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Can Sticky Price Models with Flexibly Priced Durables Explain Sectoral Comovement?*

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Abstract Strong procyclical fluctuations in the durable production are the most prominent feature of the response to monetary shocks. This paper investigates the role of preferences in matching this feature of the data in a two-sector sticky price model with flexibly priced durables. The reaction of durables depends crucially on whether preferences are separable between labor and nondurable consumption. When preferences are separable, the model exhibits perverse behavior. Flexibly priced durables contract during periods of economic expansion. However, non-separable preferences substantially improve the ability of the model to generate sectoral comovment. This result hinges upon the fact that the non-separable preferences may indicate the complementarity between nondurable consumption and labor supply, which is absent in the separable preferences.

Keywords Sticky Prices, Durables, Comovement

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1. Introduction

Durable goods feature prominently in discussions of monetary policy. According to the data, the durable goods sector is one of the sectors that seem to respond most procyclically to monetary policy[1]. As demonstrated by Barsky et al. (2003, 2004 and 2007), however, it is difficult to match this feature of the data by simply incorporating durable goods into sticky price models. In particular, if durable goods have flexible prices, but nondurable goods prices are sticky, then a monetary expansion leads to an *increase* in nondurable goods production but a *decline* in durable goods production, so that aggregate output may not change at all.

Barsky et al. (2003, 2004 and 2007) show that this negative comovement problem stems from the fact that the stock - and thus the associated shadow value - of durables is nearly constant following the monetary policy shock. As they explain, the near constancy of the shadow value of durable goods implies that the intertemporal elasticity of substitution for durable consumption is naturally high. As a result, a temporary increase in the relative price of durables might cause a large shift of expenditure away from these goods.

In addition to the near constancy of the shadow values of durables, this paper shows that the comovement problem is also attributable to how a preference assumes the interaction between aggregate consumption and labor supply. When preferences are separable between aggregate consumption and labor as in Barsky et al. (2003, 2004 and 2007), there is a strong tendency for flexibly priced durables to contract following a monetary expansion. However, I demonstrate that non-separable preferences substantially improve the ability of the model to generate sectoral comovment, so that a monetary ex-

[1] Erceg and Levin (2006) document that an exogenous increase in the interest rate, estimated through a structural VAR, reduces the consumer durables and residential investment nearly three times more than nondurable consumption. Barsky, House and Kimball (2003 and 2004) also report similar results using *Romer dates* as indicators of pronounced change in monetary policy. Following a *Romer date*, the production of durables falls far more than that of nondurables.

pansion has a significant impact on aggregate output unlike separable preferences. This result hinges upon the fact that the non-separable preferences may indicate the complementarity between nondurable consumption and labor supply[2], which is absent in the separable preferences. Introducing a complementarity between nondurable consumption and labor also has an intuitive appeal. For example, when times are good,workers put in longer hours and enjoy less leisure, but they can make up for this in part by going out to lunch and dinner too.

Barsky et al. (2003 and 2007) briefly discuss the possibility that the complementarity between nondurables and labor might temper the negative comovement problem. The contribution of this paper is to elaborate on this possibility and characterize explicitly the key feature of the preference required to resolve the comovement problem for the first time. This will definitely enhance our understanding of the nature of the comovement problem. Moreover, this paper clearly identifies the class of non-separable preferences that can generate sectoral comovement of flexibly priced durables, among those extensively used in the business cycles literature.

This paper focuses on the following two non-separable momentary utility functions as potential remedies for the comovement problem. One is the Cobb-Douglas preference and the other is the preference proposed by Greenwood, Hercowitz and Huffman (1988, hereafter the 'GHH preference'). While the Cobb-Douglas preference never produces sectoral comovement, at least within the range of reasonable parameter values, the preference substantially mitigates the contraction in production of flexibly priced durables following a monetary expansion. In contrast with the Cobb-Douglas preference, the GHH preference successfully generates sectoral comovement[3]. Durable production

[2]Since the stock - and thus the associated shadow value - of a long-lived durable is approximately unchanged in the wake of a monetary shock, the complementarity between the stock of durables and labor supply is not important.

[3]Besides the introduction of the GHH preferences, there are a couple of ways to generate sectoral comovement. Barsky et al. (2003, 2004 and 2007) propose the introduction of a sticky nominal wage as one possible solution to the comovement problem. Carlstrom and Fuerst (2006) explicitly demonstrate

rises in response to a monetary expansion in the model with the GHH preference. This is because the GHH preference induces a stronger complementarity, which stems from the property that it assumes no wealth effects in labor supply[4].

Why does the complementarity between aggregate consumption and labor play such an important role in a two-sector sticky price model? The answer is that it changes the behavior of the nominal wage following a monetary expansion. To be more specific, increased production of nondurables due to sticky nondurable prices raises the demand for labor inputs and thus increases the nominal wage. However, the complementarity between nondurable consumption and labor supply mitigates the rising pressure on the nominal wage since the increase in nondurable consumption shifts the labor supply curve out. Hence, the nominal wage might rise slowly to its eventual level rather than overshoot that level. This implies that the price of durables slowly rises and thus the relative price of durables does not rise that much. While a modest increase in the relative price of durables still works to inhibit the consumption of durables, the gradual adjustment in the price of durables boosts spending in the sector. This is why the non-separable preferences might lead to an increase in the production of flexibly priced durables even though the intertemporal elasticity of substitution for purchases of durables is high. On the contrary, separable preferences have no forces that compensate for the rise in the cost of production. Hence, the nominal wage increases substantially and the price of durable goods overshoots its eventual level in the short run. As a result, the production of durables significantly declines.

The possibility that durable goods have relatively flexible prices is empirically

that sticky wage helps to generate sectoral comovement. Another way suggested by Barksy et al. (2003, 2004 and 2007) is to consider the model with credit constraint. Monacelli (2006) confirms this.

[4]The finding here is closely related to a recent paper by Jaimovich and Rebelo (2008). In the Real-Business-Cycle (RBC) literature, many authors document the standard RBC model's inability to generate sectoral comovement between the nondurable consumption sector and the investment sector in response to contemporaneous productivity shocks and news shocks about productivity. Jaimovich and Rebelo (2008) demonstrate that very low short-run labor-supply wealth effects are essential to generate sectoral comovement.

plausible. The evidence presented by Barsky et al. (2003, 2004 and 2007) seems consistent with the notion that the prices of durable goods are much more flexible than the prices of nondurabe goods. For example, housing prices are not set in advance and the prices of new houses fall relative to other prices after a monetary contraction. Besides these empirical findings, Barsky et al. (2003, 2004 and 2007) argue that there are conceptual reasons to expect that the transaction price of many durables is effectively flexible. Some durables (like housing) are relatively expensive on a per-unit basis. If implicit or explicit menu costs have important fixed components, there is more incentive to negotiate the price of these goods. Moreover, some durables require considerable customization, which is often accompanied by price negotiations[5].

The remainder of the paper is organized as follows. Section 2. presents a two-sector sticky price model that includes nondurable and durable goods. Section 3. carries out the theoretical investigation of the model. Section 4. presents precise functional forms characterizing preferences and calibrates the model. Section 5. contains simulations of the model. Section 6. concludes.

2. The Model

The model is populated by a constant number of identical, infinitely-lived households, continua of firms in two sectors that respectively produce differentiated durable and non-durable goods, perfectly competitive final goods firms in two sectors, and a government.

[5]Zbaracki et al. (2003) present evidence obtained "in the field" on negotiation between large business customers and sales representatives of a large supplier of industrial durables. The evidence shows that salesmen have considerable leeway to offer deals to customers who express dissatisfaction with the list price.

2.1. Households

The representative household derives utility from the consumption of nondurable and from the service flow of durable goods, and incurs disutility from hours worked. Following the literature, the service flow from durable is assumed to be proportional to the stock and, without loss of generality, the coefficient of proportionality is normalized to 1. Let C_t and D_t respectively denote the household's nondurable consumption and the stock of durables, and let L_t denote labor supply. Households maximize expected lifetime utility as given by

$$U_0 = E_0 \left[\sum_{t=0}^{\infty} \beta^t \underline{U}(C_t, D_t, L_t) \right] \tag{1}$$

where $\beta \in (0, 1)$ is the subjective discount factor. The stock of durable evolves according to

$$D_t = X_t + (1 - \delta) D_{t-1} \tag{2}$$

where $\delta \in (0, 1)$ is the depreciation rate and X_t denotes newly purchased durables.

The household enter period t with a stock of private one-period nominal bond (B_{t-1}), a stock of nominal money balances (M_{t-1}). During the period, the household receives wages, dividend paid by firms, a lump-sum transfer (T_t) from the government and interest payments on bond holdings. These resources are used to purchase durable and nondurable and to acquire assets to be carried over to next period. Then, the household's budget constraint (in nominal terms) is

$$P_{c,t} C_t + P_{x,t} X_t + B_t + M_t \leq W_t L_t + \Pi_t + T_t + (1 + i_{t-1}) B_{t-1} + M_{t-1} \tag{3}$$

where $P_{x,t}$ and $P_{c,t}$ are the nominal prices of the durable and nondurable, W_t is the nominal wage rate, Π_t are profits returned to the consumer through dividends, and i_t is the nominal interest rate.

The first order conditions associated with the optimal choice of C_t, L_t and X_t are

$$\frac{\gamma_{c,t}}{P_{c,t}} = \frac{\gamma_{x,t}}{P_{x,t}} \tag{4}$$

$$-\underline{U}_L(C_t, D_t, L_t) = \gamma_{x,t}\frac{W_t}{P_{x,t}} = \gamma_{c,t}\frac{W_t}{P_{c,t}} \tag{5}$$

where $\gamma_{c,t} \equiv \underline{U}_C(C_t, D_t, L_t)$ denotes the marginal utility of nondurable consumption and $\gamma_{x,t}$ denotes the shadow value of durable consumption. $\gamma_{x,t}$ can be written as the present value of future marginal service flows from an additional unit of the durable at time t, discounted by the subjective rate of time preference and the depreciation rate:

$$\gamma_{x,t} = MU_t^D + \beta(1-\delta)E_t MU_{t+1}^D + \beta^2(1-\delta)^2 E_t MU_{t+2}^D + ... \tag{6}$$

where $MU_t^D \equiv \underline{U}_D(C_t, D_t, L_t)$ denotes the marginal utility of the service flows from an additional unit of the durable at time t.

As in Barsky et al. (2007), money demand is assumed to be proportional to nominal purchases:

$$M_t = P_{c,t}C_t + P_{x,t}X_t \tag{7}$$

2.2. Firms

I assume the existence of a continuum of monopolistically competitive firms producing differentiated intermediate goods in each sector. The latter are used as input by a (perfectly competitive) firm producing a final good in each sector.

2.2.1. Final goods firms

The final good in each sector is produced by a representative, perfectly competitive firm with the CES (constant elasticity of substitution) technology:

$$C_t = \left[\int_0^1 c_t(s)^{\frac{\varepsilon-1}{\varepsilon}} ds\right]^{\frac{\varepsilon}{\varepsilon-1}} \quad \text{and} \quad X_t = \left[\int_0^1 x_t(s)^{\frac{\varepsilon-1}{\varepsilon}} ds\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{8}$$

where $c_t(s)$ and $x_t(s)$ are the quantity of intermediate goods s used as input in each sector. $\varepsilon > 1$ is the elasticity of substitution between different intermediate goods. As $\varepsilon \to \infty$, intermediate goods become perfect substitution in the production of final good. Cost minimization by the final good producer in each sector delivers the demand for the intermediate goods

$$c_t(s) = \left(\frac{p_{c,t}(s)}{P_{c,t}}\right)^{-\varepsilon} C_t \quad \text{and} \quad x_t(s) = \left(\frac{p_{c,t}(s)}{P_{x,t}}\right)^{-\varepsilon} X_t \tag{9}$$

where the subscript c and x denote variables that are specific to the nondurable and durable sector, respectively. $p_{j,t}(s)$ is the price of intermediate good s in sector $j = c, x$ and $P_{j,t}$ is the aggregate price level in sector $j = c, x$. Finally, the zero-profit condition implies that

$$P_{j,t} = \left[\int_0^1 p_{j,t}(s)^{1-\varepsilon} ds\right]^{\frac{1}{1-\varepsilon}}, \quad \text{for} \quad j = c, x \tag{10}$$

2.2.2. Intermediate goods firms

Intermediate good producers in each sector are monopolistically competitive. Each intermediate goods firm produces its differentiated goods using the following production function.

$$c_t(s) = Al_{c,t}(s) \tag{11}$$

$$x_t(s) = Al_{x,t}(s) \tag{12}$$

where A is a parameter representing the level of factor productivity and $l_{j,t}(s)$ is labor in firms s in sector $j = c, x$ at time t. It is assumed that labor can flow freely across sectors. Thus, nominal marginal costs in either industry are simply $MC_t = W_t/A$ where W_t is the nominal wage.

Intermediate goods firms are assumed to set nominal prices in a staggered fashion, according to the stochastic time dependent rule proposed by Calvo (2003). Each firm in sector $j = c, x$ resets its price with the probability of $1 - \theta_j$ each period, independently of the time elapsed since the last adjustment. Thus, for each period a measure $1 - \theta_j$ of firms reset their price, while a fraction θ_j firms keep their prices from the previous period. An intermediate goods firm resetting its price in period t in sector $j = c, x$ will seek to maximize the present value of expected future real profits generated while that price remains effective:

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t \theta_j^t \gamma_{j,t} \frac{\Pi_{j,t}}{P_{j,t}} \right] \tag{13}$$

subject to the sequence of demand constraints, eq. (9). Here $\gamma_{j,t}$ is the shadow value of the good produced in sector j and $\Pi_{j,t}/P_{j,t}$ measures the real value of an intermediate goods firm's profit in sector j in period t. It is easy to show that the optimal reset price in sector $j = c, x$, denoted as $p^*_{j,t}$, is

$$p^*_{c,t} = \frac{\varepsilon E_t \sum_{k=0}^{\infty} \beta^k \theta_c^k MC_{t+k} (P_{c,t+k})^{\varepsilon-1} \gamma_{c,t+k} C_{t+k}}{(\varepsilon - 1) E_t \sum_{k=0}^{\infty} \beta^k \theta_c^k (P_{c,t+k})^{\varepsilon-1} \gamma_{c,t+k} C_{t+k}} \tag{14}$$

$$p_{x,t}^{*}=\frac{\varepsilon E_t\sum_{k=0}^{\infty}\beta^k\theta_x^k MC_{t+k}(P_{x,t+k})^{\varepsilon-1}\gamma_{x,t+k}X_{t+k}}{(\varepsilon-1)E_t\sum_{k=0}^{\infty}\beta^k\theta_x^k(P_{x,t+k})^{\varepsilon-1}\gamma_{x,t+k}X_{t+k}} \tag{15}$$

Finally, the equation describing the dynamics for the aggregate price level in sector $j=c,x$, is given by $P_{j,t}=\left[(1-\theta_j)(p_{j,t}^{*})^{1-\varepsilon}+\theta_j P_{j,t-1}^{1-\varepsilon}\right]^{1/(1-\varepsilon)}$.

2.3. Money Supply and Market Clearing

The government finances the transfers to households by printing additional money, so its budget constraint is

$$T_t = M_t - M_{t-1} \tag{16}$$

As in Barsky et al. (2007), it is further assumed that that the money supply follows a random walk.

$$M_t = M_{t-1} + \xi_t \tag{17}$$

where ξ_t is an independently and identically distributed ($i.i.d$) disturbance with zero mean.

I construct real GDP Y_t as $Y_t \equiv P_c C_t + P_x X_t$ where P_c and P_x are steady state prices for the nondurable and durable good. The GDP deflator is then nominal GDP divided by real GDP.

Finally, the labor market equilibriums require

$$L_t = L_{x,t} + L_{c,t} \tag{18}$$

where $L_{j,t}=\int l_{j,t}(s)ds$ is labor used in sector $j=c,x$.

3. Inspecting the Nature of the Comovement Problem

In this section I demonstrate analytically that the behavior of a flexible price sector that produces durable goods depends critically on whether preferences are separable between nondurable consumption and labor.

To understand the reaction of the durable sector to an expansion in the money suppply, note that when durable goods prices are flexible, the labor supply condition (equation. (5)) becomes

$$-\underline{U}_L(C_t, D_t, \underbrace{L_{x,t} + L_{c,t}}_{L_t}) = \gamma_{x,t}\frac{W_t}{P_{x,t}} = \frac{\gamma_{x,t}}{\mu}A \tag{19}$$

where the last equality is implied by the fact that the flexible price of durables is a constant markup (μ) over its marginal cost: $P_{x,t} = \mu\,(W_t/A)$.

Furthermore, Barsky et el. (2003, 2004 and 2007) show that the shadow values of a long-lived durable (i.e., $\gamma_{x,t}$) remain roughly constant in response to monetary shocks. This is because the stock-flow ratio is high so that even large changes in purchases will have only minor effects on the total quantity of the durable. Modest fluctuations around the steady state leave the stock of durables, and thus their shadow value, nearly constant at cyclical frequencies. As a result, one can treat $\gamma_{x,t}$ and D_t as constant. Dropping the time script of D_t and $\gamma_{x,t}$ in equation (19), we obtain

$$-\underline{U}_L(C_t, D, \underbrace{L_{x,t} + L_{c,t}}_{L_t}) = \frac{\gamma_x}{\mu}A \tag{20}$$

This equation shows that the nature of the comovement problem is closely related to the sign of cross derivative $-\underline{U}_{LC}$. First, suppose that the preference is separable between consumption and labor. In this case, the marginal disutility from labor is only a function of labor so that the cross derivative $-\underline{U}_{LC} = 0$. Thus, equation (20) becomes

$$-\underline{U}_L(C_t, D, L_t) = v(\underbrace{L_{x,t} + L_{c,t}}_{L_t}) = \frac{\gamma_x}{\mu} A \tag{21}$$

where $v^{'} > 0$. This equation clearly shows that if the production of nondurables rises in response to expansionary monetary policy, then the employment in the durable sector falls in a model with separable preferences. Following a monetary expansion, an increase in the production of nondurable goods due to sticky prices of nondurable goods raises the cost of producing durables (i.e., an increase in $v(\cdot)$). Because there are no forces that can offset a rise in the cost of production, this definitely lowers the labor employed in the durable goods sector and thus the production of durable goods falls.

However, things might be different in a model with non-separable preferences with $-\underline{U}_{LC} < 0$, which indicates the complementarity between nondurable consumption and labor. As long as $-\underline{U}_{LC} < 0$, equation (20) shows that increased nondurable consumption shifts the labor supply curve out, counteracting the rise in the cost of producing durables. Hence, the contraction of the flexibly priced durable sector might be substantially mitigated. If this effect is strong enough, it could actually raise production in the durable goods sector following a monetary expansion.

I now investigate how much of the complementarity is required to obtain sectoral comovement. In order to derive the condition, it is useful to log-linearize the equation (20) around a deterministic steady state. Define $\eta_{ll} \equiv \left(\frac{-\underline{U}_{LL}L}{-\underline{U}_L}\right)\Big|_{ss} > 0$ as the own elasticity of marginal disutility from labor and $\eta_{lc} \equiv \left(\frac{-\underline{U}_{LC}C}{-\underline{U}_L}\right)\Big|_{ss}$ as the cross-elasticity of marginal disutility from labor with respect to nondurable consumption, evaluated at the steady state respectively. Let S_j be the steady state share of good $j = c, x$ in GDP. Using $C_t = AL_{c,t}$, I write the log-linearized equation for (20) as

$$\eta_{ll} S_x \widehat{L}_{x,t} = (-\eta_{lc} - \eta_{ll} S_c) \widehat{L}_{c,t} \tag{22}$$

where a circumflex("hat") over a variable represents proportionate deviations of that variable from its steady state. This equation confirms that unless labor supply and the consumption of nondurables are complementary (i.e. $\eta_{lc} < 0$), it is impossible to obtain setoral comovement of flexibly priced durables. Given $\eta_{lc} < 0$, the required strength of the complementarity that raises the production of durables in response to a monetary expansion is given by

$$\frac{-\eta_{lc}}{\eta_{ll}} > S_c \tag{23}$$

This condition says that the higher the elasticity of marginal disutility from working, the stronger complementarity is required to obtain sectoral comovement. As the marginal disutility from working increases more rapidly, the increase in nondurable consumption from a monetary expansion raises the cost of production more. Hence, it would require a stronger complementarity to offset a higher cost of production.

4. Specification of Preferences and Calibration

4.1. Preferences

As the previous analytical discussion demonstrates, the cross-partial derivative, $-\underline{U}_{LC}$, plays an important role in shaping the reaction of the flexibly priced durables in a two-sector sticky price model. I now consider three different momentary utility functions - which have been extensively used in the business cycle literature - that differ from each other in relation to the strength of the complementarity and the with-in period separability between aggregate consumption index ($\mathbb{C}_t$) and labor:

$$\underline{U}(C_t, D_t, L_t) = \left(\frac{1}{1-\frac{1}{\sigma}}\right)\mathbb{C}_t^{1-\frac{1}{\sigma}} - \varphi\frac{L_t^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}} \tag{24}$$

$$\underline{U}(C_t, D_t, L_t) = \left(\frac{1}{1-\frac{1}{\sigma}}\right)\left[\mathbb{C}_t^{(1-\gamma)}(1-L_t)^{\gamma}\right]^{1-\frac{1}{\sigma}}, \quad \sigma \neq 1 \tag{25}$$

$$\underline{U}(C_t, D_t, L_t) = \left(\frac{1}{1-\frac{1}{\sigma}}\right)\left[\mathbb{C}_t - \phi\frac{L_t^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}}\right]^{1-\frac{1}{\sigma}} \tag{26}$$

where σ is the parameter that governs the *inter*temporal elasticity of substitution and its inverse $(1/\sigma)$ is the coefficient of risk aversion. For low values of σ, agents are unwilling to substitute consumption over time. $\mathbb{C}_t$ is a CES aggregator of nondurable and durable consumption and defined as

$$\mathbb{C}_t \equiv z(C_t, D_t) = \left(\psi_c C_t^{1-\frac{1}{\rho}} + \psi_d D_t^{1-\frac{1}{\rho}}\right)^{\frac{\rho}{\rho-1}} \tag{27}$$

Equation (24) represents separable preferences used by Barsky et al. (2003, 2004 and 2007), which implies no complementarity between nondurable consumption and labor (i.e.$-\underline{U}_{LC} = 0$). Equation (25) is the Cobb-Douglas preference. The restriction imposed on the intertemporal elasticity of substitution ($\sigma \neq 1$) ensures the non-separability between nondurables consumption and labor. When $\frac{1}{\sigma} > 1$, the consumption of nondurables and labor are complementary in this preference (i.e.,$-\underline{U}_{LC} < 0$)[6]. Note that $\frac{\partial(-\underline{U}_{LC})}{\partial(1/\sigma)} < 0$, which implies that the complementarity is increasing with the coefficient of risk aversion. The third class of utility functions (expression (26)) is the GHH preference. Among the three, the GHH preference gives the strongest complementarity because $-\underline{U}_{LC} < 0$ independently of the degree of intertemporal substitution. This feature is closely related to the property that the GHH preference assumes no wealth ef-

[6]Note that $-\underline{U}_{LD}$ also takes the negative sign when $1/\sigma > 1$. However, the complementarity between the stock of durable and labor has little impact on the behavior of the model. It is because the stock of durable changes so slightly following the monetary shock.

fects on labor supply of the aggregate consumption index, $\mathbb{C}_t$. While the Cobb-Douglas preference with $\frac{1}{\sigma} > 1$ partially offsets negative wealth effects on labor supply of increased nondurable consumption, the GHH preference induces a stronger complementarity that completely offsets these wealth effects. Finally, the complementarity between nondurables and labor supply in the GHH preferences also increases with the coefficient of risk aversion.

4.2. Calibration

This section describes the benchmark values used to compute the response of the economy to monetary shocks. I set the subjective discount factor β to $1.02^{-0.25}$, implying a steady state annualized real interest rate of 2 percent. The durable has a quarterly depreciation rate (δ) of 1.25 percent, which implies an annual rate of depreciation on the durable equal to 5 percent. I set $\varepsilon = 11$ to generate a desired markup of 10 percent, and ψ_c and ψ_d are set to give a steady-state nondurable share of 0.75 of GDP. The parameters φ, γ and ϕ are chosen to match steady state L, which is about 20% of the time available. I assume that $\rho = 1$ so that $\mathbb{C}_t = C_t^{\psi_c} D_t^{\psi_d}$. A benchmark value for the intertemporal elasticity of substitution (σ) is 0.5, implying that a benchmark coefficient of risk aversion is 2. With separable and GHH preferences, the parameters η and ν governing the elasticity of labor supply are set to 1.5, which is an intermediate value used in the literature[7]. Finally, I assume that durable goods have perfectly flexible prices ($\theta_x = 0$) and nondurable goods prices are adjusted (on average) every two and half quarters ($\theta_c = 0.6$).

The parameters σ and ν are the most important in the quantitative analysis below since they affect the η_{lc} and η_{ll}. Some analysis of the sensitivity of the quantitative results

[7] The typical RBC model assumes that this elasticity is around 2 as in Prescott (1986). Recent work by Kimball and Shapiro (2003) shows that it is about one.

to the values of these parameters will be carried out.

5. Quantitative Analysis of the Model

In this section I assess the role of preferences in determining the response of flexibly priced durables by numerically solving the parameterized version of the model. I proceed step-by-step, first working with a version of the model with separable preferences and then introducing two non-separable preferences. I compute the equilibrium path of a linear approximation of the model in the neighborhood of its non-stochastic steady state. In particular, I consider the response of the economy to a 1 percent permanent increase in the money supply.

5.1. An Economy with Separable Preferences

Figure (1) displays the reaction of the model to the monetary shock in a model with separable preferences (equation (24)). The model with separable preferences exhibits the negative comovement of nondurables and flexibly priced durables. Nondurable consumption rises by 0.88% but production of durables *falls* by 2.63% right after the monetary expansion. In the aggregate, these offsetting movements leave total production unchanged. Thus, money is essentially neutral at the aggregate level in a model with separable preferences, even though the sticky price sector (i.e., nondurable sector) is 75 percent of GDP.

The underlying mechanisms are as follows. Increased production of nondurables due to sticky nondurable prices raises the demand for labor and thus the nominal wage rises. When preferences are separable, the nominal wage significantly overshoots before converging to its new steady state level. It initially rises by about 2.1 percent, substantially larger than its eventual level (i.e., 1.0 percent increase). For producers in the flexibly priced durable goods sector, this substantial increase in the nominal wage is merely an adverse cost shock. Hence, the price of durables also substantially overshoots its eventual level in the short run and the relative price of durables also significantly increases. These two forces work to inhibit the consumption of durables. As a result, the production of durable goods significantly falls in response to a monetary expansion in the model with separable preferences.

5.2. An Economy with Non-Separable Preferences: Cobb-Douglas Preference

Figure (2) shows the response to the monetary shock in a model with the Cobb-Douglas preference (equation (25)). Even though the model with the Cobb-Douglas preference cannot generate sectoral comovement, it substantially reduces the contraction in production of durables. While the production of durables falls by 2.63% in the model with separable preferences, it only declines by 1.19% in the model with the Cobb-Douglas preference. Due to a relatively small contraction in the production of durables, the monetary shock has a significant impact on output in the model with the Cobb-Douglas preference. GDP rises above trend by 0.3 percent immediately after the shock. Hence, the neutrality result for aggregate production does not hold in the model with the Cobb-Douglas preference.

The dramatic change in the reaction of the economy to the monetary shock stems from the fact that nondurable consumption is complementary with labor supply in the Cobb-Douglas preference (i.e., $\eta_{lc} < 0$). In contrast with the separable preferences, the complementarity between nondurable consumption and labor supply mitigates an increase in the cost of production. The reaction of the nominal wage clearly shows this. An increase in the nominal wage is substantially subdued under the Cobb-Douglas preference. While the nominal wage rises by 2.1% under the separable preferences, it only rises by 1.3% under the Cobb-Douglas preference. Hence, an increase in the relative price of durables gets much smaller so that the contraction in production of durables is significantly mitigated.

I next discuss the sensitivity of the results to the choice of parameters. The value chosen for the intertemporal elasticity of substitution (σ) is a key ingredient in determining the effects of monetary shock on durables. This is not surprising because the Cobb-Douglas preference with $\sigma = 1$ essentially reduces to the separable preference. To analyze how the reaction of durables changes with different values for σ, recall that $-\eta_{lc}/\eta_{ll}$ needs to exceed the steady-state share of nondurables of GDP to obtain sectoral comovement. Figure (3.A) shows how the adjusted degree of complementarity between nondurables and labor supply (i.e., $-\eta_{lc}/\eta_{ll}$) changes with different values for risk aversion ($1/\sigma$). A higher value for risk aversion (i.e., a lower value for the intertemporal elasticity of substitution) enhances the degree of complementarity . However, $-\eta_{lc}/\eta_{ll}$ never reaches the values for the steady-state share of nondurables (0.75) within the range of reasonable risk aversion values. As a result, it seems difficult to obtain sectoral comovement in a model with the Cobb-Douglas prferences. Figure (3.B) confirms this. It shows the percent change in durable production right after the shock as the degree of risk aversion is varied. A higher value for risk aversion mitigates the contraction in the production of durables but never produces a positive reaction of durable production.

5.3. An Economy with Non-Separable Preferences: GHH Preference

Figure (4) portrays the response to the monetary shock in a model with the GHH preference (equation (26)). In contrast to the model with separable and Cobb-Douglas preferences, the GHH preference produces sectoral comovement of nondurables and flexibly priced durables. Durable production rises by 1.1% following the shock in the model with the GHH preference.

The behavior of the nominal wage sheds light on the source of the dramatic change in the response of durable production. While the nominal wage overshoots its eventual level in the model with the separable and Cobb-Douglas preferences, the nominal wage in the model with the GHH preference behaves as if it inherited some nominal rigidity. It rises by only 0.8 percent and then rises gradually to its new steady state level. This sluggish response of the nominal wage is due to a stronger complementarity between nondurables and labor supply. The sluggish adjustment of the nominal wage imparts some nominal rigidity on durable prices even if firms in the durable sector set prices freely. That is, the price of durables also slowly converges on its eventual level and an increase in the relative price of durables shrinks. Therefore, while the extent to which an increase in the relative price of durables inhibits the consumption of durables lessens, households are now willing to increase their spending on durables because of the slow adjustment of durable prices.

I now examine how the choice of parameter σ affects the reaction of the model. For a fixed labor supply elasticity (ν), lower values for risk aversion make it more difficult for the model to produce sectoral comovement. This is because the complementarity between nondurables and labor is increasing with the degree of risk aversion. For this reason, I consider lower values for risk aversion than a benchmark value of 2.0, keeping the labor supply elasticity at a benchmark value ($\nu = 1.5$). The solid line in Figure (5) shows that the minimum value of the coefficient of risk aversion consistent with sectoral comovement is only 0.8, well below the lower bound of its empirical estimates (i.e., unit value). Hence, when the labor supply elasticity is 1.5, the model with the GHH preference can produce sectoral comovement for all plausible values for the coefficient of risk aversion.

Finally, I also consider changes in the labor supply elasticity (ν). As discussed in Section 3., a lower value for ν implies a higher value for η_{ll} so that a higher value for the coefficient of risk aversion (i.e., a higher value for $-\eta_{lc}$) is required to obtain sectoral comovement. Hence, it might require an implausibly high value for risk aversion to generate sectoral comovement when the labor supply elasticity takes its lower bound from the literature ($\nu = 1$). However, the circle line in Figure (5) shows that even when $\nu = 1$, the minimum value of the coefficient of risk aversion consistent with sectoral comovement is still in the range of its empirical estimates. The coefficient of risk aversion is only required to be greater than 1.2.

6. Conclusion

In the data, strong procyclical fluctuations in the production of durable goods are the most prominent feature of the response to monetary shocks. Business and residential investment rise sharply following a monetary expansion. This paper investigates the role of preferences in matching this feature of the data in a sticky price model with flexibly priced durables. The separability between nondurable consumption and labor supply plays an important role in shaping the reaction of flexibly priced durables. When preferences are separable between nondurable consumption and labor, the model exhibits strongly counterfactual behavior. Flexibly priced durables contract substantially following a monetary expansion.

However, two non-separable preferences considered in this paper significantly change the behavior of the model. The reason is that the non-separable preferences indicate the complementarity between nondurable consumption and labor supply, absent in the separable preferences. While the Cobb-Douglas preference never produces sectoral comovement, it substantially mitigates the contraction in production of flexibly priced durables following a monetary expansion. On the other hand, the GHH preference induces a stronger complementarity so that it successfully generates sectoral comovement. The production of durables actually rises in response to a monetary expansion in the model with the GHH preference.

References

Barsky, R., C. House and M. Kimball, 2003, Do Flexible Durable Goods Prices Undermine Sticky Price Model?, NBER working papers: No. 9823.

Barsky, R., C. House and M. Kimball, 2004, Sticky Price Models and Durable Goods, Working paper, University of Michigan.

Barsky, R., C. House and M. Kimball, 2007, Sticky-Price Models and Durable Goods, American Economic Review 97, 984-998.

Calvo, G., 1983, Staggered Prices in a Utility Maximizing Framework, Journal of Monetary Economics 12, 383-398.

Carlstrom, C. and T. Fuerst, 2006, Co-movement in Sticky Price Models with Durable Goods, Working Paper 0614, Federal Reserve Bank of Cleveland.

Erceg, C. and A. Levin, 2006, Optimal Monetary Policy with Durable Consumption Goods, Journal of Monetary Economics 53, 1341-1359.

Greenwood, J., Z. Hercowitz and G. Huffman, 1988, Investment, Capacity Utilization, and the Real Business Cycle, American Economic Review 78, 402-471.

Jaimovich, N. and S. Rebelo, 2008, Can News About the Future Drive the Business Cycle?, American Economic Review (forthcoming).

Kimball, M. and M. Shapiro, 2003, Labor Supply: Are the Income and Substitution Effects Both Large or Both Small?, Working paper, University of Michigan.

Monacelli, T., 2006, New Keynesian Models, Durable Goods and Collateral Constraints, CEPR Discussion Papers: No. 5916.

Prescott, E., 1986, Theory Ahead of Business-Cycle Measurement, Carnegie-Rochester Conference Series on Public Policy 25, 11-44.

Zbaracki, M., M. Ritson, D. Levy, S. Dutta and M. Bergen, 2003, Managerial and Customer Costs of Price Adjustment: Direct Evidence from Industrial Markets, Bar-Ilan University, Economics Working Paper No. 2003.

Figure 1. Impulse Response Functions: Separable Preferences

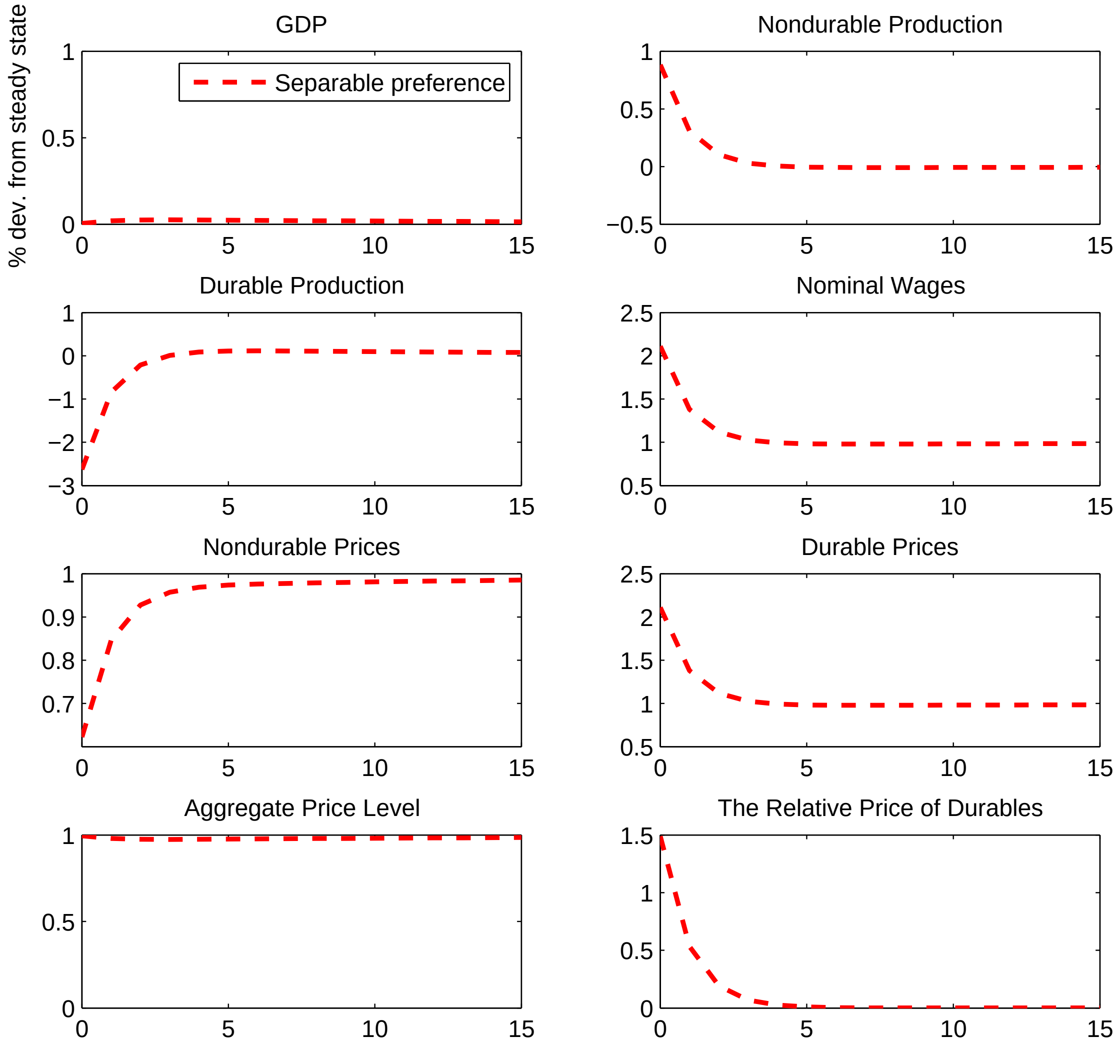

Figure 2. Impulse Response Functions: Separable vs. Cobb-Douglas (CD) Preferences

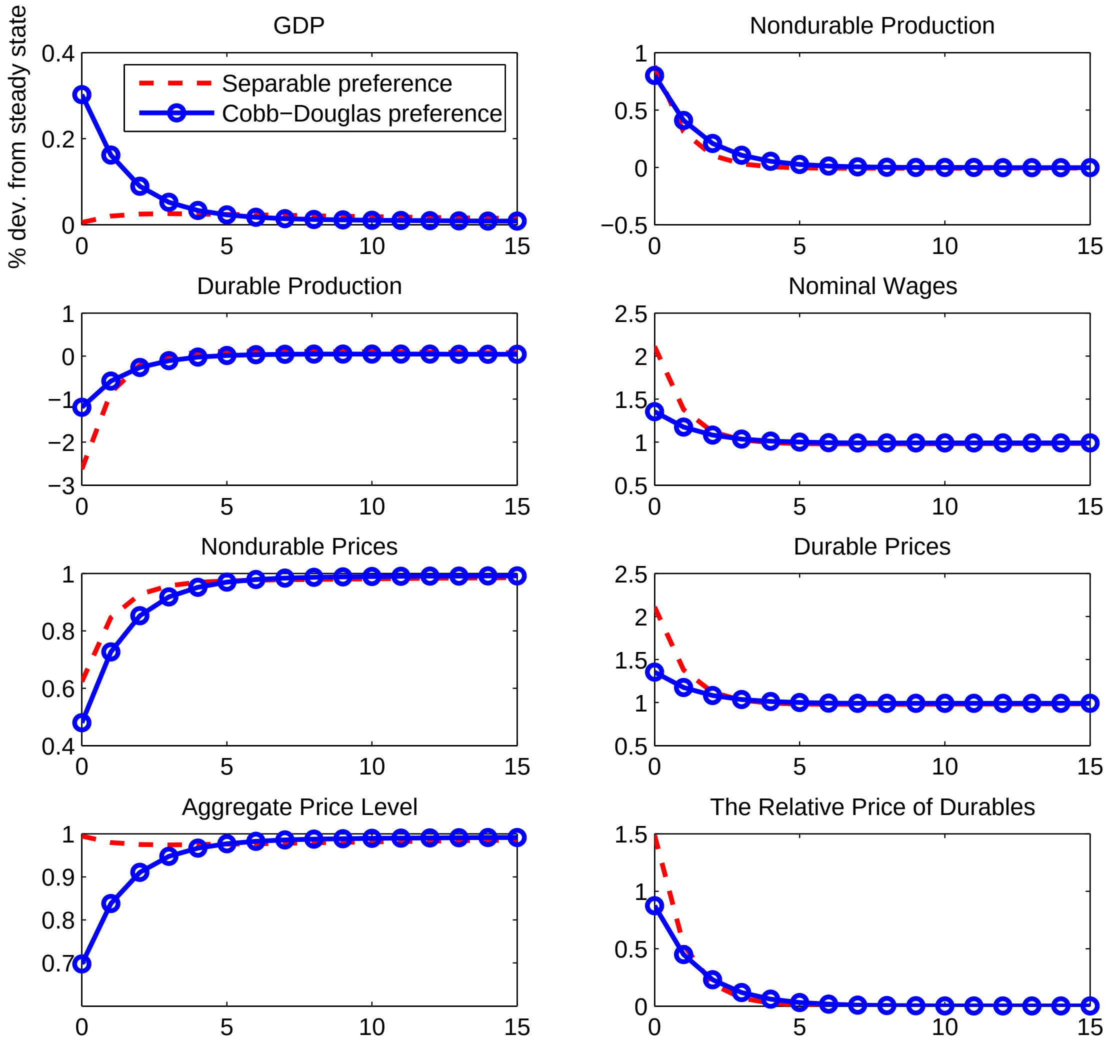

Figure 3. Robustness to Changes in the Risk Aversion $(1/\sigma)$: CD Preferences

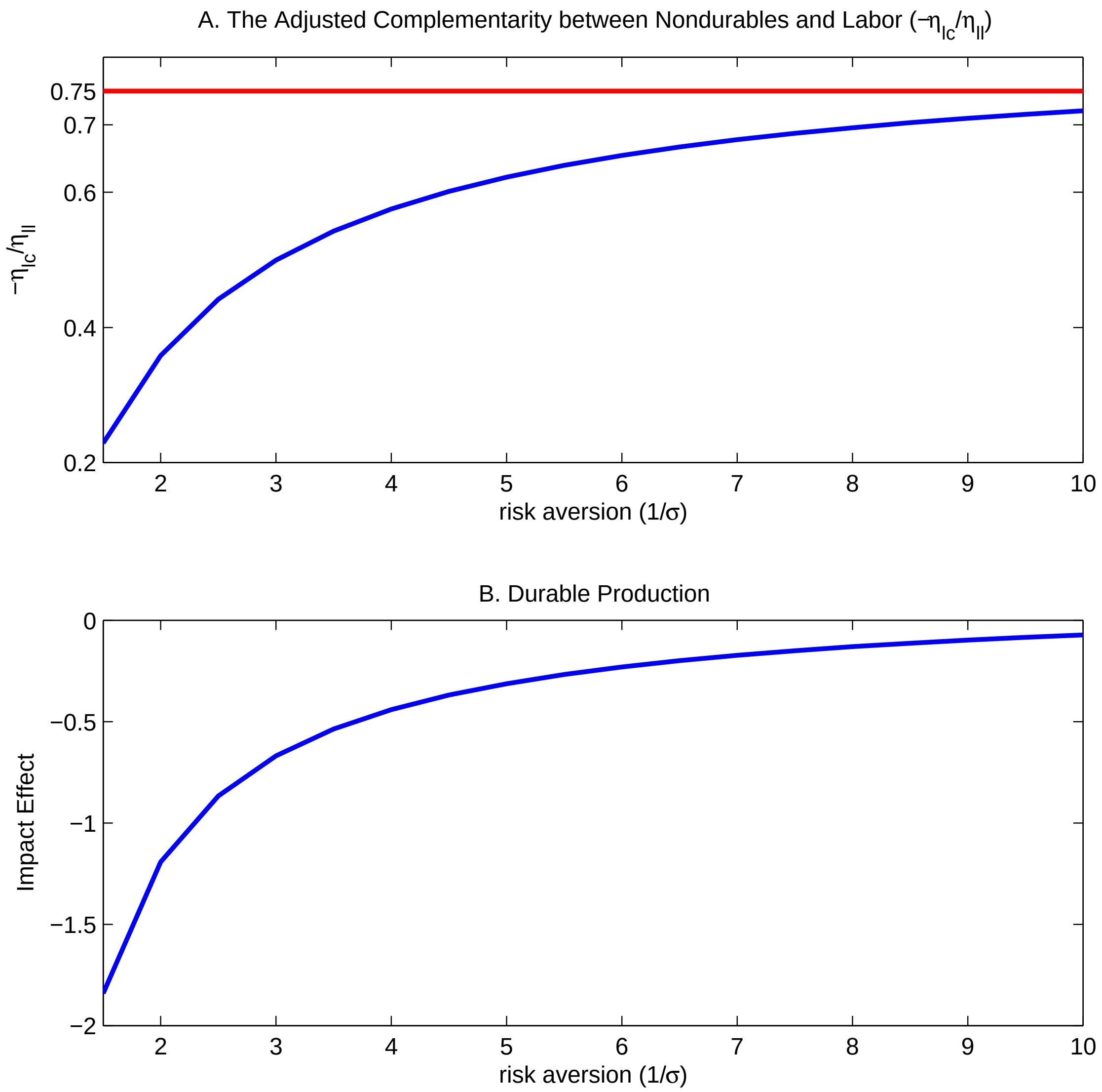

Figure 4. Impulse Response Functions: Separable, CD and GHH Preferences

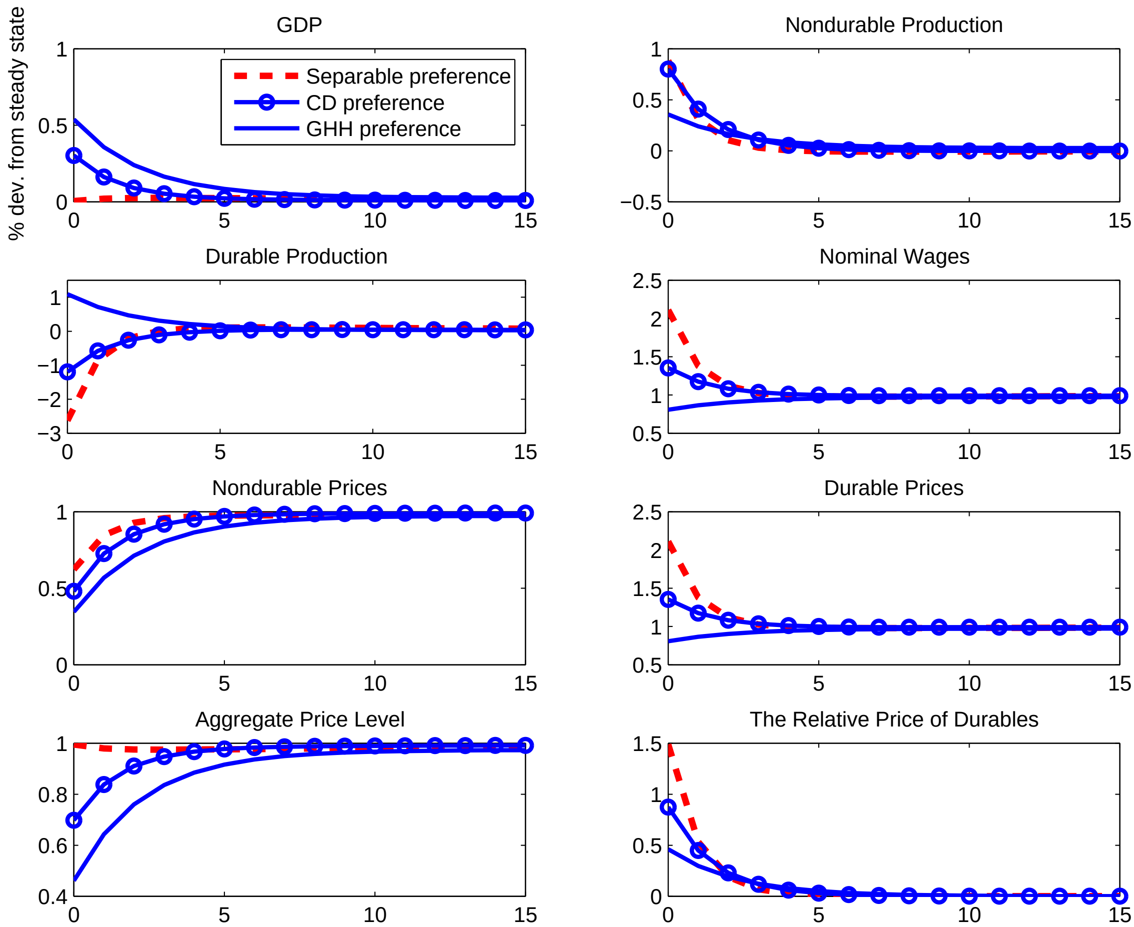

Figure 5. Robustness to Changes in the Risk Aversion ($1/\sigma$): GHH Preferences