

Search with Wage Posting under Sticky Prices

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Abstract

This paper studies the interaction between nominal rigidities, labor market frictions, and consumption risk in a model where firms face sticky prices and post wage contracts to attract risk averse workers in a frictional labor market. Comparing different versions of the model—with independent individuals versus a representative household, and a single firm subject to both pricing and labor frictions versus a wholesaler-retailer structure that separates the frictions—highlights how each channel affects economic outcomes. The model with independent individuals and firms subject to both frictions matches key moments, and leads to empirically consistent implications for labor market policies like extending unemployment benefits. Integrating these frictions implies a greater quantitative role for persistently below-target inflation. More generally, integrating these frictions mutes the response of inflation to shocks, while increases the response of real variables.

Keywords: Search, Matching, Inflation, Sticky Prices, Heterogeneity, Incomplete markets

JEL: E10, E30, E50, J60.

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1 Introduction

In the decade since the Great Recession, labor market growth has at times seemed puzzling. In the early stages of the expansion, they recovered at a relatively anemic rate, with unemployment remaining high even years after the recession ended. As the expansion progressed and the unemployment rate fell, lack of wage pressure cast doubt on the degree of labor-market slack despite low unemployment rates not seen since the 1960s. This lack of wage pressure also fed into concerns about the relative distribution of gains from the recovery. Throughout these times, inflation remained low but relatively stable, apparently showing little sensitivity to the degree of slack in labor markets.

These features of the expansion point to several issues for understanding labor markets and inflation. Early on, producers facing weak demand seemingly responded by lowering labor demand rather than lowering prices—in part due to nominal rigidities—leading to higher unemployment and lower earnings for the employed, which in turn further weakened aggregate demand. Later, a tightening labor market continued without much higher wages—possibly due to a lack of workers’ bargaining power—containing producer costs and allowing them to refrain from price increases. Throughout, the lack of risk-sharing across individuals meant that those who remained unemployed couldn’t equally share in the economy’s growing consumption levels.

Motivated by these arguments, this paper explores the macroeconomic implications of unified pricing, labor demand, and imperfect risk sharing in a model with sticky prices, search frictions in the labor market, and risk averse workers. To that end, it studies a set of New Keynesian models that differ in how price setting frictions and hiring decisions interact for firms, and how individuals or households interact with each other to make consumption and labor decisions.

More specifically, the paper investigates combinations of two alternative environments for households or individuals, as well as two on the production side of the economy. On the household side, in one setup independent individuals (II) make their own choices, and in the second a representative household (RH) exists. On the production side, in one setup matched worker-firms (MWF) have firms that make pricing decisions and post take-it-or-leave-it contracts to hire workers, and in the second the contracting and pricing decisions are separated into wholesale and retail firms (WR), respectively. These features illustrate the implications for how different assumptions on household consumption behavior and firm decisions on pricing and hiring matter for understanding macroeconomic dynamics.

A key message from the analysis is that separating pricing and hiring frictions and consumption motives matters greatly even in a parsimonious framework. Broadly speaking, the combination of independent individuals (II) paired with a firm with integrated pricing and labor market frictions (MWF) performs the best; this type of model matches key labor market moments, has policy implications consistent with empirical evidence, and shows responses to shocks that rationalize recent history. The comparison of frameworks then allows for a clear investigation of the channels that produce these conclusions.

For example, how the economy responds to changes in the level of unemployment benefits, or the costs of persistently low inflation depends greatly on the environment firms operate in and less on the specifics of the household side. When hiring firms also face sticky prices (MWF), increases in unemployment benefits lead to higher average wages, lower vacancy posting, and as a result higher unemployment and lower output. These observations are consistent with the empirical work of [Hagedorn et al. \(2013\)](#), which focuses on the extension of unemployment benefits during the Great Recession. In contrast, separating pricing and hiring frictions (WR) leads to virtually no change in response to changes in unemployment benefits. Similarly, if inflation is persistently below the explicit inflation target, firms facing pricing frictions and labor frictions (MWF) respond with a larger change in labor demand than when the frictions are separated (WR), leading to more substantial losses from low inflation.

In contrast, both the assumptions on the firm and household matter in subtle ways for understanding the propagation of technology or monetary policy shocks. In response to technology shocks, the responses of vacancies and unemployment are larger with a representative household (RH) than with independent individuals (II). This result holds regardless of the assumptions on the firm side. However, the responses of output, inflation, and interest rates depend both on the firm and household side assumptions. In response to monetary shocks, the response of interest rates is particularly sensitive to the assumptions on the firm side and less on the household side.

The alternative models studied in this paper draw mainly on the literature for New Keynesian models with frictional labor markets. The wholesaler-retailer environment is well-known, having been studied by, for example, [Walsh \(2005\)](#), [Trigari \(2006\)](#), [Svein and Weinke \(2008\)](#), and [Christiano et al. \(2016\)](#), among many others. On the other hand, [Kuester \(2010\)](#), [Barnichon \(2010\)](#), [Thomas \(2011\)](#), and [Lago Alves \(2018\)](#) study environments where firms face trade-offs from both pricing and hiring frictions.¹ This paper facilitates comparisons between the alternative models

¹Evidence presented by [Klenow and Malin \(2010\)](#) suggest strong linkages between pricing and hiring decisions.

by assuming firms post take-it-or-leave-it contracts. From an analytical standpoint, this contract ensures that all workers are offered their value of unemployment, which is independent of the firm's product price, and consequently independent of whether the firm is a price-setter or price-taker. Hence, comparing allocations across models is transparent as they solely reflect changes in firm hiring behavior. By contrast, if wages were determined by Nash bargaining, the two models would trivially produce different allocations as hiring firms and workers would be splitting a surplus that varies based on the economy's structure.² From an empirical standpoint, survey evidence from [Hall and Krueger \(2012\)](#) suggests take-it-or-leave-it offers are common in the U.S. labor market. For example, they find that only about a third of all workers bargained over pay with their current employer, the remainder presumably considering their job offers to be take-it-or-leave-it. Additionally, among those who did not bargain, 40 percent had precise knowledge about pay when they first met with their employer, a sign of wage posting.³ Further, as noted, the expansion after the Great Recession had muted wage pressures despite very low unemployment rates, suggesting a lack of worker bargaining power.

By considering environments with independent individuals versus a representative household, the paper also relates to the rapidly growing literature on heterogeneous agent New Keynesian models such as [Gornemann et al. \(2016\)](#), [Ravn and Sterk \(2016\)](#), and [Kaplan et al. \(2018\)](#), among others. An additional by-product of wage posting is tractability on the individual side. In combination with the assumed preferences that eliminate the wealth effect on labor supply, wage posting eliminates the need to keep track of the distribution of wealth, as workers who are indifferent across employment states do not save in equilibrium. A direct consequence is that solving the household problem does not require approximation techniques like those of [Krusell and Smith \(1998\)](#). As a result, the paper can pursue a transparent investigation of the implications of a representative household structure while keeping the contracting environment and production side of the economy unchanged.

The remainder of the paper is as follows. Section 2 describes the model environments, focusing on the contrasting assumptions for the household or individuals, plus the firms and whether there is a wholesaler-retailer structure or not. Section 3 considers the calibration and compares how models perform against a key moment from the data. Section 4 shows how the implications for

²An additional possibility is, in the presence of multi-worker firms, firms would use over-hiring to strategically reduce wages (see [Dossche et al., 2019](#)).

³It is worth highlighting that these are average figures and there is significant heterogeneity in contractual arrangements. For example, bargaining is more common among the college educated and less likely for those without a high school diploma. Recent job losers and blue collar workers are also less likely to bargain over pay.

policy—either unemployment benefits or below-target inflation—greatly depend on the environment. Section 5 highlights the differences in response to shocks, and Section 6 concludes.

2 The Models

This section presents the models, which are variants of a conventional New Keynesian monetary framework with frictional employment. The household side considers two separate environments: one in which independent individuals (II) operate, and one in which a representative household (RH) makes decisions at the household level. On the production side, there are also two separate environments: one in which matched worker-firm (MWF) pairs persist over time and thus integrate the hiring and price-setting frictions into a single firm, and one in which a wholesaler-retailer (WR) splits these frictions into two separate entities.

The following subsections describe the model: the households that are either II or RH, production that takes place by firms that are either MWF or WR, the evolution of the labor market, followed by policy and market clearing conditions.⁴

2.1 Two Versions of the Household

The two versions of the household, with independent individuals or a representative household, highlight the importance of bundling the consumption, savings, and labor decisions at the household level versus individuals. Each version has a household sector that consumes, saves, supplies labor, and receives compensation for labor. In the independent individual version, each individual undertakes these choices independently. In the representative household version, the decisions are taken at the aggregate level. Importantly, assumptions about preferences and the contracting environment imply that workers receive identical forms of the contract across models, leading to a clear comparison between the two.

2.1.1 Independent Individuals (II)

In this setup, there is a unit mass of individuals, indexed by $i \in [0, 1]$, which have [Greenwood et al. \(1988\)](#) preferences over consumption $c_{i,t}$ and hours worked $h_{i,t}$ of the form

$$U(c_{i,t}, h_{i,t}) = \frac{\left(c_{i,t} - \varphi h_{i,t}^{1+1/\psi}\right)^{1-\gamma} - 1}{1 - \gamma}, \quad (1)$$

⁴A full set of derivations is in the online-only Technical Appendix.

where γ is the constant of relative risk aversion, φ is the disutility of labor, and ψ is the Frisch elasticity of labor supply. Individuals discount future utility by a factor β .

The use of [Greenwood et al. \(1988\)](#) preferences, which eliminate any wealth effect on the labor supply, provides multiple benefits in the current framework. First, it greatly simplifies the contractual environment, as the presence of wealth effects on labor supply would imply that firms would vary their wage offering depending upon the wealth of the worker. Wealth effects on labor supply would also counterfactually imply asset-rich individuals preferring unemployment over employment.⁵ Second, along with the assumption on the contracting environment, the preferences eliminate the need for a perfect consumption insurance assumption typical in New Keynesian models with search (for example, [Walsh, 2005](#); [Sveen and Weinke, 2008](#); [Kuester, 2010](#); [Thomas, 2011](#)). In those models, unemployed individuals are better off compared to employed individuals, as both enjoy the same level of consumption while the former also enjoy leisure.⁶ In contrast, the current preference and contractual specification implies that unemployed individuals are no better off than employed individuals.

Individuals purchase consumption goods at price P_t and buy nominal bonds B_t which have gross return R_t in period $t + 1$. They also own shares in a mutual fund that owns all other firms in the economy; the mutual fund pays real dividends D_t .⁷ Finally, they pay real lump sum taxes equal to T_t .

The employment status $n_{i,t}$ of each individual varies between being unemployed ($n_{i,t} = u$) and employed ($n_{i,t} = e$). In each period a fraction n_t of individuals are employed, and $u_t = 1 - n_t$ are unemployed.⁸

Unemployed individuals work zero hours ($h_{i,t}^u = 0$), collect real unemployment benefits from the government equalling b , and search for employment the subsequent period, which occurs in equilibrium with probability s_t . If \mathbb{E}_t denotes the expectations operator conditional on time t

⁵ In contrast, [Mustre-del-Río \(2015\)](#) finds that for prime age males employment is roughly flat with household wealth.

⁶ See [Rogerson and Wright \(1988\)](#) for a related analysis.

⁷ Given symmetric initial conditions, in equilibrium all individuals own equal shares in the mutual fund and no trading occurs, so this result is imposed from the outset for simplicity. The online-only appendix shows derivations including a market for mutual fund shares.

⁸ For simplicity, the model abstracts from the participation decision and assumes all non-employed individuals actively search for employment.

information, an unemployed worker's problem is therefore

$$W_{i,t}^u = \max_{c_{i,t}^u, B_{i,t}^u} \left\{ \frac{(c_{i,t}^u)^{1-\gamma} - 1}{1-\gamma} + \beta \mathbb{E}_t [s_t W_{i,t+1}^e + (1-s_t) W_{i,t+1}^u] \right\} \quad (2)$$

subject to

$$c_{i,t}^u + \frac{B_{i,t}^u}{P_t} + T_t = b + \frac{R_{t-1} B_{i,t-1}}{P_t} + D_t. \quad (3)$$

Employed workers, on the other hand, work positive hours $h_{i,t}$ and are paid a real compensation level $\omega_{i,t}$. Their existing job ends with exogenous probability δ , in which case they enter unemployment the following period, and with probability $(1-\delta)$ they remain employed. An employed worker's problem is therefore

$$W_{i,t}^e = \max_{c_{i,t}^e, B_{i,t}^e} \left\{ \frac{(c_{i,t}^e - \varphi h_{i,t}^{1+1/\psi})^{1-\gamma} - 1}{1-\gamma} + \beta \mathbb{E}_t [(1-\delta) W_{i,t+1}^e + \delta W_{i,t+1}^u] \right\} \quad (4)$$

subject to

$$c_{i,t}^e + \frac{B_{i,t}^e}{P_t} + T_t = \omega_{i,t} + \frac{R_{t-1} B_{i,t-1}}{P_t} + D_t. \quad (5)$$

Note that employed workers do not choose $h_{i,t}$, as hours are determined within the contracting environment with the firm.

Standard optimality conditions yield Euler equations for the unemployed and employed

$$\lambda_{i,t}^u = \beta \mathbb{E}_t \left[\frac{s_t \lambda_{i,t+1}^e + (1-s_t) \lambda_{i,t+1}^u}{\Pi_{t+1}} \right] R_t, \text{ and } \lambda_{i,t}^e = \beta \mathbb{E}_t \left[\frac{(1-\delta) \lambda_{i,t+1}^e + \delta \lambda_{i,t+1}^u}{\Pi_{t+1}} \right] R_t, \quad (6)$$

respectively, where $\Pi_{t+1} = P_{t+1}/P_t$ is the gross inflation rate. The marginal utilities of consumption for the unemployed and employed are given by

$$\lambda_{i,t}^u = (c_{i,t}^u)^{-\gamma}, \text{ and } \lambda_{i,t}^e = (c_{i,t}^e - \varphi h_{i,t}^{1+1/\psi})^{-\gamma}, \quad (7)$$

respectively.

Workers receive take-it-or-leave-it contract offers from their matched firms. Given symmetric initial conditions on bond-holdings, the optimal contract equalizes the value of employment $W_{i,t}^e$

and unemployment $W_{i,t}^u$, which implies

$$\omega_{i,t} = b + \varphi h_{i,t}^{1+1/\psi}. \quad (8)$$

As a result of the assumed preferences and contract, in equilibrium, the marginal utilities of consumption are symmetric across employment states: $\lambda_t = \lambda_{i,t}^u = \lambda_{i,t}^e$.

2.1.2 Representative Household (RH)

In the second setup for the household, consider a framework where a representative household has preferences from [Greenwood et al. \(1988\)](#), and makes all consumption and labor decisions at the household level. Keeping all other aspects unchanged, this model implies the same contract as the II model, but with the household making the consumption and labor decisions.

In this version of the problem, the household enters the period with n_t of its members employed, and has a value function given by

$$V_t(n_t) = \frac{\left(C_t - \varphi \int_0^{n_t} h_{i,t}^{1+1/\psi} di\right)^{1-\gamma} - 1}{1-\gamma} + \beta \mathbb{E}_t V_{t+1}(n_{t+1}). \quad (9)$$

Since the household pools all income to choose aggregate consumption and bond holdings, it faces the budget constraint

$$C_t + \frac{B_t}{P_t} + T_t = b(1 - n_t) + \int_0^{n_t} \omega_{i,t} di + \frac{R_{t-1} B_{t-1}}{P_t} + D_t. \quad (10)$$

Standard optimality conditions show that the marginal utility of consumption is now

$$\lambda_t = \left(C_t - \varphi \int_0^{n_t} h_{i,t}^{1+1/\psi} di\right)^{-\gamma}, \quad (11)$$

while the optimal choice of bonds—which end up being in zero net supply—is given by

$$\beta \mathbb{E} \frac{\lambda_{t+1}}{\lambda_t} \frac{R_t}{\Pi_{t+1}} = 1. \quad (12)$$

In this setup, the marginal utility of consumption differs due to the fact that the household is aggregating income to make consumption and savings decisions. As a result, the stochastic discount factor used by firms and the relationship between expected inflation and the nominal interest rate

depend on the household's decisions.

All employed workers in the household receive wage posting offers from their firms in the period. The benefit to the household of having the n_t -th worker employed is given by the envelope condition of (9) with respect to n_t :

$$V_n(n_t) = -\varphi h_{n,t}^{1+1/\psi} \lambda_t + (\omega_{n,t} - b) \lambda_t + [(1 - \delta) - s_t] \beta \mathbb{E}_t V_{n,t+1}(n_{t+1}). \quad (13)$$

The first term is the loss in utility to the household due to one of its workers providing additional hours, the second term is the gain in utility for receiving compensation rather than unemployment benefits, and the third term is the expected future benefit of having an employed worker rather than an unemployed one.

When receiving wage offers, the household treats all workers as symmetric. Equivalently, the take-it-or-leave-it assumption implies that firms will give wage offers that make the above envelope condition equal to zero for all i in $[0, n_t]$. In other words, for any employment level, the contract makes the household indifferent at the margin between having one more worker employed or not. As a result, the optimal contract for all workers is identical to that in the II problem

$$\omega_{i,t} = b + \varphi h_{i,t}^{1+1/\psi}. \quad (14)$$

2.1.3 Discussion

Despite differences in the environments, both the II and RH setups have identical forms of the optimal contract. When firms make take-it-or-leave-it offers to workers, the contract makes compensation solely dependent on hours worked and independent of aggregate labor market tightness. Thus, cyclical variation in compensation is solely due to changes in labor demand through hours worked $h_{i,t}$. As a result, differences depend upon the structure of the production side of the economy, how hours are set, and whether or not there is a close link to the setting of prices.

However, how the optimal compensation contract translates into utility differs notably across the II and RH environments. By aggregating consumption and income and making decisions at the household level, the RH framework does not guarantee that all workers (individually) are at least as well off as the unemployed. Indeed, at a point in time, some workers may be working more than they would like given the consumption they receive. By contrast, the II allocation naturally mimics that achieved by a household that runs employment lotteries (Hansen (1985), Rogerson (1988)), and

Rogerson and Wright (1988)), since differences in consumption are offset by differences in hours worked in order to make all individuals indifferent between employed and unemployed states.

2.2 Two Versions of Intermediate Good Production

The two versions of the production sector, with matched worker-firms or a wholesaler-retailer structure, show the relevance of integrating price-setting and search frictions within one firm versus separating. Each version has a final goods producer that combines differentiated products into a bundle, which it sells to consumers. In the matched worker-firm environment, firms hire workers to produce, and sell their output to the final good producer subject to sticky prices. In the wholesaler-retailer environment, by contrast, wholesalers hire workers to produce and sell their wholesale good, who then sell repackaged wholesale goods to final goods producers, subject to sticky prices.

2.2.1 Matched Worker-Firm (MWF)

The first structure integrates the pricing and labor market frictions into a single entities. Specifically, in this matched worker-firm environment, firms hire in a frictional labor market, and when matched with a worker, sell their output subject to sticky prices. As a result, the firm internalizes the effects of each friction on both decisions. For example, the firm takes into account the stickiness of prices when making hiring and contracting decisions.

Demand arises from final good producers, which operate competitively, purchasing $Y_{j,t}$ from $j \in [0, n_t]$ operating intermediate goods firms and combining them into final output Y_t using a technology with constant elasticity of substitution ϵ :

$$Y_t = n_t \left(\frac{1}{n_t} \int_0^{n_t} Y_{j,t}^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}. \quad (15)$$

Standard cost minimization implies that the demand for each intermediate good $Y_{j,t}^d$ depends on its relative price according to

$$Y_{j,t}^d = \left(\frac{P_{j,t}}{P_t} \right)^{-\epsilon} \frac{Y_t}{n_t}. \quad (16)$$

The aggregate price level is related to individual prices by

$$P_t^{1-\epsilon} = \frac{1}{n_t} \int_0^{n_t} P_{j,t}^{1-\epsilon} dj. \quad (17)$$

Intermediate goods firms are indexed by j , and produce using a linear technology

$$Y_{j,t}^s = Z_t h_{j,t}, \quad (18)$$

where $h_{j,t}$ is hours at firm j and productivity Z_t follows

$$\log Z_t = \rho_z \log Z_{t-1} + \sigma_z \varepsilon_{z,t}. \quad (19)$$

Firms sell their output at price $P_{j,t}$ and are subject to a Calvo friction when setting prices. Firms employ a single worker; conditional on being matched with a worker the firm negotiates a contract $\Upsilon_{j,t} = (\omega_{j,t}, h_{j,t})$ that determines a compensation level $\omega_{j,t}$ and an hours requirement $h_{j,t}$. Firms face a two-stage problem: in the first stage they set prices and in the second stage they contract with labor and produce.

In the second stage, given a price $P_{j,t}$, firms make a take-it-or-leave-it offer to their worker. They choose a contract $\Upsilon_{j,t}$ to maximize current period profits subject to their demand (16), the constraint that they must meet demand at the posted price $Y_{j,t}^s \geq Y_{j,t}^d$, and the worker's participation constraint. As noted, regardless of whether the household sector is independent individuals or a representative household, the optimal contract satisfies

$$\omega_{j,t} = b + \varphi h_{j,t}^{1+1/\psi}. \quad (20)$$

Given the optimal contract, in the first stage a matched firm can re-optimize its price subject to a Calvo friction. The value of an operating firm with price $P_{j,t}$ is given by

$$J_t(P_{j,t}) = \left(\frac{P_{j,t}}{P_t} \right) Y_{j,t}^d - \omega_{j,t} + \beta (1 - \delta) \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} [\zeta J_{t+1}(P_{j,t}) + (1 - \zeta) J_{t+1}(P_{t+1}^*)], \quad (21)$$

where $\beta \frac{\lambda_{t+1}}{\lambda_t}$ denotes the stochastic discount factor, ζ the probability of not re-optimizing prices, and P_t^* denotes the optimal price set by a firm that can re-optimize at time t . Since the optimal compensation scheme depends on hours, and firms must meet demand at the posted price, the

value is given by

$$J_t(P_{j,t}) = \left(\frac{P_{j,t}}{P_t}\right)^{1-\epsilon} \frac{Y_t}{n_t} - b - \varphi \left(\left(\frac{P_{j,t}}{P_t}\right)^{-\epsilon} \frac{Y_t}{Z_t n_t} \right)^{1+1/\psi} + \beta(1-\delta) \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} [\zeta J_{t+1}(P_{j,t}) + (1-\zeta) J_{t+1}(P_{t+1}^*)]. \quad (22)$$

This expression makes explicit the fact that prices, by pinning down demand, consequently pin down hours, and hence total compensation, through the relationship

$$h_{j,t} = \left(\frac{P_{j,t}}{P_t}\right)^{-\epsilon} \frac{Y_t}{Z_t n_t}. \quad (23)$$

A firm that can re-optimize prices, hence, takes this dependence of hours and compensation on the relative price, with the optimal reset price P_t^* satisfying

$$\mathbb{E}_t \left[\sum_{k=0}^{\infty} (\beta\zeta(1-\delta))^k \frac{\lambda_{t+k}}{\lambda_t} \left\{ (1-\epsilon) \left(\frac{P_t^*}{P_{t+k}}\right)^{1-\epsilon} \frac{Y_{t+k}}{n_{t+k}} + \epsilon \left(1 + \frac{1}{\psi}\right) \varphi(h_{t+k}^*)^{1+\frac{1}{\psi}} \right\} \right] = 0, \quad (24)$$

where $h_{t+k}^* = \left(\frac{P_t^*}{P_{t+k}}\right)^{-\epsilon} \frac{Y_{t+k}}{Z_{t+k} n_{t+k}}$, represents the optimal hours choice at time $t+k$ given a reset price P_t^* . This optimal reset equation is similar to that found in typical Calvo price-setting environments. However, in the current environment the firm's marginal cost is the marginal compensation paid to the worker it is matched with, which in turn depends on the evolution of the firm's relative price. Thus, while a high relative price in the future lowers demand, the firm can reduce costs by decreasing hours worked, and hence compensation, from the matched worker.

Firms post vacancies at cost κ , which are filled with probability q_t and become productive the following period. At the beginning of $t+1$ price adjustment occurs, then contracting and production. New entrants inherit a price level in period t equal to the aggregate price level ($P_{j,t} = P_t$), and receive a Calvo shock before production in $t+1$.⁹ Because of free entry, firms post vacancies until the vacancy posting cost equals the expected return, which implies

$$\kappa = q_t \beta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} [\zeta J_{t+1}(P_t) + (1-\zeta) J_{t+1}(P_{t+1}^*)]. \quad (25)$$

⁹An alternative assumption where entrants always optimally set prices would generate slightly different dynamics between employment and inflation, and in fact might lead to larger differences between the models considered. However, that assumption would also lead to a different evolution of the price level than in standard New Keynesian models and those with labor search (for example, [Kuester, 2010](#)).

This expression highlights how expectations of future price-setting behavior affect the incentive to enter the market and hence vacancy creation.

2.2.2 Wholesaler-Retailer (WR)

The second setup is a wholesaler-retailer environment, which isolates the effects of allowing pricing and labor market frictions to interact within the firm. In this version, wholesale producers hire labor in the frictional labor market using wage posting and produce a competitively priced good. Monopolistically competitive retail firms face Calvo price frictions and purchase the wholesale good and convert it into a differentiated good.

As in the MWF model, demand stems from competitive final good producers, purchasing $Y_{j,t}$ from $j \in [0, 1]$ retailers and combining into final output Y_t using a CES technology. Since there are a constant unitary mass of retailers, the equations characterizing behavior are the same as with MWF, (15), (16), and (17), except with $n_t = 1$.

Focusing on the wholesaler problem, they operate a linear technology as in equation (18) to produce a wholesale good Y_t^w , taking the price of the wholesale good P_t^w as given. Again, regardless of the household sector being independent individuals or a representative household, wholesalers face a contracting environment that produce an optimal contract of

$$\omega_t = b + \varphi h_t^{1+1/\psi}. \quad (26)$$

A key difference of this model relative to the MWF version is that, since the wholesaler is a perfectly competitive firm with symmetry, all employed workers have identical contracts $\Upsilon_t = (\omega_t, h_t)$.¹⁰ Given this contract, wholesalers choose hours to maximize

$$J_t = \max_{h_t} \frac{P_t^w}{P_t} Z_t h_t - b - \varphi h_t^{1+1/\psi} + \beta(1 - \delta) \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} J_{t+1}. \quad (27)$$

The first-order condition with respect to hours implies that hours depend on the relative price of wholesale goods and the level of technology by

$$h_t = \left(\frac{\frac{P_t^w}{P_t} Z_t}{\varphi(1 + 1/\psi)} \right)^\psi. \quad (28)$$

Comparing this expression to equation (23) under the MWF model reveals important differences

¹⁰Given symmetry of the wholesale firms in this environment, the subscript j is omitted for simplicity.

across the two models. In the MWF model, hiring firms are price setters and demand for their differentiated good is decreasing in their relative price, so are hours worked. In contrast, in the WR model, hiring firms are price takers and because supply for their good is increasing in the relative price of wholesale goods, so are hours worked. In partial equilibrium, technology shocks also have differential effects on hours worked across models. In the MWF model, because output is pinned down given relative prices, any increase in productivity is labor saving and hence hours worked fall. In contrast, in the WR model an increase in productivity increases hours since each existing employment match is more valuable given prices.

Next, under the WR model the free-entry condition takes the usual form

$$\kappa = q_t \beta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} J_{t+1}. \quad (29)$$

Comparing this equation to (25), the free entry condition under the MWF model, highlights that frictions related to price adjustment do not directly affect vacancy creation in the WR model, while they have a direct impact in the MWF model.

To close the WR model, retailers face a standard problem summarized by the optimal reset price condition

$$\mathbb{E}_t \left[\sum_{k=0}^{\infty} (\beta \zeta)^k \frac{\lambda_{t+k}}{\lambda_t} \left\{ (1 - \epsilon) \left(\frac{P_t^*}{P_{t+k}} \right) + \epsilon \left(1 + \frac{1}{\psi} \right) \varphi \frac{h_{t+k}^{1/\psi}}{Z_{t+k}} \right\} Y_{t+k}^d \left(\frac{P_t^*}{P_{t+k}} \right)^{-\epsilon} \right] = 0, \quad (30)$$

where the expression uses the fact that marginal costs, dependent on P_t^w , can be written as a function of hours using equation (28).

2.2.3 Discussion

There are two important differences between the optimal reset price equations in the WR model (30) and the MWF model (24). First, in the MWF model, because intermediate firms face pricing and labor market frictions, they discount future revenues both by the expected duration of the current price, which depends on ζ , and the expected duration of the current match, which depends on δ . In contrast, in the WR model, retail firms do not care about match duration when setting their prices. Second and more importantly, marginal costs are notably different across the two models. In the WR model, marginal costs depend on the relative price of wholesale goods. This price in turn is related to the marginal disutility of work at h_t , which is common to all workers and

determined in general equilibrium and thus not directly dependent on the firm's chosen relative price. In contrast, in the MWF model marginal costs depend on the marginal disutility of hours worked for the matched worker h_{jt} , which—rather than being dependent solely on general equilibrium outcomes—depend critically on the firm's relative price. As a consequence, in the MWF model, price-setting firms directly consider the impact that pricing decisions have on future hours demanded and hence marginal costs, while no such trade-off exists for price-setting firms in the WR model.

2.3 Vacancy Posting and the Labor Market

Matches m_t depend upon the number of unemployed u_t workers and the number of vacancies v_t according to

$$m_t = \sigma_m u_t^\alpha v_t^{1-\alpha}, \quad (31)$$

where σ_m governs the efficiency of the matching function, and α is the elasticity of matches with respect to the number of unemployed workers. The job filling rate is $q_t = m_t/v_t$, while the job finding rate is $s_t = m_t/u_t$. New matches take one period to form, and existing matches are destroyed at an exogenous rate δ . Consequently, employment evolves according to

$$n_t = (1 - \delta) n_{t-1} + m_{t-1}. \quad (32)$$

Figure 1 shows the timing of the model.

2.4 Policy and Market Clearing

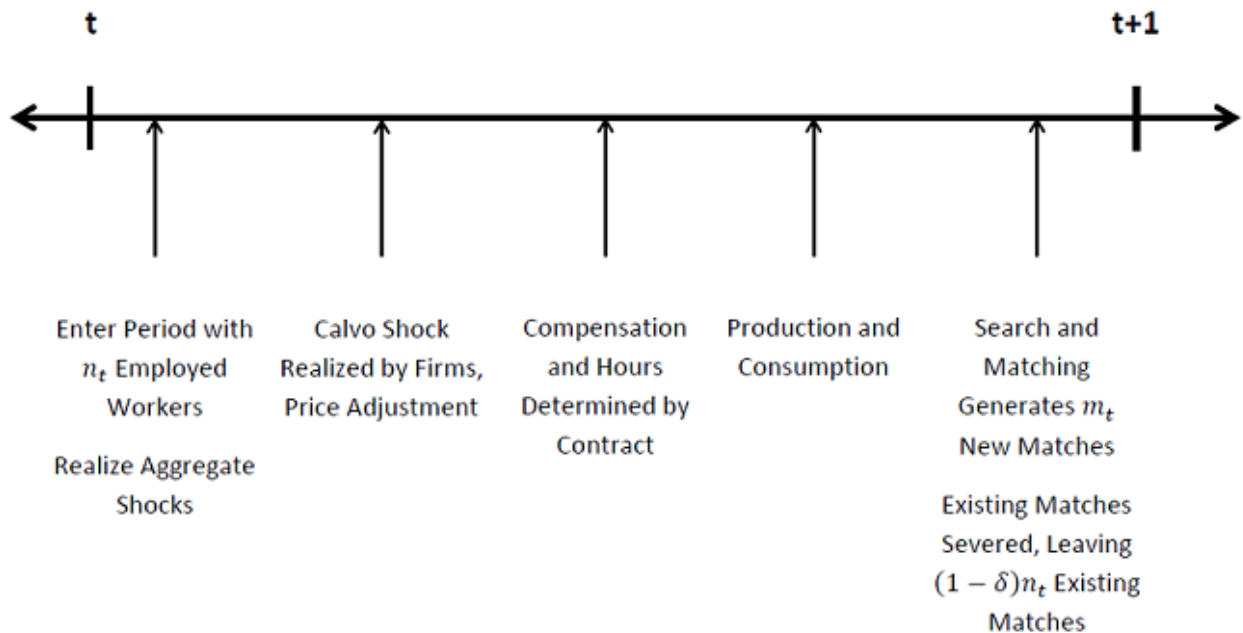
Monetary policy follows a Taylor Rule, setting the nominal rate R_t according to

$$\frac{R_t}{R_{ss}} = \left(\frac{R_{t-1}}{R_{ss}} \right)^{\rho_r} \left(\frac{\Pi_t}{\Pi_{ss}} \right)^{(1-\rho_r)\gamma_\pi} \exp(\sigma_r \varepsilon_{r,t}), \quad (33)$$

where Π_{ss} indicates the inflation target, R_{ss} the nominal rate target, ρ_r the degree of interest rate persistence, γ_π the response to inflation, and $\varepsilon_{r,t}$ denotes a monetary policy shock.

Fiscal policy adjusts lump sum taxes to balance the budget, and since its only payments are unemployment benefits b , then $u_t b = T_t$. Market clearing requires that aggregate output equals aggregate consumption $Y_t = C_t$.

Figure 1: Timing of the Model



3 Calibration and Moment Matching

Having laid out the models in Section 2, this section now turns to calibration. The four model variants considered (II-MWF, II-WR, RH-MWF, and RH-WR), have many common elements but a few slight differences to consider when choosing parameters. The calibration strategy thus takes three steps. In the first step, a number of parameters that are common across models are chosen based on typical values in the literature. In the second step, some key labor market parameters are chosen, possibly differently across models, to match certain steady state targets. Finally, the third step is to calibrate the level of unemployment benefits b differently across models to match wage and hours data in the US economy.

Table 1 lists the first set of parameters, which are fixed at standard values. Assuming the model period is a quarter, the discount factor β is set to imply a steady state real interest rate of 2%. The coefficient of risk aversion γ is set to 2 as is standard in the literature, while the Frisch elasticity of labor supply on the intensive margin ψ is set to 0.5 as suggested by Chetty et al. (2011). The probability of not re-optimizing prices ζ is set to match a median price duration of six months as reported in Bils and Klenow (2004). Following Gertler et al. (2008), the elasticity of substitution across goods is $\epsilon = 10$, which implies a steady state markup of 11%. Consistent with empirical estimates in Shimer (2005) and den Haan et al. (2000), the quarterly separation rate is 10 percent.

Table 1: Standard Calibrated Parameters

Parameter	Description	Value
β	Discount factor	0.9951
γ	Risk aversion	2
ψ	Frisch elasticity	0.5
ζ	Prob. not re-optimizing prices	0.66
ϵ	Elasticity of substitution	10
δ	Separation rate	0.1
α	Matching function elasticity	0.5
Π_{ss}	Inflation target (pp, annualized)	2.0
ρ_r	Policy persistence	0.6
γ_π	Response to inflation	1.5
ρ_z	Technology persistence	0.95
σ_r	Std Dev MP shock	0.0025
σ_z	Std Dev technology shock	0.007

The elasticity of the matching function with respect to unemployment α is set to 0.5, which is the midpoint of values typically cited in the literature. Lastly, the parameters governing shocks and monetary policy are also set to standard values.

Panel A of Table 2 lists the parameters calibrated to match steady state values, and how these differ across models. The disutility of hours worked φ is such that steady state hours worked per employed person equals 1/3. Given that preferences have identical forms across models, this target implies $\varphi = 2.7$ for each model. Following [Blanchard and Diamond \(1990\)](#), the targeted steady state unemployment rate is 11 percent, which includes both individuals who are categorized as unemployed and those out of the labor force who want a job. Following [den Haan et al. \(2000\)](#), the steady state worker finding rate is 70 percent. These assumptions directly pin down the matching efficiency parameter σ_m . Again, since the matching function and evolution of employment are identical across models, this produces $\sigma_m = 0.7526$. Given the calibration and targets, the vacancy posting cost κ is implied from the steady state free-entry condition in each model, and these differ across models due to differences in unemployment benefits b .

The calibration of the unemployment benefits b requires a relative level, in this case the steady state replacement ratio, which is defined as the ratio of unemployment benefits divided by the average compensation per worker in steady state. There are a wide range of values in the literature, as [Shimer \(2005\)](#) considers a value of 0.4 while [Hagedorn and Manovskii \(2008\)](#) consider a value close to one. Rather than choose a value within this range, the replacement ratio is chosen so that the volatility of hourly wages, relative to output, matches US data. Given the form of the optimal

Table 2: Additional Calibrated Parameters and Targets

Panel A: Calibrations and Targets						
Parameter	Description	Target	II-MWF	II-WR	RH-MWF	RH-WR
φ	Disutility of labor	$h_{j,ss} = 1/3$	2.7	2.7	2.7	2.7
σ_m	Matching efficiency	$u_{ss} = 0.11$	0.7526	0.7526	0.7526	0.7526
b/ω_{ss}	SS Replacement Ratio	$\frac{\sigma(w)}{\sigma(Y)} = 0.530$	0.4493	0.7950	0.6220	0.0063
κ	Vacancy posting	$q_{ss} = 0.70$	1.0124	1.2767	0.4589	1.3301

Panel B: Performance of Models						
Moment	Description	US Data	II-MWF	II-WR	RH-MWF	RH-WR
$\frac{\sigma(w)}{\sigma(Y)}$	Rel Vol of Avg Wage	0.530	0.530	0.530	0.530	0.530
$\frac{\sigma(H)}{\sigma(Y)}$	Rel Vol of Agg Hours	0.790	0.7947	0.4445	2.8555	0.3990

contract in the models, the b serves as a fixed cost of hiring a worker, and the variable cost depends upon hours worked. In particular, by acting as a fixed cost in the compensation of a worker, b directly impacts the level of compensation and hence the average wage. On the other hand, b only affects aggregate hours indirectly through both the optimal contract and general equilibrium effects. A higher value of b lowers the volatility of the wage by making a larger portion of the wage a fixed cost regardless of the hours choice. The implied replacement ratios vary significantly across the models, as despite the identical optimal contract, the demand for hours and general equilibrium effects vary significantly across models.

Panel B of Table 2 highlights the abilities of each model to match the volatilities of average hourly wages and aggregate hours.¹¹ These comparisons are not arbitrary, but instead chosen to highlight how the models can match or miss match moments that related frameworks typically have trouble matching (see [Svein and Weinke, 2008](#)). While the models all hit the relative volatility of the average wage by construction, the second, untargeted moment, the relative volatility of aggregate hours, differs substantially across models. The II-MWF model nearly replicates the value in the data, while the II-WR and RH-WR models underpredict the data by about half, and the II-WR has about four times the value in the data.

Relative to the MWF models, the WR models generate lower volatility of aggregate hours given the volatility of average wages. As equation (28) shows, in the WR model, the hours of each worker are completely symmetric, while the MWF model has aggregate hours that are more volatile because each workers' hours inherit additional volatility based on the relative price of the

¹¹The relevant data used are for the non-farm sector, and consist of real output, aggregate hours, and real compensation per hour, all since 1951Q1-2016Q3 and are HP filtered using a smoothing parameter of 1600.

firm. In other words, the MWF model generates more volatility in aggregate hours because it has both cross-sectional and time-series variation in individual hours, whereas the WR model only has the latter.

Comparing the II-MWF and the RH-MWF models, both have cross-sectional and time-series variation in individual hours, but the latter generates slightly too much volatility in aggregate hours. The reasons for this higher volatility are due to indirect general equilibrium effects, rather than direct ones. In particular, the consumption smoothing motive at the household level distorts the stochastic discount factor used by firms in their pricing and entry decisions, which mutes the response of average hours per worker and amplifies the response of employment in response to shocks relative to the II-MWF model. On net, larger swings in employment under the RH model generate higher volatility in aggregate hours than those in the II-MWF model.

4 Comparative Statics: The Effects of Policy

This section turns to the analysis of two different types of policy changes using comparative statics at the steady state of each model. First, motivated by the emergency extension of unemployment benefits during the Great Recession, it examines the aggregate impact of changes in the level of unemployment benefits. Second, motivated by the fact that the US has had inflation below the Federal Reserve's 2 percent target for a majority of the expansion following the Great Recession, it considers how changes in the steady state level of inflation affect economic outcomes.

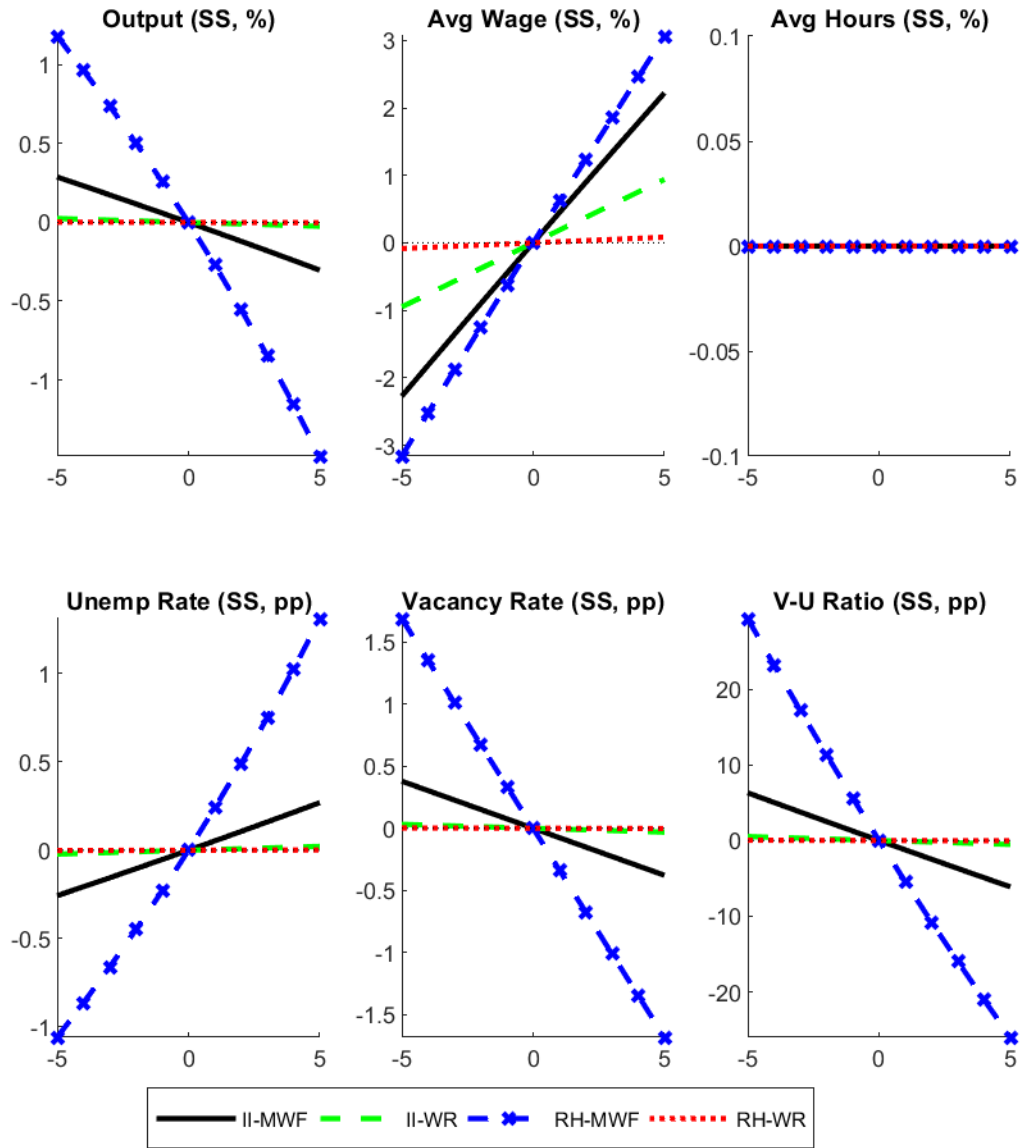
4.1 Unemployment Benefits

The presence of frictional labor markets and a contracting environment where the unemployed receive benefits from the government means that the level of these benefits possibly matters to different extents across models.

Figure 2 shows the effects of increasing or decreasing the level of unemployment benefits b by up to 5 percent across models. As noted in Table 2, the baseline calibration of benefits varies in order to hit a key moment in the US data. An immediate take-away from Figure 2 is that the policy implications from the different modeling frameworks varies significantly.

First, matched worker-firm models exhibit empirically consistent responses to changes in unemployment benefits. Increases in b increase the average wage by increasing the fixed-cost portion of compensation, which lowers vacancies, raises unemployment, and lowers output. These results are

Figure 2: Effects of Unemployment Benefits



Notes: Shows the effects of a $\pm 5\%$ change in unemployment benefits b for models with combinations of independent individuals (II) or a representative household (RH), with matched worker-firms (MWF) or wholesaler-retailers (WR).

consistent with the empirical findings of [Hagedorn et al. \(2013\)](#) regarding the general equilibrium effects of unemployment benefit extensions during the Great Recession. Indeed, they conclude that extending unemployment benefits raised equilibrium wages, which subsequently lead to a contraction in vacancy creation and a rise in unemployment. In the present context, existing firms with pricing power pass the increase in labor costs on to demand by raising prices. As demand

shrinks, this alters the incentives of new firms to post vacancies, which leads to a larger change in unemployment and output.

In contrast, the wholesaler-retailer structure that splits pricing and search frictions into separate firms leads to negligible effects when benefits change. It is still true that changes in benefits affect the fixed-cost part of the compensation contract that wholesaler firms must pay workers. This is particularly salient in the II-WR model where wholesalers still need to leave workers indifferent between employment and unemployment. Since the value of unemployment varies with b , so must wages. Under the RH structure, however, this effect is muted because of risk sharing among employed and unemployed workers in the household. More importantly, however, the pass-through of higher labor costs is fairly limited, since these competitive wholesale firms do not have pricing power. As a result, aggregate quantities like output, vacancies and unemployment barely change.

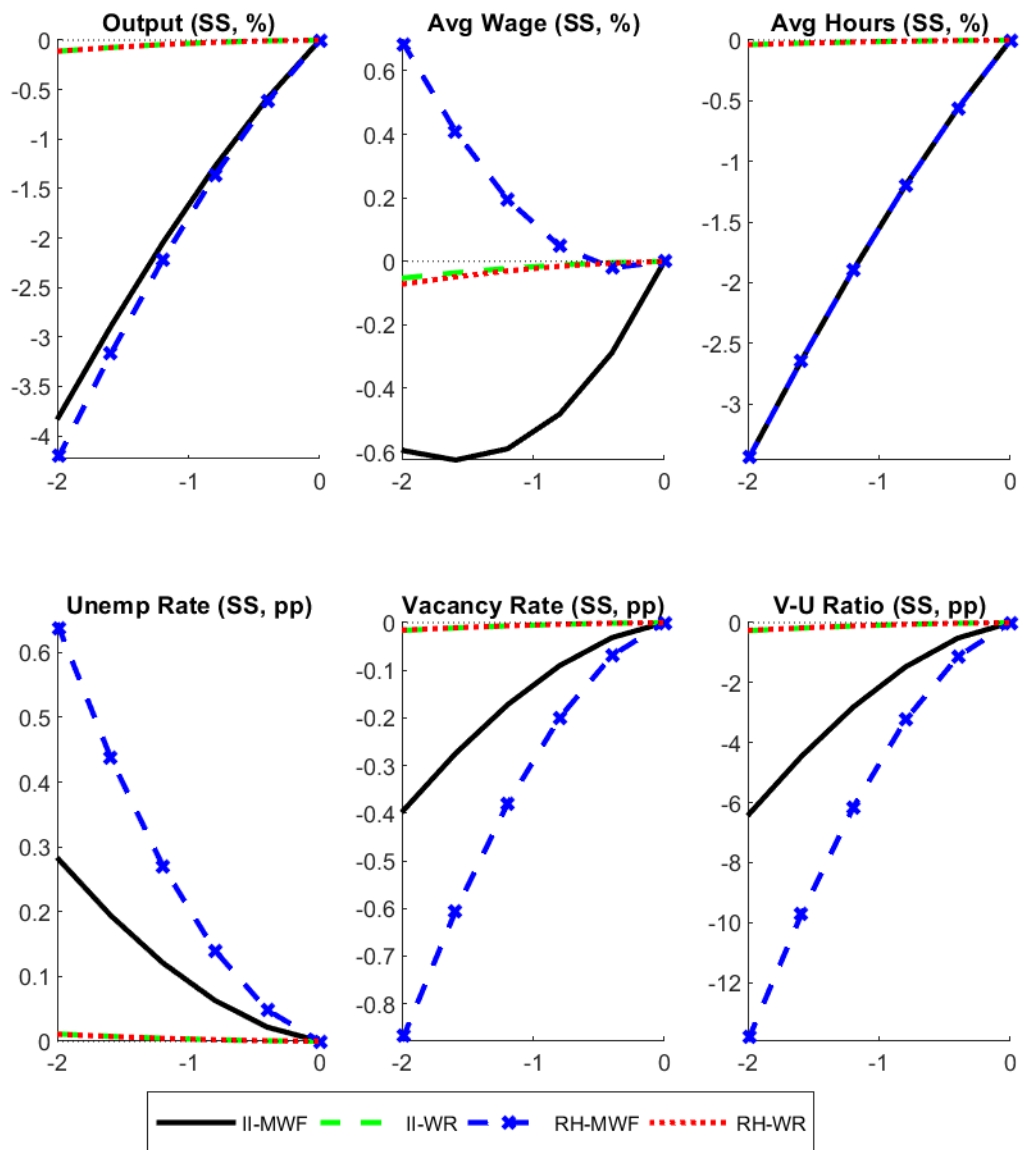
4.2 Persistently Below-Target Inflation

To consider the implications of below-target inflation, Figure 3 shows each economy's reaction to a lower inflation target, keeping fixed the fact that firms index their prices at the baseline calibration of 2 percent annually. As a result, firms that do not re-optimize their prices index them by relatively too much, leading to prices that tend to be too high, which subsequently stifles demand.¹² Overall, the effects of inflation misses mimic the effects of unemployment benefit changes in that the matched worker-firm models have significant responses to lower steady state inflation, while the wholesaler-retailer models do not.

The MWF models once again show much stronger effects in response to the policy change. Lower demand induced by relatively too-high pricing generates less entry by firms and as a result vacancies decline, leading to higher unemployment. This higher unemployment feeds back to lower demand, leading to a further contraction in demand. In total, the decreases in demand lead to much lower output levels. The differences between the representative household (RH) and independent individuals (II) are mostly magnitudes, except for the behavior of average wages. In both models average compensation and average hours fall to partly offset the fall in demand. However, in the II-MWF model the decline in hours relative to compensation is smaller, and so the average hourly rate—the ratio of compensation to hours—falls as well. In contrast, in the RH-MWF model hours fall by more relative to compensation, and so the average hourly rate rises.

¹²The analysis in this section complements [Lago Alves \(2018\)](#), which notes that positive trend inflation can help reconcile the [Shimer \(2005\)](#) puzzle.

Figure 3: Effects of Below-Target Inflation



Notes: Shows the effects of steady state inflation being $2pp - 0pp$ below the baseline level of 2% for models with combinations of independent individuals (II) or a representative household (RH), with matched worker-firms (MWF) or wholesaler-retailers (WR).

Interestingly, the II-MWF model broadly captures the concerns of the expansion in the 2010s. As the economy expanded at a modest pace, inflation remained below the 2 percent target, leading to concerns about lower output and higher labor market slack, along with stagnant wages. The II-MWF model accounts for these observations precisely because price-setting firms internalized lower demand by reducing hiring activity, which further lowers demand and keeps inflation muted.

In contrast to the MWF models, the separation of labor market and pricing frictions in the WR models leads to negligible changes in the economy. Indeed, pricing misses have little effect on the labor market, which subsequently leads to little changes in demand, which reaffirms the non-importance of relatively too-high pricing when inflation is below target. Therefore, as steady state inflation declines, there is little movement in aggregates.

4.3 Discussion

In sum, these results suggest that beyond being a purely theoretical nicety, allowing for the integration of price and search frictions within the same firm has important policy implications. Thinking of the labor market, models that integrate these frictions imply empirically consistent responses to changes in unemployment benefits. In contrast, models that separate price and search frictions across different types of firms lead to essentially no quantitative responses. Thinking of inflation, models that integrate pricing and search frictions imply significant output losses and higher unemployment in response to persistently below target inflation. In contrast, models that separate these key frictions imply essentially no response from persistently below target inflation. Overall, these results suggest each model would lead policy makers to very different conclusions on very basic questions.

5 Impulse Responses

This section examines the dynamics associated with different shocks. The focus is on a technology shock and a monetary policy shock, and how these propagate through the different models.

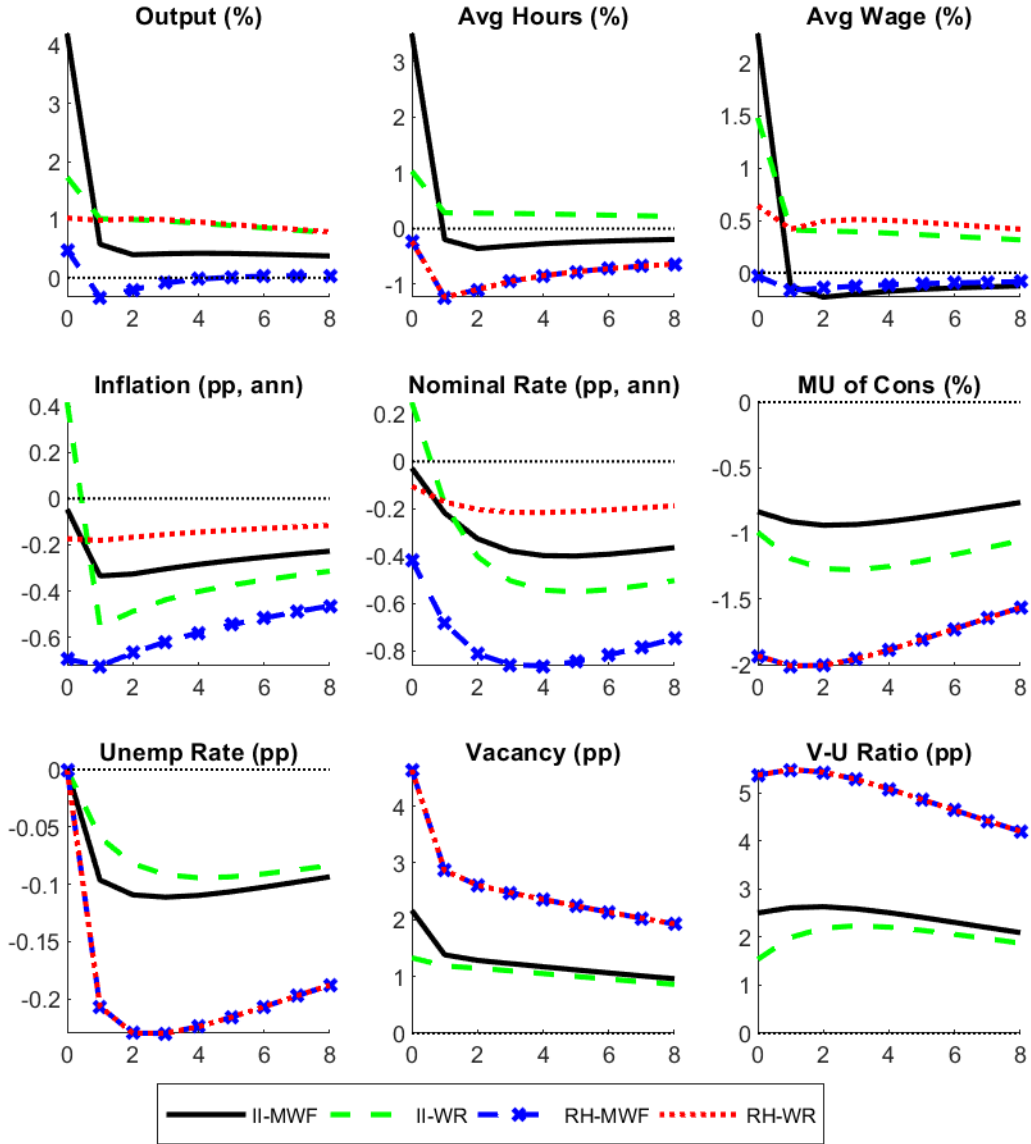
5.1 Technology Shock

Figure 4 shows the behavior of the models to a one standard deviation positive innovation in total factor productivity. Because the analyzed models are parsimonious and lack certain real rigidities, most of the change in aggregate output occurs in the first period.¹³ However, each model differs in how the instantaneous increase in demand is accommodated.

Focusing first on the II-MWF model, employment is pre-determined in the first period since matches take a period to become productive. Existing firms that can re-optimize their price face a trade-off between changing prices and changing hours and hence compensation of their matched

¹³In a framework similar to the RH-WR model, Trigari (2006) finds that consumption habits help undo some of this result.

Figure 4: Comparing the Response to a Technology Shock Across Models



Notes: Shows the effects of a 1 standard deviation TFP shock for models with combinations of independent individuals (II) or a representative household (RH), with matched worker-firms (MWF) or wholesaler-retailers (WR).

worker. With higher aggregate demand due to the shock, a firm could increase prices, reduce hours and compensation, and therefore sell fewer goods at a higher markup. Alternatively, they could decrease prices, increase hours and compensation, and sell more goods at a lower markup. On net, the incentives for the latter dominate, so inflation barely moves while individual hours and wages rise. Consumption and aggregate output rise sharply thanks to higher compensation.

However, the effect of the positive productivity shock on output, hours, and wages is relatively short-lived, since higher productivity induces firm entry. This additional entry lowers unemployment in subsequent periods, but also impacts price-setting and hours choices.¹⁴ In particular, with greater competition, the incentive to lower prices and sell more goods grows. As a result, non-price setting firms end up with high relative prices, which causes the hours of their workers to fall, leading to a dampening effect on compensation and hence aggregate demand.

Turning to the RH-MWF model reveals how the pooling of consumption changes some of the previously documented dynamics. With consumption pooling hours and wages barely move in response to the productivity shock. As a result, firm entry explodes which persistently lowers the unemployment rate. This explosion of entry induces forward-looking price-setters to reduce their prices and so inflation falls sharply on impact and remains persistently below its steady state value.

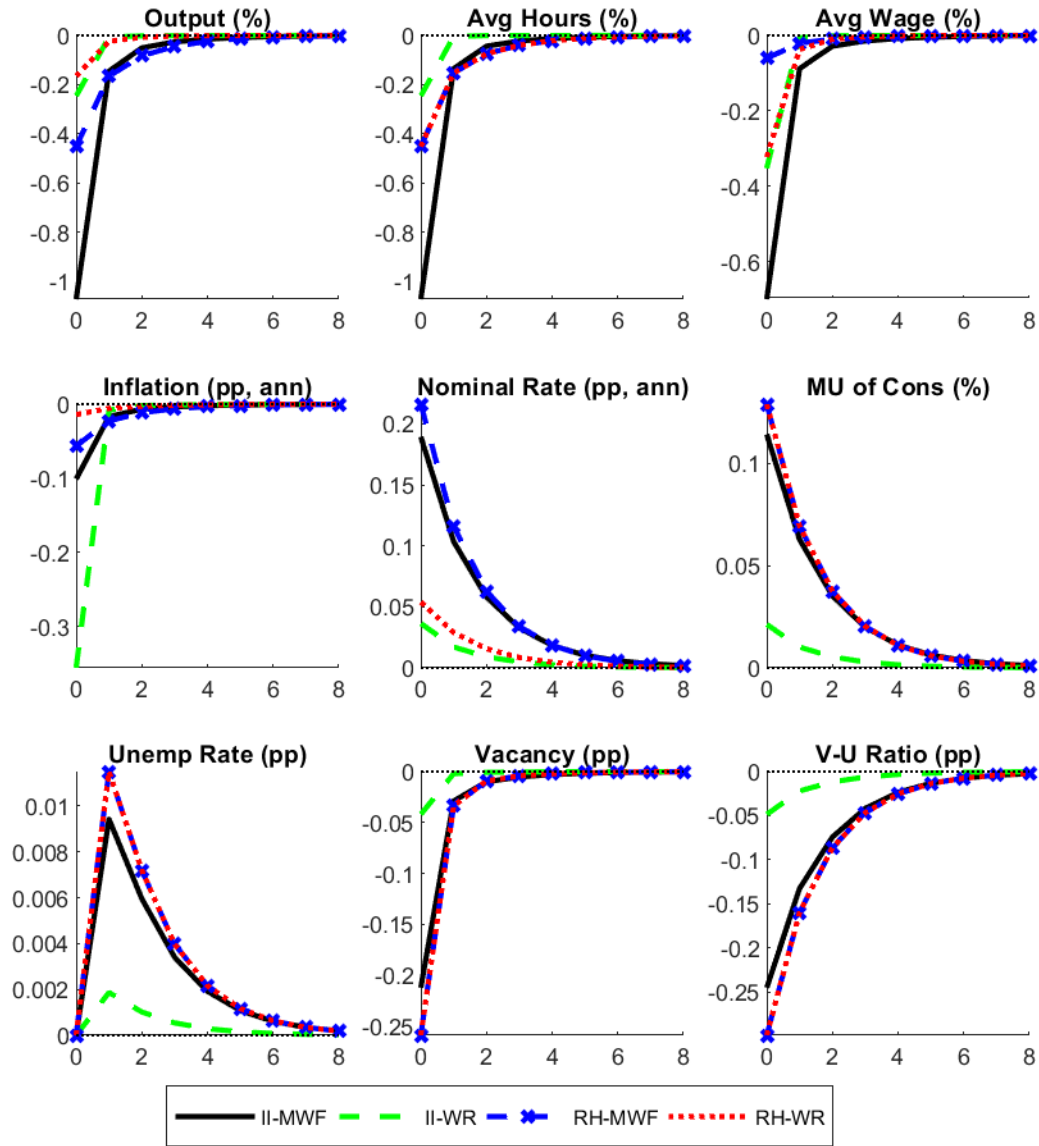
Turning next to the II-WR model, the main difference in this framework compared to the MWF models is that price-setting retail firms face do not face a trade-off between increasing prices or increasing individual hours worked as in the previous two models. Therefore, inflation rises on impact, which mutes aggregate demand and vacancy posting activity compared to the MWF models. However, the instantaneous overshooting of inflation is paid back in subsequent periods, as the entry of wholesale firms due to higher productivity leads to lower prices of the wholesale good, leading to lower inflation and stronger aggregate demand.

Lastly, the responses of the RH-WR model mimic in many respects the behavior of the RH-MWF model. Indeed, in both the cases the responses of vacancies and unemployment are essentially identical. The key difference between the two lies in the response of inflation. In RH-MWF price-setting firms account for new firm entry when resetting prices and so inflation is persistently weak. In contrast, in the RH-WR model, price-setting firms ignore firm entry and so inflation is comparatively stronger.

To summarize, after a technology shock, the responses of both macroeconomic and labor market variables vary across models. Critically, a comparison of MWF and WR models show the importance of integrating pricing and hiring frictions within the same firm, as the former produces more muted responses of inflation to a productivity shock compared to the latter. Meanwhile, comparing the II and RH models highlights that the single representative household construct, by pooling consumption between the employed and unemployed, mutes the effects of productivity shocks on

¹⁴Note that unemployment falls in response to a positive technology shock because there is no participation margin. This is in contrast to models like Galí (2011) where unemployment actually rises in response to a positive technology shock as more workers enter the labor force.

Figure 5: Comparing the Response to a Monetary Policy Shock Across Models



Notes: Shows the effects of a 1 standard deviation monetary policy shock for models with combinations of independent individuals (II) or a representative household (RH), with matched worker-firms (MWF) or wholesaler-retailers (WR).

output, average hours worked, and wages while in turn generating larger fluctuations in vacancies and unemployment. As noted in Section 3, these fluctuations end up producing too much volatility in aggregate hours given wage volatility.

5.2 Monetary Policy Shock

Figure 5 shows the behavior of the models to a one standard deviation innovation to monetary policy and reiterates many of the key mechanisms at play across each model.

In the II-MWF model, the positive shock to the nominal rate, all else equal, lowers individuals' demand in favor of savings, and hence the level of aggregate demand falls. As in the case following a productivity shock, existing firms that can re-optimize their prices face a trade-off between adjusting prices or hours. On net, firms use both margins and price adjusters, in particular, lower their prices. The lower demand and now higher relative prices of non-optimizing firms leads to a decline in hours and wages. The feedback from lower compensation causes the ensuing decline in output to be large, while the decline in the inflation rate mitigates some of the upward pressure on the nominal rate from the shock.

Again, as in the case with the productivity shock, the effects of a monetary policy shock end up being short-lived. The lower demand, paired with a higher marginal utility of consumption, causes firms to contract the number of vacancies posted, and hence unemployment increases in the period following the shock. The decline in the number of operating firms, however, dampens the need for further price reductions, which helps hours, wages, and therefore output to quickly return to their steady state values.

The effects of the monetary policy shock in the II-WR model mimic those seen in the productivity case. Since retail firms do not internalize the impact of pricing frictions on the labor market, the decline in inflation is much larger. This substantial decline in prices mutes some of the impact of tighter monetary policy on output, so hours worked and wages fall less drastically compared to the baseline. In addition, the sharp drop in inflation nearly undoes the effects of the policy shock on the nominal rate, with the rate increasing only slightly in equilibrium. Ultimately, the sharper drop in inflation generates a smaller decline in vacancies and hence the rise in unemployment is less stark.

Turning finally to the RH-MWF and RH-WR models, the household's ability to pool consumption mutes many of the effects seen in the II models. Here the pooling of consumption means that aggregate demand declines less following the shock, which therefore tempers the prices versus hours adjustment faced by firms. As a result, inflation, average hours worked, and wages fall by less than in the II models. The decline in inflation is very slight, meaning most of the effects of the monetary policy shock are passed directly to an increase in the nominal rate. This increase, coupled with the

interest rate inertia in the policy rule, leads to a more gradual increase in output in subsequent periods, and distorts the forward-looking behavior of firms through the stochastic discount factor. Thus, the ensuing decline in vacancies and rise in unemployment is then slightly more pronounced in the RH model than the II models.

In sum, these results highlight that both macroeconomic and labor market variables vary across models in how they respond to monetary shocks. The WR models, by separating labor and pricing frictions into two separate types of firms, produces more drastic swings in inflation than the MWF models. Meanwhile, the ability of the household to pool consumption, as in the RH models, generates smaller adjustments in the output, hours, wages, and inflation, than when individuals operate independently. As a result, the RH models generates slightly more variation in vacancies and unemployment.

6 Conclusion

This paper has considered the policy and macroeconomic implications of the interaction between infrequent price adjustment, labor market frictions, and consumption risk. In the New Keynesian models analyzed, risk averse workers randomly search for jobs and monopolistically competitive firms post take-it-or-leave-it wage contracts taking into account infrequent adjustment of their own price. By allowing for wage posting by firms, the model provides a direct link between pricing and hiring behavior at the micro level. Meanwhile, risk aversion and imperfect capital markets highlight the importance of consumption smoothing for aggregate price and labor market dynamics.

A key message from the analysis is that separating pricing and hiring frictions matters greatly even in this parsimonious framework. In terms of policies affecting the labor market, models that integrate these frictions imply empirically consistent responses to changes in unemployment benefits. Indeed, more generous unemployment benefits increase wages, decrease vacancies, and as a consequence, increase unemployment and decrease output. In contrast, models that separate these frictions are essentially invariant to changes in unemployment benefits. Regarding the conduct of monetary policy, models that integrate search and pricing frictions in the same firm imply quantitatively significant output losses from persistently below-target inflation. Again, models that separate these frictions imply essentially no output loss from below-target inflation.

The critical feature generating these results lies in the trade-offs faced by firms who control prices and hiring decisions, which are absent in models that separate price and labor market frictions. In

models that integrate these two frictions firms internalize how changing their prices affects demand for their goods and hence how much labor they require. As a result, comparatively less adjustment occurs through prices and more occurs through labor demand, so that vacancies and unemployment are more volatile. Not surprisingly, in the face of technology or monetary policy shocks the response of inflation is smaller in models that integrate search and pricing frictions compared to models that separate them across different firms.

While the frameworks studied are purposefully parsimonious, a number of extensions left for future research may remain tractable. For example, the take-it-or-leave-it assumption suggests the model can be easily extended to allow for ex-ante heterogeneity in worker types such as education or ability, provided this heterogeneity does not affect non-market productivity or leisure. Additionally, the framework should remain tractable when wages are also sticky, provided firms have an additional margin of adjustment such as worker effort (for example, [Bils et al., 2014](#)).

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