Nonhomothetic Preferences with Habit Formation in Nondurable and Durable Consumption: Implications for Sectoral Comovement

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We argue that nonhomothetic preferences with habit formation in nondurable and durable consumption can be a driving force behind sectoral comovement in production. We make this point by augmenting a two-sector New Keyesian model à là Barsky, House and Kimball (2007) with these two real features of the data. Our estimates imply that these two features interact to generate an empirically important mechanism that propagates monetary shocks to produce significant cross-sector comovement.

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Empirical evidence suggests that the production of nondurable and durable goods comove closely in response to monetary shocks (e.g., Barsky, House and Kimball (2003, 2007); Erceg and Levin (2002, 2006)). However, it is now well known that the standard two-sector New Keynesian model predicts the exact opposite pattern. This is shown by Barsky, House and Kimball (2007) in a two-sector model calibrated to U.S. data, where nondurable goods have sticky prices and durable goods have flexible prices, as documented by Bils and Klenow (2004),

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among others. This comovement puzzle is robust, whether monetary policy is assumed to follow a money supply rule, as in Barsky, House and Kimball (2007), or an interest rate rule, as in Carlstrom and Fuerst (2010).

This paper aims to resolve this puzzle by incorporating nonhomothetic preferences with habit formation in the consumption of nondurables and durables in the baseline model of Barsky, House and Kimball (2007). Previous studies have provided ample empirical evidence of nonhomotheticity in preferences and habit formation in consumption and have explored their implications for many issues in macroeconomics and finance, such as aggregate volatility, counter-cyclical markups, inflation dynamics, economic growth, trade patterns, and equity premium.[1] As a result of the existing empirical findings, these two real features of the data appear to be of particular importance for monetary models featuring both nondurable and durable goods. Our econometric estimations based on the data verify that nonhomotheticity and habit formation in consumption are valid assumptions for our model. Additionally, our simulation results and sensitivity analysis imply that both of these features combine to generate an empirically important mechanism that propagates monetary shocks to produce significant sectoral comovement in production.

To understand this mechanism, first consider what would happen in the baseline model of Barsky, House and Kimball (2007) following a monetary expansion. Given that the shadow value of durable goods is nearly constant, agents are virtually indifferent to the timing of durable goods purchases and will therefore respond immediately to changes in the intertemporal relative prices of durable and nondurable goods. Because durable goods have more flexible prices than do non-

[1]Okubo (2008) and Pakoš (2011) show that nonhomotheticity in preferences may account for the observed decline in the price of durables relative to that of nondurables and provide an explanation for the secular increase in the demand for durables relative to nondurables since the 1950s. However, the existing studies provide evidence on habit formation in consumption in the U.S. (e.g.,Dunn and Singleton (1986); Ferson and Constantinides (1991); Heaton (1995); Grishchenko (2010)) and abroad (e.g., Braun, Constantinides and Ferson (1993)), and they demonstrate its relevance to some important facts concerning asset prices (e.g., Sundaresan (1989); Abel (1990); Constantinides (1990); Campbell and Cochrane (1999)) and macroeconomics (e.g.,Carroll, Overland and Weil (2000); Fuhrer (2000); Boldrin, Christiano and Fisher (2001)).

durable goods, the relative price of durables to nondurables increases in response to the monetary expansion. This change reduces the demand for durables and increases the demand for nondurables. Given that output is demand-determined in the New Keynesian models, the production of durable and nondurable goods follows suit. Thus, their model predicts negative comovements in production across the two sectors and under some conditions near monetary neutrality on the aggregate.

Now consider our model economy. First, with habit formation, consumption demand becomes history-dependent. This restrains substitution between the consumption of durable and nondurable goods given changes in their relative price. In other words, habit formation makes the composition of preferred consumption bundles less sensitive to sectoral relative price. Second, with nonhomothetic preferences, the relative price of durable to nondurable goods is no longer the sole determinant of the composition of preferred consumption bundles. In particular, fluctuations in income driven by monetary shocks also affect the composition of the consumption bundles. In sum, whereas habit formation restrains the opposite movements of nondurables and durables by weakening the substitution effect, the income effect associated with nonunitary income elasticities of demand for nondurables and durables across different income levels due to nonhomothetic preferences helps to encourage comovement. The two features of the data thus reinforce and generate significant comovement in the production of durable and nondurable goods in our structural model.

Our work complements recent studies that explore alternative avenues for resolving the comovement puzzle. These avenues include the input-output linkage between the durable and nondurable goods sectors (e.g., Sudo (2012)) and its interaction with labor immobility across the two sectors (e.g., Bouakez, Cardia and Ruge-Murcia (2011)). Monacelli (2009) shows that the introduction of a borrowing constraint where durables play the role of collateral assets into a standard two-sector New Keynesian model with frictionless financial markets helps

in resolving the comovement puzzle. Carlstrom and Fuerst (2010) show that comovement between housing and nondurable consumption can arise under sticky nominal wages, adjustment costs in housing construction, and a large degree of complementarity between the consumptions of housing services and nondurable goods, whereas their model indicates that habit formation in consumption helps to move the volatility of nondurable production relative to residential investment closer to that in the data. Katayama and Kim (2010) examine the implications for sectoral comovement of the nonseparability between consumption and leisure, imperfect capital mobility, and variable capacity utilization.

Our paper has a different emphasis than the previous literature. We focus on exploring the dynamic interactions between two related features of the data, of which the former weakens the role of the substitution effect and the latter enhances the role of the income effect in shaping the composition of preferred consumption bundles. We estimate these preference parameters based on our structural model and quantify the mechanism that propagates the effects of monetary shocks to generate comovement in durable and nondurable production.

The remainder of the paper is organized as follows. We present our model in Section I, where we also derive and explain the equilibrium conditions. We describe our data, econometric model, and estimation methodology in Section II where, using recent U.S. data, we verify our assumptions regarding nonhomothetic preferences and habits-in-consumption and report our estimates for the preference parameters. We generate the model's impulse response functions and report the simulation results in Section III. In Section IV, we discuss the logic behind our results. In Section V, we conduct sensitivity analyses to determine the relative importance of each of the two features of the data and of their interaction in generating the cross-sector comovement in our structural model. Some final remarks are made in Section VI.

I. The Model

The model features a representative household and two production sectors, a nondurable goods sector and a durable goods sector indexed by $i = n, d$, respectively. Within each sector, there is a continuum of firms that produce individually differentiated goods indexed on the unit interval $[0, 1]$. At each date t, a representative distributor combines newly produced nondurable goods $\{y_t^n(j)\}_{j\in[0,1]}$ into a composite nondurable goods measure $Y_t^n = \left[\int_0^1 y_t^n(j)^{(\gamma_n-1)/\gamma_n} dj\right]^{\gamma_n/(\gamma_n-1)}$ and newly produced durable goods $\{y_t^d(j)\}_{j\in[0,1]}$ into a composite durable goods measure $Y_t^d = \left[\int_0^1 y_t^d(j)^{(\gamma_d-1)/\gamma_d} dj\right]^{\gamma_d/(\gamma_d-1)}$, where $\gamma_n \in (1, \infty)$ and $\gamma_d \in (1, \infty)$ measure the elasticity of substitution of the individually differentiated nondurable goods and the individually differentiated durable goods, respectively. The distributor takes as given the prices of the individual nondurable goods, $\{P_t^n(j)\}_{j\in[0,1]}$, and the prices of the individual durable goods, $\{P_t^d(j)\}_{j\in[0,1]}$, and chooses bundles of these intermediate goods to minimize the costs of fabricating the two composite goods. The distributor sells the composite goods to the household at their unit fabrication costs, $P_t^n = \left[\int_0^1 P_t^n(j)^{1-\gamma_n} dj\right]^{1/(1-\gamma_n)}$ and $P_t^d = \left[\int_0^1 P_t^d(j)^{1-\gamma_d} dj\right]^{1/(1-\gamma_d)}$, respectively. The resultant demand schedules for each individual nondurable and durable goods are $y_t^n(j) = [P_t^n(j)/P_t^n]^{-\gamma_n} Y_t^n$ and $y_t^d(j) = \left[P_t^d(j)/P_t^d\right]^{-\gamma_d} Y_t^d$, respectively.

The representative household derives utility from nondurable consumption, C^n; (the service flow of) durable stock, D; real money balances, M/P, where M denotes the nominal money balance and P denotes the GDP deflator (to be defined below); and disutility from labor supply, L, as characterized by the following function for expected discounted lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{U_t(C^n, D)^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} - \varphi \frac{L_t^{1+\chi}}{1+\chi} + V\left(\frac{M_{t+1}}{P_t}\right)\right], \tag{1}$$

where E is the expectations operator, $\beta \in (0, 1)$ is the subjective discount factor,

$\sigma > 0$ is the intertemporal elasticity of substitution, $\varphi > 0$ is a scaling parameter for the disutility of work, and $\chi > 0$ is the inverse Frisch elasticity of the labor supply. The period utility function over real balances is monotone increasing, concave, and twice continuously differentiable, and it satisfies the Inada conditions.

The defining feature of our paper is that it allows for the possibility of nonhomothetic preferences with habit formation in both nondurable and durable consumption. The period utility over nondurable consumption and durable stock is specified as

$$U_t(C^n, D) = \left[\frac{\left(C_t^n - h^n\, C_{t-1}^n\right)^{1-\psi^n}}{1-\psi^n} + \frac{\left(D_t - h^d D_{t-1}\right)^{1-\psi^d}}{1-\psi^d} \right], \tag{2}$$

where the curvature parameters $\left\{\psi^i\right\}_{i=n,d} > 0$ determine whether the utility function is homothetic. This general specification allows for the special case with $\psi^n = \psi^d$ where the utility function is of the standard CES type and thus is homothetic. If $\psi^n \neq \psi^d$, then the utility function is nonhomothetic. On the other hand, $\left\{h^i\right\}_{i=n,d} \in [0, 1)$ measure the degree of habit formation in nondurable consumption and durable stock, respectively.[2] As discussed in the introduction, existing studies have provided ample empirical evidence of nonhomotheticity in preferences and habit formation in consumption. In Section II, we estimate $\left\{\psi^i\right\}_{i=n,d}$ and $\left\{h^i\right\}_{i=n,d}$ based on our structural model and recent U.S. data.

At every date, there is a set of one-period, state-contingent nominal bonds that can be used to transfer nominal wealth across dates and states of the world. The no-arbitrage condition then implies the existence of a set of stochastic discount factors that can be used to determine at any date the nominal present value of a nominal quantity for any future date and state. Denote by $\Omega_{t,t+1}$ the stochastic

[2] Although internal habit is modeled here, as is consistent with the empirical evidence provided in Grishchenko (2010) based on postwar US data, our results would continue to hold under external habit specification.

discount factor from date $t+1$ to t. The nominal price at t of a one-period bond that pays off one unit of currency in a particular state of the world at $t+1$ is equal to $\Omega_{t,t+1}$ times the probability that this particular state will be realized at $t+1$ conditional on the information available at t. Other financial claims can similarly be priced. In particular, a one-period bond issued at date t that pays off one unit of currency in all states of the world at $t+1$ has a nominal value at t equal to $\mathrm{E_t}\Omega_{t,t+1}$ and, thus, a gross nominal interest rate equal to $R_t = (\mathrm{E_t}\Omega_{t,t+1})^{-1}$. In general, if the random quantity B_{t+1} denotes the holdings at t of the one-period, state-contingent nominal bonds that matures at $t+1$ with a payoff of one unit of currency in the appropriate event, then this portfolio has a nominal value at t of $\mathrm{E_t}(\Omega_{t,t+1}B_{t+1})$. The representative household owns a fixed stock of productive capital K.[3] In each period t, the household's labor and capital services are distributed among individual firms in the two production sectors with perfect mobility both across firms and across sectors at the economy-wide nominal wage and capital rental rates, W_t and R_t^k, respectively. The household's budget constraint in period t is given by

$$P_t^n C_t^n + P_t^d C_t^d + \mathrm{E_t}(\Omega_{t,t+1}B_{t+1}) + M_{t+1} \leq W_t\, L_t + R_t^k K + B_t + M_t + \Pi_t + T_t, \tag{3}$$

where C_t^d is the household's purchase of the newly produced composite durable, which adds to its composite durable stock according to

$$D_t = C_t^d + (1-\delta)\, D_{t-1}, \tag{4}$$

where $\delta \in (0,1)$ denotes the depreciation rate of the durable stock, Π_t is the household's claim to firm profits, and T_t is a lump-sum tax that the household pays to the government. The household faces a borrowing constraint $B_{t+1} \geq -B$

[3]The assumption of constant aggregate capital is appropriate for our short-term analysis in this paper. Allowing for variable aggregate capital would not significantly change our results.

for some large positive B, which serves to prevent it from playing Ponzi schemes without bounds.

The household maximizes the expected utility (1) subject to the budget constraint (3), the law of motion for the composite durable stock (4), and the borrowing constraint specified above, while taking as given its initial durable stock D_{-1} and money and bond holdings M_0 and B_0, all prices, and wage and capital rental rates. The first order conditions for C_t^n, D_t, C_t^d, L_t, B_{t+1}, and M_{t+1}, give rise to the following optimality conditions:

$$\lambda_t \, P_t^n = MRS_t^n - \beta \, E_t \left[h^n \, MRS_{t+1}^n \right] \tag{5}$$

$$\eta_t = MRS_t^d - \beta \, E_t \left[h^d \, MRS_{t+1}^d \right] \tag{6}$$

$$\eta_t = \lambda_t \, P_t^d \tag{7}$$

$$\lambda_t \, W_t = \varphi \, L_t^{\chi} \tag{8}$$

$$\lambda_t \, \Omega_{t,t+1} = \beta \, \lambda_{t+1} \tag{9}$$

$$\lambda_t = V' \left(\frac{M_{t+1}}{P_t} \right) \frac{1}{P_t} - \beta \, E_t \left[\lambda_{t+1} \right], \tag{10}$$

where $MRS_t^n = U_t^{-\frac{1}{\sigma}} \left[C_t^n - h^n C_{t-1}^n \right]^{-\psi^n}$, $MRS_t^d = U_t^{-\frac{1}{\sigma}} \left[D_t - h^d D_{t-1} \right]^{-\psi^d}$, λ_t denote the shadow value of the marginal utility of nondurable consumption and η_t denote the present value of the marginal utility of the service flow of durable stock.

A firm that produces a type of goods $j \in [0,1]$ in sector $i \in \{n, d\}$ has the following technology:

$$y_t^i(j) = [k_t^i(j)]^{\alpha} \, [l_t^i(j)]^{1-\alpha} - \phi^i, \tag{11}$$

where $k_t^i(j)$ and $l_t^i(j)$ are the firm's capital and labor inputs at date t, respectively, $\alpha \in (0,1)$ determines the share of payment to capital in total value added, and ϕ^i is a real fixed cost that is sector- but not firm-specific.

Firms are price takers in factor markets. With the free mobility of capital and labor across firms and sectors, the equilibrium capital-to-labor ratio is identical across firms and sectors:

$$\frac{k_t^i(j)}{l_t^i(j)} = \frac{K_t^i}{L_t^i} = \frac{K}{L_t}, \quad i = n, d, \quad j \in [0, 1], \tag{12}$$

where $L_t^i = \int_0^1 l_t^i(j)dj$ and $K_t^i = \int_0^1 k_t^i(j)dj$, for $i \in \{n, d\}$, and $L_t = L_t^n + L_t^d$ and $K = K_t^n + K_t^d$. It follows that the nominal marginal production cost is also identical across firms and sectors, given by

$$MC_t = \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)} \left(R_t^k\right)^{\alpha} W_t^{1-\alpha}. \tag{13}$$

Using these facts and the demand schedules, we can aggregate firms' individual production functions to obtain

$$S_t^n Y_t^n + S_t^d Y_t^d = K^{\alpha} L_t^{1-\alpha} - \phi^n - \phi^d, \tag{14}$$

where $S_t^i = \int_0^1 \left[P_t^i(j)/P_t^i\right]^{-\gamma_i} dj$ defines a measure of relative price dispersion within sector $i = n, d$. Firms are monopolistic competitors in their goods markets within each sector, where they set prices in a staggered fashion à la Calvo (1983). At any date t, each firm in sector i receives a random signal with a constant probability θ_i that forbids it to reset the price. The random signal is identically and independently distributed both across firms and across time. With the large number of firms, at each point in time, there is a fraction $(1 - \theta_i)$ of randomly selected firms in sector i that can reset prices. If a firm in sector i does not receive a signal that prompts it to reset the price optimally, its price is automatically adjusted by a weighted average of the trend and lagged inflation rates in sector i, $\pi_i^{1-\alpha_i}\pi_{it-1}^{\alpha_i}$ for $\alpha_i \in [0, 1]$, $i = n, d$. If a firm j in sector i has the opportunity to optimally reset the price, it chooses $P_t^i(j) = P_t^{i^*}(j)$ to maximize the sum of its

profits in period t and the expected present value of its profits in all events in all future periods $s > t$ in which it will not have another opportunity to change the price optimally and must therefore maintain the price it is currently choosing, up to the sectoral inflation rate, with the understanding that

$$P_s^i(j) = \begin{cases} P_s^{i^*}(j) & \text{with probability } 1-\theta_i, \\ \pi_i^{1-\alpha_i}\pi_{is-1}^{\alpha_i} P_{s-1}^i(j) & \text{with probability } \theta_i, \end{cases} \tag{15}$$

for all $s > t$. It follows that the optimal price $P_t^{i^*}(j)$ chosen at date t must maximize

$$\mathrm{E_t}\sum_{s=t}^{\infty}\theta_i^{s-t}\Omega_{t,s}\left[\pi_i^{(s-t)(1-\alpha_i)}\pi_{it,s}^{\alpha_i}P_t^{i*}(j) - MC_s\right]\left[\frac{\pi_i^{(s-t)(1-\alpha_i)}\pi_{it,s}^{\alpha_i}P_t^{i^*}(j)}{P_s^i}\right]^{-\gamma_i} Y_s^i, \tag{16}$$

where $\Omega_{t,s} = \prod_{r=1}^{s-t}\Omega_{t+r-1,t+r}$ is a s-period stochastic discount factor from t to $s > t$, with $\Omega_{t,t} \equiv 1$, and where $\pi_{it,s} = \prod_{r=1}^{s-t}\pi_{it+r-1}$ is the accumulated inflation in sector i from $t-1$ to $s-1 \geq t$ with $\pi_{it,t} \equiv 1$. The resultant optimal pricing decision is

$$P_t^{i*}(j) = \frac{\gamma_i}{\gamma_i - 1}\frac{\mathrm{E_t}\sum_{s=t}^{\infty}\theta_i^{s-t}\Omega_{t,s}\left[\pi_i^{(s-t)(1-\alpha_i)}\pi_{it,s}^{\alpha_i}\right]^{-\gamma_i} P_s^{i\gamma_i}Y_s^i MC_s}{\mathrm{E_t}\sum_{s=t}^{\infty}\theta_i^{s-t}\Omega_{t,s}\left[\pi_i^{(s-t)(1-\alpha_i)}\pi_{it,s}^{\alpha_i}\right]^{1-\gamma_i} P_s^{i\gamma_i}Y_s^i}. \tag{17}$$

As the optimal price is identical across adjusting firms within the same sector, we can omit the individual firm index j from the expression. Furthermore, we can express the pricing equation using stationary variables:

$$p_t^{i^*} = \frac{\gamma_i}{\gamma_i - 1}\frac{A_t^i mc_t^i + \mathrm{E_t}\sum_{s=t+1}^{\infty}(\theta_i\beta)^{s-t}A_s^i\left[\prod_{r=1}^{s-t}\left(\frac{\pi_{it+r-1}}{\pi_i}\right)^{-\alpha_i}\left(\frac{\pi_{it+r}}{\pi_i}\right)\right]^{\gamma_i} mc_s^i}{A_t^i + \mathrm{E_t}\sum_{s=t+1}^{\infty}(\theta_i\beta)^{s-t}A_s^i\left[\prod_{r=1}^{s-t}\left(\frac{\pi_{it+r-1}}{\pi_i}\right)^{-\alpha_i}\left(\frac{\pi_{it+r}}{\pi_i}\right)\right]^{\gamma_i-1}}, \tag{18}$$

where $p_t^{i^*} = P_t^{i^*}/P_t^i$ denotes the newly set price relative to the average price index in sector i, $mc_t^i = MC_t/P_t^i$ denotes the real marginal cost facing firms in sector i (normalized by sectoral price index), and $A_t^i = \lambda_t^i Y_t^i$ with $\lambda_t^i = \lambda_t P_t^i$ is the shadow value of the goods produced in sector i.

From the equation that defines the sector price index, we obtain

$$1 = \theta_i \left(\frac{\pi_i^{1-\alpha_i} \pi_{it-1}^{\alpha_i}}{\pi_{it}} \right)^{1-\gamma_i} (1-\theta_i) p_t^{i^{*}\,1-\gamma_i}, \tag{19}$$

and the measure of relative price dispersion within each sector evolves as follows:

$$S_t^i = \theta_i \left(\frac{\pi_i^{1-\alpha_i} \pi_{it-1}^{\alpha_i}}{\pi_{it}} \right)^{-\gamma_i} S_{t-1}^i + (1-\theta_i) p_t^{i^{*}\,-\gamma_i}, \tag{20}$$

for $i = n, d$.

An equilibrium is determined by equations (4)-(20), the market clearing conditions for the nondurable and durable composites, labor, capital, money, and bonds, and a monetary policy as described below.

We define a steady state as an equilibrium in which all shocks in the economy take on their unconditional mean values so that all stationary variables remain constant along the dynamic path. It can be inferred from (5)-(8) that in a steady state, the sectoral inflation rates π_n and π_d and the wage inflation rate coincide, denoted as π, and the Lagrangian multiplier for the household budget constraint, which determines its marginal utility of wealth, must evolve at the rate π^{-1}. It then follows from (9) that the steady state gross nominal interest rate is $R = \pi/\beta$. It can be inferred from (18)-(20) that in a steady state, optimal prices are independent of the hazard rates and the index weights, as firms that can reset prices choose the same prices as those charged by their peers in the same sector that cannot adjust their prices. In fact, we can verify that there is a unique steady state for our model with nominal friction that coincides with the steady

state equilibrium under full price flexibility.

Nominal GDP for our two-sector model economy is naturally given by $P_t^n Y_t^n + P_t^d Y_t^d$. We construct real GDP as

$$Y_t = P^n Y_t^n + P^d Y_t^d, \tag{21}$$

where P^n and P^d denote the two steady-state values of the sectoral price indices. The price level (the GDP deflator) is then defined as the nominal GDP divided by the real GDP:

$$P_t = \frac{P_t^n Y_t^n + P_t^d Y_t^d}{P^n Y_t^n + P^d Y_t^d}. \tag{22}$$

We use π_t to denote the rate of inflation in the price level. It can be shown that the steady-state value of the general price inflation rate coincides with the steady-state values of the sectoral and wage inflation rates π.

Monetary policy is described by an interest-rate feedback rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\beta_r} \left[\left(\frac{\pi_t}{\pi}\right)^{\beta_\pi} \left(\frac{Y_t}{Y}\right)^{\beta_y}\right]^{1-\beta_r} Z_{rt}, \tag{23}$$

where Y denotes the steady-state value of real GDP; β_r, β_π, and β_y are policy parameters; and Z_{rt} is a monetary policy shock following a stationary process

$$\ln Z_{rt} = \rho_r \ln Z_{rt-1} + \varepsilon_{rt}, \tag{24}$$

where $\rho_r \in (-1, 1)$ measures the persistence of the process and ε_{rt} is an i.i.d. white noise with a zero mean and a finite standard deviation σ_r.

II. Data, Econometric Model, and Estimation Methodology

In this section, we present our econometric model, which we use to estimate the preference parameters, and we explain the methodology adopted to verify the non-homotheticity and influence of habit in durable and nondurable consumption. Our model contains eighteen parameters, of which the preference parameters are ψ^n, ψ^d, σ, h^n, and h^d. For the estimation, we use quarterly data covering the 1955:I to 2007:IV period. The measures of consumption data, obtained from the National Income and Product Accounts (NIPA) of the Bureau of Economic Analysis (1955:I-2007:IV*b*) and the Federal Reserve Bank of Philadelphia (1955:I-2007:IV), are real expenditures[4] on durables[5] and nondurables.[6] As a measure for the real interest rate, we use the 3-month U.S. Treasury bill rate deflated by the percentage change in the relevant price index.[7]

Following Ogaki and Reinhart (1998*a*,*b*) and Okubo (2008), we use a two-step approach to estimate the aforementioned preference parameters. In the first step, Park (1992) canonical cointegration regression (CCR) method is used to estimate the curvature parameters of the utility function. The second step involves estimating the habit formation and the intertemporal elasticity of substitution parameters using the multiple-equation Generalized Method of Moments (GMM).

To estimate the curvature parameters, we reduce the first order conditions (5)-

[4]Population figures reported by the NIPA is used to calculate the real per-capita expenditures.

[5]Because the information on durable stock in the NIPA only includes annual data (Bureau of Economic Analysis (1955:I-2007:IV*a*)), quarterly patterns are estimated using the interpolation method. To calculate the quarterly estimates of the durable stock, we use the following formula

$$D_{t,\tau} = \frac{C_{t,\tau}}{\sum_{\tau=1}^{\tau=4} C_{t,\tau}} \left[D_t - D_{t-1} \right], \tag{25}$$

where $\tau = 1, 2, 3, 4$ are the four quarters of year t. This estimation method is also used by the NIPA, as reported in the Bureau of Economic Analysis (2009).

[6]Like Ogaki and Reinhart (1998*b*,*a*), we exclude clothing from the consumption of nondurables in the NIPA data.

[7]The real interest rate we use for our estimations are of three types; real interest rates in units of durable, nondurable, and total goods. For our calculations of the aforementioned variables, we, consecutively, use the durable, nondurable, and total goods price indices that are obtained from the NIPA. Nominal treasury bill rates are obtained from the Board of Governors of the Federal Reserve System (1955:I-2007:IV). The Federal Funds Rates (Board of Governors of the Federal Reserve System (1955:I-2007:IV)), U.S. industrial production index (Board of Governors of the Federal Reserve System (1955:I-2007:IV)) and U.S. stock returns computed from Dow-Jones index (Yahoo! Finance (January.1955-December.2007)) are also used as instruments in the GMM estimation.

(7), given in section I, to characterize the following optimality condition[8]

$$Q_t \frac{\left(C_t^d\right)^{\psi^d}}{\left(C_t^n\right)^{\psi^n}} = E_t \left[\sum_{\tau=0}^{\infty} (\beta\delta)^{\tau} \left(\frac{U_{t+\tau}}{U_t} \right)^{-1/\sigma} \left(\frac{C_t^n}{C_{t+\tau}^n} \right)^{-\psi^n} \left(\frac{D_{t+\tau}}{C_t^d} \right)^{-\psi^d} \right], \tag{26}$$

where $Q_t = P_t^d / P_t^n$. The results of the unit root tests indicate that $ln\left(Q_t\right)$, $ln\left(C_t^n\right)$, $ln\left(C_t^d\right)$ are all different with respect to stationarity.[9] Furthermore, the assumption that the growth rate of marginal utility is stationary makes the right-hand side of (26) a function of the stationary variables.[10] This further implies that $\left(ln\left(Q_t\right) - \psi^n ln\left(C_t^n\right) + \psi^d ln\left(C_t^d\right)\right)$ follows a stationary process. Hence, $ln\left(Q_t\right)$, $\ln\left(C_t^n\right)$, $\ln\left(C_t^d\right)$ are cointegrated with $\left(1, -\psi^n, \psi^d\right)$. Therefore, we estimate the following cointegrating regression using Park (1992) CCR method.[11]

$$\ln\left(Q_t\right) = \mu + \psi^n \ \ln\left(C_t^n\right) - \psi^d \ \ln\left(C_t^d\right) + \epsilon_t, \tag{27}$$

where μ is the intercept term and the stationary disturbances are represented by $\epsilon_t \sim I(0)$. In addition to using Park (1990) $H(p,q)$ to test cointegration, we use K statistics to test the homotheticity of preferences, i.e., $\psi^n = \psi^d$. Our parameter estimates, given in Table 1, are close to those obtained by Okubo (2008) for the 1951:I to 1983:IV period. According to our results, first and the foremost, our model strictly rejects the null hypothesis of homothetic preferences, as indicated by the K statistics. In addition, the $H(0,1)$ and $H(1,2)$ tests fail to reject deterministic and stochastic cointegration, respectively. Finally, the long-run point estimates of ψ^d and ψ^n are significantly different from zero and have

[8] In deriving Equation (26), we ignore habit formation in consumption because habit formation is a short-term phenomenon and it should not be considered in this long-term equation.

[9] We have used different unit root tests to test the stationarity of these series. Although we do not report here the results of these tests in order to conserve space, they are available upon request.

[10] Following Ogaki and Reinhart (1998*b*,*a*) and Okubo (2008), the assumption that marginal utility is stationary can be justified on the following grounds. The growth rate of marginal utility is a function of the growth rate of the consumption of nondurables and durable stock, i.e., the composite consumption. If the latter can be nonstationary, so can be the growth rate of marginal utility. The stationarity of the growth rate of the composite goods, i.e., the growth rate of marginal utility, is tested and verified using its generated series within the model.

[11] For our CCR estimation, we have used the GAUSS code provided by Masakatsu Okubo.

the expected signs.

TABLE 1—CANONICAL COINTEGRATING REGRESSION RESULTS

ψ^d	ψ^n	$H(0,1)$	$H(1,2)$	K
1.203	2.239	0.514	1.752	4.527
(0.096)	(0.188)	[0.473]	[0.186]	[0.033]

Note: Park (1992) canonical cointegrating regression estimates are based on the quadratic spectral kernel and the VAR(1) prewhitening technique of Andrews and Monahan (1992). $H(0,1)$ is a χ^2 test statistic for the null hypothesis of the deterministic cointegration restriction. $H(1,2)$ is χ^2 test statistics for the null hypothesis of stochastic cointegration of the 2nd order. K is a χ^2 statistic for the null hypothesis of the homotheticity of preferences, $\psi^n = \psi^d$. P-values are in square brackets. Values in parentheses are standard errors.

Having estimated the curvature parameters, ψ^d and ψ^n, we now estimate the habit formation and the intertemporal elasticity of substitution parameters, namely, σ, h^n and h^d. These parameters are estimated via GMM by fixing the discount factor, β, to 0.99, which corresponds to a 4.1 percent annual interest rate, and the curvature parameters at the values estimated in the first step. For our GMM estimations, allowing infinite horizon durability, $\{\{d_\tau^i\}_{i=n,d}\}_{\tau=0}^{\infty}$, and habit, $\{h^i\}_{i=n,d}$, in nondurable consumption

$$\mathbb{C}_t^n = \sum_{\tau=0}^{\infty} d_\tau^n \, C_{t-\tau}^n - h^n \sum_{s=1}^{\infty}\sum_{\tau=0}^{\infty} d_\tau^n \, C_{t-\tau-s}^n = d_0^n \sum_{\tau=0}^{\infty} \zeta_\tau^n \, C_{t-\tau}^n \tag{28}$$

and durable consumption

$$\mathbb{D}_t = \sum_{\tau=0}^{\infty} d_\tau^d \, D_{t-\tau} - h^d \sum_{s=1}^{\infty}\sum_{\tau=0}^{\infty} d_\tau^d \, D_{t-\tau-s} = d_0^d \sum_{\tau=0}^{\infty} \zeta_\tau^d \, D_{t-\tau}, \tag{29}$$

and given the representative household's preferences on consumption,

$$\left(1-\frac{1}{\sigma}\right)^{-1} E_0\left[\sum_{t=0}^{\infty}\beta^t\left(\frac{(\mathbb{C}_t^n)^{1-\psi^n}}{1-\psi^n}+\frac{(\mathbb{D}_t)^{1-\psi^d}}{1-\psi^d}\right)^{1-\frac{1}{\sigma}}\right], \tag{30}$$

as in Section I, we derive the Euler equations

$$1 = E_t \left[\sum_{\tau=1}^{\infty} \beta^{\tau} \, \frac{MU^i_{t+\tau}}{MU^i_t} \left(\zeta^i_{\tau-1} R^i_{t+1} - \zeta^i_{\tau} \right) \right], \quad i = n, d, \tag{31}$$

where $\zeta^i_0 = 1$ and $\zeta^i_{\tau} = \left(d^i_{\tau} - h^i \sum_{k=1}^{\tau} d^i_{\tau-k} \right) / d^i_0$, $\tau \geq 1$, for $i = n, d$. In the above equations, R^i_{t+1} is the real return on bonds in units of consumption goods $i = n, d$, and $MU^i_{t+\tau}$ is the marginal utility of consumption goods $i = n, d$, given by

$$MU^n_{t+\tau} = \left[\frac{\left(\mathbb{C}^n_{t+\tau} \right)^{1-\psi^n}}{1-\psi^n} + \frac{\left(\mathbb{D}_{t+\tau} \right)^{1-\psi^d}}{1-\psi^d} \right]^{-\frac{1}{\sigma}} \left(\mathbb{C}^n_{t+\tau} \right)^{-\psi^n}, \tag{32}$$

$$MU^d_{t+\tau} = \left[\frac{\left(\mathbb{C}^n_{t+\tau} \right)^{1-\psi^n}}{1-\psi^n} + \frac{\left(\mathbb{D}_{t+\tau} \right)^{1-\psi^d}}{1-\psi^d} \right]^{-\frac{1}{\sigma}} \left(\mathbb{D}_{t+\tau} \right)^{-\psi^d}. \tag{33}$$

Consistent with our preference specification in Section I, we consider a one-lag specification, which reduces the Euler equations for nondurables and durables to

$$1 = E_t \left[\beta \, \frac{MU^i_{t+1}}{MU^i_t} \left(R^i_{t+1} - \zeta^i_1 \right) + \beta^2 \, \frac{MU^i_{t+2}}{MU^i_t} \left(\zeta^i_1 R^i_{t+1} \right) \right], \quad i = n, d, \tag{34}$$

where $\zeta^i_1 = (d^i_1 / d^i_0) - h^i$. This specification captures habit formation in the absence of durability, or durability in the absence of habit formation, depending on the sign of ζ^i_1. If $\zeta^i_1 < 0$, that is, if $(d^i_1 / d^i_0) < h^i$, then we can conclude that habit formation dominates durability; otherwise, durability dominates habit formation. Finally, if $\zeta^i_1 = 0$, we can reject the existence of both durability and habit formation.

We simultaneously estimate the Euler equations given in (34) by using the multiple GMM framework. The results are presented in Table 2.

To determine the variables to be used in the GMM as instruments, we take the instruments used by Ferson and Constantinides (1991) and Okubo (2008)

TABLE 2—GENERALIZED METHOD OF MOMENTS RESULTS

σ	ζ^n	ζ^d	J_T
0.169	-0.444	-0.974	3.214
[0.000]	[0.010]	[0.000]	[0.9552]

Note: J_T denotes the J-test of overidentifying restrictions with 9 degrees of freedom. P-values are in square brackets.

as our points of reference and search for variables that can be used to predict the real interest rates and growth rates of nondurable and durable consumption. Hence, as our instruments, we choose the lagged spread between stock returns and the federal funds rate, the lagged spread between stock returns and the 3-month treasury bill rate, the lagged growth rate of industrial production, the lagged growth rate of real GDP, and the lagged growth rate of durable stock, in addition to an intercept term.

As evidenced by Table 2, all point estimates are significant and have the expected signs. The negative parameter values for $\{\zeta^i\}_{i=n,d}$ suggest that both nondurable and durable consumption are influenced by habit formation, which dominates durability. Moreover, the magnitude of the parameters implies that the degree of habit in durable consumption is stronger than the degree of habit in nondurable consumption. The intertemporal elasticity of substitution is estimated at 0.169; this figure is similar to Okubo (2008) estimates. The J-test indicates the appropriateness of the overidentifying restrictions.

III. Other Parameter Values and Simulation Results

Having estimated the five preference parameters as described above, we now explain how to determine the remaining parameters of the model, which are derived either by using the recent U.S. data or by using conventionally determined values. We then conduct our numerical exercises by log-linearizing the optimal conditions of the benchmark model around its nonstochastic steady state and simulating the log-linear system to obtain the impulse responses of the endogenous variables of the economy to a monetary shock.

A. Parameter Values

The firms that produce durable and nondurable intermediate goods use the Cobb-Douglas technology with the conventional 0.35 capital share value. The elasticity of substitution between the differentiated intermediate goods is set to match the 20 percent mark-up rate that the firms charge over the marginal cost of production of the final goods. We set the degree of nominal price stickiness in the nondurable sector such that the frequency of price adjustment in a year is four quarters. As θ_n is the probability that the price of a nondurable goods will stay fixed, setting $1/(1-\theta_n) = 4$, we obtain $\theta_n = 0.75$. Finally, consistent with the data and as in Barsky, House and Kimball (2007), we set $\theta_d = 0$ and we take the steady-state ratio of durable output in total output as 0.25.

The discount factor β, as mentioned above, is taken as 0.99, which corresponds to an average annual interest rate of 4.1 percent for the period 1955:I to 2007:IV. The annual depreciation rate for the durables, δ, is taken as 6 percent, consistent with the related literature. The inverse Frisch elasticity of substitution χ is set to 3 based on the steady-state equilibrium conditions.[12] We fix the utility scale parameter ϱ at 1. At the steady state, the labor supply L is 0.33.

Given that there is no durability in the consumption of nondurables, i.e., $d_o^n = d_1^n = 0$, based on the estimated habit formation parameter, the degree of habit formation in nondurable consumption, h^n, is derived as 0.444. Similarly, because $d_o^d = d_1^d = 0$, as in (4), the degree of habit formation in durable consumption, h^d, is derived as 0.974.

Finally, the interest rate smoothing factor, the weights on inflation, and the output gap in the interest rate rule are the conventionally accepted values of 0.8, 0.5 and 1.5, respectively.

[12]We normalize output at the steady state to one.

B. Parameter Values with Homothetic Preferences

It would be desirable to compare the results obtained using our benchmark model to those obtained using a model with homothetic preferences. To accomplish this, even though our results suggest otherwise, we re-estimate the parameters by restricting our preference parameters as $\psi^d = \psi^n$; thus the preferences become homothetic. Therefore, we repeat the two-step estimation method explained in section II with this constraint. The results are presented in Table 3.[13]

TABLE 3—PARAMETER ESTIMATION WITH HOMOTHETIC PREFERENCES

CCR				
	ψ^d	ψ^n	$H(0,1)$	$H(1,2)$
	0.657	0.657	2.170	4.142
	(0.074)	(0.074)	[0.141]	[0.042]
GMM				
	σ	ζ^n	ζ^d	J_T
	0.480	-0.366	-0.885	0.004
	[0.000]	[0.000]	[0.000]	[0.9530]

Note: Park (1992) canonical cointegrating regression estimates are based on the quadratic spectral kernel and the VAR(1) prewhitening technique of Andrews and Monahan (1992). $H(0,1)$ is a χ^2 test statistic for the null hypothesis of the deterministic cointegration restriction. $H(1,2)$ is the χ^2 test statistics for the null hypothesis of stochastic cointegration of the 2nd order. P-values are in square brackets. Values in parentheses are standard errors. J_T denotes the J-test of overidentifying restrictions with 1 degree of freedom. P-values are in square brackets.

C. Simulation Results

Figure 1 presents the impulse responses of the model variables to an expansionary monetary policy, indicating a 25-basis point decrease in the nominal interest rate.[14] The figure contains the impulse responses of the benchmark model and the responses of a model with homothetic preferences and no habit formation in

[13] Based on the GMM estimates, h^n and h^d are obtained as before. The list of instruments includes the intercept term and the lagged spread between the 3-month treasury bill rates and the federal funds rates.

[14] In all of the following simulations, we choose the magnitude of the shock so that the initial change in the nominal interest rate is equal to 25 basis points.

consumption. We call the latter the "baseline" model. Notice that due to the endogeneity of the policy rule and different preference specifications, the nominal interest rate impulse responses are different.

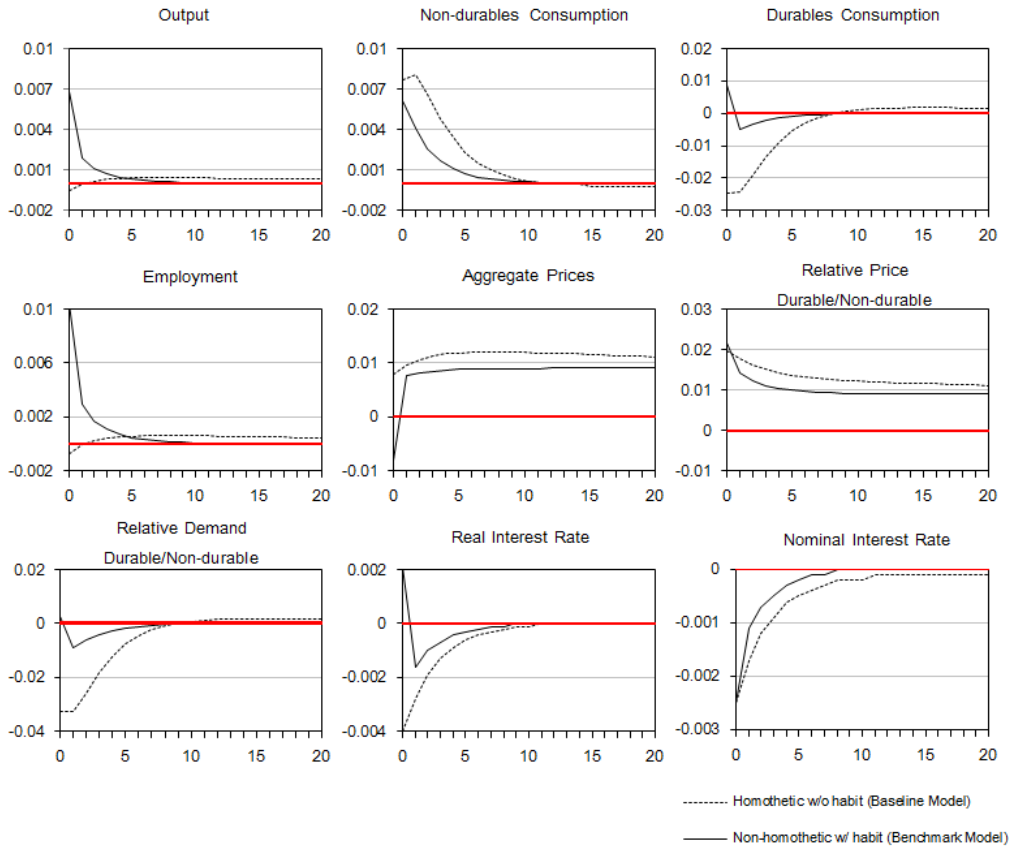


FIGURE 1. IMPULSE RESPONSE FUNCTIONS

To gain insight into the monetary transmission mechanism, we consider first the impulse responses of the baseline model. Evidently, the baseline model responses confirm the results of Barsky, House and Kimball (2007): that is, money has essentially no effect on employment and production. According to our simulation results, while the aggregate price increases by as much as 1.2 percent after the initial shock hits the economy, the output increases by only 0.04 percent. Within

the durables and nondurables sectors, production and prices move in opposite directions. Whereas the prices of nondurables move slowly, the prices of durables quickly overshoot the steady-state equilibrium. As the relative price of durables to nondurables remains above its steady-state value, consumers substitute nondurable goods for durable goods. Given that output is determined by demand in the New Keynesian models, the production of durable and nondurable goods follows suit. Thus, the model predicts negative comovement in production across the two sectors, leaving aggregate output virtually unchanged.

The benchmark model, on the other hand, generates empirically consistent impulse responses. Unlike in the baseline model, in this model, a 25-basis point decrease in the nominal interest rate leads to sharp increases in employment and output that are as high as 1 and 0.7 percent, respectively. Furthermore, the output remains above its steady-state level for almost 10 quarters, thus showing that money is nonneutral and that a decrease in interest rates would have an expansionary effect on output. Moreover, the consumption patterns of durables and nondurables comove with an average 25.2 percent correlation coefficient. Apparently, these results are a function of two features of household preferences: habit formation and nonhomothetic preferences. First, under habit formation, the consumption demand of households become history dependent. It is known that habit formation restrains substitution between durable and nondurable goods given changes in their relative price. In other words, habit formation makes the composition of preferred consumption bundles less sensitive to sectoral relative price. Second, with nonhomothetic preferences, the relative price of durable versus nondurable goods is no longer the sole determinant of the composition of preferred consumption bundles. In particular, fluctuations in income driven by monetary shocks also affect the composition of the consumption bundles. In summary, whereas habit formation restrains the opposite movement of nondurables and durables by weakening the substitution effect, the income effect associated with the nonunitary income elasticity of demand for nondurables and durables

across different income levels that arises from nonhomothetic preferences helps to direct the movements of nondurables and durables into the same direction.

IV. Analytical Discussion

In the benchmark model, the elasticities of intertemporal and intratemporal substitution are the two parameters of interest because they dramatically influence the quantitative implications of the model through the demand for nondurable and durable consumption goods. These two parameters are affected by habit formation as well as by nonhomothetic preference assumptions. For instance, because the determinant of the response of saving and consumption predicts changes in real interest rates, intertemporal substitutability is greatly affected by habit formation. As the degree of habit formation increases, the household's response in terms of total consumption expenditure to a change in the real interest rate expectations weakens. Moreover, in a two-good model, the magnitude of the intratemporal elasticity of substitution indirectly affects the magnitude of the intertemporal elasticity of substitution when the composite consumption is nonhomogeneous. In other words, with nonhomothetic preferences, Engel's income expansion paths are nonlinear functions, and a predictable change in income due to a change in the real interest rate would lead to a relatively larger change in the demand for a luxury good compared to the demand for a normal good. Below, we assess how demand for nondurables and durables is affected by substitution and income effects and by lagged consumption levels. First, we compare the intertemporal elasticity of substitutions of models with and without habit formation. Second, to determine the intratemporal effects of nonhomothetic preferences on consumption and substitutability, we estimate demand functions for nondurable and durable goods. Because our aim here is to analyze the intratemporal effects on demand for nondurable versus durable goods, we here

ignore habit formation in consumption and consider

$$\begin{aligned} \hat{C}_t^n &= C\left(RC_t, Z_t\right), \\ \hat{D}_t &= D\left(RC_t, Z_t\right). \end{aligned} \tag{35}$$

The above demand functions can be derived from the following intratemporal expenditure minimization problem

$$\min_{C_t^n, D_t} Z_t \equiv C_t^n + RC_t D_t, \tag{36}$$

under the composite consumption index

$$C_t = \left[\frac{{C_t^n}^{1-\psi_n}}{1-\psi_n} + \frac{{D_t}^{1-\psi_d}}{1-\psi_d}\right], \tag{37}$$

where Z_t is the expenditure spent on nondurable and durable goods in units of nondurable goods and where RC_t is the user (rental) cost of durables, defined as

$$RC_t = Q_t - (1-\delta)E_t\left[(1+R_t)^{-1}Q_{t+1}\right]. \tag{38}$$

Log-differentiating the demand functions yields

$$\begin{aligned} \partial \log C_t^n &= \epsilon_{nd}\ \partial \log RC_t + \xi_n\ \partial \log Z_t, \\ \partial \log D_t &= \epsilon_{dd}\ \partial \log RC_t + \xi_d\ \partial \log Z_t, \end{aligned} \tag{39}$$

and reducing them to a relative demand function, we obtain

$$\partial \log\left(\frac{C_t^n}{D_t}\right) = \underbrace{\epsilon\ \partial \log RC_t +}_{\text{substitution effect}} \underbrace{\xi\ \partial \log Z_t}_{\text{income effect}}. \tag{40}$$

Note that with homothetic preferences, there would be no income effect, whereas with nonhomothetic preferences, the substitution effect is weaker and the income effect will be significantly different than zero. In our case, given that durables are luxury goods, we expect that $\xi < 0$.

Figure 2 illustrates the response of the intertemporal elasticity of substitution in the four cases to an expansionary monetary shock. The impulse responses show that the decrease in the intertemporal elasticity of substitution is more restrained and more rapid with nonhomothetic preferences and habit formation.

Table 4 presents the OLS estimations of equation (40) using 500-period data simulated using the models with homothetic and nonhomothetic preferences, both without habit formation.[15] These results indicate that with nonhomothetic preferences, the substitution effect weakens, and the income effect captures the income sensitivity of durables relative to nondurables. Obviously, this finding helps our model to solve the comovement puzzle.

Table 4—OLS Results on Intratemporal Parameters

Nonhomothetic Preference					
	Coefficients	Standard Error	t-stat	p-value	95 percent Confidence Interval
ϵ	0.586	0.002	269.1	0.000	[0.581, 0.590]
ξ	-2.928	0.0136	-215.9	0.000	[-2.955, -2.901]
Homothetic Preference					
	Coefficients	Standard Error	t-stat	p-value	95 percent Confidence Interval
ϵ	1.057	0.001	982.4	0.000	[1.055, 1.059]

V. Sensitivity Analysis

In this section, we provide sensitivity analyses to illustrate the importance of nonhomothetic preferences and habit formation for cross-sector comovement in our structural model.

Figure 3 presents the responses of durable and nondurable consumption to an

[15]For all of our simulations, we fix the interest rate shock volatility at 0.52.

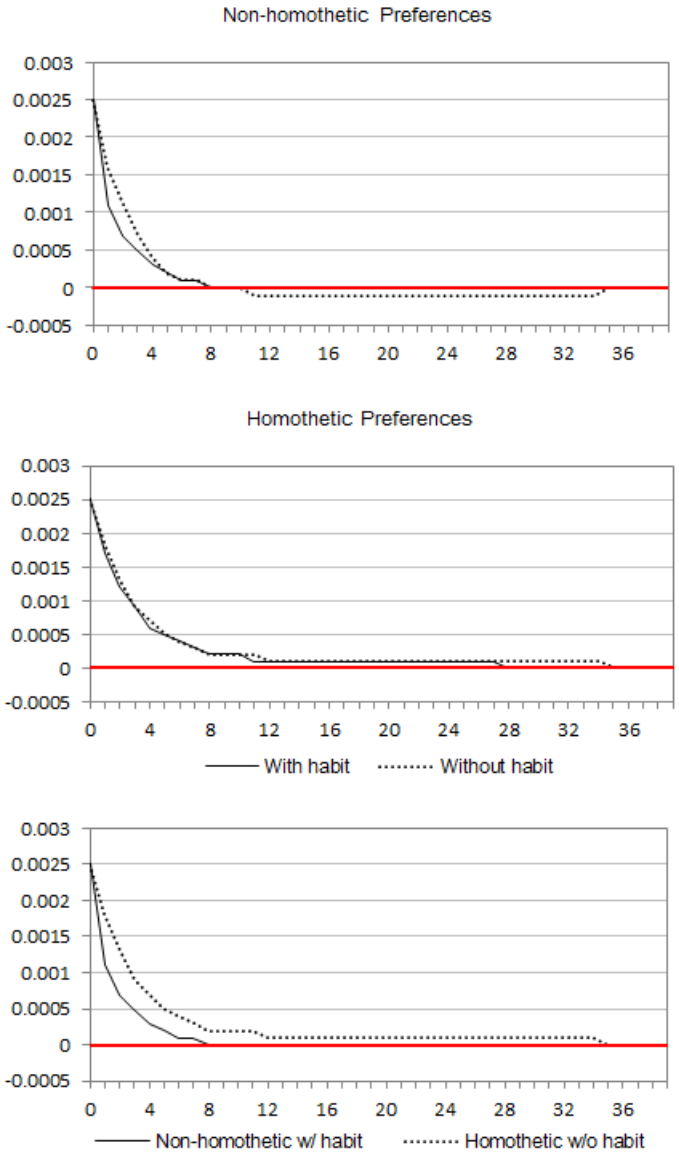


FIGURE 2. IMPULSE RESPONSE FUNCTIONS (INTERTEMPORAL ELASTICITY OF SUBSTITUTION)

expansionary monetary shock with four types of preferences. In the figure, the left panel presents the impulse response functions of our model assuming homothetic preferences, whereas the right panel shows the impulse responses under

nonhomothetic preferences.

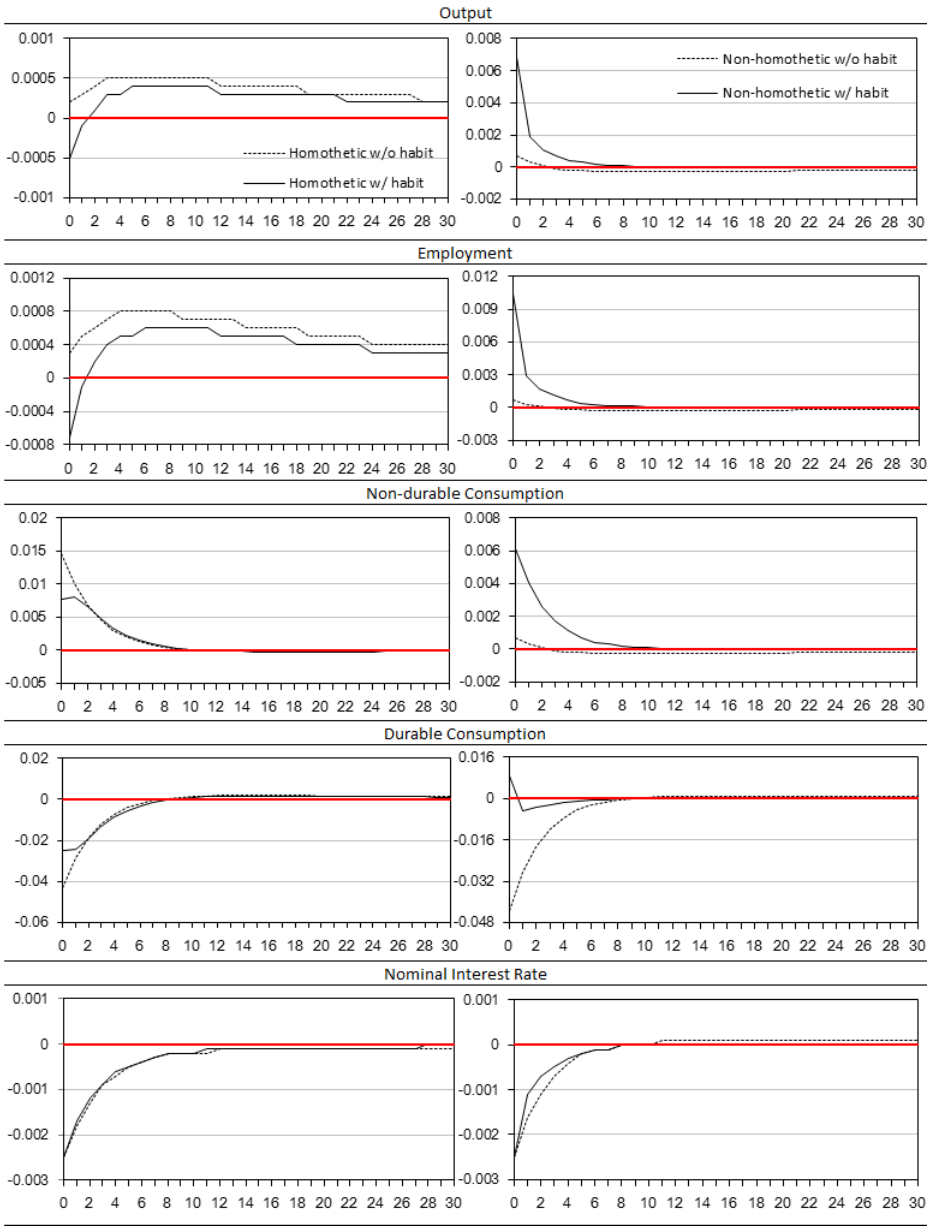


Figure 3. Impulse Response Functions

It is clear that, in both panels, habit in consumption mutes the substitution

effect and restrains the response of the relative demand for durables versus nondurables to their relative price changes. However, this effect is not sufficient to resolve the comovement puzzle. Moving from the left to the right panel, we observe that nonhomothetic preferences are also necessary to generate a positive comovement.

To elaborate more on the necessity of habit in consumption, we provide correlations between nondurable and durable consumption using data from a simulation of the model with nonhomothetic preferences under different degrees of habit formation.[16] The resulted correlations are reported in Table 5.

TABLE 5—CORRELATION: NONDURABLE AND DURABLE CONSUMPTION

	Degrees of Habit Persistence						
h_n/h_d	0.000	0.300	0.580	0.600	0.900	0.938	0.974
0.000	-0.998						-1.000
0.404							0.000
0.600						0.000	n/s
0.753					0.000		0.513
0.896				0.000			0.412
0.900			0.000				0.404
0.925		0.000					0.352
0.939	0.000						0.317

Note: The lower (upper) triangular shows the h_n and h_d combinations that resulted in positive (negative) correlations. We only provide some representative correlations. The full table is available upon request. The numbers, when necessary, are rounded to 3 decimal places. n/s stands for not stable.

The lower triangular part of the table contains pairs of degrees of habit formation that solve the comovement puzzle. Moreover, the simulations also indicate that to solve the comovement puzzle, habit formation in the consumption of nondurables is necessary. However, it can only be sufficient if it is as high as 0.939. On the other hand, habit formation in durable consumption is neither necessary nor sufficient to solve the comovement puzzle without habit formation in nondurable consumption.

Finally, we should note that matching the business cycle statistics (or, more

[16]The model is simulated for 500 periods using a 0.52 percent standard deviation for the monetary shock.

specifically, the ratio of the volatility of durable consumption to that of nondurable consumption) is beyond the scope of this paper, mainly because our model does not contain any of the relevant features, such as wage rigidity, investment adjustment costs, or credit constraints, as used in earlier studies. Moreover, our model includes an interest rate rule that is designed to alleviate output volatility. Nevertheless, the model can still generate greater volatility in durables than in nondurables.

VI. Conclusion

We have constructed and estimated a two-sector New Keynesian model with nondurables and durables that allows for a nonhomothetic utility function with habit formation in consumption. Our structural estimations are broadly in line with the existing empirical studies that provide supporting evidence for these two features of household preferences. The restricted version of our model that is abstracted from these two features nests as a special case the standard model, as presented in Barsky, House and Kimball (2007), that is well known for producing opposite movements in nondurable and durable production in response to a monetary shock and near monetary neutrality on the aggregate, which are at odds with empirical evidence. In our fully estimated model, in contrast, a monetary shock generates significant cross-sector comovement and monetary nonneutrality at both the sector and the aggregate levels, as is consistent with the data.

We have conducted a host of decomposition exercises, both analytically and numerically, to help gain insight into the mechanisms that drive our simulation results. Our findings from these exercises have led us to conclude that those two features of household preferences play complementary roles in delivering the results. First, habit formation inhibits nondurables and durables from moving in the opposite directions by restraining their cross substitution given the change in their relative price following a monetary shock. Second, nonhomotheticity in preferences makes income another determinant, in addition to sectoral relative

price, of the composition of desired consumption bundles; moreover, the income effect associated with the nonunitary income elasticity of demand for nondurables and durables across different income levels helps to guide the movements of nondurables and durables into the same direction in response to the shock. We have shown that these two mechanisms reinforce one another in propagating monetary shocks to generate significant cross-sector comovements and real effects at both the sector and the aggregate levels.

To elucidate the working of the mechanisms that drive our estimation and simulation results, our analysis has abstracted from the other features used in the existing literature to augment the standard two-sector New Keynesian model à là Barsky, House and Kimball (2007). This approach has allowed us to isolate the roles of those two features of household preferences we wish to address in this paper. As such, it is not our ambition for the model presented in this paper to provide a full quantitative account of the entire spectrum of business cycle statistics, as the model is apparently not equipped with the necessary frictions and shocks to do so. Nevertheless, compared to the standard model, it moves in the right direction -sometimes to a great degree, and other times more modestly. For instance, although our model is unable to match the entire ratio of the volatility of durable consumption to that of nondurable consumption, it can generate greater volatility in durables than in nondurables driven by monetary shocks, broadly in line with the empirical evidence.

Our study in this paper has contributed to the broad literature that emphasizes the relevance of nonhomotheticity in preferences and habit formation in consumption for a host of issues in macroeconomics and finance. Our findings suggest that these two real features of the data can be of particular importance for New Keynesian models with both nondurable and durable goods. An ambitious project for future research is to combine these and other mechanisms explored in the literature to build a quantitatively comprehensive business-cycle model to fully account for the various aspects of the data in a unified setting.

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