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The Monetary Transmission Mechanism within a Two-Sector Model

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This paper uses a Bayesian approach to estimate a two-sector sticky price model with working capital and habit formation. The estimated degrees of working capital and habit formation are all well above zero, suggesting the existence of both channels. Furthermore, we identify a new monetary policy transmission mechanism that operates through the inflation dynamics of the relative prices due to the heterogeneous degrees of working capital across sectors. Furthermore the estimated model with working capital and habit formation simultaneously accounts for the co-movement between durables and non-durables and the more sensitive response in the durable goods sector to monetary policy shocks as documented in previous studies. Using log marginal likelihood, the model with working capital and habit formation outperforms its counterpart without either of these mechanisms.

Keywords: working capital, habit formation, durable good, bayesian estimation business cycle
JEL classification: C11, E37, E52, L68

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1 Introduction

Over the past decade, one-sector dynamic New Keynesian (DNK) models have become the workhorse of modern macroeconomics. Many studies have identified the key propagation mechanisms within this class of models. Among which, the working capital and habit formation are two of the most widely acknowledged and empirically support monetary transmission mechanisms. Working capital has been extensively used in recent business cycle models to transmit interest rate shocks to real outcomes; see, for example, Christiano, Eichenbaum, and Evans (2005) and Neumeyer and Perri (2005). Furthermore, working capital can help resolve price puzzles, which refer to the increase in the price level that follows a contractionary monetary policy shock.[1] In addition, many existing studies show that VAR responses of non-durable goods consumption to a monetary policy shock are hump shaped. However, standard preferences and rational expectations imply that agents want to smooth their consumption and thus fail to generate hump-shaped response in consumption. One way to keep economic models' consumption hump shaped is by adding habit formation. With habit formation, households would like to smooth their consumption growth in response to interest rate shocks, therefore creating a hump-shaped response.

Although many studies have emphasized the importance of working capital and habit formation, the focus of the existing literature has been limited to one-sector models. To bridge the gap, this paper uses a Bayesian approach to estimate a standard two-sector sticky price model that is augmented with working capital and habit formation. The Bayesian approach is a full information approach that explores the implications of the structural model as well as the data. The Bayesian approach allows us to investigate whether working capital and habit are supported as monetary transmission channels by the data as well as whether adding these mechanisms can improve the overall fit of the model. We find (1) the estimated degree of working capital and the intensity of habit formation are all well above zero, so that both mechanisms of working capital and habit formation are supported by the data; (2) the degrees of working capital are different across durable and non-durable goods sectors; and (3) using log marginal likelihood, the

[1] One version of this view has been called the Wright Patman effeect, after US congressman Wright Patman, who argued that raising interest rates to fight inflation was like throwing gasoline on a fire.

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Bayesian approach favors the model with working capital and habit formation over its counterpart with neither working capital nor habit formation.

Our finding that the degrees of working capital are different across sectors identifies a new channel of monetary policy transmission that operates through the inflation dynamics of relative prices across sectors. In particular, the impacts of working capital are larger in the durable goods sector than that in the non-durable goods sector. Our results complement previous findings that there are cross-industry differences in the way that working capital affects inflation dynamics, e.g., Barth III and Ramey (2002) and Dedola and Lippi (2005). However, our empirical specification differs from previous studies in two ways. While most empirical specifications abstract from durable spending in estimating the impacts of working capital, this paper explicitly incorporates the durable sector in the estimation. The other difference lies in our empirical strategy. In particular, this paper relies on the full information approach, which explores the implications of the structural model as well as the data, while the previous study relies on limited information. For example, Christiano, Eichenbaum, and Evans (2005) uses the VAR approach based on a minimum distance estimator, and Ravenna and Walsh (2006) uses instrumental variables to identify the existence of a cost channel.

We estimated two models, one with both working capital and habit formation and one without either of these mechanisms.[2] There are key structural differences across these models that affect the reduced form dynamics of the observables and hence the models' overall fit to the actual data. To investigate what drives the differences between the performance of the models, we compare their posterior second moments. The model that features both working capital and habit formation does a better job of matching the volatilities and the correlations between key variables relative to the model without either mechanism. The high volatility generated by the model without either mechanism is due to its higher estimated standard deviations of the exogenous shocks as well as the absence of sluggish responses in variables induced by internal habits. Moreover, the specification that features working capital and habit generates a positive correlation between durables and non-

[2]We treat habit formation and working capital as a bundle in our estimation. This is because Tsai (2016) shows that the two sector sticky price model needs these two mechanisms to simultaneously accounts for the co-movement between durables and non-durables and the more sensitive response in the durable goods sector to monetary policy shocks.

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durables that is consistent with the data while its counterpart without either mechanism generates a negative correlation between them that is inconsistent with the data. This explains why the specification with working capital and habit performs better in the marginal likelihood comparison exercise.

The paper is related to the so-called co-movement puzzle — the fact that standard two-sector sticky price models cannot account for the positive co-movement between durable and non-durable goods consumption following a monetary policy shock as pointed out by Barsky, House, and Kimball (2007, hereafter BHK). The co-movement problem is essentially driven by the fact that the shadow value of a long-lived durable is approximately unchanged in the wake of a monetary policy shock. The near consistency of the shadow value implies that consumers are nearly indifferent to the timing of durable goods purchases. Therefore, even a small change in the relative price of durable goods can cause a dramatic adjustment in household expenditures on durable goods. A contractionary policy shock which causes a fall in the relative price of durable goods thus leads to an increase in the purchase of durable goods. To resolve the co-movement problem, we introduce the working capital and habit formation into a standard two-sector sticky price model á la Tsai (2016). The working capital channel causes production costs to rise, thereby discouraging production in both durable and non-durable sectors. Furthermore, working capital reduces the fall in the relative price of durables, and hence mitigates the incentive to purchase durable goods. In addition, habit formation in household consumption of non-durable goods which dampens the response of consumption of non-durable goods and allows our model to generate a less sensitive response in the non-durable goods sector as observed in the data. Indeed, our estimated model with working capital and habit formation simultaneously accounts for the co-movement between durables and non-durables and the more sensitive response in the durable goods sector to monetary policy shocks. [3] In contrast, the estimated model without either mechanism fails to generate the co-movement between durables and non-durables.

[3]The existing literature provides several mechanisms, in addition to working capital and habit, which can resolve the co-movement puzzle. For example, Kim and Katayama (2013) address the issue by incorporating a non-separable preference in the standard BHK setting; Carlstrom and Fuerst (2010) consider the role of sticky wages; and Sudo (2012) presents an input-output model, where non-durables act as an intermediate input for durable production.

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This paper complements recent work by Tsai (2016) that also incorporates these two mechanisms into the two-sector sticky price model. The main differences between this paper and Tsai (2016) lie in the number of structural shocks we introduce and the methodology for estimating the two-sector sticky price model. This paper also relates to Dey and Tsai (2017) which uses Bayesian approach to evaluate the importance of the competing mechanisms that resolve the co-movement puzzle. However, it is unclear whether the estimated model with working capital and habit can successfully resolve the co-movement puzzle based on their nested model. In contrast to Dey and Tsai (2017) that evaluates the role of several competing mechanisms, we focus on the important role of working capital and habit in resolving the co-movement problem. Furthermore, this paper allows for a more general set-up for the price-setting behaviors of the durable goods sector. In particular, we allow for different degrees of price stickiness while Dey and Tsai (2017) focus only on the case where non-durable goods prices are sticky and the durable goods are flexible following the specification of Barsky, House, and Kimball (2007). We find that the estimation results continue to favor the model with working capital and habit over its counterpart without either mechanism, irrespective of the assumption for price-setting behaviors of durable goods.

Finally, this paper is also related to the growing literature on the estimation of general equilibrium models using Bayesian techniques that systematically evaluate the importance of various shocks and frictions in causing business cycle fluctuations such as Smets and Wouters (2003, 2007), Justiniano, Primiceri, and Tambalotti (2010), Lubik and Schorfheide (2006), and Rabanal and Tuesta (2010).

The rest of the paper is organized as follows. We present our model in Section 2 and the estimation results in Section 3. Section 4 discusses what causes the disparities between the data and the models, and Section 5 conducts a robustness check of alternative model specifications. Section 6 concludes.

2 Model

Our model is based on the framework developed in BHK and Tsai (2016). There are three types of agents in this economy: firms, households, and the monetary authority. We describe their optimal behaviors below.

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2.1 Firms

There are two sectors on the production side: durable and non-durable goods sectors. Within each sector, there is a continuum of monopolistically competitive intermediate firms, indexed by $f \in [0, 1]$, each producing a differentiated product, $Y_{jt}(f)$ where the subscript $j \in \{c, x\}$. The subscripts c and x refer to the non-durable goods and durable goods sectors respectively. There is a representative firm in each sector that combines the differentiated products into a single sectoral output Y_{jt} according to the CES production functions

$$Y_{jt} = \left[\int_0^1 Y_{jt}(f)^{\frac{\varepsilon_j - 1}{\varepsilon_j}} df\right]^{\frac{\varepsilon_j}{\varepsilon_j - 1}}, \tag{1}$$

where ε_j is the elasticity of substitution of intermediate goods in sector j. The representative firm chooses the bundle of intermediate goods to minimize the cost of producing a given quantity of the sectoral output. The cost minimization problem for the final good producer in each sector implies that the demand for intermediate goods is given by

$$Y_{jt}(f) = \left(\frac{P_{jt}(f)}{P_{jt}}\right)^{-\varepsilon_j} Y_{jt}, \tag{2}$$

which depends on the relative price $P_{jt}(f)$ of each good $Y_{jt}(f)$ and the total quantity demand for the sectoral output Y_{jt}. Moreover, the sectoral price index can be expressed as $P_{jt} = [\int_0^1 P_{j,t}(f)^{1-\varepsilon} df]^{1/1-\varepsilon}$, for $j = c, x$.

Each intermediate good firm chooses $K_{jt}(f)$ and $L_{jt}(f)$ to produce its differentiated product. All firms within each sector face the same Cobb-Douglas production function. The production functions for firms in non-durable and durable goods sectors are respectively,

$$Y_{ct}(f) = K_{c,t}(f)^{\alpha} \left(A_t L_{c,t}(f)\right)^{1-\alpha}, \tag{3}$$

$$Y_{xt}(f) = K_{x,t}(f)^{\alpha} \left(A_t Z_t L_{x,t}(f)\right)^{1-\alpha}, \tag{4}$$

where α is the share of capital in production, A_t denotes the aggregate productivity shock which has the following law of motion:

$$A_t = A_{t-1} e^{g_{a,t}} \tag{5}$$

$$g_{a,t} = \rho_a g_{a,t-1} + \eta_t^a, \tag{6}$$

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where $\eta_t^a \sim N(0, \sigma_a^2)$, and Z_t is the relative price shock and follows

$$Z_t = Z_{t-1} e^{g_{z,t}}, \tag{7}$$

$$g_{z,t} = \rho_z g_{z,t-1} + \eta_t^z, \tag{8}$$

where $\eta_t^z \sim N(0, \sigma_z^2)$. Note that, in equilibrium,

$$\frac{1}{Z_t} = \frac{P_{x,t}}{P_{c,t}}. \tag{9}$$

These intermediate goods firms are competitive in the factor market and take factor prices as given. Since the firm needs to borrow to pay its labor, the production cost depends on not only wages but also on interest rates, which is the so-called working capital channel. We allow for cross-sectoral differences in how working capital affects inflation dynamics. In particular, the wage bill in each sector is $R_t^{\vartheta_j} W_t L_t(i)$ where R_t is the short-term interest rate on the firm's loan and ϑ_j is the parameter governing the degree of working capital in sector j. The cost minimization problems imply that marginal cost for firms within non-durable and durable goods sector are respectively,

$$MC_{c,t} = \frac{R_t^{\vartheta_c} W_t L_{c,t}^{\alpha}}{(1-\alpha) K_{c,t}^{\alpha} A_t^{1-\alpha}}. \tag{10}$$

$$MC_{x,t} = \frac{R_t^{\vartheta_x} W_t L_{x,t}^{\alpha}}{(1-\alpha) K_{x,t}^{\alpha} (A_t Z_t)^{1-\alpha}}. \tag{11}$$

The prices are adjusted in a staggered manner. In each period, a fraction $1-\theta_j$ of firms in sector j can choose their prices to maximize their profit regardless of the time of their last price adjustment. The remaining fraction, θ_j, of the firms use the same price as in the previous period. Therefore, when an intermediate good producer f in sector j is allowed to reset its price in period t, it chooses $P_{j,t}^*(f)$ to maximize its discounted profit,

$$\max_{P_{j,t}^*(f)} \sum_{s=0}^{\infty} (\beta\theta_c)^s E_t \frac{\Lambda_{t+s}}{P_{j,t+s}} \Big[P_{j,t+s}(f) Y_{j,t+s}(f) - R_{t+s}^{\vartheta_j} W_{t+s} L_{j,t+s}(f) - R_{j,t+s} K_{j,t+s}(f) \Big], \tag{12}$$

subject to the demand for its product (2) and production function (3), where Λ_{t+j} denotes the marginal utility of consumption for period $t+j$. The

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first-order conditions for $P^*_{j,t}(f)$ is

$$P^*_{j,t}(f) = \frac{\varepsilon_j}{\varepsilon_j - 1} \frac{\sum_{s=0}^{\infty} \left(\beta\theta_j\right)^s E_t \Lambda_{t+s} MC_{j,t+s} \left(\frac{1}{P_{j,t+s}}\right)^{1-\varepsilon_j} Y_{j,t+s}}{\sum_{s=0}^{\infty} \left(\beta\theta_j\right)^s E_t \Lambda_{t+s} \left(\frac{1}{P_{j,t+s}}\right)^{1-\varepsilon_j} Y_{j,t+s}}. \tag{13}$$

The sectoral output price index can be written as,

$$P_{j,t} = \left[\left(1-\theta_j\right) P^{*1-\varepsilon_j}_{j,t} + \theta_j P^{1-\varepsilon_j}_{j,t-1}\right]^{\frac{1}{1-\varepsilon_j}}. \tag{14}$$

2.2 Households

In every period, there is a representative household that maximizes its expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \epsilon^g_t \left\{ \frac{\left[(C_t - h_b C_{t-1})^{\psi_c} (D_t - h_b D_{t-1})^{\psi_d \epsilon^d_t}\right]^{1-\sigma}}{1-\sigma} - \epsilon^l_t \phi L_t^{1+\nu} \right\}, \tag{15}$$

where β is the discount factor, σ is the intertemporal elasticity of substitution, h_b is the habit persistence, ψ_c is the weight of non-durable goods in the household's consumption composite, ψ_d is the weight of durable goods in the household's consumption composite, ϕ is the parameter measures that disutility form working, and ν is the inverse of the Frisch labor supply elasticity. C_t, D_t and L_t denote respectively non-durable consumption, a durable consumption stock, and labor services. The term ϵ^g_t is the intertemporal preference shock that follows an AR(1) process:

$$\epsilon^g_t = \rho^g \epsilon^g_{t-1} + \eta^g_t, \tag{16}$$

where $\eta^g_t \sim N(0, \sigma^2_g)$. ϵ^l_t is the intratemporal preference shock, which has the following law of motion:

$$\epsilon^l_t = \rho^l \epsilon^l_{t-1} + \eta^l_t, \tag{17}$$

where $\eta^l_t \sim N(0, \sigma^2_l)$. Also, ϵ^d_t is the durable preference shock, which has the following law of motion:

$$\epsilon^d_t = \rho^d \epsilon^d_{t-1} + \eta^d_t, \tag{18}$$

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where $\eta_t^d \sim N(0, \sigma_d^2)$.

Each household enters period t with initial bond holdings of S_{t-1} and fixed stock of capital $\bar{K}$, receives wage income, $W_t L_t$, profits, Π_t, and government transfers, T_t, and purchases non-durable goods, $P_{c,t}C_t$, durable goods, $P_{x,t}X_t$, and a risk-free bond, S_t/R_t. The household's budget constraint is

$$\begin{aligned} P_{c,t}C_t + P_{x,t}X_t + P_{x,t}\left[\frac{1}{2}\phi_1\frac{(X_t - \delta D_{t-1})^2}{D_{t-1}}\right] &\leq W_t L_t \\ + \sum_{j=c,x} R_{j,t}u_{j,t}\bar{K}_{j,t} + \Pi_t + T_t + S_{t-1} - \frac{S_t}{R_t} & \\ - \sum_{j=c,x} P_{j,t}a\left(u_{j,t}\right)\bar{K}_{j,t}, \quad t = 0, 1, \cdots, & \end{aligned} \tag{19}$$

and the law of motion for durable goods consumption is

$$D_t = (1-\delta)D_{t-1} + X_t, \tag{20}$$

where S_{-1} and D_{-1} are given and δ is the depreciation rate. $R_{j,t}$, $K_{j,t}$ and $u_{j,t}$ are the rental rates of capital, productive capital stock, and variable capital utilization rates in each sector $j = c, x$, respectively. Hence, the capital services in each sector are given by $K_{j,t} = u_{j,t}\bar{K}_{j,t}$. The cost of setting the capital utilization rate is given by $a(u_{j,t})$, which is increasing and convex in $u_{j,t}$. We assume that $\bar{u}_j = 1, a(1) = 0$. The elasticity of capital utilization is given by $(a''(1)/a'(1))$. Furthermore, to smooth the behavior of durable goods consumption, we add adjustment costs in the household budget constraint along the lines of Engel and Wang (2011). Here, ϕ_1 is the adjustment cost parameter. Next, we discuss each of the household decisions in turn.

By letting $B_t = (C_t - h_b C_{t-1})^{\psi_c}(D_t - h_b D_{t-1})^{\psi_d \epsilon_t^d}$, the first-order conditions from the household optimization problem with respect to C_t, X_t, D_t, L_t, $u_{c,t}$, $u_{x,t}$ are:

$$\Lambda_t P_{c,t} = \psi_c \epsilon_t^g \frac{B_t^{1-\sigma}}{(C_t - h_b C_{t-1})} - h_b \beta \psi_c E_t \epsilon_{t+1}^g \frac{B_{t+1}^{1-\sigma}}{(C_{t+1} - h_b C_t)}, \tag{21}$$

$$\Lambda_t P_{x,t} + \Lambda_t P_{x,t}\phi_1\frac{(X_t - \delta D_{t-1})}{D_{t-1}} = \Xi_t, \tag{22}$$

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$$\Xi_t - \beta(1-\delta)E_t\Xi_{t+1} = \psi_d \frac{B_t^{1-\sigma}}{D_t - h_b D_{t-1}}\epsilon_t^g \epsilon_t^d - h_b\beta\psi_d E_t \frac{B_{t+1}^{1-\sigma}}{D_{t+1} - h_b D_t}\epsilon_{t+1}^g \epsilon_{t+1}^d + \beta\Lambda_{t+1}P_{x,t+1}\left[\phi_1\delta\frac{(X_{t+1} - \delta D_t)}{D_t} + \frac{\phi_1}{2}\frac{(X_{t+1} - \delta D_t)^2}{D_t^2}\right], \quad (23)$$

$$\phi(1+\nu)L_t^{\nu}\epsilon_t^g\epsilon_t^l = \Lambda_t W_t, \quad (24)$$

$$R_{c,t} = P_{c,t}a'\left(u_{c,t}\right), \quad (25)$$

$$R_{x,t} = P_{x,t}a'\left(u_{x,t}\right), \quad (26)$$

$$\frac{\Lambda_t}{P_{c,t}} = \beta E_t\left[\Lambda_{t+1}\frac{R_t}{P_{c,t+1}}\right]. \quad (27)$$

Here Λ_t, Ξ_t represent the Lagrangian multipliers for constraints (19) and (20), respectively. Equation (21) represents the marginal utility of non-durable consumption. Equation (22) and (23) combined represent the trade-off between non-durable and durable goods. Equations (24) represent the trade-off between non-durable consumption and leisure. The first order condition for a capital utilization rate, given by equations (25) and (26), set the marginal benefit from utilizing an extra unit of capital, given by the rental price of capital services, to marginal user cost. Lastly, equation (27) represents the trade-off between non-durable consumption and bond holdings.

2.3 Monetary policy

The central bank follows the Taylor rule by adjusting the nominal interest rate in response to changes in inflation and the output gap.[4] We allow the monetary authority to partially adjust toward the optimal interest target and use the following specification

$$R_t = R_{t-1}^{\rho_r}\left(\pi_t\right)^{(1-\rho_r)\phi_\pi}\left(Y_t\right)^{(1-\rho_r)\phi_y}\epsilon_t^r, \quad (28)$$

where ρ_r determines the degree of interest rate smoothing and ϵ_t^r is an i.i.d. monetary policy shock such that $\epsilon_t^r \sim N(0, \sigma_r^2)$.

[4]Inflation is defined as a weighted average of non-durable goods inflation and durable goods inflation, $\widehat{\pi}_t = (C/Y)\widehat{\pi}_{ct} + (X/Y)\widehat{\pi}_{xt}$.

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2.4 Market clearing

Finally, the model is closed with market clearing conditions in the labor, capital, and goods markets. The labor market equilibrium requires

$$L_t = L_{c,t} + L_{x,t}. \tag{29}$$

The capital market equilibrium requires

$$\bar{K} = \bar{K}_{c,t} + \bar{K}_{x,t},\ K_{c,t} = u_{c,t}\bar{K}_{c,t},\ K_{x,t} = u_{x,t}\bar{K}_{x,t}. \tag{30}$$

and the goods market equilibrium requires that

$$Y_t = C_t + X_t + a\left(u_{x,t}\right)\bar{K}_{x,t} + a\left(u_{c,t}\right)\bar{K}_{c,t}. \tag{31}$$

2.5 The alternative model specification

In addition to the benchmark model, we also estimate the model with neither working capital nor habit formation. In the following sections, we will assess alternative model specifications that are crucial for simultaneously fitting the data well and resolving the co-movement puzzle.

3 Bayesian estimation

In this section, we take our model to the data. We estimate the parameters of our model using Bayesian methods.

3.1 Data

To estimate the parameters of our model, we use six observables: real durable goods consumption expenditure, X_t, real non-durable goods consumption expenditure, C_t, the relative price of non-durables to durables, P_t, hours worked, N_t, the real wage growth rate, W_t, and a short-term interest rate, R_t. The sample period is from 1959:02 to 2010:04, at a quarterly frequency. The first three series are constructed using the data from the US Department of Commerce - Bureau of Economic Analysis databank.[5] The next three series are taken from FRED of the St. Louis Fed. To compute the real wage index, we dividie the non-farm business sector compensation per hour by

[5] Please refer to Kim and Katayama (2013) for a detailed description of how to construct these series.

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the GDP deflator. All series are seasonally adjusted. The set of observable variables is given by:

$$Z_t = [dlX_t, dlC_t, dlP_t, lN_t, dlW_t, lR_t]', \tag{32}$$

where l and dl stand for the log and log difference, respectively. The corresponding log-linearized measurement equations, mapping the observables and transformed variables, are as follows:

$$\begin{bmatrix} dlX_t \\ dlC_t \\ dlP_t \\ lN_t \\ dlW_t \\ R_t \end{bmatrix} = \begin{bmatrix} (\hat{x}_t - \hat{x}_{t-1}) \\ (\hat{c}_t - \hat{c}_{t-1}) \\ (\hat{p}_{c,t} - \hat{p}_{x,t}) - (\hat{p}_{c,t-1} - \hat{p}_{x,t-1}) \\ \hat{n}_t \\ (\hat{w}_t - \hat{w}_{t-1}) \\ \hat{r}_t \end{bmatrix} + \begin{bmatrix} \hat{g}_{a,t} + \hat{g}_{z,t} \\ \hat{g}_{a,t} \\ \hat{g}_{z,t} \\ 0 \\ \hat{g}_{a,t} \\ 0 \end{bmatrix}. \tag{33}$$

3.2 Calibrated Parameters

Our model is calibrated at a quarterly frequency. We fix some of the deep parameters, which are either difficult to estimate or better identified using other information. In particular, the quarterly depreciation rate of the durables stock, δ, is set equal to 0.025, consistent with an annual depreciation rate of 10 percent. The discount rate, β, is set to 0.99, implying a steady-state annual real interest rate of 4 percent. We assume that the intertemporal elasticity of substitution parameter $\sigma = 1$ and the Frisch elasticity of labor supply $\nu = 1$. These settings for the preference parameters are well within the range typically estimated in the empirical literature. For the durable goods adjustment cost, ϕ_1, is set at 4 following Smets and Wouters (2007) and Christiano, Eichenbaum, and Evans (2005). Also, ψ_c and ψ_d are set to give a steady-state non-durable share of 0.75 in consumption.[6] We impose the Calvo parameters for the durable goods sector, $\theta_x = 0$, which implies flexible durable goods prices. This corresponds to the setting in BHK that features the co-movement problem between durables and non-durables. Finally, the steady state markup is set at 6. The rest of the parameters are estimated.

[6] In steady state, $\psi_c = \{[c/d/1 - \beta(1-\delta)]/[1 + (c/d/1 - \beta(1-\delta))]\}$, where c, d are steady-state values of non-durable and durable consumption, respectively.

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Table 1: Priors of structural parameters

Parameter	Description	Distribution	Mean	Std. Dev
h_b	habit parameter	Gamma	0.70	0.10
ϑ_R^x	working capital parameter for durables	Gamma	1.00	0.25
ϑ_R^c	working capital parameter for non-durables	Gamma	1.00	0.25
θ_c	probability of not optimizing prices	Beta	0.66	0.10
ϕ_π	Taylor rule response to inflation	Normal	1.70	0.3
ϕ_y	Taylor rule response to output	Normal	0.13	0.05
ρ_r	Taylor rule inertia	Beta	0.6	0.20
ρ_a	persistence of productivity shock	Beta	0.5	0.2
ρ_g	persistence of preference shock	Beta	0.5	0.2
ρ_l	persistence of labor supply shock	Beta	0.5	0.2
ρ_v	persistence of relative price shock	Beta	0.5	0.2
ρ_d	persistence of durable preference shock	Beta	0.5	0.2
σ^a	s.d. of productivity shock	Inverse Gamma	0.10	2.00
σ^g	s.d. of preference shock	Inverse Gamma	0.10	2.00
σ^l	s.d. of labor supply shock	Inverse Gamma	0.10	2.00
σ^v	s.d. of relative price shock	Inverse Gamma	0.10	2.00
σ^r	s.d. of monetary policy shock	Inverse Gamma	0.10	2.00
σ^g	s.d. of durable preference shock	Inverse Gamma	0.10	2.00

Notes: This table lists the description and prior distributions of the structural parameters in the benchmark and its counterpart model specification.

3.3 Prior Distributions

Our priors are in Table 1. Overall, they are consistent with previous studies. For the standard deviations of all structural shocks, we assume they follow inverse gamma priors with mean of 0.1 and standard error of 2.0. For the AR(1) coefficients, we choose beta distributions with mean of 0.5 and standard error of 0.2. The habit persistence parameter, h_b, follows a beta distribution with mean of 0.7 and standard error of 0.1. The working capital parameters ϑ_R^x, ϑ_R^c, are assumed to follow a gamma distribution with mean of 1.0 and standard error of 0.25.

We set the prior mean of the Calvo parameter for the non-durable goods sector, θ_c, at 0.66 with a standard error of around 0.10, which is consistent with Khan and Tsoukalas (2011). This implies that the average durations of the price contracts are approximately three-quarters. The monetary policy shock parameters are set at standard calibration values. The coefficients for inflation, ϕ_π, and the output gap, ϕ_y, follow normal distributions with

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means of 1.7 and 0.13 and standard errors of 0.3 and 0.05, respectively (based on Khan and Tsoukalas (2011)). The interest rate smoothing parameter is assumed to have a mean of 0.6 and a standard error of 0.20.

4 Estimation results

This section presents estimation results. We first show parameter estimates for our benchmark model and then compare it with the counterpart model without either working capital or habit formation.

4.1 Posterior distributions of the parameters

Table 2 reports the posterior estimates of all the parameters for the specification of both models. We report the posterior mean, and the 5th and 95th percentiles of the posterior distribution of the parameters that are obtained through the Metropolis-Hastings sampling algorithm. The results are based on 250,000 draws from the posterior distribution.[7] The column labeled benchmark presents the posterior distribution for the model that incorporates both working capital and habit formation, while the column labeled alternatives presents the counterpart model that with neither working capital nor habit. All the parameters are estimated to be significantly different from zero.

Let's first look at the estimation results of our benchmark model. The posterior mean of the intensity of habit persistence, h_b, is 0.55, and the corresponding 90% probability interval is from 0.53 to 0.57, which is well above zero, indicating that the data strongly support the channel of habit formation. This finding is consistent with earlier studies, such as Smets and Wouters (2007). The posterior means of working capital for the nondurable and durable goods sectors are 1.07 and 1.8, and their associated 90% confidence intervals are from 0.98 to 1.17 and 1.73 to 1.91, respectively. Since the estimates of the working capital parameters for both sectors are significantly different from zero, the data support the existence of working capital channels for both sectors. In addition, their 90% intervals do not overlap with each other, indicating that the degrees of working capital in

[7] We run two chains of the MH algorithm, each with 250,000 draws. The acceptance rate is around 0.25. The plots of the prior and posterior distributions of the parameter estimates under all the models are available on request.

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Table 2: Posterior of structural parameters

Parameter	Benchmark		alternatives	
h_b	0.55	[0.53, 0.57]	–	–
ϑ_R^c	1.07	[0.98, 1.17]	–	–
ϑ_R^x	1.80	[1.73, 1.91]	–	–
ρ_r	0.51	[0.50, 0.52]	0.50	[0.50, 0.51]
ϕ_π	1.72	[1.64, 1.81]	1.22	[1.19, 1.25]
ϕ_y	0.13	[0.12, 0.15]	0.08	[0.08, 0.08]
θ_c	0.71	[0.65, 0.75]	0.85	[0.82, 0.88]
ρ_a	0.45	[0.38, 0.50]	0.34	[0.33, 0.35]
ρ_g	0.94	[0.92, 0.96]	0.99	[0.99, 1.00]
ρ_l	0.98	[0.97, 1.00]	0.96	[0.95, 0.97]
ρ_v	0.26	[0.20, 0.33]	0.22	[0.20, 0.24]
ρ_d	0.95	[0.93, 0.96]	0.55	[0.53, 0.57]
σ^a	0.01	[0.01, 0.01]	0.01	[0.01, 0.01]
σ^v	0.01	[0.01, 0.01]	0.01	[0.01, 0.01]
σ^g	0.03	[0.03, 0.04]	0.09	[0.06, 0.12]
σ^r	0.01	[0.01, 0.01]	0.01	[0.01, 0.01]
σ^l	0.01	[0.01, 0.01]	0.17	[0.15, 0.19]
σ^d	0.01	[0.01, 0.01]	0.06	[0.05, 0.06]
Marginal Likelihood	3909.568		3572.724	
Bayes' Factor	2.28×10^{146}		0	

Notes: This table lists the posterior distributions of the structural parameters in the benchmark specification and the alternative specification. The two numbers in the parentheses are the 5% and 95% confidence intervals. The table reports log marginal likelihoods from each model. The Bayes' factor is given by calculating the difference between log marginal likelihoods of the benchmark specification and the alternative specification.

each of these two sectors are heterogeneous; specifically, the degree of working capital is higher in the durable goods sector than in the non-durable goods sector. This implies that firms borrow more in advance in the durable sector than in the non-durable sector. This result complements previous studies that find cross-industry differences in the way which working capital

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affects inflation dynamics. The price stickiness parameter, θ_c, is estimated to be 0.71, with the 90% confidence intervals estimated from 0.65 to 0.75. The estimation result is consistent with previous findings such as Smets and Wouters (2007) and implies that the average duration of the price contract is around 3.3 quarters.

Turning to the estimate of the parameters governing the exogenous shocks, the three preference shocks (intertemporal, labor supply, and durable preference) are all estimated to be very persistent, while the productivity shocks and the relative price shocks are estimated to be less persistent in the benchmark specification. The estimate of the interest rate smoothing parameter indicates an intermediate degree of smoothing. The mean of the reaction coefficient to inflation is larger than one. However, monetary policy does not appear to react very strongly to the output gap in the short run. The estimated standard deviation of the intertemporal preference shocks is more volatile than other shocks in the model.

Table 2 also reports the posterior distribution under the model specification without either mechanism. Overall, the posterior means of most parameters are similar in both cases. However, some key similarities and differences are worth mentioning. Note that the working capital channel helps to reduce the model's reliance on sticky prices. Therefore, in the model that does not allow for working capital, the estimates for the price stickiness parameter are higher and the average duration of price contracts increases dramatically. In particular, the posterior mean of θ_c increases from 0.71 in the benchmark to 0.85 in the counterpart, and the corresponding average duration of price contracts increases from 3.45 to 6.67 quarters. This increase also seems to be statistically significant since the 90% probability intervals do not overlap. Relative to the benchmark specification, the durable preference shock is estimated to be less persistent, and the intertemporal preference, durable preference, and labor supply shocks are all estimated to be more volatile in the counterpart specification.

4.2 Model comparison

Recall that our estimation exercise has two goals: to examine how well the estimated model can (i) explain the co-movement puzzle and (ii) fit the data. To pursue the first goal, we plot the impulse responses of key variables to a policy shock computed at the posterior means of the parameters. To achieve the second goal of the estimation exercise, we compare the log

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marginal likelihood, which is based on Geweke's harmonic mean estimator. Our estimation results show that working capital and habit help resolve the co-movement puzzle and significantly improve the overall fit (empirical performance) of the model.

4.2.1 Impulse responses

Figure 1 shows the impulse responses of key variables to a one standard deviation monetary policy shock under the benchmark model and its counterpart. The impulse responses are computed at the estimated posterior means of the parameters under each model. On the one hand, we observe that the benchmark model, which includes both mechanisms of working capital and habit formation, successfully resolves the co-movement puzzle. On the other hand, the alternative model, which does not incorporate either channel, fails to resolve the puzzle. Moreover, the estimated benchmark model also successfully accounts for the more sensitive response in the durable goods sector to monetary policy shocks.

Following a positive interest rate shock, the working capital channel raises production costs, thereby discouraging production of both durable and non-durable goods. Moreover, the working capital channel mitigates the fall in the relative price of durables due to the increase in the interest rate, which reduces the incentive to purchase durable goods. In addition, habit formation induces households to smooth the growth rate of non-durable goods consumption, and therefore mitigates the fall in non-durable goods. These two channels together solve the co-movement problem and successfully generate a more sensitive response to policy shocks in the durable goods sector as observed in the data.

In Figure 2–6, we also report the impulse responses of key variables to alternative shocks under the benchmark model and its counterpart. In contrast to the impulse responses to monetary policy shocks, the impulse responses to alternative shocks are qualitative similar regardless of the specification of these two models. This indicates that working capital and habit formation mainly affect the monetary transmission mechanisms. Finally, non-durable consumption and durable consumption move positively in response to labor supply and aggregate technology shocks, while they move negatively with all the remaining shocks.

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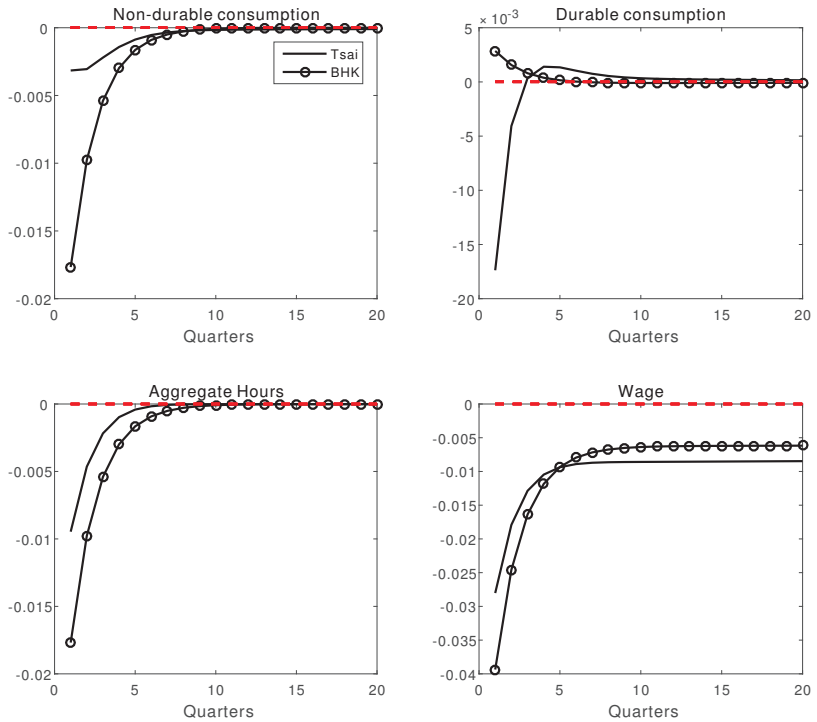


Figure 1: IRF from one std. deviation contractionary monetary policy shock.

Notes: Responses of model variables to one standard deviation monetary policy shock under the benchmark (solid line) and its counterpart (circled line) specifications. All the impulse responses are computed at the mean of posterior distributions obtained under each model.

4.2.2 Model fit

Table 2 also reports the marginal likelihood under each specification. One advantage of Bayesian analysis is that it can be employed to assess the relative plausibility of alternative model specifications by comparing the log marginal likelihood.[8] It is quite evident that the data strongly favors the benchmark specification over its counterpart specification. The marginal

[8]This tool has been successfully used to make comparisons across models in Lubik and Schorfheide (2006), Rabanal and Tuesta (2010), Smets and Wouters (2007), and Justiniano,

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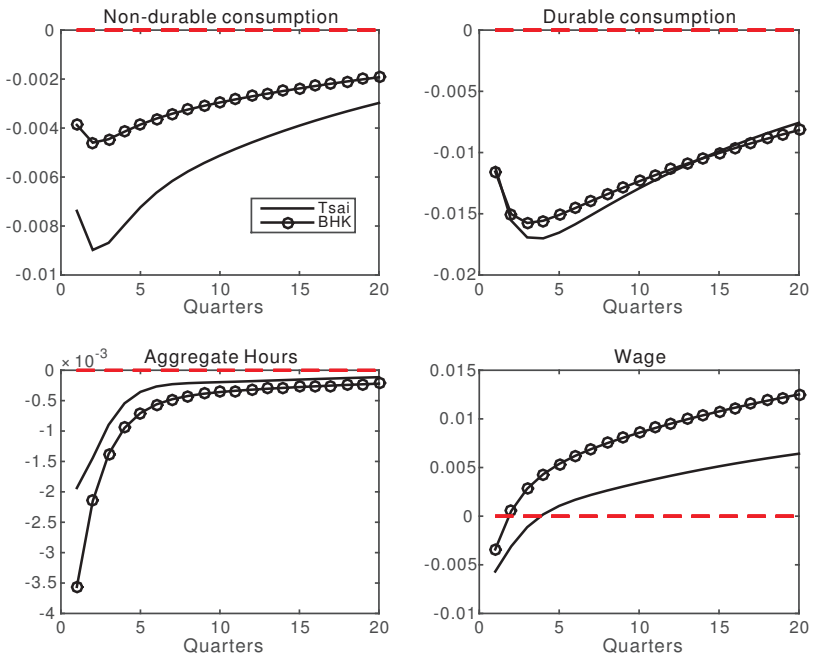


Figure 2: IRF from one std. deviation technology shock

Notes: Responses of model variables to one standard deviation technology shock under the benchmark (solid line) and its counterpart (circled line) specifications. All the impulse responses are computed at the mean of posterior distributions obtained under each model.

log-likelihood under the alternative model decreases by 336.764 compared to the benchmark model, which means that priors that favor the alternative model over the benchmark model by a factor of $\exp(337) \approx 2.28 \times 10^{146}$ are needed in order to accept it after observing the data. This factor is substantially high, which indicates that the data strongly favors the benchmark model over the alternative specification since it lacks all the key channels needed to generate co-movement between durable and nondurable goods consumption.

Primiceri, and Tambalotti (2010). Fernández-Villaverde and Rubio-Ramírez (2004) argue that Bayesian inference based on marginal likelihood comparisons across models is valid even if the models are non-nested, mis-specified and non-linear.

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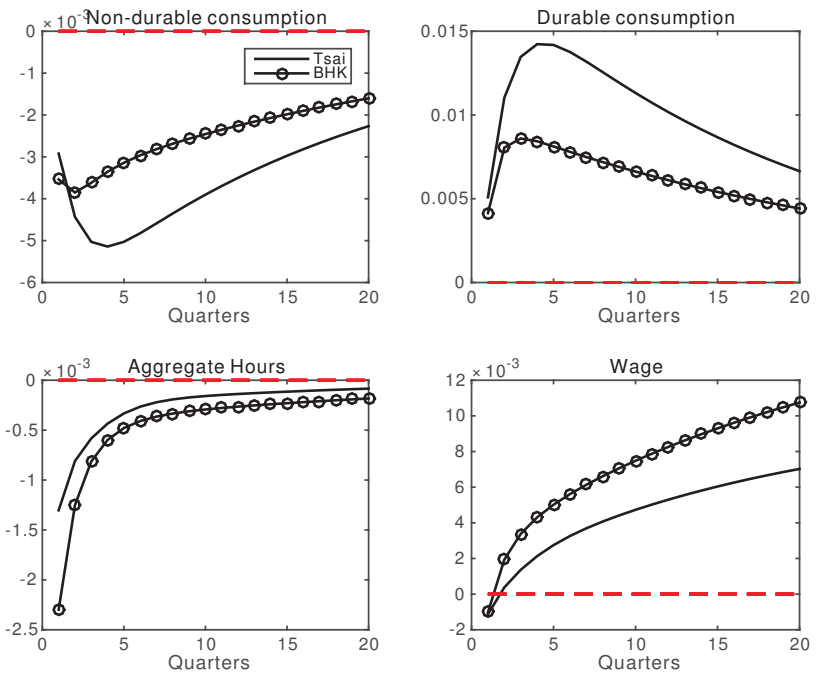


Figure 3: IRF from one std. deviation relative price shock

Notes: Responses of model variables to one standard deviation relative price shock shock under the benchmark (solid line) and its counterpart (circled line) specifications. All the impulse responses are computed at the mean of posterior distributions obtained under each model.

4.3 Causes of the disparities between the data and the models

There are key structural differences across the models that affect the reduced-form dynamics of the observables and hence the models' overall fit to the actual data. To better understand why the model with working capital and habit out-performs the one without either mechanism, we compare their posterior second moments with the data.

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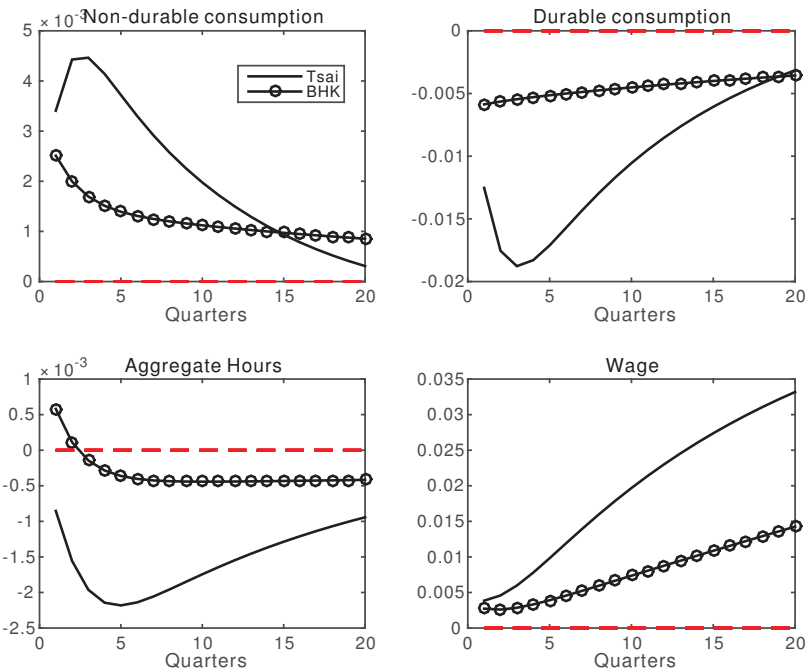


Figure 4: IRF from one std. deviation preference shock

Notes: Responses of model variables to one standard deviation preference shock under the benchmark (solid line) and its counterpart (circled line) specifications. All the impulse responses are computed at the mean of posterior distributions obtained under each model.

4.3.1 Posterior second moments

The top panel of Table 3 reports the posterior standard deviations of the observables in the data and the models. The key findings are as follows. First, both models tend to generate too much volatility of the observables compared to the data, except for hours. Second, the benchmark model specification does a better job of matching the volatilities of durable consumption growth, non-durable consumption growth, relative price, interest rate, and wage growth when compared to the alternative specification. This explains partly why this specification performs much better in the marginal likelihood comparison exercise. In addition, the alternative specification over-predicts the volatility of almost all variables compared to the data (see

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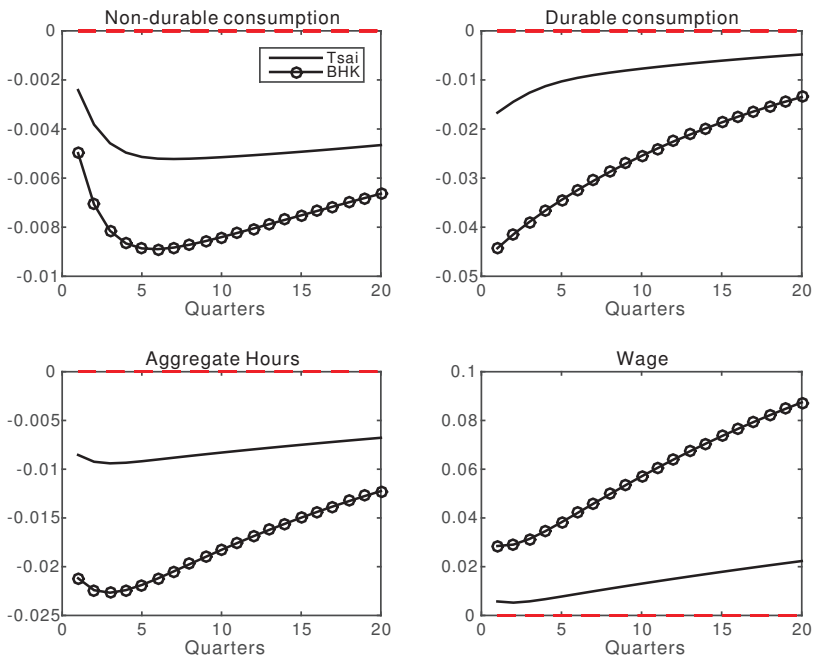


Figure 5: IRF from one std. deviation labor supply shock

Notes: Responses of model variables to one standard deviation labor supply shock under the benchmark (solid line) and its counterpart (circled line) specifications. All the impulse responses are computed at the mean of posterior distributions obtained under each model.

Table 3). This is partly due to high estimates of standard deviations of labor supply, intertemporal, and durable preference shocks under this specification (see Table 2), and partly due to the fact that this specification provides a strong internal amplification mechanism for these shocks due to the absence of habit persistence, making them important drivers of these variables, as suggested in the variance decomposition exercise.

The bottom three panels of Table 3 present the unconditional and conditional correlations of the observables under different specifications. The key findings are as follows. First, the benchmark model specification generates a positive correlation between the durable and non-durable consumption growth rates as observed in the data, while the specification of the alternative generates a negative correlation that is inconsistent with the data

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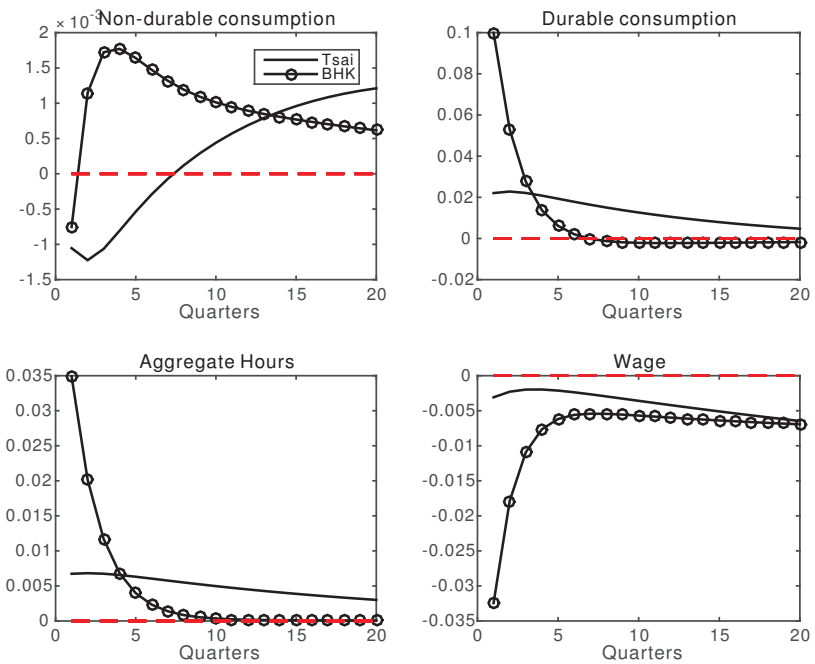


Figure 6: IRF from one std. deviation durable preference shock

Notes: Responses of model variables to one standard deviation durable preference shock under the benchmark (solid line) and its counterpart (circled line) specifications. All the impulse responses are computed at the mean of posterior distributions obtained under each model.

(panel b). Second, durable consumption growth and inflation are uncorrelated in the data; however, they are negatively correlated under both specifications (panel c). Lastly, both specifications generate a negative correlation between non-durable consumption and inflation as shown in the data (panel d), but the prediction of the benchmark model is closer to the data.

Note that we acknowledge that the overall performance of both models in matching second moments is relatively poor. However, we would like to emphasize that our focus is to see whether the data support, the monetary transmission through its impacts on relative price dynamics and whether working capital and habit can resolve the co-movement puzzles.

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Table 3: Posterior second moments

(a) Standard Deviations

	Data	Benchmark	Alternative
Labor	0.0784	0.0500	0.0527
Durable Consumption growth	0.0135	0.0515	0.0752
Non-Durable Consumption growth	0.0087	0.0098	0.0227
Relative Price Inflation	0.0052	0.0183	0.0230
Interest Rate	0.0085	0.0107	0.0153
Wage growth	0.0066	0.0324	0.0504

(b) Unconditional and conditional correlation between durable and non-durable consumption growth

		Data	Benchmark	Alternative
Unconditional		0.49	0.29	−0.00
Conditional on	TFP		0.80	0.96
	Relative price		−0.99	−0.94
	Preference		−0.99	−0.98
	Monetary		0.78	−1.00
	Labor supply		0.69	0.85
	Durable pref.		−0.91	−0.69

(c) Unconditional and conditional correlation between durable consumption growth and inflation

		Data	Benchmark	Alternative
Unconditional		0.00	−0.36	−0.17
Conditional on	TFP		−0.47	−0.22
	Relative price		0.87	0.94
	Preference		−0.39	−0.52
	Monetary		−0.99	1.00
	Labor supply		−0.82	0.65
	Durable pref.		−1.00	−0.99

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Table 3: Posterior second moments (Cont.)

(d) Unconditional and conditional correlation between non-durable consumption growth and inflation

		Data	Benchmark	Alternative
Unconditional		−0.13	−0.44	−0.72
Conditional on	TFP		−0.64	0.02
	Relative price		−0.85	−0.98
	Preference		0.29	0.34
	Monetary		−0.86	−1.00
	Labor supply		−0.75	0.21
	Durable pref.		0.93	0.62

Notes: Panel (a) reports the standard deviations. The first column is the standard deviation of the observables. The second and third column report the posterior standard deviations of the variables with the benchmark and the alternative specifications. Panels (b), (c), and (d) present the conditional and unconditional correlations between durable and non-durable consumption growth, durable consumption growth and inflation, and non-durable consumption growth and inflation under different model specifications, respectively.

4.3.2 Variance decomposition

The estimated model can be used to address a number of key business cycle issues. To dig in, we present the contribution of each shock to the forecast error variance decomposition of the six observables under the two specifications in Table 4. There are several points worth mentioning. First, monetary policy shocks play an important role in explaining the fluctuations in both the wage growth rate and relative price inflation in both cases. In the alternative model, monetary policy also plays an important role in accounting for the variations in non-durable goods consumption. Relative to the alternative, the role of policy shocks has been substantially reduced in the benchmark, which is more consistent with the previous literature in VAR and Bayesian DSGE that finds monetary policy shocks play a less important role in causing fluctuations in key macroeconomic variables.[9] Second, we find

[9] See Christiano, Eichenbaum, and Evans (2005), Smets and Wouters (2007), Justiniano, Primiceri, and Tambalotti (2010, 2011), etc.

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Table 4: Variance Decomposition under Different Specifications

	Monetary	Preference	Technology	Relative Price	Labor Supply	Durable Pref.
			(a) Benchmark			
Interest Rate	11.92	55.36	4.95	3.90	22.73	1.14
Labor	3.63	1.26	0.24	0.11	77.41	17.34
Rel. Price Inflation	51.97	0.75	5.31	36.56	0.16	5.25
Non-durable Cons. growth	12.98	10.35	53.31	13.06	8.67	1.63
Durable Cons. growth	18.33	5.03	35.31	14.13	8.96	18.23
Wage growth	77.78	3.83	11.03	0.60	5.69	1.07
			(b) Alternative			
Interest Rate	8.66	80.24	1.75	1.24	7.97	0.14
Labor	17.97	7.10	0.94	0.39	46.14	27.46
Rel. Price Inflation	69.85	0.45	2.34	24.23	0.19	2.95
Non-durable Cons. growth	73.84	8.13	14.50	2.39	0.03	0.31
Durable Cons. growth	0.18	3.86	4.96	5.04	4.78	81.18
Wage growth	60.24	13.49	5.14	0.52	4.82	15.78

Notes: The table reports the percent contribution of each shock to fluctuations in each variable under the benchmark and the alternative model specifications.

that intertemporal preference shocks play an important role in explaining the fluctuations in interest rates in both specifications. Third, technology shocks play an important role in explaining non-durable and durable consumption growth in the benchmark model. However, they only play an intermediate role in explaining the fluctuations in the non-durable consumption growth in the alternative specification.

The fluctuations in relative prices are mainly driven by the relative price shocks and monetary policy shocks, and the fluctuations in labor hours are mainly driven by the labor supply shocks and durable preference shocks. The large size of the estimated standard deviations of intertemporal and labor supply shocks (see Table 2) explains why the alternative specification over-predicts the volatility of interest rates in Table 3. Finally the durable preference shock plays an important role in explaining the fluctuations of labor hours and durable consumption growth in the alternative model, while its role is substantially reduced under the benchmark specification.

Note that all these findings point to key differences in the propagation mechanism of structural shocks under the estimated models. In particular, they explain the large discrepancy between the benchmark model and its

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counterpart, as well as the data.

5 Robustness checks

Thus far, we have assumed that non-durable goods prices are staggered and the durable goods prices are flexible following the specification of Barsky, House, and Kimball (2007). While the literature of co-movement puzzle starts from the premise that price adjustment of durable goods is flexible, there is empirical work against it. For example, the work by Bils and Klenow (2004) documents that the frequency of price adjustment of consumer durable is lower than that of non-durables but higher than that of service goods. For the robustness analysis, we investigate the following questions: (1) is the assumption of flexible durable goods prices compatible with the data? (2) do our findings supporting the existence of both working capital and habit depend on the assumptions of price-setting behaviors? and (3) can we still find heterogeneity in the way that working capital affects different sectors under alternative price-setting assumptions?

To address these questions, we estimate our model under alternative price-setting behavior by estimating not only the Calvo parameter for the non-durables goods sector but also the parameter for the durable goods sector. We use the same prior distribution of Calvo parameters for both durables and non-durables. Table 5 summarizes the posterior distribution of the selected parameters and the corresponding log marginal likelihoods when both Calvo parameters are estimated. The key findings are the following. First, the estimation results continue to favor the model with working capital and habit over its counterpart without either mechanism, irrespective of the assumption for price-setting behaviors of durable goods. Second, when we estimate the Calvo parameters for both sectors, both models cannot reject that the prices of durable goods are sticky. In particular, the estimate of the price stickiness parameter, θ_x, is around 0.62 in the benchmark model and 0.85 in the counterpart model. Their implied average durations of the price contracts are around 2.63 and 6.67 quarters, respectively. The durable goods price is estimated to be more flexible than non-durable goods in the benchmark specification, but that is estimated to be more sticky in the alternative specification. Note that without the working capital channel, a drop in the interest rate does not reduce firms' marginal cost. Therefore, the relative price might fall in a drastic way if the prices of durables are more flexible than that of non-durables. More sticky durable goods prices prevent

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Table 5: Posterior of structural parameters with price stickness

Parameter	Benchmark		alternatives	
h_b	0.65	[0.63, 0.66]	–	–
ϑ_R^c	0.33	[0.30, 0.35]	–	–
ϑ_R^x	1.56	[1.47, 1.66]	–	–
ρ_r	0.50	[0.50, 0.50]	0.50	[0.50, 0.51]
ϕ_π	1.93	[1.88, 2.04]	1.68	[1.55, 1.80]
ϕ_y	0.12	[0.10, 0.15]	0.09	[0.09, 0.09]
θ_c	0.75	[0.73, 0.79]	0.50	[0.50, 0.50]
θ_x	0.62	[0.59, 0.64]	0.85	[0.82, 0.87]
ρ_a	0.43	[0.41, 0.45]	0.39	[0.34, 0.42]
ρ_g	0.17	[0.09, 0.29]	0.42	[0.38, 0.45]
ρ_l	0.89	[0.64, 0.95]	0.80	[0.75, 0.84]
ρ_v	0.51	[0.41, 0.58]	0.34	[0.30, 0.38]
ρ_d	0.92	[0.90, 0.93]	0.54	[0.49, 0.59]
σ^a	0.01	[0.01, 0.01]	0.01	[0.01, 0.01]
σ^v	0.01	[0.01, 0.01]	0.01	[0.01, 0.01]
σ^g	0.03	[0.02, 0.03]	0.02	[0.02, 0.02]
σ^r	0.01	[0.01, 0.01]	0.01	[0.01, 0.01]
σ^l	0.01	[0.01, 0.01]	0.04	[0.03, 0.05]
σ^d	0.01	[0.01, 0.01]	0.09	[0.08, 0.10]
Marginal Likelihood	3,523.722		3,065.950	
Bayes' Factor	8.07×10^{198}		0	

Notes: This table lists the posterior distributions of the structural parameters in the benchmark specification and the alternative specification. The two numbers in the parentheses are the 5% and 95% confidence intervals.

the drastic fall in the relative prices of durables following the contractionary policy shocks, which helps to resolve the co-movement problem when the model does not feature working capital. Third, imposing sticky durable goods prices reduces the fit with the data, and the marginal likelihood falls from 3910 to 3524 in the benchmark specification and from 3573 to 3066 in the alternative specification. Why does the model without sticky durable

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goods prices perform better than the model with sticky durable goods prices? The reason is because the model with sticky durable goods prices has more hyperparameters to be estimated, and the Bayes factor discriminates against them. This attractive feature of the Bayes factor is that it embodies a strong preference for parsimonious modelling. Fourth, the data continues to support both mechanisms of habit formation and working capital when the prices of durables are sticky. The posterior mean of habit is 0.65, and the 90% confidence interval ranges from 0.63 to 0.66. For the estimates of working capital, their posterior means are 0.33 and 1.56 and their 90% confidence intervals are from 0.3 to 0.35 and 1.47 to 1.66 for non-durables and durables, respectively. Note that while the degrees of working capital for both sectors are lower than their counterparts when durable goods prices are flexible, we still find heterogeneity in the way that working capital affects inflation dynamics across sectors, as their 90% interval does not overlap. Since both working capital and habit are both important in terms of co-movement between durables and non-durables, if one or more are turned off, the others have to work harder to generate co-movement in the data. Therefore, when we also estimate the parameter of price stickiness for durables goods, working capital does not need to work as hard to generate co-movement between durables and non-durables.

6 Conclusion

The paper uses a Bayesian approach to estimate a two-sector sticky price model that is augmented with working capital and habit formation. Our estimation results indicate that working capital and habit are both supported by the data as channels of monetary policy transmission. Furthermore, we find that the model with working capital and habit substantially improves the overall fit of the model relative to the model without these mechanisms and resolves the co-movement problem. Finally, our estimation results identify a new monetary transmission mechanism in the two-sector model which operates through the heterogeneity in the way working capital affects inflation dynamics across sectors.

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兩部門模型的貨幣傳導機制

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本文擴充傳統兩部門隨機動態模型, 考慮廠商的借貸行爲及消費者的消費慣性, 我們使用貝氏方法去估計其相關參數。估計結果顯示營運資金及消費慣性都是影響貨幣傳導機制的重要因素。此外, 在兩部門中因不同部門對營運資金需求的差異, 在給定相同的貨幣衝擊下, 對兩部門的價格有不同的影響, 進而造成其相對價格的變動。這是本文發現新的貨幣傳導機制, 相較於傳統的模型, 有考慮廠商營運資金及消費慣性的兩部門模型更能貼近現實社會。

關鍵詞: 營運資金, 消費慣性, 耐久財, 貝氏估計
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