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Federico Di Pace
Matthias S. Hertweck

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Labour Market Frictions, Monetary Policy and Durable Goods*

Federico Di Pace† University of Warwick

Matthias S. Hertweck‡ University of Konstanz

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Abstract

The standard two-sector monetary business cycle model suffers from an important deficiency. Since durable good prices are more flexible than non-durable good prices, optimising households build up the stock of durable goods at low cost after a monetary contraction. Consequently, sectoral outputs move in opposite directions. This paper finds that labour market frictions help to understand the so-called sectoral "comovement puzzle". Our benchmark model with staggered *Right-to-Manage* wage bargaining closely matches the empirical elasticities of output, employment and hours per worker across sectors. The model with *Nash bargaining*, in contrast, predicts that firms adjust employment exclusively along the extensive margin.

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†Contact Address: University of Warwick, Department of Economics, Coventry, CV4 7AL, United Kingdom. Email: f.dipace@warwick.ac.uk , Homepage: http : //www2.warwick.ac.uk/fac/soc/economics/

‡Contact Address: University of Konstanz, Department of Economics, Box 145, 78457 Konstanz, Germany. Email: matthias.hertweck@uni − konstanz.de, Homepage: http : //www.hertweck.org/

1 Introduction

The seminal work of Barsky, House & Kimball (2007) demonstrates that a two-sector monetary business cycle model with *Walrasian labour markets* suffers from an important deficiency. Based on the microeconometric evidence provided by Bils & Klenow (2004) and Klenow & Kryvtsov (2008), the authors assume that prices of non-durable goods and services change only infrequently, while durable good prices are perfectly flexible. Consequently, after a monetary contraction, durable good prices fall stronger than non-durable good prices. The asymmetric price dynamics incentivise the representative household to build up the stock of durable goods and to reduce the consumption of non-durable goods. For this reason, the model predicts that sectoral outputs move in opposite directions, which implies that monetary policy shocks are close to neutral for *aggregate* output. This outcome is clearly at odds with the data.

We show that labour market frictions help to understand the so-called sectoral "comovement puzzle". Optimising households increase durable good expenditure only if durable good prices fall sharply. As durable good prices are perfectly flexible, this requires that real marginal costs in the durable sector are sufficiently elastic. In other words, the model with Walrasian labour markets fails to generate sectoral comovement because real marginal costs in the durable sector are too elastic (Carlstrom & Fuerst 2010). In this paper, we argue that labour market frictions are able to reduce the elasticity of real marginal costs along two dimensions. First, through the presence of job search and matching frictions (Pissarides 2000). Second, by the impact of staggered Right-to-Manage wage bargaining (Christoffel & Kuester 2008) — a sequential bargaining protocol where nominal wages are negotiated before firms may choose the number of hours per worker unilaterally.

The introduction of job search and matching frictions is motivated by the results from a structural vector autoregression (SVAR) model. Our SVAR documents that a contractionary monetary policy shock causes a persistent economic downturn across the entire economy. In both sectors, output, employment and hours per worker fall significantly. In contrast to the previous literature, our model with job search and matching frictions is able to address the decline in labour input along both margins explicitly. Furthermore, we confirm the finding of Erceg & Levin (2006) that, in the durable sector, output and employment respond much stronger — although the durable good price index falls sharper than the price index of non-durable goods and services. Rather, the high sensitivity of the durable sector is driven by the longevity of durable goods (Bils, Klenow & Malin 2012). Since durable goods depreciate only slowly, current purchases constitute only a small proportion of the aggregate stock. This explains why the durable sector accounts for more than 50% of the variance in aggregate labour input, but only for less than 20% of all employees.

Our benchmark model with staggered Right-to-Manage wage bargaining is able (*i*) to generate positive comovement between the durable and the non-durable sector, (*ii*) to replicate the high elasticity of durable output relative to non-durable output and (*iii*) to match the empirical pattern of labour adjustment along the extensive and intensive margins after a contractionary monetary policy shock. Right-to-Manage wage bargaining (Trigari 2006) establishes a direct link between the nominal wage rate and the real marginal cost. For this reason, any stickiness in nominal wages directly reduces the elasticity of real marginal costs (the so-called "wage channel", see Christoffel & Kuester 2008). Thus, staggered Right-to-Manage wage bargaining is able to generate a large contraction in durable production even at a moderate degree of nominal wage stickiness, in line with the empirical evidence documented by Gottschalk (2005).

Moreover, we investigate the impact of the specific wage bargaining protocol, the importance of labour mobility across sectors and the role of hiring firms' profits for the quantitative performance of our model. First, when nominal wages are set by Nash (1953) bargaining, the model successfully generates sectoral comovement — even if nominal wages are fully flexible. However, the model version with Nash bargaining predicts that firms adjust labour input exclusively along the extensive margin. Second, we find that our model generates sufficient stickiness in durable real marginal costs only if job searchers are mobile across sectors.[1] In this case, the non-arbitrage condition for vacancy creation equalises real marginal costs in both sectors. Consequently, stickiness originating in the non-durable sector may be transmitted to the durable sector. Third, we show that the elasticity of employment depends on the elasticity of hiring firms' profits. Thus, when hiring firms' are small, any given monetary policy shock is "leveraged" into large employment fluctuations.[2] Otherwise, as hiring firms may set the number of hours per worker unilaterally, Right-to-Manage wage bargaining gives rise to excessive labour adjustment along the intensive margin. The latter finding is consistent with the conclusion by Christoffel & Kuester (2008) in a one-sector monetary business cycle model.

In recent years, the sectoral comovement puzzle has sparked a large number of investigations[3]. However, to our knowledge, no study has yet examined the impact of job search and matching frictions in this context. Building on Iacoviello (2005), Monacelli (2009), Iacoviello & Neri (2010) and Sterk (2010) show that the introduction of collateral constraints reduces the households' ability to smooth consumption. Bouakez, Cardia & Ruge-Murcia (2009, 2011) assert that non-durable (durable) goods account for almost 50% (about 10%) of the material input expenditure by the durable (non-durable) sector. Therefore, they introduce an input-output structure that syncronises economic activity across sectors. Carlstrom & Fuerst (2010) evaluate the impact of nominal wage stickiness in a two-sector version of the model by Erceg, Henderson & Levin (2000). Yet, the model is unable to replicate the long-lived decline in durable production unless two additional modifications (i.e.; output adjustment costs in durable goods as well as habit formation in non-durable consumption goods and services from durable goods) are considered.

The remainder of this paper is organised as follows. Section (2) provides empirical evidence on the cross-sectoral effects of a contractionary monetary policy shock. Section (3) presents the model environment. Section (4) calibrates the model and evaluates its quantitative performance. Section (5) concludes.

[1] This assumption seems reasonable, given the high degree of inter-industry mobility of workers in the U.S. — as documented by Kambourov & Manovskii (2008) and Herz & van Rens (2011).

[2] A similar argument was made by Hagedorn & Manovskii (2008) in a search economy subject to technology shocks.

[3] Further contributions include Kitamura & Takamura (2008) who consider a model with sticky information; Katayama & Kim (2010) who evaluate the impact of non-separable preferences; Tsai (2010) who studies a model with working capital and habit formation; DiCecio (2009) develops a medium-scale DSGE models with nominal wage stickiness; and Levin & Yun (2011) who analyse a model with preference shocks to leisure and incomplete financial markets.

2 Empirical Evidence

This section provides empirical evidence on the cross-sectoral effects of a contractionary monetary policy shock. We estimate a SVAR model using the identification scheme developed by Christiano, Eichenbaum & Evans (1996). The following variables are included in the information set: the growth rate in the relative price of durable goods, $\Delta p_{d,t}$, the relative hourly wage of workers in the durable sector, $\omega_{d,t}$, the inflation rate in the non-durable sector, $\pi_{c,t}$, the employment rate in the non-durable sector, $n_{c,t}$, the employment rate in the durable sector, $n_{d,t}$, hours per worker in the non-durable sector, $h_{c,t}$, hours per worker in the durable sector, $h_{d,t}$, output per capita in the non-durable sector, $y_{c,t}$, output per capita in the durable sector, $y_{d,t}$ and the Federal Funds rate, R_t. Our sample period covers US data between 1964Q1 and 2007Q4.[4] Precise definitions can be found in the Appendix (Tables 1 and 2).

2.1 Identification & Estimation

We consider the following reduced-form VAR:

$$\begin{aligned}
x_t &= a + B(L)x_{t-1} + e_t, \\
x_t &= \begin{bmatrix} z_t & R_t \end{bmatrix}', \\
z_t &= \begin{bmatrix} \Delta p_{d,t} & \omega_{d,t} & \pi_{c,t} & n_{c,t} & n_{d,t} & h_{c,t} & h_{d,t} & y_{c,t} & y_{d,t} \end{bmatrix}',
\end{aligned}$$

where $B(L)$ is a lag polynomial of order M. By premultiplying with β_0, we obtain the structural VAR:

$$\beta_0 x_t = \alpha + \beta(L)x_{t-1} + \epsilon_t,$$

where ϵ_t denotes the vector of fundamental shocks. The orthogonality assumption implies that its covariance matrix $V_\epsilon = E(\epsilon_t' \epsilon_t)$ is diagonal. Moreover, we normalise the diagonal of β_0 to a 10x1 vector of ones. When estimating the SVAR, we also include constant terms and a linear trend. Following the AIC rule (with $M_{max} = 6$), the VAR order is set to $M = 3$.[5]

Our identification strategy is based on short-run restrictions. In particular, we impose that the Fed's information set includes the contemporaneous values of all other variables in our SVAR (Christiano et al. 1996). This assumption implies that no other variable may respond contemporaneously to an unexpected change in the Federal Funds rate. Consequently, the process for the Federal Funds rate depends on the current and past values of all other variables, but no other process depends on its current realisations. Hence, the last column of the contemporaneous coefficient matrix β_0 consists of zeros, apart from the last element which is normalised to unity. The order of the variables included in the vector z_t imposes a number of additional short-run restrictions.

[4] The endpoint of our sample marks the start of the Great Recession when the Federal Reserve adopted several unconventional monetary policy measures, which are unlikely to be appropriately captured by our identification procedure.

[5] None of our results are sensitive to the specific estimation strategy.

2.2 Results

Figure (1) illustrates the Cholesky orthogonalised impulse responses to an unexpected increase in the Federal Funds rate. We examine a one-standard-deviation shock at horizons up to 16 quarters. The blue solid line is the point estimate. The red dashed lines represent the associated two-standard-deviation confidence interval. In line with our identifying assumptions, the impact of the monetary policy shock is temporary. After the initial increase, we find that the Federal Funds rate remains above its steady state level for about six quarters. In response to the hike in the nominal interest rate, we notice a delayed but persistent decline in the inflation rate of non-durable prices (Sims 1992).

Our SVAR documents that a contractionary monetary policy shock causes a persistent economic downturn across the entire economy. In both sectors, output and labour input fall significantly. In particular, we find that labour input contracts along the extensive and the intensive margin. Furthermore, we confirm the result of Erceg & Levin (2006) that, in the durable sector, output and employment respond significantly stronger — output by factor six and employment by factor three[6] — although the durable good price index falls sharper than the price index of non-durable goods and services. Rather, the high sensitivity of the durable sector is driven by the longevity of durable goods (Bils et al. 2012). Since durable goods depreciate only slowly, current purchases constitute only a small proportion of the aggregate stock. This explains why the durable sector accounts for more than 50% of the variance in aggregate labour input, but only for less than 20% of all employees. Besides, we note that the relative wage of workers in the durable sector remains virtually unchanged.

3 The Model

We introduce labour search and matching frictions into a two-sector monetary business cycle model akin to Barsky et al. (2007). Individual household members derive utility from a composite consumption good and leisure. The composite consumption good is defined as an aggregate of non-durable consumption goods and the flow of services from the stock of durable goods. Both non-durable consumption and durable expenditure are CES aggregates of differentiated goods. These goods are produced by sector-specific monopolistically competitive good firms, facing Calvo (1983) type restrictions at the retail level. The factor market for labour services, instead, is assumed to be perfectly competitive. Labour services are provided by sector-specific hiring firms searching for workers on frictional labour markets. The nominal wage rate is determined by staggered Right-to-Manage bargaining Christoffel & Kuester (2008). This sequential bargaining protocol assumes that the nominal wage rate is negotiated before the hiring firm may choose the number of hours per worker unilaterally (Trigari 2006).

3.1 The Labour Market

At the beginning of period t, the share u_t of the labour force (which is normalised to unity) searches for employment opportunities in both sectors. Along with them, there is an infinite

[6] For the reader's convenience, the scale of all variables concerning the durable sector is multiplied by factor three.

mass of sector-specific hiring firms with unfilled positions. Each hiring firm can hire at most one worker. Hiring firms with an unfilled position may decide whether or not to post a vacancy, where posting a vacancy entails a cost. Let $v_{c,t}$ and $v_{d,t}$ denote the number of vacancies that are posted by hiring firms in the non-durable (c) and durable (d) sectors respectively. The number of newly formed firm-worker pairs is given by a Cobb-Douglas matching function with constant returns to scale. The matching function relates aggregate job matches m_t to the number of aggregate vacancies $v_t = v_{c,t} + v_{d,t}$ and the number of job searchers u_t in the labour market:

$$m\left(v_t, u_t\right) = \bar{m} v_t^{\xi} u_t^{1-\xi},$$

where ξ denotes the elasticity of the matching function with respect to aggregate vacancies and $\bar{m}_s$ is the efficiency of the matching process. By linear homogeneity of the matching function, the aggregate job finding rate $p(\theta_t)$ and the aggregate vacancy filling rate $q(\theta_t)$ depend only on the value of aggregate labour market tightness ($\theta_t = v_t/u_t$):

$$p(\theta_t) = \frac{m_t}{u_t} = \theta_t \frac{m_t}{v_t} = \theta_t q(\theta_t).$$

Note that the tighter the aggregate labour market, the longer the expected time to fill a vacancy, but the shorter the expected time searching for a job (and vice versa). We assume that job searchers are randomly matched with vacancies of either kind. Hence, the aggregate job finding rate equals the sum of the sectoral job finding rates:

$$p(\theta_t) = \frac{m_t}{u_t}\left(\frac{v_{c,t}}{v_t}\right) + \frac{m_t}{u_t}\left(\frac{v_{d,t}}{v_t}\right) = p(\theta_{c,t}) + p(\theta_{d,t}),$$

where $\theta_{s,t} = v_{s,t}/u_t$ is the sector-specific measure of labour market tightness. Furthermore, given free entry into the labour market, random matching entails that the vacancy filling rate is equalised across sectors:

$$q\left(\theta_{s,t}\right) = \frac{v_{s,t}}{v_t}\frac{m\left(v_t, u_t\right)}{v_{s,t}} = q\left(\theta_t\right).$$

Following Ravenna & Walsh (2008) and Blanchard & Gali (2010), we impose that new matches become immediately productive.[7] Moreover, at the end of period t, a constant share ρ_s ($s = \{c, d\}$) of pre-existing employment relationships is terminated.[8] The evolution of sectoral employment $n_{s,t}$ is therefore governed by:

$$n_{s,t} = \frac{v_{s,t}}{v_t} m\left(v_t, u_t\right) + \left(1 - \rho_s\right) n_{s,t-1}. \tag{1}$$

[7] As demonstrated by Thomas & Zanetti (2009), it is reasonable to assume instantaneous matching in models that are calibrated to a quarterly frequency.

[8] As shown by Shimer (2012), Fujita & Ramey (2009) and Hertweck & Sigrist (2012) most of the cyclical variation in employment in the U.S. is due to job creation rather than job separation. Thus, for simplicity, we assume that all separations are exogenous.

Accordingly, the number of job searchers at the beginning of period t equals the share of individuals who did not have a job in the previous period, $1 - n_{c,t-1} - n_{d,t-1}$, minus the flow of workers who have just lost their job, $\rho_c n_{c,t-1} + \rho_d n_{d,t-1}$:

$$u_t = 1 - (1 - \rho_c)\, n_{c,t-1} - (1 - \rho_d)\, n_{d,t-1}. \tag{2}$$

3.2 Households

There is a large number of identical households with unit measure, each of which consists of a continuum of individuals. The members of the representative household are either employed by sector-specific hiring firms or search for a job in the labour market. The expected life-time utility of an individual household member j can be represented by:

$$\mathcal{H}^j_{s,t} = E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[\frac{\left(\mathcal{C}^j_\tau\right)^{1-\sigma} - 1}{1-\sigma} - \chi_s \frac{\left(h^j_{s,\tau}\right)^{1+\varrho_s}}{1+\varrho_s} \right] = E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \mathcal{I}^j_{s,\tau},$$

where E_t is the expectations operator conditional on period t information, $\beta \in (0,1)$ is the discount factor, $\mathcal{C}^j_t$ is the composite consumption good, σ is the inverse of the elasticity of intertemporal substitution, χ_s is the utility cost parameter in sector-specific labour supply, $h^j_{s,t}$ is the number of hours worked by an employed individual j in sector s and ϱ_s denotes the labour supply elasticity along the intensive margin of individuals employed in sector s. The period utility of an individual household member j is summarised by $\mathcal{I}^j_{s,t}$.

3.2.1 The Composite Consumption Good

The composite consumption good consists of a CES aggregate of non-durable consumption goods, c^j_t and the flow of services from the stock of durable goods, d^j_t:

$$\mathcal{C}^j_t = \left(c^j_t\right)^{\zeta} \left(d^j_t\right)^{1-\zeta},$$

where ζ is the steady-state share of non-durable consumption.[9] In the limit, when σ goes to 1, the period utility of an individual household member j, $\mathcal{I}^j_{s,t}$, becomes separable in non-durable consumption, the flow of durable services and sectoral hours:

$$\mathcal{I}^j_{s,t} = \zeta \ln c^j_t + (1-\zeta) \ln d^j_t - I_N \left[\chi_s \frac{\left(h^j_{s,t}\right)^{1+\varrho_s}}{1+\varrho_s} \right],$$

where I_N is an indicator function equal to zero if the individual household member j is unemployed and otherwise equal to one.

[9] The results of our paper remain unchanged when durable and non-durable goods are assumed to be complements. Only in the extreme case when durable and non-durable goods are near-Leontief, the model of Barsky et al. (2007) is able to generate comovement across sectors. Such a high degree of complementarity, however, cannot be found in the data (Bernanke 1984).

Non-durable consumption is a CES aggregate of differentiated non-durable goods:

$$c_t^j = \left[\int_0^1 \left(c_t^{ji} \right)^{1-1/\epsilon_c} di \right]^{1/(1-1/\epsilon_c)}, \tag{3}$$

where $\epsilon_c > 1$ denotes the intra-temporal elasticity of substitution among individual varieties of non-durable goods c_t^{ji}. Given that $P_{c,t}^i$ denotes the nominal price of the non-durable good i, expenditure minimisation implies that its relative demand is given as:

$$c_t^{ji} = \left(\frac{P_{c,t}^i}{P_{c,t}} \right)^{-\epsilon_c} c_t^j. \tag{4}$$

By integrating equation (4) and imposing (3), we obtain the associated price index of non-durable consumption:

$$P_{c,t} = \left[\int_0^1 \left(P_{c,t}^i \right)^{1-\epsilon_c} di \right]^{1/(1-\epsilon_c)}.$$

Newly acquired durable goods, x_t^j, are represented by a CES aggregate of differentiated new durable goods:

$$x_t^j = \left[\int_0^1 \left(x_t^{ji} \right)^{1-1/\epsilon_d} di \right]^{1/(1-1/\epsilon_d)}, \tag{5}$$

where $\epsilon_d > 1$ denotes the intra-temporal elasticity of substitution among varieties of new durable goods x_t^{ji}. The law of motion for the aggregate stock of durable goods is given by:

$$x_t^j = d_t^j - (1-\delta)\, d_{t-1}^j, \tag{6}$$

where δ denotes the depreciation rate of the stock of durable goods. Given that $P_{d,t}^i$ denotes the nominal price of the durable good i, expenditure minimisation implies that the relative demand for the durable-good variety x_t^{ji} is given as:

$$x_t^{ji} = \left(\frac{P_{d,t}^i}{P_{d,t}} \right)^{-\epsilon_d} x_t^j. \tag{7}$$

By integrating equation (7) and imposing (5), we obtain the associated price index of newly acquired durable goods:

$$P_{d,t} = \left[\int_0^1 \left(P_{d,t}^i \right)^{1-\epsilon_d} di \right]^{1/(1-\epsilon_d)}.$$

3.2.2 Evolution of Sectoral Employment

From the perspective of the representative household, aggregate employment in sector s evolves according to:

$$n_{s,t} = (1-\rho_s)\, n_{s,t-1} + \theta_{s,t} q\left(\theta_{s,t}\right) u_t \quad \text{for} \quad s = \{c, d\}, \tag{8}$$

where the sectoral job finding rate, $\theta_{s,t} q\left(\theta_t\right)$, is exogenous to the household's decision problem.

3.2.3 Budget Constraint

Following Merz (1995) and Andolfatto (1996), we assume that employed and unemployed household members insure each other completely against idiosyncratic income risk from unemployment. Thus, the nominal budget constraint of the representative household reads as:

$$P_{c,t}c_t + P_{d,t}x_t + B_t = R_{t-1}B_{t-1} + \sum_{s=\{c,d\}} \left[\int_0^{n_{s,t}} W_{s,t}^j h_{s,t}^j dj + \Phi_{s,t} \right] + (1 - n_{c,t} - n_{d,t}) P_{c,t}\bar{b} - \bar{T}_t. \quad (9)$$

Employed household members earn the nominal sector-specific wage rate $W_{s,t}^j$ per working hour $h_{s,t}^j$, while the share of unemployed household members, $(1 - n_{c,t} - n_{d,t})$, receives nominal unemployment benefits $P_{c,t}\bar{b}$. The lump-sum transfer T_t imposed by the government finances unemployment benefits and rebates any seigniorage revenue to the representative household (see Section 3.6). Nominal risk-free government bonds, B_t, pay a nominal interest rate, R_t, in period $t+1$. Moreover, the representative household receives lump-sum dividends, $\Phi_{c,t}$ and $\Phi_{d,t}$, remitted by retail and hiring firms in both sectors.

3.2.4 First Order Conditions

The representative household maximises the unweighted expected life-time utilities of its individual household members, $\int_0^1 \mathcal{H}_{s,t}^j dj$, subject to the evolution of sectoral employment (8), the budget constraint (9), a set of initial conditions for the state variables $\{d_0,\ n_{s,0},\ W_{s,0}\}$ and a stochastic time path for R_t. The representative household takes all aggregate variables as given. Therefore, the choices with respect to c_t, B_t and d_t have to satisfy the following first order conditions:

$$\lambda_t = \zeta \frac{\mathcal{C}_t^{1-\sigma}}{c_t}, \quad (10)$$

$$\frac{1}{R_t} = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \frac{P_{c,t}}{P_{c,t+1}}, \quad (11)$$

$$\lambda_t \varphi_{d,t} = \frac{(1-\zeta)\, \mathcal{C}_t^{1-\sigma}}{d_t} + \beta (1-\delta) E_t \lambda_{t+1} \varphi_{d,t+1}, \quad (12)$$

where λ_t is the Lagrange multiplier associated with the budget constraint (9) and $\varphi_{d,t} = P_{d,t}/P_{c,t}$ is the (real) price of durable goods relative to the price of non-durable goods. We define gross inflation in sector s as $\pi_{s,t} = P_{s,t}/P_{s,t-1}$. The first order conditions describe the marginal utility of the composite consumption good (equation 10), the standard Euler equation for government bonds (equation 11) and the asset pricing equation for durable goods (equation 12). By forward iteration of equation (12), we can express the relative price of durable goods as the present discounted value of future rents generated by services from the stock of durable goods.

3.2.5 The Net Marginal Value of Employment

The net marginal value of employment to the representative household is given by:

$$\begin{aligned} \mathcal{W}_{s,t}\left(W_{s,t}^{j}\right) &= \frac{W_{s,t}^{j}}{P_{c,t}} h_{s,t}^{j} - \left[b + \frac{\chi_s}{\lambda_t} \frac{\left(h_{s,t}^{j}\right)^{1+\varrho_s}}{1+\varrho_s} \right] + \\ &+\beta\left(1-\rho_s\right) E_t \frac{\lambda_{t+1}}{\lambda_t} \left\{ \tilde{\vartheta}_s \mathcal{W}_{s,t+1}\left(W_{s,t}^{j}\right) + \left(1-\tilde{\vartheta}_s\right) \mathcal{W}_{s,t+1}\left(W_{s,t+1}^{*}\right) \right\} \\ &-\beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \sum_{l=\{c,d\}} \left(1-\rho_l\right) q\left(\theta_{t+1}\right) \theta_{lt+1} \left[\tilde{\vartheta}_l \mathcal{W}_{lt+1}\left(W_{lt}\right) + \left(1-\tilde{\vartheta}_l\right) \mathcal{W}_{lt+1}\left(W_{lt+1}^{*}\right) \right] \right\}. \end{aligned} \tag{13}$$

If an unemployed household member finds a job in sector s, the net income of the representative household increases, but the marginal worker suffers disutility from working time (first line of equation 13). In addition, the household gains the continuation value of employment at that firm (second line), minus the opportunity cost of searching for a job and finding it elsewhere (third line). We also note that both new and ongoing matches are subject to staggered wage contracts with Calvo (1983) probability $\tilde{\vartheta}_s$. Workers in ongoing matches that are unable to renegotiate in period $t+1$ receive the same nominal wage rate as in the previous period; i.e., $W_{s,t}^{j}$. Workers in new matches that are unable to bargain receive the average nominal wage rate prevailing at time t in the respective sector[10]; i.e., W_{lt}.

3.3 Final Good Producers - Retailers

There is a continuum of monopolistically competitive retailers, indexed by $i \in [0,1]$, in both sectors of the model economy. Each retailer produces a distinct final good variety, $y_{s,t}^{i}$, according to the following linear production technology:

$$y_{s,t}^{i} = \bar{y}_{s,t}^{i},$$

with labour services $\bar{y}_{s,t}^{i}$ as the only factor of production. We assume that final good firms rent labour services from hiring firms on a perfectly competitive factor market.

In the non-durable retail market, final good firms face Calvo (1983) type restrictions in price setting. At the beginning of period t, only a fraction $1-\vartheta_c$ of final good firms is able to re-optimise the price of its variety i. All non-durable producers that are able to re-optimise prices choose the same retail price, $P_{c,t}^{*}$, given that they all face the same real marginal cost of production. Non-durable producers that cannot re-optimise keep their prices unchanged. This specification implies that the log-linearised New Keynesian Phillips curve in the non-durable sector is given by:

$$\hat{\pi}_{c,t} = E_t\left[\beta \hat{\pi}_{c,t+1}\right] + \frac{(1-\beta\vartheta_c)(1-\vartheta_c)}{\vartheta_c} \hat{\varphi}_{c,t}^{m}, \tag{14}$$

where the hat, $\hat{x}_t$, denotes the log-deviation of variable x_t from its non-stochastic steady state at time t.

[10] See also Section (3.5)

In the durable retail market, on the contrary, prices are assumed to be perfectly flexible. Thus, profit maximising durable producers set their prices, $P^i_{d,t}$, as a constant mark-up over real marginal cost, $P^m_{d,t}$:

$$P^i_{d,t} = \frac{\epsilon_d}{\epsilon_d - 1} P^m_{d,t}. \tag{15}$$

Furthermore, we note that the ratio of durable inflation to non-durable inflation equals the period change in the relative price of durable goods:

$$\frac{\varphi_{d,t}}{\varphi_{d,t-1}} = \frac{\pi^p_{d,t}}{\pi^p_{c,t}}. \tag{16}$$

3.4 Hiring Firms

There is a continuum of potential hiring firms on the unit interval $j \in [0, 1]$, that provide specialised labour services to final good producers. Each hiring firm can employ at most one worker j. Hiring firms with unfilled positions may decide whether or not to open a sector-specific vacancy, $v_{s,t}$, where posting a vacancy entails a cost κ_s. Therefore, the hiring firm can expect to gain the average value of a filled position $\mathcal{J}_{s,t}$ with probability $q(\theta_t)$. With probability $1 - q(\theta_t)$ the vacancy remains unfilled. Furthermore, we assume that a newly matched firm-worker pair in sector s is only able to renegotiate the nominal wage contract $W^*_{s,t}$ with probability $\left(1 - \tilde{\vartheta}_s\right)$. Otherwise, the firm-worker pair simply adopts the average nominal wage rate prevailing at $t-1$, $W_{s,t-1}$. Thus, the value of an unfilled vacancy, $\mathcal{V}_{s,t}$, is given as:

$$\mathcal{V}_{s,t} = -\kappa_s + q(\theta_t)\left[\tilde{\vartheta}_s \mathcal{J}_{s,t}(W_{s,t-1}) + \left(1 - \tilde{\vartheta}_s\right)\mathcal{J}_{s,t}\left(W^*_{s,t}\right)\right] + \beta E_t \frac{\lambda_{t+1}}{\lambda_t}\left[1 - q(\theta_t)\right]\mathcal{V}_{s,t+1}.$$

Free entry into both sectoral matching markets ensures that the outside option of hiring firms is zero in each period, $\mathcal{V}_{s\tau} = 0 \quad \forall \quad \tau \geq t$. Hence, the non-arbitrage condition for vacancy creation is given by:

$$\kappa_s = q(\theta_t)\left[\tilde{\vartheta}_s \mathcal{J}_{s,t}(W_{s,t-1}) + \left(1 - \tilde{\vartheta}_s\right)\mathcal{J}_{s,t}\left(W^*_{s,t}\right)\right]. \tag{17}$$

Hiring firms with filled positions have access to a strictly concave and twice differentiable production function:

$$\bar{y}^j_{s,t} = \left(h^j_{s,t}\right)^{\alpha_s},$$

where $\bar{y}^j_{s,t}$ is the quantity of specialised labour services, h^j_t is the number of hours worked by individual j and $\alpha_s < 1$ is the production elasticity of working hours. At the sectoral level, the quantity of specialised labour services in period t is given by:

$$\bar{y}_{s,t} = n_{s,t} h^{\alpha_s}_{s,t} = \int_0^{n_{s,t}} \left(h^j_{s,t}\right)^{\alpha_s} dj = \int_0^1 \bar{y}^i_{s,t} di, \tag{18}$$

where $n_{s,t}$ denotes the number of filled positions in sector s. Labour services produced by hiring firm j, $\bar{y}^j_{s,t}$, are rented to final good firms at the competitive price $\varphi^m_{s,t}$. Hence, real per-period profits of hiring firm j are given by:

$$\phi^j_{s,t} = \varphi^m_{s,t} \left(h^j_{s,t} \right)^{\alpha_s} - h^j_{s,t} \left(W^j_{s,t} / P_{c,t} \right) - \mu_s,$$

where $W^j_{s,t}/P_{c,t}$ is the real hourly wage paid by firm j in sector s and μ_s is the sector-specific non-labour cost of production[11]. Thus, the value of employment for firm j in sector s is equal to

$$\mathcal{J}_{s,t} \left(W^j_{s,t} \right) = \phi^j_{s,t} + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} (1 - \rho_s) \left[\tilde{\vartheta}_s \mathcal{J}_{s,t+1} \left(W^j_{s,t+1} \right) + \left(1 - \tilde{\vartheta}_s \right) \mathcal{J}_{s,t+1} \left(W^*_{s,t+1} \right) \right], \quad (19)$$

where the second term denotes the expected continuation value of employment for the firm — conditional on surviving exogenous job destruction at the end of period t. In particular, the expected continuation value reflects the fact that nominal wages are subject to staggered contracts with a constant renegotiation probability of $1 - \tilde{\vartheta}_s$.

3.5 Wage Determination

Frictions in the labour market and decreasing-returns-to-scale at the hiring firm level create economic rents between matched firm-worker pairs. These rents are shared by wage bargaining. Following Andolfatto (1996), the representative household takes the labour supply decision for all its members. In particular, we assume that the household bargains with each employer separately, while taking wages in all other matches as given (Pissarides 2000, Chapter 3).

The nominal wage rate is determined by Right-to-Manage wage bargaining.[12] This bargaining protocol presumes the following sequential setting. First, the two parties agree on a nominal wage rate per hour, $W^j_{s,t}$, according to the Nash rule. Second, the hiring firm may choose *unilaterally* the number of hours per worker, $h^j_{s,t}$. Therefore, the hiring firm sets the number of hours per worker so as to maximise its surplus share:

$$\frac{W^j_{s,t}}{P_{c,t}} = \varphi^m_t \alpha_s \left(h^j_{s,t} \right)^{\alpha_s - 1}. \quad (20)$$

Equation (20) states that, in each sector, the real wage rate, $W^j_{s,t}/P_{c,t}$, must be equal to the real marginal revenue product per hour worked. As a result, the real wage rate is allocative for the number of hours per worker, $h^j_{s,t}$. This establishes a direct link (the so-called "wage channel" Christoffel & Kuester 2008) between the real marginal cost, φ^m_t, and the real wage rate.

[11]Note that the sector-specific non-labour cost is paid per worker. Thus, at the aggregate level, non-labour costs are proportional to the current employment level. Non-labour costs therefore represent variable production costs that are independent of the actual number of hours per worker. For instance, these costs include overhead costs like administrative services or health insurance costs (Christoffel & Kuester 2008).

[12]Section (4.3.1) evaluates the model under Nash (1953) bargaining.

In other words, the hiring firm has full bargaining power in *stage two.* As both parties are fully rational, they internalise the way hours per worker are set when bargaining over the nominal wage rate in *stage one.* Backward induction implies that the Nash rule is now given by:

$$\gamma \mathcal{J}_{s,t}^{*} \left. \frac{\partial \mathcal{W}_{s,t}^{j}}{\partial W_{s,t}^{j}} \right|^{*} W_{s,t}^{*} = (1-\gamma)\, \mathcal{W}_{s,t}^{*} \left. \frac{\partial \mathcal{J}_{s,t}^{j}}{\partial W_{s,t}^{j}} \right|^{*} W_{s,t}^{*}, \tag{21}$$

where asterisks denote the optimal choice of real hourly wages and the optimal choice of hours associated with these wages. The parameter γ_s denotes the time-invariant "nominal" bargaining power of the representative household in sector s. The sectoral "effective" bargaining power, however, is a time-varying variable:

$$\gamma_{s,t}^{*} = \frac{\gamma_s \eta_{s,t}^{w}}{\gamma_s \eta_{s,t}^{w} + (1-\gamma_s)\eta_{s,t}^{f}}, \tag{22}$$

where $\eta_{s,t}^{w}$ is the marginal benefit of a change in the nominal wage rate to the representative household:

$$\eta_{s,t}^{w} = \left. \frac{\partial \mathcal{W}_{s,t}^{j}}{\partial W_{s,t}^{j}} \right|^{*} W_{s,t}^{*} = f_{1t} - f_{2t}, \quad \text{where} \tag{23}$$

$$f_{s,t}^{1} = \frac{w_{s,t}^{*} h_{s,t}^{*}}{1-\alpha_s} \frac{\chi_s}{\lambda_t} \frac{\left(h_{s,t}^{*}\right)^{\varrho_s}}{w_{s,t}^{*}} + \beta \tilde{\vartheta}_s (1-\rho_s)\, E_t \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{w_{s,t+1}^{*} \pi_{c,t+1}}{w_{s,t}^{*}} \right)^{\frac{1+\varrho_s}{1-\alpha_s}} f_{s,t+1}^{1} \quad \text{and} \tag{24}$$

$$f_{s,t}^{2} = \alpha_s \frac{w_{s,t}^{*} h_{s,t}^{*}}{1-\alpha_s} + \beta \tilde{\vartheta}_s (1-\rho_s)\, E_t \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{w_{s,t+1}^{*} \pi_{c,t+1}}{w_{s,t}^{*}} \right)^{\frac{\alpha_s}{1-\alpha_s}} f_{s,t+1}^{2} \tag{25}$$

and $\eta_{s,t}^{f}$ is the marginal benefit of a change in the nominal wage rate to the firm:

$$\eta_{s,t}^{f} = - \left. \frac{\partial \mathcal{J}_{s,t}^{j}}{\partial W_{s,t}^{j}} \right|^{*} W_{s,t}^{*} = w_{s,t}^{*} h_{s,t}^{*} + (1-\rho_s)\, \beta \tilde{\vartheta}_s E_t \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{w_{s,t+1}^{*} \pi_{c,t+1}}{w_{s,t}^{*}} \right)^{\frac{\alpha_s}{1-\alpha_s}} \eta_{s,t+1}^{f}. \tag{26}$$

Furthermore, we assume that both new and ongoing matches are subject to staggered *nominal* wage contracts with Calvo (1983) probability $\tilde{\vartheta}_s$. Hence, the average sectoral nominal wage evolves according to:[13]

$$W_{s,t} = \tilde{\vartheta}_s W_{s,t-1} + \left(1 - \tilde{\vartheta}_s\right) W_{s,t}^{*}. \tag{27}$$

[13] Haefke, Sonntag & van Rens (2012) as well as Petrongolo & Pissarides (2008) document that the elasticity of wages in new matches is higher than the elasticity of wages in ongoing matches. Under Right-to-Manage wage bargaining (our preferred specification, see below), however, the dynamics of the model remain essentially unchanged when we consider a lower stickiness parameter for new matches.

3.6 Government and Monetary Authority

The government finances unemployment benefits $\bar{b}$, issues bonds B_t that pay a nominal interest rate R_t in period $t+1$ and rebates any seigniorage revenue to the representative household. Each period, the budget balance is maintained by imposing a lump-sum tax $\bar{T}$:

$$\bar{T}_t + B_t - R_{t-1}B_{t-1} = (1 - n_{c,t} - n_{d,t})\,\bar{b}P_{c,t}.$$

When setting the nominal interest rate, the monetary authority obeys a generalised Taylor (1993) rule as suggested by Clarida, Gali & Gertler (1999).

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\mu_r} \left[\left(\frac{\pi_{c,t}}{\pi_c}\right)^{r_p} \left(\frac{y_t}{y}\right)^{r_y}\right]^{1-\mu_r} \varepsilon_{rt} \quad \text{with} \quad \varepsilon_{rt} \sim i.i.d., \tag{28}$$

where $\mu_r \in [0,1)$ governs the degree of monetary policy inertia. The parameters $r_p \in [0,\infty)$ and $r_y \in [0,\infty)$ control the responsiveness of the monetary authority to temporary shifts in non-durable price inflation, $\pi_{c,t}$,[14] and aggregate output, y_t. The latter is defined as the sum of non-durable goods and durable goods in terms of non-durable prices: $y_t = c_t + \varphi_{d,t}x_t$. Moreover, letters without a time subscript refer to the steady state value of the associated variable.

3.7 Market Clearing

We assume that vacancy posting costs, $\kappa_s v_{s,t}$ and the non-labour cost of production at the hiring firm level, $\mu_s n_{s,t}$, are bundled in *both sectors* using the same technology as the non-durable CES aggregator.[15] Hence the sectoral resource constraints can be written as:

$$y_{c,t} = c_t + \kappa_c v_{c,t} + \kappa_d v_{d,t} + \mu_c n_{c,t} + \mu_d n_{d,t}, \tag{29}$$

$$y_{d,t} = x_t = d_t - (1-\delta)\,d_{t-1}. \tag{30}$$

3.8 Competitive Equilibrium

A stationary competitive equilibrium is a set of endogenous stationary processes, $y_{s,t}$, y_t, x_t, λ_t, c_t, d_t, $w_{s,t}$, $\mathcal{W}^*_{s,t}$ $\mathcal{J}^*_{s,t}$, $\eta^w_{s,t}$, $\eta^f_{s,t}$, $\varphi_{d,t}$, $h_{s,t}$, $n_{s,t}$, $v_{s,t}$, u_t, $\varphi^m_{s,t}$, R_t, $\hat{\pi}_{s,t}$ and an exogenous process $\{\varepsilon_{rt}\}_{t=0}^{\infty}$ satisfying equation (1), (2), (6) and (10)-(30), given initial conditions for d_{-1}, $n_{s,-1}$, R_{-1}, $w_{s,-1}$ and $\varphi_{d,-1}$.

4 Model Evaluation

The following section evaluates the quantitative performance of the model economy. We parameterise our benchmark model and examine the effects of a contractionary monetary policy shock. Therefore, we log-linearise the model around the non-stochastic steady state and solve for the recursive law of motion using Dynare 4.2.5 (Adjemian, Bastani, Juillard, Mihoubi, Perendia,

[14] All results remain essentially unchanged when the central bank targets wage inflation instead.

[15] All results are robust when the costs in each sector are cleared in terms of sector-specific output.

Ratto & Villemot 2011). Furthermore, we discuss the role of the wage bargaining protocol, the degree of labour mobility and the size of hiring firms' profits.

4.1 Parameterisation

We assume zero steady-state inflation in both sectors. All structural parameters — except for the degree of price stickiness — are chosen symmetrically across sectors. The time period of the model corresponds to one quarter.[16] Table (3) provides a summary of the key parameters.

Preferences All preference parameters are calibrated using conventional values. The discount factor, $\beta = 0.99$, is chosen to match an annual real interest rate of four percent. Furthermore, we assume logarithmic preferences in the composite consumption good ($\sigma = 1$), such that within-period utility of the representative household is separable in non-durable consumption and durable services (as in Barsky et al. 2007). The share of non-durable consumption in the utility function, $\zeta = 0.76$, implies that the steady-state share of non-durable production in consumption is about 81%. The elasticity of substitution among sectoral varieties is set to $\epsilon_s = 11$. This value is consistent with a steady-state value of sectoral mark-ups equal to 10%. The labour supply elasticity along the intensive margin, ϱ_s, is calibrated to 2.8, which is within the admissible range suggested by MaCurdy (1983) and Card (1994). The average number of hours per worker, $\bar{h}_s$, is normalised to unity (Trigari 2006), which requires setting the utility cost parameter in sector-specific labour supply, χ_s, equal to 0.79.

Production and Technology As documented by Fraumeni (1997), the service life of durable goods owned by consumers ranges from three years (e.g. auto parts) to 40 years (e.g. residential investment). Thus, we set the quarterly depreciation rate of durable goods equal to $\delta = 0.025$, corresponding to a mid-life of about ten years (Erceg & Levin 2006).

Firm-Worker Matches Given that the average number of hours per worker, $\bar{h}_s$, is normalised to unity, we find a negative relationship between the sectoral production elasticity of working hours, α_s and sectoral non-labour costs, μ_s. Following Bouakez et al. (2011), we set $\mu_s = 0.54$, such that the labour input expenditure share, $w_s h_s/(w_s h_s + \mu_s) = 40\%$, is in line with US industry data on input expenditure (Jorgenson & Stiroh 2000).[17] The implied value of α_c is equal to 0.40. Importantly, we note that hiring firms' profits are small under the current parameterisation. As demonstrated by Christoffel & Kuester (2008) in a model with Right-to-Manage wage bargaining, only if hiring firms' profits are small, a given monetary policy shock

[16] When the model period is set to be one month, Right-to-Manage wage bargaining induces excessive labour adjustment along the intensive margin. Therefore, we simulate the model at a quarterly frequency and impose instantaneous matching in order to capture the fast US labour market dynamics.

[17] This value is clearly lower than the conventional value of about 66% reflecting the compensation of employees in aggregate NIPA data. In our model, however, the labour input expenditure share represents the income share of production workers excluding overhead costs. As surveyed by Christoffel & Kuester (2008), these overhead costs may be substantial. For instance, Ramey (1991) documents that the share of non-production workers in the manufacturing sector is about 30%. Basu (1996) finds even higher values. See also Footnote (18) and Section (4.3.3).

can be leveraged into large employment fluctuations.[18] Otherwise, hiring firms tend to adjust excessively along the intensive margin.

Moreover, we assume that both the "nominal" and the steady-state "effective" bargaining power are symmetrically distributed; i.e., $\gamma_s = \gamma_s^* = 0.5$. As explained by Consolo & Hertweck (2010), this implies that, in the steady state, the real wage rate is equal to the marginal rate of substitution (see equations 23 and 26). The value chosen for the labour supply elasticity along the intensive margin ensures that this condition is satisfied.[19]

Search in the Labour Market Following Shimer (2012), we target an average unemployment rate, $1 - n_{c,t} - n_{d,t}$, equal to 6% and a steady-state job separation rate, ρ_s, equal to 10% per quarter. Therefore, we set the sectoral hiring cost parameter to $\kappa_s = 0.07$, the efficiency parameter in the matching function to $\bar{m} = 0.95$ and unemployment benefits to $\bar{b} = 0.24$. These values imply that the ratio of vacancy posting costs to aggregate output is equal to 0.5% (as in Cheron & Langot 2004). The total replacement ratio (i.e., the sum of unemployment benefits, $\bar{b}$ and the value of the leisure surplus during unemployment, $\bar{l}$, divided by the real wage) is equal to 0.91.[20] The average job finding rate of the measure of aggregate job searchers, $u_t = 0.15$, is equal to $p(\theta) = 0.61$. Besides, we set the matching elasticity of vacancies, ξ, equal to 0.5. This value is within the interval $[0.3, 0.5]$ proposed by Petrongolo & Pissarides (2001).

Price and Wage Stickiness Using the data set provided by Klenow & Kryvtsov (2008), we find that the quarterly frequency of price changes for the median product category in non-durable goods & services (here: automobile insurance) is equal to $1 - \vartheta_c = 0.30$. On the other hand, we find that about 70% of durable expenditure is due to housing, vehicles and personal computers; i.e, very flexibly priced product categories. For instance, the quarterly frequency of price changes for personal computers is equal to 94%. Therefore, as is standard in the literature with durable production (see e.g. Iacoviello 2005, Sterk 2010), we set the Calvo parameter for price stickiness in the non-durable sector, ϑ_c, equal to 0.7 and assume perfect price flexibility in the durable sector; i.e., $\vartheta_d = 0$. Importantly, we note that the "comovement puzzle" is aggravated by the strong asymmetry in cross-sectoral price flexibility imposed by the current parameterisation. Furthermore, according to the estimate of Gottschalk (2005), we set the degree of nominal wage stickiness equal to $\tilde{\vartheta}_s = 0.4$ in both sectors. This value corresponds to an average wage contract duration of about five months.[21] The symmetric parameterisation of wage stickiness across sectors is in line with the results of our SVAR model (see Section 2).

Monetary Policy Finally, the policy parameters of the generalised Taylor rule, $\mu_r = 0.8$, $r_p = 2.0$ and $r_y = 0.3$, are taken from Gertler, Sala & Trigari (2008).

[18] A similar argument was made by Hagedorn & Manovskii (2008) in a search economy with Nash bargaining subject to technology shocks. As a robustness check, Section (4.3.3) examines the model dynamics when μ_s^{alt} is lowered to 0.28 such that the labour input expenditure share equals 68% and the implied value of α_c^{alt} is equal to 0.65.

[19] Together with $\xi = 0.5$ (see below), the current parameterisation implies that the non-stochastic steady-state of our model economy is efficient — independent of the wage bargaining protocol.

[20] See Footnote (18).

[21] As pointed out by Gottschalk (2005), the estimate may be biased by spurious statements. Thus, we also evaluate the model when $\tilde{\vartheta}_s$ set equal to 0.7 (corresponding to an average wage contract duration of ten months).

4.2 The Dynamic Effects of a Monetary Policy Shock

The following section examines the dynamic effects of a contractionary monetary policy shock. Section (4.2.1) demonstrates that the elasticity of real marginal costs is key to understand the monetary transmission mechanism in a two-sector business cycle model. Section (4.2.2) discusses the impulse response functions under staggered Right-to-Manage wage bargaining.

4.2.1 The Role of Stickiness in Real Marginal Costs

The model generated monetary policy shock represents a temporary, but persistent hike in the nominal interest rate. Given that prices of non-durable goods are sticky, the monetary contraction leads to a rise in the real interest rate via the standard Euler equation (11). Consequently, the marginal utility of the composite consumption good, λ_t, rises. Furthermore, we note that the depreciation rate, δ, is low and that the subjective discount factor, β, is close to unity. For this reason, short-run fluctuations in durable expenditure have only little effect on the aggregate stock of durable goods. As a result, the shadow value of durable goods; i.e., the right hand side of the asset pricing equation, equation (12), remains essentially unchanged after a temporary monetary contraction:

$$\lambda_t \varphi_{d,t} \approx \bar{C}.$$

As demonstrated by Barsky et al. (2007), the "near constancy" property of the shadow value of durable goods, $\bar{C}$, implies that the *rise* in the marginal utility of consumption, λ_t, is accompanied by a deep *fall* in the relative price of durable goods, $\varphi_{d,t}$. In particular, if the percentage decline in the relative price of durable goods is greater than the percentage increase in the marginal utility of the composite consumption good, the representative household has incentives to build up the stock of durable goods, d_t, at low costs.

This mechanism implies that households reduce durable expenditure only if the percentage decline in the relative price of durable goods, $\varphi_{d,t}$ is smaller than the percentage increase in the marginal utility of consumption, λ_t. Since durable good prices are perfectly flexible, the percentage decline in the relative price of durable goods is exactly identical to the percentage decline of real marginal costs in the durable sector, $\varphi^m_{d,t}$. When labour markets are frictionless, as in Barsky et al. (2007), real marginal costs in both sectors are flexible. Thus, the standard monetary business cycle model with Walrasian labour markets predicts that sectoral outputs move in opposite direction. On the contrary, when real marginal costs in the durable sector are inelastic, the relative price of durable goods falls only moderately. If this effect is sufficiently strong, the representative household has incentives to lower durable expenditure. Thus, we conclude that sectoral comovement requires that the real marginal cost in the durable sector is sufficiently inelastic (see also Carlstrom & Fuerst 2010).

In our model environment, real marginal costs in both sectors, $\varphi^m_{s,t}$, behave exactly identical to the relative price of durable goods, $\varphi_{d,t}$. This result stems from the fact that (*i*) durable prices are perfectly flexible, which allows durable producers to set prices equal to marginal costs and (*ii*) job searchers are perfectly mobile, which equalises real marginal costs across sectors. More precisely, hiring firms in the durable (non-durable) sector increase (decrease) the number of open vacancies until the non-arbitrage condition is satisfied. This cross-sectoral spillover effect reduces the elasticity of real marginal costs in the durable sector and increases the elasticity of real marginal costs in the non-durable sector, until the response of real marginal costs is symmetric in both sectors (see also Section 4.3.2).

In summary, the potential of our model to reduce the elasticity of real marginal cost arises from two sources. First, through the presence of job search and matching frictions (Pissarides 2000). Second, by the impact of staggered Right-to-Manage wage bargaining (Christoffel & Kuester 2008). Furthermore, some stickiness originating in the non-durable sector may affect real marginal costs in the durable sector via cross-sectoral spillovers. In the following, we analyse whether these effects are sufficiently strong such that sectoral outputs move in the same direction.

4.2.2 Right-to-Manage Bargaining

Figure (2) illustrates the impulse responses under Right-to-Manage wage bargaining. This bargaining protocol imposes that the hiring firm and the representative household first bargain over the nominal wage rate (which may be subject to staggered wage contracts). Second, hiring firms choose the number of hours per worker unilaterally (Trigari 2006). Importantly, hiring firms take the real wage rate — which was already fixed in the preceding bargaining step — as given when choosing the profit-maximising number of hours per worker. Thus, Right-to-Manage wage bargaining establishes a direct link between the nominal wage rate and the real marginal cost; i.e., the so-called "wage channel" (Christoffel & Kuester 2008).

The red dashed line represents the impulse responses of our benchmark model, i.e; nominal wages are subject to staggered contracts with Calvo parameter $\tilde{\vartheta}_s = 0.4$. Our benchmark model comes close to replicating the pattern observed in the data. First, the model is able to generate sectoral comovement. Second, the model closely matches the high elasticity of output and employment in the durable sector relative to the non-durable sector — output by factor six and employment by factor five. Third, in each sector, the elasticity of average working hours[22] is clearly lower than the elasticity of employment.[23]

On the contrary, when nominal wages are negotiated period-by-period, the model is less successful in replicating the empirical pattern. Both durable output and employment display a U-shaped decline, but the impact effect is positive (represented by the blue solid line in Figure 2). Only if nominal wages are sticky (represented by the red dashed and green dotted line), the model is able to generate marked negative responses in both sectors. The stronger the degree of wage stickiness, the larger are the elasticities of output and employment in the durable sector. The mechanism behind the observed pattern is the following. On the one hand, stickiness in nominal wages, $W_{s,t}$, reduces the elasticity of real marginal costs, $\varphi^m_{s,t}$, in both sectors (see equation 20). On the other hand, perfect mobility of job searchers entails that some stickiness originating in the non-durable sector spills over to the durable sector. For this reason, both real marginal costs in the durable sector, $\varphi^m_{d,t}$, and the relative price of durable goods, $\varphi_{d,t}$, become

[22] Staggered Right-to-Manage wage bargaining gives rise to dispersion in the number of hours per worker. Strictly speaking, the impulse response function depicted in Figure (2) shows the number of hours per worker associated with the average nominal wage rate.

[23] As all sectoral parameters are chosen symmetrically and job searchers are assumed to be randomly matched with hiring firms from both sectors, the response of working hours is identical in both sectors.

less elastic when nominal wages are subject to staggered wage contracts. As a result, households lose the incentive to build up the stock of durable goods after a monetary contraction.

In order to understand the response of hours per worker, it seems advantageous to rewrite equation (20) as follows:

$$h^j_{s,t} = \left(\frac{\alpha_s \varphi^m_t P_{c,t}}{W^j_{s,t}} \right)^{\frac{1}{1-\alpha_s}} . \tag{31}$$

Accordingly, any reduction in sectoral real marginal costs, $\varphi^m_{s,t}$, is accompanied by a decline in the real wage rate, $W^j_{s,t}/P_{c,t}$ and/or the amount of hours per worker, $h^j_{s,t}$. Thus, the higher the degree of nominal wage stickiness, the sharper the drop in the number of hours per worker. In particular, we observe that only our benchmark model, which adopts a moderate degree of nominal wage stickiness (Gottschalk 2005), is able to replicate the dynamics of labour adjustment along the extensive and intensive margin. When nominal wages change less frequently, the model predicts that the elasticity of hours per worker in the non-durable sector is of the same magnitude as the elasticity of employment. The latter result is not consistent with the empirical evidence.

The reason why our benchmark model exhibits such a strong "wage channel" is the sequential bargaining setting. In the first stage, the representative household anticipates the lack of influence on working hours. The anticipation effect strengthens its "effective" bargaining power, $\gamma^*_{s,t}$, during the wage bargaining process, which induces additional stickiness in the real wage rate (Consolo & Hertweck 2010). The resulting low elasticity of the real wage rate gives firms in both sectors strong incentives to adjust labour mainly along the intensive margin.

4.3 Discussion

The previous section has shown that the Right-to-Manage wage bargaining model with moderate nominal wage stickiness (Gottschalk 2005) comes closest to matching the pattern observed in the data. The current section analyses the impact of the following three assumptions. First, we investigate sensitivity to the wage bargaining protocol. Therefore, we evaluate the model dynamics under Nash (1953) bargaining. When nominal wages are bargained period-by-period, this model version allows us to quantify the impact of job search and matching frictions in comparison to the model of Barsky et al. (2007). Second, we study the effects of labour mobility for the cross-sectoral transmission of stickiness in real marginal costs. Third, we examine the role of hiring firms' profits for the amplification of employment fluctuations.

4.3.1 Nash Bargaining

Model Environment In contrast to Right-to-Manage wage bargaining, Nash bargaining assumes that the nominal wage rate and the number of hours per worker are chosen simultaneously in order to maximise the weighted product of each party's surplus share:

$$\max_{W^j_{s,t}, h^j_{s,t}} \quad \left[\mathcal{W}_{s,t} \left(W^j_{s,t} \right) \right]^{\gamma_s} \left[\mathcal{J}_{s,t} \left(W^j_{s,t} \right) \right]^{1-\gamma_s} ,$$

where γ_s is the bargaining power of the household in sector s. Thus, the first order conditions with respect to $W^*_{s,t}$ and $h_{s,t}$ are:

$$\gamma \mathcal{J}_{s,t}\left(W^*_{s,t}\right) = (1-\gamma)\, \mathcal{W}_{s,t}\left(W^*_{s,t}\right) \tag{32}$$

and

$$\varphi^m_{s,t} \alpha_s h^{\alpha_s - 1}_{s,t} = \frac{\chi_s h^{\varrho_s}_t}{\lambda_t}. \tag{33}$$

Equation (33) shows that hours per worker are set such that the real marginal revenue product of labour (left hand side) equals the marginal rate of substitution between consumption and labour (MRS, right hand side). This rule maximises each party's surplus share and, therefore, is made by mutual agreement. Therefore, the dynamics of real marginal costs are determined by the cyclical behaviour of the MRS — and not by the nominal wage rate. The nominal wage rate only divides the joint surplus into two shares, but has no impact on its size. This explains why the model with Nash bargaining lacks a direct "wage channel". For this reason, staggered nominal wage contracts can affect the dynamics of real marginal costs only *indirectly* through the vacancy posting decision.

To find the stationary competitive equilibrium under Nash bargaining we substitute equations (20)-(21) for (32)-(33) and we remove the set of equations (23)-(26). We parameterise this model version such that its non-stochastic steady state is identical to our benchmark model. As mentioned above, this parameterisation implies that hiring firms' profits are small.

Impulse Response Analysis Figure (3) illustrates the impulse responses to a contractionary monetary policy shock when nominal wages are determined by Nash bargaining. We observe that the model successfully generates sectoral comovement — even if nominal wages are negotiated period-by-period. This result indicates that the introduction of job search and matching frictions helps the model to solve the "comovement puzzle". In particular, the costly and time-consuming search for workers in the labour market and the existence of long-run employment relationships lead to a reduction in the elasticity of real marginal costs.

As a result, real marginal costs in both sectors are now less elastic than in the model with frictionless labour markets (Barsky et al. 2007). The inelasticity of the real marginal cost in the durable sector translates into sluggish dynamics of the relative price of durable goods. Therefore, the representative household abstains from using durable goods as an investment device to smooth aggregate consumption. However, we note that the effect is not sufficiently strong to replicate the high elasticity of durable output and employment relative to the non-durable sector.

When nominal wages are subject to staggered contracts,[24] we observe that the model generates more elastic responses in durable output and employment. However, the model replicates the high elasticity of durable output and employment relative to the non-durable sector only if the Calvo parameter ($\tilde{\vartheta}_s$=0.7) is higher than observed in the data (Gottschalk 2005). As

[24]Note that, when labour market are frictional, nominal wage stickiness does not necessarily distort the employment formation/separation decision between a matched firm and a worker. As explained by Hall (2005), the joint match surplus establishes a set of infinitely many equilibrium wages. Thus, as long as the wage rate lies within the bargaining set, the Barro (1977) critique does not apply.

explained above, nominal wage stickiness under Nash bargaining affects real marginal costs only indirectly as it changes hiring firms' incentives to adjust the number of vacancies. Thus, the effects of nominal wage stickiness are limited. This finding is related to the "irrelevance" result documented by Krause & Lubik (2007) who show that, when wages are determined by Nash bargaining, real wage stickiness is almost irrelevant for inflation dynamics.

However, the most important deficiency of the model with Nash bargaining is that the model generated response of working hours, $h_{s,t}$, is very close to zero in both sectors. In the data, on the contrary, labour input contracts significantly along both margins. Rewriting equation (33) reveals that the zero response of working hours is due to the "near constant" shadow value of durable goods:

$$\bar{C} \approx \varphi^m_{s,t}\lambda_t = \frac{\chi_s h^{\varrho_s}_{s,t}}{\alpha_s h^{\alpha_s - 1}_{s,t}}.$$

In other words, working hours in both sectors are nearly constant because real marginal costs, $\varphi^m_{s,t}$ and the marginal utility of the composite consumption good, λ_t, move in opposite directions. More precisely, as the rise in λ_t is marginally higher than the fall in $\varphi^m_{s,t}$, working hours even display a slight increase.

4.3.2 Sector-Specific Labour Markets

The cross-sectoral spillover effect occurs through labour mobility between the two sectors. If job searchers are perfectly mobile, as in the baseline version of our model, random matching with vacancies of either kind entails that both types of hiring firms face the same vacancy filling rate. This channel equalises real marginal costs across sectors and, thus, may transmit stickiness from one sector to the other. In the following, we examine the potential of labour market frictions to reduce the elasticity of real marginal costs in a two-sector monetary business cycle model.

Our benchmark model assumes that job searchers are randomly matched with hiring firms from both sectors. This assumption seems reasonable, given the high degree of inter-industry mobility of workers in the U.S. — as documented by Kambourov & Manovskii (2008) and Herz & van Rens (2011). In order to highlight the importance of labour mobility, the current subsection presents a model version where job searchers are immobile across sectors. More specifically, there is a separate matching market for workers previously employed in the durable and non-durable sector respectively. These job searchers can only be matched with hiring firms from the same sector.[25]

Figure (4) compares the impulse responses of the current model specification with the benchmark model. In both model versions, nominal wages are subject to staggered Right-to-Manage bargaining with Calvo parameter $\tilde{\vartheta}_s = 0.4$. When job searchers are immobile across sectors, the non-arbitrage condition for vacancy creation is no longer satisfied. Therefore, the dynamic effects of the vacancy filling rate are sector-specific. This modification eliminates the spillover effect that equalises real marginal costs across sectors. Thus, compared to the benchmark model, the elasticity of the real marginal cost rises in the durable sector, but falls in the non-durable sector. This effect reduces the representative household's incentives to decrease durable expenditure

[25]The non-stochastic steady state of this alternative model version is parameterised such that all sectoral transition rates are symmetric.

after a monetary contraction. Consequently, the sign of the impulse responses in the durable sector remains negative, but the degree of stickiness in real marginal costs is not sufficient to replicate the sharp fall in durable production.

This result indicates that labour mobility plays an important role in the transmission of monetary policy shocks. Only if job searchers are mobile across sectors, stickiness originating in the non-durable sector can spill over to the durable sector. This indirect channel makes the real marginal cost in the durable sector sufficiently sticky in order to replicate the high elasticity of durable production. Therefore, we conclude that the assumption of random matching seems a good approximation.[26] The shape of the impulse responses, however, is not sensitive to the degree of labour mobility.

4.3.3 Alternative Parameterisation

The benchmark parameterisation presented in Section (4) calibrates the non-labour cost of production, $\mu_s = 0.54$, such that the steady state labour input expenditure share, $w_s h_s/(w_s h_s + \mu_s)$, is equal to 40%, which is in line with U.S. industry data on input expenditure (Jorgenson & Stiroh 2000). In the following, we examine the model dynamics when the non-labour cost of production, $\mu_s^{alt} = 0.28$, is set such that the labour input expenditure share is equal to 68%, which is consistent with aggregate NIPA data from the BEA. The alternative calibration target implies that the production elasticity of working hours rises from $\alpha_s = 0.45$ to $\alpha_s^{alt} = 0.65$. At the same time, we adjust the vacancy posting cost parameter, $\kappa_c^{alt} = 0.46$, such that the steady state unemployment rate, $1 - n_c - n_d = 6\%$, remains unchanged.

The value chosen for the non-labour cost of production is important, as it reduces the size of hiring firms' profits. Only when hiring firms' profits are small, a given monetary policy shock can be "leveraged" into large employment fluctuations (Christoffel & Kuester 2008). This effect follows from the non-arbitrage condition for vacancy creation (equation 17), which establishes a link between the elasticity of vacancies and the elasticity of hiring firms' profits. Otherwise, as hiring firms may set the number of hours per worker unilaterally, Right-to-Manage wage bargaining gives rise to excessive labour adjustment along the intensive margin. The current section quantifies this effect.

Figure (5) illustrates the impulse responses under the alternative parameterisation. We observe that, under the alternative parameterisation, the elasticity of working hours is three times larger than in our benchmark model. In addition, due to the assumption of perfect labour mobility across sectors, the response of working hours is symmetric. As a result, hiring firms in the non-durable sector tend to adjust labour input almost exclusively along the intensive margin. This outcome is clearly at odds with the empirical evidence. For this reason, we conclude that small profits of hiring firms improve the quantitative performance of our model. Qualitatively, however, the model's ability to generate comovement across sectors does not depend on the specific parameterisation.

[26] Note that Bouakez et al. (2011) reach the opposite conclusion in a model with input-output interactions.

5 Conclusion

The seminal work of Barsky et al. (2007) demonstrates that a two-sector monetary business cycle model *with Walrasian labour markets* fails to replicate sectoral comovement after a monetary contraction. Since durable goods prices are flexible, but their shadow value is "near constant", optimising households build up the stock of durable goods at low cost and reduce the consumption of non-durable goods and services. Thus, the model predicts that sectoral outputs move in opposite directions. This outcome is clearly at odds with the data.

We show that the model with Walrasian labour markets fails to generate sectoral comovement because the real marginal cost in the durable sector is too elastic. In this paper, we argue that labour market frictions are able to reduce the elasticity of real marginal costs along two dimensions. First, through the presence of job search and matching frictions (Pissarides 2000). Second, by the impact of staggered Right-to-Manage wage bargaining (Christoffel & Kuester 2008) - a sequential bargaining protocol where nominal wages are negotiated before firms may choose the number of hours per worker unilaterally.

Our benchmark model with staggered Right-to-Manage wage bargaining is able (*i*) to generate positive comovement between the durable and the non-durable sector and (*ii*) to replicate the high elasticity of durable output relative to non-durable output and (*iii*) to match the empirical pattern of labour adjustment along the extensive and intensive margin after a contractionary monetary policy shock. Right-to-Manage wage bargaining (Trigari 2006) establishes a direct link between the nominal wage rate and the real marginal cost. For this reason, any stickiness in nominal wages directly reduces the elasticity of real marginal costs (the so-called "wage channel", see Christoffel & Kuester 2008). Thus, staggered Right-to-Manage wage bargaining is able to generate a large contraction in durable production even at a moderate degree of nominal wage stickiness, in line with the empirical evidence documented by Gottschalk (2005).

Furthermore, we investigate the impact of the specific wage bargaining protocol, the importance of labour mobility across sectors and the role of hiring firms' profits for the quantitative performance of our model. First, when nominal wages are set by Nash bargaining, the model successfully generates sectoral comovement — even if nominal wages are fully flexible. However, the model version with Nash bargaining predicts that firms adjust labour input exclusively along the extensive margins. Second, we find that our model generates sufficient stickiness in the durable's sector real marginal cost only if job searchers are mobile across sectors. Thus, the non-arbitrage condition for vacancy creation equalises real marginal costs across sectors. Consequently, stickiness originating in the non-durable sector may be transmitted to the durable sector. Third, we show that the elasticity of employment depends on the elasticity of hiring firms' profits. Thus, when hiring firms' are small, a given monetary policy shock is "leveraged" into large employment fluctuations. Otherwise, as hiring firms may set the number of hours per worker unilaterally, Right-to-Manage wage bargaining gives rise to excessive labour adjustment along the intensive margin. The latter finding is equivalent to the conclusion by Christoffel & Kuester (2008) in a one-sector monetary business cycle model.

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A The Log-Linearised Model

A.1 Main Equations

$$\hat{m}_t = \frac{\xi}{v_c + v_d}\left(v_c \hat{v}_{ct} + v_d \hat{v}_{dt}\right) + (1-\xi)\,\hat{u}_t, \tag{34}$$

$$n_c \hat{n}_{ct} - (1-\rho_c)\, n_c \hat{n}_{ct-1} + n_d \hat{n}_{dt} - (1-\rho_d)\, n_d \hat{n}_{dt-1} = m \hat{m}_t, \tag{35}$$

$$v_d n_c \left[\hat{v}_{dt} + \hat{n}_{ct} - (1-\rho_c)\left(\hat{v}_{dt} + \hat{n}_{ct-1}\right)\right] = v_c n_d \left[\hat{v}_{ct} + \hat{n}_{dt} - (1-\rho_d)\left(\hat{v}_{ct} + \hat{n}_{dt-1}\right)\right], \tag{36}$$

$$u \hat{u}_t = -(1-\rho_c)\, n_c \hat{n}_{ct-1} - (1-\rho_d)\, n_d \hat{n}_{dt-1}, \tag{37}$$

$$\hat{\lambda}_t = (1-\sigma)\,\hat{\omega}_t - \hat{c}_t, \tag{38}$$

$$\hat{\lambda}_t = \hat{R}_t + E_t\left[\hat{\lambda}_{t+1} - \hat{\pi}_{ct+1}\right], \tag{39}$$

$$\hat{\lambda}_t + \hat{\varphi}_{dt} = \left[1 - \beta(1-\delta)\right]\left[(1-\sigma)\,\hat{\omega}_t - \hat{d}_t\right] + \beta(1-\delta)\, E_t\left[\hat{\lambda}_{t+1} + \hat{\varphi}_{dt+1}\right], \tag{40}$$

$$\hat{\omega}_t = \zeta \hat{c}_t + (1-\zeta)\,\hat{d}_t, \tag{41}$$

$$\hat{\pi}_{ct} = \beta E_t\left[\hat{\pi}_{ct+1}\right] + \frac{(1-\beta\vartheta_c)(1-\vartheta_c)}{\vartheta_c}\hat{\varphi}^w_{ct}, \tag{42}$$

$$\vartheta_d \hat{\pi}_{dt} = \vartheta_d \beta E_t\left[\hat{\pi}_{dt+1}\right] + (1-\beta\vartheta_d)(1-\vartheta_d)\left(\hat{\varphi}^w_{dt} - \hat{\varphi}_{dt}\right), \tag{43}$$

$$\hat{\varphi}_{dt} - \hat{\varphi}_{dt-1} = \hat{\pi}_{dt} - \hat{\pi}_{ct}, \tag{44}$$

$$\hat{y}_{ct} = \hat{n}_{st} + \alpha_c \hat{h}_{ct}, \tag{45}$$

$$\hat{y}_{dt} = \hat{n}_{dt} + \alpha_d \hat{h}_{dt}, \tag{46}$$

$$\hat{q}_t = (1-\xi)\left[\hat{u}_t - \frac{1}{v_c + v_d}\left(v_c \hat{v}_{ct} + v_d \hat{v}_{dt}\right)\right], \tag{47}$$

$$\hat{w}_{ct} = \tilde{\vartheta}_c\left(\hat{w}_{ct-1} - \hat{\pi}_{ct}\right) + \left(1 - \tilde{\vartheta}_c\right)\hat{w}^*_{ct}, \tag{48}$$

$$\hat{w}_{dt} = \tilde{\vartheta}_d\left(\hat{w}_{dt-1} - \hat{\pi}_{ct}\right) + \left(1 - \tilde{\vartheta}_d\right)\hat{w}^*_{dt}, \tag{49}$$

$$y_c \hat{y}_{ct} = c\hat{c}_t + \kappa_c v_c \hat{v}_{ct} + \kappa_d v_d \hat{v}_{dt} + \mu_c n_c \hat{n}_{ct} + \mu_d n_d \hat{n}_{dt}, \tag{50}$$

$$y \hat{y}_t = y_c \hat{y}_{ct} + \varphi_d y_d\left(\hat{y}_{dt} + \hat{\varphi}_{dt}\right), \tag{51}$$

$$\hat{R}_t = r_r \hat{R}_{t-1} + (1-r_r)\, r_p \hat{\pi}_{ct} + (1-r_r)\, r_y \hat{y}_t + \varepsilon_{rt}, \tag{52}$$

$$\delta \hat{y}_{dt} = \hat{d}_t - (1-\delta)\,\hat{d}_{t-1}, \tag{53}$$

$$\hat{\theta}_{ct} = \hat{v}_{ct} - \hat{u}_t, \tag{54}$$

$$\hat{\theta}_{dt} = \hat{v}_{dt} - \hat{u}_t, \tag{55}$$

$$-\frac{\kappa_c}{q}\hat{q}_t = \frac{\tilde{\vartheta}_c w_c h_c}{1 - \beta(1-\rho_c)\,\tilde{\vartheta}_c} E_t\left[\hat{w}^*_{ct} + \hat{\pi}_{ct} - \hat{w}_{ct-1}\right] + \mathcal{J}_c \hat{\mathcal{J}}^*_{ct}, \tag{56}$$

$$-\frac{\kappa_d}{q}\hat{q}_t = \frac{\tilde{\vartheta}_d w_d h_d}{1 - \beta(1-\rho_d)\,\tilde{\vartheta}_d} E_t\left[\hat{w}^*_{dt} + \hat{\pi}_{ct} - \hat{w}_{dt-1}\right] + \beta \mathcal{J}_d \hat{\mathcal{J}}^*_{dt}. \tag{57}$$

A.2 Nash Bargaining - Equations

$$\hat{\varphi}^m_{ct} = (1 - \alpha_c + \varrho_c)\,\hat{h}_{ct} - \hat{\lambda}_t, \tag{58}$$

$$\hat{\varphi}^m_{ct} = (1 - \alpha_d + \varrho_d)\,\hat{h}_{dt} - \hat{\lambda}_t, \tag{59}$$

$$\hat{\mathcal{J}}^*_{ct} = \hat{\mathcal{W}}^*_{ct}, \tag{60}$$

$$\hat{\mathcal{J}}^*_{dt} = \hat{\mathcal{W}}^*_{dt}, \tag{61}$$

$$\begin{aligned} \mathcal{J}_c \hat{\mathcal{J}}^*_{ct} =& \varphi^m_c z_c h_c\left(\hat{\varphi}^m_{ct} + \alpha_c \hat{h}_{ct}\right) - w_c h_c\left(\hat{w}^*_{ct} + \hat{h}_{ct}\right) + \\ &+ \frac{\beta(1-\rho_c)\,\tilde{\vartheta}_c w_c h_c}{1 - \beta(1-\rho_c)\,\tilde{\vartheta}_c} E_t\left[\hat{w}^*_{ct+1} + \hat{\pi}_{ct+1} - \hat{w}^*_{ct}\right] + +\beta(1-\rho_c)\,\mathcal{J}_c E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\mathcal{J}}^*_{ct+1}\right], \end{aligned} \tag{62}$$

$$\begin{aligned} \mathcal{J}_d \hat{\mathcal{J}}^*_{dt} =& \varphi^m_d z_d h_d\left(\hat{\varphi}^m_{dt} + \alpha_d \hat{h}_{dt}\right) - w_d h_d\left(\hat{w}^*_{dt} + \hat{h}_{dt}\right) + \\ &+ \frac{\beta(1-\rho_d)\,\tilde{\vartheta}_d w_d h_d}{1 - \beta(1-\rho_d)\,\tilde{\vartheta}_d} E_t\left[\hat{w}^*_{dt+1} + \hat{\pi}_{ct+1} - \hat{w}^*_{dt}\right] + \beta(1-\rho_d)\,\mathcal{J}_d E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\mathcal{J}}^*_{dt+1}\right], \end{aligned} \tag{63}$$

$$
\begin{aligned}
\mathcal{W}_c\hat{\mathcal{W}}^*_{ct} =& w_c h_c \left(\hat{w}^*_{ct} + \hat{h}_{ct}\right) - \chi_c \frac{h_c^{1+\varrho_c}}{(1+\varrho_c)\lambda}\left[(1+\varrho_c)\hat{h}_{ct} - \hat{\lambda}_t\right] + \\
&+ \frac{\beta\tilde{\vartheta}_c(1-\rho_c)}{1-\beta\tilde{\vartheta}_c(1-\rho_c)} w_c h_c E_t\left[\hat{w}^*_{ct} - \hat{\pi}_{ct+1} - \hat{w}^*_{ct+1}\right] - \\
&- \frac{\beta\tilde{\vartheta}_c(1-\rho_c)}{1-\beta\tilde{\vartheta}_c(1-\rho_c)} w_c h_c q\theta_c E_t\left[\hat{w}_{ct} - \hat{\pi}_{ct+1} - \hat{w}^*_{ct+1}\right] + \\
&+ \frac{\beta\tilde{\vartheta}_d(1-\rho_d)}{1-\beta\tilde{\vartheta}_d(1-\rho_d)} w_d h_d q\theta_d E_t\left[\hat{w}_{dt} - \hat{\pi}_{ct+1} - \hat{w}^*_{dt+1}\right] + \\
&+ \beta(1-\rho_c)(1-q(\theta)\theta_c)\mathcal{W}_c E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\mathcal{W}}^*_{ct+1}\right] - \\
&- \beta(1-\rho_c)q(\theta)\theta_c\mathcal{W}_c E_t\left[\hat{q}_{t+1} + \hat{\theta}_{ct+1}\right] - \\
&- \beta(1-\rho_d)q(\theta)\theta_d\mathcal{W}_d E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\mathcal{W}}^*_{dt+1}\right] - \\
&- \beta(1-\rho_d)q(\theta)\theta_d\mathcal{W}_d E_t\left[\hat{q}_{t+1} + \hat{\theta}_{dt+1}\right],
\end{aligned} \tag{64}
$$

$$
\begin{aligned}
\mathcal{W}_d\hat{\mathcal{W}}^*_{dt} =& w_d h_d \left(\hat{w}^*_{dt} + \hat{h}_{dt}\right) - \chi_d \frac{h_d^{1+\varrho_d}}{(1+\varrho_d)\lambda}\left[(1+\varrho_d)\hat{h}_{dt} - \hat{\lambda}_t\right] + \\
&+ \frac{\beta\tilde{\vartheta}_d(1-\rho_d)}{1-\beta\tilde{\vartheta}_d(1-\rho_d)} w_d h_d E_t\left[\hat{w}^*_{dt} - \hat{\pi}_{ct+1} - \hat{w}^*_{dt+1}\right] - \\
&- \frac{\beta\tilde{\vartheta}_d(1-\rho_d)}{1-\beta\tilde{\vartheta}_d(1-\rho_d)} w_d h_d q\theta_d E_t\left[\hat{w}_{dt} - \hat{\pi}_{ct+1} - \hat{w}^*_{dt+1}\right] + \\
&+ \frac{\beta\tilde{\vartheta}_c(1-\rho_c)}{1-\beta\tilde{\vartheta}_c(1-\rho_c)} w_c h_c q\theta_c E_t\left[\hat{w}_{ct} - \hat{\pi}_{ct+1} - \hat{w}^*_{ct+1}\right] + \\
&+ \beta(1-\rho_d)(1-q(\theta)\theta_d)\mathcal{W}_d E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\mathcal{W}}^*_{dt+1}\right] - \\
&- \beta(1-\rho_d)q(\theta)\theta_d\mathcal{W}_d E_t\left[\hat{q}_{t+1} + \hat{\theta}_{t+1}\right] - \\
&- \beta(1-\rho_c)q(\theta)\theta_c\mathcal{W}_c E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\mathcal{W}}^*_{ct+1}\right] - \\
&- \beta(1-\rho_c)q(\theta)\theta_c\mathcal{W}_c E_t\left[\hat{q}_{t+1} + \hat{\theta}_{ct+1}\right].
\end{aligned} \tag{65}
$$

A.3 Right-to-Manage Bargaining - Equations

$$\hat{\varphi}^w_{ct} + (\alpha_c - 1)\hat{h}_{ct} = \hat{w}_{ct}, \tag{66}$$

$$\hat{\varphi}^w_{dt} + (\alpha_d - 1)\hat{h}_{dt} = \hat{w}_{dt}, \tag{67}$$

$$\hat{\mathcal{J}}^*_{ct} + \hat{\eta}^w_{ct} = \hat{\mathcal{W}}^*_{ct} + \hat{\eta}^f_{ct}, \tag{68}$$

$$\hat{\mathcal{J}}^*_{dt} + \hat{\eta}^w_{dt} = \hat{\mathcal{W}}^*_{dt} + \hat{\eta}^f_{dt}, \tag{69}$$

$$
\begin{aligned}
\mathcal{J}_c\hat{\mathcal{J}}^*_{ct} =& w_c h_c\left[\frac{\hat{\varphi}^w_{ct}}{\alpha_c} - \hat{w}^*_{ct} + \frac{\beta(1-\rho_c)\tilde{\vartheta}_c}{1-\beta(1-\rho_c)\tilde{\vartheta}_c} E_t\left[\hat{w}^*_{ct+1} + \hat{\pi}_{ct+1} - \hat{w}^*_{ct}\right]\right] + \\
&+ \beta(1-\rho_c)\mathcal{J}_c E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\mathcal{J}}^*_{ct+1}\right],
\end{aligned} \tag{70}
$$

$$
\begin{aligned}
\mathcal{J}_d\hat{\mathcal{J}}^*_{dt} =& w_d h_d\left[\frac{\hat{\varphi}^w_{dt}}{\alpha_d} - \hat{w}^*_{dt} + \frac{\beta(1-\rho_d)\tilde{\vartheta}_d}{1-\beta(1-\rho_d)\tilde{\vartheta}_d} E_t\left[\hat{w}^*_{dt+1} + \hat{\pi}_{ct+1} - \hat{w}^*_{dt}\right]\right] + \\
&+ \beta(1-\rho_d)\mathcal{J}_d E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\mathcal{J}}^*_{dt+1}\right],
\end{aligned} \tag{71}
$$

$$
\begin{aligned}
\hat{\eta}^f_{ct} =& \frac{\left[1-\beta(1-\rho_c)\tilde{\vartheta}_c\right]}{1-\alpha_c}\left(\hat{\varphi}^w_{ct} - \alpha_c\hat{w}^*_{ct}\right) + \\
&+ (1-\rho_c)\beta\tilde{\vartheta}_c E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \left(\frac{\alpha_c}{1-\alpha_c}\right)\left(\hat{w}^*_{ct+1} + \hat{\pi}_{ct+1} - \hat{w}^*_{ct}\right) + \hat{\eta}^f_{ct+1}\right],
\end{aligned} \tag{72}
$$

$$
\begin{aligned}
\hat{\eta}^f_{dt} =& \frac{\left[1-\beta(1-\rho_d)\tilde{\vartheta}_d\right]}{1-\alpha_d}\left(\hat{\varphi}^w_{dt} - \alpha_d\hat{w}^*_{dt}\right) + \\
&+ (1-\rho_d)\beta\tilde{\vartheta}_d E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \left(\frac{\alpha_d}{1-\alpha_d}\right)\left(\hat{w}^*_{dt+1} + \hat{\pi}_{ct+1} - \hat{w}^*_{dt}\right) + \hat{\eta}^f_{dt+1}\right],
\end{aligned} \tag{73}
$$

$$\eta_c^w \eta_{ct}^{\hat{w}} = \left[\frac{1+\varrho_c}{1-\alpha_c}\left(\hat{\varphi}_{ct}^w - \hat{w}_{ct}^*\right) - \hat{\lambda}_t\right] \frac{\chi_c}{\lambda} \frac{h_c^{1+\varrho_c}}{1-\alpha_c} - \frac{\alpha_c w_c h_c}{\left(1-\alpha_c\right)^2}\left(\hat{\varphi}_{ct}^w - \alpha_c \hat{w}_{ct}^*\right) + \\ + \frac{\beta\tilde{\vartheta}_c\left(1-\rho_c\right)}{1-\beta\tilde{\vartheta}_c\left(1-\rho_c\right)}\left[\frac{\left(1+\varrho_c\right)}{\left(1-\alpha_c\right)^2}\frac{\chi_c h_c^{1+\varrho_c}}{\lambda} - \left(\frac{\alpha_c}{1-\alpha_c}\right)^2 w_c h_c\right] E_t\left[\hat{w}_{ct+1}^* + \hat{\pi}_{ct+1} - \hat{w}_{ct}^*\right] + \\ + \eta_c^w \beta\tilde{\vartheta}_c\left(1-\rho_c\right) E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\eta}_{ct+1}^w\right], \tag{74}$$

$$\eta_d^w \eta_{dt}^{\hat{w}} = \left[\frac{1+\varrho_d}{1-\alpha_d}\left(\hat{\varphi}_{dt}^w - \hat{w}_{dt}^*\right) - \hat{\lambda}_t\right] \frac{\chi_d}{\lambda} \frac{h_d^{1+\varrho_d}}{1-\alpha_d} - \frac{\alpha_d w_d h_d}{\left(1-\alpha_d\right)^2}\left(\hat{\varphi}_{dt}^w - \alpha_d \hat{w}_{dt}^*\right) + \\ + \frac{\beta\tilde{\vartheta}_d\left(1-\rho_d\right)}{1-\beta\tilde{\vartheta}_d\left(1-\rho_d\right)}\left[\frac{\left(1+\varrho_d\right)}{\left(1-\alpha_d\right)^2}\frac{\chi_d h_d^{1+\varrho_d}}{\lambda} - \left(\frac{\alpha_d}{1-\alpha_d}\right)^2 w_d h_d\right] E_t\left[\hat{w}_{dt+1}^* + \hat{\pi}_{ct+1} - \hat{w}_{dt}^*\right] + \\ + \eta_d^w \beta\tilde{\vartheta}_d\left(1-\rho_d\right) E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\eta}_{dt+1}^w\right], \tag{75}$$

$$\mathcal{W}_c \hat{\mathcal{W}}_{ct}^* = \frac{w_c h_c}{1-\alpha_c}\left(\hat{\varphi}_{ct}^m - \alpha_c \hat{w}_{ct}^*\right) - \chi_c \frac{h_c^{1+\varrho_c}}{\left(1+\varrho_c\right)\lambda}\left[\frac{1+\varrho_c}{1-\alpha_c}\left(\varphi_{ct}^m - \hat{w}_{ct}^*\right) - \hat{\lambda}_t\right] + \\ + \beta\tilde{\vartheta}_c\left(1-\rho_c\right)\left\{f_c^1 E_t\left[\frac{\alpha_c}{1-\alpha_c}\left(\hat{w}_{ct+1}^* + \hat{\pi}_{t+1} - \hat{w}_{ct}^*\right)\right] - f_c^2 E_t\left[\frac{1+\varrho_c}{1-\alpha_c}\left(\hat{w}_{ct+1}^* + \hat{\pi}_{t+1} - \hat{w}_{ct}^*\right)\right]\right\} \\ - \beta\tilde{\vartheta}_c\left(1-\rho_c\right) q\left(\theta\right)\theta_c E_t\left[f_c^1\left(\frac{\alpha_c}{1-\alpha_c}\left(\hat{w}_{ct+1}^* + \hat{\pi}_{t+1} - \hat{w}_{ct}\right)\right) - \frac{1+\varrho_c}{1-\alpha_c} f_c^2\left(\hat{w}_{ct+1}^* + \hat{\pi}_{t+1} - \hat{w}_{ct}\right)\right] \\ - \beta\tilde{\vartheta}_d\left(1-\rho_d\right) q\left(\theta\right)\theta_d E_t\left[f_d^1\left(\frac{\alpha_d}{1-\alpha_d}\left(\hat{w}_{dt+1}^* + \hat{\pi}_{t+1} - \hat{w}_{dt}\right)\right) - \frac{1+\varrho_d}{1-\alpha_d} f_d^2\left(\hat{w}_{dt+1}^* + \hat{\pi}_{t+1} - \hat{w}_{dt}\right)\right] \\ + \beta\left(1-\rho_c\right)\left(1-q\left(\theta\right)\theta_c\right)\mathcal{W}_c E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\mathcal{W}}_{ct+1}^*\right] - \beta\left(1-\rho_c\right) q\left(\theta\right)\theta_c \mathcal{W}_c E_t\left[\hat{q}_{t+1} + \hat{\theta}_{ct+1}\right] \\ - \beta\left(1-\rho_d\right) q\left(\theta\right)\theta_d \mathcal{W}_d E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\mathcal{W}}_{dt+1}^*\right] - \beta\left(1-\rho_d\right) q\left(\theta\right)\theta_d \mathcal{W}_d E_t\left[\hat{q}_{t+1} + \hat{\theta}_{dt+1}\right], \tag{76}$$

$$\mathcal{W}_d \hat{\mathcal{W}}_{dt}^* = \frac{w_d h_d}{1-\alpha_d}\left(\hat{\varphi}_{dt}^m - \alpha_d \hat{w}_{dt}^*\right) - \chi_d \frac{h_d^{1+\varrho_d}}{\left(1+\varrho_d\right)\lambda}\left[\frac{1+\varrho_d}{1-\alpha_d}\left(\varphi_{dt}^m - \hat{w}_{dt}^*\right) - \hat{\lambda}_t\right] + \\ + \beta\tilde{\vartheta}_d\left(1-\rho_d\right)\left\{f_d^1 E_t\left[\frac{\alpha_d}{1-\alpha_d}\left(\hat{w}_{dt+1}^* + \hat{\pi}_{t+1} - \hat{w}_{dt}^*\right)\right] - f_d^2 E_t\left[\frac{1+\varrho_d}{1-\alpha_d}\left(\hat{w}_{dt+1}^* + \hat{\pi}_{t+1} - \hat{w}_{dt}^*\right)\right]\right\} \\ - \beta\tilde{\vartheta}_d\left(1-\rho_d\right) q\left(\theta\right)\theta_d E_t\left[f_d^1\left(\frac{\alpha_d}{1-\alpha_d}\left(\hat{w}_{dt+1}^* + \hat{\pi}_{t+1} - \hat{w}_{dt}\right)\right) - \frac{1+\varrho_d}{1-\alpha_d} f_d^2\left(\hat{w}_{dt+1}^* + \hat{\pi}_{t+1} - \hat{w}_{dt}\right)\right] \\ - \beta\tilde{\vartheta}_c\left(1-\rho_c\right) q\left(\theta\right)\theta_c E_t\left[f_c^1\left(\frac{\alpha_c}{1-\alpha_l}\left(\hat{w}_{ct+1}^* + \hat{\pi}_{t+1} - \hat{w}_{ct}\right)\right) - \frac{1+\varrho_c}{1-\alpha_c} f_c^2\left(\hat{w}_{ct+1}^* + \hat{\pi}_{t+1} - \hat{w}_{ct}\right)\right] \\ + \beta\left(1-\rho_d\right)\left(1-q\left(\theta\right)\theta_d\right)\mathcal{W}_d E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\mathcal{W}}_{dt+1}^*\right] - \beta\left(1-\rho_d\right) q\left(\theta\right)\theta_d \mathcal{W}_d E_t\left[\hat{q}_{t+1} + \hat{\theta}_{dt+1}\right] \\ - \beta\left(1-\rho_c\right) q\left(\theta\right)\theta_c \mathcal{W}_c E_t\left[\hat{\lambda}_{t+1} - \hat{\lambda}_t + \hat{\mathcal{W}}_{ct+1}^*\right] - \beta\left(1-\rho_c\right) q\left(\theta\right)\theta_c \mathcal{W}_c E_t\left[\hat{q}_{t+1} + \hat{\theta}_{ct+1}\right], \tag{77}$$

with $f_c^1 = \frac{w_c h_c}{1-\beta\tilde{\vartheta}_c(1-\rho_c)}$ and $f_c^2 = \frac{\chi_c h^{1+\varrho_c}}{(1+\varrho_c)\lambda\left[1-\beta\tilde{\vartheta}_c(1-\rho_c)\right]}$ and $f_d^1 = \frac{w_d h_d}{1-\beta\tilde{\vartheta}_d(1-\rho_d)}$ and $f_d^2 = \frac{\chi_d h^{1+\varrho_d}}{(1+\varrho_d)\lambda\left[1-\beta\tilde{\vartheta}_d(1-\rho_d)\right]}$.

B Tables

B.1 Sources and Definitions of Data

Series	Definition	Source	Mnemonic
NG_d	nominal durable goods	BEA	Table 1.1.5
NG_n	nominal non-durable goods	BEA	Table 1.1.5
NG_s	nominal services	BEA	Table 1.1.5
NG_i	nominal residential investment	BEA	Table 1.1.5
PD_d	price deflator, durable goods	BEA	Table 1.1.9
PD_n	price deflator, non-durable goods	BEA	Table 1.1.9
PD_s	price deflator, services	BEA	Table 1.1.9
PD_i	price deflator, residential investment	BEA	Table 1.1.9
WA_s	hourly earnings, services	BLS	CES0800000008
WA_c	hourly earnings, construction	BLS	CES2000000008
WA_d	hourly earnings, durable goods	BLS	CES3100000008
WA_n	hourly earnings, non-durable goods	BLS	CES3200000008
HO_s	weekly hours, services	BLS	CES0800000007
HO_c	weekly hours, construction	BLS	CES2000000007
HO_d	weekly hours, durable goods	BLS	CES3100000007
HO_n	weekly hours, non-durable goods	BLS	CES3200000007
EM_s	employees, services	BLS	CES0800000006
EM_c	employees, construction	BLS	CES2000000006
EM_d	employees, durable goods	BLS	CES3100000006
EM_n	employees, non-durable goods	BLS	CES3200000006
POP	civilian non-institutional population 16+	FRED	CNP16OV
FFR	effective Federal Funds rate	FRED	FEDFUNDS

Table 1: This table displays the definitions of the raw series used. The monthly series are aggregated to quarterly data. All time series are seasonally adjusted (where applicable). We define the durable sector (D) as the sum of durable goods (d) and residential investment (i) when using BEA data and the sum of durable goods (d) and construction (c) when using BSL data, respectively. Accordingly, the non-durable sector (N) is defined as the sum of the non-durable goods (n) and services (s) in both databases used (BEA, BLS). We then use nominal quantity series and price deflators to compute real Törnqvist (1936) quantity indices (QI_N, QI_D).

B.2 Definition of Variables in the SVAR

Variable	Symbol	Definition
relative price of durable goods	Δp_t^d	log of (PD_D/PD_N)
relative wage of workers in the durable sector	Δw_t^d	log of (WA_D/WA_N)
inflation rate in the non-durable sector	π_t	first difference of log (PD_C)
employment rate in the non-durable sector	n_t^c	log of (EM_N/POP)
employment rate in the durable sector	n_t^d	log of (EM_D/POP)
hours per worker in the non-durable sector	h_t^c	log of (HO_C)
hours per worker in the durable sector	h_t^d	log of (HO_D)
output per capita in the non-durable sector	y_t^c	log of (QI_N/POP)
output per capita in the durable sector	y_t^d	log of (QI_D/POP)
Federal Funds rate	r_t	FFR

Table 2: This table displays the variables that enter the SVAR.

Table 3: Parameter Values - Baseline Calibration

Description	Parameter	Value
Preferences		
discount factor	β	0.99
inverse of the inter-temporal elasticity of substitution	σ	1
weight of non-durable goods in the utility function	ζ	0.76
share of non-durable goods in consumption (implied)	$c/(c+\varphi y_d)$	0.81
elasticity of substitution between varieties	ϵ_s	11
labour supply elasticity along the intensive margin	ϱ_s	2.8
hours per worker (normalisation)	h_s	1
utility cost of working time (implied)	χ_s	0.79
Production and Technology		
durable depreciation rate	δ	0.025
Firm-Worker Matches		
non-labour cost of production	μ_s	0.54
labour input expenditure share (implied)	$w_s h_s/(w_s h_s + \mu_s)$	0.40
production elasticity of labour (implied)	α_s	0.40
nom./eff. bargaining power of the rep. household	γ_s, γ_s^*	0.5
Search in the Labour Market		
aggregate unemployment rate (implied)	$1 - n_c - n_d$	0.06
separation rate	ρ_s	0.10
vacancy posting cost	κ_s	0.07
efficiency of the matching function	$\bar{m}$	0.95
unemployment benefits	$\bar{b}$	0.24
ratio of vacancy posting costs to aggregate output (implied)	$(\kappa v)/y$	0.005
total replacement ratio (implied)	$(\bar{b}+\bar{l})/w$	0.91
aggregate job searchers (implied)	u_t	0.15
job finding rate (implied)	$p(\theta)$	0.61
matching elasticity of vacancies	ξ	0.5
Price and Wage Stickiness		
Calvo price stickiness in sector c	ϑ_c	0.7
Calvo price stickiness in sector d	ϑ_d	0
Calvo wage stickiness (symmetric across sectors)	$\tilde{\vartheta}_s$	0.4
Monetary Policy		
monetary policy inertia	μ_r	0.8
monetary policy responsiveness to inflation	r_p	2.0
monetary policy responsiveness to the output gap	r_y	0.3

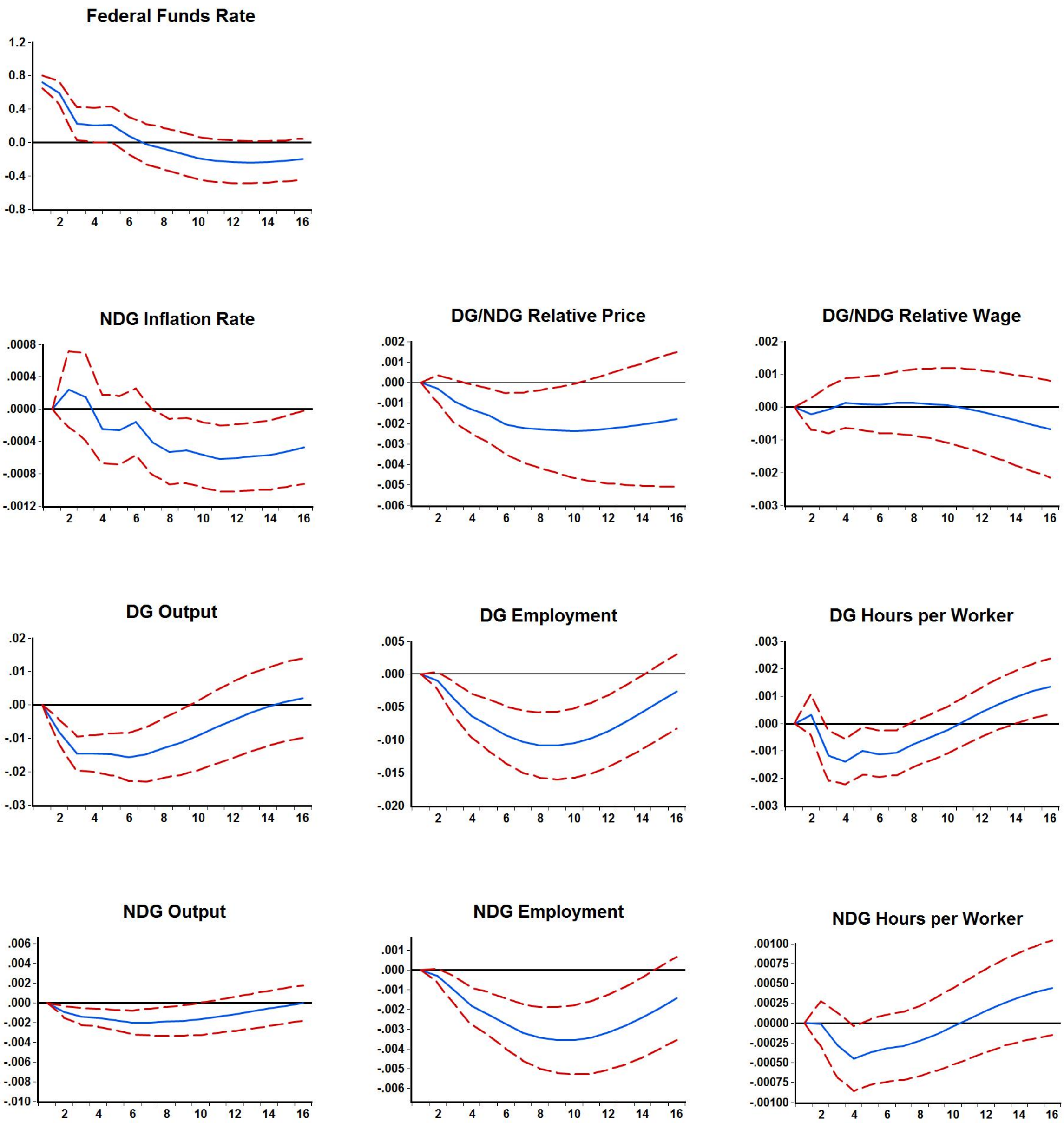

Figure 1: The figure illustrates the Cholesky orthogonalised impulse responses to a contractionary monetary policy shock. The blue solid line is the point estimate. The red dashed lines represents the two standard error confidence band.

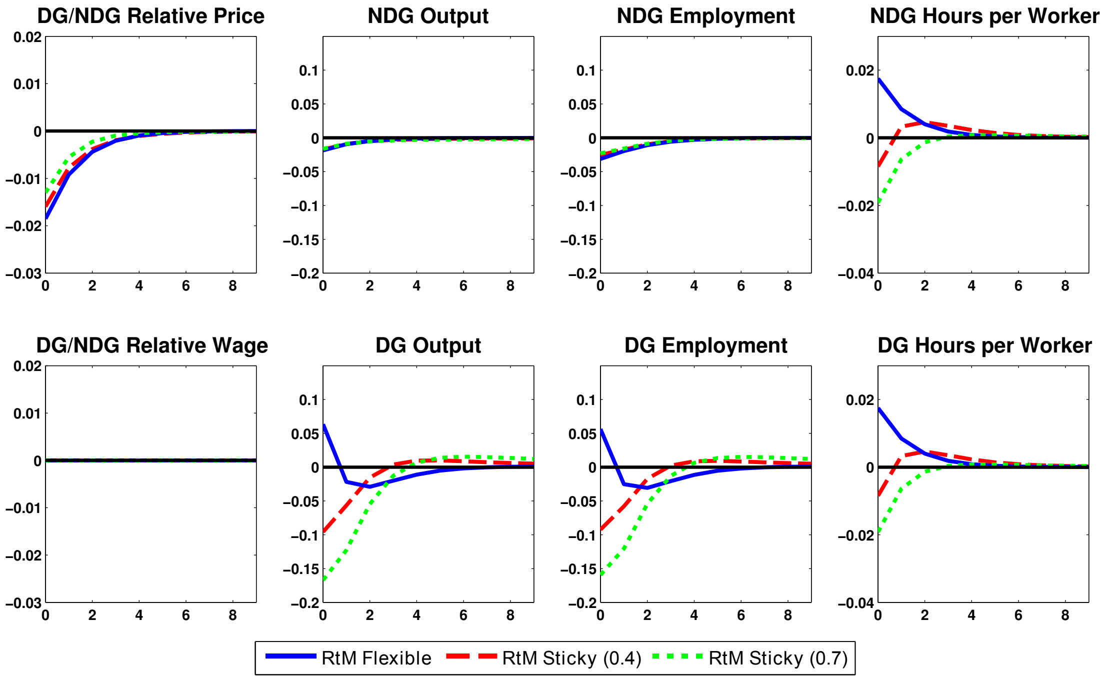

Figure 2: The figure illustrates the impulse responses to a contractionary monetary policy shock under Right-to-Manage bargaining. The blue solid line represents the flexible wage regime. The red dashed line represents the sticky wage regime (with $\vartheta = 0.4$).

Figure 3: The figure illustrates the impulse responses to a contractionary monetary policy shock under Nash bargaining. The blue solid line represents the flexible wage regime. The red dashed line represents the sticky wage regime (with $\vartheta = 0.4$).

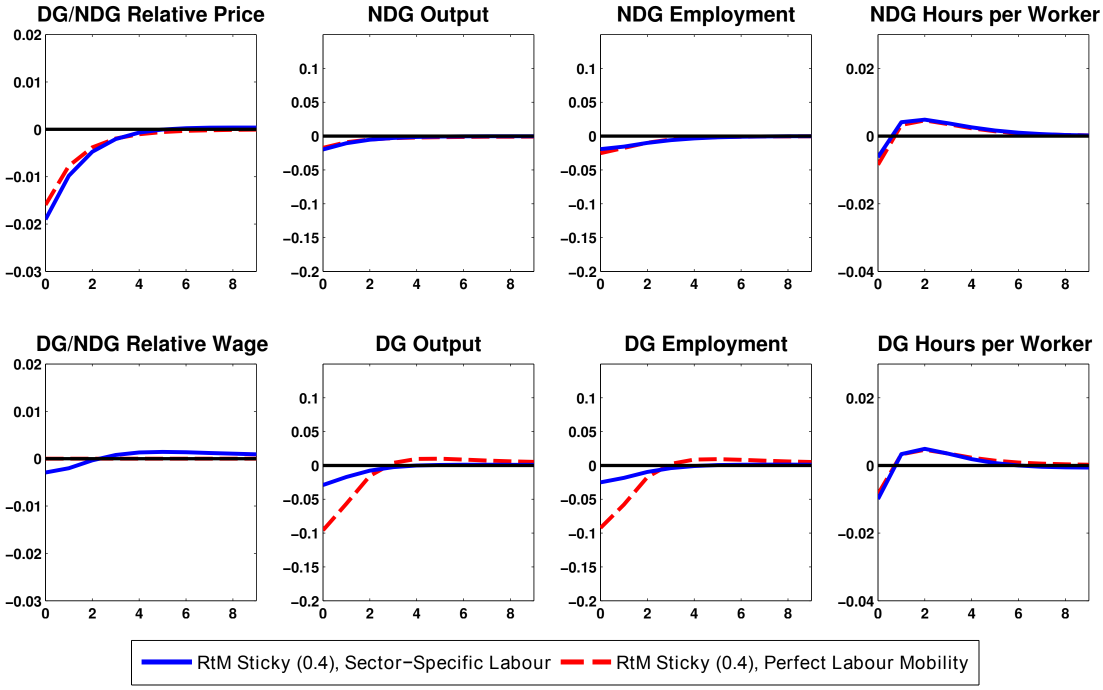

Figure 4: The figure illustrates the impulse responses to a contractionary monetary policy shock under different degrees of cross-sectoral labour mobility. The blue solid line represents the model with perfect cross-sectoral labour mobility. The red dashed line represents the model where labour is sector-specific. Nominal wages are sticky under both model versions (with $\vartheta = 0.4$).

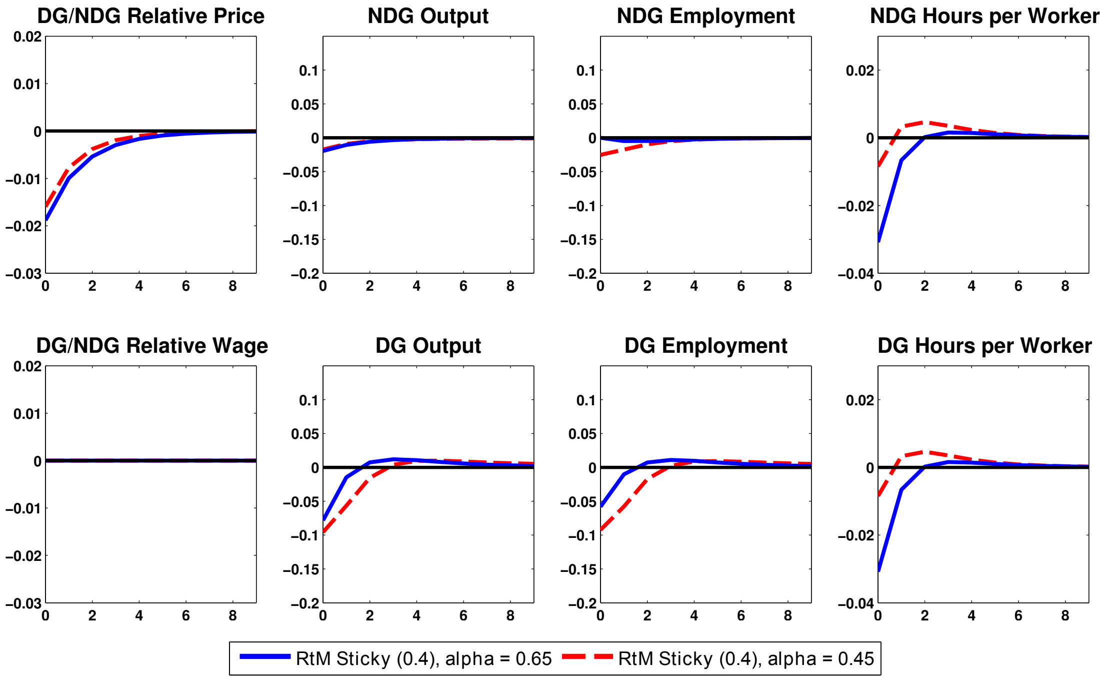

Figure 5: The figure illustrates the impulse responses to a contractionary monetary policy shock under two different model parameterisations. The blue solid line represents the model when $\alpha_s = 0.65$. The red dashed line represents the model when $\alpha = 0.45$. Nominal wages are sticky under both model versions (with $\vartheta = 0.4$).