cournot-Nash type competition in both product and labor markets. The model here incorporates three key differences relative to the standard New Keynesian framework of Christiano et al. (2005) and Smets and Wouters (2007), all of which are important in generating the key results of the paper: (i) labor supply is firm-specific rather than economy-wide, (ii) labor market power is modeled on the firm (i.e., demand) side rather than the household (i.e., supply) side of the market, and (iii) there is a finite number of firms within each sector, and therefore, competition in the goods and labor markets are characterized by oligopolistic and oligopsonistic competition, respectively, rather than monopolistic competition. In addition, we allow for endogenous firm entry and exit, in the spirit of Jaimovich and Floetotto (2008).²

The first two features imply that the model features a different “labor wedge” from a “business cycle accounting” perspective (Chari et al., 2009); in particular, real wages are not marked up relative to the marginal rate of substitution of households as in the standard New Keynesian setup, but instead they are *marked down* relative to the marginal product of labor. The third feature related to the finite number of firms in each industry leads to strategic interaction between firms’ decisions, which results in flatter price and wage-Phillips curves relative to the standard New Keynesian setup with monopolistic competition. In particular, firms now internalize the fact that their price and wage decisions affect the industry-wide prices and wages, and this pass-through from the firm-specific to industry-wide prices and wages is stronger as the number of competitors in each industry falls. With reduced competition, firms do not have to respond as much to changes in their marginal cost or labor productivity when they alter prices and wages, which in the aggregate gives rise to the flattening of both the price and the wage Phillips curves. Note that the wage Phillips curve in the model reflects

¹We provide a description of the related literature establishing these phenomenon in the following section.

²The model features firm-specific labor supply with a more generalized form than used in the earlier literature such as Woodford (2003) and Carvalho and Nechio (2016), differentiating between the elasticities of labor supply to firms within an industry and across industries, as well as for aggregate labor supply (i.e., labor versus leisure). Also see Mongey (2018), which features a continuum of sectors, but only two firms within each sector that engage in duopolistic competition in the goods sector subject to menu costs in pricing. In contemporaneous work to this paper, Berger et al. (2019) consider oligopsonistic competition in labor markets within a real business cycle setup with heterogeneous firms.

the wedge between the marginal product of labor and the real wage, and therefore, as the wage Phillips curve flattens, a change in total factor productivity (TFP) that raises the marginal product of labor leads to a smaller impact on real wages. Furthermore, increased industry concentration leads to larger steady-state price markups as well as larger wage markdowns, both of which are key in accounting for the decline in the labor share of income in the data.³

We calibrate the model to match various data moments and micro-evidence, to show that increased industry concentration can contribute towards explaining these changes quantitatively to a significant degree.⁴ But if we were to rely on this as the sole source to fully account for these changes with industry concentration, one needs to entertain that product and labor markets within sectors have essentially been reduced to a duopoly-duopsony structure with only two remaining significant competitors.

The strategic interaction effect arising from oligopolistic-oligopsonistic competition described above is shown to be inversely and non-linearly related to the steady-state number of firms in each industry, N . When N is relatively high (i.e., $N \geq 5$), a decrease from N to $N - 1$ firms have only a negligible impact on the labor share of income or on the slopes of the Phillips curves. Once N decreases below a certain threshold however, further decreases in N start to have a much more sizable impact. This suggests that earlier rounds of industry consolidation observed in the U.S. may not have had noticeable effects on the labor share of income or Phillips curves' slopes, but the more recent waves of mergers and acquisitions have likely had a larger impact. Note that the results of the model crucially depends on the number of firms within an industry N ; in particular, the model is able to account for the data patterns discussed above (i.e., declining labor income share and flattening of price and wage Phillips curves) only if the number of firms in each industry was low enough to begin with (i.e., $N < 8$), and thus further decreases have significant impact. Otherwise, industry consolidation going from, say, 32 to 8 firms, would not have a quantitatively large impact on these patterns. As discussed later, the evidence from the anti-trust literature and empirical estimates of firm markups lend support to the notion that N was indeed low enough initially. Therefore, the model results show that increased industry concentration has likely been a major contributor for these trends, consistent with the arguments laid out in Philippon (2019), even though it cannot account for them fully by itself.⁵

This paper contributes to the business cycle literature utilizing New Keynesian DSGE frameworks by modeling labor market power on the demand side (i.e., firms), rather than the supply side (i.e., to households), of the labor market. As mentioned before, the latter is typically assumed in

³The model also predicts that increased concentration would lead to a decline in capital's income share as well, while the share of pure profits in total income rises. This prediction is consistent with Barkai (2020), who uses an opportunity cost of capital measure to separate the returns to capital from pure profits in the national income accounts, and shows that both the shares of labor and capital in total income have declined over time.

⁴Although the model is silent about the underlying causes for the increase in industry concentration, one could capture higher entry barriers (Van Reenen, 2018) in the model as the driver of increased concentration by increasing the firms' fixed costs over time.

⁵Note that all one requires is that there are only few *significant* competitors within each industry. Thus, the results would go through in a setup where there are N dominant firms that lead the market, along with a unit measure of competitive fringe firms that follow the pricing decisions of the industry leaders.

the standard DSGE framework, which in effect captures the role of labor unions in wage setting (Gnocchi, 2009). Note however that the role of labor unions has significantly declined in post-war U.S. (Schnabel, 2013), while labor-replacing technological progress and the increase in market concentration in key industries have increased the bargaining power of firms in hiring and wage setting (Haldane et al., 2018). Thus, it is important to analyze alternatives to the labor market structure typically assumed in the standard DSGE setup. In order to show the importance of how labor market power is modeled, we compare the impulse responses from the baseline model with oligopsonistic competition in labor markets to the standard DSGE setup where labor market power is on the household side. This analysis reveals that dynamics are qualitatively similar in the two models with respect to all shocks, with the exception of “wage shocks”. Wage shocks act analogous to adverse labor supply shocks in the standard DSGE framework.⁶ In particular, they increase the markup in real wages relative to the marginal rate of substitution of households, increasing the marginal cost of firms, and thereby prompting them to cut hiring and output while raising prices. Thus in equilibrium, aggregate output and labor decline, while inflation and real wages increase. In the oligopsony labor setup here, positive wage shocks reduce the net markdown in wages relative to the marginal product of labor, prompting firms to instead increase hiring and production, while cutting prices in order to sell the increased output. In equilibrium, this results in a simultaneous increase in real wages, labor services, and output, while inflation declines.⁷

In the next subsection, we start by summarizing the empirical evidence on the main motivating feature behind our analysis: rising industry concentration. Section 2 introduces the baseline model and Sections 3 and 4 describe the main results of the paper discussing the implications of the role of market power in the labor and product markets, qualitatively and quantitatively, respectively and Section 5 concludes.

1.1 Related literature on labor share, slope of the Phillips curve and industry concentration

This section provides some of the existing evidence underpinning the analysis here: decline in the share of aggregate income that has accrued to labor, a slowdown in the pass-through from productivity growth to labor compensation, and a flattening of the price and wage Phillips curves.

Figure 1 plots three different measures for the labor share in income: (i) the ratio of the total compensation of employees relative to GDP in the U.S. national accounts, (ii) a Bureau of Labor Statistics (BLS) measure of labor’s income share in non-farm business constructed by Giandrea and Sprague (2017), and (iii) an alternative measure for the whole economy constructed using a

⁶As Chari et al. (2009) and Gali et al. (2012) note, labor supply shocks and wage markup shocks cannot be separately identified in the standard setup unless one puts more structure into the labor side of the model or on the two exogenous processes. This is not the case for the model with oligopsonistic competition in labor markets featured in this paper.

⁷This result is consistent with some of the empirical literature on minimum wages, which find that minimum wage increases have often led to an increase rather than a decrease in employment. See for example, Card and Krueger (1994).

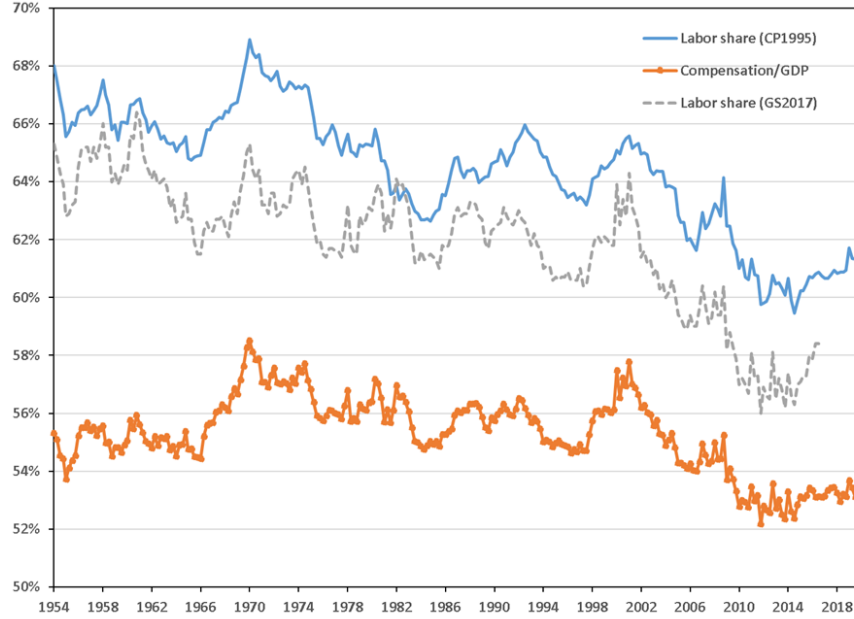


Figure 1: Labor’s share in total income in the post-war period. CP series uses the Cooley and Prescott (1995) methodology to allocate proprietors’ income to labor and capital in proportion to the rest of the economy, while the GS2017 series is the labor share constructed by Giandrea and Sprague (2017).

methodology similar to Cooley and Prescott (1995), which allocates proprietor’s income to labor and capital in the same proportion as the rest of the economy.⁸ These measures suggest that the labor share in total income has declined by about 3-4 percentage points (pp) since the early 1980s, with the declining trend becoming stronger since the 2000s.⁹ The decline in labor’s share is apparent in micro-level data as well. In particular, Autor et al. (2017b) show that the change in the payroll share of value added in the 388 manufacturing industries has been negatively correlated with the change in the concentration ratios in these industries since 1987, and this negative correlation has strengthened over time.¹⁰

A second and related development is the stagnation of labor compensation growth relative to labor productivity. Giandrea and Sprague (2017) report that the gap between the growth of labor productivity and compensation has increased over time, from an average of 0.63 pp between 1973-

⁸In contrast to Cooley and Prescott (1995), the Giandrea and Sprague (2017) measure allocates proprietors’ income to labor based on the share of labor hours of the proprietors versus employees in these establishments. All data, except for consumption of fixed capital are from Table 1.12, titled “National Income by Type of Income” of the National Income and Product Accounts prepared by the Bureau of Economic Analysis (BEA), while the consumption of fixed capital figures are from Table 1.7.5, which relates Gross and Net National Product.

⁹Also see Elsby et al. (2013) for the labor share decline in the U.S. over the last three decades, and Karabarbounis and Neiman (2014), who document a similar decline in other countries. Blanchard and Giavazzi (2003) argue that the decline in the labor share is related to the decrease in the bargaining power of labor.

¹⁰For the decrease in the labor share, the literature has considered rising market power, as well as automation in certain parts of the production process (Acemoglu and Autor, 2011), decline in the relative price of investment goods (Bergholt et al., 2021), access to foreign capital (Leblebicioglu and Weinberger, 2021), and changes in corporate taxation (Kaymak and Schott, 2018) as possible alternatives.

1990 to 0.68 pp between 1990-2000, and to 1.13 pp between 2000-2015. Brill et al. (2017) analyze this “productivity-compensation gap” at the industry level, and report that the average annual percent change in labor productivity outpaced compensation between 1987-2015 in 83% of the 183 industries covered in their study.¹¹ A third, and seemingly unrelated development is the flattening of the price and wage Phillips curves. Kuttner and Robinson (2010) use 15-year rolling regressions on the hybrid form of the New-Keynesian Phillips curve, and show that the slope parameter on the marginal cost measure has declined from around 0.04 in the 1980s to around 0.01 in the 2000s. Del Negro et al. (2020) provide further evidence of a flattening of the price Phillips curve due to a muted reaction of inflation to cost pressures in recent times. Similarly, Leduc and Wilson (2018) and Gali and Gambetti (2019) find substantial evidence of flattening in the empirical wage-Phillips curve linking the unemployment gap to wage inflation.

There is growing evidence that industry concentration in the U.S. has increased during the last several decades. Autor et al. (2017a) document that top firms in 2012 account for a significantly larger share of sales and employment in their respective industries relative to 1982. In particular, the sales concentration ratio of the top 4 firms in manufacturing industries has increased from 38% to 43% on average, while there has been a corresponding increase from 24% to 35% in finance, from 11% to 15% in services, from 29% to 37% in utilities and transportation, from 15% to 30% in retail trade, and from 22% to 28% in wholesale trade. Autor et al. (2017b) report similar findings of rising concentration using Herfindahl-Hirschman indexes (HHI) for U.S. industries, and they attribute this to the globalization of markets and the value chain, as well as to the introduction of new technologies, which have led to the proliferation of large “superstar” firms in many industries and have transformed these markets into the “winner-take-most” variety.¹² An important example of this phenomenon is in the market for smart phones, where Apple and Samsung control about three fourths of the U.S. market. Similarly, three companies (Verizon, AT&T, and T-Mobile) make up essentially the whole market for wireless carriers.¹³

The increase in industry concentration can have consequences, not only in product markets, but also in labor markets. The types of labor services supplied by households can be fairly specialized to specific industries, while there may exist various frictions in labor markets that prevent employees to switch jobs costlessly even within the same industry, such as locational preferences or “no-compete” clauses in existing labor contracts barring them from working for their employer’s rivals. As noted

¹¹See Kehrig and Vincent (2021), who find that labor share dynamics in manufacturing establishments are largely driven by employment, and not the wage rate, and employment has become less responsive to positive technology shocks over time.

¹²See Grullon et al. (2017), Van Reenen (2018), and Philippon (2019) for arguments put forward to explain the increase in industry concentration. These include the weakening of anti-trust enforcement, increase in the regulatory burden, and the rise in technological barriers to entry.

¹³Whether industry consolidation observed at the national level has the same impact on competition at the local level is contested however. Using the National Establishment Time Series (NETS) dataset, Rossi-Hansberg et al. (2018) find that, although product market concentration has increased at the national level, it has indeed declined at the local level, with an overall fewer number of national firms competing in more local markets. Karabarbounis and Neiman (2018) and Bridgman (2019), who use Compustat and National Accounts data, respectively, find only a modest increase in firm markups in the last few decades.

above, Autor et al. (2017a, 2017b) show increasing industry concentration not only by sales, but also by employment. Azar et al. (2017) document significant labor market concentration in the U.S. using HHI indexes for job vacancies by occupation within each commuting zone, and estimate that “going from the 25th percentile to the 75th percentile in concentration is associated with a 15-25% decline in posted wages, suggesting that concentration increases labor market power”. Similarly, Benmelech et al. (2018) use Census data over 1977-2009, and find that local-level employer concentration has increased over time, with the employment-weighted mean local-level employer HHI index defined at the four-digit SIC (Standard Industrial Classification) level increasing by about 5.8 percentage points (pp) between the late 70s and the 2000s. Furthermore, they find that wages are negatively related to labor market concentration, consistent with monopsony power in labor markets.

The U.S. Treasury (2016) reports that around 18% of all workers, or nearly 30 million people, are covered by no-compete agreements in their labor contracts, even though only less than half of these workers report possessing some form of trade secrets. Similarly, Krueger and Ashenfelter (2018) document that 58% of all major franchise chains in the U.S. use “no-poaching” language in their franchise contracts. Recent evidence from a variety of settings also suggests that firms face upward-sloping labor supply curves, thus possessing some monopsony power in their labor markets (Boal and Ransom, 1997; Manning, 2011). As Manning (2003) and Hirsch et al. (2010) indicate, monopsony power may arise even when there are many firms competing for workers due to the presence of search frictions, heterogeneous preferences among workers, and mobility costs or barriers.¹⁴ An increase in industry concentration could thus enhance firms’ market power in wage setting, especially when labor markets are characterized more in line with oligopsonistic competition.

2 Model

In this paper we consider a setting where labor market power rests with the firms. Notably, the model features firms that possess oligopsony power in labor markets and face upward-sloping firm-specific labor supply curves, while households are price and wage takers. Similar to Jaimovich and Floetotto (2008), it features oligopolistic competition in product markets and firm entry-exit. The model also incorporates real frictions in the form of external habit formation in consumption, investment adjustment costs, and costs of capital utilization, as well as nominal frictions in the form of price- and wage-stickiness, similar to the standard New Keynesian DSGE setups of Christiano et al. (2005) and Smets and Wouters (2007). Price- and wage-stickiness are introduced through quadratic adjustment costs in the price- and wage-setting decisions of firms similar to Rotemberg (1982), while monetary policy is conducted via a Taylor rule on the policy rate.

¹⁴For labor markets with search and matching frictions where firms enjoy some bargaining power, see for example Walsh (2005), Ravenna and Walsh (2012), Colciago and Rossi (2015), and Christiano et al. (2016). Bhaskar and To (1999) develop a model of monopsonistic competition in which workers have heterogeneous preferences over a non-wage characteristic of jobs, such as the distance from home to work. Azar and Vives (2018) consider the effects of an increase in “effective” market concentration, defined as the overlapping ownership of various non-financial firms by the same few financial firms, which can lead to declines in employment, real wages, and the labor share. Goetz (2013) argue that the decrease in house prices following the recent financial crisis has reduced the labor mobility of homeowners.

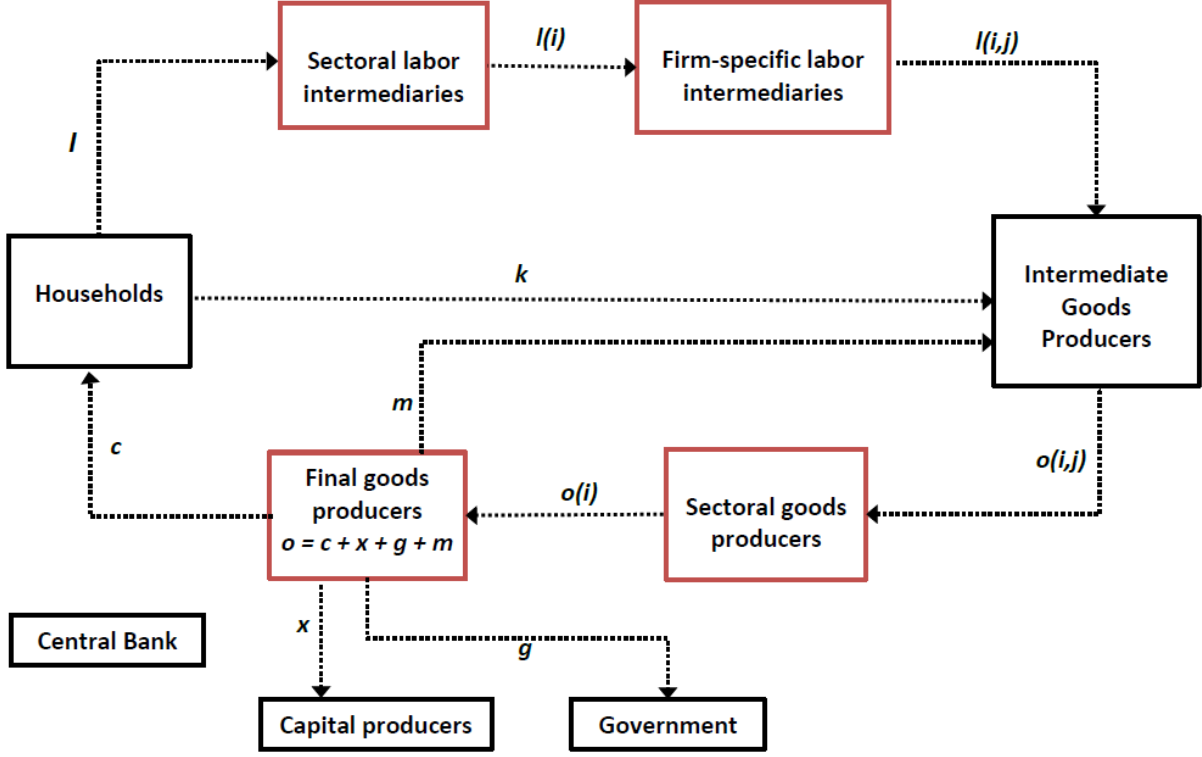


Figure 2: Bird's-eye view of the model

Figure 2 provides a bird's-eye view of the model. Households supply homogenous capital and firm-specific labor to firms. There is a unit measure of sectors indexed by i , each of which has a finite number of intermediate-goods producers indexed by j . Within each sector, these firms engage in Cournot-Nash competition in both the product and labor markets. Labor intermediaries and goods aggregators are added to the model for convenience. In particular, perfectly competitive labor intermediaries differentiate the aggregate labor supplied by households into sector- and firm-specific labor, while perfectly-competitive sectoral- and final-goods aggregators combine intermediate goods into the final output goods, which can then be used for households' consumption, investment in new capital, government expenditure, or as material intermediates utilized in production. In what follows, we describe the optimization problems solved by each type of agent in the model, while Appendix A provides a complete list of equilibrium conditions.

2.1 Households

The economy is populated by a unit measure of infinitely-lived households, whose intertemporal preferences over consumption, c_t , and aggregate labor, l_t , are described by the following expected

utility function:

$$E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left(\log(c_{\tau} - \zeta \bar{c}_{\tau-1}) - \Theta_t \frac{l_{\tau}^{1+\vartheta}}{1+\vartheta} \right),$$

where t indexes time, $\beta < 1$ is the time-discount parameter, \bar{c}_t denotes aggregate consumption, ζ is the (external) habit parameter, and $1/\vartheta$ is the Frisch-elasticity of aggregate labor supply. Θ_t is a labor supply externality, which helps reduce the income-elasticity of labor supply in the short-run.¹⁵

The households' period budget constraint is given by

$$c_t + q_t [k_t - (1 - \delta) k_{t-1}] + \frac{B_t}{R_t P_t} \leq \frac{W_t}{P_t} l_t + r_{k,t} k_{t-1} + \frac{B_{t-1}}{P_t} + \frac{\Pi_t}{P_t} - \frac{T_t}{P_t},$$

where P_t is the aggregate price index, k_t denotes capital, q_t is the relative price of installed capital, B_t is holdings of 1-period government bonds, R_t is the nominal interest rate set by the central bank, W_t is the aggregate nominal wage rate, $r_{k,t}$ is the real rental rate of capital, Π_t denotes the pure profits of firms, and T_t refers to lump-sum taxes paid to the government.

2.2 Labor intermediaries and firm-specific labor supply

There is a unit measure of sectors in the economy indexed by $i \in [0, 1]$, and there are a finite number N_t Cournot-Nash competitor (intermediate-goods) firms indexed by $j \in \{1, 2, \dots, N_t\}$ in each sector. The homogenous (aggregate) labor supplied by households is differentiated by perfectly-competitive labor intermediaries into first, sector-specific, and then into firm-specific, labor services.¹⁶

The disaggregation from aggregate labor, l_t , to sector-specific labor, $l_t(i)$, conforms with the following aggregator function:

$$l_t = \left[\int_0^1 l_t(i)^{\frac{\eta_l+1}{\eta_l}} di \right]^{\frac{\eta_l}{\eta_l+1}},$$

where η_l denotes the labor supply elasticity at the sectoral level (i.e., it captures the percent increase in labor services supplied to a particular sector as the sectoral wage increases by one percent, all else equal). Given perfect competition across the labor intermediaries, the above formulation gives rise to a sector-specific labor supply curve for sector i given by

$$l_t(i) = \left(\frac{W_t(i)}{W_t} \right)^{\eta_l} l_t, \quad (2)$$

¹⁵The specification here follows Gali et al. (2012), which preserves the existence of a balanced growth path with

$$\Theta_t = \frac{h_t}{\bar{c}_t - \zeta \bar{c}_{t-1}}, \text{ with } h_t = (\bar{c}_t - \zeta \bar{c}_{t-1})^{\varrho} h_{t-1}^{1-\varrho}, \quad (1)$$

where h_t is the trend level of (surplus) consumption and ϱ is a persistence parameter which regulates the strength of the income-elasticity of labor supply in the short run. In particular, setting $\varrho = 1$ eliminates the externality altogether, while lowering ϱ towards 0 weakens the short-run income-elasticity of labor supply. This feature is not key to obtain the main results in the paper, but provides a slightly better fit to the data by altering the short-run dynamics of labor with respect to productivity shocks.

¹⁶The optimization problems of these labor intermediaries can alternatively be imposed directly within the households' labor supply problem, and one would obtain the exact same firm-specific labor supply expressions. we follow the labor intermediaries approach here for convenience, and for symmetry with the goods market specification.

where $W_t(i)$ denotes the nominal wage index in sector i , and the aggregate wage index, W_t , is linked to the sector-specific wage indexes by

$$W_t = \left(\int_0^1 W_t(i)^{1+\eta_l} di \right)^{\frac{1}{1+\eta_l}}.$$

Similarly, the disaggregation from sector-specific labor, $l_t(i)$, to firm-specific labor, $l_t(i, j)$, conforms with the following aggregator function:

$$l_t(i) = N_t^{\frac{1}{\chi_l+1}} \left(\sum_{j=1}^{N_t} l_t(i, j)^{\frac{\chi_l+1}{\chi_l}} \right)^{\frac{\chi_l}{\chi_l+1}}, \quad (3)$$

where χ_l denotes the labor supply elasticity at the firm level (i.e., it captures the percent increase in labor services supplied to a specific firm within a sector as the firm-specific wage increases by one percent, all else equal). We assume that $\chi_l > \eta_l$, indicating that labor supply is more elastic within a sector relative to across sectors.¹⁷ The first-term on the right-hand side of equation (3) ensures that there is no “variety effect” on sectoral labor supply, which implies that, in a symmetric equilibrium, $N_t l_t(i, j) = l_t(i) = l_t$ for all i and j . Given perfectly competitive labor intermediaries, the above formulation gives rise to a firm-specific labor supply curve for firm j in sector i given by

$$l_t(i, j) = \left(\frac{W_t(i, j)}{W_t(i)} \right)^{\chi_l} \frac{l_t(i)}{N_t}, \quad (4)$$

where $W_t(i, j)$ denotes the wage rate paid by firm j in sector i . Accordingly, the sector-specific wage index in sector i is linked to the firm-specific wages in that sector by

$$W_t(i) = N_t^{-\frac{1}{1+\chi_l}} \left(\sum_{j=1}^{N_t} W_t(i, j)^{1+\chi_l} \right)^{\frac{1}{1+\chi_l}}, \quad (5)$$

which also indicates that, in a symmetric equilibrium, $W_t(i, j) = W_t(i) = W_t$ for all i and j .

Note that the intermediate goods firms that will be introduced later are oligopsonistic competitors in labor markets. Combining (2) and (4), firm j in sector i faces a labor supply function for its individual type of labor as

$$l_t(i, j) = \left(\frac{W_t(i, j)}{W_t(i)} \right)^{\chi_l} \left(\frac{W_t(i)}{W_t} \right)^{\eta_l} \frac{l_t}{N_t}, \quad (6)$$

where it takes into account that its firm-specific wage rate, $W_t(i, j)$, will have an impact on the

¹⁷Note that when $\chi_l = \eta_l = 1/\varphi$, the labor intermediaries’ problem can be imbedded easily into the household’s problem, where the disutility term from labor in the period utility expression of households can be written as $\frac{N_t(i)^\vartheta}{1+\vartheta} \int_0^1 \sum_{j=1}^{N_t(i)} l_t(i, j)^{1+\vartheta} di$, similar to the firm-specific labor supply specification in Carvalho and Nechio (2016).

sectoral wage, $W_t(i)$, based on equation (5). This effect is given by

$$\frac{\partial W_t(i)}{\partial W_t(i, j)} = \left(\frac{W_t(i)}{W_t(i, j)} \right)^{-\chi_l} \frac{1}{N_t}, \quad (7)$$

which implies that, in a symmetric equilibrium, the pass-through from the firm-specific to the sectoral wage rate is equal to the inverse of the number of firms in each sector; i.e., $1/N_t$. When $N_t = 1$, there is complete pass-through by construction, and thus, the labor supply elasticity faced by a single firm is equal to η_l , while as N_t increases, the pass-through from the firm-level to sectoral wages is weakened, and therefore the labor supply elasticity is effectively increased to χ_l . As will be discussed later, the above expressions are the source of the strategic interaction term in the wage Phillips curve.

2.3 Final goods producers and firm-specific goods demand

Similar to the setup for labor supply, the demand curve faced by each intermediate goods firm for its differentiated good is derived by considering the problems of perfectly-competitive final goods and sectoral goods aggregators.¹⁸ The aggregation from sector-specific output goods, $o_t(i)$, to the aggregate output good, o_t , is conducted by perfectly-competitive aggregators using the following function:

$$o_t = \left(\int_0^1 o_t(i)^{\frac{\eta_y-1}{\eta_y}} di \right)^{\frac{\eta_y}{\eta_y-1}},$$

where η_y is the elasticity of substitution between the sectoral goods. Thus, the demand curve for sectoral output goods is obtained as

$$o_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\eta_y} o_t, \quad (8)$$

where $P_t(i)$ denotes the price index in sector i , and the aggregate price index, P_t , is given by, $P_t = \left(\int_0^1 P_t(i)^{1-\eta_y} di \right)^{\frac{1}{1-\eta_y}}$.

Similarly, the aggregation from firm-specific goods, $o_t(i, j)$, to sector-specific goods, $o_t(i)$, is conducted by perfectly-competitive aggregators using the following function:

$$o_t(i) = N_t^{-\frac{1}{\chi_y-1}} \left(\sum_{j=1}^{N_t} o_t(i, j)^{\frac{\chi_y-1}{\chi_y}} \right)^{\frac{\chi_y}{\chi_y-1}},$$

where χ_y is the elasticity of substitution between the firm-specific goods. Following Jaimovich and Floetotto (2008), we assume that $\chi_y > \eta_y$, implying that goods within a sector are more substitutable than goods across sectors. Similar to the setup for labor supply, the variety effect on sectoral output is eliminated and thus, in a symmetric equilibrium, $N_t o_t(i, j) = o_t(i) = o_t$ for all i and j . The

¹⁸The setup for goods aggregators is similar to that in Jaimovich and Floetotto (2008).

resulting demand curve for firm-specific goods is then obtained as

$$o_t(i, j) = \left(\frac{P_t(i, j)}{P_t(i)} \right)^{-\chi_y} \frac{o_t(i)}{N_t}, \quad (9)$$

where $P_t(i, j)$ denotes the price of the output good of firm j in sector i , and the sector-specific price index in sector i is given by

$$P_t(i) = N_t^{\frac{1}{\chi_y - 1}} \left(\sum_{j=1}^{N_t} P_t(i, j)^{1 - \chi_y} \right)^{\frac{1}{1 - \chi_y}}, \quad (10)$$

with $P_t(i, j) = P_t(i) = P_t$ for all i and j in a symmetric equilibrium.

Combining (8) and (9), the goods demand curve facing firm j in sector i is given by

$$o_t(i, j) = \left(\frac{P_t(i, j)}{P_t(i)} \right)^{-\chi_y} \left(\frac{P_t(i)}{P_t} \right)^{-\eta_y} \frac{o_t}{N_t}, \quad (11)$$

where the firm takes into account that its firm-specific price, $P_t(i, j)$, will impact the sector-specific price index, $P_t(i)$, based on equation (10). The derivative of the sectoral price index to firm-specific prices is given by

$$\frac{\partial P_t(i)}{\partial P_t(i, j)} = \left(\frac{P_t(i)}{P_t(i, j)} \right)^{\chi_y} \frac{1}{N_t}, \quad (12)$$

which indicates that the pass-through from the firm-specific to the sectoral price level is inversely related to the number of firms in each sector.¹⁹

2.4 Intermediate goods producers

As noted before, there is a unit measure of sectors in the economy indexed by $i \in [0, 1]$, while there are a finite number N_t intermediate goods producers indexed by $j \in \{1, 2, \dots, N_t\}$ in each sector. These firms possess oligopoly power in the goods market as well as oligopsony power in labor markets.²⁰

The gross output of firm j in sector i , is described by the following Leontief function:

$$o_t(i, j) = \min \left\{ \frac{m_t(i, j)}{s_m}, \frac{y_t(i, j)}{1 - s_m} \right\}, \quad (13)$$

where $m_t(i, j)$ is the material inputs used in production with s_m denoting the share of materials

¹⁹Thus, when $N_t = 1$, there is complete pass-through to sectoral prices with the own-price elasticity of demand faced by a single firm equaling $-\eta_y$, while as N_t increases, the pass-through is weakened and demand facing the firm effectively becomes more elastic, approaching $-\chi_y$.

²⁰For tractability, we assume that firms are facing the same number of competitors in both the goods and labor markets. Furthermore, the model abstracts from geographic differentiation and focuses on market power at the sectoral level. One could potentially interpret each sector here as a sector-location combination, with equal elasticities of substitution across sectors and geographical locations.

in gross output, while $y_t(i, j)$ denotes the value added of the firm. This value added is in turn described by a Cobb-Douglas production function as:

$$y_t(i, j) = z_t [u_t(i, j) k_{t-1}(i, j)]^\alpha [l_t(i, j)]^{1-\alpha} - f, \quad (14)$$

where u_t is the capital utilization rate, α is the share of capital, and z_t denotes the total factor productivity (TFP) shock, which follows an AR(1) process. f denotes the fixed cost of production.

The intermediate goods firm's profits in period t is given by

$$\begin{aligned} \frac{\Pi_t(i, j)}{P_t} = & \frac{P_t(i, j)}{P_t} o_t(i, j) - m_t(i, j) - \frac{W_t(i, j)}{P_t} l_t(i, j) - r_{k,t} k_{t-1}(i, j) - \frac{\kappa_u}{1 + \varpi} \left(u_t(i, j)^{1+\varpi} - 1 \right) k_{t-1}(i, j) \\ & - \frac{\kappa_p}{2} \left(\frac{P_t(i, j)/P_{t-1}(i, j)}{\pi} - 1 \right)^2 \frac{o_t}{N_t} - \frac{\kappa_w}{2} \left(\frac{W_t(i, j)/W_{t-1}(i, j)}{\pi} - 1 \right)^2 \frac{W_t}{P_t} \frac{l_t}{N_t}, \end{aligned}$$

where the last three terms are the costs related to capacity utilization, price and wage adjustment, respectively. Here, κ_p and κ_w denote the level parameters for the price- and wage-adjustment costs, and κ_u and ϖ are the level and elasticity parameters for the utilization cost specification.²¹

An intermediate goods firm's objective is to maximize the present value of their profits and choose its input quantities, $m_t(i, j)$, $l_t(i, j)$ and $k_{t-1}(i, j)$, capital utilization rate, $u_t(i, j)$, value added and gross output quantities, $y_t(i, j)$ and $o_t(i, j)$, output price, $P_t(i, j)$, and the firm-specific wage rate, $W_t(i, j)$, while taking as given the decisions of its competitors in the same industry i and economy-wide aggregates for the current period as well as all future periods and states. When solving this maximization problem, each firm takes into account how its own wage and price decisions would impact the sectoral wages and prices based on the sectoral wage and price indexes defined in (5) and (10), respectively, while treating its rivals' current and future actions as parameters. As such, we are considering "open-loop" strategies for these firms with respect to the dynamic effects of their actions.²²

2.5 Firm entry-exit

The model features free entry and exit of firms based on sectoral profitability.²³ Let N_t^* denote the number of firms that would ensure that intermediate-goods firms make zero profits under no nominal rigidities. Given the firms' profit expression, this *long-run target* number of firms is given by

$$N_t^* = \left(\frac{\theta_{p,t}}{(1 - \alpha)\theta_{w,t} + \alpha} - 1 \right) \frac{y_t(i)}{f},$$

²¹As is standard, κ_u is set equal to the steady-state value of $r_{k,t}$ to ensure that the capital utilization rate, u_t , is, without loss of generality, equal to 1 at the steady-state.

²²Thus, the equilibria we consider are open-loop Nash equilibria, which are not necessarily subgame perfect (Fershtman and Kamien, 1987 and Fudenberg and Tirole, 1988). Considering subgame perfect "closed-loop" equilibria is significantly challenging given our setup, and is thus not attempted here.

²³The setup here largely follows Jaimovich and Floetotto (2008). Also see Bilbiie et al. (2012), Etro and Colciago (2010), and Lewis and Poilly (2012) for the interaction between firm entry and markups.

which, after imposing symmetry and log-linearization, can be written as

$$\hat{N}_t^* = \hat{y}_t + \frac{\theta_p}{\theta_p - [(1 - \alpha)\theta_w + \alpha]} \left(\hat{\theta}_{p,t} - \frac{(1 - \alpha)\theta_w}{(1 - \alpha)\theta_w + \alpha} \hat{\theta}_{w,t} \right). \quad (15)$$

We posit that there is inertia in the number of firms operating at any time based on short-run frictions in reaching the aforementioned long-run number of firms. Thus, the actual number of firms in the economy, N_t , is determined partly by the past number of firms, N_{t-1} , and partly by the long-run target number of firms, N_t^* , as

$$N_t = \left\lfloor N_{t-1}^{\rho_N} (N_t^*)^{1-\rho_N} \right\rfloor, \quad (16)$$

where ρ_N is the persistence parameter and $\lfloor \cdot \rfloor$ denotes the “floor” function (i.e., the greatest integer equaling or less than its argument).²⁴

2.6 Capital producers

Capital producers are perfectly competitive. After goods production takes place, these firms purchase the un-depreciated part of the installed capital from households at a relative price of q_t , and the new investment goods, x_t , from final goods producers at a (relative) price of 1, and produce the capital stock to be carried over to the next period. This production is subject to adjustment costs in the change in investment, and is described by the following law-of-motion for capital:

$$k_t = (1 - \delta_k) k_{t-1} + \left[1 - \frac{\kappa_x}{2} \left(\frac{x_t}{x_{t-1}} - 1 \right)^2 \right] x_t, \quad (17)$$

where κ_x is the adjustment cost parameter.

After capital production, the end-of-period installed capital stock is sold back to households at the installed capital price of q_t . The capital producers’ objective is thus to maximize

$$E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \frac{\lambda_{\tau}}{\lambda_t} [q_{\tau} k_{\tau} - q_{\tau} (1 - \delta) k_{\tau-1} - x_{\tau}],$$

subject to the law-of-motion of capital, where future profits are discounted using the patient households’ stochastic discount factor. The first-order-condition of capital producers with respect to investment goods yields an investment demand expression relating investment to Tobin’s marginal q , which, after detrending and log-linearization, can be written as,

$$\hat{x}_t - \hat{x}_{t-1} = \beta (E_t \hat{x}_{t+1} - \hat{x}_t) + \frac{1}{\kappa_x} \hat{q}_t. \quad (18)$$

²⁴Since we log-linearize the model, we will ignore this floor function in our simulations, and will treat N_t as a continuous variable.

2.7 Monetary and fiscal policy

The central bank targets the nominal interest rate using the following Taylor rule:

$$\log R_t = \rho \log R_{t-1} + (1 - \rho) \left(\log R + a_\pi \log \frac{\pi_t}{\pi} + a_y \log \frac{y_t}{y} \right) + \tilde{\varepsilon}_{R,t}, \quad (19)$$

where ρ determines the degree of interest rate smoothing, R is the steady-state value of the (gross) nominal policy rate, and a_π and a_y are the long-run response coefficients for inflation and output gap, respectively. $\tilde{\varepsilon}_{R,t}$ denotes the monetary policy shock, which follows an AR(1) process.

On the fiscal policy side, we assume that government bonds are in zero supply; hence, $B_t = 0$ for all t . The government runs a balanced budget each period, financing its expenditures with lump-sum taxes from households as $T_t = P_t g_t$, where g_t denotes real government expenditures, which are assumed to be exogenous and follow an AR(1) process.

2.8 Market clearing conditions

The final goods market clearing condition is given by

$$c_t + x_t + g_t = y_t = o_t - m_t, \quad (20)$$

where total materials is given by $m_t = \int_0^1 \sum_{j=1}^{N_t} m_t(i, j) di$, and the costs related to price and wage adjustment are assumed to have no resource consequences, and are therefore treated as lump-sum transfers to households with profits. All input markets clear as well. Thus, the demand for labor services of firm j in sector i is equal to the firm-specific labor supply of the labor intermediaries for each i and j every period. Similarly, in the context of capital, market clearing implies that, $k_t = \int_0^1 \sum_{j=1}^{N_t} k_t(i, j) di$. We only consider symmetric equilibria where firm-specific variables indexed by i and j are equal across all firms. As a result, the firm's production function in (14) can be aggregated and log-linearized to give

$$\hat{y}_t = \left(1 + \frac{Nf}{y} \right) \left[\hat{z}_t + \alpha \left(\hat{u}_t + \hat{N}_t - \hat{N}_{t-1} + \hat{k}_{t-1} \right) + (1 - \alpha) \hat{l}_t \right] - \frac{Nf}{y} \hat{N}_t \quad (21)$$

3 Implications of the role of the market power in the labor and product markets

In this section we consider the qualitative implications of the role of the market power in the labor and product markets on the price and wage Phillips curve and labor share in income.

3.1 Price Phillips curve

The intermediate goods firm's pricing decision gives rise to the following Phillips curve expression in (22), after imposing a symmetric equilibrium and log-linearization:²⁵

$$\hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \frac{(1 - s_m) \left(\chi_y - \frac{\chi_y - \eta_y}{N} \right) - 1}{\kappa_p} \left(\hat{\Omega}_t + \hat{\theta}_{p,t} \right), \quad (22)$$

where Ω_t denotes the Lagrange multiplier with respect to the production function in (14), and captures the firm's real marginal cost of production. Here, $\theta_{p,t}$ denotes the firms' gross markup of price over marginal cost in the *absence* of price rigidities:

$$\hat{\theta}_{p,t} = - (1 - s_m) \left(\frac{\chi_y - \eta_y}{N} \right) \frac{(\theta_p - 1)^2}{\theta_p} \hat{N}_t. \quad (23)$$

There are several things to note regarding the expression above. First, the presence of material inputs in production (i.e., $s_m > 0$) leads to a larger price markup relative to the standard setup, since firms are marking up their output prices including the costs related to their material inputs. Second, $\theta_{p,t}$ is inversely related to the number of firms, N_t , since $\chi_y > \eta_y$. Thus, the gross price markup in the model, $1/\Omega_t$, is endogenously countercyclical over the business cycle not only due to the presence of price adjustment costs as in the standard setup (i.e., $\kappa_p > 0$), but also due to endogenous firm entry-exit as expansions result in increases in the number of firms. Third, if the economy becomes more concentrated over the long run (i.e., the steady-state number of firms, N , decreases over time), this would generate a higher steady-state price markup, θ_p .

Panel (a) of Figure 3 illustrates an intermediate firm's price markup in the goods market in the absence of price rigidities. In the figure, D denotes the downward-sloping demand curve facing the individual firm's output as in equation (11), while the MR and the MC curves denote the marginal revenue and the marginal cost of production, respectively.²⁶ Note that MC is upward sloping, since the firm internalizes the fact that it will have to increase the wage rate as it hires more labor to increase output. Similarly, MR is below price for a given output level, since the firm internalizes the fact that it would need to cut its price as it increases output. At the optimum, the firm produces where MR equals MC , and sets the price at a markup relative to its marginal cost, as shown by the arrow on the figure.

Since the slope of the price Phillips curve, in (22), is positively related to the steady-state number of firms, N , it predicts a flattening of the Phillips curve as industry concentration increases. Note also that the above expression reduces to the standard Phillips curve expression in the literature if we abstract from material inputs (i.e., $s_m = 0$) and let the number of firms in each sector approach infinity (i.e., $N \rightarrow \infty$). In particular, the demand elasticity facing each firm would be equal to χ_y ,

²⁵Note that we are imposing a symmetric equilibrium *after* taking the first-order condition with respect to the firm's price, $P_t(i, j)$. Rival firms' current and future prices are treated as given.

²⁶The use of straight-line demand curves in the Figure is for illustrative purposes only.

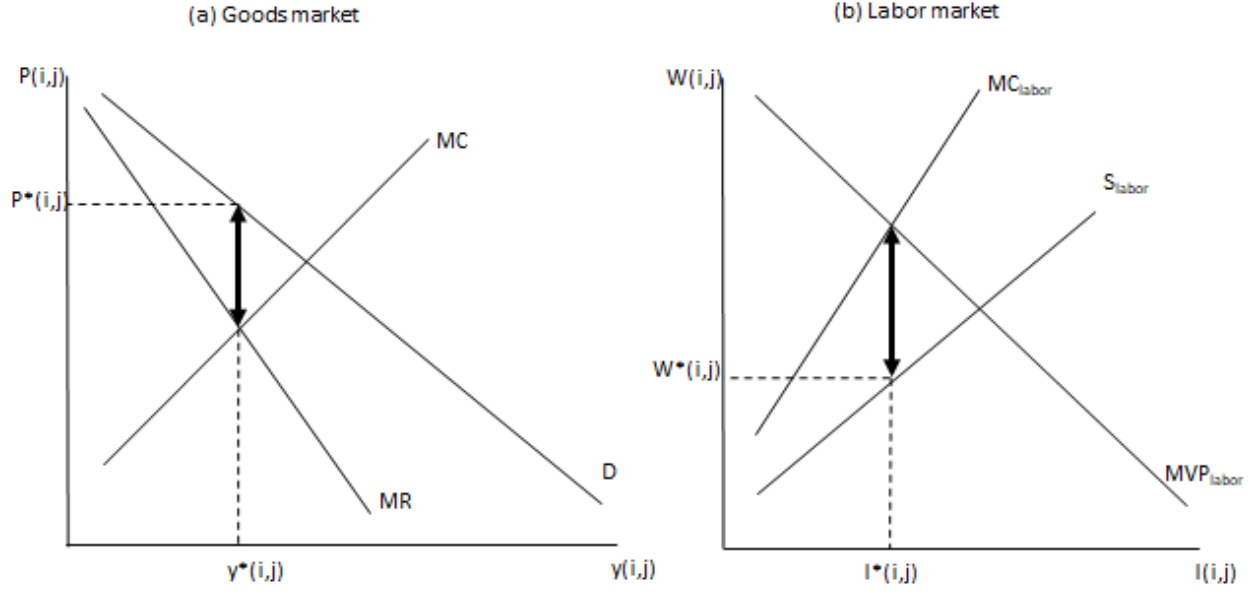


Figure 3: Firms take as given the goods demand and labor supply curves, and set prices at a markup relative to the marginal cost of production and wages at a markdown relative to the marginal value product of labor.

and the gross markup of price over marginal cost would be $\chi_y / (\chi_y - 1)$. With Rotemberg-type price rigidities, the slope of the Phillips curve would now be $(\chi_y - 1) / \kappa_p$. With a finite number of firms however, the *effective* elasticity of demand facing a firm, and therefore its gross markup, is altered by a strategic interaction term that arises from the oligopolistic competition between firms. This strategic interaction term reduces the effective elasticity of demand facing the firm to $\chi_y - \frac{\chi_y - \eta_y}{N}$, thereby altering the steady-state gross markup of firms as in (23) and the slope of the aggregate price Phillips curve as in (22).²⁷

To build intuition for this result, remember from the previous section that the goods demand facing firm j in sector i in (11) can be written as

$$y_t(i, j) = P_t(i, j)^{-\chi_y} P_t(i)^{\chi_y - \eta_y} P_t^{-\eta_y} \frac{y_t(1 - s_m)}{N_t}, \quad (24)$$

and in a symmetric equilibrium, the pass-through from firm-specific price, $P_t(i, j)$, to the sectoral price, $P_t(i)$, is given by $1/N_t$ (see equation (12)). The latter is the source of the strategic interaction term discussed above, since firms internalize the impact of their own pricing on the sectoral price, and this effect is inversely related to the number of firms, N_t . Thus, they do not have to respond

²⁷Note that $\chi_y - \frac{\chi_y - \eta_y}{N} = \frac{N-1}{N} \chi_y + \frac{1}{N} \eta_y$; thus, the effective demand elasticity facing the firm is determined by a weighted average of the demand elasticity parameters, χ_y and η_y , with the corresponding weights given by the number of competitors, N .

as much to changes in their marginal cost when they alter prices, which in the aggregate gives rise to the flattening of the Phillips curve. This strategic effect is proportional to $\chi_y - \eta_y$, which is the difference between the within-sector and across-sector demand elasticities. When these elasticities are close to each other, the goods across sectors are viewed as close substitutes to goods within the same sector, which effectively reduces the market power of firms within the industry.

3.2 Wage Phillips curve

Similar to the pricing decision, the intermediate goods firm's wage decision gives rise to the following wage-Phillips curve expression after log-linearization:

$$\hat{\pi}_{w,t} = \beta E_t \hat{\pi}_{w,t+1} + \frac{\chi_l - \frac{\chi_l - \eta_l}{N} + 1}{\kappa_w} \left[\hat{\Omega}_t + \hat{z}_t + \alpha \left(\hat{u}_t + \hat{N}_t - \hat{N}_{t-1} + \hat{k}_{t-1} - \hat{l}_t \right) - \hat{w}_t + \hat{\theta}_{w,t} \right], \quad (25)$$

where $\pi_{w,t} = W_t/W_{t-1} = \pi_t w_t/w_{t-1}$ refers to the nominal wage-inflation factor, and $\theta_{w,t}$ denotes the firms' gross wage markdown in the *absence* of wage rigidities:

$$\hat{\theta}_{w,t} = \left(\frac{\chi_l - \eta_l}{N} \right) \frac{(1 - \theta_w)^2}{\theta_w} \hat{N}_t + \varepsilon_{w,t} \quad (26)$$

where $\varepsilon_{w,t}$ is an exogenous and *i.i.d.* wage shock. Similar to the price Phillips curve, the slope of the wage-Phillips curve is increasing in the steady-state number of firms, N , given $\chi_l > \eta_l$. Thus, increased concentration over time is also consistent with a flattening of the wage-Phillips curve. This in turn would result in a slower pass-through from productivity shocks, z_t , to wages.

In particular, when $\kappa_w = 0$ and there is no wage adjustment cost, the wage-Phillips curve expression reduces to

$$\hat{w}_t - \left[\hat{\Omega}_t + \hat{z}_t + \alpha \left(\hat{u}_t + \hat{N}_t - \hat{N}_{t-1} + \hat{k}_{t-1} - \hat{l}_t \right) \right] = \hat{\theta}_{w,t} \quad (27)$$

which indicates that real wages are marked down relative to the marginal product of labor by factor $\theta_{w,t} < 1$. Note that $\theta_{w,t}$ is positively related to the number of firms, N_t , since $\chi_l > \eta_l$. Thus, the *net* markdown in real wages, $1 - \theta_{w,t}$, becomes countercyclical as $\theta_{w,t}$ gets closer to 1 in expansions and move away from 1 in recessions. Similarly, a secular increase in market concentration (i.e., a lower steady state N) would drive θ_w further below 1, generating a larger (gross) markdown in real wages in the long run.

Panel (b) of Figure 3 illustrates the markdown of wages in the labor market in the absence of wage rigidities. S_{labor} denotes the upward-sloping labor supply curve facing the individual firm as in equation (6), the MC_{labor} curve is the (nominal) marginal cost of hiring an additional unit of labor, and MVP_{labor} denotes the marginal value product of labor (i.e., price of the firm's product times the marginal product of labor). Note that MC_{labor} is above the wage rate for a given level of labor, since the firm internalizes the fact that it would need to raise its wage for all workers as it hires more labor. Similarly, MVP_{labor} is downward sloping, since the firm has to reduce its goods

price as it hires more labor and increase its output. At the optimum, the firm equates MC_{labor} to MVP_{labor} when hiring labor services, and sets the wage rate at a markdown relative to the marginal value product, as shown by the arrow on the figure.

Similar to the price Phillips curve, oligopsonistic competition among firms generates a strategic effect on the effective firm-specific labor supply elasticity, since a firm's wage decision affects the sectoral wage and the firm internalizes this effect. If there were infinitely many firms within the industry, and thus firms were engaging in monopsonistic competition instead of oligopsonistic competition in labor markets, then the firm-specific labor supply elasticity would be χ_l , the gross markdown of real wages relative to the marginal product of labor would be equal to $\chi_l/(\chi_l + 1)$, and the slope of the wage Phillips curve would be $(\chi_l + 1)/\kappa_w$. With finite number of firms and oligopsonistic competition, the firm-specific labor supply facing firms is given in (6) and the pass-through from the firm-specific wage, $W(i, j)$, to the sectoral wage, $W(i)$ is $1/N_t$ in a symmetric equilibrium as in (7). Thus, the firm effectively faces a labor supply function with an elasticity of $\chi_l - \frac{1}{N_t}(\chi_l - \eta_l)$, which results in a larger (gross) wage markdown and a flattening of the wage Phillips curve slope, relative to the monopsonistic competition case.

Intuitively, with oligopsony power, firms do not have to alter their wages as much when they respond to changes in productivity, since their decisions have an impact on the sectoral wage, and firms internalize this effect. This in the aggregate gives rise to the flattening of the wage Phillips curve. Furthermore, similar to the price Phillips curve case, the strategic effect with oligopsonistic competition depends on the difference between the within-sector and the across-sector labor supply elasticities, $\chi_l - \eta_l$. When this difference is close to 0, labor can move within a sector and across sectors with almost equal ease, and therefore the effective labor market power of firms is reduced.

3.3 Labor share of income

One can obtain the factor shares of income from the intermediate goods producers' optimality conditions. At the steady state of the model, the labor share of income is given by

$$\frac{wl}{y} = \frac{(1 - \alpha)\theta_w}{\theta_p} \left(1 + \frac{Nf}{y}\right), \quad (28)$$

while the capital's share is

$$\frac{r_k k}{y} = \frac{\alpha}{\theta_p} \left(1 + \frac{Nf}{y}\right), \quad (29)$$

and the intermediate goods producers earn oligopoly and oligopsony profits equaling

$$\frac{\Pi/P}{y} = 1 - \frac{r_k k}{y} - \frac{wl}{y} = 1 - \frac{(1 - \alpha)\theta_w + \alpha}{\theta_p} \left(1 + \frac{Nf}{y}\right). \quad (30)$$

As discussed in the previous subsections, the gross price markup factor, θ_p , is inversely related to the steady-state number of firms, N , while the wage gross markdown factor, θ_w , is positively related to N . Thus, as N decreases, the model predicts a secular decline in the labor share of income,

consistent with the data presented in the Introduction, while the sum of the shares that accrue to capital and to firm owners as pure profits would rise. As N decreases and therefore θ_p increases, the model would also predict a secular decline in the capital share of income in (29), but this effect would be smaller than the effect on the labor share, since the latter is adversely effected by the decrease in θ_w as well as the increase in θ_p .

4 Quantitative implications of the role of market power in the labor and product markets

4.1 Calibration

We calibrate the relevant main parameters of the model to get a sense of the quantitative importance of industry concentration on labor income share and the slope of the price and wage Phillips curve.

The time-discount factor of households, β , is set to 0.995 to match an annualized 4% real interest rate at the steady state. The depreciation rate of capital, δ , is set to 0.02 to match a 8% depreciation rate in annualized terms, and the share of materials in gross output, s_m , is set to 0.45 based on the difference of GDP and gross national output in the NIPA accounts of BEA during the post-war period. Similarly, the capital in the value-added production function, α , is set to 0.3, while the share of government expenditure in GDP, g/y , is set to 0.2.

Based on the literature, we set the cross-sector elasticity parameter, η_y , equal to 2.²⁸ The within-sector elasticity of substitution used in the related literature is typically larger and ranges between 3 and 20.²⁹ We use a value of 12 for the within-sector elasticity parameter, χ_y . Based on these baseline figures, we set the steady-state number of firms in each industry, N , equal to 8, to match a steady-state net markup in prices of 20%, which is within the range of mark-up estimates reported in Barkai (2020) and De Loecker et al. (2020).

Recent micro-level studies on the firm-specific (within-sector) labor supply elasticity, χ_l , suggest a fairly inelastic labor supply. Given existing estimates in the literature, we use a value of 10 for the firm-specific labor supply elasticity parameter, χ_l , which implies a near 10% steady-state markdown in wages. We detail the related literature in the Appendix. As argued in the model section, the labor supply elasticity at the sectoral level, η_l , is likely lower than χ_l , indicating less willingness of workers to switch jobs across sectors, relative to within a sector, for the same wage differential. There is not adequate micro-level evidence on this parameter however, and thus, we will provide identification by assuming that the sectoral labor supply elasticity, η_l , is equal to the households' labor supply elasticity in the aggregate, $1/\varphi$, where we calibrate φ to be 2.³⁰

²⁸Hobijn and Nechio (2017) use European Union expenditure data at the 3-digit expenditure categories ("classes") around value-added tax changes, and find a cross-sector elasticity of substitution of around 3 with an upper bound of 5, while the parameterization used in Jaimovich and Floetotto (2008) implies an elasticity of substitution across sectors of close to 1.

²⁹See Figure 1 of the 2015 version of Hobijn and Nechio (2017) for a summary of this related literature and further details in the Appendix.

³⁰One interpretation of this is to think of leisure time as encompassing non-market work, which is then regarded

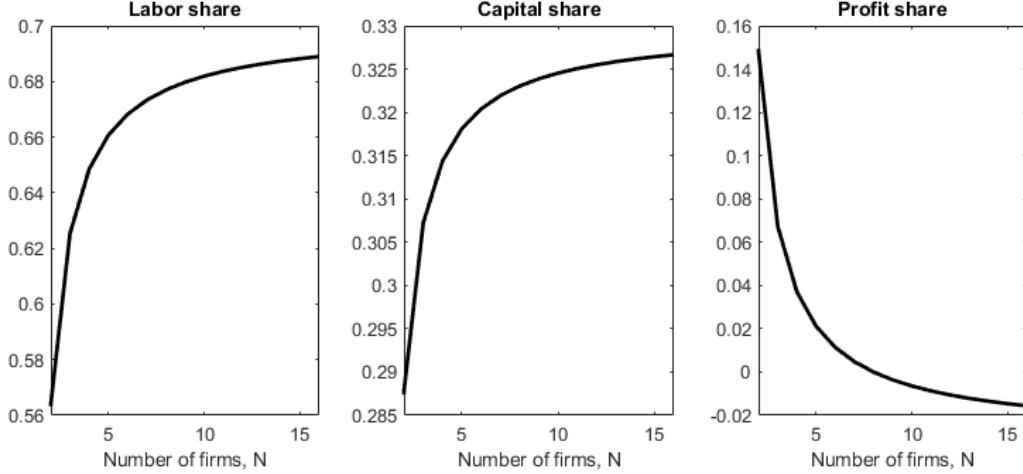


Figure 4: The steady-state share of income accruing to labor, capital, and pure profits as a function of the number of firms in each industry, N .

We calibrate the Rotemberg price-adjustment and wage-adjustment parameters, κ_p and κ_w respectively to match the slope of the Phillips curves in our specification with ones in a standard new Keynesian model with Calvo style price and wage stickiness where the Calvo parameter takes a value of 0.75, which implies an average duration of four quarters for price and wage contracts. Given the calibration of all other parameters above, this implies a value of 58 for κ_p and 118 for κ_w .³¹ For the monetary policy rule, we set ρ to be 0.8 to allow interest rate smoothing, and use relatively standard parametrization from the monetary literature to set the inflation coefficient, α_π to be 1.5 and α_y to be 0.125. We need to calibrate some additional parameters such as the habit formation, ζ , which we set to be 0.8, investment adjustment cost parameter to be 4 and utilization parameter, ϖ , which implies that the elasticity of capacity utilization with respect to the rental rate of capital is 2. These parameters are consistent with estimates from Christiano et al. (2005) and Smets and Wouters (2007).

Further details on calibration are provided in the Appendix.

4.2 Industry concentration and labor share of income

Figure 4 presents the distribution of aggregate income between labor, capital and pure profits at the steady state of the baseline model with $N = 8$, and analyzes how these would change as the steady-state number of competitors, N , is altered. The steady-state income share figures are calculated using the expressions derived in (28)-(30).

as just another sector by households with the same inter-industry labor supply elasticity. We thank Roberto Burguet for this insight.

³¹Note that this approach is matching the Phillips curve slope to a standard new Keynesian model. For instance, in the case of Calvo price stickiness, if the Calvo parameter, denoted by $\alpha^p = 0.75$, then the slope is given by $(1 - \alpha^p)(1 - \beta\alpha^p)/\alpha^p$, which equals 0.0865. Our parametrization of κ^p will ensure that we match this price Phillips curve slope in steady state. We apply a similar methodology for the wage Phillips curve.

In the baseline case, where $N = 8$, the labor share in total income is 67.7%, capital share is 32.3%, while pure profits make up 0% of total income. The results indicate a non-linearity with respect to the distribution of income in terms of N , which captures industry concentration. In particular, the distribution of income does not significantly change as N increases relative to the baseline case, with the labor share increasing only to 68.9% with $N = 16$. Going to the extreme case with infinitely many firms (i.e., monopolistic and monopsonistic competition in the goods and labor markets, respectively) generates a labor share of 69.9%, only slightly higher than the baseline case. The results are materially affected when industry concentration, N declines however. The labor share is reduced to 64.8% with $N = 4$, while a duopoly-duopsony structure with $N = 2$ reduces the labor share further to 56.4%. In the extreme case with $N = 1$ (i.e., a monopoly-monopsony structure within each industry, not shown in Figure 4), the labor share is reduced to merely 27.5%.

Figure 4 shows that as N becomes smaller we also see a decline in capital income share, though this decline is smaller than the one for labor income share. This is accompanied by a rise in profit share.³²

The decline in the labor share of income seen in the aggregate data since the 1980s has been of the order of 4-5 pp. Generating this type of a change solely through increased industry concentration would require N to decrease from 8 to around 2-3. Thus, the analysis here suggests that, while increased industry concentration has likely contributed to the decline in the labor share of income, it cannot account for the change fully given that N is likely to be around 4-5 in the post-1984 period based on regulations imposed on mergers and acquisitions by the FTC.

Note that industry concentration affects the distribution of income through its effects on the firms' price markups and wage markdowns at the steady state (see Equations (28)-(30)), and is therefore also the source of the non-linearity in its effects on income shares. Figure 5 presents the price markup, θ_p and the wage markdown, θ_w , based on steady-state expressions shown (23) and (26), respectively, as we vary the steady-state number of competitors, N . The figure shows that the gross price markups and wage markdowns are fairly stable past a threshold level of N , while they change significantly when N is low. As N declines, we see larger price markups and wage markdowns. In particular, the net price markup and wage markdown is only 1-2 pp different for $N = 1,000,000$ relative to the baseline case with $N = 8$, while reducing the goods and labor markets to duopoly-duopsony (i.e., $N = 2$) affects these wedges by 6-15 pp.³³ Note that the FTC's preferred threshold of 4 remaining significant firms when conducting merger policy seems by and large appropriate from this perspective, and perhaps could be slightly tightened to 5-6 firms to get

³²This is largely consistent with Barkai (2020), who uses an opportunity cost of capital measure to separate the returns to capital from pure profits in the national income accounts data, and shows that both the shares of labor and capital in total income have declined over time. However, he finds that the capital share has declined by about the same percentage points as the labor share, where both decline by about 7 percentage points while pure profits increase by about 14 pp, over 1984-2014. (Since the capital share is smaller, this amounts to a much larger percent decline in the capital share.)

³³The evidence in De Loecker et al. (2020) points to an almost doubling of price markups between the pre and post 1980s periods, but the model here can generate this type of a markup increase only if N is reduced to 1 (i.e., a monopoly-monopsony setup). Since this is unlikely for the economy as a whole, other factors that increased concentration are likely to be at play as well.

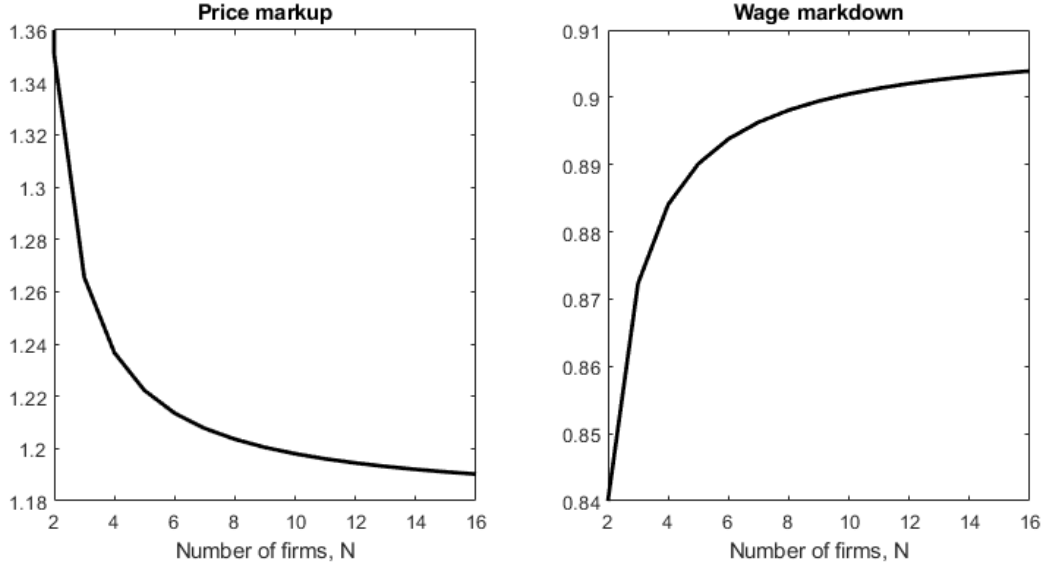


Figure 5: The firms' gross price markup and wage markdown as a function of the number of firms in their industry, N .

the equilibrium very close to that with monopolistic-monopsonistic competition.³⁴

4.3 Industry concentration and the slopes of the wage and price Phillips curves

Figure 6 plots the slopes of the price and wage Phillips curves with the baseline $N = 8$, and shows how the slopes would adjust as N changes while keeping all other parameters the same as in the baseline case. The non-linearity that was evident for the income shares is also evident here. The Phillips curve slopes are not materially affected when N is above a certain threshold. However, if we consider a reduction in N , to capture industry concentration, then both the price and wage Phillips curve slopes are substantially reduced. If we consider a steady-state number of competitors to be 4 instead of the baseline 8, we would see a 14% and 12% decline in the slopes of the price and wage Phillips curve, respectively.

This suggests that the rise in industry concentration has the potential to partially explain the reduction in the price and wage Phillips curve seen in recent decades.

4.4 Role of endogenous firm entry/ exit

We next consider the importance of firm entry and exit in this model in the propagation of shocks for business cycle implications.

In the baseline model with firm entry and exit, we set $\rho_n = 0$ in (16) to maximize the effects

³⁴This ignores the possible effect of variety on household utility, consistent with the treatment in the model here, while focusing solely on the market power implications of concentration. Note also that, a well known result in the industrial organization literature is that an industry with 5-6 oligopolistically competitive firms can reasonably approximate the equilibrium for a monopolistically competitive market.

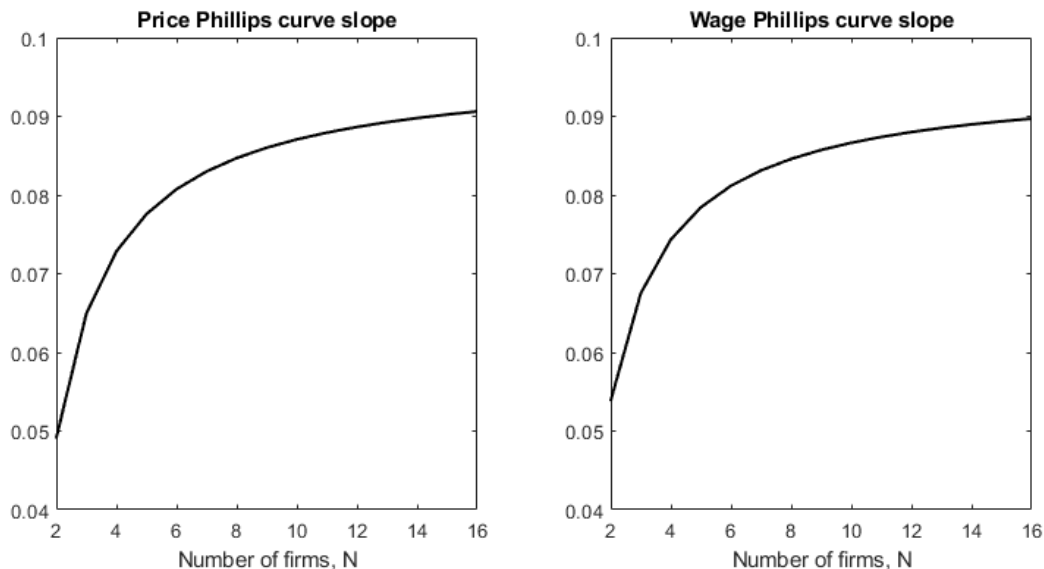
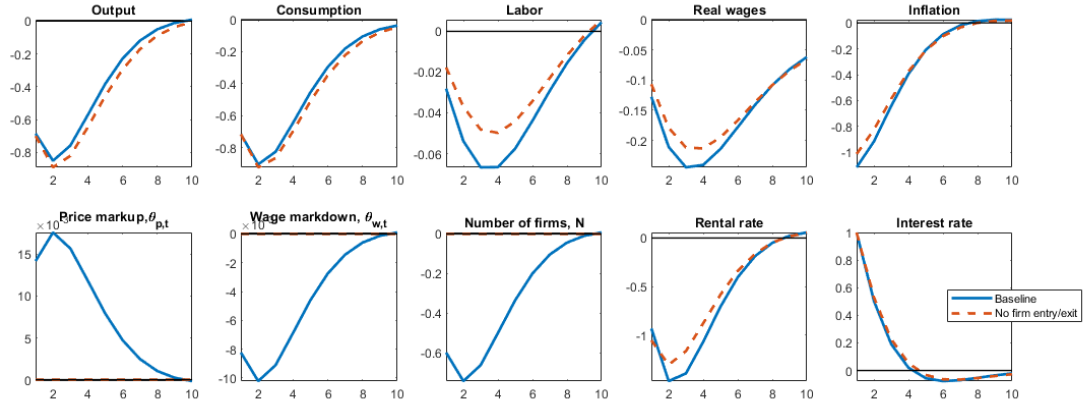


Figure 6: Slope of the price and wage Phillips curves as a function of the number of firms, N .

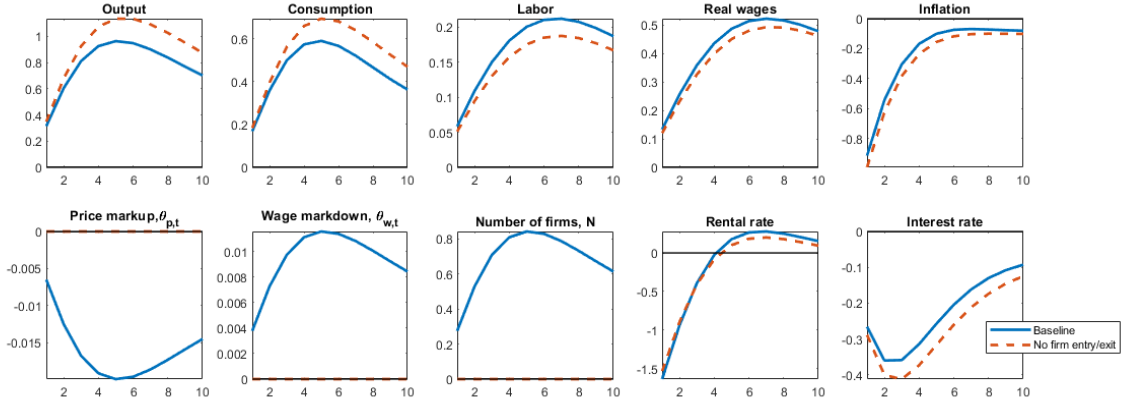
coming from firm entry/exit. Figure 7 shows the responses to a number of shocks in the baseline model, along with one where we do not allow for firm entry and exit and set $\hat{N}_t = 0$. A contractionary monetary policy shock, shown in the top panel, has standard effects on macroeconomic variables. In addition, the fall in output due to a rise in interest rates results in firm exit, and the number of firms, N_t , falls. This reduced competition implies that the gross price markup rises, as it is countercyclical, and the gross wage markdown falls. In comparison, in the case where we do not allow firm entry/exit, N is fixed and the gross price markup and wage markdown in the absence of price and wage rigidities, $\theta_{p,t}$ and $\theta_{w,t}$, respectively do not respond, and we see a dampening of the inflation response and the output response is larger. However, note that the differences are quantitatively small. One reason is that we are considering a transitory shock, where the nominal interest rate returns to steady state in close to 6 quarters. Another reason is that a shock this magnitude, while it results in firm exit and the number of firms deviates from its steady state level of $\bar{N} = 8$, the movement is too small to generate more meaningful shifts in the Phillips curve seen in the previous sections.

The second panel of Figure 7 shows the responses to a positive technology shock, which leads to a rise in output and consumption and a fall in inflation. In this case, since this is an expansionary shock, the number of firms, N_t rises. Due to increased competition, the price markup falls and the wage markdown is reduced, as evident in (23) and (26), respectively. Overall relative to a model with no firm entry and exit, we thus see a relatively dampened response of inflation in the baseline case. Similarly, the lower wage markdown leads to higher wages and thus higher labor supply in a model with firm entry and exit. The output response in a model with firm entry and exit is smaller because total fixed costs increase as number of firms rises (see (21), where the second term dominates the first term given the respective coefficients).

(a) Monetary shock



(b) Technology shock



(c) Wage shock

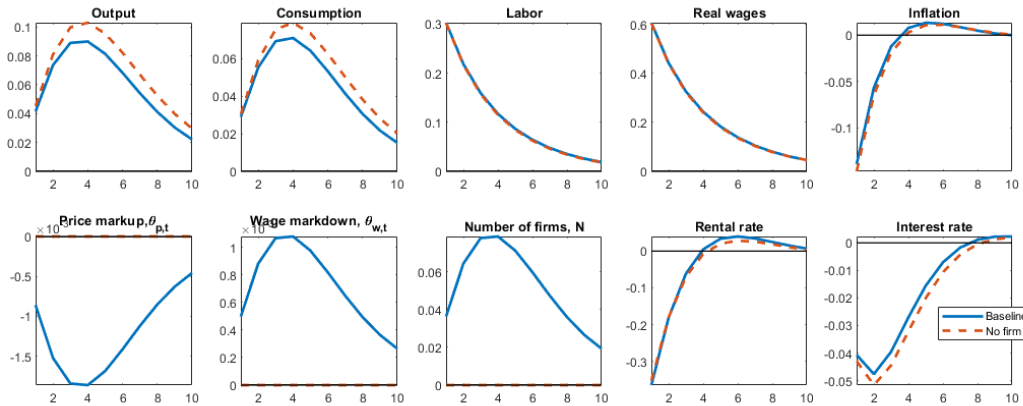


Figure 7: Response to shocks in the baseline model (solid blue) and one without firm entry/exit (red dashed).

A wage shock has similar effects as a technology shock as it is an expansionary shock which leads to firm entry. Overall, in a model with firm entry and exit, the inflation response is relatively dampened due to declining price markups, and output response is also smaller due to increasing fixed costs.

The results here suggests that in our model, while secular trends in the number of firms plays a large role in explaining steady state shares of labor income or the slope of Phillips curve, smaller fluctuations due to endogenous firm entry and exit driven by transitory shocks also play a non-trivial role, depending on the source of fluctuations.

5 Comparison to a model with oligopolistic competition in labor markets

In this section, we compare the labor market structure considered in this paper with the more commonly used structure in the literature where the labor market power rests with the household.

In the baseline model with oligopsonist firms in labor markets presented in Section 2, the aggregate labor supply expression equates the households' marginal rate of substitution with the real wage rate, which, in log-linearized form can be written as

$$\vartheta \hat{l}_t = \hat{w}_t + \hat{\lambda}_t, \quad (31)$$

while the wage Phillips curve expression is obtained from the firms' problem as (25), whereby wage rigidities drive an additional wedge between the marginal product of labor and the real wage rate.

On the other hand, in the standard DSGE framework where labor market power is on the household (i.e., supply) side, the wage Phillips curve expression is obtained from the households' problem, whereby wage rigidities drive a wedge between the households' marginal rate of substitution and the real wage rate as

$$\hat{\pi}_{w,t} = \beta E_t \hat{\pi}_{w,t+1} + \frac{\chi_l - \frac{1}{N}(\chi_l - \eta_l) - 1}{\kappa_w} \left(\vartheta \hat{l}_t - \hat{w}_t - \hat{\lambda}_t + \hat{\theta}_{w,t} \right). \quad (32)$$

Note that χ_l and η_l are now interpreted as capturing the elasticity of labor demand at the firm and sectoral levels, respectively. With oligopolistic labor, $\theta_w > 1$ at the steady state; thus, real wages are *marked up* relative to the marginal rate of substitution.³⁵ Similarly, the firms' problem now implies that the marginal cost of production is also obtained by the ratio of real wages to the marginal product of labor; hence,

$$\hat{\Omega}_t + \hat{z}_t + \alpha \left(\hat{u}_t + \hat{k}_{t-1} - \hat{l}_t \right) = \hat{w}_t. \quad (33)$$

In order to compare the implications of the labor market structure on the propagation of shocks, we compare the impulse responses of key model variables to shocks under the baseline model with

³⁵Note that in this case θ_w , while affecting the steady state labor share of income, does not alter any of the dynamic equations of the model.

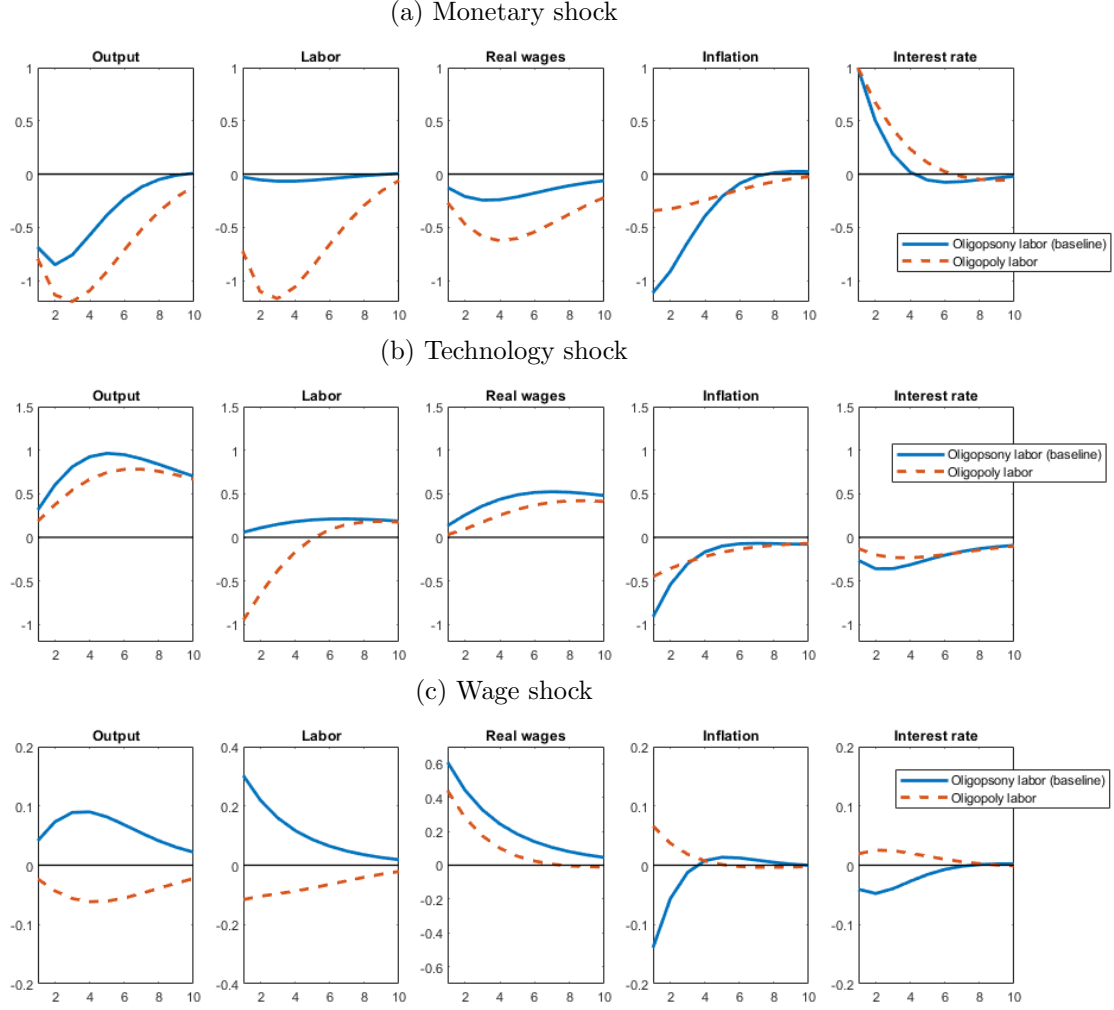


Figure 8: Response to shocks in the baseline model with labor market power on the firm side (solid blue) and alternative model with labor market power on the household side (red dashed).

oligopsonistic competition in labor markets versus the alternative model where households have labor market power and engage in oligopolistic competition in labor markets. We set all parameters to the same values across the two models, including those for χ_l and η_l , even though the interpretation of these two parameters are now slightly different as noted earlier.

Figure 8 top panel shows the responses to a monetary policy shock in the two models where the nominal interest rate rises 100 bps. It shows that the transmission of the shocks to macroeconomic variables, particularly output and inflation are qualitatively not that different, although there are quantitative differences. In particular, the baseline model with oligopsony labor generates significantly weaker impulse responses for the equilibrium levels of labor relative to the oligopoly labor model. Since firms internalize the increase in the marginal cost of hiring an additional worker, they are less inclined to hire labor.

In both models, in response to a positive productivity shock, productivity shifts the firms'

marginal cost curve, prompting them to increase their production levels, while cutting prices. The difference in the response of output in response to a productivity shock across the two models are far less pronounced, see middle panel of Figure 8. This is primarily since capital utilization compensates for differences in labor on the production side. Inflation responses are also slightly more pronounced in the baseline case relative to the oligopoly labor case, for both technology and monetary shocks. Since capital utilization is higher in the baseline model, this has a larger impact on the rental of rate of capital and therefore the firms' marginal cost of production. In response to a technology shock, the response of labor is not only muted in the oligopsony case but also has a different sign. Positive wealth effects drive down labor supply, while the increase in productivity raises the marginal product of labor, but the decrease in the firm's price lowers their marginal value product. These opposing effects work to generate a negative response of labor in the short-run in the oligopolistic model, and a small but positive response of labor in the baseline model with oligopsony. This is an equilibrium result that comes from some of the different factors affecting the household and firms' labor market decisions, listed above and parameterisation.

In departure from productivity and monetary policy shocks, wage shocks generate qualitatively different dynamics in the two models for most variables of interest. In particular, in the oligopoly labor model, a positive shock to wages acts analogous to an adverse labor supply shock, see bottom panel of Figure 8. Thus, the wage shock acts as a cost-push shock, effectively increasing the marginal costs of firms, and prompting them to lower their hiring and production levels while increasing their prices. In the baseline model with oligopsony labor however, positive wage shocks temporarily reduce the firm's net markdown in wages, which prompts them to instead increase their hiring and output levels, while cutting prices to be able to sell their increased output.³⁶ Thus, in equilibrium, a positive shock to the wage markdown leads to an increase, not only in the aggregate real wage rate, but also in aggregate labor, output, consumption and investment, while the inflation rate decreases.

6 Conclusion

This paper analyzes how changes in industry concentration can affect the slope of the Phillips curves as well as the labor share of income within the context of a medium-scale New Keynesian DSGE model with oligopsonistic competition in labor markets and oligopolistic competition in goods markets. The results indicate that an increase in industry concentration would lead to a flattening of the aggregate price and wage Phillips curves, and the increase in the oligopoly and the oligopsony power of firms in product and labor markets would result in a decline in the labor's income share as well as a weaker pass-through from productivity shocks to real wages. Fully accounting for these patterns through increased industry concentration would nevertheless require a duopoly-duopsony structure within sectors, which indicates that industry concentration can only explain these developments partially.

³⁶Note that an exogenous increase in $\theta_{w,t}$ brings the *gross* markdown closer to 1; hence, the net markdown becomes smaller.

In terms of the policy implications of the paper, the results indicate that FTC’s more recent stance of allowing mergers to go through uncontested when there are 5 remaining significant competitors is by and large appropriate, but could be slightly strengthened to 6-7 firms. Given the results on wage shocks, the model also support the notion that higher minimum wages may not necessarily hurt the employment prospects of the lowest-paid households, if the related labor markets are characterized more in line with oligopsony power. Finally, the analysis here also indicates that increased industry concentration may have implications for monetary policy as well, since it does not solely affect the steady-state markup of firms, but also flattens the Phillips curves. While the former would not alter the monetary policy stance of the Federal Reserve from an optimal policy perspective (Ramey, 2018), the latter would lead to a worsening of the trade-off faced by the central bank with respect to cost-push shocks, while also increasing the effectiveness of monetary policy shocks on real variables (Kuttner and Robinson, 2010).

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A Log-Linearized Model

This section lists the equilibrium conditions of the model presented in Section 2 after log-linearization. A “hat” above a variable denotes the log-deviation of the variable from its steady state (e.g., $\hat{c}_t = \log(c_t) - \log(\bar{c})$).

Consumption demand

$$\hat{c}_t = \frac{\zeta}{1+\zeta} \hat{c}_{t-1} + \frac{1}{1+\zeta} E_t \hat{c}_{t+1} - \frac{1-\zeta}{1+\zeta} \left(\hat{R}_t - E_t \hat{\pi}_{t+1} + \hat{\phi}_t \right) \quad (34)$$

Investment demand

$$\hat{x}_t = \frac{1}{1+\beta} \hat{x}_{t-1} + \frac{\beta}{1+\beta} E_t \hat{x}_{t+1} + \frac{1}{(1+\beta) \kappa_x} (\hat{q}_t) \quad (35)$$

Aggregate labor supply

$$\hat{h}_t + \vartheta \hat{l}_t = \hat{w}_t \quad (36)$$

Labor supply externality

$$\hat{h}_t = \frac{\varrho}{1-\zeta} (\hat{c}_t - \zeta \hat{c}_{t-1}) + (1-\varrho) \hat{h}_{t-1} \quad (37)$$

Relative price of capital

$$\hat{q}_t = (1-\delta) \beta E_t \hat{q}_{t+1} + [1 - (1-\delta) \beta] E_t \hat{r}_{k,t+1} - \left(\hat{R}_t - E_t \hat{\pi}_{t+1} + \hat{\phi}_t \right) \quad (38)$$

Law of motion of capital

$$\hat{k}_t = (1-\delta) \hat{k}_{t-1} + (1-1+\delta) \hat{x}_t \quad (39)$$

Production function

$$\hat{y}_t = \left(1 + \frac{Nf}{y} \right) \left[\hat{z}_t + \alpha \left(\hat{u}_t + \hat{N}_t - \hat{N}_{t-1} + \hat{k}_{t-1} \right) + (1-\alpha) \hat{l}_t \right] - \frac{Nf}{y} \hat{N}_t \quad (40)$$

Number of firms in each sector

$$\hat{N}_t = \rho_N \hat{N}_{t-1} + (1-\rho_N) \left[\hat{y}_t + \frac{\theta_p}{\theta_p - [(1-\alpha) \theta_w + \alpha]} \left(\hat{\theta}_{p,t} - \frac{(1-\alpha) \theta_w}{(1-\alpha) \theta_w + \alpha} \hat{\theta}_{w,t} \right) \right] \quad (41)$$

Marginal cost of production

$$\hat{\Omega}_t + \hat{z}_t + (\alpha-1) \left(\hat{u}_t + \hat{N}_t - \hat{N}_{t-1} + \hat{k}_{t-1} - \hat{l}_t \right) = \hat{r}_{k,t} \quad (42)$$

Capital utilization rate

$$\hat{u}_t = \frac{1}{\varpi} \hat{r}_{k,t} \quad (43)$$

Price Phillips curve

$$\hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \frac{(1 - s_m) \left(\chi_y - \frac{\chi_y - \eta_y}{N} \right) - 1}{\kappa_p} \left(\hat{\Omega}_t + \hat{\theta}_{p,t} \right) \quad (44)$$

Price markup

$$\hat{\theta}_{p,t} = - (1 - s_m) \left(\frac{\chi_y - \eta_y}{N} \right) \frac{(\theta_p - 1)^2}{\theta_p} \hat{N}_t \quad (45)$$

Relating nominal wage inflation and real wage growth

$$\hat{\pi}_{w,t} - \hat{\pi}_t = \hat{w}_t - \hat{w}_{t-1} \quad (46)$$

Wage Phillips curve

$$\hat{\pi}_{w,t} = \beta E_t \hat{\pi}_{w,t+1} + \frac{\chi_l - \left(\frac{\chi_l - \eta_l}{N} \right) + 1}{\kappa_w} \left[\hat{\Omega}_t + \hat{z}_t + \alpha \left(\hat{u}_t + \hat{N}_t - \hat{N}_{t-1} + \hat{k}_{t-1} - \hat{l}_t \right) - \hat{w}_t + \hat{\theta}_{w,t} \right] \quad (47)$$

Wage markdown

$$\hat{\theta}_{w,t} = \left(\frac{\chi_l - \eta_l}{N} \right) \frac{(1 - \theta_w)^2}{\theta_w} \hat{N}_t + \varepsilon_{w,t} \quad (48)$$

Goods market clearing

$$\frac{c}{y} \hat{c}_t + \frac{x}{y} \hat{x}_t + \frac{g}{y} \hat{g}_t = \hat{y}_t \quad (49)$$

Taylor rule

$$\hat{R}_t = \rho \hat{R}_{t-1} + (1 - \rho) (a_\pi \hat{\pi}_t + a_y \hat{y}_t) + \tilde{\varepsilon}_{R,t} \quad (50)$$

In the above expressions, the steady-state share of government expenditure, g/y , can be treated as a parameter, while the share of investment is given by $x/y = \delta k/y$, where $k/y = \alpha (1 + Nf/y) / [\theta_p (1/\beta - 1 + \delta)]$ with $Nf/y = \theta_p / [(1 - \alpha) \theta_w + \alpha] - 1$, and the share of consumption can be calculated as a residual, $c/y = 1 - x/y - g/y$.

Note that the steady-state price markup is $\theta_p = (1 - s_m) \left(\chi_y - \frac{\chi_y - \eta_y}{N} \right) / \left[(1 - s_m) \left(\chi_y - \frac{\chi_y - \eta_y}{N} \right) - 1 \right]$, while the steady-state wage markdown is $\theta_w = (\chi_l - \frac{\chi_l - \eta_l}{N}) / (\chi_l - \frac{\chi_l - \eta_l}{N} - 1)$.

B Parameter calibration

Parameter calibration		
	Symbol	Value
Time-discount factor	β	0.995
Depreciation rate of capital	δ	0.02
Capital share in production	α	0.3
Share of materials in gross output	s_m	0.45
Share of gov. expenditure in GDP	g/y	0.2
Steady-state no. of firms within each sector	N	8
Habit in consumption	ζ	0.8
Inverse aggregate labor supply elast.	ϑ	2
Externality in labor supply	ϱ	0.02
Investment adjustment cost	κ_x	4
Utilization cost elasticity	ϖ	0.5
Price adjustment cost	κ_p	58
Wage adjustment cost	κ_w	118
Taylor rule - persistence	ρ	0.8
- inflation	a_π	1.5
- output gap	a_y	0.25
Persistence in no. of firms	ρ_N	0
Intermediate goods elast. of subst. - within sector	χ_y	12
- across sectors	η_y	2
Labor supply elasticity - within sector	χ_l	10
- across sectors	η_l	$= 1/\vartheta$
Fixed costs relative to GDP	Nf/y	$= \frac{\theta_p}{(1-\alpha)\theta_w+\alpha} - 1$

Based on the literature, we set the cross-sector elasticity parameter, η_y , equal to 2.³⁷ The within-sector elasticity of substitution used in the related literature is typically larger and ranges between 3 and 20. It takes a value of 3 in Midrigan (2011), 4 in Nakamura and Steinsson (2010), 5 in Eusepi et al. (2011), 7 in Carvalho and Nechio (2016), 8 in Woodford (2003) and Bouakez et al. (2009), 10 in Carvalho and Nechio (2011), 11 in Carvalho (2006), Hobijn et al. (2006), and Karadi and Reiff (2008), and close to 20 in Jaimovich and Floetotto (2008). See Figure 1 of the 2015 version of Hobijn and Nechio (2017) for a summary of this related literature.

Recent micro-level studies on the firm-specific (within-sector) labor supply elasticity, χ_l , suggest a fairly inelastic labor supply. Given existing estimates in the literature, we use a value of 10 for the

³⁷Hobijn and Nechio (2017) use European Union expenditure data at the 3-digit expenditure categories (“classes”) around value-added tax changes, and find a cross-sector elasticity of substitution of around 3 with an upper bound of 5, while the parameterization used in Jaimovich and Floetotto (2008) implies an elasticity of substitution across sectors of close to 1.

firm-specific labor supply elasticity parameter, χ_l , which implies a near 10% steady-state markdown in wages.

In particular, Staiger et al. (2010) estimates that nurses' labor supply to individual U.S. Veterans Administration hospitals has a short-run elasticity of around 0.1. Ransom and Sims (2010) and Falch (2010) estimate labor supply elasticity of teachers to individual schools in Missouri and Norway to be around 3.7 and 1.4, respectively. Hirsch et al. (2010) calculate a firm-specific labor supply elasticity between 1.9 and 2.6 for female and between 2.5 to 3.7 for male workers in western Germany. Similarly, Ransom and Oaxaca (2010) analyze grocery store chains in the U.S., and report a firm-specific labor supply elasticity between 1.5-2.5 for female and between 2.4-3.0 for male workers. As noted, these figures would indicate a fairly inelastic firm-specific labor supply elasticity, along with a significant amount of labor market power on behalf of firms leading to a markdown of wages relative to marginal product of labor in the order of 25%-35%. However, earlier studies on the issue, such as Nelson (1973), indicate a much more elastic labor supply to individual firms in the U.S., with estimates closer to 20, which would imply a 5% markdown on wages.

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