New Keynesian Models, Durable Consumption and Borrowing Constraints

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Abstract

Econometric evidence suggests that, in response to monetary policy shocks, durable and non-durable spending comove positively and that durable spending exhibits a much larger sensitivity to policy shocks. A two-sector New Keynesian model is able to match this fact only if durable prices are assumed to be sticky and the elasticity of substitution between durable and non-durable services is sufficiently high. This paper shows that the introduction of borrowing constraints and the consideration of durables as collateral assets help in reconciling the model with the observed empirical evidence. In this vein, borrowing constraints act as a substitute of nominal rigidities in durable prices. On the other hand, the fact that, in the model, borrowing limits are sensitive to durable price movements generates a credit-cycle-driven excess sensitivity of non-durable spending to policy shocks. This leaves room for relaxing the assumption of price stickiness even for non-durable goods, in line with some recent micro-based evidence. In an extreme case of our model, in which prices are flexible in both sectors, a policy shock can still generate some degree of monetary non-neutrality and the correct sectoral comovement. In this vein, borrowing constraints may act as a substitute of price stickiness altogether.

Keywords: durable goods, sticky prices, borrowing constraint.

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1 Introduction

New Keynesian models of the last generation, featuring imperfect competition and price stickiness as central building blocks, have recently become a workhorse reference for the analysis of business cycles and monetary policy.[1] Surprisingly, most of these models have largely ignored the role played by durable goods, despite their important contribution to the dynamics of aggregate spending. *Figure 1* displays the (evolution of the) share of durable consumption and residential investment in total GDP. This share has historically been fluctuating between 12 and 15 percent. *Figure 2* reports a decomposition of total private consumption spending in three main categories: non-durables, services and durables. Hence we see that, in the sample period 1952-2005, the share of services has remarkably increased (from 35 to 60 percent), the share of non-durables has decreased (from 50 to 30 percent), whereas the share of durable consumption has remained remarkably stable, around 12 percent.

However, and beside this non-negligible role in GDP accounting, a better appreciation of the role of durable spending emerges when considering two additional aspects. First, and relative to non-durable consumption, durable spending is a component of GDP much more sensitive to variation in monetary policy. Below we provide statistical evidence (based on a structural VAR analysis) that this is indeed the case. We show that spending in durables (measured either as durable goods consumption or as a composite including residential investment) is considerably more sensitive to identified innovations in monetary policy relative to non-durable spending (measured as the sum of non-durable consumption and services).[2] As a result, the dynamics of durable spending is potentially of significant importance for the evolution of GDP at business cycle frequencies.

A second, and probably more important, aspect concerns the role that durable goods (especially housing) play as collateral in household borrowing. Among the most important facts observed in several OECD countries in the last decade has been the sizeable increase in house prices combined with an unprecedented rise in household debt. *Figure 3* displays the evolution of total and mortgage household debt as a share of total households' assets in the US. Although clearly a historical phenomenon, this

[1] To name a few, Rotemberg and Woodford (1997), Clarida et al. (1999), Woodford (2003), Goodfriend and King (1997).

[2] This evidence is similar to the one reported in Erceg and Levin (2004) and Barski et al. (2005). Here we complement their evidence by adding household debt in the analysis. See below for more details.

increase in households' leverage ratio has featured a remarkable acceleration in the last few years. It is generally believed that lower interest rates (and hence lower average inflation) and widespread financial deregulation (leading to an easing of liquidity constraints) have been major determinants of these phenomena (Debelle, 2004). Furthermore, the increase in both debt and asset prices have been usually perceived as mutually reinforcing phenomena. The rise in house prices has induced households to increasingly extract equity from their accumulated assets thereby encouraging further borrowing against the realized capital gains. Dynamics of this sort have been considered important in sustaining the level of private spending in several countries, especially during the business cycle downturn of 2001.

Large part of the observed increase in household borrowing has been in the form of collateralized debt. Hence the role of durable goods -especially housing- as a form of debt collateralization has also increased over time. *Figure 4* displays the evolution of mortgage debt (as a prototype form of secured debt) as a share of total outstanding household debt. This share has increased from about 60% in 1952 to about 75% in 2005. Considering also vehicles loans, the share of collateralized debt in the U.S. rises to about 90%.[3]

These two elements that are peculiar to durable spending (i.e., its larger sensitivity to policy shocks and its role for collateralized borrowing) essentially motivate our analysis. We begin by analyzing a baseline version of our economy. This consists in a basic New Keynesian framework augmented with an additional sector producing durables. In both sectors (durables and non-durables) a continuum of monopolistic competitive firms operates under price adjustment costs. The model nests the scenario of full price flexibility (in either sector) as a special case. When durable prices are assumed to be flexible, we show that the benchmark model generates two basic *anomalies* in response to a monetary policy innovation: i) A countercyclical response of durable spending; ii) A negative comovement of spending between the two sectors. The basic source of the anomaly lies in the equilibrium behavior of the relative price of durable goods. Consider a policy tightening. If non-durable prices are sticky and the labor is free to move across sectors, this induces a fall in the real wage. In turn, this also induces a fall in the real marginal cost in the durable sector. When durable prices are flexible, sustaining a constant markup allocation in that sector necessarily requires a *fall* in the relative price of durables, which in turn reduces the user cost of durables and stimulates the household to substitute towards durable consumption.

[3]Campbell and Hercowitz (2004), Aizcorbe, Kennickell and Moore (2003).

Thus the maintained assumption on the degree of price stickiness of durable goods emerges as key. [4] It turns out that the baseline model is able to broadly replicate the empirical evidence on the response to policy shocks only under two conditions: i) Durable prices are sticky; and ii) The elasticity of intratemporal substitution between durable and non-durable spending is sufficiently high.

However, as recently suggested by Barski et al. (2004), the assumption of sticky durable prices appears particularly heroic in the case of long-lived durables, e.g., housing, whose prices exhibit large overshooting phenomena. Thus the paper explores the possibility that the introduction of borrowing constraints and collateralized debt help in reconciling an otherwise baseline New Keynesian model with the empirical effects of monetary policy shocks. In our economy, we assume the presence, along with two sectors, of two types of households, a borrower and a saver. The borrower is subject to a collateral constraint. Importantly, the borrowing limit is endogenously tied to the value of the existing stock of durables and is sensitive to the evolution of asset prices in that it depends on the dynamics of the relative price of durables. The two agents differ in terms of their exogenously assumed degree of patience rate. As a result, the borrower does not act as a consumption smoothing agent, but exhibits preferences more tilted towards current consumption (an implicit definition of a binding borrowing constraint). The higher the value of borrowing at the margin, the more pronounced this feature of temporal impatience in consumption.[5] In equilibrium, debt accumulation (by the borrower) reflects intertemporal trading between the two agents.

We show that, even under *full flexibility* of durable prices, this version of the model is broadly in line with the empirical evidence on the sensitivity to policy shocks. Under standard assumptions on the degree of rigidity of non-durable prices, the model with borrowing limits generate a negative response of durable spending to a policy tightening and a positive sectoral comovement. The main intuition for why the presence of collateral constraints induce a procyclical response of durable spending works as follows. Consider, under flexible durable prices, a policy tightening, in the form of an interest rate hike. There are two basic channels through which monetary policy affects spending in the presence of collateral limits. First, by rising the service cost of debt, it increases both the marginal value of relaxing the borrowing constraint and the user cost of durables, and therefore induces a substitution towards non-

[4] Although with some differences, similar points are discussed in Barski et al. (2004).

[5] Introducing heterogeneity in patience rates is a minimum requirement to generate an equilibrium trading of debt. See Kiyotaki and Moore (1997), Iacoviello (2004), Campbell and Hercowitz (2005).

durable consumption. Second, by lowering the relative price of durables (once again necessary to sustain a constant markup in the durable sector), it also lowers the collateral value of the durable asset, thereby affecting the borrowing capability also on the extensive margin. This reduced borrowing capability in turn reduces the demand for durable goods.

Overall, the presence of borrowing constraints may act as a substitute of nominal rigidity in durable prices and contribute to conform the response of spending to policy shocks to the one observed empirically.

Notice that the presence of collateral valuation effects, thereby movements in the real price of durables endogenously affect the borrowing limit (in a way similar to the credit cycle effects exposed in Kiyotaki and Moore (1997) and Iacoviello (2004)), induce an acceleration phenomenon on non-durable spending. The mechanism is simple. The fall in the real price of durables induced by the policy tightening induces a rise in the marginal value of borrowing (i.e., a tightening of the borrowing constraint). This implies, for the borrower, a rise in the marginal utility of current (non-durable) consumption relative to the option of shifting consumption intertemporally (in other words, a violation of the Euler equation), which can be validated only by a fall in current consumption. Yet, the reduced demand for borrowing further depresses durable demand and in turn the real price of durables, inducing a vicious circle that further depresses (non-durable) consumption. As a result, the presence of this credit-cycle channel leaves natural room for relaxing the assumption of stickiness in non-durable prices, somewhat in line withe recent micro evidence on the frequency of price adjustment provided in Bils and Klenow (2004). Interestingly, in our simulations, even the model with full price flexibility in both sectors stills exhibits some degree of money non-neutrality. In this vein, the presence of borrowing constraints and collateralized debt can not only act as a substitute of nominal rigidity in the durable sector, but more broadly as a substitute of nominal stickiness altogether.

The role of durable goods in New Keynesian models has only recently received some attention. Erceg and Levin (2005) study optimal monetary policy in a two-sector New Keynesian model. In a similar environment, Barski et al. (2004) analyze the transmission of monetary shocks and show that this is largely affected by the assumption on the degree of flexibility of durable goods prices. Our analysis is related to Barski et al. (2004). In a nutshell, and regardless on the assumption on the presumed flexibility of durable goods prices, we show that the introduction of borrowing constraints can be potentially helpful in better reconciling the implications of

New Keynesian models with the observed behavior of both durable and non-durable spending in response to variations in the monetary policy stance.

2 Some Evidence on the Response of Durable Spending and Debt to Monetary Policy Shocks

In this section we present evidence on two stylized features that characterize the evolution of durable and non-durable spending in response to (appropriately identified) monetary policy shocks. First, durable spending co-moves positively with non-durable spending in response to monetary policy shocks. Second, the sensitivity of durable spending to policy shocks is significantly larger than the one of non-durable spending. In addition we also provide some evidence on the cyclical behavior of (real) household debt in response to monetary shocks. This evidence is akin to the one documented in Erceg and Levin (2005) and Barski et al. (2005), with additional documentation on the implied behavior of private debt.

To assess the impact of monetary policy shocks we estimate a quarterly VAR model for the U.S. specified as follows:

$$X_t = \sum_{j=1}^{L} A_j \; X_{t-j} + B \; \mathcal{E}_t \tag{1}$$

where $\mathcal{E}_t$ is a vector of contemporaneous disturbances. The vector X_t comprises six variables: (log) real *GDP*, a real index of *durables* spending, real spending in *non-durables* and services, the *GDP deflator*, total real *household debt* and the *federal funds* rate. Except for the funds rate, all variables are in logs and have been deflated by the GDP deflator. The VAR system features a constant and four lags, and is estimated over the sample 1952:1- 2005:1.

To identify a monetary policy shock we resort to a standard recursive identification scheme (Christiano et al., 1999). We assume that monetary policy is conducted by means of a feedback interest rate rule in which the funds rate is the policy instrument. In particular, the element $\varepsilon_{r,t}$ of the vector $\mathcal{E}_t$, which represents the innovation to the policy rule, is assumed to be orthogonal to the current information set available to the monetary authority (and comprising observed values of the variables included in X_t other than the funds rate).

Figure 5 displays estimated responses of real GDP, real non-durable spending, real durable spending, and total real household debt to a one standard deviation innovation in the federal funds rate. Dashed lines represent two standard error bands. Hence we see that both components of spending and GDP react negatively to the policy tightening. The smooth and persistent response of these variables is in line with a recent widespread empirical evidence (Rotemberg and Woodford (1997), Christiano et al. (1999)). Importantly, the fall in durable spending peaks earlier than the one of non-durables and, more importantly, is three times larger at the peak. In addition, we also observe that real debt falls in response to the policy tightening, smoothly and persistently after to the shock.[6]

In *Figure 6* we refine our analysis and look at the effects of a policy innovation on mortgage debt (as opposed to total household debt) and on a real index of residential investment. Hence we observe that mortgage debt is roughly as sensitive to the policy shock as total debt. Furthermore, residential investment shows a much larger sensitivity to a policy shock than durable spending alone. The response of residential investment is almost twice as large at the peak than the one of durable consumption.

3 The Model

In this section we build an optimizing general equilibrium model of monetary non-neutrality with the goal of rationalizing the facts illustrated above. The economy is composed of two types of households, *borrowers* and *savers*, and of two *sectors* (producing durable and non durable goods respectively), each populated by a large number of monopolistic competitive firms. Households derive utility from consumption of a non-durable final good and from services of a durable final good. Debt accumulation reflects intertemporal trading between borrowers and savers. Borrowers are subject to a *collateral constraint*, with the borrowing limit tied to the value of the existing stock of durables.

3.1 Final Good Producers

In each sector ($j = c, d$) a perfectly competitive final good producer purchases $Y_{j,t}(i)$ units of intermediate good i. The final good producer in sector j operates the production function :

[6] These results are robust to the specification of alternative orderings, less or additional lags, and to the introduction of alternative variables.

$$Y_{j,t} \equiv \left(\int_0^1 Y_{j,t}(i)^{\frac{\varepsilon_j - 1}{\varepsilon_j}} di \right)^{\frac{\varepsilon_j}{\varepsilon_j - 1}} \tag{2}$$

where $Y_{j,t}(i)$ is quantity demanded of the intermediate good i by final good producer j, and ε_j is the elasticity of substitution between differentiated varieties in sector j. Notice, in particular, that in the durable good sector $Y_{d,t}(i)$ refers to expenditure in the *new* durable intermediate good i (rather than services). Maximization of profits yields demand functions for the typical intermediate good i in sector j:

$$Y_{j,t}(i) = \left(\frac{P_{j,t}(i)}{P_{j,t}} \right)^{-\varepsilon_j} Y_{j,t} \qquad j = c, d \tag{3}$$

for all i. In particular, $P_{j,t} \equiv \left(\int_0^1 P_{j,t}(i)^{1-\varepsilon_j} di \right)^{\frac{1}{1-\varepsilon_j}}$ is the price index consistent with the final good producer in sector j earning zero profits.[7]

3.2 Borrower

The borrower consumes an index of consumption *services* of durable and *non-durable* final goods, defined as:

$$X_t \equiv \left[(1-\alpha)^{\frac{1}{\eta}} \ (C_t)^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} \ (D_t)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{4}$$

where C_t denotes consumption of the final non-durable good, D_t denotes *services* from the stock of the final durable good at the end of period t, α is the share of durable goods in the composite consumption index and $\eta \geq 0$ is the elasticity of substitution between services of non-durable and durable goods. In the case $\eta \rightarrow 0$ non-durable consumption and durable services are perfect complements, whereas if $\eta \rightarrow \infty$ the two services are perfect substitutes. Eichenbaum and Hansen (1990) provide evidence of non-separability between durable and non-durable services. More recently, Ogaki and Reinhart (1998) and Piazzesi, Schneider and Tuzel estimate values for η above unity.

The borrower maximizes the following utility program

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(X_t, N_t) \right\} \tag{5}$$

[7] Hence the problem of the final good producer j is: *max* $P_{j,t} Y_{j,t} - \int_0^1 P_{j,t}(i) Y_{j,t}(i) di$ subject to (2).

subject to the sequence of budget constraints (in *nominal* terms):

$$P_{c,t}\ C_t + P_{d,t}(D_t - (1-\delta)D_{t-1}) + B_{t+1} \leq R_{t-1}B_t + W_t N_t + T_t \tag{6}$$

where B_{t+1} is end-of-period t nominal debt, R_{t-1} is the nominal lending rate on loan contracts stipulated at time $t-1$, W_t is the nominal wage, N_t is labor supply and T_t are net government transfers. Labor is assumed to be perfectly mobile across sectors, implying that the nominal wage rate is common across sectors.

In real terms (units of non-durable consumption), (6) reads

$$C_t + q_t(D_t - (1-\delta)D_{t-1}) + b_{t+1} \leq R_{t-1}\frac{b_t}{\pi_{c,t}} + \frac{W_t}{P_{c,t}}N_t + \frac{T_t}{P_{c,t}} \tag{6}$$

where $q_t \equiv \frac{P_{d,t}}{P_{c,t}}$ is the relative price of the durable good, and $b_t \equiv \frac{B_t}{P_{c,t-1}}$ is real debt.

Below we will specialize the form of the utility function as follows:

$$U(X_t, N_t) = \log(X_t) - \frac{\upsilon}{1+\varphi}N_t^{1+\varphi}$$

where φ is the inverse elasticity of labor supply and υ is a scale parameter indexing the amount of hours worked in the steady state.

Collateral Constraint Private borrowing is subject to a limit. We assume that the whole stock of debt is collateralized. The borrowing limit is tied to the value of the durable good stock:

$$B_{t+1} \leq (1-\chi)D_t P_{d,t}$$

where χ is the fraction of the durable stock value that cannot be used as a collateral.

In general, one can think of χ as the down payment rate, or the inverse of the *loan-to-value ratio*, and therefore a direct measure of the tightness of the borrowing constraint. Jappelli and Pagano (1989) provide evidence on the presence of liquidity constrained agents by linking their share to more structural features of the credit markets. In particular, they find that the share of liquidity constrained agents is larger in countries in which a measure of the loan-to-value ratio is lower.

Notice that movements in the durable good price affect the ability of borrowing. It is widely believed that capital gains working through the revaluation of collateral have been important for the recent business cycle evolution in the US, in which the link between house price fluctuations and ability of borrowing has played a major role in determining household spending patterns.[8]

Assuming that, in a neighborhood of the deterministic steady-state, equation (6) is always satisfied with the equality, we can rewrite the collateral constraint in real terms (i.e., in units of non-durable consumption) as follows

$$b_{t+1} = (1-\chi)\ q_t D_t \tag{8}$$

Given $\{b_0,\ D_{-1}\}$ the borrower chooses $\{N_t,\ b_{t+1,}\ D_t,\ C_t\}$ to maximize (5) subject to (6) and (8). By defining λ_t and $\lambda_t \psi_t$ as the multipliers on constraints (6) and (8) respectively, and $U_{x,t}$ as the marginal utility of variable x, efficiency conditions for the above program read:

$$\frac{-U_{n,t}}{U_{c,t}} = \frac{W_t}{P_{c,t}} \tag{9}$$

$$U_{c,t} + \lambda_t = 0 \tag{10}$$

$$q_t U_{c,t} = U_{d,t} + \beta(1-\delta) E_t \{U_{c,t+1} q_{t+1}\} + (1-\chi)\, U_{c,t} q_t \psi_t \tag{11}$$

$$\psi_t = 1 - \beta E_t \left\{ \frac{U_{c,t+1}}{U_{c,t}} \frac{R_t}{\pi_{c,t+1}} \right\} \tag{12}$$

Equations (9) and (10) are standard. Equation (11) is an intertemporal condition on durable demand. It requires the borrower to equate the marginal utility of current non-durable consumption to the marginal gain of durable services. The latter depends on three components: i) the direct utility gain of an additional unit of durable; ii) the expected utility stemming from the possibility of expanding future consumption by means of the realized resale value of the durable purchased in the previous period; iii) the marginal utility of marginally relaxing the borrowing constraint.

Alternatively, one can interpret expression (11) as equating the *user cost* of the durable good to the marginal rate of substitution between durable and non-durable consumption. In particular, by rearranging (11), the user cost can be written as

[8] For instance, Alan Greenspan's view is summarized by the following excerpt: "*Among the factors contributing to the strength of spending and the decline in saving have been developments in housing markets and home finance that have spurred rising household wealth and allowed greater access to that wealth. The rapid rise in home prices over the past several years has provided households with considerable capital gains (...)*" (Congress Testimony, February 2005).

$$Z_t \equiv q_t \left[1-(1-\chi)\,\psi_t\right] - \beta(1-\delta)E_t\left\{\frac{U_{c,t+1}}{U_{c,t}}q_{t+1}\right\} \tag{13}$$

We will return later to a more detailed analysis of this equation. It suffices to notice, at this stage, that the presence of an endogenous borrowing limit affects the user cost expression directly, via movements in the multiplier ψ_t. A rise in ψ_t which signals a tightening of the borrowing constraint, induces (ceteris paribus) a fall in the user cost.

Equation (12) is a modified version of an Euler equation. Indeed it reduces to a standard Euler condition in the case of $\psi_t = 0$ for all t (absence of borrowing constraint). Alternatively, it has the interpretation of an asset price condition. In fact, the marginal value of additional borrowing (the left hand side ψ_t) is tied to a payoff (right hand side) that captures the deviation from a standard Euler equation. Consider, for the sake of argument, ψ_t rising from zero to a positive value. This implies, from (12), that $U_{c,t} > \beta E_t\left\{U_{c,t+1}\frac{R_t}{\pi_{c,t+1}}\right\}$. In other words, the marginal utility of current consumption exceeds the marginal gain of shifting one unit of consumption intertemporally. The higher ψ_t, the higher the net marginal benefit from acquiring today the durable asset which allows, by marginally relaxing the borrowing constraint, to purchase additional current consumption.

3.3 Savers

The economy is composed of a second category of consumers, labeled savers. We assume that the representative saver is the owner of the monopolistic firms in each sector. He/she maximizes the utility program:

$$E_0\left\{\sum_{t=0}^{\infty}\gamma^t U(\widetilde{C}_t,\ \widetilde{D}_t)\right\} \tag{14}$$

Importantly, the impatience rate γ is such that $\gamma > \beta$. The saver's sequence of budget constraints reads (in nominal terms):

$$P_{c,t}\,\widetilde{C}_t + P_{d,t}\left(\widetilde{D}_t - (1-\delta)\widetilde{D}_{t-1}\right) + \widetilde{B}_{t+1} - R_{t-1}\widetilde{B}_t \leq +\widetilde{T}_t + \sum_j \widetilde{\Gamma}_{j,t} \tag{15}$$

where $\widetilde{C}_t$ is saver's non-durable consumption, $\widetilde{D}_t$ is the saver's utility services from the stock of durable goods, $\widetilde{B}_{t+1}$ is end-of-period t nominal debt (credit), $\widetilde{T}_t$ are net government transfers and $\widetilde{\Gamma}_{j,t}$ are nominal profits from the holding of monopolistic competitive firms in sector j. For simplicity, we assume that the saver' s labor supply is rigid.

The efficiency conditions for this program are a standard Euler equation:

$$U_{\tilde{c},t} = \beta E_t \left\{ \frac{U_{\tilde{c},t+1}}{\pi_{c,t+1}} R_t \right\} \tag{16}$$

and a durable demand condition (in the absence of borrowing constraints)

$$q_t U_{\tilde{c},t} = U_{\tilde{d},t} + \beta(1-\delta) E_t \left\{ U_{\tilde{c},t+1} q_{t+1} \right\} \tag{17}$$

3.4 Production and Pricing of Intermediate Goods

A typical intermediate good firm i in sector j hires labor (supplied by the borrowers) to operate a linear production function:

$$Y_{j,t}(i) = A_{j,t} N_{j,t}(i) \tag{18}$$

where $A_{j,t}$ is a productivity shifter common to all firms in sector j. Each firm i has monopolistic power in the production of its own variety and therefore has leverage in setting the price. In so doing it faces a quadratic cost equal to $\frac{\vartheta_j}{2}\left(\frac{P_{j,t}(i)}{P_{j,t-1}(i)} - 1\right)^2$, where the parameter ϑ_j measures the degree of sectoral nominal price rigidity. The higher ϑ_j the more sluggish is the adjustment of nominal prices in sector j. In the particular case of $\vartheta_j = 0$, prices are flexible.

The problem of each monopolistic firm is to choose the sequence $\{N_{j,t}(i), P_{j,t}(i)\}_{t=0}^{\infty}$ in order to maximize expected discounted nominal profits:

$$E_0 \left\{ \sum_{t=0}^{\infty} \Lambda_t \left(P_{j,t}(i) Y_{j,t}(i) - W_t N_{j,t}(i) - \frac{\vartheta_j}{2} \left(\frac{P_{j,t}(i)}{P_{j,t-1}(i)} - 1 \right)^2 P_{j,t} \right) \right\} \tag{19}$$

subject to (18). In (19), $\Lambda_{j,t} \equiv \gamma E_t \left\{ \frac{\widetilde{\lambda}_{t+1}}{\widetilde{\lambda}_t} \right\}$ is the saver's stochastic discount factor and $\widetilde{\lambda}_t$ is the saver's marginal utility of nominal income. Let's denote by $\frac{P_{j,t}(i)}{P_{j,t}}$ the relative price of variety i in sector j. In a *symmetric* equilibrium in which $\frac{P_{j,t}(i)}{P_{j,t}} = 1$ for all i and j, and all firms employ the same amount of labor in each sector, the first order condition of the above problem reads:

$$((1-\varepsilon_j)+\varepsilon_j mc_{j,t})\, Y_{j,t} \;=\; \vartheta_j\,(\pi_{j,t}-1)\,\pi_{j,t} \qquad (20)$$
$$-\vartheta_j E_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} \frac{P_{j,t+1}}{P_{j,t}} (\pi_{j,t+1}-1)\,\pi_{j,t+1} \right\} \qquad (j=c,d)$$

where $\pi_{j,t} \equiv \frac{P_{j,t}}{P_{j,t-1}}$ is the gross inflation rate in sector j and

$$mc_{j,t} \equiv \frac{W_t}{P_{j,t}A_{j,t}} \qquad (21)$$

is the real marginal cost in sector j.[9]

In the particular case of *flexible prices the* real marginal cost must be constant and equal to the inverse steady-state markup $\frac{\varepsilon_j - 1}{\varepsilon_j}$. By using (9), the pricing condition (20) reads:

$$\frac{-U_{n,t}}{U_{c,t}A_{c,t}} = \frac{\varepsilon_c - 1}{\varepsilon_c} \qquad \text{if } j=c \qquad (22)$$

$$\frac{-U_{n,t}}{U_{c,t}\ A_{d,t}} q_t^{-1} = \frac{\varepsilon_d - 1}{\varepsilon_d} \qquad \text{if } j=d \qquad (23)$$

Notice that, in the durable sector, variations in the relative price of durables (possibly due to a sectoral asymmetric shock) drive a wedge between the marginal rate of substitution between consumption and leisure on the one hand and the marginal product of labor on the other. Hence the real marginal cost is directly affected by movements in the relative price.

3.4.1 CPI Inflation

To define a utility-based aggregate price index (henceforth CPI) one needs to assume the existence of an additional final good producer, whose task consists in assembling *services* of durable and non durable goods via the production function (4). The price index consistent with maximization of profits by this producer reads

[9] To better interpret (20), notice that the following holds:

$$E_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} \frac{P_{c,t+1}}{P_{c,t}} \right\} = E_t \left\{ \frac{U_{c,t+1}}{U_{c,t}} \right\}, \quad \text{if} \quad j=c$$

and

$$E_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} \frac{P_{d,t+1}}{P_{d,t}} \right\} = E_t \left\{ \frac{U_{c,t+1}}{U_{c,t}} \frac{q_{t+1}}{q_t} \right\}, \quad \text{if } j=d$$

$$P_t \equiv \left[(1-\alpha)\ (P_{c,t})^{1-\eta} + \alpha\ (P_{d,t})^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{24}$$

Next we can define the following relative price indexes. The CPI-non-durable price ratio can be written as

$$\frac{P_t}{P_{c,t}} = [(1-\alpha) + \alpha\ q_t^{1-\eta}]^{\frac{1}{1-\eta}} \equiv g_{c,t}$$

Similarly we have:

$$\frac{P_t}{P_{d,t}} = [\alpha + (1-\alpha)\ q_t^{-(1-\eta)}]^{\frac{1}{1-\eta}} \equiv g_{d,t} \tag{25}$$

Notice that, regardless of η, we have $\frac{\partial g_{c,t}}{\partial q_t} > 0$ and $\frac{\partial g_{d,t}}{\partial q_t} < 0$. Finally, we can link CPI and sectoral inflation as follows:

$$\pi_{,t} = \pi_{j,t} \frac{g_{j,t}}{g_{j,t-1}} \tag{26}$$

for $j = c, d$, where $g_{j,t} = g_{_j}(q_t)$.

3.5 Monetary Policy

We assume that monetary policy is conducted by means of a simple Taylor-type rule

$$\frac{R_t}{R} = \left(\frac{\widetilde{\pi}_t}{\widetilde{\pi}}\right)^{\phi_\pi} \varepsilon_t \tag{27}$$

where R is the steady-state nominal interest rate, $\widetilde{\pi}_t$ is an inflation-index and ε_t is a policy shock which is assumed to evolve according to

$$\varepsilon_t = \exp(\varepsilon_{t-1})^\rho + u_t$$

with $u_t\tilde{\ }iid$. Depending on the choice of the relevant inflation index, we can define two alternative monetary policy rules: (i) *Non-durable* inflation based (*NDI*) (if $\widetilde{\pi}_t = \pi_{c,t}$); (ii) *CPI inflation* based (if $\widetilde{\pi}_t = \pi_t$).

3.6 Market Clearing

Equilibrium in the goods market of sector j requires that the production of the final good be allocated to expenditure and to resource costs originating from the adjustment of prices

$$Y_{c,t} = C_t + \widetilde{C}_t + \frac{\vartheta_c}{2}\left(\pi_{c,t} - 1\right)^2 \tag{28}$$

$$Y_{d,t} = D_t - (1-\delta)D_{t-1} + \widetilde{D}_t - (1-\delta)\widetilde{D}_{t-1} + \frac{\vartheta_d}{2}\left(\pi_{d,t} - 1\right)^2 \tag{29}$$

Equilibrium in the debt and labor market requires respectively

$$B_t + \widetilde{B}_t = 0 \tag{30}$$

$$\sum_j N_{j,t} = N_t \tag{31}$$

3.7 Equilibrium

An (imperfectly) *competitive allocation,* with sticky prices in both sectors and a borrowing constraint, is a sequence for N_t, $N_{c,t}$, $N_{d,t}$, b_{t+1}, D_t, C_t, $\widetilde{C}_t$, $\pi_{c,t}$, $\pi_{d,t}$, R_t, ψ_t, q_t, mc_t satisfying (6), (8), (9)-(12), (16), (20), (28), (29), (31), (27).

4 Deterministic Steady State

We assume that the steady state (net) rate of non-durable inflation is zero, $\pi_c = 1$. In the deterministic steady state the shadow value of relaxing the borrowing constraint is always positive. In other words, the borrower will always choose to hold a positive amount of debt. To show this, we simply combine the steady state version of (16), which implies $R = \frac{1}{\gamma}$, with (12), obtaining:

$$\psi = \left(1 - \frac{\beta}{\gamma}\right) > 0 \tag{32}$$

Hence, heterogeneity in impatience rates is a sufficient condition for generating a steady state with a positive amount of debt (making the distinction between borrower and saver meaningful in equilibrium).

In a flexible price steady-state for both sectors, taking the ratio of (22) and (23) the relative price of durables reads

$$q = \frac{\frac{\varepsilon_d - 1}{\varepsilon_d}}{\frac{\varepsilon_c - 1}{\varepsilon_c}} \tag{33}$$

By evaluating (11) in the steady state we obtain the borrower's relative consumption of durables:

$$\frac{D}{C}=\frac{\alpha}{(1-\alpha)}\left[q\left(1-(1-\chi)\psi\right)\left(1-\beta(1-\delta)\right)\right]^{-\eta} \tag{34}$$

Thus relative consumption of durables is increasing in the marginal value of borrowing ψ and decreasing in the relative price of durables q. Notice that a tightening of the borrowing constraint, captured by a rise in χ, induces a relative fall in the demand for durables.

Finally, one can express the steady state leverage ratio as follows:

$$\frac{b}{D}=(1-\chi) \tag{35}$$

Hence a relaxation of the borrowing constraint, in the form of a lower value of χ, increases the steady state borrower's leverage ratio.

5 Calibration

We set the saver's and borrower's discount factors respectively to $\gamma = 0.99$ and $\beta = 0.96$. This implies an annual real interest rate (which is pinned down by the saver's degree of time preference) of $\left(\frac{1}{\gamma}\right)^4 = 1.04$. The choice of durables depreciation rate is complicated by the observed heterogeneity between durables like vehicles, for which the annual depreciation rate is around 15%, and very long-lived durables like housing, for which the annual depreciation rate is much slower and comprised between 1.5% and 3%. We therefore choose $\delta = 0.02$, which implies an annual average depreciation rate of 8%.

The annual average loan-to-value (LTV) ratio on home mortgages is roughly 0.75. This is the average value over the 1952-2005 period. However *Figure XX* shows that this number has increased over time, as a consequence of financial liberalization, from about 72% at the beginning of the sample to a peak of 78% around the year 2000. The figure also shows that this number is only slightly higher when considering mortgages on new houses only.[10] LTV ratios for automobile loans are higher[11]. The average in the period 1994-2004 is roughly 0.92. Normalizing all outstanding private debt to being collateralized, the share of mortgage debt is roughly 0.87 and the share of

[10] The source for these numbers is the Federal Housing Finance Board.

[11] Data on automobile loans are from the Federal Reserve Statistical Release-Consumer Credit.

automobiles loans is roughly 0.13. Hence we compute the LTV ratio as a weighted average of the LTV ratios of the two types of secured debt: $(1-\chi) = 0.75(0.87) + 0.92(0.13) = 0.77$, which yields $\chi = 0.23$.

The share of durable consumption in the aggregate spending index, defined by α, is set in such a way that $\delta(D + \widetilde{D})$, the steady-state share of durable spending in total spending, is 0.2. This number is consistent with the combined share of durable consumption and residential investment in the NIPA Tables.

The elasticity of substitution between varieties ε is set equal to 6, which yields a steady state mark-up of 20%. We set the degree of nominal rigidity in non-durable prices ϑ_c in order to generate a frequency of price adjustment of about four quarters. This is a standard calibration in the recent literature, although somewhat higher than the estimates, based on microeconomic evidence, provided by Bils and Klenow (2004) for the U.S. As for the degree of rigidity in durable prices, we experiment with alternative values, ranging from full flexibility ($\vartheta_d = 0$) to sizeable stickiness ($\vartheta_d = \vartheta_c$).

6 Benchmark: Durable Spending Dynamics without Borrowing Constraints

In this section we analyze the equilibrium dynamics of the model economy in response to monetary policy shocks. We start by studying a benchmark case, namely the one of a standard New Keynesian model *without borrowing limits* and simply augmented by the presence of a durable goods sector.

To obtain such benchmark version of our model it suffices to evaluate the system of first order conditions (9)-(12) in the particular case of $\psi_t = 0$. For the sake of exposition we report here a brief description of that version of the model. In particular, in that case, the key equations driving relative consumption demand and the relative price of durables can be written

$$q_t = \frac{U_{d,t}}{U_{c,t}} + \beta(1-\delta)E_t\left\{\frac{U_{c,t+1}}{U_{c,t}}q_{t+1}\right\} \tag{36}$$

$$1 = \beta E_t\left\{\frac{U_{c,t+1}}{U_{c,t}}\frac{R_t}{\pi_{c,t+1}}\right\} \tag{37}$$

A rational expectations equilibrium of the New Keynesian model augmented with durable consumption is a set of processes for N_t, $N_{c,t}$, $N_{d,t}$, D_t, C_t, $\pi_{j,t}$, R_t, q_t, mc_t

satisfying (9), (20), (27), (28), (29), (31), (36), (37) for $j = c, d$.

6.0.1 Comovement Problem in Response to Monetary Policy Shocks

In this section we show that, when durable prices are flexible, the behavior of durable and non-durable spending in response to a monetary policy shock is at odds with the empirical evidence reported in the early part of the paper. The anomaly consists in the fact that, in the case of flexible durable prices, the response of durable spending to a policy shock is countercyclical and comoves negatively with non-durable spending. To the contrary, the empirical evidence suggests a strongly procyclical response of durable spending, a positive comovement with non-durable spending and a much larger sensitivity of durable spending to the shock.

To illustrate this point, *Figure 7* displays the effect on selected variables of a 25 basis points innovation in the policy rule (27) in the benchmark model (no borrowing constraints). Solid lines denote responses in the case of flexible durable prices, whereas dashed lines identify the case of sticky durable prices. In this benchmark exercise we assume that monetary policy is conducted via a *NDI rule*.

Under *flexible* durable prices the relative price of durables q_t falls substantially in response to the shock. To understand the latter effect it is instructive to rewrite the form of the markup equation in this case:

$$mc_t^d = \frac{\varepsilon_d - 1}{\varepsilon_d} = \frac{\frac{W_t}{P_{d,t}}}{A_{d,t}} = \frac{N_t^{\varphi}\ C_t}{A_{d,t}\ q_t}$$

The fall in non-durable consumption (bottom-left panel), induced by a higher real interest rate, and the fall in employment generate a fall in the real wage $N_t^{\varphi}\ C_t$. Since sectoral productivity is unchanged, markup constancy in the durable sector requires a fall in the relative price q_t. In turn, the latter effect dominates the dynamic response of the user cost, which displays a large and persistent fall below its steady state value. In particular, recall that the user cost equation reads (by combining (11) and (12)):

$$Z_t \equiv q_t - \frac{(1-\delta)}{RR_t} E_t \{q_{t+1}\} \tag{38}$$

When durable prices are flexible, current and expected movements in q_t dominate the behavior of the user cost. On the other hand, in the case of sticky durable prices (see also below), movements in q_t are smooth and variations in the user cost are mostly driven by the real interest rate. Hence, the user cost rises much less on impact and then falls gradually over time. In general, the more dampened the response of the user cost, the smaller the substitution effect between durable and non durable goods.

Not surprisingly, in the case of *sticky* durable prices, the relative price q_t barely moves in the short run, and then rises gradually. As a result, the user cost drops much less on impact and then rises gradually above its steady-state value. This generates a dynamic more in line with our empirical evidence. In particular, durable spending initially rises but then falls persistently below steady state. In a parallel fashion, non durable consumption initially falls, but then gradually rises above the steady-state.

Thus, a first lesson can be drawn from these results: the presence of sticky durable prices seems a necessary ingredient to help reconciling the model's behavior with the observed empirical evidence. However, this seems hardly sufficient, for durable spending is still observed to rise on impact (although in a short-lived fashion) and non-durable spending to fall but then to start rising after a few quarters.

So far we have studied the effects of a policy shock under the assumption that the assumed interest rate rule featured a reaction to non-durable inflation. *Figure 8* displays the effects of the same shock but now in the case in which the policy rule is based on the *CPI* measure of inflation. The figure suggests that the basic message is unaltered. By responding to CPI inflation, the monetary authority is now implicitly responding to the (rate of change of the) relative price of durables. Under flexible prices, this dampens the initial response of q_t, and therefore also the response of durable spending. However, after a few quarters, the response of both the user cost and of the relative price of durables are aligned to the one observed under NDI targeting. As a result, the implied behavior of durable and non-durable spending replicates the one observed under NDI targeting.

Effect of Varying the Elasticity of Substitution In our context, the equilibrium behavior of the relative price of durables is also a function of η, the elasticity of substitution between durable and non-durable services. The higher η, the stronger the sensitivity of the relative demand for durables to relative price variations. In practice, η measures the strength of the expenditure switching effect between durable and non-durable services.

Recent empirical evidence consistently rejects the hypothesis of separability between durable and non-durable utility services. For parameter η, Ogaki and Reinhart (1998) estimate a value of 1.24, while Piazzesi, Schneider and Tuzel (2004) estimate a value of 1.27. Hence below we explore the sensitivity of our results to the assumed value of the elasticity of substitution.

Figure 9 shows equilibrium responses of durable and non-durable spending under flexible durable prices and alternative values of η. Notice that the intermediate case ($\eta = 1.25$) is in line with the empirical estimates discussed above. The choice of η has significant effects on the size of the equilibrium responses of both durable and non-durable spending. As η rises, the relative price q_t drops more on impact. As a result, the substitution effect is strenghtened: the drop in non-durable spending is magnified while the response of durable spending is dampened.

Figure 10 displays the effects of varying η in the case of sticky durable prices. In this case, a larger η dampens the response of the relative price. For a value of $\eta = 1.5$, only a bit higher than the one suggested by the econometric estimates, the response of durable and non-durable spending replicates the empirical evidence fairly well. Both components of spending fall, with durable spending dropping more substantially on impact. Somewhat in contrast with the empirical evidence, though, the response of durable spending does not exhibit any hump-shaped behavior, while the latter is instead a feature of the response of non-durable spending.

7 The Role of Borrowing Constraints and Collateralized Debt

Thus far the general implication of our analysis is that two ingredients are needed for a standard New Keynesian model -when augmented with durable consumption- to replicate the observed response of durable and non-durable spending to a monetary policy shock: (i) stickiness in durable prices, and (ii) a certain degree of substitutability between durable and non-durable consumption services. However, and as also discussed by Barski et al. (2004), the assumption of sticky nominal prices for durable goods appears particularly heroic for durable items such as housing, whose prices tend to display a large overshooting behavior.

In this section of the paper we investigate the hypothesis that the introduction of borrowing constraints and of durable goods as collateral assets may help in reconciling the behavior of the model with our empirical evidence. In particular, we study the hypothesis that borrowing constraints may act as a substitute for nominal inertia in durable prices.

To illustrate the potential effect of the introduction of borrowing constraints on the dynamics of durable and non-durable consumption, it is instructive to report below the log-linearized expression for the user cost in our general model. By combining (11) and (12) this can be written as follows:

$$\begin{aligned} z\,\widehat{z}_t \;\equiv\; & [1-(1-\chi)\psi]\,\widehat{q}_t \;+\; [\psi(\gamma(1-\delta)-(1-\chi)]\;\widehat{\psi}_t \\ & -[\gamma(1-\delta)(1-\psi)]\;\;(E_t\{\widehat{q}_{t+1}\}-\widehat{r}_t) \end{aligned} \tag{39}$$

where the symbol "$\widehat{\ }$" denotes percent deviations from the corresponding steady-state values (variables without time subscripts). Notice that the above equation reduces to the log-linearized version of (38) in the case $\psi = 0$. As already hinted above, the main implication of the introduction of borrowing constraints is that $\widehat{\psi}_t$, the marginal value of relaxing the borrowing constraint, affects the user cost. Movements in $\widehat{\psi}_t$ (see equation (10)) denote deviations from the consumption plan that would alternatively be dictated by the Euler equation. In particular, for the borrower, a rise in ψ_t is akin to a rise in the marginal utility of current consumption above the marginal discounted value of shifting resources intertemporally, i.e., $U_{c,t} > \beta U_{c,t+1} R_t$. The higher ψ_t, the tighter the borrowing constraint, for the higher would be the marginal value for the borrower of tilting the consumption plan towards current consumption.

Intuitively, a monetary policy tightening, by rising the service cost of outstanding debt, induces also a tightening of the borrowing constraint and, in turn, via (39), also a rise in the user cost. From equation (39), a rise in $\widehat{\psi}_t$ induces (*ceteris paribus*) a rise in $\widehat{z}_t$ if the condition $\gamma(1-\delta) > (1-\chi)$ is satisfied. Notice that this condition is easily satisfied under our benchmark parameterization and the more easily the higher is the down payment rate χ, higher values of which denote tighter borrowing conditions. Importantly, the effect on the user cost of movements in $\widehat{\psi}_t$ is absent in the baseline model without borrowing constraints, in which the dynamics of the user cost is mainly driven by the dynamic evolution of the asset price (i.e., movements in $\widehat{q}_t$ relative to $E_t\{\widehat{q}_{t+1}\}$).

However, there is an important additional effect induced by the introduction of borrowing constraints. Namely, movements in the asset price q_t affect the ability of borrowing directly (see equation (8)). A fall in the relative price of durables induces also a fall in the collateral value of the durable asset, which induces a direct fall in borrowing and in turn a rise in $\widehat{\psi}_t$. We illustrate the mechanics of this effect below.

Figure 11 displays impulse responses to a monetary policy tightening by comparing the baseline case of our model (solid line, no borrowing constraints) to the general version of our model in which borrowing constraints are binding (dashed line). Importantly, we maintain throughout that durable prices are *flexible* and that the elasticity of substitution η equals 1 (which implies Cobb-Douglas preferences in durable and non-durable services). In this case, we know that the baseline economy without borrowing limits delivers the counterfactual implication that durable consumption rises in light of a monetary tightening. Consider now the effect of introducing borrowing constraints. As in the frictionless case, the result of the policy shock is a fall in the relative price of durables.[12] However, notice that now the fall in q_t acts in the direction of reducing directly the collateral value, and therefore the amount borrowed.

Notice also that the dynamic of the user cost is significantly affected in the case in which the borrowing constraint is binding. There are two competing effects at work. On the one hand, as in the absence of borrowing constraints, the dynamic of the relative price q_t acts in the direction of lowering the user cost on impact and in a persistent fashion (see solid line). On the other hand, the rise in the marginal value of borrowing (recall equation (39)) contributes to dampen the short-run response of the user cost (actually, the user cost slightly rises on impact), which then falls very gradually over time. As a result of tighter borrowing conditions, real debt falls, the demand for durables drops significantly on impact and then starts to gradually revert back towards steady-state as the user cost gradually falls. Notice also that the fall in real debt in response to a policy tightening is in line with the empirical evidence discussed in the early part of the paper.

The dynamic of non-durable consumption is also in line with our introductory stylized facts, although only qualitatively. In fact, the response of non-durable consumption under borrowing constraints is excessively magnified by the shock. This is the result of an *inter*temporal substitution effect. The rise in the marginal value of borrowing induces a relative rise in the marginal utility of current non-durable consumption, so that in equilibrium current consumption falls (see equation (12)). This effect is absent in the case in which the borrowing constraint is not binding, and is akin to a "credit cycle" type of dynamic.[13] The fall in the real price of durables induces a direct fall in the collateral value and therefore in the ability of borrowing. This increases the marginal value of borrowing, depresses durable demand and in turn the relative price of durables (notice, in fact, that q_t falls more in the case in which

[12] Recall that this is necessary, in equlibrium, to sustain a constant markup allocation in the durable sector.

[13] See Kyotaki and Moore (1997).

the borrowing constraint binds). In turn, the fall in the relative price q_t feedbacks on the collateral value, inducing a further rise in the marginal value of borrowing, and hence a further tightening of the borrowing constraint. Thus, the larger the increase in the marginal value of borrowing, the larger the relative rise in the marginal utility of non-durable consumption and therefore the larger the fall in non-durable consumption.

Can Borrowing Constraints Substitute for Price Stickiness Altogether? Thus far we have worked under the assumption that non-durable prices are sticky. Our goal has been to explore the possibility that borrowing constraints may act as a substitute of nominal rigidity in durable prices in making the prediction of a standard New Keynesian model in line with the empirical evidence on the effects of monetary policy shocks. Our results suggest that this is indeed the case. Despite the presence of flexible durable prices, the model with borrowing constraints and collateralized debt induces a significant fall in durable spending and a positive comovement with non-durable spending in response to a monetary policy tightening.

However, despite being qualitatively in line with the empirical evidence on the effects of monetary policy shocks, the model with borrowing constraints seems to suggest a different type of drawback. Namely, the model displays an excess sensitivity of non-durable spending to the policy shock. This outcome is the result of two combined effects: First, a typical effect of monetary *non-neutrality* under (non-durable) price stickiness. Second, a *credit-cycle* effect induced by the presence of collateral requirements. As argued above, the latter channel depends on the interaction between movements in the relative price of durables and the assumed endogenous specification of the borrowing limit. A policy tightening, by inducing a fall in the relative price of durables, depresses also the collateral value, and therefore the borrowing capability. This induces a rise in the marginal value of borrowing (i.e., the multiplier on the borrowing constraint rises). As a result, the marginal value of tilting the (non-durable) consumption path towards current consumption rises, and therefore current non-durable consumption falls. At the same time, a parallel decrease in the demand for durables (induced by the fall in borrowing demand) induces a further fall in the relative price of durables, which in turn triggers an even larger fall in the collateral value, all in a self-reinforcing fashion.

It is important to notice that the degree of rigidity in non-durable prices assumed thus far is significantly higher than the one reported in a recent (micro-based) study by Bils and Klenow (BK) (2004) for the US. The latter suggest that the average frequency of price adjustment is in the order of four months. In principle, and in light of the observed excess sensitivity of non durable spending to the policy shock, our model with borrowing constraints leaves room for decreasing the assumed degree of stickiness in non-durable prices.

Figure 12 displays selected responses to a policy tightening under alternative degrees of price stickiness in *non-durable* prices. Throughout we continue to assume that durable prices are flexible. We present results for three cases: i) Full (non-durable) price flexibility. Combined with our maintained assumption of flexible durable prices, this case describes an economy with fully flexible prices in both sectors; ii) L*ow stickiness*, which corresponds to a value of ϑ_c consistent with the evidence in BK; iii) *High stickiness,* which replicates to the standard four-quarter rigidity assumption.

Hence we see that decreasing the degree of stickiness in non-durables works in the direction of dampening the response of non-durable consumption. However, the most interesting evidence emerges in the case of full price flexibility. In that extreme case, prices in both sectors fall on impact, leading to a flat response of the relative price q_t. Despite prices being flexible in *both* sectors, a monetary policy shock displays non-trivial (although small) real effects on both categories of spending. This non-neutrality works entirely through the presence of endogenous borrowing limits. Although the effects on both categories of spending are not large, it is remarkable that the model with borrowing limits and fully flexible prices in both sectors is more in line with the empirical evidence than the baseline case studied in the onset of our analysis, and featuring no borrowing restrictions, flexible durable and sticky non-durable prices.

8 Conclusions

Econometric evidence suggests that, in response to monetary policy shocks, durable and non-durable spending comoves positively and that durable spending exhibits a much larger sensitivity to the policy shock. We have shown that a two-sector New Keynesian model augmented with durable consumption is able to match this fact only if durable prices are assumed to be sticky and the elasticity of substitution between durable and non-durable services is sufficiently high. However, as recently suggested by Barski et al. (2004), the assumption of sticky durable prices appears particularly heroic in the case of long-lived durables, e.g., housing, whose prices exhibit large overshooting phenomena. This paper shows that the introduction of borrowing constraints and collateralized debt help in reconciling the behavior of an otherwise baseline New Keynesian model with the empirical effects of monetary policy shocks. Under the standard assumption that non-durable prices are sticky, the model with borrowing limits generate a negative response of durable spending to a policy tightening and a positive sectoral comovement, broadly in line with the empirical evidence. In this sense, borrowing limits act as a substitute of stickiness in durables. However, the version of the model with borrowing constraints, which maintains the assumption of sticky non-durable prices, generates a drawback of the opposite sign: namely, it generates a too large sensitivity of non-durable spending to monetary policy shocks. This outcome depends on the presence of a "credit cycle" effect that works via the interaction of durable prices with the endogenously determined value of the collateral limit. Hence, the model leaves room even for relaxing the assumption of stickiness in non-durable prices, somewhat in line withe recent micro evidence provided, e.g., in Bils and Klenow (2004). We show that even the model with full price flexibility in both sectors still exhibits some degree of non-neutrality. In this vein, the presence of borrowing constraints and collateralized debt can not only act as a substitute of nominal rigidity in the durable sector, but more broadly as a substitute of nominal stickiness altogether.

References

[1] Barski Robert, C. House and M. Kimball (2004), " Sticky Price Models and Durable Goods", Mimeo University of Michigan.

[2] Bernanke B., (2002), "Remarks by Governor Ben S. Bernanke Before the New York Chapter of the National Association for Business Economics", New York.

[3] Bernanke, B., M. Gertler, (2001),"Agency Costs, Net Worth and Business Fluctuations", *American Economic Review*, March, 14-31.

[4] Bernanke, B., M. Gertler, (2001), "Should Central Banks Respond to Movements in Asset Prices?" *American Economic Review Papers and Proceedings*, 91 (2), 253-257.

[5] Bernanke, B., M. Gertler and S. Gilchrist, (1999), "The Financial Accelerator in a Quantitative Business Cycle Framework", in J.B. Taylor, and M. Woodford, eds., *Handbook of Macroeconomics*, Amsterdam: North-Holland.

[6] Campbell J. and Z. Hercowitz (2005), "The Role of Collateralized Household Debt in Macroeconomic Stabilization", NBER w.p 11330.

[7] Carlstrom, C. and T. Fuerst (1997), "Agency Costs, Net Worth and Business Fluctuations: A Computable General Equilibrium Analysis", *American Economic Review,* 87, 893-910.

[8] Carlstrom, C. and T. Fuerst (1998), "Agency Costs and Business Cycles", *Economic Theory* 12(3), 583-597.

[9] Cecchetti S., H. Genberg and S. Wadhwani (2002) "Asset Prices in a Flexible Inflation Targeting Framework", NBER w.p # 8970.

[10] Chari V.V, P. Kehoe and E. McGrattan (2004), "Business Cycle Accounting", *Federal Reserve Bank of Minneapolis Staff Report,* 328.

[11] Christiano L., M. Eichenbaum and C. Evans (2003), "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy, forthcoming *Journal of Political Economy.*

[12] Dupor, B. (2003), "Nominal Price versus Asset Price Stabilization", mimeo Ohio State University.

[13] Erceg C., A. Levin, (2005), “Optimal Monetary Policy with Durable Consumption Goods", International Finance Discussion Paper 748, Board of Governors.

[14] Gilchrist, S. and Leahy, J. V., (2002), “Monetary policy and asset prices”, *Journal of Monetary Economics*, vol. 49(1), pages 75-97, 1.

[15] Iacoviello, M. (2005), ””House Prices, Borrowing Constraints and Monetary policy in the Business Cycle”, *American Economic Review.*

[16] Ireland P.(2003), ”Endogenous Money or Sticky Prices”, *Journal of Monetary Economics.*

[17] Khan, A., R. King and A.L. Wolman, (2003), “Optimal Monetary Policy”, *Review of Economic Studies*, 60,4.

[18] King R. and S. Rebelo, (1999), “Resuscitating Real Business Cycles,” in J.B. Taylor, and M. Woodford, eds., *Handbook of Macroeconomics*, Amsterdam: North-Holland.

[19] King, R. and A. L. Wolman, (1999), “What Should the Monetary Authority Do When Prices Are Sticky”, in Taylor, J. B., ed., Monetary Policy Rules, Chicago: university of Chicago Press, 349-398.

[20] Kiyotaki, N. and J. Moore, (1997), “Credit Cycles”, *Journal of Political Economy*, 105, April , 211-48.

[21] Krusell P. and A. Smith (1998), "Income and Wealth Heterogeneity in the Macroeconomy", *Journal of Political Economy,* 106, 867-896.

[22] Rotemberg, J. and M. Woodford, (1997), “An Optimization-Based Econometric Model for the Evaluation of Monetary Policy”, *NBER Macroeconomics Annual,* 12: 297-346.

[23] Schmitt-Grohe S. and M. Uribe, (2003), ”Optimal, Simple, and Implementable Monetary and Fiscal Rules”, mimeo Duke University.

[24] Schmitt-Grohe S. and M. Uribe, (2004a), ”Solving Dynamic General Equilibrium Models Using a Second-Order Approximation to the Policy Function”, *Journal of Economic Dynamics and Control* 28, 645-858.

[25] Schmitt-Grohe S. and M. Uribe, (2004b), "Optimal Operational Monetary Policy in the Christiano-Eichenbaum-Evans Model of the U.S. Business Cycle ", mimeo Duke University.

[26] Woodford, Michael (2003), *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University Press.

Figure 1. GDP Share of Durable Consumption and Residential Investment

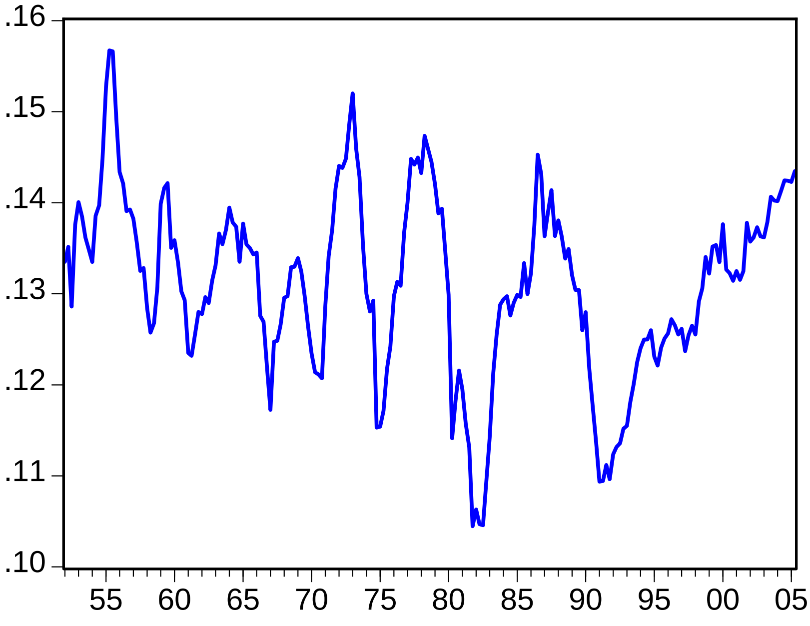

Figure 2. Consumption Shares: Durables, Non-Durables, Services

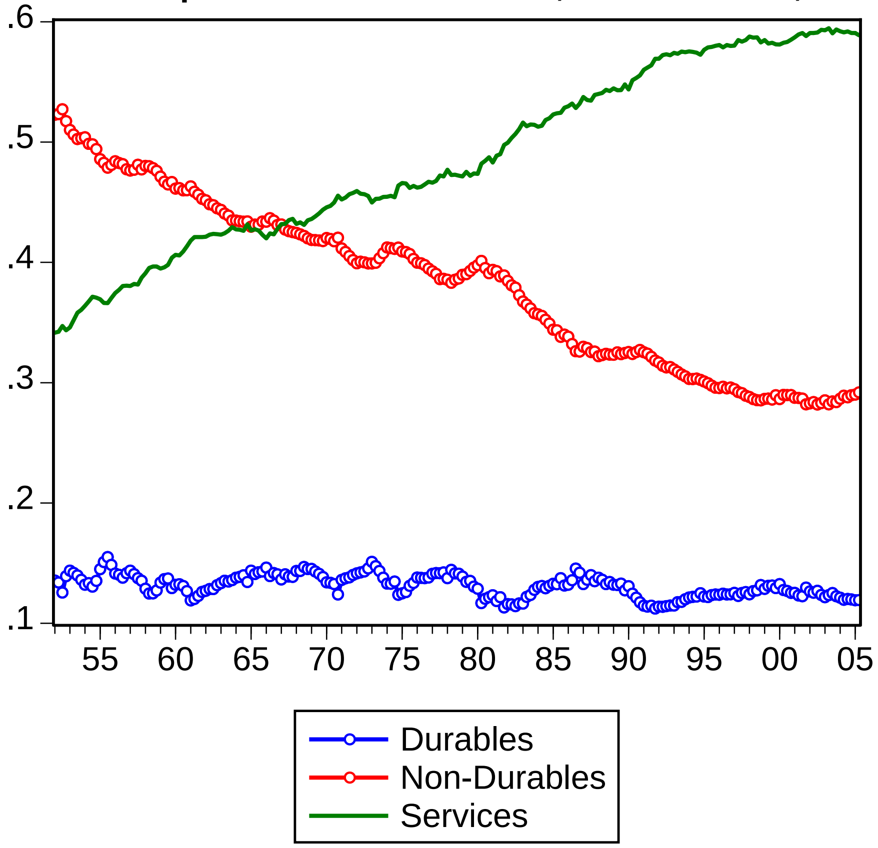

Figure 3. Household Leverage Ratio

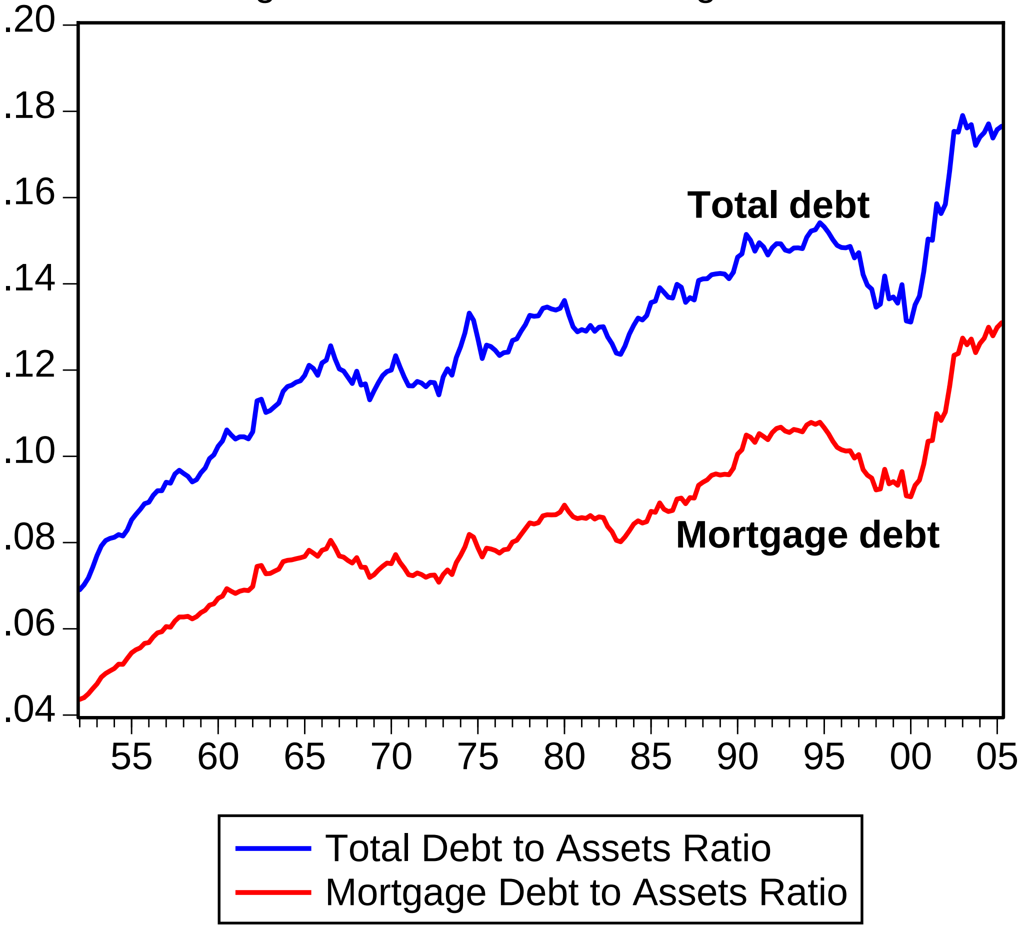

Figure 4. Household Mortgage Debt: Share ot Total Debt

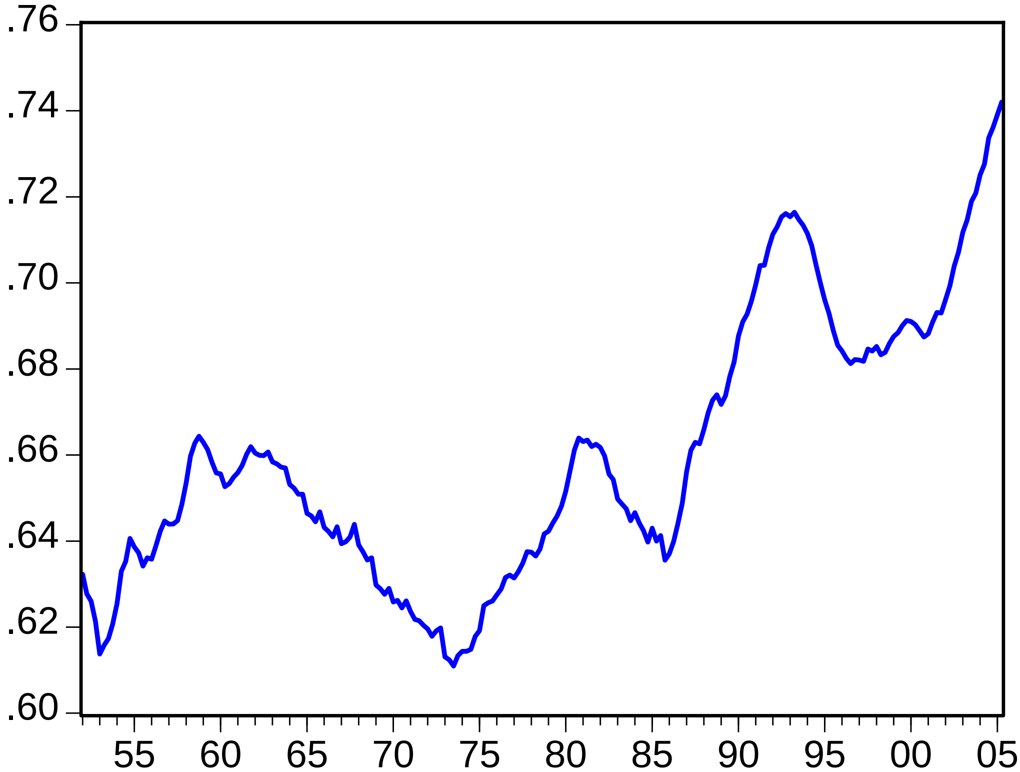

Figure 5. Estimated Responses to a Monetary Policy Tightening

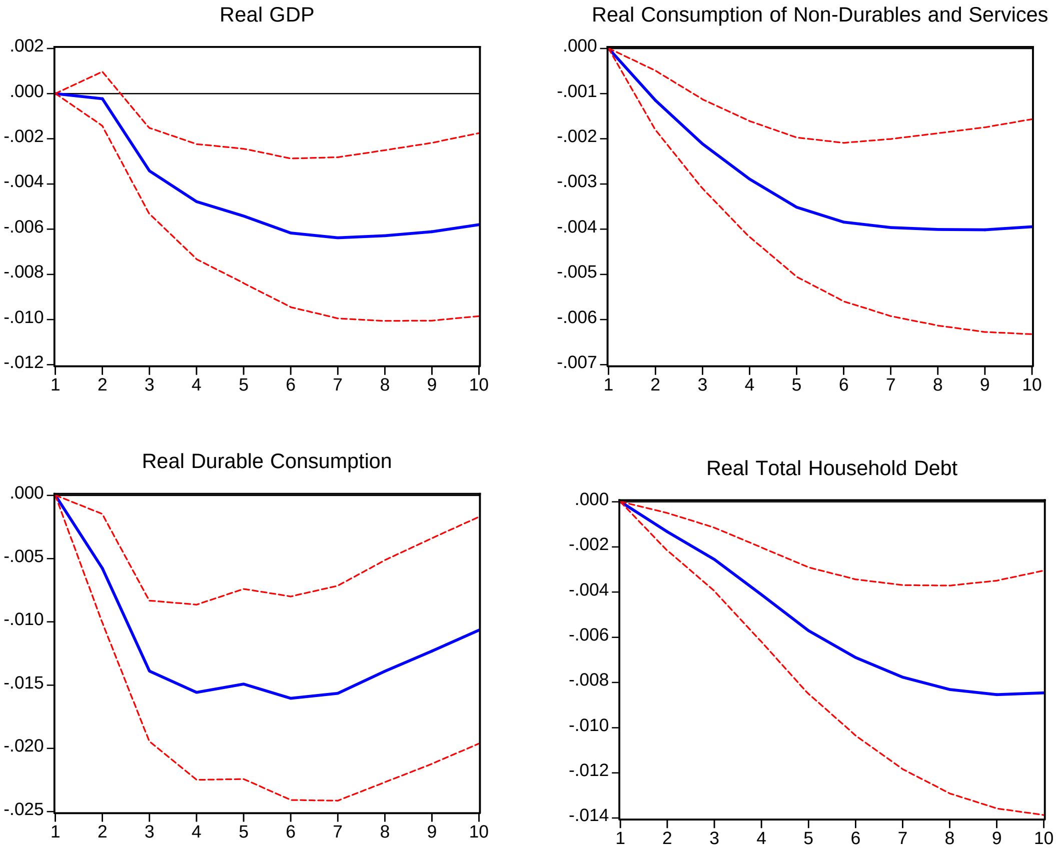

Figure 6. Estimated Responses to a Monetary Policy Tightening

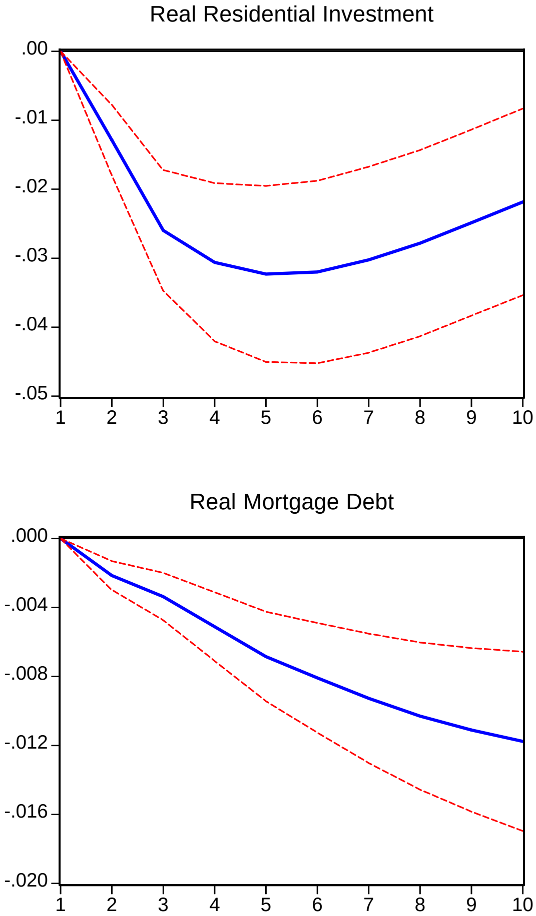

Figure 7. Impulse Responses to a Monetary Policy Tightening (no bc)

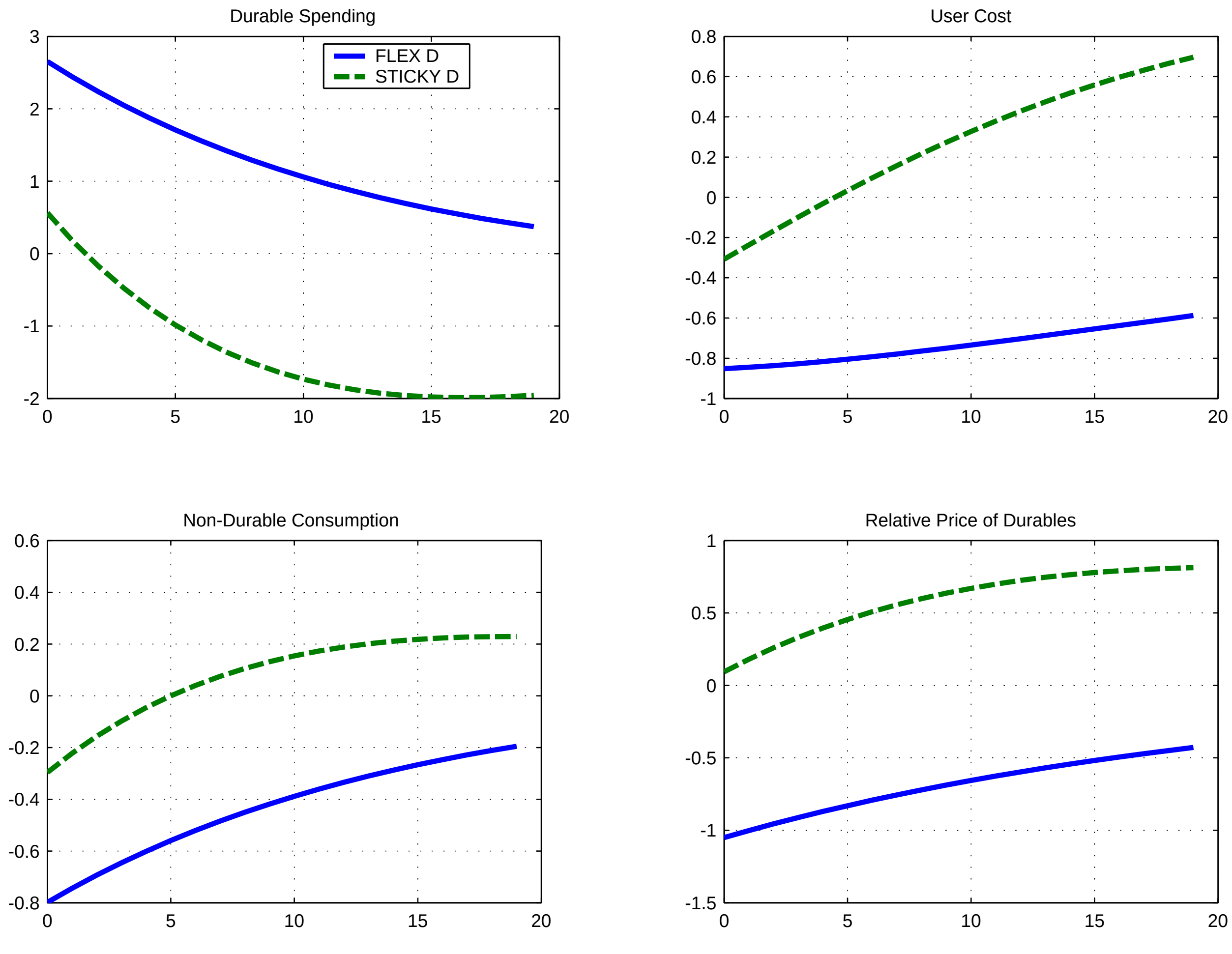

Figure 8. Impulse Responses to a Monetary Policy Tightening (no bc, CPI rule)

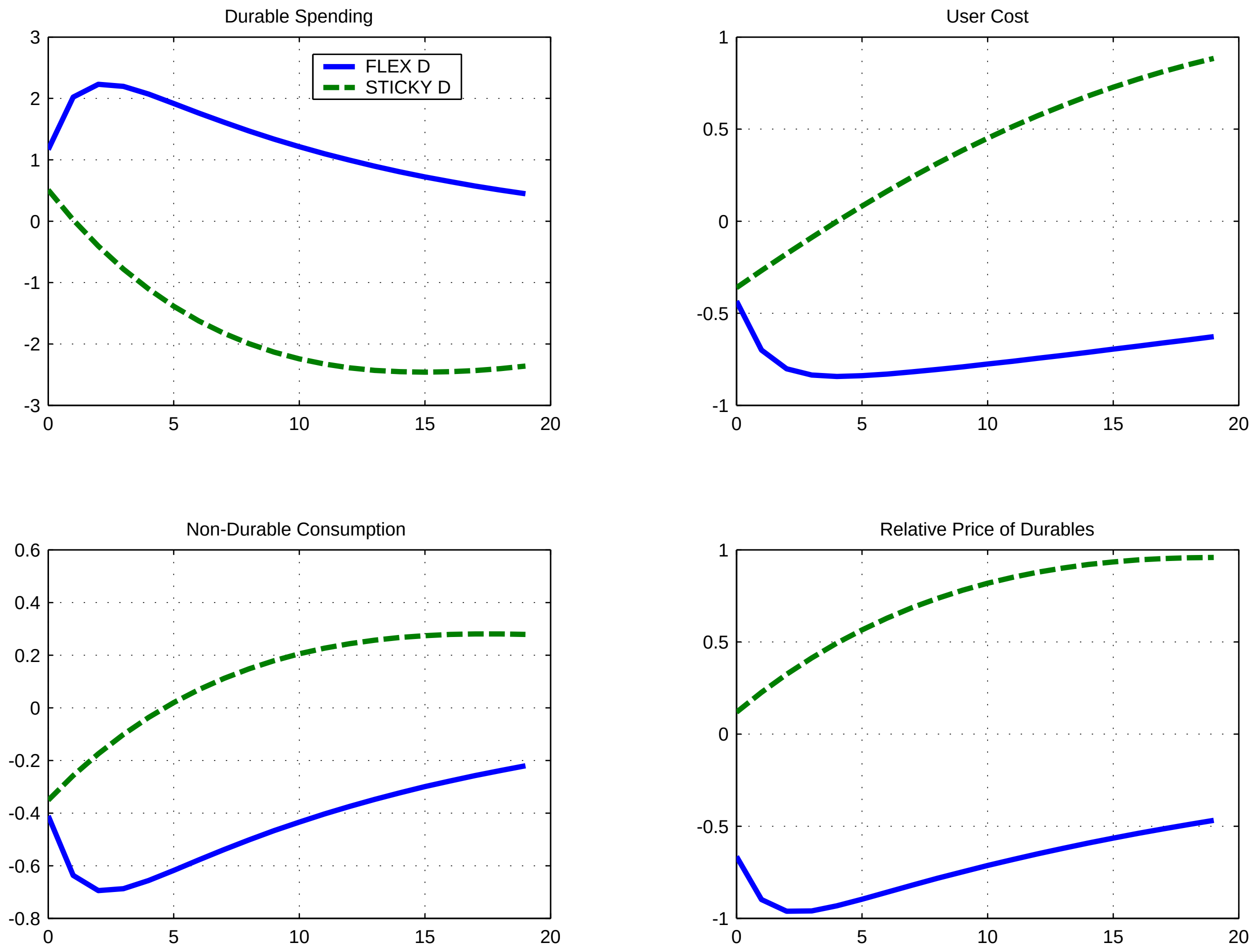

Figure 9. Policy Tightening: Effect of Varying the Elasticity of Substitution (flex D)

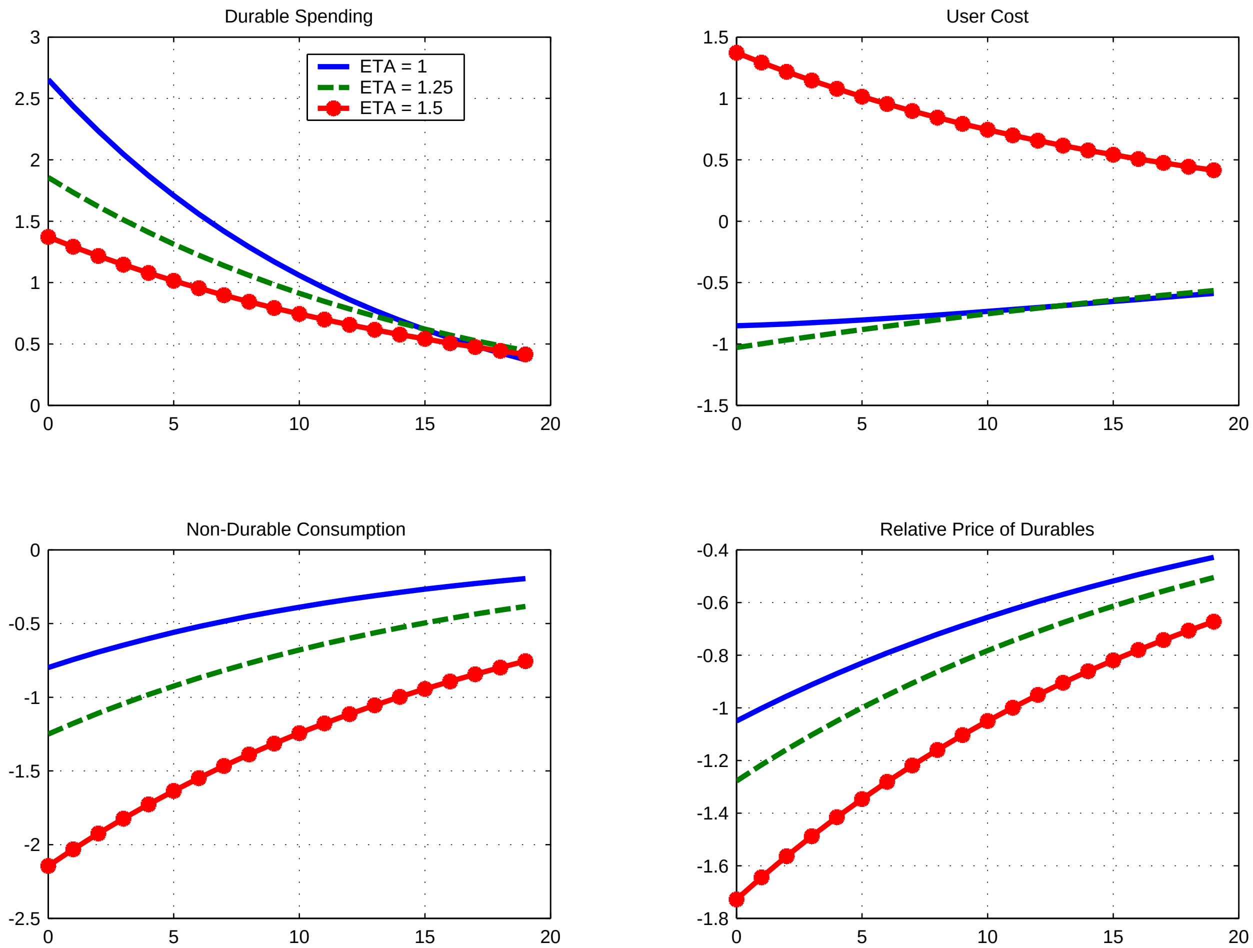

Figure 10. Policy Tightening: Effect of Varying the Elasticity of Substitution (sticky D)

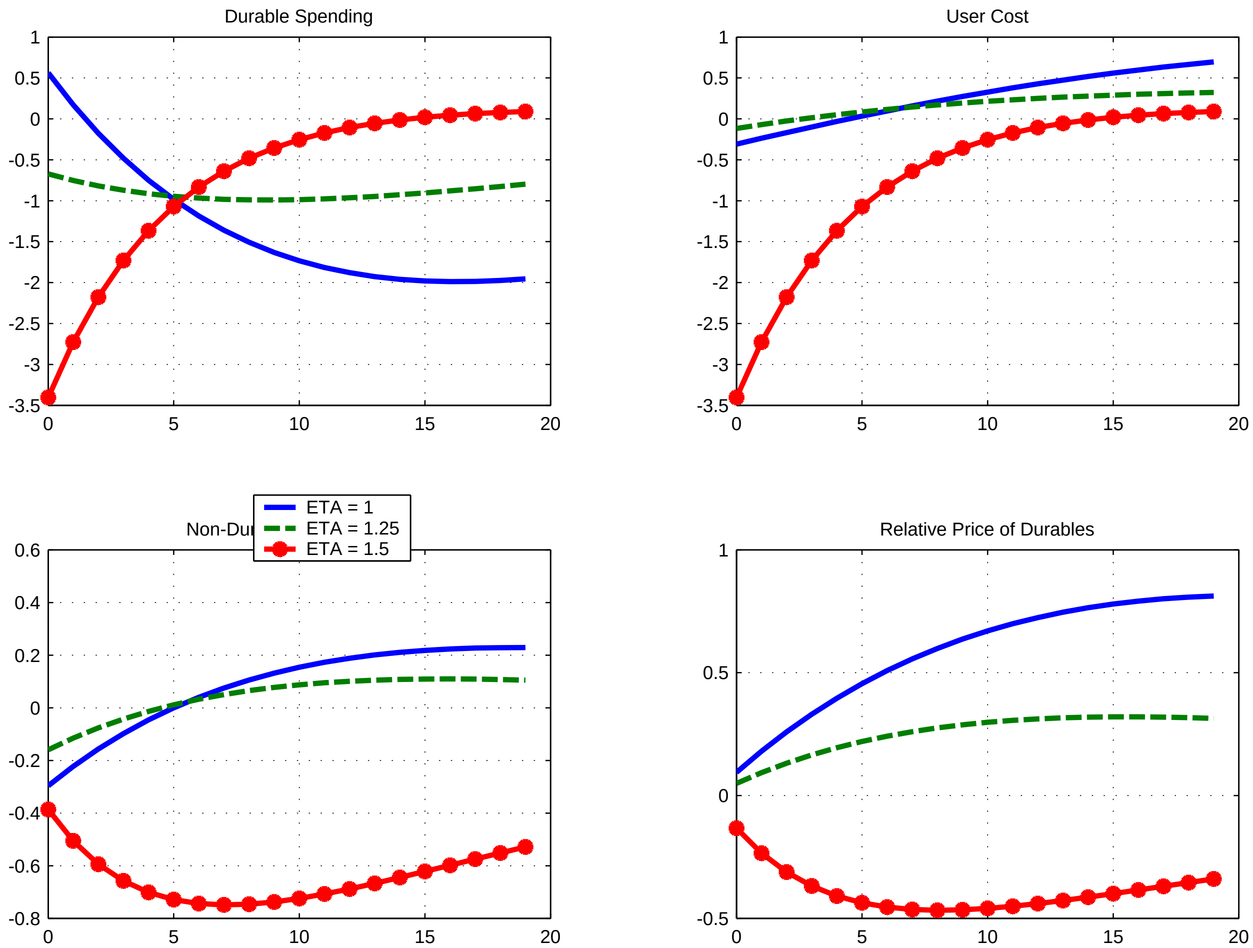

Figure 11. Monetary Policy Tightening: with and without Borrowing Constraints (flex D prices)

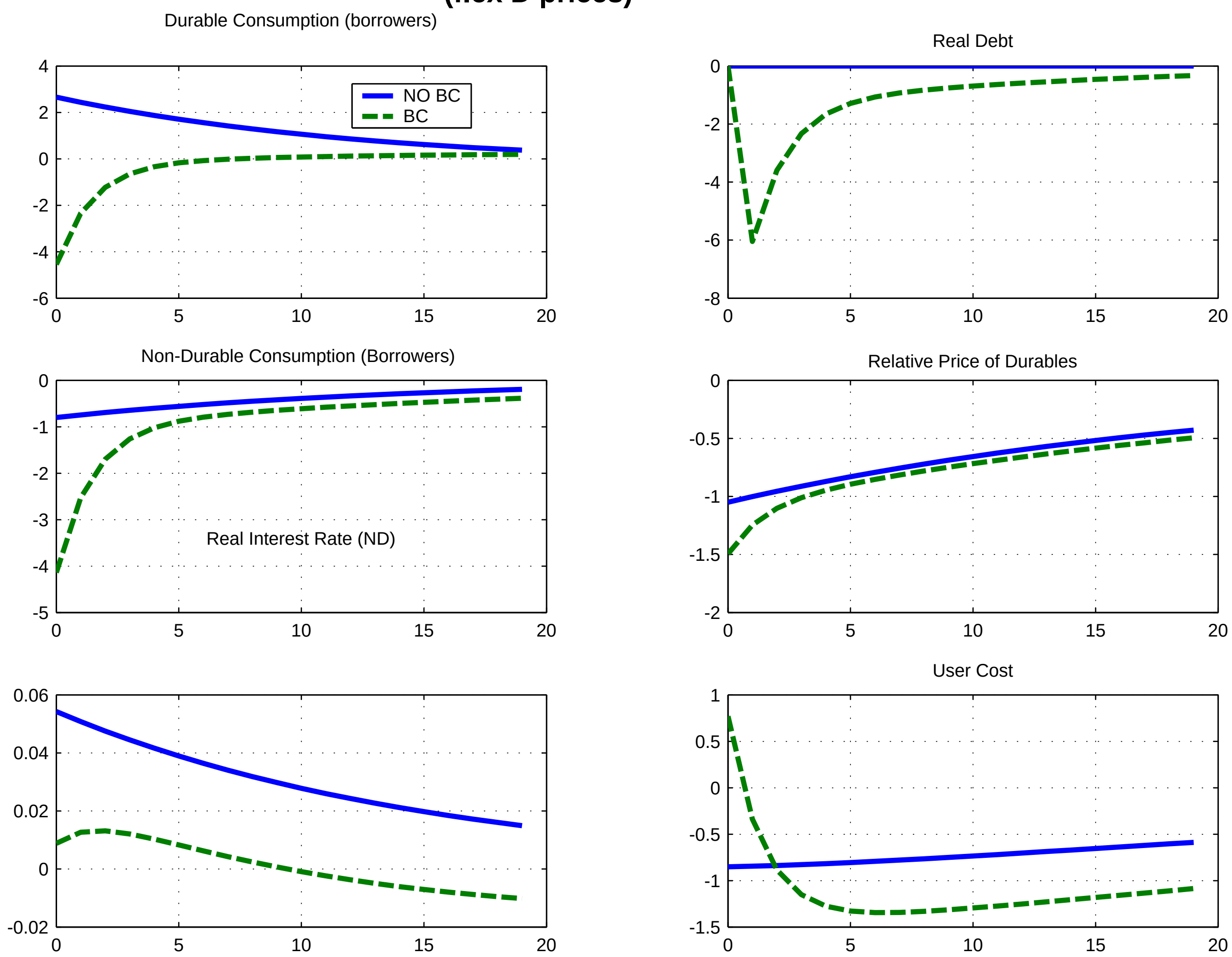

Figure 12. Policy Tightening: Effect of Varying Stickiness in ND Prices (model with BC and flex D prices)