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A Murder Mystery

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Who Killed the Phillips Curve? A Murder Mystery*

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Abstract

Is the Phillips curve dead? If so, who killed it? Conventional wisdom has it that the sound monetary policy since the 1980s not only conquered the Great Inflation, but also buried the Phillips curve itself. This paper provides an alternative explanation: labor market policies that have eroded worker bargaining power might have been the source of the demise of the Phillips curve. We develop what we call the "Kaleckian Phillips curve", the slope of which is determined by the bargaining power of trade unions. We show that a nearly 90 percent reduction in inflation volatility is possible even without any changes in monetary policy when the economy transitions from equal shares of power between workers and firms to a new balance in which firms dominate. In addition, we show that the decline of trade union power reduces the share of monopoly rents appropriated by workers, and thus helps explain the secular decline of labor share, and the rise of profit share. We provide time series and cross sectional evidence.

JEL Classification: E31, E32, E52
Keywords: bargaining power, profits, inflation dynamics

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John Ydstie: *"But these days, jobs are very plentiful, yet inflation remains very low. That's got some people writing the obituary for the Phillips curve."*

James Bullard: *"If you put it in a murder mystery framework – "Who Killed The Phillips Curve?"– it was the Fed that killed the Phillips curve."*

NPR, October 29, 2018, 4:28 PM ET

1 Introduction

The Phillips curve has long been a workhorse model of inflation, and perhaps the central model underpinning successful monetary policy. The experience in the last decade puts in doubt the stability and usefulness of the Phillips curve in predicting inflation and conducting monetary policy. First, the Phillips curve failed to predict the stable inflation seen in the aftermath of the Global Financial Crisis (GFC) during 2008-2009 period, dubbed the "missing deflation" puzzle. Second, and more importantly, the Phillips curve failed to predict stable inflation during the recovery from the GFC. In September 2019 in the U.S. economy, the civilian unemployment rate fell to 3.5 percent, having fallen 6.5 percentage points since October 2009, the largest drop seen in any economic expansion since 1950. And yet, the inflation rate, as measured by the growth rate of core Personal Consumption Expenditure (PCE) price index, has shown no sign of acceleration. Mirroring the missing deflation, this has been called "the missing inflation" puzzle.

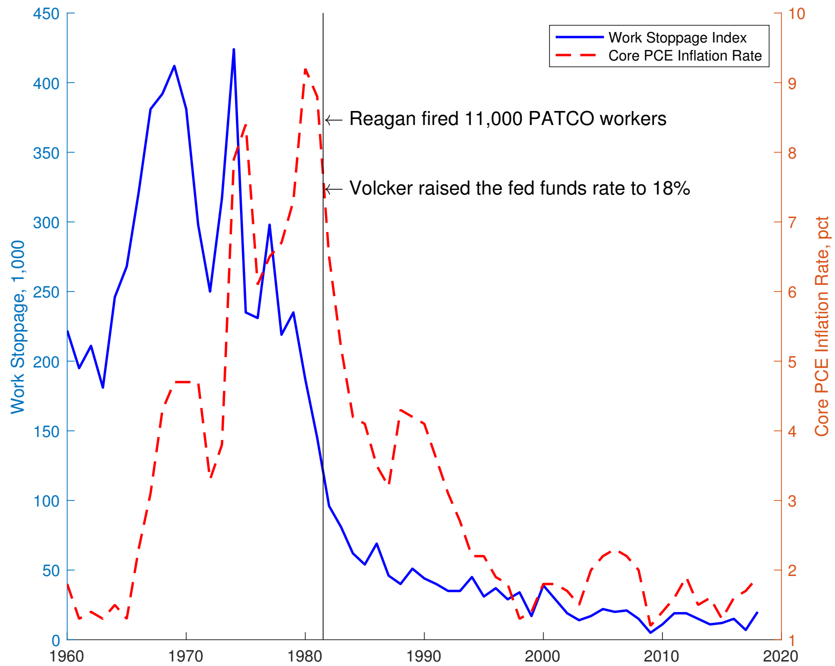
The two puzzles together suggest that developments in prices and wages have been disconnected with developments in real activity. A growing number of economists and commentators of different backgrounds have gone so far as to declare the death of the Phillips curve. A former Governor of the Federal Reserve Board summarized the difficulties in monetary-policy making in a world without a well-functioning Phillips curve:

> "The substantive point is that we do not, at present, have a theory of inflation dynamics that works sufficiently well to be of use for the business of real-time monetary policy-making. The sociological point is that many (though certainly not all) good monetary policymakers who were formally trained as such have an almost instinctual attachment to some of those problematic concepts and hard-to-estimate variables" (Tarullo (2017), p.2).

Governor Tarullo's quote suggests that monetary policy will face substantial challenges if the root causes of the demise of the Phillips curve are not better understood, or new models of inflation dynamics are not developed.[1]

[1] Recently McLeay and Tenreyro (2018) attempt to explain the empirical failure of the Phillips curve as a consequence of optimal monetary policy. The idea is based on a classic case of identification failure: if monetary policy is not optimal in the sense that it allows aggregate demand shocks to move the aggregate demand curve up and down against a given Phillips curve, one can recover the slope of the Phillips curve in aggregate data;

Figure 1: Bargaining Power of Workers and Inflation



Notes: Work stoppage index data is from the Bureau of Labor Statistics.

In this paper, we ground our explanation of the change in the Phillips curve relationship on structural changes in the labor market since the 1980s. In particular, we build a theoretical model in which workers' bargaining power determines the slope of the Phillips curve. We argue that the "missing inflation" puzzle is due to a collapse of workers' bargaining power that has in turn left the slope of the Phillips curve nearly flat.

Figure 1 juxtaposes the work stoppage index for the United States (blue solid line, the left axis), one potential measure of workers' bargaining power, and the core PCE price inflation rate (red dashed line, the right axis). The figure suggests that the bargaining power of workers may be an important driver of the inflation dynamics during 1960s and 1970s. Both the bargaining power of workers and the inflation rate suddenly collapsed around the mid-1980s. Correlation is, of course, not causation and another interpretation is possible: monetary-policy tightening under Paul Volcker led to the disinflation shown in the figure, which in turn may have made striking for cost of living adjustment less urgent as the inflation rate has been stabilized.

In fact, the two interpretations of the figure are consistent with the existence of two different schools of thought regarding the cause of inflation. The dominant view, called

however, if the optimal monetary policy insulates the economy from demand shocks, econometricians cannot identify the Phillips curve using standard methods. We are open to this possibility. However, we note that this explanation fails in the presence of price/wage markup shocks. Even when monetary policy is suboptimal, the presence of markup shocks that shift the Phillips curve up and down prevents the identification of Phillips curve, which raises the question of how the Phillips curve could have been identified before Paul Volker's tenure.

Monetarism (including New Keynesianism), asserts that money or monetary policy controls inflation. The second school of thought, called conflict theory of inflation (mostly developed by Post-Keynesians), contends that inflation has a real root rather than a monetary root, and the cause of inflation can be found in the class conflict between capitalists and workers.

The conflict theory of inflation starts from the recognition that workers together with capitalists constitute stakeholders of the firms and may have some claims on production rents through trade union power. The theory posits that trade unions have preferences over the relative shares of workers' income. In the theory, militant trade unions with strong bargaining power try to achieve a certain target labor share in collective bargaining. The resulting wage contract stipulates the rate of inflation that agents in the economy should anticipate. The theory also assumes that capitalists have a target profit share. However the target profit share is not necessarily equal to the profit share implied by the wage contract. The difference is called the "aspiration gap" (see Rowthorn (1977) and Rosenberg and Weisskopf (1981)). Given the market power of the firms, the only way to achieve the target share is then to raise the price above and beyond what is anticipated in the wage contract. The stronger the trade union power, the greater the conflict of class interests. The greater the aspiration gap, the greater the unanticipated inflation.[2]

In this paper we attempt to bring the broad contours of conflict theory into a dynamic general equilibrium framework. We start with the assumption that workers are represented by trade unions, and that workers can extract a share of the production rents through their labor union power. In particular, we assume that the trade unions have preferences over the total earnings of its members, and therefore both the size of employment and the wage rate.[3] Given monopolistic competition, the conditional labor demand of firms is declining in relative product prices, implying that the more successful the trade unions is in securing a larger workforce, the lower are product prices and markups. This is consistent with the conflict theory of inflation in which "trade-union power restrains the markups" (Kalecki (1971), p.161). The markups of monopolistically competitive firms are determined not only by their market power (the elasticity of substitution as in a standard New Keynesian model), but also by the real bargaining power of trade unions.

[2]James Tobin, while neither a Post-Keynesian nor a New Keynesian, could not have expressed the idea more eloquently:

> "inflation is the symptom of deep-rooted social and economic contradiction and conflict. There is no real equilibrium path. The major economic groups are claiming pieces of pie that together exceed the whole pie. Inflation is the way that their claims, so far as they are expressed in nominal terms, are temporarily reconciled. But it will continue and indeed accelerate so long as the basic conflicts of real claims and real power continue" (Tobin (1981), p.28).

From this perspective, the current lack of inflation is indicative of the lack of "conflicts of real claims and real power", as can be seen in the decline of work stoppage index, union density, or in the decline of labor share.

[3]The idea of bargaining over employment size as well as wage and thereby workers sharing the production rents with firms as stakeholders of the firms dates back, at least as far as we know, to McDonald and Solow (1981) and McDonald and Solow (1985).

Using these assumptions, we derive what we call the Kaleckian Phillips curve, which nests the New Keynesian Phillips curve as a special case. We show that the slope of the Kaleckian Phillips curve is an increasing function of the bargaining power of trade unions in dividing production rents.[4] From our theoretical point of view, the lack of inflation pressure in the current situation reflects the lack of bargaining power of workers despite the extremely low rate of unemployment. In stark contrast to the standard New Keynesian result, we find that non-monetary factors are an important determinant of inflation dynamics. Instead, we show that the process that governs inflation dynamics is intimately related to the distribution of bargaining power between workers and firms.

Using our model, we perform two analyses. First, we conduct a comparative static analysis to study the real and financial consequences of transitioning from equal shares of power between workers and firms to a new balance in which firms dominate. The results show that a substantial part of the secular trends in income distribution and factor shares can be generated by the changes in the balance of bargaining power. In particular, the change in union bargaining power can explain the secular decline of the labor and capital shares, and the secular rise of the profit share observed in the last four decades. The change in bargaining power can also explain the large increases in Tobin's Q and stock market capitalization ratio (market capitalization-to-nominal GDP). What is remarkable is that all of these secular trends can be generated without the hypothesis of the rise of market concentration, a common feature underlying several influential studies such as De Loecker et al. (2018), Barkai (2016), Farhi and Gourio (2018) and Gutiérrez and Philippon (2017).

Second, using our general equilibrium model, we show that the assumed change in bargaining power, and the resulting flattening of the Phillips curve, reduces inflation volatility by 87 percent *without* any changes in the monetary policy regime. This result casts doubt on the dominant view that the disinflation since the 1980s was due to Volcker's monetary policy. It suggests an alternative view that labor market policy since the 1980s, and structural changes in the labor market, led to reduced worker bargaining power, and it was those forces which induced the large disinflation. In addition, the consequences of the disinflation may not have been shared equally across economic agents, as workers bore the brunt of economic consequences of the decline in their bargaining power.

We finish our analysis by documenting time series and cross sectional evidence on the relationship between worker bargaining power and the slope of the Phillips curve. We estimate our theoretical Phillips curve using labor share and GDP deflator data from the U.S. and U.K, both of which have experienced substantial declines in labor union density since the 1980s. We divide the sample into pre- and post-Reagan/Thatcher era. The Kaleckian Phillips curve specification allows us to construct a semi-structural estimate of bargaining power from the estimated Phillips curve. For the pre-Reagan/Thatcher era (1961-1980 for U.S and 1961-

[4] Search and matching frictions introduce the notion of bargaining power of workers in sharing the match surplus that arises from the search friction. Importantly, however, worker bargaining power derived from search frictions does not affect the slope of the Phillips curve.

1978 for U.K.), the estimates of firms' bargaining power is 0.52 and 0.54 for U.S. and U.K. respectively, indicating that the balance of power between workers and firms were relatively even during the earlier period. However, for the post-Reagan/Thatcher era, we estimate that firms' bargaining power was 0.92 and 1.0 for the U.S. and U.K., respectively, implying that the balance of power has been tilted nearly completely toward firms in the later period. These estimates are also consistent with a "flat" Phillips curve.

Finally, we exploit the substantial regional heterogeneity in labor union density, and hence worker bargaining power, across regions in the U.S. We estimates Phillips curves using MSA-level data as well as state-level data on inflation, unemployment, labor share, and union density to uncover the empirical relationship between the slope of reduced-form Phillips curves and worker bargaining power. We find consistent evidence that in cities and states with higher union density, the slope of the Phillips curve is steeper.

The rest of the paper is organized as follows: Section 2 develops our theoretical model and derives what we call Kaleckian Phillips curve; Section 3 presents quantitative results regarding the role of bargaining power of workers in explaining inflation dynamics and labor/profit shares; Section 4 presents time series and cross sectional evidence for the positive relationship between the bargaining power of workers and the slope of Phillips curve; Section 5 concludes.

2 Model

The model economy consists of a continuum of monopolistically competitive firms, which produce intermediate goods; two households, one earning dividend income, and the other earning labor income; a government collects lump-sum taxes and distributes unemployment benefits; a monetary authority conducts monetary policy. Firms face nominal rigidities in product markets and face search and matching frictions the in labor market. Before we introduce the nominal rigidity, we consider a flexible economy below to show how the standard markup pricing rule in a monopolistically competitive industry is modified in our framework.

2.1 Generalized Markup Pricing Rule

Monopolistically competitive firms, indexed by $i \in [0,1]$, combine capital and labor to produce intermediate goods using a linear technology,

$$y_t(i) = a_t k_{t-1}(i)^{\alpha} n_t(i)^{1-\alpha}, \tag{1}$$

where $n_t(i)$ is the labor input and a_t is the aggregate technology level. The outputs are combined in a CES aggregator to produce the final consumption good:

$$y_t = \left[\int_0^1 y_t(i)^{\frac{\epsilon-1}{\epsilon}} di\right]^{\frac{\epsilon}{\epsilon-1}},$$

where ϵ is the elasticity of substitution. Due to the presence of monopolistic competition, product demand is downward sloping in the relative price of the product:

$$y_t(i) = p_t(i)^{-\epsilon} y_t, \tag{2}$$

where $p_t(i) \equiv P_t(i)/P_t$, the relative price of firm i.

In determining the product price, the firm must negotiate with a labor union, another stakeholder of the firm, which bargains not only over the wage, but also over the product price, and hence the markup. To see why a labor union has prefernces over the product price and markup decision, consider the following conditional labor demand function. Assuming that the capital rental decision is made efficiently such that

$$r_t^K = \mu_t(i)\alpha \frac{y_t(i)}{k_{t-1}(i)},$$

we can express production as a linear function of the stock of employment :

$$y_t(i) = \tilde{a}_t n_t(i) \tag{3}$$

where

$$\tilde{a}_t = a_t^{\frac{1}{1-\alpha}} \left(\alpha \frac{\mu_t(i)}{r_t^K} \right)^{\frac{\alpha}{1-\alpha}}$$

By equating product supply (3) with product demand (2), we derive the conditional labor demand as

$$n_t(i) = p_t(i)^{-\epsilon} \frac{y_t}{\tilde{a}_t}. \tag{4}$$

The fact that product demand and hence labor demand decline in the product price implies that the labor union has an incentive to restrain the markup: if the firm raises prices and thus the markup, this reduces labor demand, and thus the aggregate well-being of its members. Therefore, when bargaining power is strong, workers will attempt to intervene in the product pricing decision through their union representation.

We assume that the union and firm bargain over Nash product in determining the relative price and hence, given the one-to-one relationship (4), the employment size:

$$S_t^p(i) = \max_{p_t(i)} \Pi_t(i)^b U_t(i)^{1-b}, \tag{5}$$

where Π_t is the profit of the firm and $U_t(i)$ is the utility level of the labor union, and $b \in (0, 1]$ is the bargaining power of the firm.[5]

[5] The idea that workers and firms bargain over employment size as well as wage is not new. See McDonald and Solow (1981) and McDonald and Solow (1985). However, Layard et al. (1991) dismiss this approach simply because supporting evidence in the U.S. is weak. One interpretation of such dismissal is that by the time of early 1990s, the workers' bargaining power had been weakened so much that empirical researchers could not find substantial evidence for bargain over employment size. In fact, in (5), as the firms' bargaining power

The union's utility $U_t(i)$ is specified as

$$U_t(i) = W_t(i)h(n_t(i)) = W_t(i)h\left(p_t(i)^{-\epsilon}\frac{y_t}{\tilde{a}_t}\right), \quad h(0) = 0 \text{ and } h'(\cdot) > 0, \tag{6}$$

where $W_t(i)$ is the value of a job to a worker, which will be given a formal definition in the discussion of the labor market. The specific functional form for $h(\cdot)$ is not essential in deriving the generalized markup pricing rule and we will explicitly assume the simplest linear form, that is, $h(n_t(i)) = n_t(i)$. What matters for now and is different from the canonical model is that the union bargains over the size of the employment stock, or equivalently, over the relative price rather than only the value of the job per worker.

The firm's profit is static and is given by the revenue minus total cost,

$$\Pi_t(i) = p_t(i)^{1-\epsilon}y_t - \mu_t(i)p_t(i)^{-\epsilon}y_t, \tag{7}$$

where $\mu_t(i)$ is the real marginal cost of production. Using (4)∼(7), we derive the FOC for pricing as

$$\frac{\partial \Pi_t(i)}{\partial p_t(i)} = -\frac{1-b}{b}\frac{\partial U_t(i)}{\partial p_t(i)}\frac{\Pi_t(i)}{U_t(i)}.$$

Note that the price elasticity of the utility of trade union is given by

$$-\frac{\partial U_t(i)}{\partial p_t(i)}\frac{p_t(i)}{U_t(i)} = \epsilon,$$

which is the same as the price elasticity of product demand by construction. Using this, we can express the FOC as

$$\frac{\partial \Pi_t(i)}{\partial p_t(i)} = \epsilon(1/b - 1)\frac{\Pi_t(i)}{p_t^*(i)} \geq 0 \tag{8}$$

Since $b \in (0, 1]$, the right hand side of (8) is positive and the optimal price is chosen at the level where the marginal profit is positive. In other words, the price is chosen at a level such that profit could still be increased in the absence of the bargaining power of the trade union. The right hand side can be viewed as production rents extracted by the trade union.

Combining (7) and (8), we derive the generalized markup pricing rule as

$$p_t(i) = \frac{\epsilon}{\epsilon - b}\mu_t(i). \tag{9}$$

Note that the generalized markup pricing rule nests the special case of $b = 1$, which is the case of the New Keynesian markup pricing rule. (9) is what Sen and Dutt (1995) called the Kaleckian markup pricing formula. The price markup $p_t(i)/\mu_t(i) = \epsilon/(\epsilon - b)$ is increasing in

approaches 1, the influence of workers on employment size approaches zero and the labor market appears to be consistent with 'right-to-manage' framework that assigns absolute power to managers to determine employment size. From this perspective, our study is to analyze the implications for inflation dynamics of such transition from collective bargaing framework to 'right-to-manage' framework in determining employment size.

the bargaining power b of the firm and decreasing in the bargaining power $1-b$ of the trade union.[6]

2.2 Kaleckian Phillips Curve

We now introduce nominal rigidity by assuming a price adjustment cost a la Rotemberg (1982) and Ireland (2005). The profit function given by (7) is now replaced by

$$\Pi_t = \mathbb{E}_t \sum_{s=t}^{\infty} m_{t,s}^F \left[p_s(i)^{1-\epsilon} y_s - \mu_s(i) p_s(i)^{-\epsilon} y_s - \frac{\theta}{2} \left(\frac{\pi_s}{\pi_{s-1}^{\chi} \bar{\pi}^{1-\chi}} \frac{p_s(i)}{p_{s-1}(i)} - 1 \right)^2 y_s \right], \tag{10}$$

where $m_{t,s}^F$ is the stochastic discounting factor of the owners of the firms, θ is the cost parameter of price adjustment and $\bar{\pi}$ is the trend inflation rate.[7]

With the value of the firm redefined by (10), the bargaining problem is still given by

$$S_t^p(i) = \max_{p_t(i)} \Pi_t(i)^b U_t(i)^{1-b},$$

and the optimization condition is still characterized by (8). What is different is that the effect of changing the relative price is dynamic due to the presence of the adjustment cost. It is straightforward to show that the FOC (8) now implies the following Phillips curve, after imposing the symmetric equilibrium condition $p_t(i) = 1$ for all $i \in [0,1]$:

$$\begin{aligned} 1 + \frac{\theta}{\epsilon - 1} \frac{\pi_t}{\pi_{t-1}^{\chi} \bar{\pi}^{1-\chi}} \left(\frac{\pi_t}{\pi_{t-1}^{\chi} \bar{\pi}^{1-\chi}} - 1 \right) &= \frac{\epsilon}{\epsilon - 1} \left[\mu_t - (1/b - 1) \frac{\Pi_t}{y_t} \right] \\ &+ \frac{\theta}{\epsilon - 1} \mathbb{E}_t \left[m_{t,t+1} \frac{\pi_{t+1}}{\pi_t^{\chi} \bar{\pi}^{1-\chi}} \left(\frac{\pi_{t+1}}{\pi_t^{\chi} \bar{\pi}^{1-\chi}} - 1 \right) \frac{y_{t+1}}{y_t} \right] \end{aligned} \tag{11}$$

In the steady state where $\pi_t = \bar{\pi}$, the real marginal cost of the firm is determined as

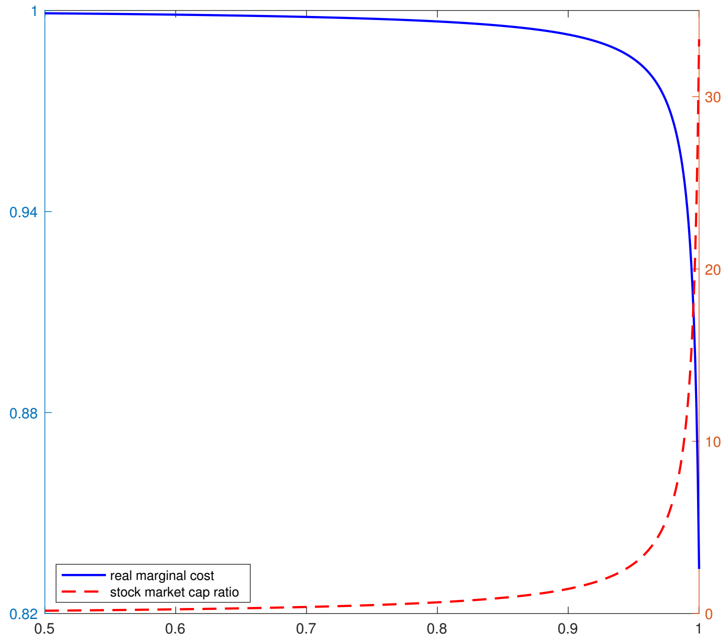
$$\mu = \frac{\epsilon - 1}{\epsilon} + (1/b - 1) \frac{\Pi}{y} \geq \frac{\epsilon - 1}{\epsilon}. \tag{12}$$

The second term is where we differ from the conventional New Keynesian model. The second term on the right side is the share of the monopoly rents claimed by the workers. In other words, the trade union secures more labor earnings by preventing the firm from choosing a higher markup and thus maintaining a greater workforce. As will be shown, such a move leads to a higher labor share and a lower profit share. Since the stock market capitalization to GDP ratio is $\Pi/y = (1-\mu)/(1-\beta)$ where β is the time discount factor of the firms,

[6] Sen and Dutt (1995) derived a slightly different and slightly more complicated markup pricing rule because they assumed oligopolistic competition with homogeneous goods among a finite number of firms. However, the essence of the formula is identical.

[7] We maintain the New Keynesian assumption that the central bank is in control of the trend inflation rate, that is, $\bar{\pi} = \pi^*$. In the absence of shocks hitting the economy, this would equal the anticipated inflation rate.

Figure 2: Bargaining Power, Real Marginal Cost and Stock Market Capitalization



substituting this in (12) and solving for μ yields

$$\mu = \frac{1-\beta}{1/b-\beta}\left(\frac{\epsilon-1}{\epsilon}+\frac{1/b-1}{1-\beta}\right). \tag{13}$$

Figure 2 shows that as the bargaining power of the firm increases, the real marginal cost of the firm declines (blue solid, left axis), and the stock market capitalization ratio rises (red dashed, right axis) as the redistribution of production rents toward the owners of the firm elevates the value of the firm.

Log-linearizing (11) around $\bar{\pi}$ and (13) yields the following log-linearized Phillips curve:

$$\hat{\pi}_t = \frac{\chi}{1+\chi\beta}\hat{\pi}_{t-1} + \frac{\epsilon}{\theta(1+\chi)}\left[\mu\hat{\mu}_t - (1/b-1)\frac{\Pi}{y}(\hat{\Pi}_t - \hat{y}_t)\right] + \frac{\beta}{1+\chi\beta}\mathbb{E}_t[\hat{\pi}_{t+1}]. \tag{14}$$

(14) shows that the current inflation rate depends on four terms: lagged inflation rate, real marginal cost $\hat{\mu}_t$, market cap ratio $\hat{\Pi}_t - \hat{y}_t$ and the inflation expectations $\mathbb{E}_t[\hat{\pi}_{t+1}]$. Note that the coefficient on market cap ratio is $-(1/b-1) < 0$. This means that the rise of market cap ratio is associated with a decline in the rate of inflation. Since the market cap ratio is the inverse of future real marginal cost, that is,

$$\hat{\Pi}_t - \hat{y}_t = -\frac{\mu}{\bar{\Pi}/\bar{y}}\mathbb{E}_t\left[\sum_{s=0}^{\infty}\beta^s\hat{\mu}_{t+s}\right], \tag{15}$$

it is not hard to see why the market cap ratio appears in the Phillips curve with a negative sign. It is interesting to check if such a negative relationship is supported by the data.

Figure 3: Inflation and Stock Market Capitalization Ratio (Wilshire 5000-to-GDP)

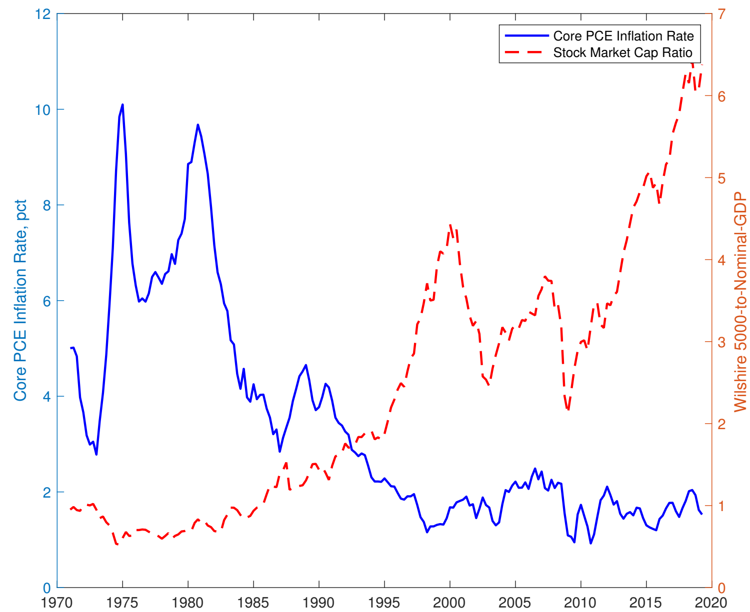


Figure 3 jusxtaposes the core PCE inflation rate (blue solid, left axis) and the Wilshire 5000 stock market value-to-GDP ratio. The figure shows that while the inflation rate of the U.S. economy steadily fell from 10 percent per annum, the stock market cap ratio nearly sextupled. We do not suggest that disinflation is the driver of the rise of stock market value or the other way around. We merely suggest that both may be driven by the same cause: the decline of real marginal cost due to the decline of workers' bargaining power.[8]

While (14) can be estimated with Generalized Method of Moments, it is not possible to disentangle the key parameter b from the estimated reduced-form parameters. However, by substituting (15) in (14), one can derive the following semi-structural form of the Phillips curve as

$$\hat{\pi}_t = \frac{\chi}{1+\chi\beta}\hat{\pi}_{t-1} + \kappa_1(b)\hat{\mu}_t + \kappa_2(b)\sum_{s=0}^{\infty}\beta^s\mathbb{E}_t[\hat{\mu}_{t+s}] + \frac{\beta}{1+\chi\beta}\mathbb{E}_t[\hat{\pi}_{t+1}] \tag{16}$$

where

$$\kappa_1(b) \equiv \frac{\epsilon}{\theta}\frac{(1-\beta)(\epsilon-1)/\epsilon + 1/b - 1}{1/b - \beta} = \frac{\epsilon - 1}{\theta} \text{ if } b = 1.$$

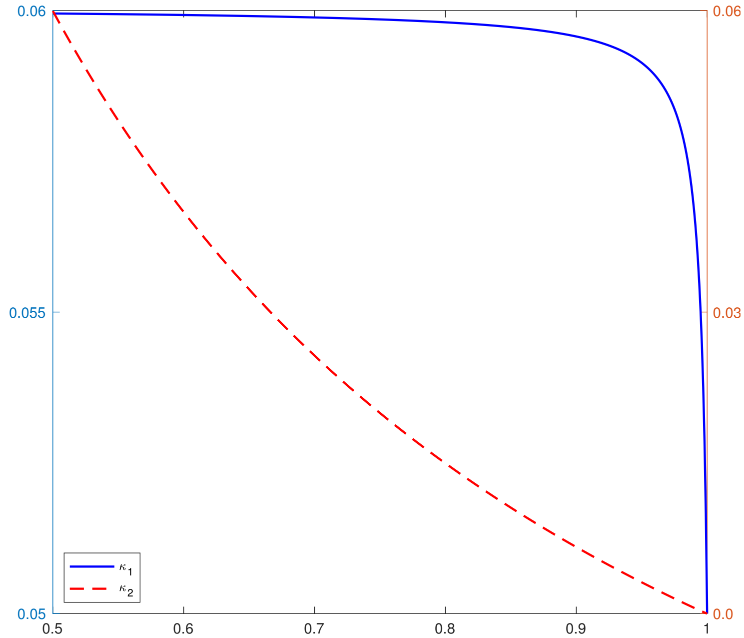
and

$$\kappa_2(b) = \kappa_1(b)(1/b - 1) = 0 \text{ if } b = 1.$$

The empirical advantage of (16) over (14) is that as long as the expected present value of future real marginal cost is available, it allows the semi-structural GMM estimation of b since

[8] Greenwald et al. (2019) empirically show that 54 percent of the increase in stock market value is attributable to a reallocation of rents to shareholders in a decelerating economy, consistent with our theoretical results.

Figure 4: Slope of the Phillips Curve



$\hat{b} = (\hat{\kappa}_2/\hat{\kappa}_1 + 1)^{-1}$.[9]

Figure 4 shows how the increase in the bargaining power of the firm affects the two slope coefficients $\kappa_1(b)$ and $\kappa_2(b)$. As the bargaining power of the firm approaches 1, $\kappa_1(b)$ declines and converges to the traditional slope of the New Keynesian Phillips curve, $(\epsilon - 1)/\theta$. $\kappa_2(b)$ declines as well as the bargaining power of the firm increases and converges to zero. This is our hypothesis that the rise of the bargaining power of the firms is the origin of the demise of the Phillips curve not only in terms of declining $\kappa_1(b)$ but also in terms of $\kappa_2(b)$ vanishing to nil, which we will test in section 4.

2.3 Labor Market

In this section, we describe the equilibrium wage, which we assume is determined in a separate bargaining process. We adopt a conventional framework of search and matching. The description of this process will be brief as the material is standard.

In every period, a fraction ρ of existing workforce is separated from the firm. In order to recruit new hires, the firm has to post vacancies, $v_t(i)$, which generate a cost ξ per vacancy. Once a job is posted, it has a probability q_t to be filled. The employment stock of the firm follows the following law of motion:

$$n_t(i) = (1 - \rho)n_{t-1}(i) + q_t v_t(i).$$

[9]In the Appendix, we show that If we assume staggered pricing friction a la Calvo (1983), we can still show that the bargaining power b is still an important determinant of the nonlinear dynamics of inflation. However, we also show that somewhat paradoxically, the log-linear dynamics of inflation is not affected by b.

The present value of the vacancy posting cost during the duration of the vacancy is given by ξ/q_t. The zero profit condition in vacancy posting then requires that the value of the marginal job to the firm, denoted by $J_t(i)$, is equated with the expected present value of the cost of vacancy posting, i.e.,

$$J_t(i) = \xi/q_t, \tag{17}$$

where the value of marginal worker is given by

$$J_t(i) = \mathbb{E}_t\left[\sum_{s=t}^{\infty} m_{t,s}^F (1-\rho)^s \left(\mu_{t+s}(i)(1-\alpha)\frac{y_{t+s}(i)}{n_{t+s}(i)} - w_{t+s}(i)\right)\right]. \tag{18}$$

The production efficiency also requires that the marginal productivity of capital rental evaluated at the marginal cost should be equalized with the rental rate:

$$0 = \mu_t(i)\alpha\frac{y_t(i)}{k_{t-1}(i)} - r_t^K. \tag{19}$$

The wage is determined by bargaining between the firm and the trade union to maximize the joint surplus given by

$$S_t^w(i) = \max_{w_t(i)} J_t(i)^b W_t(i)^{1-b}, \tag{20}$$

where $W_t(i)$ is the same value of job for a matched worker that appears in (6).[10] The value of job for a worker is given by

$$W_t(i) = w_t(i) - \underline{w}_t + (1-\rho)\mathbb{E}_t[m_{t,t+1}^W W_{t+1}(i)], \tag{21}$$

where $\underline{w}_t$ is the outside option of the worker given by

$$\underline{w}_t = b^U + (1-\rho)\mathbb{E}_t\left[m_{t,t+1}^W p_{t+1}\int_0^1 \frac{v_{t+1}(j)}{v_{t+1}} W_{t+1}(j)dj\right], \tag{22}$$

where $v_{t+1}(j)/v_{t+1}$ is the probability of meeting a vacancy from firm j.

The efficiency condition that maximizes (20) is given by the rent sharing condition, $(1-b)J_t(i) = bW_t(i)$. This, together with the zero profit condition (17), the value of marginal worker (21), the worker's value function (21) and the outside option (22) implies the following

[10] Note that in the determination of relative product price, (5) assumes that the trade union maximizes the total surplus of the entire workforce whereas (20) assumes that the trade union maximizes the surplus of each matched worker given the size of total workforce. This is equivalent since (20) is homogeneous of degree 1. Also, note that we use the same notation b to denote the bargaining power of the firm as in (5). In principle, the two bargaining powers can differ.

equalibrium wage:

$$w_t = (1-b)\mu_t(1-\alpha)\frac{y_t}{n_t} + bb^U \\ +(1-b)(1-\rho)\mathbb{E}_t\left[[m^F_{t,t+1} - m^W_{t,t+1}(1-p_{t+1})]\frac{\xi}{q_{t+1}}\right] \quad (23)$$

Regarding the matching technology, the following functional form is assumed:

$$m(v_t, \tilde{u}_t) = \frac{v_t \tilde{u}_t}{(v_t^\gamma + \tilde{u}_t^\gamma)^{1/\gamma}}$$

where $\tilde{u}_t = 1 - \psi - (1-\rho)n_{t-1}$ is the total number of unemployed at the beginning of tiem period t with $1-\psi$ being the total number of workers, employed and unemployed. The probabilities of job finding rate and of vacancy filling are given by $p_t = m(v_t, \tilde{u}_t)/\tilde{u}_t = 1/(1 + (v_t/\tilde{u}_t)^{-\gamma})^{1/\gamma}$ and $q_t = m(v_t, \tilde{u}_t)/v_t = 1/(1 + (v_t/\tilde{u}_t)^{\gamma})^{1/\gamma}$. The specification of the matching function is from den Haan et al. (2000). This functional form ensures that $0 < p_t$, $q_t < 1$.

2.4 Households

There are two types of households. Each type is composed of a continuum of members who form a large family structure that insures each member against idiosyncratic shocks by type. The first type (type F), whose population share is denoted by ψ, owns the firms and accumulates capital and nominal bonds. The second type, whose population share is denoted by $1-\psi$, earns wages when employed and collects unemployment benefits and searches for new jobs while unemployed. The second type (type W) neither own the firms nor invests in capital. To allow consumption smoothing for workers, we assume that workers trade nominal bonds with owner-type households. At any point in time, bond market clearing requires

$$0 = \psi b_t^F + (1-\psi)b_t^W \quad (24)$$

where $b^i > 0$ (< 0) denotes per capita lending (borrowing) for $i = F, W$.[11] The efficiency conditions for type F are given by the two Euler equations, one for bond investment and the other for capital accumulation. The efficiency condition for type W is given by the consumption Euler equation.

[11] To pin down the steady state level of debt as zero, we assume that lending and borrowing are subject to a convex adjustment cost.

2.4.1 Owners of the Firms

Owners of the firms maximize expected utility,

$$\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s u(c^F_{t+s} - hc^F_{t+s-1}) \tag{25}$$

subject to

$$c^F_t + b^F_t + \frac{\eta}{2}(b^F_t)^2 + \frac{q^K_t k_t}{\psi} = \frac{(1-\tau)\Pi_t}{\psi} + \frac{1+(1-\tau)i_{t-1}}{\pi_t} b^F_{t-1} + \frac{r^K_t k_{t-1} + q^K_t (1-\delta) k_{t-1}}{\psi} - T_t \tag{26}$$

where c^F_t is the per capita consumption of the owners of the firms, h is the degree of external consumption habit, b^F_t is the per capita government bonds held by the owners of the firms, k_t is the aggregate capital stock, q_t is the price of capital, Π_t is the aggregate profit, i_{t-1} is the nominal interest rate, δ is the depreciation rate of the capital stock, τ is the personal income tax rate, $(\eta/2)(b^F_t)^2$ is the adjustment cost of nominal bonds and T_t is the lump-sum tax.

The efficiency conditions of the owners of the firms are given by

$$1 = \mathbb{E}_t \left[m^F_{t,t+1} \frac{1+(1-\tau)i_t}{\pi_{t+1}(1+\eta b^F_t)} \right] \tag{27}$$

and

$$1 = \mathbb{E}_t \left[m^F_{t,t+1} \frac{r^K_{t+1} + (1-\delta) q^K_{t+1}}{q^K_t} \right], \tag{28}$$

where $m^F_{t,t+1} \equiv \beta u'(c^F_{t+1} - hc^F_t)/u'(c^F_t - hc^F_{t-1})$. Note that if the nominal interest is determined as $i = (\bar{\pi}/\beta - 1)/(1-\tau)$, (27) pins down the steady state level of lending as $b^F = 0$ in the steady state.

2.4.2 Workers

Workers maximize expected utility,

$$\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s u(c^W_{t+s} - hc^W_{t+s-1}), \tag{29}$$

subject to

$$c^W_t + b^W_t + \frac{\eta}{2}(b^W_t)^2 = \frac{1+(1-\tau)i_{t-1}}{\pi_t} b^W_{t-1} + \frac{1-\tau}{1-\psi} \left[\int w_t(i) n_t(i) di + b^U u_t \right], \tag{30}$$

where $u_t = 1 - \psi - n_t$ is the total number unemployed at the end of period. The workers' efficiency condition is given by

$$1 = \mathbb{E}_t \left[m^W_{t,t+1} \frac{1 + (1-\tau)i_t}{\pi_{t+1}(1 + \eta b^F_t)} \right], \tag{31}$$

where $m^W_{t,t+1} \equiv \beta u'(c^W_{t+1} - hc^W_t)/u'(c^W_t - hc^W_{t-1})$.

2.5 Government

The fiscal authority balances the budget each period by imposing a personal income tax to finance unemployment benefits:

$$\tau \left[\int w_t(i)n_t(i)di + b^U u_t + \Pi_t \right] = b^U u_t, \tag{32}$$

where tax revenue on interest income is exactly offset by the tax deduction on interest expenses, that is, $[\psi b^F_{t-1} + (1-\psi)b^W_{t-1}]i_{t-1}/\pi_t = 0$.

The monetary authority sets the nominal interest rate acording to an inertial Taylor rule:

$$i_t = \rho_i i_{t-1} + (1-\rho_i)[i^* + \rho_\pi \log(\pi_t/\bar{\pi}) + \rho_y \log(y_t/y^*_t) + \sigma_i \epsilon_{i,t}]. \tag{33}$$

3 Quantitative Results

3.1 Calibration

We set the elasticity of substitution ϵ equal to 3.5. In a conventional New Keynesian framework, this translates to a 40 percent price markup, which is in the middle of the range reported by De Loecker et al. (2018) over the 1980-2016 period. However, in our Kaleckian framework, the same elasticity of substitution can be consistent with a range of markups depending on the level of bargaining power of the firms. For instance, when the bargaining power of the firm is 0.5, the value of ϵ implies a markup of 16 percent, while the implied markup is equal to 40 percent if the bargaining power of the firms is perfect ($b = 1$). Below, we do not calibrate a unique value for b, but consider a range under the assumption that b has gone up from a relatively low value to a very high value over time. The markup is equal to 30 percent when the bargaining power of the firm is 0.8, which is in the middle of the range of bargaining powers considered. Below, we calibrate the other parameters given a bargaining power of 0.8.

Regarding household preferences, we choose a conventional value of 0.99 for the time discounting factor, 0.67 (= 1/1.5) for the intertemporal elasticity of substitution and 0.85 for the external consumption habit. For the portfolio adjustment cost (η), which is a device to pin down zero nominal bonds in steady state, we choose a small number of 0.1. A moderate

Table 1: Calibration forBaseline Economy

Parameters	Value
Elasticity of Substitution (ϵ)	3.500
Discounting Factor (β)	0.990
Separation Rate (ρ)	0.210
Unemployment benefit (b^U)	0.950 ($= 0.68 \times w$)
Vacancy Posting Cost (ξ)	0.300 ($= 0.11 \times y$)
Population Share of Firm Owners (ψ)	0.010
Matching Function (γ)	1.050
Production Share of Capital (α)	0.300
Depreciation Rate (δ)	0.025
Habit Formation (h)	0.850
Portfolio Adjustment Cost (η)	0.100
Indexation (χ)	0.500
Intertemporal Elasticity of Substitution (σ)	0.667
Investment Adjustment Cost (κ)	5.000
Price Adjustment Cost (θ)	2,000
Output Gap Coefficient (ρ_y)	1.000
Inflation Gap Coefficient (ρ_π)	1.500
Policy Inertia (ρ_i)	0.850

change in this parameter does not affect the linear perturbation-dynamics around the non-stochastic steady state. We calibrate the population share of the owners of the firms (ψ) as 1 percent.

For the production technology, we choose a standard set of parameters: the production share of capital (α) is set equal to 0.3; the depreciation rate of capital stock (δ) is equal to 0.025. We assume a small degree of investment adjustment frictions (κ), 0.5. Regarding the labor market frictions, we choose the vacancy posting cost (ξ) of 0.30 such that it is equal to 11 percent of output when the bargaining power of the firms is 0.8. The replacement ratio (b^U) is chosen to equal 68 percent of steady state wages. We set the quarterly separation rate (ρ) equal to 0.21 such that the quarterly net separation rate is equal to 6.2 percent as in the Current Population Survey (CPS). The matching function parameter is set equal to 1.05, which is close to den Haan et al. (2000).

Regarding nominal rigidity, we set the price indexation (χ) of 0.5, and the price adjustment cost (θ) equal to 4,000. Given the elasticity of substitution and indexation, the adjustment cost implies an equivalent of a probability of 97.8% of not being able to reset the product price as in the Calvo (1983) setting. This is chosen to replicate the standard deviation of annual inflation of 3.71 when the bargaining power of firms is set to 0.8. This volatility is close to what is observed in the total PCE price inflation rate over 1980-2018 period. Finally, regarding the monetary policy rule, we adopt Taylor (1999) with an inertial component of 0.85. Our calibration strategy is summarized in Table 1.

3.2 Comparative Statics

In this section, we assume that the bargaining power of the firms has steadily increased since the early 1980s and analyze the real and financial consequence of such a transition. As an illustration, we assume that the balance of power between firms and workers was more or less even ($b = 0.50$) at the beginning of the transition, and the economy has evolved over time into one in which firms have obtained nearly all of the bargaining power ($b = 0.99$).[12]

Panel (a) of Figure 5 shows that the real wage in the model declines about 37 percent from 1.6 to 1 roughly as the bargaining power of the firm increases. The model assumes no trend productivity growth. Hence, the decline of the real wage should not be taken literally. Rather the decline should be interpreted as the decline of the ratio of real wage relative to productivity. According to one estimate (Bivens and Mishel (2015)), the ratio of real median compensation relative to net productivity has declined 37 percent since 1976. The range of bargaining power in our experiment ($0.50 - 0.99$) can be considered plausible in this regard. Note that the ratio of median real compensation to labor productivity is essentially identical to what Levy and Temin (2007) called Bargaining Power Index (BPI) of workers.[13]

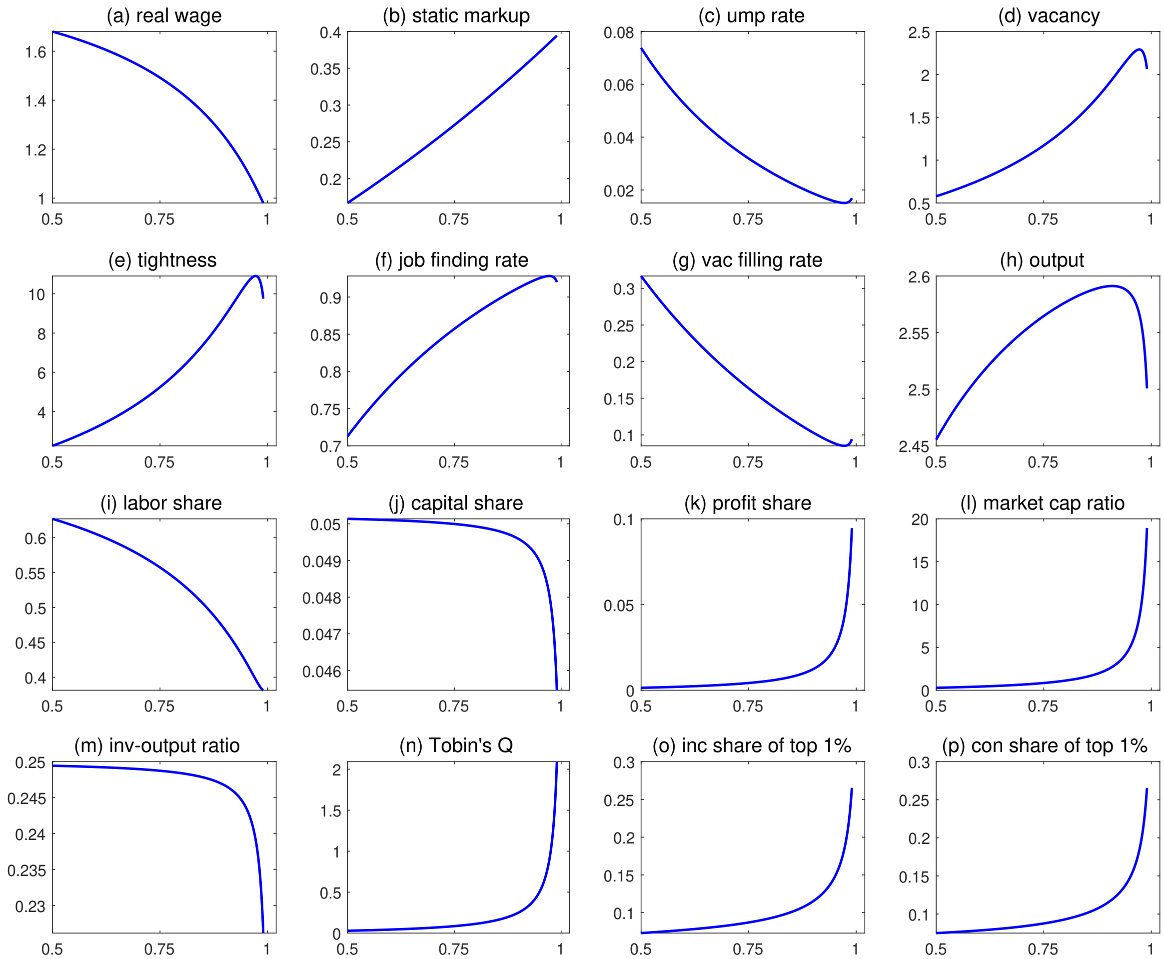
Panel (b) of the figure shows the rising (net) markup from 15 percent to 40 percent, which is consistent with Hall (2018), De Loecker et al. (2018) and Barkai (2016). However, in contrast to this literature, the markup is determined as $\epsilon/(\epsilon - b)$, and what drives up the markup in our model is not the elasticity of substitution ϵ, but the bargaining power of the firms. Given our calibration of $\epsilon = 3.5$, the range ($0.50 - 0.99$) is realistic in terms of explaining the observed rise in the markup. However, as will be shown below, the shift in bargaining power is wider than necessary to explain the secular trends in factor shares and stock market capitalization.

The large decline of the natural rate of unemployment, shown in Panel (c), from greater than 7 percent to nearly 2 percent is explained by the fact that job creation becomes much more profitable as a greater share of production rents is now distributed to the owners of

[12]Note that our theoretical model implicitly assumes that all workers are covered by union contract. This is an extreme assumption, especially for the U.S. where union density is around 11 percent (Hirsch and MacPherson (2003)). Our approach is to model the decline of bargaining power of workers using the secular decline of $1 - b$ rather than the decline of union coverage or density. This choice has been made for simplicity. A more elaborate approach is to introduce labor market segmentation where the labor market is composed of a unionized primary sector and a "competitive" secondary sector along the line of McDonald and Solow (1985) and to model the decline of the bargaining power of the workers as a shrinking share of the unionized primary sector. However, analyzing the transitional dynamics of labor market in this way in a dynamic general equilibrium model is a challenging task, and we leave this for future research.

[13]Since bargaining power is declining in our paper, it is no surprise that the model's empirical BPI is indeed declining. If median real compensation and labor productivity increase at the same rate, the BPI would not change over time. What is known as "Treaty of Detroit" was a contract between United Auto Workers and the big three automobile companies to raise nominal wages according to productivity gains and the increase in the cost of living (inflation). The fact that the BPI has been declining since 1980 implies that the "Treaty of Detroit" has broken down. The efficiency condition for labor is given by $w = \mu\alpha(y/n)$. Despite rising labor productivity, the real wage remaining constant requires a drop in the real marginal cost, μ, the inverse of markup. In a way, the "Treaty of Detroit" was a treaty to maintain a constant markup ($1/\mu$) by making w and y/n move in lock steps in $w = \mu\alpha(y/n)$. In Barkai (2016), as in any monopolistic competition literature, the real marginal cost is given by $(\epsilon - 1/\epsilon)$ whereas it is determined as $(\epsilon - b/\epsilon)$ in this paper.

Figure 5: Comparative Statics



the firms. As a direct result, the firms essentially quadruple vacancy postings between the poles of our bargaining power comparative static, and as a result, market tightness (panel (e)) and the job finding rate (panel (f)) increase substantially.[14] The large decline of the natural rate resembles the pre-Pandemic data: extremely low unemployment rate, but the absence of inflation pressure with almost no bargaining power of workers as measured by the work stoppage index or BPI.

Note that the rise of firms' bargaining power has two opposite effects on output. On the one hand, the rising bargaining power of the firms increases output through the job creation channel as noted above. On the other hand, the rising bargaining power reduces output through an increased markup channel. Panel (h) shows that initially it is the job creation channel that dominates. However, the markup channel eventually dominates and output begins to decline after the bargaining power of the firm reaches 0.9.

Panel (i)$\sim$(k) show how the rise of firms' bargaining power affects factor shares, i.e., labor, capital and profit shares. The rise of the bargaining power $(0.50 - 0.99)$ lowers the

[14]See Figura and Ratner (2015) and Cairó and Sim (2020) for the potential role of the decline of the bargaining power in generating the fall of the natural rate of unemployment.

labor share from 0.62 to 0.40, which is notably greater than what is observed in the data.[15] In contrast, the rise of the profit share shown in panel (k) is more comparable with the magnitude observed in the data. The share of corporate profits after tax (without IVA and CCAdj) marked the lowest point at 3.4 percent in 1986Q3 and thereafter steadily increased, reaching its highest point in 2012Q1 of 12 percent.

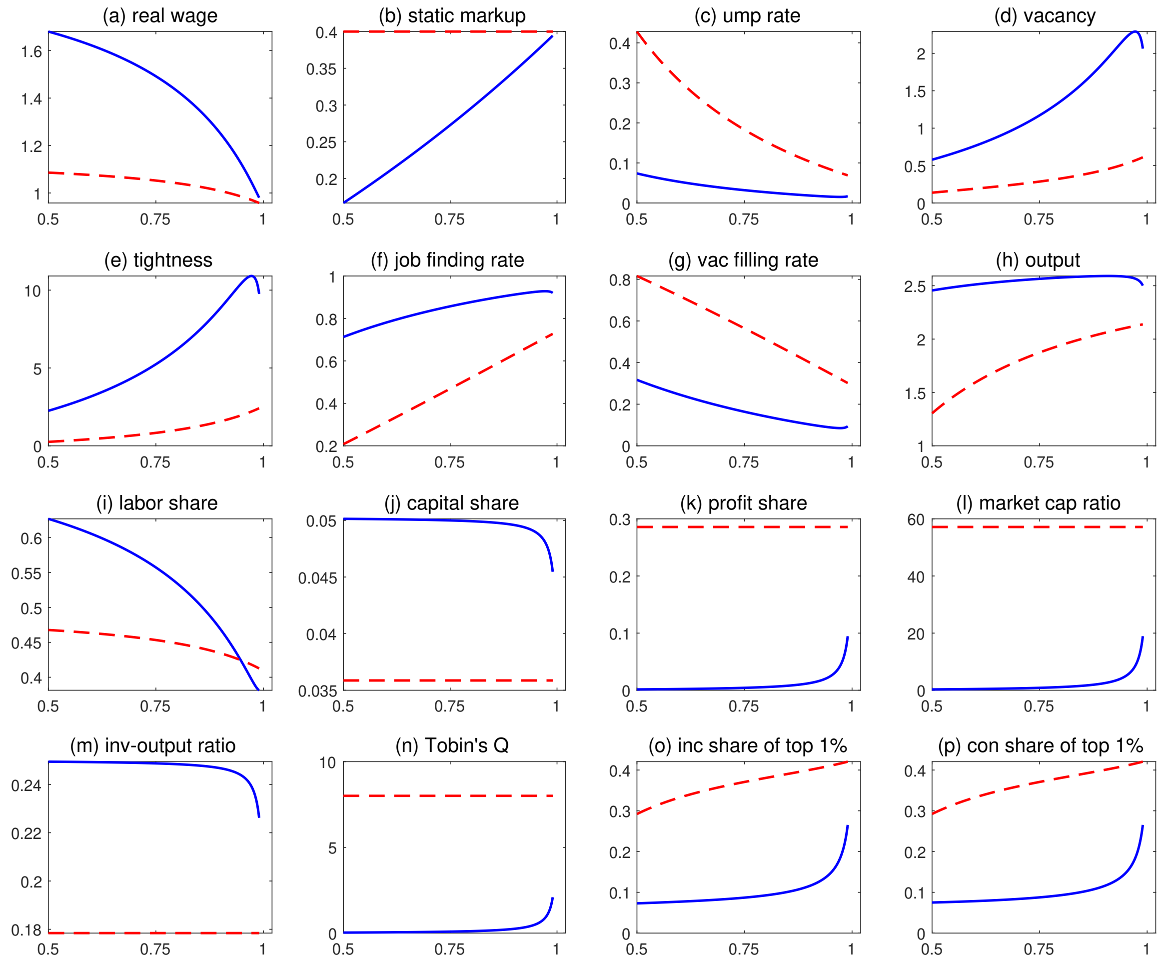
The model generated market cap ratio (the stock market value relative to nominal GDP), shown in panel (l), is consistent with the data shown in Figure 3. The difference is that the market cap ratio in the data has risen only 6 times since 1980 while it reaches nearly 20 times in the model. This suggests that the proper range of bargaining power that is consistent with the financial market data is perhaps 0.5 to 0.9. Panel (n) shows the other aspect of financial markets: Tobin's Q. The panel shows that depending on the bargaining power of the firms, Tobin's Q can be anywhere between 0 and 2. In contrast to Eggertsson et al. (2018) and Gutiérrez and Philippon (2017), we generate this result through a collective bargaining channel rather than through a market concentration channel. The same thing can be said regarding the secular decline of investment-to-output ratio. De Loecker et al. (2018), Eggertsson et al. (2018) and Barkai (2016) generate the same result through market concentration channel. Finally, our model, while using a simple Two-Agent New Keynesian (TANK) model structure, can generate the secular trend of income inequality: Panel (o) shows that we can match the rise of top income share of 1 percent in the data (proxied by firms owners in our model) through the weakening of collective bargaining power of the workers.

Note that the model assumes that bargaining between firms and workers takes place through two channels: bargaining over product prices (distribution of production rents) and bargaining over wages (distribution of match surplus). Traditional search and matching models assume only the second type of bargaining, but not the first type. A natural question is how much of the aforementioned secular trends in factor shares and financial market ratios can be explained by the traditional bargaining channel in the labor market. In other words, if the model assumes no bargaining over production rents, how much of the secular trends could be explained?

To show this, we set $b = 1$ for bargaining over product prices while varying the wage bargaining power from 0.5 to 0.99. Figure 6 shows the comparison, where blue solid lines are baseline and red dashed lines show the alternative case. Panel (a) and (c) show the counterfactual aspects of the alternative case: the real wage to productivity ratio declines slightly more than 10 percent, which can be considered much smaller than in the data; in

[15] One might conclude that the model generates too much decline of labor income share compared with the data. However, we want to point out that the official statistics on labor share is somewhat misleading. According to Economic Policy Institute (see Mishel (2012)), the *median* real hourly compensation has grown 10.7 percent since 1975 whereas productivity has grown 80.4 percent until 2012. Since labor share is $wn/y = w/(y/n)$, these numbers imply that that the labor share declined 35 percent from what it was in 1975. If the median labor income share was 65 percent, that means the current median labor income share is about 42 percent, a 23 percentage point decline, which is essentially the same magnitude generated by our model.

Figure 6: Comparative Statics: Search and Matchng Friction Only



addition, setting the initial markup equal to $\epsilon/(\epsilon-1)$ instead of $\epsilon/(\epsilon-b) = \epsilon/(\epsilon-0.5)$ would imply an unrealistically high initial unemployment rate.

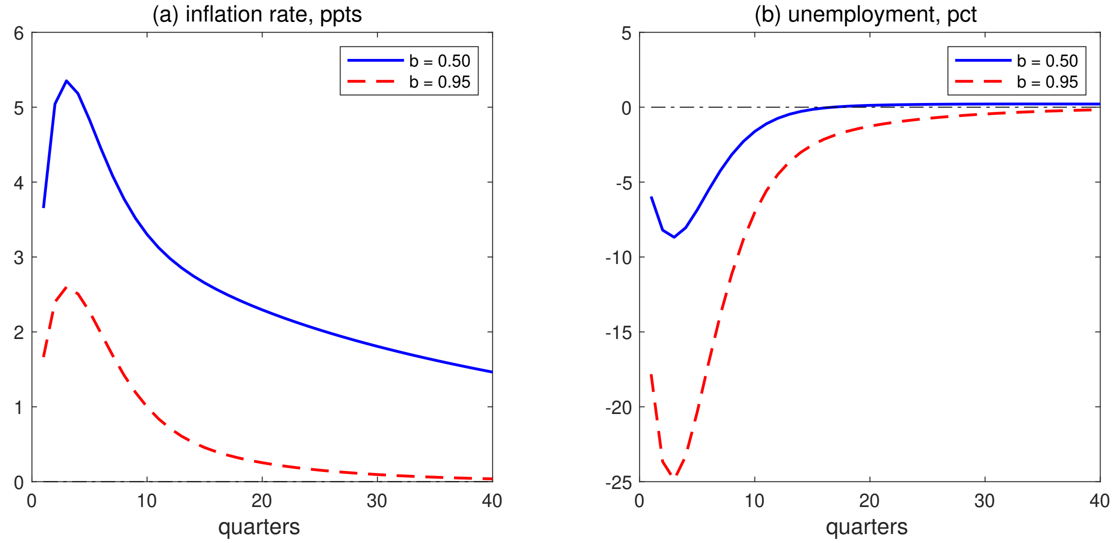
Panel (i) shows that the reduction in labor share that can be generated through the rise of firms' bargaining power in wage bargaining alone is quite limited. Panel (j)$\sim$(n) also show that the wage bargaining channel alone cannot explain any of the secular trends in the financial markets variables. The changes in the bargaining power in dividing the production rents is thus essential to being able to generate the secular trends in financial markets.

3.3 Trade Union Power and Inflation Dynamics

In this subsection, we show how the rise of the bargaining power of the firms changes inflation dynamics in the model.

Figure 7 compares the impulse response functions of the inflation rate and unemployment rate for two cases with $b = 0.50$ (blue solid) and $b = 0.95$ (red dash) in response to a risk premium shock of Smets and Wouters (2007), which is considered a representative demand shock in the literature. It is important that the two cases are considered under an identical

Figure 7: Impulse Responses of Inflation and Unemployment Rates to a Demand Shock: The Case of the Kaleckian Phillips Curve



monetary policy regime, which is specified as a inertial Taylor (1999) rule. The specific levels of bargaining power, namely, 0.5 and 0.95, considered in this subsection, correspond to the semi-structural estimates of b in section 4 as will be shown below.

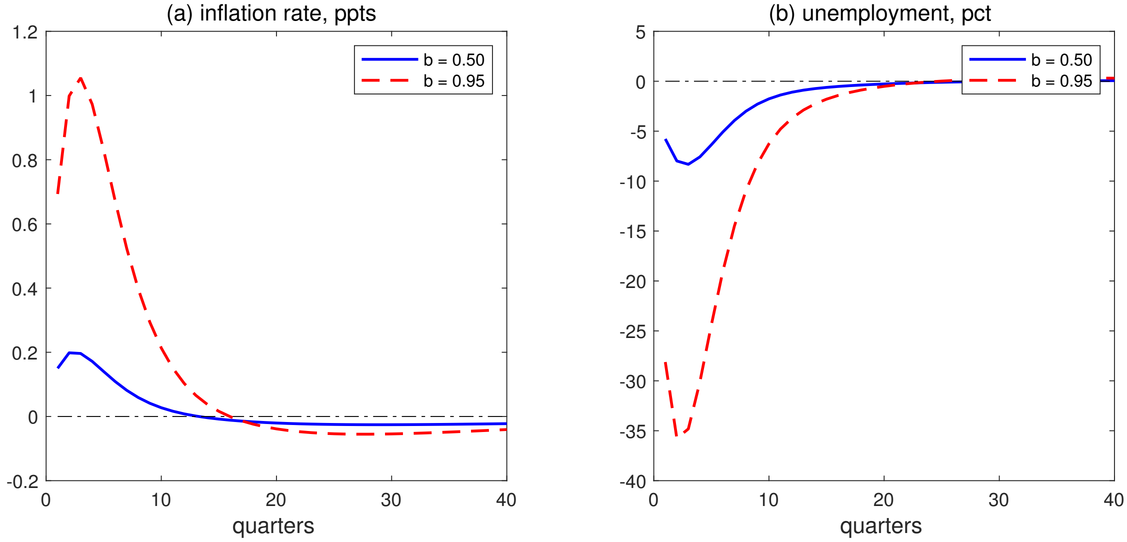
On the left panel, with the workers maintaining a substantial degree of collective bargaining power, the Kaleckian Phillips curve is relatively steep. Consequently, a one standard deviation shock leads to a large increase in the inflation rate: the response on impact is as large as 3 percentage points and the peak response reaches 5.5 percentage points. On the right hand side, the response of the unemployment rate falls by 8 percent at its nadir. Comparing the peak responses of the inflation rate and the unemployment rate, one reaches a rough estimate of the slope of the Phillips curve of $-5.5/8.0 = -0.7$.

When the labor relationship is completely reorganized such that firms hold the dominant hand in both the distribution of production rents and over the match surplus ($b = 0.95$, red dash), we get the exact opposite patterns of responses of prices and quantities: in the left panel, the response of inflation is notably muted, peaking at 2.5 percentage points; on the right panel, the unemployment rate reacts much more strongly with its peak impact reaching nearly a 25 percent decline. Comparing the peak responses, one reaches a ratio of $-2.5/25 = -0.1$, a seven times flatter reduced-formed estimate of the slope of the Phillips curve.

For a comparison, Figure 8 shows the results of the same experiment, but using the New Keynesian Phillips curve. Like in Figure 7, we assume that the wage bargaining power of the firm rises from 0.5 (blue solid) to 0.95 (red dashed). However, in contrast to Figure 7 where firms' markup rises from $\epsilon/(\epsilon - 0.5)$ to $\epsilon/(\epsilon - 0.95)$, the markup in Figure 8 is held constant at $\epsilon/(\epsilon - 1)$.

The most noticeable difference from the case of the Kaleckian Phillips curve is shown on

Figure 8: Impulse Responses of Inflation and Unemployment Rates to Demand Shock: The Case of New Keynesian Phillips Curve



the left panel: the magnitudes of the inflation responses are reversed. It is the case with the greater bargaining power for firms ($b = 0.95$) that brings the most inflation pressure, though both inflation responses of New Keynesian Phillips curve smaller than any of the case of Kaleckian Phillips curve.

As emphasized by Figura and Ratner (2015) and Cairó and Sim (2020), the decline of workers' bargaining power drastically shifts out job creation condition for firms. In response to a positive demand shock, job creation booms, as can be seen in 35 percent decline of the unemployment rate in the right panel (red dashed).[16] Such a boom leads to a stronger response of inflation, which is the reason why the order of magnitudes of the inflation response is reversed. When the workers' bargaining power is stronger ($b = 0.5$, blue solid line), the firms do not create as many jobs as in the opposite case (red dashed line). Such a lukewarm response in job creation leads to a muted inflation response on the left panel.

Note that despite this difference between $b = 0.5$ and $b = 0.95$, reduced-form estimates of the slope of the Phillips curve do not change. By comparing the peak responses of the unemployment and inflation rates, we note that the slope of the Phillips curve remains the same: When $b = 0.5$, the peak ratio is $-0.2/0.8 \approx 0.03$; When $b = 0.95$, the peak ratio is $-1.02/35 \approx 0.03$. In contrast to the case of the Kaleckian Phillips curve, the change in bargaining power alone does not affect the slope of the Phillips Curve. The change in bargaining power does lead to the change in the dynamics of real marginal cost, but the response of the inflation rate for a given level of real marginal cost remains the same. As

[16]The comparative static for unemploymen may appear unrealistically large. However, we report the percent change in the unemployment rate, rather than the percentage point change (see the next footnote for the reason why we report the percent decline). Hence if the natural rate is 6 percent during normal times, a 35 percent decline in the unemployment rate would represent a 2 percentage point decline in the unemployment rate, which is not an unusually large decline during a typical boom.

Table 2: Bargaining Power and Volatility

b (bargaining power of the firms)	0.40	0.55	0.75	0.99
	STD(π) $\times$ 100			
Demand shock only	1.77	2.06	1.92	0.29
Supply shock only	4.01	3.77	3.28	0.44
Both shocks (50:50)	4.37	4.29	3.80	0.53
	STD(u)/E(u) $\times$ 100			
Demand shock only	5.87	7.44	10.7	49.3
Supply shock only	4.75	5.82	9.06	40.8
Both (50:50)	4.74	9.45	14.1	40.6

shown by the blue solid and red dashed lines in Figure 8, the inflation response is materially different in response to the same shock. However, the difference is only due to the difference in real marginal cost and has nothing to do with the slope of the Phillips curve. This is the main difference from the case of Kaleckian Phillips curve.

Table 2 shows what happens to the volatility of inflation and the unemployment rate as firms achieve greater bargaining power in our environment. Regardless of whether the business cycle is driven by demand shocks or supply shocks or a 50-50 mix, greater bargaining power for firms always lead to a lower volatility of inflation and higher volatility of the unemployment rate.[17] The pre-Pandemic experience after the GFC is consistent with this pattern: a greater volatility of unemployment coupled with surprising tranquility of inflation resembles our theoretical regime in which the bargaining power of the workers nearly collapsed and the firms' market power is unprecedentedly strong.[18] Figure 8 indicates that this is not the case for the New Keynesian Phillips curve: the changes in bargaining power under the New Keynesian Phillips curve always move the volatilities of inflation and unemployment in the same direction.

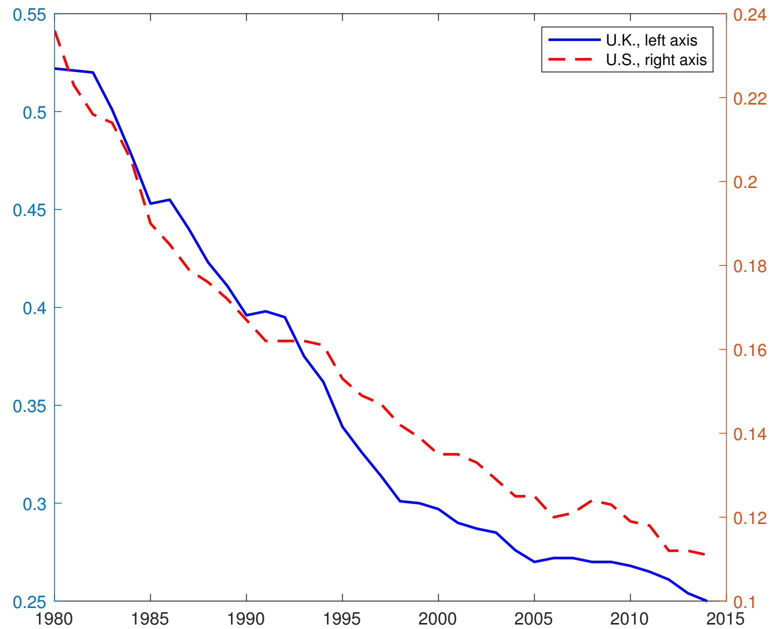
4 Empirical Evidence

In this section, we provide evidence that the slope of the Phillips curve is shaped by institutions in the labor market that determine worker and firm bargaining power.

[17] As we have shown in the comparative statics, the rise of firms' bargaining power is associated with the decline of the mean unemployment rate. As a result, when the slope of the Phillips curve becomes flatter, it is possible that the absolute magnitude of the standard deviation for the unemployment rate may go down. To prevent this, we report a coefficient of variation, that is the standard deviation normalized by the mean of the unemployment rate.

[18] We note that this is not the only explanation of "missing deflation" after the GFC. For instance, Gilchrist et al. (2017) explains the missing deflation puzzle by pointing out the incentive of cash-strapped firms to raise internal funds, sacrificing long-term market share to survive the current liquidity crisis. This explanation does not rely on labor market frictions at all. However, even in this case, their Phillips curve is a major departure from the conventional New Keynesian case, featuring deep habit (habit formation at the goods level) and financial frictions for pricing firms.

Figure 9: Labor Union Density: U.K. and U.S. Since 1980



Notes: 1980-2014, AMECO databases, European Commision

4.1 Time Series Evidence

We first present time series evidence using data on the labor share and GDP deflators for the U.S. and U.K.. Figure 9 shows labor union density in each of the two countries since 1980. Since around that time, labor market policies and other forces have led to virtually monotonic declines in labor union coverage over the last four decades. While their starting level at the beginning of 1980s were different, both countries have experienced nearly 50 percent declines in union density since then. If our theory is correct, such changes will be reflected in the slopes of the Kaleckian Phillips curves. We test this hypothesis in this section.

The log-linearized version of the Kaleckian Phillips curve from above implies the following time series regression equation:

$$\pi_t = \kappa_1 s_t + \kappa_2 PV_t^s + \gamma_1 \pi_{t-1} + \gamma_2 \mathbb{E}_t[\pi_{t+1}] + \epsilon_t \tag{34}$$

where s_t is labor share corresponding to the real marginal cost of the theoretical model, $\hat{\mu}_t$ and PV_t^s is the present value of labor share corresponding to the expected present value of the labor share in the theoretical model, $\sum_{s=0}^{\infty} \beta^s \mathbb{E}_t[\hat{\mu}_{t+s}]$. Here we follow the convention to use labor share to approximate the real marginal cost (see Galí and Gertler (1999)), and accordingly we approximate the present value of real marginal cost by the present value of labor shares.

An immediate challenge is to construct the empirical measure of the present value of the labor share. To this end, we follow Abel and Blanchard (1986). We first estimate a vector autoregression model

$$x_t = Ax_{t-1} + \epsilon_t$$

where $x_t = [y_t \ s_t]'$ where y_t may include any variable that helps predict labor share. For instance, we use labor union density (Another possible choice might be the work stoppage index, or the aforementioned BPI from Levy and Temin (2007)). Once the VAR model is estimated, the present value of the labor share can be obtained as

$$PV_t^s = c_2'(1-\beta)^{-1}(I - \beta\hat{A})^{-1}\beta\hat{A}^2 x_{t-1}$$

where $c_2 = [0 \ 1]'$ and β is the discounting factor of the model.[19] Using this present value series, one can estimate (34) and recover the structural value of the bargaining power of the firms from the theoretical model as

$$b = (\hat{\kappa}_2/\hat{\kappa}_1 + 1)^{-1}. \tag{35}$$

Table 3 shows the Generalized Method of Moments (GMM) estimation results for the U.S. The first two columns are estimated using pre-Reagan time period (1961-1980) and the last two columns are estimated using post-Reagan period (1981-2014). The first and third columns are traditional hybrid New-Keynesian Phillips curve. These two columns are included for comparison with other estimates such as Galí and Gertler (1999). The first column shows that our early sample estimation results are not very different from Galí and Gertler (1999): the labor share is highly significant as a predictor of inflation and forward- and backward-looking terms of inflations are highly significant and their magnitudes are economically sensible. However, in the third column, the labor share is no longer significant in the second sample period.

The second and fourth columns are the Kaleckian Phillips curve developed in this paper. In the first sample, while the traditional labor share term is not statistically significant, the present value of the labor share is highly significant. Most importantly, the implied bargaining power of the firms: $b = (\hat{\kappa}_2/\hat{\kappa}_1 + 1)^{-1} = 0.519$, which suggests that the pre-Reagan era is characterized by a balance of power between firms and workers in sharing the production rents. However, in the post-Reagan era, both coefficients have the wrong signs and the implied value of bargaining power is 0.923, which is consistent with a dominant bargaining position of firms relative to workers. Indeed, these estimation results are consistent with the range of bargaining power considered for the comparative static analysis above.

Table 4 shows the estimation results for U.K. As in the case in the U.S., we use the labor union density together with labor share data to construct the present value of future labor

[19] The same formula has been used by Gilchrist and Himmelberg (1998) to measure the expected present values of the investment fundamental and financial constraints. Such present value estimation technique is also frequently used in large scale econometric models such as the FRB/US model used by the Federal Reserve Board.

Table 3: GMM Estimation of Phillips Curve: U.S.

	1961-1980		1981-2014	
s_t	0.055	0.044	0.073	-0.130
	(5.573)	(0.850)	(0.714)	(-1.410)
PV_t^s	-	0.041	-	-0.011
		(2.267)		(-2.290)
$E_t[\pi_{t+1}]$	0.573	0.941	0.936	1.219
	(49.43)	(3.999)	(4.814)	(3.380)
π_{t-1}	0.486	0.366	0.430	0.411
	(32.37)	(3.042)	(4.459)	(3.500)
b	-	0.519	-	0.923
Adj R^2	0.716	0.701	0.862	0.863
J-stat	4.848	2.291	5.441	3.601
p-value	0.676	0.514	0.364	0.463

Notes: Parentheses are for t-statistics.

Table 4: GMM Estimation of Phillips Curve: U.K.

	1961-1978		1979-2014	
s_t	0.072	0.051	-0.028	-0.012
	(3.162)	(1.969)	(0.546)	(-0.804)
PV_t^s	-	0.045	-	0.003
		(0.437)		(0.255)
$E_t[\pi_{t+1}]$	0.456	0.349	0.441	0.453
	(7.038)	(2.700)	(6.898)	(6.344)
π_{t-1}	0.506	0.646	0.583	0.587
	(9.496)	(2.835)	(8.249)	(8.318)
b	-	0.536	-	1.000
Adj R^2	0.629	0.568	0.858	0.855
J-stat	4.288	3.195	4.562	4.951
p-value	0.368	0.526	0.472	0.422

Notes: Parentheses are for t-statistics.

share. The first subsample (pre-Thatcher) period is slightly different from the U.S. case as her term began in 1979.

The conventional estimates of the hybrid New Keynesian Phillips curve, shown in the first and third column, exhibit similar features to those in the U.S.: a highly significant role of the labor share in the early sample, but an insignificant slope coefficient (labor share) in the later sample, as in the U.S. case. The estimates of the Kaleckian Phillips curve, shown in the second and fourth columns, suggest that the bargaining power of the firms in early period was 0.536, quite similar to the U.S. estimate, while, it is equal to 1.0, a corner solution due to the truncation of b, in the later period (The unrestricted value is given by $b = (\hat{\kappa}_2/\hat{\kappa}_1 + 1)^{-1} = 1.333$). This is exactly the same pattern as obtained in the U.S. case: in the pre-Thatcher era, the power was evenly distributed between firms and workers; in the post-Thatcher era, the slope of the traditional Phillips curve appears to be no different from zero and the estimate of the Kaleckian Phillips curve implies essentially no bargaining power for workers at all. The estimation results point to a possibility that both the post-1980s disinflation and the concurrent flattening of the Phillips curve owe as much to the labor market institutions of these two countries as to the monetary policies of these two countries.[20]

A recent, influential study by Hazell et al. (2022), using panel data estimation of Phillips curve based on state-level Cnsumer Price Index (CPI), has reached somewhat different conclusion from ours: The slope of the Phillips curve has been farely flat in entire sample. They derive this conclusion from two findings.

First, using the state-level panel data, they show that the slope of the Phillips curve in their pre 90s subsample was already low and the slope coefficient declined only moderately in their post 90s sample. It is unfortunate that their data cover only 1978-2018, which is essentially the same as our second subsample, in which we have shown that the bargaining power of workers has collapsed, and as a result, the Phillips curve relationship has broken down.[21] In this sense, it is no surprising that they found that the slope of the Phillips curve has been always flat.

Second, Hazell et al. (2022) suggests, based on close relationship between current inflation rate and 1-year ahead inflation expectations by Survey of Professional Forecasts (SPF), that "the slope of the Phillips curve was small throughout our sample period" (pp. 1312). They argue that since the canonical New Keynesian Phillips curve is given by $\pi_t = \beta \mathbb{E}_t \pi_{t+1} - \kappa(u_t - u_t^n) + \nu_t$ where $u_t - u_t^n$ measures the unemployment gap and ν_t, if what they call "inflation gap", $\pi_t - \beta \mathbb{E}_t, \pi_{t+1}$ is measured so small throught the period since 1980, the estimate of κ cannot be large. However, measuring the "inflation gap" using 1-year ahead inflation expectations by SPF is problematic because the SPF forecasters probably extrapolate the current inflation rate to forecast 1-year ahead inflation rate. In other words, the current inflation rate explains the SPF 1-year ahead forecast, not the other way around.

We now turn to cross-sectional data analysis. However, due to the data coverage limit of cross-sectional data pointed above, we use these data differently. If available date belongs to an identical statistical regime, it is hard to learn from time dimension. This is why we try to learn from cross-sectional dimension, controling the heterogeneity of bargaining power of different cross-sectional, regional units.

4.2 Cross-Sectional Results

In this section, we provide corroborating evidence on the implications of worker bargaining power on the Phillips curve using cross-sectional evidence from regional data in the United States. We approach the cross-sectional empirical analysis building on the recent work by

[20] Surprisingly, the results are not restricted to the Anglo-Saxon countries. We have similar results for Denmark and Sweden in Appendix B.

[21] Stock and Watson (2019), using time series covering sample over 1960-2019 also reached a conclusion similar to ours. The slope of the Phillips curve is estimated as 0.63 during 1960-1983 sample, but is near zero during 2000-2019 sample.

Babb and Detmeister (2017), Hazell et al. (2020), Hooper et al. (2020), Kiley (2015), and McLeay and Tenreyro (2019). Below, we provide evidence using both MSA-level and state-level variation. The basic specification we employ is a simple reduced-form Phillips curve

$$\pi_{it} = \alpha_i + \alpha_t + \beta u_{it} + \gamma \pi_{it-1} + \nu_{it}$$

where α_i represent region-specific fixed effects, α_t time period fixed effects, and β is the slope of this reduced-form Phillips curve. Following the recent literature, we assume that the region fixed effects control for time-invariant differences in the natural rates of unemployment and the time fixed effects capture common movements in the natural rate across regions.

As a proxy for worker bargaining power, we exploit the substantial variation in labor union densities across states and cities within the United States. Figure 10 shows average union density rates over the period 1986-2017 from Current Population Survey microdata on 20 MSAs that can be coded uniformly over time, as well as linked to the same MSAs in BLS CPI data. Union density rates vary from just over 5 percent in Houston, Dallas and Atlanta to nearly 25 percent in New York City and Honolulu.[22]

We first estimate Phillips curves following Babb and Detmeister (2017) and Kiley (2015) using the sample of 20 MSAs over the period 1986H2 to 2017H2, where the bi-annual data and time span are determined by the availability of BLS and CPS data.[23]

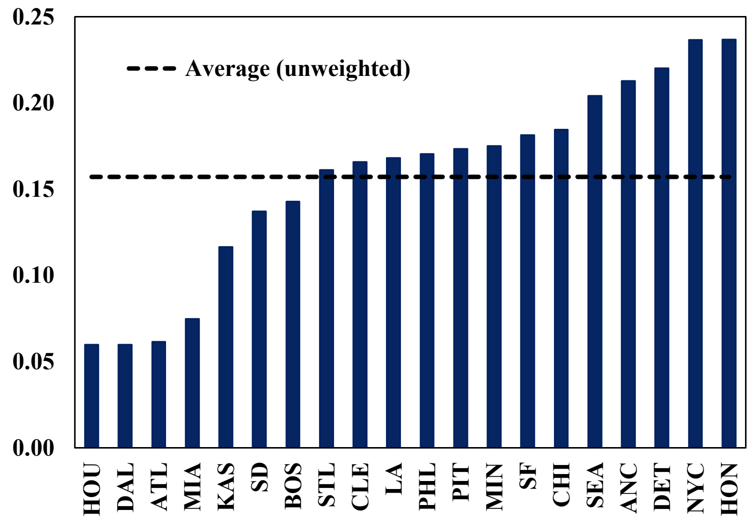
Table 5 presents estimates from several specifications of the Phillips curve using these MSA data. All specifications include MSA-level fixed effects and period fixed effects, and the standard errors are clustered at the MSA and period levels. Column (1) replicates the results in Kiley (2015) and Babb and Detmeister (2017) which show that the Phillips curve estimated off of regional data reveal a substantial tradeoff between unemployment and inflation. Our baseline estimate in column (1) shows that a one percentage point decrease in the unemployment rate raises inflation by 0.34 percentage points.

To test the implication of the Kaleckian Phillips curve—one in which the slope of the Phillips curve is shaped by bargaining power—we now split cities by union densities and estimate Phillips curve by these groups. Columns (2) and (3) split the sample into cities

[22] Union densities fell over time from 1986 to 2017 across 19 of the 20 cities, with the exception of Los Angeles in which union density rose only slightly. Nonetheless, the relative ranking of cities at the beginning of the sample and the end was very high, with a rank order correlation of 0.75. For this reason, we focus on average union densities over time within cities.

[23] Because the BLS revised their MSA-level CPI data in 2018 and reduced the number of MSAs (as well as changed their geographic definitions), we have used the pre-2018 data, downloading the final vintage of these data from early 2018. There are twenty cities in our semi-annual dataset, three fewer than in Babb and Detmeister (2017) after excluding Milwaukee-Racine, Cincinnati-Hamilton, Portland-Salem, Honolulu, and Denver-Boulder-Greeley as those MSAs were only available at the annual frequency. MSA-level unemployment rates and union density rates are available from October 1985 when the Current Population Survey (CPS) began providing geographic detail at that level of disaggregation. We estimate the unemployment rate from the basic monthly CPS files. Union membership is estimated from the outgoing rotation groups of the CPS for all workers except the self-employed and unpaid family workers, following the methodology in Hirsch and MacPherson (2003). We average monthly observations over the six months of each half-year and are left with 62 halves of data for each of the 20 MSAs.

Figure 10: Labor Union Density: U.S. MSAs, 1986-2017



Notes: Average union density over 1986-2017 for sample of 20 MSAs. Authors' analysis of Current Population Survey data.

with below-median union densities (column (2)) and above-median union densities (column (3)). The results reveal a striking difference in the Phillips curve slope between the low- and high-union groups: the slope coefficient is 0.11 percentage points steeper in higher-union cities.

In order to test whether the slope coefficients are statistically different across the two sets of states (below- and above-median union density), we augment the specification above by adding an interaction term as follows

$$\pi_{it} = \alpha_i + \alpha_{td} + \beta u_{it} + \beta_{int} u_{it} \mathbf{1}(d_i > \bar{d}) + \gamma \pi_{it-1} + \nu_{it}.$$

$\mathbf{1}(d_i > \bar{d})$ is an indicator variable for whether union density in state i, d_i, is above the median union density ($\bar{d}$). (Note that we now also include period-by-union-group dummies, α_{td}). Column (4) presents the results from this two-group interaction, where the coefficient β_{int} in the second row gives the difference in the coefficients in high union states vs. low. We find that the coefficients are not just economically quite different—indeed, in this specification the slope in the high-density cities is nearly double than in the low-density cities—but also statistically significant. Finally, the last column breaks union density into three groups: the bottom 25th percentile, the middle 50th percentile, and the top 25th percentile. The coefficients on the interaction of the unemployment rate with the middle and highest union density groups both are negative and coefficient on the top union group is large (0.27 percentage points) and statistically significant, further confirming the result that higher union density, and thus higher worker bargaining power, steepens in the slope of the Phillips curve.

Table 6 provides additional suggestive evidence of the role of that union density has in shaping the dynamics of the Phillips curve relationship. Here, we follow the recent work by

Hazell et al. (2020) who develop a state-level inflation dataset derived from BLS microdata and use these data to estimate state-level Phillips curve of the following form:

$$\pi_{it} = \alpha_i + \alpha_t + \beta u_{i,t-4} + \nu_{it}.$$

Compared to the estimates from the MSA-level data in Table 5, the covariate of interest is the four-quarter lag of the unemployment following the specification in Hazell et al. (2020).[24] Column (1) roughly replicates the baseline result from Table 1 of Hazell et al. (2020) which indicate a modest Phillips curve relationship and one that is slightly less steep (and precise) than found in the MSA-level data.[25] Columns (2) and (3) again break our sample into two groups, below- and above-median union density states and estimate the Phillips curve separately for these two groups; the results again show that the slope of the Phillips curve is steeper in high-union states, although the standard errors are relatively larger so that we cannot statistically distinguish the coefficients.[26]

Our final robustness exercise mimics, in a reduced-form way, the empirical results in Section 4.1 by estimating Phillips curve using labor share as the covariate of interest. In particular, we average over the quarters of the state-level panel used in columns (1)-(3) of Table 6 and merge in data from the Bureau of Economic Analysis on the labor share. We estimate the following specification:

$$\pi_{it} = \alpha_i + \alpha_t + \beta s_{i,t-1} + \nu_{it},$$

where the periods are now years instead of quarters due to the limitations of the BEA data on labor share by state. The results are shown in columns (4) - (6) of Table 6. Column (4) shows the baseline result that the labor share, a proxy for real marginal cost, has a positive and significant effect on inflation. Columns (5) and (6) again break our sample into below- and above-median union density states. The results show a substantially larger slope of the Phillips curve in high union states, although the standard errors are large enough such that we cannot statistically distinguish the estimates.

[24]For Table 6, we draw the unemployment rate data from the BLS's LAUS tables and union densities from Hirsch and MacPherson (2003).

[25]We use non-tradeable inflation for the dependent variable but we do not include data on the relative price of tradeable goods, which are included in the estimates in Table 1 of Hazell et al. (2020). We also omit lagged inflation as a covariate, following their specification.

[26]We conduct the statistical test again by augmenting the baseline specification with the interaction terms and including period-by-group fixed effects.

Table 5: Cross-Sectional Phillips Curves using MSA-level data

VARIABLES	(1) Overall	(2) Below Median	(3) Above Median	(4) Two-group interaction	(5) Three-group interaction
Unemp rate	-0.335***	-0.259***	-0.373***	-0.241***	-0.196***
	(-6.839)	(-5.392)	(-8.721)	(-5.285)	(-3.020)
UR. * Top 50th				-0.185**	
				(-2.124)	
UR. * Middle 50th					-0.0813
					(-1.197)
UR. * Top 25th					-0.274**
					(-2.701)
Observations	1,240	620	620	1,240	1,240
R^2	0.667	0.693	0.695	0.689	0.715
Lagged Dep.	YES	YES	YES	YES	YES
MSA FE	YES	YES	YES	YES	YES
Period FE	YES	YES	YES		
Period * Union Group FE				YES	YES

Standard errors are clustered at state and quarter

Table 6: Cross-Sectional Phillips Curves using State-level data

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Overall	Below Median	Above Median	Overall	Below Median	Above Median
Lur	-0.152*	-0.0234	-0.217*			
	(-1.808)	(-0.353)	(-2.134)			
Lagged Labor Sh.				0.135	-0.0577	0.192
				(1.375)	(-0.775)	(1.478)
Observations	3,024	1,152	1,872	648	144	504
R^2	0.703	0.751	0.690	0.721	0.865	0.702
Lagged Dep.	NO	NO	NO	NO	NO	NO
MSA FE	YES	YES	YES	YES	YES	YES
Quarter FE	YES	YES	YES			
Year FE				YES	YES	YES

Columns (1)- (3) are at the quarterly frequency using data from Hazell et al. (2020), the BLS, and Hirsch and MacPherson (2003). Columns (4) - (6) average the quarters to the yearly frequency and merge in BEA data on labor share. Standard errors are clustered at state and quarter for columns (1) - (3) and state and year for columns (4) - (6).

5 Conclusion

The pre-Pandemic data since the 1990s suggests that the Phillips curve relationship, a central tenet of New Keynesian monetary economics, appears to have broken down. This paper develops a "Kaleckian Phillips curve", the slope of which positively depends on the strength of worker bargaining power under the assumption that workers bargain with firms not only over match surplus (as in the standard search and matching literature) but also over production rents. Our comparative static and dynamic analyses show that the origin of the break down of the Phillips curve relationship may be found in the collapse of worker bargaining power since 1980s. The econometric evidence based on both time series and cross-sectional data renders robust support for this theoretical analysis.

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Online Appendix - Not Intended for Publication

A Staggered Pricing Version

In this appendix, we assume that the firms have probability $1-\gamma$ of reset their prices. With probability γ, the firms are assumed index their prices to the general price index, The present value of profits are given by

$$\Pi_t = E_t \sum_{i=0}^{\infty} \gamma^i \beta^i \Lambda_{t,t+i} \left[\left(\frac{P_t^*}{P_{t+i}} \prod_{k=1}^{i} \pi_{t+k-1}^{\gamma_P} \right)^{1-\varepsilon} - \mu_{t+i} \left(\frac{P_t^*}{P_{t+i}} \prod_{k=1}^{i} \pi_{t+k-1}^{\gamma_P} \right)^{-\varepsilon} \right] y_{t+i}$$

where now γ_P represents the degree of indexation. The bargaining problem can be expressed again the same as

$$S_t^p = \max_{P_t^*} \Pi_t^b U_t^{1-b}$$

where P_t^* is the optimal reset price that maximizes the joint surplus function. Due to the staggered pricing, now the surplus of union is also dynamic and is given by

$$U_t = E_t \sum_{i=0}^{\infty} \gamma^i \beta^i \Lambda_{t,t+i}^W \frac{W_{t+i}}{\tilde{a}_{t+i}} \left(\frac{P_t^*}{P_{t+i}} \prod_{k=1}^{i} \pi_{t+k-1}^{\gamma_P} \right)^{-\varepsilon} y_{t+i} \tag{A.1}$$

We assume that the union uses the stochastic discounting factor of the workers.

The FOC to the problem is the same as in the main text and is given by

$$\frac{\partial \Pi_t}{\partial P_t^*} = -\frac{1-b}{b} \frac{\partial U_t}{\partial P_t^*} \frac{\Pi_t}{U_t}, \tag{A.2}$$

where

$$\begin{aligned} \frac{\partial \Pi_t}{\partial P_t^*} = & -(\varepsilon - 1) \left(P_t^*\right)^{-\varepsilon} E_t \sum_{i=0}^{\infty} \gamma^i \beta^i \Lambda_{t,t+i} \left(\frac{1}{P_{t+i}} \prod_{k=1}^{i} \pi_{t+k-1}^{\gamma_P} \right)^{1-\varepsilon} y_{t+i} \\ & + \varepsilon \left(P_t^*\right)^{-\varepsilon-1} E_t \sum_{i=0}^{\infty} \gamma^i \beta^i \Lambda_{t,t+i} \mu_{t+i} \left(\frac{1}{P_{t+i}} \prod_{k=1}^{i} \pi_{t+k-1}^{\gamma_P} \right)^{-\varepsilon} y_{t+i} \end{aligned} \tag{A.3}$$

and

$$\frac{\partial U_t}{\partial P_t^*} = -\varepsilon \left(P_t^*\right)^{-\varepsilon-1} E_t \sum_{i=0}^{\infty} \gamma^i \beta^i \Lambda_{t,t+i}^W \frac{W_{t+i}}{\tilde{a}_{t+i}} \left(\frac{1}{P_{t+i}} \prod_{k=1}^{i} \pi_{t+k-1}^{\gamma_P} \right)^{-\varepsilon} y_{t+i} \tag{A.4}$$

Combining (A.2)~(A.4) yields

$$\begin{aligned} & \left(P_t^*\right)^{-\varepsilon} E_t \sum_{i=0}^{\infty} \gamma^i \beta^i \Lambda_{t,t+i} \left(\frac{1}{P_{t+i}} \prod_{k=1}^{i} \pi_{t+k-1}^{\gamma_P} \right)^{1-\varepsilon} y_{t+i} \\ = & \frac{\varepsilon}{\varepsilon - 1} \left(P_t^*\right)^{-\varepsilon-1} E_t \sum_{i=0}^{\infty} \gamma^i \beta^i \Lambda_{t,t+i} \mu_{t+i} \left(\frac{1}{P_{t+i}} \prod_{k=1}^{i} \pi_{t+k-1}^{\gamma_P} \right)^{-\varepsilon} y_{t+i} \\ & - \frac{1-b}{b} \frac{\varepsilon}{\varepsilon - 1} \left(P_t^*\right)^{-\varepsilon-1} \frac{\Pi_t}{U_t} E_t \sum_{i=0}^{\infty} \gamma^i \beta^i \Lambda_{t,t+i}^W \frac{W_{t+i}}{\tilde{a}_{t+i}} \left(\frac{1}{P_{t+i}} \prod_{k=1}^{i} \pi_{t+k-1}^{\gamma_P} \right)^{-\varepsilon} y_{t+i} \end{aligned}$$

Multiplying the both sides by $(P_t^*)^{\varepsilon+1}$ yields

$$P_t^* = \frac{\varepsilon}{\varepsilon-1}\frac{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}\mu_{t+i}P_{t+i}^{\varepsilon}\prod_{k=1}^{i}\pi_{t+k-1}^{-\varepsilon\gamma_P}y_{t+i}}{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}P_{t+i}^{\varepsilon-1}\prod_{k=1}^{i}\pi_{t+k-1}^{(1-\varepsilon)\gamma_P}y_{t+i}}$$
$$-\frac{\varepsilon}{\varepsilon-1}(1/b-1)\frac{\Pi_t}{U_t}\frac{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}^{W}(W_{t+i}/\tilde{a}_{t+i})P_{t+i}^{\varepsilon}\prod_{k=1}^{i}\pi_{t+k-1}^{-\varepsilon\gamma_P}y_{t+i}}{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}P_{t+i}^{\varepsilon-1}\prod_{k=1}^{i}\pi_{t+k-1}^{(1-\varepsilon)\gamma_P}y_{t+i}}$$

Defining $p_t^* \equiv P_t^*/P_{t-1}$ as the optimal reset price inflation, we can express the optimality condition as

$$p_t^* = \frac{\varepsilon}{\varepsilon-1}\frac{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}\mu_{t+i}\prod_{k=1}^{i}\pi_{t+k-1}^{\varepsilon(1-\gamma_P)}y_{t+i}}{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}\prod_{k=1}^{i}\pi_{t+k-1}^{(\varepsilon-1)(1-\gamma_P)}y_{t+i}}$$
$$-\frac{\varepsilon}{\varepsilon-1}(1/b-1)\frac{\Pi_t}{U_t}\frac{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}^{W}(W_{t+i}/\tilde{a}_{t+i})\prod_{k=1}^{i}\pi_{t+k-1}^{\varepsilon(1-\gamma_P)}y_{t+i}}{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}\prod_{k=1}^{i}\pi_{t+k-1}^{(\varepsilon-1)(1-\gamma_P)}y_{t+i}}$$

Note that the above can be written as

$$p_t^* = \frac{\varepsilon}{\varepsilon-1}\left[\frac{J_t^N}{J_t^D} - (1/b-1)\frac{\Pi_t}{U_t}\frac{J_t^K}{J_t^D}\right] \tag{A.5}$$

where

$$J_t^N = \mu_t y_t + \gamma\beta E_t[\pi_t^{\varepsilon(1-\gamma_P)}\Lambda_{t,t+1}J_{t+1}^N], \tag{A.6}$$

$$J_t^D = y_t + \gamma\beta E_t[\pi_t^{(\varepsilon-1)(1-\gamma_P)}\Lambda_{t,t+1}J_{t+1}^D], \tag{A.7}$$
$$J_t^K = (W_t/\tilde{a}_t)y_t + \gamma\beta E_t[\pi_t^{\varepsilon(1-\gamma_P)}\Lambda_{t,t+1}^W J_{t+1}^K],$$

and

$$\frac{\Pi_t}{U_t} = \frac{P_t^* E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}P_{t+i}^{\varepsilon-1}\prod_{k=1}^{i}\pi_{t+k-1}^{\gamma_P(1-\varepsilon)}y_{t+1}}{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}^{W}\frac{W_{t+i}}{\tilde{a}_{t+i}}P_{t+i}^{\varepsilon}\prod_{k=1}^{i}\pi_{t+k-1}^{-\varepsilon\gamma_P}y_{t+i}}$$
$$-\frac{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}\mu_{t+i}P_{t+i}^{\varepsilon}\prod_{k=1}^{i}\pi_{t+k-1}^{-\varepsilon\gamma_P}y_{t+i}}{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}^{W}\frac{W_{t+i}}{\tilde{a}_{t+i}}P_{t+i}^{\varepsilon}\prod_{k=1}^{i}\pi_{t+k-1}^{-\varepsilon\gamma_P}y_{t+i}}.$$

Dividing both numerator and denominator by P_{t-1}^{ε} yields

$$\frac{\Pi_t}{U_t} = \frac{p_t^* E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}\prod_{k=1}^{i}\pi_{t+k-1}^{(\varepsilon-1)(1-\gamma_P)}y_{t+1}}{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}^{W}\frac{W_{t+i}}{\tilde{a}_{t+i}}\prod_{k=1}^{i}\pi_{t+k-1}^{\varepsilon(1-\gamma_P)}y_{t+i}}$$
$$-\frac{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}\mu_{t+i}\prod_{k=1}^{i}\pi_{t+k-1}^{\varepsilon(1-\gamma_P)}y_{t+i}}{E_t\sum_{i=0}^{\infty}\gamma^i\beta^i\Lambda_{t,t+i}^{W}\frac{W_{t+i}}{\tilde{a}_{t+i}}\prod_{k=1}^{i}\pi_{t+k-1}^{\varepsilon(1-\gamma_P)}y_{t+i}}$$

Note that this can be simplified into

$$\frac{\Pi_t}{U_t} = \frac{p_t^* J_t^D - J_t^N}{J_t^K}.$$

Hence, by substituting this in (A.5), we get

$$p_t^* = \frac{\varepsilon}{\varepsilon - 1}\left[\frac{J_t^N}{J_t^D} - (1/b - 1)\frac{p_t^* J_t^D - J_t^N}{J_t^K}\frac{J_t^K}{J_t^D}\right]$$
$$= \frac{\varepsilon}{\varepsilon - 1}\left[\frac{J_t^N}{J_t^D} - (1/b - 1)\left(p_t^* - \frac{J_t^N}{J_t^D}\right)\right]$$

Solving for p_t^* yields

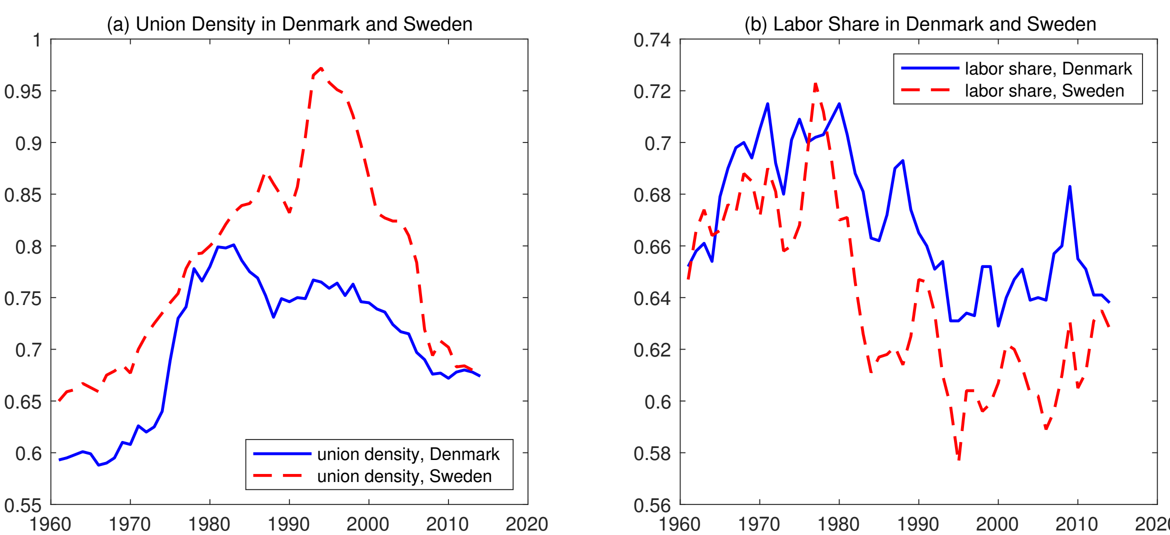
$$p_t^* = \frac{\varepsilon}{\varepsilon - b}\frac{J_t^N}{J_t^D} \tag{A.8}$$

If $b = 1$, this is the conventional Calvo model with J_t^N and J_t^D exactly the same as in conventional Calvo model with indexation. Therefore, we can conclude that if the bargaining power of the firm is less than perfect, the bargaining power of the firm is an important determinant of nonlinear inflation dynamics in Calvo model. However, we can also conclude that the loglinear dynamics is not affected by b in $\hat{p}_t^* = \hat{J}_t^N - \hat{J}_t^D$.

B Estimates of Kaleckian Phillips Curve Using European Countries

B.1 Union Density and Labor Share in Denmark and Sweden

Figure 11: Union Density and Labor Share in Denmark and Sweden



Notes: Data source is AMECO.

The union densities in Denmark and Sweden have changed in inverted U-shape, that is, increading in earlier sample but decreasing later sample. However, the turning points were different. In Sweden, the union density had continuted to go up until early 1990s before turning down since then. In Denmark, the union density had peaked at around 1980. Since then the labor union density has declined over 4 decades as shown in panel (a) of Figure 11.

The labor share in these two countries exhibit similar time series patterns as shown in panel (b) of Figure 11. In both countries, the labor shares continued to go up until late 1970s. Since then the labor shares declined secularly.

B.2 The Case of Sweden

Table 7: GMM Estimation of Phillips Curve: Sweden

	1961-1978		1979-2014	
s_t	0.036	0.034	0.073	-0.026
	(2.956)	(3.552)	(-0.521)	(-0.316)
PV_t^s	-	0.021	-	-0.001
		(1.390)		(-0.196)
π_{t-1}	0.515	0.644	0.557	0.563
	(13.27)	(4.830)	(3.715)	(3.607)
$E_t[\pi_{t+1}]$	0.575	0.576	0.376	0.368
	(21.16)	(7.119)	(2.113)	(2.027)
b	-	0.618	-	0.977
Adj R^2	0.812	0.789	0.822	0.817
J-stat	3.328	3.534	0.115	0.072
p-value	0.650	0.473	0.998	0.995

Notes: Parentheses are for t-statistics.

B.3 The Case of Denmark

Table 8: GMM Estimation of Phillips Curve: Denmark

	1961-1978		1979-2014	
s_t	0.024	0.024	-0.060	-0.060
	(2.074)	(1.200)	(-1.260)	(-1.273)
PV_t^s	-	0.010	-	0.008
		(0.757)		(0.988)
π_{t-1}	0.515	0.535	0.310	0.246
	(6.826)	(3.448)	(1.932)	(1.145)
$E_t[\pi_{t+1}]$	0.574	0.546	0.829	0.901
	(5.812)	(4.087)	(5.343)	(4.192)
b	-	0.706	-	1
Adj R^2	0.611	0.586	0.689	0.661
J-stat	1.414	1.378	2.668	2.347
p-value	0.842	0.711	0.751	0.672

Notes: Parentheses are for t-statistics.