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Richard Holt

Abstract

This paper focuses on the reallocation of labour resources in a New Keynesian environment with labour market search and endogenous separations. We show that the introduction of variation in hours per worker alters the incentives for intertemporal substitution in a way that generates a more steeply downward sloping Beveridge curve and reduces the tendency to synchronize gross job flows. We find that the impact of labour supply elasticity on the slope of the Beveridge curve and the correlation of gross job flows is determined primarily by variation in the response to monetary shocks. When hours variation is suppressed, the correlation of job creation with job destruction and that of unemployment with vacancies are strongly positive in response to monetary shocks. With variation in hours both measures of reallocation take on the correct negative sign.

KEYWORDS: job reallocation, unemployment, hours, labour market fluctuations, New Keynesian macroeconomics

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1 Introduction

Recent research extends the New Keynesian paradigm to incorporate labour market search, motivated by the explicit account it provides of unemployment.[1] Following Shimer (2005) and Hall (2005), who argue that unemployment dynamics are driven by fluctuations in outflows not inflows, the bulk of the literature holds the inflow (separation) rate constant.[2] Yet, subsequent empirical evidence indicates that variation of inflows also plays an important role in unemployment dynamics.[3] This makes a model with endogenous separations a natural starting point.

Mortensen and Pissarides (1994) develop a Schumpeterian model of labour market dynamics, which features restructuring through endogenous separation of the least productive matches. In this literature on restructuring, the slope of the Beveridge curve (correlation of unemployment with vacancies) and the synchronization of gross job flows (correlation of job creation with job destruction) are critical measures of the reallocation process. Both are negative in US data. Suppressing inflow variation, i.e. following Shimer (2005), avoids the positive correlation of job flows and generates a downward sloping Beveridge curve; however, it does so by assuming away reallocation decisions. The Schumpeterian perspective on business cycles suggests that recessions are the best time to undertake microeconomic restructuring, since the opportunity costs of doing so are low. Mortensen and Pissarides (1993) show that a temporary shock to profitability produces strong positive correlation of gross job flows and an upward sloping Beveridge curve, in the context of a (constrained) efficient equilibrium labour market search model with endogenous separations (one which satisfies the Hosios condition). Krause and Lubik

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[1] Authors have examined the role played by labour market search, and wage rigidities in determining dynamic behaviour of unemployment, output and inflation. In so doing they address the amplification and persistence puzzles highlighted by Shimer (2005), Chari, Kehoe and McGrattan (2000), Cogley and Nason (1995).

[2] This literature includes Moyen and Sahuc (2005), Christoffel and Linzert (2005), Christoffel et al. (2006), Jung and Kuester (2006), Trigari (2006), Faia (2007), Kuester (2007) and Thomas (2007).

[3] Elsby et al. (2007) show that Shimer's result, that unemployment inflows are invariant over the cycle, is overstated even using his own data and methodology. Davis et al. (2006) and Fujita and Ramey (2007a) present evidence from job flows and other data sources to support the view that inflows are an important component of unemployment dynamics at business cycle frequencies, accounting for up to a third of the variation in unemployment.

(2007) find a similar effect in a New Keynesian framework when, as in the Mortensen-Pissarides model, labour input varies on the extensive margin(s) only. However, it is possible to reconcile models of reallocation and restructuring with the US stylised facts, while adhering to the Hosios condition, by incorporating additional features into firms' decision problems so as to alter the incentives for intertemporal substitution. For example, Mortensen (1994) achieves this by introducing on-the-job search and distinguishing between job and worker flows, while Den Haan et al. (2000) do so by including capital accumulation.

This paper examines the reallocation of labour resources in a New Keynesian environment with labour market search and endogenous separations. We show that the introduction of variation in hours per worker alters the incentives for intertemporal substitution in a way that generates a downward sloping Beveridge curve and reduces the tendency to synchronize gross job flows.[4] The New Keynesian framework imposes the discipline of general equilibrium on our analysis. It introduces frictions in price setting which permits meaningful discussion of the impact of both productivity and monetary shocks.[5] We show that the effect of labour supply elasticity on the slope of the Beveridge curve and the correlation of gross job flows is determined primarily by changes in the response to monetary shocks. Specifically, under inelastic labour supply, both the correlation of job creation with job destruction and that of unemployment with vacancies are strongly positive in response to monetary shocks, whereas under elastic labour supply both measures of reallocation take on the correct negative sign. The volatility of unemployment is relatively high with or without hours variation. The introduction of hours variation actually raises the volatility of unemployment, but reduces that of vacancies. Vacancies fail to exhibit sufficient persistence and are too strongly correlated with job creation.

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[4] As a by-product, this also produces a positive correlation of hours and employment at business cycle frequencies. Fluctuations in hours per worker account for a substantial proportion of the variation in labour input at business cycle frequencies, Cho and Cooley (1994). Despite its role in labour input, variation of hours per worker is frequently omitted from models with labour market search, presumably on grounds of parsimony.

[5] Shimer (2005) notes that an upward sloping Beveridge curve arises when *exogenous* shocks to the (aggregate) job destruction rate are permitted - this may be interpreted as an aggregate reallocative shock. It is possible that a suitable choice of correlation of reallocative shocks and productivity shocks could generate a Beveridge curve with the appropriate slope. However, Davis and Haltiwanger (1999) are unable to find a clear and important role for such aggregate reallocative shocks. For this reason it is more interesting to examine whether a negatively sloped Beveridge curve can arise when job destruction varies endogenously in response to aggregate productivity and money supply growth disturbances, which are standard in a New Keynesian setting.

Moreover, variation in hours reduces the volatility of wages, but this remains too high.

The mechanism by which variation in hours per worker affects reallocation is relatively straightforward. Variation of hours per worker allows existing matches to adjust labour input to shocks by varying hours as well as through separations - firms equate marginal costs of factor adjustment across each margin. This extra flexibility alters rents, and, as a consequence, the incentives both to dissolve existing matches and to create new ones. Labour adjustment on the extensive margin is attenuated and the tendency to synchronize creation and destruction activity is also reduced. One potential problem is that variation on the intensive margin may worsen the volatility puzzle highlighted by Shimer (2005) by substituting for variation on the extensive margin and attenuating fluctuations in unemployment. However, our calibration strategy adjusts parameters to maintain the standard deviation of job destruction constant across experiments, so that unemployment volatility remains roughly constant; in fact, it increases slightly when hours can vary.

The sensitivity of reallocative measures to variation in hours is enhanced by the presence of monetary shocks. It is costly to dissolve existing matches or create new matches in response to transitory shocks, yet hours variation within existing matches does not entail long-run considerations. Since monetary shocks are less persistent than productivity shocks, the introduction of hours variation has its greatest effect on the response to monetary shocks. Nonetheless, even for productivity shocks, realistic hours variation alters the incentives for intertemporal substitution sufficiently to produce a negative job flows correlation.

Krause and Lubik (2007), Trigari (2005), Braun (2006), Walsh (2005) and Andres et al. (2006) incorporate endogenous separations into the New Keynesian treatment of unemployment. These authors all provide the same rationale and broadly address the same issues as considered in the literature which assumes a constant separation rate (see footnotes (1) and (2)). For the most part, they do not address questions on the timing of reallocation that we consider and that a model with endogenous job destruction is designed to answer. In particular, the joint behaviour of the Beveridge curve and the correlation of gross job flows is considered only by Krause and Lubik (2007), who, as noted above, find both measures of reallocation to be positive, in an environment with endogenous job destruction and labour input variation on the extensive margin only.[6]

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[6] Krause and Lubik also find that the introduction of (complete) wage rigidity can produce a downward-sloping Beveridge curve, but they are unable to avoid positively correlated

The combination of endogenous hours along with endogenous job destruction that we discuss below was introduced by Trigari (2005). Our principal contribution is to demonstrate the effect of realistic hours variation on measures of reallocative activity. We also illustrate the role of different shocks in determining the effect of hours variation on reallocation. Trigari does not directly consider the correlation of gross job flows, nor does she attempt to match the behaviour of unemployment or vacancies. Nonetheless her impulse response analysis is likely to be consistent with the effects of hours variation on reallocation that we outline here.[7] We use a simplified version of Trigari's model to compare the behaviour of measures of reallocation obtained under different assumptions about labour supply elasticity. Our focus on contrasting the impact of particular (implicit) assumptions on hours variation in a relatively simple New Keynesian model leads us to calibrate rather than estimate the elasticity of hours directly. It also means that we take a stand on the shocks that affect the economy and match unconditional moments. Although not immune from criticism, this strategy facilitates comparison with Krause and Lubik (2007) and Walsh (2005); Trigari (2005) considers the (conditional) response to monetary shocks alone.[8]

Walsh (2005) was the first to integrate a New Keynesian model with labour market search and endogenous job destruction. Following from Den Haan et al., he does not allow variation in hours per worker and does not consider measures of reallocation at all. Andres et al. (2006) extend Walsh's model.[9] They find a role for price rigidity in determining the variability of unemployment, vacancies and labour market tightness. Although they do not compute the slope of the Beveridge curve, it can be inferred from the results they present. For the version of their model (without capital and distortionary taxation) which most closely approximates ours, it is -0.08: negative but much smaller than in US data, just as we find when we suppress variation in hours. They do not display any data for the volatility of gross job flows or related measures

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gross job flows. Indeed, they are unable to match the Beveridge curve if wage rigidity is set to match observed wage volatility.

[7] Trigari (2005) estimates key parameters so as to match the impulse responses of job flows, employment, hours, inflation and output to an interest rate shock.

[8] A natural extension of our approach, which imposes formal statistical discipline, would be to estimate the relative importance of the shocks using a full information approach, as in the treatment of a model with exogenous job destruction provided by Jung and Kuester (2007). Given the difficulties we find in capturing the behaviour of vacancies, we avoid this latter approach.

[9] Their benchmark model also allows for habit persistence, capital accumulation and distortionary taxes.

of reallocation, which we consider here.[10] Our analysis suggests that because they suppress variation in hours per worker, the correlation of gross job flows would be positive but that this can be corrected by allowing hours variation. Our results differ from theirs both because we allow variation in hours per worker and because we permit monetary as well as productivity shocks. Braun (2006) applies Trigari's methodology to worker flows rather than job flows; she considers a New Keynesian framework with capital accumulation.

We consider a New Keynesian model without capital accumulation. While capital can help discipline model calibration, much early work in the New Keynesian tradition both for structural modelling and policy analysis suppresses this margin, see Gali (2003), Woodford (2003), as does more recent work with unemployment, Blanchard and Gali (2006), Christoffel and Linzert (2005), Faia (2007), Trigari (2005). The main justification (often implicit) for this simplification appears to be the limited role played by capital accumulation.[11] Our omission of capital accumulation and other intertemporal features, such as habit persistence, serves to highlight the role of the intensive margin.[12]

The model is outlined in Section 2. Calibration and solution method are summarised in Section 3. Section 4 presents and discusses the results. Section 5 concludes. An appendix contains details of the data used, and the calibration strategy.

2 Model

The economy contains four types of agent: intermediate good producers, final goods producers, households and a government. Production of the intermedi-

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[10] In addition, direct comparison between our results and those of Andres et al. (2006) is complicated by the fact that they appear only to calibrate idiosyncratic shocks and the properties of the productivity shock in the benchmark case, and proceed to allow the variability of job destruction and output to vary across experiments.

[11] In the literature on unemployment dynamics, Hagedorn and Manowskii (2005) point out that match-level profits are an important determinant of the amplitude of fluctuations in unemployment and vacancies. Krussell et al. (2005), surveying developments in that literature, comment that the calibration of this critical profit share parameter could be improved if capital accumulation were incorporated as a disciplining device, but Jung (2005) demonstrates that the introduction of capital accumulation does not overturn the insight of Hagedorn and Manowskii (2005).

[12] An earlier version of this paper, Holt (2006), modelled capital accumulation. The results on the role of hours variation are similar to those displayed below. Hence a New Keynesian environment with capital accumulation does not necessarily alter incentives sufficiently to generate a negative job flows correlation, contrary to the real business cycle based analysis of Den Haan et al (2000).

ate good requires labour. Labour can be varied on both extensive and intensive margins. Hours worked while employed are determined through Nash bargaining rather than unilaterally by individual workers. The strength of variation in hours per worker is determined by preferences over leisure (the elasticity of labour supply). The model structure is based on that of Trigari (2005). We simplify her model in several ways in order to highlight the role of hours variation and facilitate comparison with the literature. Firstly, we omit habit persistence to simplify the dynamic structure of the model. Secondly, we target the Bureau of Labor Statistics (BLS) estimate of average unemployment (6%) rather than the high (25%) unemployment she uses. The high steady state unemployment rate that she assumes acts to stabilize the unemployment pool and hence vacancies in response to shocks, while our assumption makes it easier to match observed unemployment volatility. Thirdly, in the light of evidence of instability of the interest rate rule that she employs for monetary policy over our sample period, we follow Krause and Lubik (2007) and adopt a money supply growth rule. Fourthly, we adopt idiosyncratic production costs rather than idiosyncratic preference shocks, which is slightly more intuitive in the light of our interest in reallocation based on profitability. Finally, we specify preferences over leisure, following Andolfatto (1996), rather than hours worked as is common in the New Keynesian literature. Below we discuss the decision problem of households, the specification of goods and labour markets and the equilibrium characterization of the economy.

2.1 Households

Assume that the economy contains a continuum of identical households of unit mass. Each household is a family with a continuum of members. In equilibrium some family members are employed while others are unemployed. Each member i, of family f has the following period utility function defined over consumption, C, money balances $\frac{M}{P}$ and hours, H,

$$\frac{\left(C_{i,t}^{f}\right)^{1-\phi}}{1-\phi}+\frac{\Upsilon_{\frac{M}{P}}}{1-\xi}\left(\frac{M_{i,t}^{f}}{P_t}\right)^{1-\xi}+\left(1-I_{it}^{U}\right)\Upsilon_H\frac{\left(1-H_{i,t}^{f}\right)^{1-\varphi}}{1-\varphi}+I_{it}^{U}\frac{(1-e)^{1-\varphi}}{1-\varphi}$$

Here ϕ, the inverse of the elasticity of intertemporal substitution, φ, the curvature of utility derived from lesiure, ξ, the income elasticity of money demand, $\Upsilon_{\frac{M}{P}}$, the relative weight on money balances in the utility function, Υ_H, the relative weight on leisure during employment and e, the time spent undertaking search when unemployed are all positive constants. I_{it}^{U} is an indicator function taking the value 1 if the individual i is unemployed at date t and zero otherwise. To avoid the distributional issues that arise through differing employment histories, we assume that family members perfectly insure each other against (cross-section) variation in the marginal utility of consumption. Separability of the individual's utility in consumption, money balances and leisure, ensures that family members have identical consumption and money holdings. Under these simplifying assumptions, the decisions of household members can be analyzed in terms of a representative household.[13] The representative household chooses consumption and money balances to maximize the expected utility of its members over their lifetimes:

$$E_0 \left[\sum_{t=0} \beta^t \left[\begin{array}{c} \frac{(C_t)^{1-\phi}}{1-\phi} + \frac{\Upsilon_{\frac{M}{P}}}{1-\xi} \left(\frac{M_t}{P_t} \right)^{1-\xi} + \\ \Upsilon_H \int_0^{1-U_t} \frac{(1-H_{i,t})^{1-\varphi}}{1-\varphi} di + U_t \frac{(1-e)^{1-\varphi}}{1-\varphi} \end{array} \right] \right].$$

Here β, is the discount factor and U_t represents the fraction of the household membership which is unemployed (we suppress the household superscript, f, for convenience). Hours of work during employment are determined through bargaining between the individual worker and the firm rather than being unilaterally determined by the household, see below.

Households own all firms. They can save by holding 1-period interest-bearing bonds, or non interest-bearing money balances. The representative household maximizes members' expected lifetime utility subject to the following sequence of constraints

$$P_t C_t + R_t^n B_t + M_t = \mathcal{I}_t + B_{t-1} + M_{t-1} + P_t T_t, \qquad t \geq 0. \tag{1}$$

Here B_t represents holdings of a nominal 1-period bond at the end of period t, and R_t^n represents the gross nominal interest rate on this bond. M_t represents holdings of nominal money balances, $P_t T_t$ represents lump-sum nominal transfers. C_t is a composite index of final goods consumption. $\mathcal{I}_t$ is the household's nominal income (household labour income, plus the household's share of firms' profits net of expenditures on vacancies).[14]

The solution to the representative household's problem is characterized by first-order conditions for bond holdings, B_t, consumption, C_t and money balances, M_t. Substituting the first order condition for the shadow value of

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[13] This sort of assumption is a common simplification in the literature on business cycle fluctuations under labour market search designed to facilitate tractability, see e.g. Andolfatto (1996), Merz (1995).

[14] Under the representative family assumption, all families hold the same share of firms' profits, so in equilibrium this share is one at all dates.

wealth using the marginal utility of consumption in the remaining conditions we have:

$$1 = \beta R_t^n E_t \left[\frac{P_t}{P_{t+1}} \left(\frac{C_t}{C_{t+1}} \right)^{\phi} \right]. \tag{2}$$

$$\Upsilon_{\frac{M}{P}} \left(\frac{M_t}{P_t} \right)^{-\xi} - \beta E_t \left[C_{t+1}^{-\phi} \frac{P_t}{P_{t+1}} \right] = C_t^{-\phi} \tag{3}$$

2.2 Goods and Labour Markets

2.2.1 Labour Market Flows

Production of the intermediate good takes place in matched firm-worker pairs, or, for notational ease, *matches*. The match specific production, bargaining and separation decisions described below depend on the probability that unemployed workers find jobs and the probability that vacancies are filled. Here we define these probabilities and the associated labour market flows.

Define the number of matches at the beginning of period t as $N_t \in [0, 1]$. Following the literature, we allow some job destruction in the form of quits, which are assumed exogenous and independent of the match-specific profitability. We capture this by allowing a fraction, λ^x, of matches to separate prior to the realization of period t shocks. Subsequently, shocks are realized, including an idiosyncratic cost shock, X, drawn from distribution $F(X)$ and a match may choose to break up if the value of the match surplus is negative. Let the $\bar{X}_t$ denote the threshold value of the cost shock, so that higher realizations of idiosyncratic costs cause matches to separate. Endogenous separation thus occurs with probability $\lambda^n(\bar{X}_t) = 1 - \int^{\bar{X}_t} dF(X) = 1 - F(\bar{X}_t)$. The overall separation rate in period t is

$$\lambda_t = \lambda^x + (1 - \lambda^x)\left(1 - F\left(\bar{X}_t\right)\right). \tag{4}$$

Variation in the separation rate arises through changes in the threshold value of the idiosyncratic cost shock, $\bar{X}_t$. We model matching frictions using an aggregate matching function. Matching occurs at the same time as production. Assume that there is a continuum of potential firms, with infinite mass, and a continuum of workers with unit mass. Unmatched firms choose whether or not to post a vacancy and incur a cost κ per period. Free entry of unmatched firms determines the size of the vacancy pool. Define the mass of firms posting vacancies in period t as V_t. Let the mass of searchers, unmatched workers, be U_t. All unmatched workers may enter the matching market in period t - even if their match dissolved at the start of period t, so

$$U_t = 1 - (1 - \lambda_t)\, N_t. \tag{5}$$

New matches in date t begin production in date $t+1$, while unmatched workers remain in the worker matching pool. The flow of successful matches created in period t, $\mathcal{M}_t$, is given by the constant returns matching function

$$\mathcal{M}_t = \mathfrak{M} U_t^{\gamma} V_t^{1-\gamma}. \tag{6}$$

where $\gamma \in (0,1)$ is the elasticity of match creation with respect to unemployment and $\mathfrak{M} > 0$ is a scaling parameter. The number of employed workers at the start of period $t+1$ is

$$N_{t+1} = (1 - \lambda_t)\, N_t + \mathcal{M}_t. \tag{7}$$

Denote the probability that a vacancy is filled in date t as

$$p_t^V = \frac{\mathcal{M}_t}{V_t}, \tag{8}$$

and the probability that an unemployed worker enters employment in period t as

$$p_t^U = \frac{\mathcal{M}_t}{U_t}. \tag{9}$$

The gross job destruction rate is the number of employment relationships that separate, less exogenous separations that rematch within the period as a fraction of current employment

$$JD_t = \frac{\lambda_t N_t - p_t^V \lambda^x N_t}{N_t} = \lambda_t - p_t^V \lambda^x. \tag{10}$$

Gross job creation is the flow of new matches (as a fraction of existing employment) less matches due to firms filling vacancies that resulted from exogenous separations

$$JC_t = \frac{\mathcal{M}_t - p_t^V \lambda^x N_t}{N_t} = \frac{\mathcal{M}_t}{N_t} - p_t^V \lambda^x. \tag{11}$$

2.2.2 The Intermediate Sector

Production Production of the intermediate good takes place in matches. Each match consists of one worker and one firm, who together engage in production until the employment relationship is terminated. By assumption, both firms and workers may only participate in a single employment relationship at any given time. Matches are subject to aggregate productivity and idiosyncratic cost shocks, Z_t and X_t respectively.[15] Following Den Haan et al. (2000), assume that idiosyncratic cost disturbances are serially uncorrelated. Date t production occurs after realization of the date t shocks. At date t an ongoing match (one facing idiosyncratic shock $X_t < \bar{X}_t$) produces

$$Y^I(X_t) = AZ_tH(X_t) + \mathcal{F} - X_t$$

units of intermediate good. The parameters A, a scaling factor, and $\mathcal{F}$, the steady-state expected idiosyncratic shock, are positive constants. Matches are price takers and sell their homogeneous intermediate output at (nominal) price P_t^I. The formal separation of the job-destruction and price-setting decision problems is maintained for tractability. It is consistent with the view that prices are not set at the level of an individual match. Current profits of an ongoing match are

$$\Pi^I(X_t) \equiv \frac{AZ_tH(X_t)}{\mu_t} + \frac{\mathcal{F} - X_t}{\mu_t} - \frac{W(X_t)H(X_t)}{P_t}, \tag{12}$$

where $\mu_t = \frac{P_t}{P_t^I}$ is the markup of the index of final goods prices over the price of the intermediate good (the reciprocal of marginal cost) and $W(X_t)$ is the match specific (nominal) wage. Notice that, for a given idiosyncratic cost and holding other variables constant, a monetary expansion reduces the markup, μ_t, because final goods prices do not immediately adjust in proportion to the monetary innovation. As a result profits rise following a monetary shock. Similarly, an increase in productivity, Z_t, raises profits.

Value Functions Consider the value functions for firms' and workers' decision problems.

In equation (13), V_t^U, the date t value of unemployment expressed in final goods, comprises the consumption value of utility from search, plus the discounted present value of ongoing unemployment next period, V_{t+1}^U, and the difference between the value of employment, $V^W(X)$, and that of unemployment in the event that the worker matches this period (with probability

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[15] Cost shocks are a natural way to model heterogenous productivity underlying the process of creative destruction at the heart of the model. Trigari (2005) adopts a formally equivalent but, given our interest in reallocation, arguably less appealing approach in which the idiosyncratic disturbances affect the utility derived from leisure.

p_t^U) and the match survives to produce in the next period (with probability $(1-\lambda^x)\,F\left(\bar{X}_{t+1}\right)$):

$$\begin{aligned} V_t^U &= \frac{(1-e)^{1-\varphi}}{1-\varphi} C_t^{\phi} \\ &\quad + \beta E_t \left[\frac{C_t^{\phi}}{C_{t+1}^{\phi}} \left[\begin{array}{c} V_{t+1}^U + \\ p_t^U \left(1-\lambda^x\right) \int^{\bar{X}_{t+1}} \left[V^W(X) - V_{t+1}^U \right] dF(X) \end{array} \right] \right] \end{aligned} \tag{13}$$

Matching and production occur simultaneously, so that a match which is formed in period t cannot produce until period $t+1$, after aggregate and idiosyncratic shocks have been realized. As a result a new match survives with probability $(1-\lambda^x)\,F\left(\bar{X}_{t+1}\right)$.

Let $V^W(X_t)$ denote the date t value, expressed in terms of consumption goods, to a worker, of employment in an ongoing match with idiosyncratic cost shock X_t.

$$\begin{aligned} V^W(X_t) &= \frac{W(X_t)\,H(X_t)}{P_t} + \Upsilon_H \frac{\left(1-H(X_t)\right)^{1-\varphi}}{1-\varphi} C_t^{\phi} \\ &\quad + \beta E_t \left[\frac{C_t^{\phi}}{C_{t+1}^{\phi}} \left[\begin{array}{c} V_{t+1}^U + \\ \left(1-\lambda^x\right) \int^{\bar{X}_{t+1}} \left[V^W(X) - V_{t+1}^U \right] dF(X) \end{array} \right] \right] \end{aligned} \tag{14}$$

The worker supplies $H(X_t)$ hours of labour to the firm for real hourly wage $\frac{W(X_t)}{P_t}$. Both wage and hours are outcomes of a bargaining process - described below. Hours worked generate income, but hours spent in the workplace reduce utility. These concerns are captured in the first two terms in (14). The remainder of the date t value to an employed worker from the ongoing match is the discounted present value, $\beta E_t\left[\frac{C_t^{\phi}}{C_{t+1}^{\phi}} V_{t+1}^U\right]$, of unemployment plus the difference between the value of employment, $V^W(X)$, and that of unemployment in the event that the match continues to produce in the next period (where we sum across values of X which do not lead to termination prior to date $t+1$ production).

The date t value, $V^J(X_t)$, of a firm that forms part of an ongoing match with current match specific shock X_t, consists of current profits plus the appropriately discounted value to the firm of the sum of a date $t+1$ vacancy, V_{t+1}^V, in the event that the match terminates prior to production in period $t+1$ (where termination occurs with probability $\lambda_{t+1} = \lambda^x + (1-\lambda^x)\left(1-F\left(\bar{X}_{t+1}\right)\right)$) and the expected value in the event that the match continues to produce in $t+1$;

$$V^J(X_t) = \Pi^I(X_t) + \beta E_t \left[\frac{C_t^\phi}{C_{t+1}^\phi} \left[\lambda_{t+1} V_{t+1}^V + (1-\lambda^x) \int^{\bar{X}_{t+1}} V^J(X)\, dF(X) \right] \right].$$

Assume posting a vacancy costs κ per period. Then the value at date t of a firm with an unfilled vacancy, V_t^V, reflects the cost of posting that vacancy plus the value, V_{t+1}^V, of the firm in the event that it fails to fill the vacancy by date $t+1$ or else the event that the vacancy is filled but the match is terminated prior to production in period $t+1$ (which occurs for a sufficiently adverse realization of the idiosyncratic shock, $X_t > \bar{X}_{t+1}$), and finally, the value, $V^J(X)$, in the event that the vacancy is filled and the period $t+1$ idiosyncratic cost shock takes a value $X \leq \bar{X}_{t+1}$, which does not lead to termination:

$$V_t^V = -\kappa + \beta E_t \left[\frac{C_t^\phi}{C_{t+1}^\phi} \left[\begin{array}{c} \left(1 - p_t^V (1-\lambda^x) F\left(\bar{X}_{t+1}\right)\right) V_{t+1}^V + \\ p_t^V (1-\lambda^x) \int^{\bar{X}_{t+1}} V^J(X)\, dF(X) \end{array} \right] \right].$$

The standard free entry condition on vacancies drives the value of a vacancy to zero, $V_t^V = 0$, $\forall t$, so the Bellman equations for $V^J(X_t)$ and V_t^V, respectively, become:

$$V^J(X_t) = \Pi^I(X_t) + (1-\lambda^x)\beta E_t \left[\frac{C_t^\phi}{C_{t+1}^\phi} \int^{\bar{X}_{t+1}} V^J(X)\, dF(X) \right] \tag{15}$$

$$\kappa = p_t^V (1-\lambda^x)\beta E_t \left[\frac{C_t^\phi}{C_{t+1}^\phi} \int^{\bar{X}_{t+1}} V^J(X)\, dF(X) \right]. \tag{16}$$

Moreover, using (15), we can re-write (16) as a Bellman equation for p_t^V:

$$\frac{\kappa}{p_t^V} = \beta(1-\lambda^x) E_t \left[\frac{C_t^\phi}{C_{t+1}^\phi} \int^{\bar{X}_{t+1}} \left[\Pi^I(X) + \frac{\kappa}{p_{t+1}^V} \right] dF(X) \right]. \tag{17}$$

Bargaining: Hours and Wages We assume that for each match engaged in production, the firm and worker adopt Nash bargaining over both hours worked and the hourly wage. Given the full consumption insurance against unemployment risk provided by our family structure, some care is required to ensure that this problem is well defined. We discuss this issue first before turning to the outcome of the bargaining process.

Assume that workers evaluate the consequences of their actions on the basis of the contributions these make to their family's lifetime utility. Then the worker's surplus from employment, $V^W(X_t) - V_t^U$ is the same as the value (in terms of consumption) of the change in the family's utility from having one more additional member in employment, $\frac{\partial\Omega_t}{\partial(1-U_t)} \cdot C_t^\phi$. That is $V^W(X_t) - V_t^U = \frac{\partial\Omega_t}{\partial(1-U_t)} \cdot C_t^\phi$, where Ω_t is the representative family's value function. To check this, note that we can write Ω_t recursively as

$$\Omega_t = \begin{bmatrix} \frac{(C_t)^{1-\phi}}{1-\phi} + \frac{\Upsilon_{\frac{M}{P}}}{1-\xi}\left(\frac{M_t}{P_t}\right)^{1-\xi} + \\ \Upsilon_H \int_0^{1-U_t} \frac{(1-H(X_{i,t}))^{1-\varphi}}{1-\varphi} di + U_t \frac{(1-e)^{1-\varphi}}{1-\varphi} \end{bmatrix} + \beta E_t \left[\Omega_{t+1} \middle| X \leq \bar{X}_{t+1} \right]$$

subject to the date t constraint in (1), and the evolution equation for the number of individuals engaged in production:

$$1 - U_{t+1} = [1 - \lambda_{t+1}][1 - U_t] + p_t^U [1 - \lambda_{t+1}] U_t.$$

Computing the derivative with respect to $(1 - U_t)$ we find

$$\frac{\partial\Omega_t}{\partial(1-U_t)} \cdot C_t^\phi = \begin{matrix} \frac{W(X_t)H(X_t)}{P_t} - \Upsilon_H \frac{(1-H(X_t))^{1-\varphi}}{1-\varphi} C_t^\phi + \frac{(1-e)^{1-\varphi}}{1-\varphi} C_t^\phi + \\ \left(1 - p_t^U\right) \beta \left(1 - \lambda^x\right) E_t \left[\frac{C_t^\phi}{C_{t+1}^\phi} \int^{\bar{X}_{t+1}} \left[V^W(X) - V_{t+1}^U \right] dF(X) \right] \end{matrix}$$

Combining equations (13) and (14) we find that this equals $V^W(X_t) - V_t^U$, as required. So a worker's threat point in the bargaining process is well defined in terms of household welfare. The problem of the division of the match surplus,

$$S(X_t) = V^W(X_t) - V_t^U + V^J(X_t) - V_t^V = V^W(X_t) - V_t^U + V^J(X_t), \quad (18)$$

on a period by period basis can then be written as:

$$\max_{W(X_t), H(X_t)} \left[V^W(X_t) - V_t^U \right]^\eta \left[V^J(X_t) - V_t^V \right]^{1-\eta}.$$

The first order conditions for hours and wages respectively are

$$\frac{\eta V^J(X_t)}{(1-\eta)} \left[\frac{W(X_t)}{P_t} - \Upsilon_H \frac{(1-H(X_t))^{-\varphi}}{C_t^{-\phi}} \right] = -\left\{ \begin{matrix} \left(V^W(X_t) - V_t^U \right) \cdot \\ \left[\frac{AZ_t}{\mu_t} - \frac{W(X_t)}{P_t} \right] \end{matrix} \right\}, \quad (19)$$

$$\eta V^J(X_t) = (1-\eta) \left(V^W(X_t) - V_t^U \right). \quad (20)$$

Combining (19) and (20) we write optimal hours worked in terms of date t

flow variables as:

$$\Upsilon_H \frac{(1-H(X_t))^{-\varphi}}{C_t^{-\phi}} = \Upsilon_H \frac{(1-H_t)^{-\varphi}}{C_t^{-\phi}} = \frac{AZ_t}{\mu_t} \qquad \forall X_t \leq \bar{X}_t. \tag{21}$$

Equation (21) says that, under Nash bargaining, the marginal rate of substitution between consumption and hours worked is equal to the marginal product of labour. Hours per worker in ongoing matches are decreasing in the markup, but increasing in aggregate productivity. Since inflation is directly related to the markup (see below), this equation is important in understanding the inflation response of the model. Variation in hours per worker is decreasing in φ, so choice of φ can be used to shut down the intensive margin in our experiments. Finally, notice that hours per worker are independent of the match specific shock: $H(X_t) = H_t$.[16]

Turning to optimal wages, we use the Bellman equations above to express the wage as a function of date t flow variables. Recall that the worker's surplus from employment is

$$V^W(X_t) - V_t^U = \begin{array}{c} \frac{W(X_t)H_t}{P_t} + \Upsilon_H \frac{(1-H_t)^{1-\varphi}}{1-\varphi} C_t^{\phi} - \frac{(1-e)^{1-\varphi}}{1-\varphi} C_t^{\phi} + \\ \left(1-p_t^U\right)\beta\left(1-\lambda^x\right) E_t\left[\frac{C_t^{\phi}}{C_{t+1}^{\phi}} \int^{\bar{X}_{t+1}} \left[V^W(X) - V_{t+1}^U\right] dF(X)\right] \end{array}.$$

Using (20) and (16) it follows that the worker's surplus can be written in terms of current variables as

$$V^W(X_t) - V_t^U = \begin{array}{c} \frac{W(X_t)H_t}{P_t} + \Upsilon_H \frac{(1-H_t)^{1-\varphi}}{1-\varphi} C_t^{\phi} \\ -\frac{(1-e)^{1-\varphi}}{1-\varphi} C_t^{\phi} + \frac{\eta}{1-\eta}\left(1-p_t^U\right)\frac{\kappa}{p_t^V} \end{array}.$$

Lastly, combining (15) and (16) allows the value of the firm to be written in current variables

$$V^J(X_t) = \frac{AZ_t H_t}{\mu_t} + \frac{\mathcal{F} - X_t}{\mu_t} - \frac{W(X_t)H_t}{P_t} + \frac{\kappa}{p_t^V}.$$

So the optimal wage for a match with idiosyncratic cost realization X_t becomes

$$\frac{W(X_t)H_t}{P_t} = \begin{array}{c} \eta\left[\frac{AZ_t H_t}{\mu_t} + \frac{\mathcal{F} - X_t}{\mu_t} + \kappa \frac{p_t^U}{p_t^V}\right] \\ -(1-\eta)\left[\Upsilon_H \frac{(1-H_t)^{1-\varphi}}{1-\varphi} - \frac{(1-e)^{1-\varphi}}{1-\varphi}\right] C_t^{\phi} \end{array}.$$

---

[16] An additive idiosyncratic shock avoids wide variation of hours across matches, Cooley and Quadrini (1999).

The first term within the first square brackets on the right hand side of this equation represents the worker's share of the market value of production, the second term reflects the market value of idiosyncratic costs (relative to steady state), and the third term reflects the impact of labour market tightness. The remaining terms reflect the worker's reservation wage. This equation reveals that high idiosyncratic costs act to lower labour income. Also, other things being equal, a rise in productivity, Z, raises labour income. A monetary expansion tends to raise output and marginal costs, yet since the prices of final goods do not adjust immediately, the markup, μ_t, falls. So a monetary expansion also tends to raise labour income.

Finally, define aggregate labour income as $\frac{W_t H_t}{P_t} = H_t \int^{\bar{X}_t} \frac{W(X_t)}{P_t} dF(X)$. Then

$$\frac{W_t H_t}{P_t} = \left\{ \begin{array}{c} \eta \left[\frac{AZ_t H_t}{\mu_t} + \frac{1}{\mu_t} \left[\mathcal{F} - \frac{\int^{\bar{X}_t} X \, dF(X)}{F\left(\bar{X}_t\right)} \right] + \kappa \frac{p_t^U}{p_t^V} \right] \\ -(1-\eta) \left[\Upsilon_H \frac{(1-H_t)^{1-\varphi}}{1-\varphi} - \frac{(1-e)^{1-\varphi}}{1-\varphi} \right] C_t^{\phi} \end{array} \right\} F\left(\bar{X}_t\right). \tag{22}$$

Separation For values of the idiosyncratic cost shock above a certain threshold level, $\bar{X}_t$, separation occurs. The condition $S\left(\bar{X}_t\right) = 0$, pins down this threshold value of the match specific shock. Combining (18) and (20), $V^J(X_t) = (1-\eta) S(X_t)$. So $\bar{X}_t$ is determined by the condition $V^J\left(\bar{X}_t\right) = 0$:

$$\frac{AZ_t H_t}{\mu_t} + \frac{\mathcal{F} - \bar{X}_t}{\mu_t} - \frac{W\left(\bar{X}_t\right) H_t}{P_t} + \frac{\kappa}{p_t^V} = 0.$$

This equation indicates that a job is destroyed when costs are sufficiently high that the value of production net of idiosyncratic cost shock and wage equals the (expected) cost of posting a vacancy. Substituting for the match specific wage, the threshold value $\bar{X}_t$ is determined by

$$(1-\eta) \left[\begin{array}{c} \frac{AZ_t H_t}{\mu_t} + \frac{\mathcal{F} - \bar{X}_t}{\mu_t} \\ + \left[\Upsilon_H \frac{(1-H_t)^{1-\varphi}}{1-\varphi} - \frac{(1-e)^{1-\varphi}}{1-\varphi} \right] C_t^{\phi} \end{array} \right] - \eta \kappa \frac{p_t^U}{p_t^V} + \frac{\kappa}{p_t^V} = 0. \tag{23}$$

2.2.3 Final Goods Sector

Assume that there is a continuum of final goods producers, with unit mass. Final good firm z acquires the wholesale good at price P_t^I and costlessly transforms it into the divisible final good z which is then sold directly to households at price $p_t(z)$. Define $P_t = \left(\int_0^1 p_t(z)^{1-\varepsilon} dz \right)^{\frac{1}{1-\varepsilon}}$ as the utility based price index associated with the consumption composites. The market for final goods is characterized by monopolistic competition - ε represents the elasticity of substitution across varieties of final good. Aggregate demand for the final good z in period t is $c_t(z)$. Aggregate supply of the final good z in period t is $y_t(z)$. The optimal choice of consumption expenditures on final good z is then $c_t(z) = \left(\frac{p_t(z)}{P_t}\right)^{-\varepsilon} C_t$, where aggregate consumption, $C_t = \left(\int_0^1 c_t(z)^{\frac{\varepsilon-1}{\varepsilon}} dz\right)^{\frac{\varepsilon}{1-\varepsilon}}$ and aggregate final good output $Y_t = \left(\int_0^1 y_t(z)^{\frac{\varepsilon-1}{\varepsilon}} dz\right)^{\frac{\varepsilon}{1-\varepsilon}}$ are composite indices of final goods.

Frictions prevent the continual adjustment of final goods prices, which follow a hybrid Calvo - style adjustment scheme. With probability $(1-\omega)$ a final good producer can set the price of its output in period t. This probability is independent of when the firm last adjusted price. Then the average price for final goods producers who do not adjust their price is simply P_{t-1}. Define the average price set by firms who do adjust price as $\bar{p}_t$. Since pure forward-looking price adjustment schemes seem not to account adequately for observed inflation dynamics, we employ a hybrid scheme (following Gali and Gertler (1999)). Assume that a fraction $(1-\tau)$ of the final goods producers are forward-looking and set prices optimally (to maximize expected discounted profits given the probability of future adjustment). Define the price set by forward-looking producer z at date t as $p_t(z)$. Since all forward-looking firms setting price at date t face the same expected future demand and cost conditions, they choose the same price, so $p_t(z) = p_t^*$, where

$$p_t^* = \frac{\varepsilon}{1-\varepsilon} \frac{E_t \sum_{s=0}^{\infty} \omega^s \beta^s \frac{C_t^{\phi}}{C_{t+s}^{\phi}} \left(\frac{p_t^*}{P_{t+s}}\right)^{1-\varepsilon} Y_{t+s} P_{t+s}^I}{E_t \sum_{s=0}^{\infty} \omega^s \beta^s \frac{C_t^{\phi}}{C_{t+s}^{\phi}} \left(\frac{p_t^*}{P_{t+s}}\right)^{1-\varepsilon} Y_{t+s}} \tag{24}$$

The remaining fraction, τ, of firms which reset price in period t are assumed to set a price equal to the average of the prices reset in the previous period, corrected for inflation, π_{t-1}:

$$p_t^b = \bar{p}_{t-1} \pi_{t-1}. \tag{25}$$

The average price set in period t is $\bar{p}_t = \left[(1-\tau)\left(p_t^*\right)^{1-\varepsilon} + \tau\left(p_{t-1}^b\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}$, and the aggregate retail price index evolves according to

$$P_t^{1-\varepsilon} = (1-\omega)\left(\bar{p}_t\right)^{1-\varepsilon} + \omega P_{t-1}^{1-\varepsilon}. \tag{26}$$

2.3 Macroeconomic Policy and Exogenous Shocks

We set government spending to zero and assume that the government maintains a balanced budget by rebating seigniorage revenues to households in the form of lump-sum transfers. The government budget constraint is thus $P_t T_t = M_t - M_{t-1}$, where M_t is the aggregate money stock. Monetary policy is specified by

$$M_t = M_{t-1} e^{\upsilon_t} \tag{27}$$

where υ_t, the monetary shock, evolves according to the AR(1) process

$$\upsilon_t = \rho_\upsilon \upsilon_{t-1} + \varepsilon_{\upsilon,t}. \tag{28}$$

The logarithm of aggregate productivity also follows an AR(1) process:

$$\ln Z_t = \rho_Z \ln Z_{t-1} + \varepsilon_{Z,t} \tag{29}$$

where $\varepsilon_{\nu,t}$ and $\varepsilon_{Z,t}$ are mutually and temporally independent mean-zero processes, while ρ_Z and ρ_υ are positive constants.

2.4 Equilibrium

Under the representative consumer framework, household choices (superscript f) are identical across households and in equilibrium $M_t^f = M_t$ etc., in (1) to (3). Aggregate income, $\mathcal{I}_t$, comprises labour income, plus profits of final goods producers, plus profits of intermediate goods producers (net of vacancy posting costs) $\mathcal{I}_t = (1-\lambda^x) N_t W_t H_t + P_t \Pi_t^F + P_t \Pi_t^I$. Here, nominal profits of final goods producers are $P_t \Pi_t^F = \int p_t(z) y_t(z) dz - P_t^I \int y_t(z) dz = P_t Y_t - P_t^I Y_t^I$, where

$$Y_t^I = (1-\lambda^x) N_t \int_0^{\bar{X}_t} [A Z_t H_t + \mathcal{F} - X] \, dF(X) - \kappa \mu_t V_t \tag{30}$$

denotes aggregate intermediate output net of vacancy posting costs.[17] Nominal intermediate good producers' profit can be written as the sum of output net of vacancy costs, less aggregate wage payments: $P_t \Pi_t^I = P_t^I Y_t^I - (1-\lambda^x) N_t W_t H_t$. Using these insights and cancelling terms we find $\mathcal{I}_t = P_t Y_t$. In equilibrium, when combined with the government budget identity, the household budget

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[17] Note $Y_t^I = \int_0^1 y_t(z)\, dz$. Using the demand function for final good z: $y_t(z) = \left(\frac{p_t(z)}{P_t}\right)^{-\varepsilon} Y_t$, we have $Y_t^I = \int_0^1 \left(\frac{p_t(z)}{P_t}\right)^{-\varepsilon} Y_t dz = \left(\frac{P_t}{\tilde{P}_t}\right)^{\varepsilon} Y_t$, where $\tilde{P}_t = \int_0^1 p_t(z)^{-\varepsilon} dz$, is an auxiliary price index.

Parameter	**Meaning**	**Value**
β	Rate of time preference	0.99
ε	Elasticity of substitution between goods	21
ω	Probability of price non-adjustment	0.8
τ	Fraction of backward-looking firms	0.5
ρ_Z	Productivity shock autocorrelation	0.95
ρ_v	Monetary shock autocorrelation	0.5
σ_v	Monetary shock standard deviation	0.004
ξ	(Income) Elasticity of money demand	1
$\Upsilon_{\frac{M}{P}}$	Scaling factor: utility of real balances	17
λ	Separation rate	0.1
p^U	Probability of finding employment	0.61
p^V	Probability of filling a vacancy	0.7
$\mathfrak{M}$	Scaling factor: matching function	0.654
λ^x	Exogenous separation rate	0.068
JD	Job destruction rate	0.052
μ_X	Mean of idiosyncratic cost distribution	-1.5
η	Worker bargaining power	0.5
κ	Cost of posting a vacancy	0.034
ϕ	Elasticity of intertemporal substitution	1
H	Hours per worker / total time endowment	0.33
e	Hours of search per unemployed worker	0.0033

Table 1: Experiment-Invariant Parameter Values

constraint reduces to the aggregate (final) goods market equilibrium condition

$$Y_t = C_t \tag{31}$$

Thus the system of equations governing equilibrium in the economy consists of the numbered equations (1) - (12), (17) and (21) - (31).

3 Data, Calibration & Model Solution Method

The data we use is discussed in the Appendix. We log-linearize the model about its (zero-inflation, zero-growth) steady state and use stochastic simulations to tease out the dynamic structure of the economy.[18] Model solution

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[18] The log-linear approximation to equation system (1)-(12), (17), (21)-(31) is solved with MATLAB, 7.0.1, using McCallum's (1999) undetermined coefficients version of Klein's

requires calibration of parameters governing steady state values of labour and goods market variables; nominal rigidity, and household preferences. We also specify the processes governing idiosyncratic costs, aggregate productivity and money supply growth. Parameter values which are invariant across experiments are summarized in Table 1. The Appendix contains discussion of the rationale for these choices and those concerning parameters which vary across experiments.

4 Results

In this section we discuss evidence as to the impact of variation in hours per worker on the strength and timing of reallocative activity and on other standard macroeconomic aggregates.

We contrast the behaviour of a model variant in which hours variation is suppressed (which represents the standard approach in models of labour market search with endogenous job destruction) with that of a set up in which the elasticity of labour supply, governed by the parameter ψ, is selected to match the variation of hours in US data. To provide a fair basis of comparison, we hold constant across experiments both the standard deviation of simulated output and the standard deviation of simulated job destruction relative to simulated output. To do this, we adjust the standard deviation of productivity shocks to allow the standard deviation of (Hodrick-Prescott filtered) model output to match the standard deviation of output in US data (Hodrick-Prescott filtered GDP), which is 1.69%.[19] The standard deviation of idiosyncratic cost shocks is varied in order to match the volatility of job destruction relative to that of output. These dimensions cannot be used for falsification. Instead, we examine the ability of the model to capture two key aspects of the strength and timing of reallocative behaviour: i) the Beveridge curve and ii) the correlation of gross job flows. We explain the mechanism by which variation in hours per worker improves the treatment of labour reallocation. We also consider the operation of the labour market as captured by the correlation of hours with employment, the behaviour of job creation and vacancies and standard macroeconomic aggregates such as unemployment. Finally, we examine the robustness of the results to plausible variation in labour supply elasticity and consider the role played by different shocks.

(1997) generalized Schur decomposition method.

[19] We hold the autocorrelation of productivity shocks, both standard deviation and serial correlation of money supply growth shocks, constant across these experiments.

4.1 Reallocation and Hours Variation

Table (2) illustrates the role of labour supply elasticity (variation in hours) in determining the nature of reallocation. Column (1) of Table (2) displays properties of US Data. The other columns of Table (2) correspond to a particular model variant.[20] For column (X >1), the entry in the row labelled 'Output,Y' indicates the volatility of output generated by the model (in Column (X)) relative to the volatility of output in US data. The next ten entries in column (X) correspond to the volatility of some variable relative to that of output. The final two entries in each column are serial correlation statistics for output and inflation. The penultimate six simple correlation statistics capture aspects of labour market activity.

Labour supply elasticity, ϵ_H, is $\frac{1}{\psi}\left[\frac{1-H}{H}\right] = \frac{2}{\psi}$, since in steady state $H = 1/3$. In the limit as $\psi \rightarrow \infty$, $\epsilon_H \rightarrow 0$, and variation in hours is eliminated. Column (2) reports results for the model where labour supply elasticity is set to a low value, 0.01, using $\psi = 200$. This suppresses hours variation which allows our model to approximate the framework used by Krause and Lubik (2007). Column (5) displays simulation results when labour supply elasticity is set to match the volatility of hours observed in US data. This enables our model to approximate the model of Trigari (2005). Columns (2) and (5) report properties of the model under different assumptions about labour supply elasticity while subject to both monetary and productivity shocks using the calibration strategy described above. The other columns are discussed in Section (4.4).

With inelastic labour supply, it is not possible to generate the patterns of reallocation found in the data, see Columns (1) and (2). The correlation of unemployment with vacancies shows that Beveridge curve is almost flat while the correlation of gross job flows is positive. This mirrors the finding of Krause and Lubik (2007). It is exactly the effect that one would expect, in the light of the wider literature on reallocation under constrained efficient search, Mortensen and Pissarides (1993). This result may appear to confirm the difficulties of allowing for endogenous job destruction outlined in Shimer (2005). Here, however, movements in job destruction arise endogenously through aggregate productivity and monetary disturbances, rather than as the result of (reallocative) shocks to exogenous job destruction which he discusses. Once realistic variation in hours is permitted, the model is much better able to cap-

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[20] All statistics (for model simulations and data) are computed from Hodrick-Prescott filtered data. The business cycle statistics for model variants are computed by averaging across 200 simulations. Each simulation contains 250 data points but the first 50 are omitted when undertaking detrending and computing moments.

	Data	**Inelastic Labour** $\psi = 200$ $\sigma_X = 0.8$			**Elastic Labour** $\psi = 2.25$ $\sigma_X = 0.23$		
Shock		**All**	**M**	**Z**	**All**	**M**	**Z**
Col. No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Standard Deviations							
Output, Y	1.00	1.00	0.29	0.95	1.00	0.52	0.86
Inflation, π	0.21	0.40	0.72	0.34	0.28	0.21	0.31
Wage, W/P	0.52	5.95	13.31	4.48	1.65	1.64	1.66
Hours / worker, H	0.55	0.10	0.24	0.08	0.57	0.34	0.65
Employment, N	0.66	0.67	0.57	0.68	0.76	0.55	0.82
Unemployment, U	7.21	5.19	7.11	4.93	6.15	4.36	6.62
Vacancies, V	8.04	5.06	5.06	5.04	2.88	2.08	3.14
Tightness, U/V	15.02	7.73	2.67	8.08	7.69	5.54	9.69
Job Creation, JC	5.09	7.26	10.94	6.70	5.45	3.80	8.29
Job Destruction, JD	8.97	8.87	20.33	6.53	8.89	6.19	5.91
Job Reallocation, JR	4.27	7.52	15.27	6.12	4.31	2.92	4.69
Cross-*Correlations*							
U, V	-0.94	-0.15	0.96	-0.32	-0.37	-0.41	-0.36
JC, JD	-0.41	0.74	0.90	0.71	-0.34	-0.39	-0.34
V, JC	-0.03	0.86	0.98	0.86	0.61	0.61	0.62
U, JD	0.67	0.42	0.88	0.25	0.62	0.62	0.63
H, N	0.89	0.13	-0.11	0.21	0.24	0.08	0.24
U, π	-0.65	-0.65	-0.97	-0.56	-0.95	-0.95	-0.95
Autocorrelations							
Output: Y, Y_{-1}	0.87	0.89	0.47	0.94	0.87	0.65	0.95
Inflation: π, π_{-1}	0.57	0.59	0.49	0.64	0.84	0.84	0.84

Table 2: Business Cycle Statistics

All statistics computed from Hodrick-Prescott filtered series, smoothing parameter 1600. All model statistics are averaged across 100 simulations. Column (1): US data, 1972:2 - 1993:4. Columns (3) and (6), labelled 'M': simulations use monetary shocks only, where $\rho_v = 0.5, \sigma_u = 0.004$. Columns (4) and (7), labelled 'Z': simulations use productivity shocks only, where $\rho_Z = 0.95$ throughout, $\sigma_Z = 0.009$, for Column (4) and $\sigma_Z = 0.021$ for Column (7). Columns (2) and (5), labelled 'All': simulations use monetary and productivity shocks, where $\rho_v = 0.5, \sigma_u = 0.004$ and $\rho_Z = 0.95$ throughout, $\sigma_Z = 0.009$ for Column (2) and $\sigma_Z = 0.021$ for Column (5).

ture the direction of reallocation, see Columns (1), (2) and (5). However, the strength of the relationship between unemployment and vacancies is not fully captured since the Beveridge curve, while downward sloping, is not as steep as that in the data. It is worth spending some time trying to understand the mechanism by which variation in hours alters the incentives to create and destroy jobs.

Firstly, notice that, from an accounting viewpoint, a rise in unemployment can be achieved in a variety of ways including a rise in job destruction and a fall in job creation, or by one of these in isolation with no change in the other, by a fall in job creation combined with a smaller fall in job destruction or even by a rise in job creation combined with a larger rise in job destruction. The first of these cases would tend to give rise to a negative contemporaneous correlation of job creation with job destruction. The last two of the cases described here would tend to produce a positive contemporaneous correlation of job creation with job destruction. Secondly, it is not clear that there should be a strong association between the correlation of gross job flows and the slope of the Beveridge curve. The relationship between the two will depend on the extent to which high levels of vacancies are strongly associated with periods of above average job creation and that to which periods of above average job destruction are associated with periods of above average unemployment.

Now consider in detail the case where variation in hours is suppressed. This is an environment in which the correlation of gross flows takes a different sign to the slope of the Beveridge curve. Separations are efficient and job destruction facilitates the creation of jobs, so the best time to create jobs is at the point at which the opportunity cost of doing so is at its lowest, namely when match level profits (rents) are low. For this reason job creation and job destruction move together when hours variation is suppressed, see Column (2), in contrast to US data, see Column (1). This correlation alone does not enable us to distinguish whether a rise in unemployment is associated with a fall in job creation combined with a smaller fall in job destruction or with a rise in job creation combined with a larger rise in job destruction. However, the positive correlation of job destruction with unemployment indicates that the second of these mechanisms is at work in the model when hours variation is suppressed. To see how the constrained efficiency of separations impacts on the Beveridge curve when variation in hours is suppressed, notice that job creation and vacancies move together very closely in Column (2), whereas these variables appear virtually uncorrelated in US data, Column (1). Despite the strong negative correlation of job creation with job destruction and that of vacancies with job creation, unemployment and vacancies are less strongly correlated than in US data because job destruction is relatively weakly correlated with unemployment in the model compared to the data.

Next consider the environment in which ψ is set to match the volatility of hours in US data, σ_H/σ_Y (to achieve this we set $\psi = 2.25$, see Column (5)). With realistic variation in hours, the model generates a positive correlation between hours per worker and employment (albeit weaker than that in the data). Hours per worker will thus be above average in an expansion, as unemployment falls, and below average in a recession, as unemployment rises. Variation in hours per worker reduces the extent to which rents vary in response to shocks because match level rents are convex in hours per worker.

Other things being equal, increased variation in hours per worker is likely to reduce the variation on the extensive margin. One might expect the introduction of realistic volatility in hours per worker to be associated with a decline in job reallocation, where job reallocation, JR_t is the sum of job creation and job destruction: $JR_t = JC_t + JD_t$.[21] In particular, the response of job destruction to shocks may be more muted when hours per worker can vary and insulate the economy from the full reallocative effects of any shock. The incentives for vacancy and job creation (in response to a shock that raises unemployment) may be attenuated for two reasons as a direct result of such a reduced response of job destruction. Firstly, the reduced response of job destruction will leave a larger number of ongoing matches, which may reduce the potential rents available to new matches and consequently reduce job creation and vacancy creation. Secondly, the response of job creation may be attenuated because the probability of filling an open vacancy will fall, due to the reduction in the size of the pool of unemployed workers (which follows from the more muted response of job destruction). In addition, the job creation response is likely to be attenuated, independently of any variation in job destruction, since the flexibility of hours allows ongoing matches to respond to improved conditions (as the economy moves back towards steady state following a shock).

Other things are not equal, however, since our calibration strategy holds the variability of job destruction constant across experiments at the value observed in US data, σ_{JD}/σ_Y. This leaves the final effect described in the previous paragraph, which is independent of any effect on job destruction. So job reallocation declines over and above the effect due purely to decline in the cor-

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[21] The standard deviation of job reallocation, σ_{JR} can be written as $\left[\sigma_{JD}^2 + \sigma_{JC}^2 + 2 \cdot \rho_{JC,JD} \cdot \sigma_{JD} \cdot \sigma_{JC}\right]$, where $\rho_{JC,JD}$ is the correlation of job creation with job destruction. It is possible to generate a reduction in the volatility of job reallocation simply through the decline in the correlation of job creation with job destruction; indeed, there could even be an increase in the volatility of job creation and of that of job destruction. However, in Table (2) it is clear that the decline in job reallocation is associated with a decline in both $\rho_{JC,JD}$ and σ_{JC}, while σ_{JD} is constant.

relation of job creation with job destruction. Columns (2) and (5) confirm that greater elasticity of hours reduces the variability of job creation, as would be expected under the latter effect. The shift in the timing of job creation alters the correlation of gross job flows, so that, in response to a shock which raises unemployment, job creation rises while job destruction falls, as in the data. This occurs despite the fact that we require the economy to satisfy the Hosios condition. Vacancies remain positively correlated with job creation when hours display realistic variation (Column (5)) and the correlation is weaker than with hours variation suppressed (Column (2)). By contrast, the correlation of job destruction with unemployment is stronger in the variable hours environment than with hours variation suppressed. It is this combination of a higher correlation of job destruction with unemployment, and a lower correlation of job creation with vacancies, which permits a negative correlation of job creation with job destruction together with a negatively sloped Beveridge curve. The Beveridge curve, however, remains shallower than required by the data.

Nevertheless, the joint behaviour of vacancies with job creation is one area in which the variation of hours does not really get close to matching US data. In US data there is virtually no relationship between the job creation and the number of open vacancies, yet as just discussed, even with realistic hours variation the model generates a positive correlation between vacancies and job creation. This reflects the lack of persistence in vacancies (not displayed in Table (2)): in US data the first order serial correlation coefficient for vacancies is 0.92, while in the model with hours variation it takes the value 0.08.

4.2 Hours Variation and Macroeconomic Aggregates

It is important to understand whether the improvement in the account of reallocative activity provided by realistic hours volatility leads to a deterioration of other aspects of model performance. Here we provide a brief summary of the other properties of the model. As indicated in the introduction, some of these issues have been discussed by Trigari (2005) for the model with elastic hours variation and Walsh (2005), Krause and Lubik (2007) and Andres et al. (2006) for the case where variation is suppressed. Rather than repeat their detailed analysis of the mechanisms present, we highlight the impact of hours variation on the volatility of unemployment, vacancies and the Beveridge curve.[22]

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[22] Trigari (2005) and Walsh (2005) discuss the role of labour market search and matching frictions in enhancing the persistence of inflation and output in response to shocks (compared to a standard New Keynesian framework with a frictionless Walrasian labour market). Trigari (2005) outlines the impact of variation on the extensive margin for the behaviour of

In contrast to the results of Shimer (2005), who finds that the volatility of unemployment is only one tenth of that in US data, we find that the model generates unemployment volatility that is at least 75% of that in the data. This is true regardless of the elasticity of hours per worker. In fact unemployment volatility is higher when hours are elastic.

Andres et al. (2006) argue that this mainly reflects the presence of nominal rigidities in the New Keynesian model. As Walsh (2005) observes, if one holds the standard deviation of idiosyncratic shocks (and other parameters) constant, then an increase in nominal price setting frictions will raise the amplitude and persistence of output fluctuations. The intuition is that the introduction of nominal rigidities flattens the supply curve and raises the output response to shocks at the expense of price adjustment. This explains the impact of price stickiness on unemployment pointed out by Andres et al. (2006), Since unemployment volatility will increase with that of output.

In Andres et al., however, i) the standard deviation of output varies across experiments and ii) the standard deviation of job flows appears to be calibrated only in the benchmark case so that it too can vary across experiments. Since both output and job destruction variability are held constant across our experiments, their mechanism can not explain why unemployment volatility rises in our model as variation in hours is introduced (see Columns (2) and (5)). Instead, as the volatility of job destruction is held constant across experiments, the change in unemployment volatility reflects the fact that unemployment is less strongly correlated with job destruction in the inelastic labour supply case. The decline in the use of the extensive margin, associated with the introduction of variable hours, therefore shows up as a reduction in the volatility of vacancies (and also in the volatility of job creation). As it happens, the volatility of labour market tightness is unaffected, see Columns (2) and (5). These results suggest that, if we insist on adjusting parameters to hold the volatility of job destruction constant, there may still be some role for more standard resolutions of the unemployment-vacancies-tightness puzzle, such as wage rigidity or low worker bargaining power (departures from the

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marginal cost, while Walsh (2005) demonstrates that output and inflation persistence can be enhanced by the introduction of habit persistence in consumption and by increasing the strength of frictions in nominal price setting. Krause and Lubik (2007) provide evidence that the unemployment-vacancy-tightness volatility puzzle identified by Shimer (2005) can be resolved by incorporating real wage rigidity through an ad hoc wage norm. Andres et al. (2006) argue that (in conjunction with habit persistence in consumption, capital accumulation and distortionary taxation) the frictions in price setting in a New Keynesian model make it possible to solve the unemployment - vacancy - tightness variability puzzle without resort to either wage rigidity, as in Shimer (2005), or departures fron the Hosios condition as in Hagedorn and Manowskii (2005).

Hosios condition).

The serial correlation of output is not greatly affected by the introduction of hours variation and is close to its value in US data. Model-generated inflation displays greater persistence than US data once realistic hours variation is admitted. This acts to synchronize the movements in inflation and the already persistent unemployment, which raises the correlation of inflation and unemployment, or equivalently the slope of the Phillips curve. Increased inflation persistence is associated with lower inflation volatility, which is closer to the value in US data when hours per worker can exhibit realistic variation than when this is suppressed. To understand the volatility of inflation, note that the first order condition for hours,

$$\Upsilon^{H}\frac{(1-H_t)^{-\varphi}}{C_t^{-\phi}}=\frac{AZ_t}{\mu_t},$$

can be rearranged to give an expression for marginal cost, μ_t^{-1}, as a function of hours worked (as well as consumption and productivity). Given our assumptions on the nature of price adjustment, inflation depends on the discounted present value of future marginal costs (and lagged inflation). In the inelastic case, $\psi = 200$, so even though hours do not vary a great deal, the size of ψ makes marginal cost, and hence inflation, sensitive to small variation in hours. This leads inflation to be more variable with hours variation suppressed.

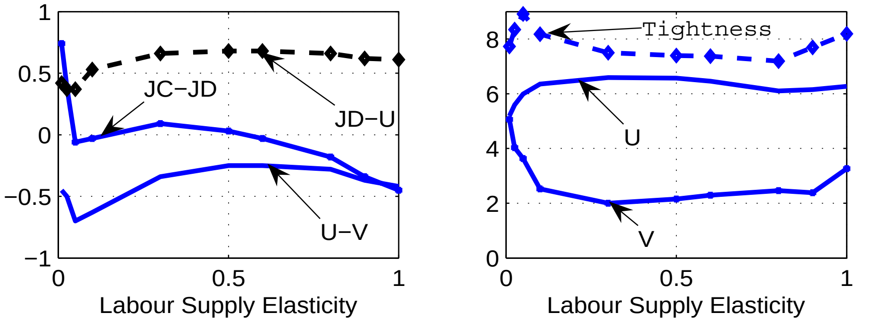
The same is true for wages. The wage equation reflects a role for variation in μ_t^{-1} as well as an effect through the term in the disutility of hours worked $(1-H_t)^{1-\varphi}$, which exhibits substantial variation for high values of ψ. However, even with elastic variation in hours per worker, wages are three times more variable than in the data. This may suggest scope for the introduction of wage rigidity.

$$\frac{W_tH_t}{P_t}=\left\{\begin{array}{c}\eta\left[\frac{AZ_tH_t}{\mu_t}+\frac{1}{\mu_t}\left[\mathcal{F}-\frac{\int^{\bar{X}_t}X\,dF(X)}{F\left(\bar{X}_t\right)}\right]+\kappa\frac{p_t^U}{p_t^V}\right]\\-(1-\eta)\left[\Upsilon_H\frac{(1-H_t)^{1-\varphi}}{1-\varphi}-\frac{(1-e)^{1-\varphi}}{1-\varphi}\right]C_t^{\phi}\end{array}\right\}F\left(\bar{X}_t\right).$$

4.3 Robustness to Labour Supply Elasticity

A labour supply elasticity of 0 is implicit in studies in the labour market search literature that rely only on the extensive margin for adjusting labour input. Our preferred model is calibrated to a labour supply elasticity of 0.9 (i.e.

(a) U−V, JC−JD, JD−U Correlations (b) Unemployment, Vacancies, Tightness



(c) H−N, U−Pi JC−V Correlations (d) Inflation, Hours, Wages, Job Creation

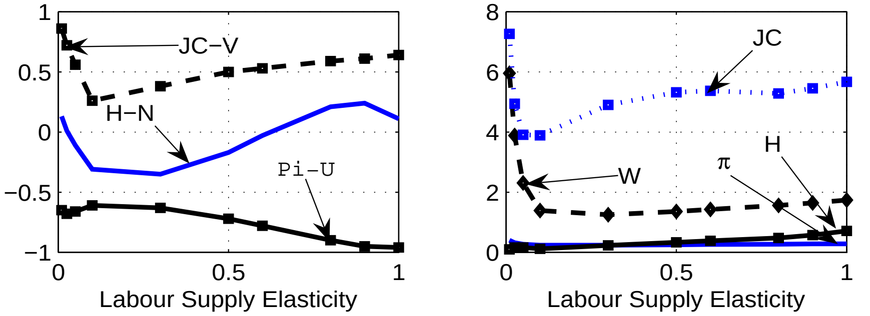


Figure 1: Role of Labour Supply Elasticity

$\psi = 2.25$) in order to match the volatility of hours per worker. Conditional on the structure of the model and our calibration strategy, this is the "correct" ψ. However, a range of $\psi \in [0, 1]$, is supported by empirical evidence, Blundell and MaCurdy (1999). Here we briefly consider the sensitivity of our measure of reallocative and other macroeconomic activity in our model to alternative values of ψ. We consider values of $\epsilon_H \in [0.01, 1]$. Our results are summarized in Figure (1). In constructing this Figure we adjust the standard deviation of productivity shocks to hold the volatility of output constant and adjust the standard deviation of idiosyncratic shocks to hold the volatility of job destruction constant at their respective values observed in US data. Panel (a) displays measures of reallocation and other correlations relating to labour market flows. Panels (b), (c) and (d) show, among other things, the volatility of unemployment, labour market tightness, job creation and vacancies. In the light of our earlier discussion we interpret Figure (1) in terms of the effect of raising labour supply elasticity. For comparison, Table (2) column (1) provides values for the statistics in US data.

Increases in labour supply elasticity raise the volatility of hours (see panel (d)). This increase occurs relatively smoothly as elasticity increases, yet, for many variables there is a relatively sharp change in behaviour at low labour supply elasticities, and these metrics are nonlinear non-monotonic functions of the elasticity of labour supply.

Panel (a) shows that there is a dramatic decline in the correlation of job creation with job destruction at very low levels of labour supply elasticity, bringing it closer to US data. A further, more gradual improvement occurs at higher levels of labour supply elasticity. Although a labour supply elasticity of around 0.1 minimizes the slope of the Beveridge curve (at about -0.7), a relatively high level of labour supply elasticity, near that required to match hours volatility, is needed if the model is to match the correlation of job creation with job destruction.

Panel (b) shows that the largest changes in unemployment volatility and vacancy volatility occur at low levels of elasticity. Panels (a) and (b) shows that the rise in unemployment volatility is associated with a rise in the correlation of job destruction with unemployment (recall that the variability of job destruction is held constant). The decline in vacancy volatility reflects the decline in reallocative activity associated with increased variation in hours. This effect of labour supply elasticity is also seen in the initial decline in the volatility of job creation at low elasticities in panel (d). For elasticities above around 0.3 the variability of job creation is close to that in the data, see Table (2) column (1).

Panel (c) shows that, at low levels of labour supply elasticity, the correlation of hours with employment is negative, so that hours per worker substitute for employment. Only at higher levels of elasticity, which are required to match the volatility of hours, does this correlation become positive. In our model it never attains values close to those seen in the data. Panel (d) shows that the volatility of inflation is relatively constant, declining slightly as labour elasticity rises. Panel (c) shows that the correlation of unemployment with inflation, the slope of the Phillips curve, is close to the value in the data at low elasticities but becomes steeper at high elasticities. This is due to increased inflation persistence (associated with lower wage variability), which acts to synchronize inflation and unemployment adjustment. Under Nash-bargained wages, the model never manages to match the low variability of real wage in the data, see panel (d) and Table (2) column (1). However, low levels of labour supply elasticity lead to a large increase in the volatility of wages, since for inelastic labour supply, any variation in hours requires more extreme movements in wages.

Although the improvements associated with the introduction of variation in hours per worker do not rely on very elastic parameterization of labour supply, a relatively high labour supply elasticity is needed to match the volatility of hours and the correlation of job creation with job destruction and to obtain a positive correlation of hours with employment.

4.4 The Effect of Real and Nominal Shocks

Finally, we use stochastic simulation and impulse response analysis to examine the role of different shocks in determining the impact of variation in labour supply elasticity on reallocative activity. Our simulation results are summarized in Columns (3), (4), (6) and (7) in Table (2). We deliberately avoid re-calibrating to match features of the data, as our aim is to show the role of individual shocks in the overall response. Column (3) reports the effect under inelastic labour supply of allowing monetary shocks (labelled 'M' in Table (2) and calibrated as in Table (1)), while suppressing productivity shocks. Column (4) reports the effect under inelastic labour supply of allowing productivity shocks (labelled 'Z' in Table (2) and calibrated as in Column (2) of Table (2)), with monetary shocks suppressed. Columns (6) and (7) report the same experiments for the elastic labour supply version of the model (using the calibration of column (5) of Table (2)).[23] Figures (2) and (3) document impulse response functions for inelastic and elastic labour supply versions of the model (using the parameter values summarized in Table (1) and Table (2)). In these Figures, impulses are one percentage point deviation from steady state rather than one standard deviation, in order to facilitate comparison across different shocks and elasticities of labour supply.

4.4.1 Monetary Shocks

Notice from Table (1) that monetary shocks exhibit less persistence than productivity shocks. Figures (2) and (3) confirm the relative lack of persistence of the effects of a monetary shock in comparison to a technology shock. We argue that this difference is key to understanding the effect of labour supply elasticity on measures of reallocation and other variables.

From Columns (3) and (6) of Table (2), we see that monetary shocks account for a lower fraction of output variation with inelastic labour supply than

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[23] Our approach requires that we take a stand on the number of shocks and their properties. A natural extension of our approach which imposes formal statistical discipline would be to estimate the relative importance of the shocks using a full information approach. Given the difficulties of matching the behaviour of vacancies we avoid this latter approach.

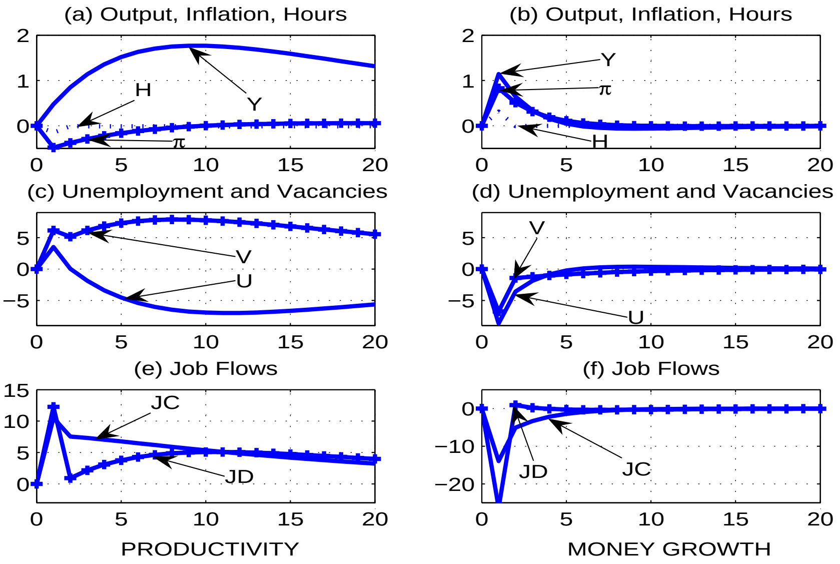

Figure 2: Inelastic Hours Impulse Responses to 1% Shocks

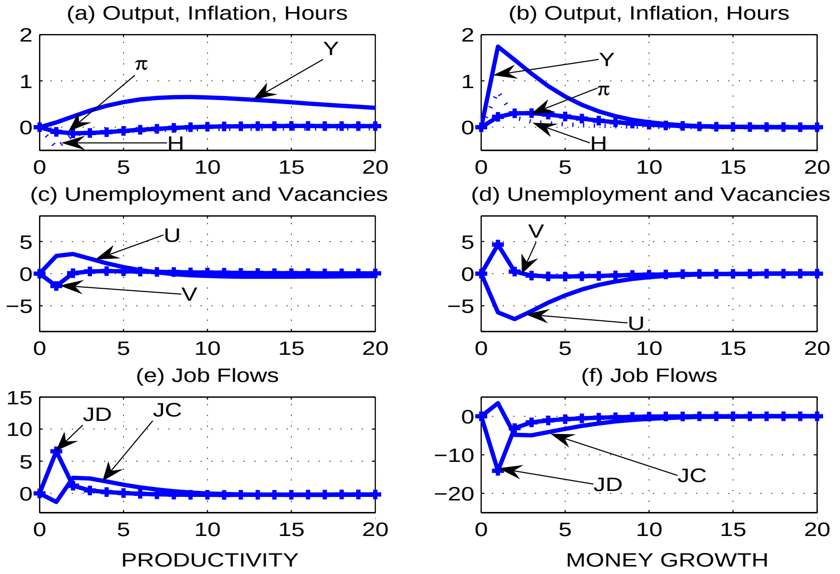

Figure 3: Elastic Hours Impulse Responses to 1% Shocks

in the elastic case. To understand this recall that when adjusting to shocks, firms equate the marginal cost across each margin. This means that in the inelastic environment, where the cost of adjusting hours is high, the intensive margin is likely to be used to lesser extent than in the elastic hours environment, so that firms will be more reliant on the extensive margin. Simulation results in Columns (3) and (6) of Table (2) confirm this and the same effect is revealed by comparison of the hours and unemployment responses to monetary shocks in panels (b) and (d) of Figures (2) and (3). If firms make use of the extensive margin to adjust to shocks, then long-run relationships must either be created or destroyed. Of course it will be particularly costly to adjust to temporary shocks in this way. For this reason monetary shocks will account for a relatively small component of output fluctuations in the inelastic hours case.

Regardless of our assumptions about supply elasticity, firms will tend, in the short-run, to make greater use of job destruction rather than job creation to respond to shocks, since the latter activity is more costly. Panels (e) and (f) of Figures (2) and (3) confirm this. Now, for the inelastic hours case, consider a monetary shock that leads to a fall in job destruction and unemployment (as illustrated in Figure (2)). The deviation of output from steady state in response to a monetary shock is relatively short-lived (compared either with the effects of a productivity shock, Figure (2) Panel (a), or with a monetary shock in the elastic hours environment, Figure (3), panel (b)). It seems likely that a monetary shock does not greatly raise the value of creating a new match, and the shock itself generates little incentive to raise the number of vacancies. At the same time, the fall in the fraction of unemployed workers in Figure (2) panel (d) reduces the probability of filling a match, and this acts to reduce the number of vacancies. Taking these effects together, vacancies and job creation will be below average at the very point in time when job destruction and unemployment are low, see Figure (2) panels (d) and (f). This generates a positively sloped Beveridge curve and a positive correlation (synchronization) of gross job flows as in Column (3).

By contrast, when hours can vary, this margin can be used more cheaply to adjust to shocks. Reversing our previous argument, this enables (transitory) monetary shocks to play a greater role in accounting for output variability than in the inelastic case. For example, compare the output responses in panel (b) of Figures (2) and (3).[24] As discussed in Section (4.1), the response

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[24] Notice that the standard deviation of monetary shocks is set independently of labour supply elasticity, so this is an alternative way to understand the contribution of monetary shocks as labour supply elasticity varies that we observed in Columns (3) and (6) of Table (2).

to monetary shocks under elastic hours affects rents in a way that reduces the economy's reliance on the extensive margin, desynchronizes job flows and generates a downward sloping Beveridge curve, see Column (6). This insight is confirmed in Figure (3) panels (d) and (f), where unemployment and vacancies move in opposite directions in response to monetary shocks, as do job creation and job destruction.

Finally, note that the impulse responses to a monetary shock, as described in Figure (2), are similar to those in Krause and Lubik (2007), in their Figure (2). Our responses exhibit slightly less persistence than Krause and Lubik's. This may be because, even in the inelastic case we consider, costly hours variation feeds through to inflation (recall our equation (21) for optimal hours), whereas the limit case they consider eschews any such link to inflation. The responses in our Figure (3), the elastic hours case, are similar to those obtained by Trigari (2005), see her Figures (4) and (5) on the quantitative importance of intensive and extensive margins and on labour market dynamics on the extensive margin, respectively (note that she considers a monetary contraction). The key difference between our Figure (3) and her Figure (5) lies in the vacancy response: she finds that after initially moving in the opposite direction to unemployment (as in our Figure (3), vacancies subsequently exhibit the same sign as unemployment. This may be a result of the changes in the timing of adjustment introduced by her limited information assumption.[25] Her Figure (4) gives a relatively greater role to employment fluctuations over hours variation than our Figure (3).[26] One reason for this may be that the manufacturing industry hours per worker series that we use (for consistency with the job flows data) exhibits greater variability than that for the non-farm business sector in her study. Another reason for this difference may be differences between the conditional hours per worker series implied by the limited information approach and the unconditional hours series employed in our approach.

4.4.2 Productivity Shocks

With price-setting frictions, a positive productivity shock initially raises unemployment.

Consider the inelastic hours case in Figure (2) panel (c). In the short-run,

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[25] She assumes that, in the theoretical model, variables respond to shocks with a two-period lag. This is designed to be consistent with the identifications restrictions that she employs to recover impulse responses.

[26] We do not display the response for employment, but it can be recovered from our unemployment responses - recall that deviations in employment are $U/(1-U)$ times unemployment deviations, where U denotes a steady state value.

unemployment and vacancies both rise in the face of a positive productivity shock. Thereafter, new matches are formed in the light of the relative abundance of unemployed workers and as the price level adjusts, unemployment declines. Nonetheless, due to the persistence of the productivity shock, high rents lead to persistently high vacancies. So in the inelastic case it appears to be the long-run behaviour of unemployment and vacancies which generates a downward sloping Beveridge curve under productivity shocks, see Column (4). Separations are efficient and job creation and job destruction are positively correlated, see Column (4) of Table (2). In the impulse responses, this positive correlation manifests itself in the impact effect and in the long-run adjustment to productivity shocks, see Figure (2) panel (e). To reconcile the evidence on the Beveridge curve with that on the correlation of gross job flows, note that job destruction is only weakly correlated with unemployment in Table (2), Column (4).

The introduction of hours variation acts to reduce the degree of synchronization of job flows in response to a productivity shock. To see this, compare panel (e) in Figures (2) and (3). In the elastic case, the responses to a productivity shock are more muted than in the inelastic case. Allowing greater adjustment on the intensive margin reduces the persistence of unemployment and vacancies. These two features are obviously linked. The reduced persistence of unemployment deviations lessens the probability of filling a vacancy and hence the number of vacancies created. Since the long-run effects on unemployment and vacancies are less important in the inelastic hours case, the short-run relationship between these two determines the slope of the Beveridge curve. For reasons discussed above, the Beveridge curve takes a negative slope in Table (2) Column (7). For similar reasons, the correlation of job creation with job destruction is also negative. The impulse response functions also illustrate the strong degree of association of vacancies and job creation and the comparative lack of persistence in these two variables in the elastic hours case.

5 Conclusions

In this paper we build on Trigari (2005), who developed a New Keynesian model of unemployment with hours variation and endogenous job destruction. We use a simplified version of her model to extend our understanding of reallocative behaviour, as summarized by the slope of the Beveridge curve and the correlation of job creation and job destruction. We explain the key role of hours variation in determining the timing of separations and thus the direction of reallocative activity. We also show that the improvement in the account of reallocative activity is driven by the response to monetary shocks.

These results appear to be interesting for several reasons. Our paper extends the scope of the New Keynesian literature on unemployment; there is considerable evidence that reallocative activity and microeconomic restructuring underlie business cycles and growth, see Davis et al. (1998), yet it is almost completely ignored in the New Keynesian literature on unemployment, even in those papers which allow endogenous job destruction. Secondly, the paper contributes to the literature on the timing of efficient reallocation. It shows that a plausible modification of a New Keynesian model with unemployment, to allow hours variation, while satisfying the Hosios condition, provides incentives for intertemporal substitution which can resolve the difficulties of the standard model with inelastic labour supply in capturing measures of reallocation based on gross job flows. Such a resolution may not be unique. Other authors have found that different features have similar effects in real business cycle and equilibrium labour market search frameworks, see Mortensen (1994) and Den Haan et al. (2000). Our mechanism is, to our knowledge, the first identified in a New Keynesian context and has the advantage that it can be easily embedded in the sort of small scale model typically used for monetary policy analysis, Gali (2003).[27]

Allowing realistic variation in hours leads to an improvement in the volatility of other more traditional macroeconomic aggregates such as unemployment, inflation and even wages. Our strategy of adjusting parameters to maintain the variability of job destruction and of output across experiments allows us to confirm, using a different methodology from Andres et al. (2006), that a New Keynesian model with frictions in price setting captures a large part of the volatility of unemployment. In a strict sense our model does not fit, since it is unable to match the data exactly for a number of labour market and other macroeconomic variables of interest (such as vacancies, unemployment, tightness, job creation, wages and inflation). Nevertheless, to the extent that one believes reallocative activity to be an important economic phenomenon, variation in hours provides a partial resolution of the inability of models without hours variation to account for key aspects of reallocative behaviour, and may provide the basis for future research into the role of monetary policy on unemployment and reallocation.

The lack of fit on various dimensions provides an avenue for future work.

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[27] An earlier version of this paper, Holt (2006), adopted a framework with capital accumulation. The results on the role of hours variation are similar to those discussed above. Unlike the real business cycle framework considered by Den Haan et al., capital accumulation itself does not alter incentives sufficiently to generate a negative job flows correlation in a New Keynesian environment when hours variation is suppressed.

Of particular concern are the properties of vacancies and job creation. Neither exhibits sufficient volatility or persistence and they are much more strongly associated than would be suggested by the data. One possible solution to the absence of vacancy persistence, which might break the tight link between vacancies and job creation, would be to introduce fixed costs of posting a vacancy, as in Fujita and Ramey (2007b). This might be done in conjunction with variation in worker bargaining power to raise the volatility of vacancies, see Hagedorn and Manowskii (2005). The behaviour of wages, which are too volatile, may be more problematic. Because of the high level of unemployment variability generated in the model (by nominal rigidities), it may not be possible to capture wage volatility using the now standard solution of an ad hoc wage norm, as in Hall (2005), Krause and Lubik (2007), without distorting unemployment and reallocative behaviour. This may point to a more fundamental revision of contractual foundations for wages in long-term relationships governed by search along the lines of Rudanko (2005). We leave these issues for future research.

Finally, in our framework, monetary shocks are less persistent than productivity shocks, and we argue the improvement in the account of reallocative activity is due to the value of varying hours rather than creating or destroying long term relationships given the temporary nature of the monetary disturbances. To shed further light on this issue, it might be interesting to examine the intensive and extensive margin responses to other shocks of differing degrees of persistence.

6 Appendix: Data and Calibration

6.1 Data

We attempt to match the second moments of seasonally adjusted quarterly US macroeconomic and labour market data. Unless otherwise indicated, the data used are available on the Bureau of Economic Analysis (BEA) website (http://www.bea.gov/) and Bureau of Labour Statistics (BLS) website (http://www.bls.gov/). As our measure of output we use seasonally adjusted GDP data from the BEA National Income and Product Accounts (NIPA); this data is expressed at an annualized rate in $billions. To express this in real per capita terms, we deflate first by the seasonally adjusted NIPA implicit GDP deflator (an indexed series with the year 2000=100) and then by the BLS non institutional civilian population aged 16 years and over (this series has the code LN300000000). The BLS population and labour market data that we use are observed at a monthly frequency. To obtain quarterly data we compute three-month arithmetic averages of these data. Our measure of inflation is the percentage change in the seasonally adjusted NIPA implicit GDP deflator. To estimate the properties of the money supply process we use seasonally adjusted data on the M1 monetary aggregate. This is taken from OECD Main Economic Indicators database with code US.MANMNM101.STSA.

The unemployment rate is the official BLS unemployment rate for those over 16, (code LNS14000000). The Conference-Board-Help-Wanted Index is used as our measure of vacancies. Quarterly gross job creation and job destruction data are available only for the manufacturing sector and are available from Haltiwanger's website (http://www.econ.umd.edu/~haltiwan/). We use the seasonally adjusted data on gross job creation and gross job destruction rates provided by Davis et al. (2006) and restrict our attention to the sample period, 1972:2-1993:4, in common with other studies of the role of job flows, to facilitate comparison.

Because of the sector-specific nature of the job flows data, there is an inherent tension in economy-wide analysis to the extent that job flows in the manufacturing sector are unrepresentative of the economy as a whole. To ensure consistency with the job flows series, we use BLS labour market data for the manufacturing sector for employment, wages and hours per worker. In particular we use BLS data on numbers of all employees in manufacturing (CES 3000000001), average hourly earnings of production workers (CES 3000000008) and weekly hours of production workers (CES 3000000007). Trigari (2005) considers non-farm business sector labour market data, which is less consistent with the job flows data, but is not at the same level of aggregation as output, price and unemployment data for the US economy as a whole. The data for manufacturing exhibit higher volatility than for the non-farm business sector, e.g. the standard deviation of Hodrick-Prescott filtered hours (relative to output) is around 0.35 for non-farm-business sector hours and is 0.55 for manufacturing hours.[28]

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[28] One source of controversy in the literature concerns data for total hours worked per capita. Economy wide data appear to exhibit a trend. If the hours per capita data contain a unit root, then authors may use differenced data in analysing the economy's response to a technology shock. This choice may determine the sign of the response to a technology shock; see Christiano et al. (2004), Gali (1999) for further discussion. However, the data (and the model simulated series) we use are HP-filtered which removes any (unwanted) trend before moments are calculated so this debate is of less direct relevance to our analysis.

6.2 Calibration

Those calibrated parameters of the model which are invariant across experiments are summarized in Table (1). Here we discuss the targets for those parameters and the values assigned to parameters which vary across experiments. We begin with a number of relatively uncontroversial parameters. The discount factor, β, is set to 0.99 to target an annual real interest rate of 4%. The elasticity of substitution between goods in the final goods sector is set at $\varepsilon = 21$ to give a markup of 5%, as in Jung and Kuester (2006). The value of ε is at the upper end of those found in the New Keynesian literature. It implies low final goods producers' profits, consistent with NIPA compensation data.

The severity of nominal price-setting frictions is governed by the parameters τ and ω. The first, τ, represents the fraction of those firms which set prices in any given period that do so in a backward-looking manner. The second, ω, determines the probability with which any given final good producer gets the opportunity to reset the price of the good. This determines the average duration of a newly set price. While we could set ω to whatever value is required to match inflation volatility, the implied price durations would be unreasonable. Instead, we set $\omega = 0.8$, which indicates that on average a newly set price lasts for 5 quarters before being reset. This is within the range of values considered reasonable from estimates of the underlying price adjustment model with aggregate data, Gali and Gertler (1999). Recent evidence from micro data, Bils and Klenow (2004), has suggested that prices may change more frequently, on average once every six months. This is difficult to rationalize in environments, such as ours, where the price setting and factor adjustment decisions are separated.[29] Given the separation assumption that we make, it is more appropriate to target the price duration estimates obtained from aggregate data. Following the evidence of Gali and Gertler (1999) and Christiano et al. (2005) and others we set $\tau = 0.5$. The deviation between model generated inflation and the data, gives an indication of model fit along this dimension.

We follow the standard approach in the literature and set, ρ_Z, the autocorrelation of aggregate productivity innovations in quarterly data to 0.95. We allow the standard deviation, σ_Z, of aggregate productivity shocks to vary across our experiments in order to target the standard deviation of output in the data over our sample period: $\sigma_Y = 0.0168$. In the inelastic labour supply

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[29] Altig (2005) and others have made progress, in reconciling the new micro price adjustment evidence with observed aggregate inflation dynamics, by extending the standard New Keynesian model to allow for firm specific capital adjustment decisions. Kuester (2007) integrates price setting, production and factor adjustment decisions in a single sector, but he only allows for exogenous job destruction.

case σ_Z takes the value 0.009, while in the elastic labour supply case its value is 0.021. In relation to money supply growth, we adopt the approach of Krause and Lubik (2007) and model growth in M1 as an $AR1$ process. These authors use the estimates provided by Cooley and Hansen (1989). For our sample period the estimate of the autocorrelation coefficient, $\rho_v = 0.5$, as in Cooley and Hansen (1989), while the standard deviation of the innovation process is, $\sigma_v = 0.004$. We set the elasticity of money demand with respect to consumption, $\xi = 1$, consistent with the estimates provided by Mankiw and Summers (1986). Then $\Upsilon_{\frac{M}{P}} = \frac{M}{PY}$ is set at 17, to target average income velocity of money over the sample period.

Next we turn to labour market parameters; we begin with relatively uncontroversial parameters concerning labour market flows and the parameters of the matching function. The average job destruction rate is set at 10% per quarter, $\lambda = 0.1$, following the evidence of Den Haan et al. (2000) and Shimer (2005). We follow Shimer (2005), Jung (2005) and others in targeting a steady state employment rate of $N = 0.94$, consistent with BLS estimates of the average unemployment rate.[30] To achieve our target, we set the probability of finding a job $p^U = 0.61$.[31] We follow Den Haan et al. (2000) in calibrating the probability of filling a vacancy, $p^V = 0.7$ to match US data. The scaling parameter of the matching function, $\mathfrak{M} = 0.654$ is chosen to target a matching function exponent of $\gamma = 0.5$. This lies within the range of plausible values discussed by Petrongolo and Pissarides (2001), who suggest $\gamma \in [0.3, 0.5]$. Following Den Haan et al. (2000), the fraction of jobs destroyed exogenously in steady state is set at $\lambda^x = 0.068$ to target a steady state job creation rate of 0.052, as estimated from plant level data by Davis et al. (1998). The rate of job destruction and job creation will be equal in steady state.

There is little formal evidence to guide the properties of the distribution of idiosyncratic shocks. We follow Den Haan et al. in assuming that idiosyncratic shocks are log-normally distributed, with mean $\mu_X = E[\ln X]$ and standard deviation σ_X. Rather than allow both μ_X and σ_X to vary across experiments, we follow the standard approach in the literature and fix μ_X. We then allow

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[30] Some authors, Andolfatto (1996), Trigari (2005) employ much lower values of steady state employment, 0.54 and 0.75 respectively. One justification for this approach is that it implicitly allows for the presence of transitions from employment to out of the labour force. However, it is then difficult to argue that one can match the properties of unemployment data. In addition, this approach may distort the cyclical properties of the model by allowing the size of the pool of unemployed individuals to remain stable in the face of shocks.

[31] This is higher than in Shimer (2005), Jung (2005). The reason is that in discrete time models with endogenous job destruction, following Den Haan et al. (2000), job destruction occurs prior to search and the number of searchers in steady state is given by $1 - (1 - \lambda) N$ rather than $1 - N$ as with exogenous destruction.

the standard deviation of idiosyncratic shocks, σ_X, to vary across experiments so as to match the variability of job flows in the data relative to that of output, σ_{JD}/σ_Y. Increases in μ_X raise σ_X. At low $\mu_X \approx 0$ the numerical integration over X that we use sometimes do not converge so here we set $\mu_X = -1.5$, but our results do not depend on this particular choice. In the elastic hours case σ_X takes the value 0.23, while in the elastic hours case it takes the value 0.8. Given μ_X, σ_X, λ and λ^x, we compute the job destruction threshold, $\bar{X}$, and then determine $\mathcal{F} = F\left(\bar{X}\right)^{-1} \int_0^{\bar{X}} Xf\left(X\right) dX$.[32] For the elastic labour supply case $\mathcal{F} = 0.22$, while it takes the value $\mathcal{F}$ =0.27 in the inelastic hours case.

There has been considerable discussion over the calibration of worker bargaining power, the match surplus (the profits over which both parties in a match bargain), and the value of a worker's outside option. Hagedorn and Manowskii (2005) argue that the results of Shimer (2005) on the failure of the canonical Mortensen-Pissarides model are sensitive to his calibration of these features.[33] Hagedorn and Manowskii (2005) show that the volatility of unemployment, vacancies and labour market tightness, key problems identified by Shimer, can be rectified by assigning a low value to the match surplus, a low bargaining power for workers as captured by η and a high value for the outside option (due implicitly to home production and the utility value of non-work) so as to give a small difference between the value of work and non-work. By contrast, Shimer adopts the standard Hosios condition $\eta = \gamma$ and assumes that a worker's outside option comprises only the value of unemployment benefits. Then to obtain sufficient variability in unemployment and vacancies, he introduces wage rigidity in an ad hoc manner.

For worker bargaining power, since we wish to examine the effect of hours variation on the slope of the Beveridge curve and the correlation between gross job flows in a constrained efficient environment, we assume that worker bargaining power satisfies the Hosios condition $\eta = \gamma = 0.5$. The free entry condition links the cost of vacancy creation to the match surplus (or more precisely the profit share attributable to matches). Jung (2005) argues that,

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[32] Because we allow idiosyncratic shocks to enter firms' profit functions additively, we include the constant, $\mathcal{F}$, to eliminate the effect of cost shocks on aggregate profits. In Krause and Lubik (2007), Walsh (2005) this does not arise because idiosyncratic shocks enter multiplicatively. We avoid the latter structure as it generates unreasonable idiosyncratic hours. In Trigari (2005) this concern does not arise because additive idiosyncratic shocks enter the utility function.

[33] Jung (2005) generalises Hagedorn and Manowskii's analysis to a real business cycle framework with capital, risk averse agents and hours choice. Both Hagedorn and Manowskii (2005) and Jung (2005) follow Shimer (2005) and suppress the endogenous job destruction that is key to our analysis.

unlike the vacancy posting cost, this profit share is directly observable, at least in principle (e.g. from NIPA compensation data). In his model, which lacks monopolistic competition, he suggests sensible values lie in the range $[0.002, 0.05]$. In our New Keynesian environment, with monopolistic competition, a figure of less than 1% seems plausible. This is consistent with the estimates of Jung and Kuester (2006). Consequently we set vacancy costs, $\kappa = 0.034$, to target a profit share attributable to matches of 0.5%.

Shimer (2005) adopts a value for the outside option of 40% of labour income, based on the role of benefits alone. Krussell et al. (2005) argue that such a figure is likely to overstate the value of unemployment benefits. They suggest that the evidence favours an upper bound of 20% of labour income. As Hagedorn and Manowskii (2005), Jung (2005) argue, rather than the replacement ratio implied by benefits per se, it is the difference between the value of work and of non-work that is of critical importance for the amplitude of unemployment fluctuations. The value of non-work may include formal unemployment benefits and the value of home production and leisure. Jung (2005) shows that realistic unemployment variation may arise despite relatively low formal unemployment benefits. Our approach implicitly sets benefits equal to zero and allows the value of leisure to determine the worker's outside option.

When individuals are risk averse and hours of employment can vary, then the parameters ϕ and ψ, governing the intertemporal and intratemporal elasticities of substitution can affect the value of a worker's outside option. To avoid the use of ϕ, the inverse of the elasticity of substitution, as a free parameter, we normalize $\phi = 1$. This normalisation is appropriate since we use σ_Z to pin down the variability of output and equilibrium requires that $C_t = Y_t$. In any case, utility logarithmic in consumption is easily justifiable as a target on the basis of microeconometric and macroeconomic evidence. Reichling (2007) claims that unemployed workers spend on average as little as three minutes per week engaged in job search. We set hours worked as a fraction of the time endowment as $H = 0.33$. We set $e = 0.01H$ which means search occupies around 5 minutes. Then we vary ψ across experiments and allow the value of leisure to vary as a result, with the first order condition for hours determining Υ_H to ensure that steady state hours take the value $H = 0.33$. Then Υ_H is 1.38 in the elastic labour supply case and 5.88×10^{-35} in the inelastic labour supply case. We normalize steady state consumption to unity. Then A, the scaling parameter on the production function takes the value 3.58 in the elastic labour supply case and 3.55 under inelastic labour supply.

References

[1] Altig, D., L. J. Christiano, M. Eichenbaum, and J. Linde, (2005), "Firm Specific Capital, Nominal Rigidities and the Business Cycle." NBER Working Paper 11034.

[2] Andolfatto, D., (1996), "Business Cycles and Labor Market Search." *American Economic Review*, **86** (1), pp. 112-132.

[3] Andres, J., R. Domenech, and J. Ferri, (2006), "Price Rigidity and the Volatility of Vacancies and Unemployment." University of Valencia, Institute of International Economics, Working Paper #601.

[4] Bils, M., and P. Klenow, (2004), "Some Evidence on the Importance of Sticky Prices." *Journal of Political Economy,* **112** (5), pp. 947-985.

[5] Blanchard, O. J., and J. Gali, (2006), "A New Keynesian Model with Unemployment." National Bank of Belgium, Research Series, #2006-10.

[6] Blundell, R., and T. MaCurdy, (1999), "Labor Supply: A Review of Alternative Approaches." in O. Ashenfelter and D. Card (Eds.), *Handbook of Labor Economics*, Vol. 3.1. North Holland, Amsterdam.

[7] Braun, H., (2006), "(Un)employment Dynamics: The Case of Monetary Policy Shocks." http://www.econ.ubc.ca/ine/Braun/braunhm.htm.

[8] Chari, V. V., P. J. Kehoe, and E. R. McGrattan, (2000), "Sticky Price Models of The Business Cycle: Can The Contract Multiplier Solve the Persistence Problem." *Econometrica*, **68**, (5), pp. 1151-1179.

[9] Cho, J-O., and T. F. Cooley, (1994), "Employment and Hours over the Business Cycle." *Journal of Economic Dynamics and Control*, **18**, pp. 411-432.

[10] Christiano, L. J., M. Eichenbaum, and C. Evans, (2005), "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy*, **113**, (1), pp. 1-45.

[11] Christiano, L. J., M. Eichenbaum, and R. Vigfusson (2004), "The Response of Hours to a Technology Shock: Evidence Based on Direct Measures of Technology." NBER Working Paper, #10254.

[12] Christoffel, K., and T. Linzert, (2005), “The role of real wage rigidity and labor market frictions for unemployment and inflation dynamics.” ECB Working Paper #556.

[13] Christoffel, K., T. Linzert, and K. Kuester, (2006), “Identifying the Role of Labor Markets for Monetary Policy in an Estimated DSGE model.” ECB Working Paper #635.

[14] Cogley, T., and J. Nason, (1995), “Output Dynamics in Real Business Cycle Models.” *American Economic Review*, **85**, pp. 492-511.

[15] Cooley, T. F., and G. Hansen, (1989), “Inflation Tax in a Real Business Cycle Model.” *American Economic Review*, **79** (4), pp. 733-748.

[16] Cooley, T. F., and V. Quadrini, (1999), “A Neoclassical Model of the Phillips Curve Relation.”, *Journal of Monetary Economics*, **44**, (2), pp.165-193.

[17] Davis, S. J., R. J. Faberman, and J. C. Haltiwanger, (2006), “The Flow Approach to Labor Markets: New Data Sources and Micro-Macro Links.” *Journal of Economic Perspectives*, **20** (3) pp.

[18] Davis, S. J., and J. C. Haltiwanger, (1999), “On the Driving Forces Behind the Cyclical Movements in Employment and Job Reallocation.” *American Economic Review,* **89** (5), pp. 1234-1258.

[19] Davis, S. J., J. C. Haltiwanger, and S. Schuh, (1998), *Job Creation and Destruction*, MIT Press, Cambridge MA.

[20] Den Haan, W. J., G. Ramey, and J. Watson, (2000), “Job Destruction and the Propagation of Shocks.” *American Economic Review*, **90**, (3), pp. 482-498.

[21] Elsby, M., R. Michaels, and G. Solon, (2007), “The Ins and Outs of Cyclical Unemployment.” NBER Working Paper #12853.

[22] Faia, E., (2007), “Optimal Monetary Policy Rules with Labor Market Frictions.” Forthcoming *Journal of Economic Dynamics and Control.*

[23] Fujita, S., and G. Ramey, (2007a), “Reassessing the Shimer Facts.” Federal Reserve Bank of Philadelphia, Working Paper #07-02.

[24] Fujita, S., and G. Ramey, (2007b), “Vacancy Persistence.” *Journal of Economic Dynamics and Control*, **31** (11), pp. 3671-3698.

[25] Gali, J., (1999), "Technology Shocks, Employment and The Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations?" *American Economic Review*, **89**, (1), pp. 249-271.

[26] Gali, J., (2003), "New Perspectives on Monetary Policy, Inflation and the Business Cycle." in M. Dewatripont, L. Hansen, and S. Turnovsky (Eds.), *Advances in Economic Theory*, Cambridge University Press, Cambridge, UK.

[27] Gali, J., and M. Gertler, (1999), "Inflation Dynamics: A Structural Econometric Analysis." *Journal of Monetary Economics*, **44**, pp. 195-222.

[28] Hagedorn, M., and I. Manowskii, (2005), "The Cyclical Behaviour of Unemployment and Vacancies Revisited." mimeo University of Pennsylvania.

[29] Hall, R. E., (2005), "Employment Fluctuations and Equilibrium Wage Stickiness." *American Economic Review*, **95**, (1), pp. 50-65.

[30] Holt, R. W. P., (2006), "Whither Job Destruction? Unemployment, Job Flows and Hours in a New Keynesian Model." Edinburgh School of Economics Discussion Paper #146.

[31] Jung, P., (2005), "Capital, Unemployment and Hours - on the Quantitative Performance of a DGE Labor Market Model." http://www.wiwi.uni-frankfurt.de/~pjung/.

[32] Jung, P., and K. Kuester, (2006), "Unemployment Fluctuations with Complete and Incomplete Insurance." http://www.wiwi.uni-frankfurt.de/~pjung/.

[33] Kuester, K., (2007), "Real Price and Wage Rigidities in a Model with Matching Frictions." ECB Working Paper #720.

[34] Klein, P., (1997), "Using the Generalized Schur form to Solve Systems of Linear Expectational Difference Equations." *Journal of Economic Dynamics and Control,* **24**, pp. 1405-1423.

[35] Krause, M., and T. A. Lubik, (2007), "The (Ir)relevance of Real Wage Rigidity in the New Keynesian Model with Search Frictions." *Journal of Monetary Economics*, **54**, (3), pp. 706-727.

[36] Krussell, P., A. Hornstein, and G. L. Violante, (2005), "Unemployment and Vacancy Fluctuations in the Matching Model: Inspecting the Mechanism." *Federal Reserve Bank of Richmond Quarterly*, **91**(3)**,** pp. 19-51.

[37] Mankiw, N. G., and L. H. Summers, (1986), "Money Demand and The Effects of Fiscal Policies." *Journal of Money Credit and Banking*, **18** (4) pp. 415-429.

[38] McCallum, B. T., (1999), "Solutions to Linear Rational Expectations Models: A Compact Exposition." *Economics Letters,* **61**, pp. 143-147.

[39] Merz, M., (1995), "Search in the Labor Market and the Real Business Cycle." *Journal of Monetary Economics*, **36**, (2), pp. 269-300.

[40] Mortensen, D. T., (1994), "The Cyclical Behaviour of Job and Worker Flows." *Journal of Economic Dynamics and Control,* **18**, (6), pp. 1121-1142.

[41] Mortensen, D. T., and C. A. Pissarides, (1993), "The Cyclical Behavior of Job Creation and Job Destruction." in J. C. Ours, G.A. Pfann, and G. Ridder, (Eds.), *Labor Demand and Equilibrium Wage Formation*, North-Holland, Amsterdam.

[42] Mortensen, D. T., and C. A. Pissarides, (1994), "Job Creation and Job Destruction in the Theory of Unemployment." *Review of Economic Studies*, **61**, pp. 397-415.

[43] Moyen, S., and J-G. Sahuc, (2005), "Incorporating Labour Market Frictions into an Optimizing Monetary Model." *Economic Modelling,* **22**, (1), pp. 159-186.

[44] Petrongolo, B., and C. A. Pissarides, (2001), "Looking into the Black Box: A Survey of the Matching Function." *Journal of Economic Literature*, **39**, (2), pp. 390-431.

[45] Reichling, F., (2007), "Optimal Unemployment Insurance in Labor Market Equilibrium when Workers can Self-insure." http://mpra.ub.uni-muenchen.de/view/people/Reichling,_Felix.html.

[46] Rudanko, L., (2005), "Labor Market Dynamics Under Long-Term Contracting." http://people.bu.edu/rudanko.

[47] Shimer, R., (2005), "The Cyclical Behaviour of Unemployment and Vacancies." *American Economic Review*, **95**, (1), pp. 25-49.

[48] Thomas, C., (2006), "Search and Matching Frictions and Optimal Monetary Policy." CEP Discussion Paper #2006-12.

[49] Trigari, A., (2005), "Equilibrium Unemployment, Job Flows and Inflation Dynamics." http://www.igier.unibocconi.it/whos.php?vedi=1686&tbn=albero&id_folder=177.

[50] Trigari, A., (2006), "The Role of Search Frictions and Bargaining for Inflation Dynamics." IGIER Working Paper No. 304.

[51] Walsh, C. E., (2005), "Labor Market Search, Sticky Prices and Interest Rate Policies." *Review of Economic Dynamics,* **8,** (4), pp. 829-849.

[52] Woodford, M., (2003), *Interest and Prices,* Princeton University Press.