

1 Money Demand Heterogeneity and the Great Moderation*

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3 **Abstract**

4 A forward-looking model of the demand for money based on heterogeneous and sluggish portfolio
5 adjustment can simultaneously account for the low short-run and high long-run semi-elasticities
6 reported in the literature. The parameter estimates from the model for the short-run and long-run
7 interest semi-elasticities are 1.04 and 13.16, respectively. A simulated version of the model suggests
8 that the Great Moderation can be partially attributed to financial innovations in the late 1970s.
9 When moving toward a more flexible portfolio, the model can account for almost one-third of the
10 observed decline in the volatilities of output, consumption, and investment.

11 *Keywords:* Financial Innovation, Great Moderation, GMM, Money Demand, Sluggish Portfolio Adjustment, Monetary and Tech-
12 nology Shocks.

13 *JEL classification:* E41, E47

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13 1. Introduction

14 The demand for money has been a long-standing puzzle in the monetary economics litera-
 15 ture. Indeed, since the seminal papers of Friedman (1959) and Meltzer (1963), the literature
 16 has yielded conflicting estimates for the coefficients of the money demand equation. For ex-
 17 ample, whereas Lucas (1988) suggests that the long-run interest rate semi-elasticity of money
 18 demand falls between 5 and 10, other researchers (e.g., Goldfeld and Sichel 1990) find that
 19 the short-run semi-elasticity lies around 1. Understanding the demand for money is critical
 20 because of its implications for welfare analysis (Lucas, 2000), the dynamics of exchange rates
 21 (Engel and West, 2005), and optimal monetary policy (Khan, King, and Wolman, 2003).

22 Similarly, the Great Moderation (the sustained decline in the volatility of economic activ-
 23 ity; McConnell and Perez-Quiroz, 2000, and Stock and Watson, 2002) has been a controversial
 24 topic without a consensus on its cause. The moderation has been attributed to better mone-
 25 tary policy (Clarida et al., 2000), less volatile productivity shocks (Fernandez-Villaverde and
 26 Rubio-Ramirez, 2007, and Justiniano and Primiceri, 2008), and unknown forms of good luck
 27 reflected in smaller forecast errors (Stock and Watson, 2002). Table 1, which reports the
 28 volatilities for some variables in the U.S., shows that real variables are at least 50 percent less
 29 volatile after 1984 than before.¹ For example, the volatility of output growth declined 54%
 30 in the post-1984 sample. We also observe a much less discussed fact: the substantial increase
 31 in the variability of real balances. This paper investigates what frictions might account for
 32 the considerable difference between the short- and long-run semi-elasticities of the demand
 33 for money. Furthermore, I argue that the interaction between money demand and financial
 34 innovations of the late 1970s contributed to the Great Moderation.

35 This paper develops a model in which households divide their money holdings (portfolio)
 36 into two parts: money for consumption purchases and money for savings. Re-balancing the
 37 composition of their portfolio is costly, however. To capture this cost, the model assumes
 38 households use time-dependent rules to re-optimize their money holdings, a supposition that

¹The results in McConnell and Perez-Quiroz (2000) and Sims and Zha (2004) suggest 1984 as the most likely year when the Great Moderation started.

39 yields non-trivial heterogeneity across households. Moreover, the presence of those costs
 40 implies that households look forward when re-balancing their portfolios between cash and
 41 deposits.

42 In the model, velocity depends on its own lagged value and a forward-looking element
 43 capturing households' expectations of the short-term interest rate. When this equilibrium
 44 condition is estimated via the generalized method of moments (GMM), I uncover (1) short-
 45 run and long-run interest semi-elasticities of 1.04 and 13.16, respectively; (2) that house-
 46 holds re-optimize their money balances on average once every 4.5 quarters; and (3) a sig-
 47 nificant forward-looking component in money demand. Notably, the estimated short-run
 48 semi-elasticity agrees with the findings of Christiano et al. (2005, CEE), and the long-run
 49 semi-elasticity is in the range reported in Lucas (1988), and Stock and Watson (1993). More-
 50 over, the estimated portfolio sluggishness is consistent with the microdata-based evidence in
 51 Vissing-Jorgensen (2002). There is little statistical evidence against the model.

52 The late 1970s and early 1980s were characterized by significant financial innovations,
 53 such as banking de-regulation and ATMs. These innovations most likely decreased the cost
 54 of transacting in financial markets, which resulted in frequent portfolio re-balancing. In the
 55 model, additional portfolio flexibility allows households to efficiently adjust money balances
 56 when shocks buffet the economy and hence facilitates consumption smoothing. Consequently,
 57 my model suggests that financial innovations of the 1970s and 1980s contributed to the Great
 58 Moderation. To support this hypothesis, two exercises are undertaken. First, I re-estimate
 59 the model over the pre-1984 and post-1984 samples. Whereas the short- and long-run interest
 60 semi-elasticities in the first subsample equal 3.00 and 16.67, respectively, those elasticities
 61 fall to 0.42 and 4.72, respectively, in the second subsample. Furthermore, the frequency of
 62 portfolio re-optimization changes from six quarters in the pre-1984 sample to three quarters
 63 in the post-1984 sample. This analysis suggests that financial innovations did indeed lead to
 64 a more frequent portfolio adjustment.

65 To fully explore the effects of portfolio flexibility, the second step involves embedding the
 66 model of money demand into a standard New Keynesian framework. The resulting model

67 is then simulated using different degrees of portfolio sluggishness. This exercise reveals that
68 when moving from high portfolio sluggishness, in which households re-balance their portfolios
69 on average every 6 quarters, to moderate flexibility (portfolios are reviewed every 3 quarters),
70 the model accounts for almost one-third of the observed decline in the volatilities of output,
71 consumption, inflation, and investment. Interestingly, the model is capable of explaining one-
72 third of the rise in the volatility of real balances found in the data (Table 1). As will become
73 apparent below, this increase in volatility is crucial to understanding the workings of the
74 model.

75 The rest of the paper is organized as follows. Section 2 describes the main innovations that
76 hit financial markets in the 1970s and 1980s. The model of money demand and its estimation
77 are discussed in Sections 3 and 4. Simulations and the relation of the results to the existing
78 literature are in Section 5. The last section provides concluding remarks.

79 **2. Financial Innovations**

80 Undoubtedly progress in computer and information technology has been one of the main
81 sources of innovation in financial markets. Most of those important innovations happened
82 during the late 1970s and early 1980s, including the production of Intel's 16-bit microprocessor,
83 the 8086, and the introduction of the first personal computers: the Apple II in 1977, and the
84 IBM PC in 1981. These advances in turn had significant effects on the banking sector. To
85 begin with, automated teller machines (ATMs) and electronic fund transfers (EFTs) became a
86 standard in the industry.² Customers in turn could deposit and withdraw money more quickly
87 and at a reduced fee compared to person-based transactions. Next, financial institutions
88 gained access to statistical software that greatly simplifies credit risk assessment (VisiCalc,
89 introduced in 1979, was the first spreadsheet for personal computers). This newly acquired
90 ability enabled financial intermediaries to lend money more efficiently. Firms also benefited
91 from the new risk valuation techniques as they progressively gained access to a market for

²Sienkiewicz (2002) reports that the number of ATMs rose from less than 10,000 terminals in 1978 to roughly 324,000 in 2001.

92 high-risk debt.³

93 A related source of innovations resulted from major changes in banking legislation. The
 94 Depository Institutions Deregulation and Monetary Control Act (DIDMCA) was introduced
 95 in 1980, which allowed, among other things, NOW and sweep accounts nationwide; eliminated
 96 interest rate ceilings on deposits and usury ceilings on loans; and increased deposit insurance
 97 to \$100,000 per account. In 1982, Congress passed the Depository Institutions Act (Garn-St.
 98 Germain), which permitted depository institutions to offer money market deposit accounts
 99 (MMDAs). Together, these laws fostered greater integration between capital and credit mar-
 100 kets and therefore led to better access to financing (see Campbell and Hercowitz, 2004; Dynan
 101 et al., 2006).

102 Financial sophistication also came through the introduction of new banking products and
 103 interstate banking, both aimed to boost banks' profits. For example, in 1975 California allowed
 104 lending institutions to issue adjustable-rate mortgages, characterized by low initial interest
 105 rates, which made them very popular among homeowners. With respect to branching, states
 106 such as Maine and Massachusetts introduced new legislation (1975 and 1982, respectively)
 107 that permitted out-of-state companies to buy banks in those states. Finally, the Chicago
 108 Board of Trade introduced financial derivatives in the mid-1970s.

109 Figure 1 displays velocity (nominal GDP to money), interest rates and some financial
 110 innovations in the U.S. This figure clearly reveals that the arrival of the innovations precedes
 111 the Great Moderation and coincides with two changes in the data: 1) A sharp rise followed
 112 by a sustained decline in velocity and interest rates, and 2) These two variables tend to co-
 113 move, which is quite apparent after 1977, the year when the Apple II was introduced. Such
 114 findings suggest that money balances, and hence velocity, became more flexible over time,
 115 most likely because of the financial innovations.⁴ As will become clear, my model precisely
 116 predicts that sophistication in financial markets, as captured by flexible portfolio adjustment,

³Dynan et al. (2006) report that new issuance of junk bonds went from nothing in the mid-1970s to more than 40 percent of total non-financial bond issuance in 2004.

⁴The change in interest rates and velocity may also be a consequence of a switch in monetary policy or smoother shocks hitting the economy. In the simulations in Section 5, I control for such possible scenarios to show that financial innovations alone can generate a sizable smoothing of the economy.

117 indeed implies a more flexible money demand.

118 Yet anecdotal evidence is no guarantee that financial innovations ultimately translated
 119 into more flexible portfolio adjustment. Fortunately, the empirical results in Section 4 lend
 120 support to the link between financial sophistication and frequency of portfolio re-balancing.
 121 Moreover, Vissing-Jorgensen (2002) estimates that the annual cost for participating in the
 122 stock market declined 43% between 1984 and 1994. Consistent with this decline in costs, she
 123 finds that household participation in the stock market increased from 28% to 44% for the
 124 same period. Her results, therefore, indicate that transaction costs declined and households
 125 traded more frequently.

126 **3. Model**

127 The basic formulation of my model is based on Altig et al. (2005, ACEL), and Schmitt-
 128 Grohe and Uribe (2004). Their models are rich enough to capture the business cycle properties
 129 of key variables after monetary and technology shocks.

130 *3.1. Households*

131 The model features a continuum of households, indexed by $j \in (0, 1)$. Before any un-
 132 certainty is revealed, households can buy insurance against idiosyncratic shocks (described
 133 below). After learning the current state of nature, households make decisions regarding con-
 134 sumption, $C_{j,t}$, investment, $I_{j,t}$, and labor supply, $h_{j,t}$. Simultaneously, households allocate
 135 their beginning-of-period money holdings, $M_{j,t}$, between deposits at a bank and cash to be
 136 used for consumption transactions, $Q_{j,t}$. By sending resources to the bank, households are
 137 entitled to collect a return, R_t , at the end of the period. The model assumes that households
 138 face a Calvo lottery every time they optimize transaction balances.

139 Each household is a monopolistic supplier of a differentiated labor supply. Moreover,
 140 she sets her wage subject to a Calvo scheme similar to that in place in the financial service
 141 sector. However, my model allows the Calvo probabilities in each market to differ. Therefore,

142 households make their decisions based on the following maximization problem

$$143 \quad \max_{\substack{C, M, Q, I \\ K, w, h}} E_t \sum_{l=0} \beta^l [\log(C_{j,t+l} - bC_{j,t+l-1}) - \psi_L \frac{h_{j,t+l}^2}{2}] \quad (1)$$

144 subject to

$$\begin{aligned} (1 + \eta(V_{j,t}))p_t C_{j,t} + p_t \Upsilon_t^{-1} I_{j,t} + M_{j,t+1} &\leq R_t(M_{j,t} - Q_{j,t} + (x_t - 1)M_t^a) + \\ &\quad A_{j,t} + w_{j,t}h_{j,t} + p_t r_t^k K_{j,t} + Q_{j,t}, \\ \text{and } K_{j,t+1} &= (1 - \delta)K_{j,t} + (1 - S(\frac{I_{j,t}}{I_{j,t-1}}))I_{j,t}. \end{aligned}$$

145 Here, $b > 0$ is the habit formation parameter; $\psi_L > 0$; p_t is the price level; and S is a
 146 function reflecting the costs associated with adjusting investment. This function is assumed
 147 to be increasing and convex satisfying $S = S' = 0$ and $S'' \equiv \varkappa > 0$ in steady state. A_j is
 148 household j 's net cash inflow from the insurance markets. The term Υ_t is an investment-
 149 specific shock. The quantity $(x_t - 1)M_t^a$ is a lump-sum transfer made to household j by the
 150 monetary authority, and x_t is the gross growth rate of the aggregate stock of money, M_t^a .
 151 Following Sims (1994), money is introduced into the model by assuming that the purchase
 152 of goods requires the payment of transaction services. These transaction costs depend on
 153 individual velocity, $V_{j,t} \equiv p_t C_{j,t} / Q_{j,t}$, through the function η with positive first, η' , and second,
 154 η'' , derivatives.

155 3.1.1. Money Holdings Setting

156 The main assumption in this paper comes from time-dependent portfolio adjustment:
 157 Agents re-optimize their cash balances, Q , infrequently, similar in spirit to the price- and
 158 wage-setting model of CEE. Specifically, a fraction, $1 - \xi$, of randomly chosen households is
 159 allowed to re-optimize their balances every period. For inactive households, the literature
 160 on portfolio choice provides little guidance regarding their behavior (Campbell and Viceira,
 161 2002). Hence, if a household is not allowed to re-optimize today, her money holdings are
 162 adjusted according to the rule $Q_{j,t} = \pi g_c Q_{j,t-1}$, where π represents the steady state inflation,

163 and g_c is the growth rate of aggregate consumption in the steady state.⁵

164 This sluggish-portfolio assumption is likely to capture two important aspects of the econ-
 165 omy. First, it measures the degree of access to financial services enjoyed by households. Prior
 166 to the widespread use of ATMs, electronic banking, and the branching liberalization of the late
 167 1970s, households spent substantial resources managing their accounts. For instance, money
 168 deposits and withdrawals had to be made during business days, since banks were closed on
 169 weekends. Hence, households had limited access to such services, which is parsimoniously
 170 captured in the model by infrequent portfolio re-balancing. Indeed, a decline in ξ implies
 171 more frequent portfolio adjustment or higher household participation in the financial system.

172 Second, the time-dependent assumption captures the costs faced by households when as-
 173 sessing the uncertainty surrounding the economy. The presence of large costs makes it harder
 174 for households to determine the state of the economy and in particular the risk exposure of
 175 banks. As a consequence, households may opt to limit their participation in financial mar-
 176 kets. This infrequent participation in turn makes households factor in future outcomes when
 177 choosing their portfolio. Moreover, households may keep real balances for purchase purposes
 178 as well as for precautionary motives. The financial innovations of the late 1970s most likely
 179 contributed to decreasing those costs and ultimately increasing household participation in
 180 financial markets.

181 For tractability reasons, let us assume that agents can contract upon the uncertainty
 182 created by the Calvo lotteries with perfectly competitive insurance companies. Such an as-
 183 sumption, which has been extensively used in the sticky price literature (Erceg et al., 2000),
 184 aims to reduce the degree of heterogeneity across households resulting from time-dependent
 185 portfolio adjustment. In fact, market completeness ensures that households value an extra
 186 dollar equally: $\lambda_{j,t} = \lambda_{k,t}$ for households j and k , where λ is the budget multiplier (CEE). By
 187 employing this assumption, we focus on the direct effects of the Calvo friction on consumption
 188 and money balances. The optimal money holdings for household j that can re-optimize at

⁵The presence of g_c in the indexation rule implies that there are no distortions from portfolio disper-
 sion along the steady state growth path. Gueron-Quintana (2007a) explores the implications of alternative
 indexation rules.

189 time t obey:

$$190 \quad R_t = 1 + (\eta_{j,t})' (V_{j,t})^2 + \tilde{E}_t \sum_{l=1}^{\infty} (\xi \beta \pi g_c)^l \frac{\lambda_{t+l+1}}{\lambda_t} \left[(-R_{t+l} + 1) + (\eta_{j,t+l})' (V_{j,t+l}^t)^2 \right], \quad (2)$$

191 where $\eta_{j,t+l} \equiv \eta(V_{j,t+l}^t)$, $V_{j,t+l}^t \equiv \frac{p_{t+l} C_{j,t+l}}{(\pi g_c)^l Q_{j,t}}$, and \tilde{E}_t is the expectation operator upon the event
 192 that household j does not re-optimize her money balances after period t . The Lagrangian
 193 multiplier, λ_t , is not indexed reflecting the assumption of insurance markets. In the absence
 194 of time-dependent portfolio adjustment, the optimal condition for money balances requires
 195 that the cost of an extra unit of balances, R_t , equal the benefits of the decrease in the
 196 transaction cost: $R_t = 1 + \eta'(V_t) (V_t)^2$. In contrast, with sluggish portfolio adjustment, the
 197 costs and benefits of an extra unit of money balances extend beyond the current period because
 198 with positive probability households must retain their current nominal balances, indexed by
 199 inflation, next period. In the second period, losses come from the forgone interest income
 200 $\pi g_c R_{t+1}$, whereas gains come from the savings on transaction costs, $\pi g_c + \frac{(\eta_{t+1})'}{\pi g_c} \left(\frac{p_{t+1} C_{t+1}}{Q_t} \right)^2$.
 201 Because these costs and gains arrive during the next period with probability ξ , they must be
 202 discounted using the household's stochastic discount factor, $\xi \beta \frac{\lambda_{t+1}}{\lambda_t}$. The combination of these
 203 terms corresponds to the second element of equation (2). Hence, a direct implication of the
 204 infrequent portfolio friction is that households must look forward every time they are allowed
 205 to optimize money balances.

206 Deriving a tractable money demand equation from equation (2) presents two challenges.
 207 First, the conditional expectation $\tilde{E}_t (\eta_{j,t+l})' (V_{j,t+l}^t)^2$ must be evaluated only across those his-
 208 tories in which household j has not re-optimized her money balances. However, her consump-
 209 tion, $C_{j,t+l}$, depends on all continuation histories including those in which the household can
 210 re-optimize her balances. Second, in spite of the insurance market assumption, the presence
 211 of the transaction function η implies that consumption is still heterogeneous across agents.
 212 This is so, since contingent markets equate the marginal utility of wealth across households,

$$213 \quad \frac{U_{c,t}(j)}{[1 + \eta(V_{j,t}) + \eta'(V_{j,t})V_{j,t}]} = \frac{U_{c,t}(k)}{[1 + \eta(V_{k,t}) + \eta'(V_{k,t})V_{k,t}]} \quad (3)$$

214 for households j and k . Because money holdings differ across households, so too does con-
 215 sumption.

216 To manage these complications, this paper borrows ideas from the procedure outlined in
 217 Woodford (2005), who solves a forward-looking pricing model with heterogeneity. First, take
 218 a log-linear approximation of equation (2) about the steady state. As shown in the technical
 219 appendix, this equation admits a first-order Taylor approximation under mild assumptions.
 220 Second, because only active households absorb additional funds in the market after an ex-
 221 pansionary monetary shock, other things equal, their velocity is smaller than that of inactive
 222 households. The only source of this differential lies in the sluggish adjustment setup. Thus,
 223 I guess and verify that, as a log-linear approximation, individual velocity is a function of
 224 economy-wide velocity plus a term that depends on individual money holdings relative to
 225 economy-wide money balances: $\widehat{V}_{j,t} = \widehat{V}_t^* + \Psi \left(\widehat{\frac{Q_{j,t}}{Q_t^*}} \right)$, where Ψ is a coefficient to be deter-
 226 mined, starred variables refer to aggregate variables, and a hat indicates log-deviations.⁶ By
 227 combining equations (2) and (3), the aggregate money demand equation is given by:

$$228 \quad \widetilde{R}_t = \phi_1 \widehat{V}_t^* + \phi_3 (\widehat{\pi}_t + \widehat{g}_{c,t}^* + \widehat{V}_{t-1}^*) + E_t[\phi_2 (\widehat{V}_{t+1}^* - \widehat{g}_{c,t+1}^* - \widehat{\pi}_{t+1})]. \quad (4)$$

229 Here, \widetilde{R}_t , represents deviations of the interest rate from its steady state value; the reduced-
 230 form coefficients, ϕ_i and Ψ , depend on the structural parameters (the mappings can be found
 231 in the technical appendix). Furthermore, I find that $\Psi < 0$, which confirms the suspicion that
 232 households with larger money holdings have smaller individual velocities.

233 Equation (4) resembles Goldfeld's (1976) partial adjustment model.⁷ This new formula-
 234 tion differs from his model in several ways, however. First, unlike Goldfeld's model, money
 235 balances do not appear explicitly in the last equation; instead, they enter indirectly through
 236 their influence on velocity. By using velocity as the main variable, the model takes directly
 237 into account Lucas' (1988) suggestion that recovering the semi-elasticity of money demand
 238 requires imposing an income elasticity of 1.⁸ Second, equation (4) involves the growth rate of

⁶In Woodford's (2005) setup, the firm's price decision is a linear function of a price index and individual capital, which is heterogeneous across firms. Guerron-Quintana (2008) shows how this approach can be exploited to solve models with heterogeneous wage settings.

⁷Goldfeld's (1976) model is given by $\ln m_t = b_0 + b_1 \ln y_t + b_2 \ln r_t + b_3 \ln m_{t-1} + b_4 \pi_t$, where m refers to real balances, y to real output, and r to short-term interest rates.

⁸Lucas (1988) argues that the empirical evidence overwhelmingly supports the finding of unitary income elasticity. Hence, by imposing an income elasticity of 1, we can obtain sharper estimates for the interest elasticity.

239 consumption, whereas the original model focused on the level of output. This result follows
 240 from my model assuming that money is used for transaction purposes. Interestingly, Khan et
 241 al. (2003) derive a money demand model where velocity and consumption play a preponderant
 242 role. Finally, the new dynamic money equation includes a forward-looking term, V_{t+1} , which,
 243 as previously discussed, is a consequence of the staggered portfolio adjustment assumption.

244 With sticky portfolios, only a fraction of the population re-optimizes their balances fol-
 245 lowing a monetary shock. As time goes by, the probability of participating in the financial
 246 market rises, which implies that more agents optimize their balances. Hence, we expect that
 247 money balances will be mildly responsive in the short run but highly elastic in the long run.
 248 Based on this argument, define the interest semi-elasticity of money demand, ζ , as the per-
 249 centage change in real balances stemming from a permanent increase of 100 basis points in
 250 the annualized interest rate:

$$251 \quad \zeta = -\frac{1}{4} \frac{\partial(\log(Q/P)_t)}{\partial R_t}. \quad (5)$$

252 This equation accounts for the quarterly time period of the model. Combining this last
 253 definition and equation (4) is straightforward to show that the short- and long-run semi-
 254 elasticities are given by:

$$255 \quad \zeta_{short} = -\frac{1}{4\phi_2\lambda_2(1-\lambda_2^{-1})}, \text{ and } \zeta_{long} = -\frac{1}{4\phi_2\lambda_2(1-\lambda_1)(1-\lambda_2^{-1})}, \quad (6)$$

256 where λ_1 and λ_2 are the inverse of the roots in the polynomial $\frac{\phi_3}{\phi_2}z^2 + \frac{\phi_1}{\phi_2}z + 1 = 0$. With these
 257 results in hand, we can argue that the estimates in Christiano et al. (1999) correspond to
 258 what the model identifies as a short-run semi-elasticity, while the elasticities reported in Lucas
 259 (1988) and others reflect a long-run semi-elasticity. For the last statement to be true, we need
 260 to show that $0 < \zeta_{short} < \zeta_{long}$. This condition follows trivially from the observation that
 261 $0 < \lambda_1 < 1 < \lambda_2$ and $\phi_2 < 0$. Furthermore, as the Calvo probability declines, the distinction
 262 between the short- and long-run behavior vanishes, i.e., $\zeta_{short} \rightarrow \zeta_{long}$, which results in the
 263 flexible money demand: $R_t = 1 + \eta'(V_t)(V_t)^2$. This is precisely what we observe in Figure
 264 1: as financial innovations arrive, velocity becomes more flexible and more correlated with
 265 interest rates.

266 *3.1.2. Wage Setting*

267 Each household is a monopolistic supplier of a differentiated labor service, say $h_{j,t}$. House-
 268 holds sell these labor services to a competitive firm that aggregates labor and sells it to inter-
 269 mediate firms. The technology used by the aggregator is $H_t = \left[\int_0^1 h_{j,t}^{1/\lambda_w} dj \right]^{\lambda_w}$, $1 \leq \lambda_w < \infty$.
 270 It is straightforward to show that the relation between the labor aggregate and the wage
 271 aggregate, W_t , is given by $h_{j,t} = \left[\frac{W_t}{w_{j,t}} \right]^{\frac{\lambda_w}{\lambda_w - 1}} H_t$. As in CEE, I assume some households do not
 272 change nominal wages (with exogenous probability ξ_w). In those cases, wages are set accord-
 273 ing to the rule $w_{j,t} = \pi_{t-1} \mu_{z^*} w_{j,t-1}$. The term μ_{z^*} is needed to avoid wage dispersion along
 274 the steady state growth path, where μ_{z^*} corresponds to the growth rate of $z_t^* = \Upsilon_t^{\frac{\alpha}{1-\alpha}} z_t$ and z
 275 is a neutral technology shock defined below.

276 *3.2. Firms and the Loan Market*

277 The economy consists of two types of firms: final- and intermediate-good firms. The
 278 former behave competitively while the latter enjoy some monopoly power. At time t , a
 279 consumption good, Y_t , is produced by the perfectly competitive firm. This good is produced
 280 by combining a continuum of intermediate goods indexed by $i \in [0, 1]$, according to the
 281 technology $Y_t = \left[\int_0^1 y_t(i)^{1/\lambda_f} di \right]^{\lambda_f}$. Here, $1 \leq \lambda_f < \infty$ measures the degree of substitutability
 282 among intermediate goods. Perfect competition implies that the final-good firm takes output
 283 and input prices as given.

284 Each intermediate-good firm has monopoly power in the supply of good i . This good is
 285 produced using the technology $y_t(i) = K_t(i)^\alpha (z_t h_t(i))^{1-\alpha} - \Theta z_t^*$, where, $0 < \alpha < 1$, $h(i)$ and
 286 $K(i)$ denote labor and capital used by firm i , and Θ is a fixed cost that guarantees profits are
 287 zero in the steady state. Intermediate firms rent capital and labor in perfectly competitive
 288 factor markets. Furthermore, these firms must borrow the wage bill in advance from a financial
 289 intermediary at the gross interest rate, R_t . Finally, prices are set in a Calvo fashion. That
 290 is, each period, an intermediate-good firm revises its price with an exogenous probability
 291 $1 - \xi_p$. If this firm does not re-optimize prices, then its price is updated according to the
 292 rule: $P_t(i) = \pi_{t-1} P_{t-1}(i)$, where π_{t-1} is inflation over the previous period. The log-deviations

293 of the growth rates of z and Υ , $\hat{\mu}_z$ and $\hat{\mu}_\Upsilon$, follow $AR(1)$ processes: $\hat{\mu}_{z,t} = \rho_z \hat{\mu}_{z,t-1} + \varepsilon_{z,t}$,
 294 $\hat{\mu}_{\Upsilon,t} = \rho_\Upsilon \hat{\mu}_{\Upsilon,t-1} + \varepsilon_{\Upsilon,t}$, where $0 < \rho_z < 1$; $\varepsilon_{z,t}$ and $\varepsilon_{\Upsilon,t}$ are iid shocks with standard deviations
 295 σ_Υ and σ_z , respectively.

296 Banks receive $M_t - Q_t + (x_t - 1)M_t$ from households (which includes the monetary transfer
 297 from the government, $x_t M_t^a$.) Note that the equilibrium condition, $M_t = M_t^a$, has been im-
 298 posed. Banks in turn lend money to firms and request a gross interest rate R_t . At the end of
 299 the period, the financial intermediary transfers principal plus interest payments to households.
 300 Market clearing in the loan market requires $w_t H_t = x_t M_t - Q_t$.

301 3.3. Monetary and Fiscal Policy

302 Monetary policy has a parsimonious representation:

$$\begin{aligned} \hat{x}_t &= \hat{x}_{z,t} + \hat{x}_{M,t} + \hat{x}_{\Upsilon,t}, & \hat{x}_{M,t} &= \rho_M \hat{x}_{M,t} + \varepsilon_{M,t}, & (7) \\ \hat{x}_{z,t} &= \rho_{xz} \hat{x}_{z,t-1} + \varsigma_z \varepsilon_{z,t} + \varsigma_z^1 \varepsilon_{z,t-1}, & \hat{x}_{\Upsilon,t} &= \rho_{x\Upsilon} \hat{x}_{\Upsilon,t-1} + \varsigma_\Upsilon \varepsilon_{\Upsilon,t} + \varsigma_\Upsilon^1 \varepsilon_{\Upsilon,t-1} \end{aligned}$$

303 Here, x represents the gross growth rate of the aggregate stock of money, M_{t+1}^a/M_t^a . The
 304 disturbance ε_M denotes a monetary policy shock with standard deviation σ_M . The terms $\hat{x}_{z,t}$
 305 and $\hat{x}_{\Upsilon,t}$ capture the response of the monetary authority to innovations in neutral and capital
 306 embodied technology, respectively. An accommodative monetary policy like (7) improves
 307 the model's predictions with respect to the effects of technology shocks (see, for example,
 308 ACEL). Finally, the government adjusts lump sum taxes to ensure that its intertemporal
 309 budget constraint is satisfied.

310 The experiments outlined in Section 5 analyze the effects of financial innovations by assum-
 311 ing that every aspect of the economy except the portfolio selection part remains unchanged.
 312 Hence, the monetary policy described in equation (7) is a good approximation of the Fed's pol-
 313 icy prior to the financial innovations of the early 1980s (see, Christiano et al., 1999, Friedman
 314 and Kuttner, 1996, and Walsh, 2003).

315 3.4. *Parameterization*

316 Table 2 reports the parameters used for the simulations reported in Section 5; the values
 317 are taken from CEE and ACEL. A crucial parameter in the model is the Calvo probability
 318 of money adjustment: ξ . The related literature offers little guidance on how to choose this
 319 parameter. One possibility is to resort to Vissing-Jorgensen's (2002) study about investors'
 320 preferences. However, setting ξ to match her findings is a poor approximation, since my study
 321 does not directly model the stock market. Here, because the money demand equation (4) is
 322 a moment restriction, I choose to estimate it via GMM. Such an approach allows us to infer
 323 the semi-elasticities and the Calvo probability associated with money directly from the data.

324 4. **Estimating the Demand for Money**

325 Data are U.S. quarterly and the sample period covers 1960:I-2005:IV. All data come from
 326 the St. Louis Fed. Nominal consumption is measured by personal consumption expenditure
 327 on non-durable goods (GCN), plus personal consumption expenditure on services (GCS). The
 328 price index is measured by the ratio of nominal to real output. The gross interest rate,
 329 R_t , is computed using the 3-month Treasury bill rate (TB3MS). Output corresponds to real
 330 chain-weighted output (GDPQ).

331 The results in Goldfeld and Sichel (1990) and Guerron-Quintana (2007a) indicate that: 1)
 332 M1 is an inappropriate measure of money for transaction purposes, and 2) M1-based money
 333 demand is unstable. Although M2 might seem an obvious replacement for M1, this monetary
 334 aggregate includes small time deposits issued by financial institutions, which do not measure
 335 money spent in transactions as required by my formulation. I propose measuring transaction
 336 balances, Q_t in the model, with M2-minus (M2MSL). This monetary indicator, available from
 337 the St. Louis Fed, comprises M2 minus small-denomination time deposits. Hence, velocity is
 338 defined as the log of nominal income to M2-minus. The resulting variable is stationary, which
 339 is desirable for GMM estimation.

340 4.1. Results

341 Based on the studies of Eichenbaum and Fisher (2007), Gali and Gertler (1999) and Staiger
 342 and Stock (1997), I propose the following set of instruments: $X_{t-1} = \{1, g_{c,t-j}^*, V_{t-j}^*, R_{t-j}, j =$
 343 $1, 2\}$. As shown in Guerron-Quintana (2007a), using additional lags, alternative instruments,
 344 or different measures of interest rates and money (e.g. fed funds rate and money zero maturity)
 345 does not significantly change the results reported in Table 3. Optimal weighting matrices
 346 are used in the computation of the GMM estimates. The column J_T corresponds to the p-
 347 value of Hansen’s statistic for overidentifying restrictions. Values in parentheses are standard
 348 deviations.

349 The estimation exercise indicates that all coefficients are statistically significant. Hansen’s
 350 J statistic does not reject the model. More important, the estimated parameters concur with
 351 the model’s predictions: 1) The statistical significance of ϕ_2 indicates that the data support
 352 the presence of a forward-looking term in money demand, and 2) There is a substantial
 353 difference between short- and long-run elasticities; a permanent increase in interest rates of
 354 100 basis points implies an immediate decline of 1.04% and a long-run decline of 13.16% in
 355 real balances. The first figure is close to the low estimates reported in the literature (e.g.,
 356 ACEL; and Goldfeld and Sichel, 1990). Taking into account sampling error, the long-run
 357 estimate also falls in line with values found in the literature. Mankiw and Summers (1986),
 358 for example, find an interest semi-elasticity of 11. Furthermore, Stock and Watson’s (1993)
 359 study reports long-run semi-elasticities around 12.

360 The results described in this section and reported in Table 3 illustrate this paper’s first
 361 main point: different elasticities reported in the literature are not puzzling after taking into
 362 account the short- and long-run dynamics of money. Furthermore, the statistical and economic
 363 significance of the model indicates that the forward-looking money equation (4) satisfactorily
 364 describes the data covering 1960 – 2005.

365 **Subsample Analysis** As previously discussed, the late 1970s and early 1980s featured
 366 continuous financial innovations, including electronic banking and new banking regulations.

367 Additionally, several authors have argued that the U.S. economy became less volatile in the
 368 early 1980s, resulting in what Stock and Watson (2002) call the Great Moderation. Motivated
 369 by these observations, the money demand equation is re-estimated splitting the sample around
 370 1984 (Sims and Zha, 2004, identify this year as the most likely start of the moderation).

371 The results in Table 3 reveal that the money demand elasticities are closer to each other
 372 after 1984.⁹ To observe this pattern, compare $\zeta_{short} = 0.42$ and $\zeta_{long} = 4.72$ in the final
 373 sample with $\zeta_{short} = 3.00$ and $\zeta_{long} = 16.67$ in the initial period. The difference between the
 374 short- and long-run elasticities declines by a factor of three in the post-1984 sample. Guerron-
 375 Quintana (2007a) shows that this decline in the elasticities is robust to alternative breaking
 376 years. The elasticities' closeness in the second sample suggests that financial innovations in
 377 the 1970s and 1980s might entail reduced transaction costs, making it easier for households
 378 to adjust their money balances.¹⁰ Indeed, we observe in Figure 1 that the arrival of financial
 379 innovations nicely coincides with changes in interest rates and velocity.

380 In the model, easier portfolio adjustment and a diminishing distinction between the short-
 381 run and long-run dynamics of money are only possible with a decline in the Calvo probability
 382 ξ . As the next section discusses this decline is exactly what happens with the implied Calvo
 383 probabilities.

384 **Implied Frequency of Re-optimization** The model's expected time of portfolio rebal-
 385 ancing is given by $\frac{1}{1-\xi}$. We can use the GMM results to infer the implied frequency of
 386 re-optimization. In particular, the structural parameters are computed by solving the non-
 387 linear mapping $\tilde{\Phi} - \Phi(x) = 0$. Here, $x = [\eta \ \eta'' \ \xi]'$, $\tilde{\Phi}$ is the vector of estimated coefficients
 388 from our GMM procedure, η'' is the second derivative of the cost function, and $\Phi(x)$ is the
 389 vector mapping the structural parameters space into the reduced-form coefficients space (the
 390 interested reader is referred to the technical appendix for further details).

391 According to the results reported in Table 3, the probability of portfolio adjustment, ξ ,

⁹Lagged inflation and $(\hat{\pi}_{t-1} + \hat{g}_{c,t-1}^* + \hat{V}_{t-2}^*)$ were included as additional instruments to improve the model's statistical fit.

¹⁰Using a different methodology, Khan et al. (2003) uncover a decline in elasticity of money demand.

392 ranges from 0.67 to 0.84, meaning that households re-optimize their portfolios every 6 quarters
 393 on average in the upper bound, whereas they review their financial decisions every 3 quarters
 394 in the lower bound. Under the full sample scenario, the Calvo probability is 0.77. This large
 395 probability (and its implied frequency of re-optimization) is close to the microdata-based
 396 values reported in Vissing-Jorgensen (2002). Moreover, the smaller Calvo probability in the
 397 second subsample implies that households waited longer before re-optimizing in the pre-1984
 398 sample versus the post-1984 sample. Indeed, this result suggests that re-balancing money
 399 holdings became easier after 1984, thus confirming the hypothesis that money balances have
 400 become more flexible over time. Finally, the estimated transaction function, η , is close to
 401 the 0.036 found in ACEL. For the curvature of the transaction function, η'' , the estimation
 402 yields numbers close to zero, the largest being 0.004. To understand this result, note that the
 403 long-run semi-elasticity of money is proportional to the term $(2\eta' + \eta''V)^{-1}$; here, V is the
 404 steady state velocity. Hence, small values of η'' seem necessary to deliver a large long-run
 405 semi-elasticity.¹¹

406 5. Financial Sophistication and the Great Moderation

407 In the last section, I argued that financial innovations in the 1970s caused the structural
 408 break found in the demand for money. It now remains to show the link between the change in
 409 money demand and the Great Moderation in a DSGE framework. Two elements are essential
 410 to understanding this connection: 1) sluggish portfolios, and 2) households' use of cash to
 411 purchase consumption. To begin with, sticky portfolios imply that current money holdings
 412 were determined in the past. Unable to replenish cash balances, households must adjust
 413 consumption in response to shocks so that marginal utility remains constant as required by
 414 the complete market condition (3). Hence, volatility from shocks is passed to consumption.

415 In contrast, when portfolio re-balancing is more flexible, households can efficiently adjust
 416 cash balances to buffer shocks and achieve consumption smoothing. In terms of condition (3),
 417 money absorbs fluctuations in prices to keep consumption constant. Yet, one may wonder

¹¹The slope of the transaction cost function is pinned down by the steady state relation $R = 1 + \eta'V^2$.

418 to what extent financial innovations alone can account for the smoothing in the economy.
 419 To formally answer this question, consider the following experiment: Start by selecting three
 420 degrees of portfolio stickiness: $\xi = 0.84, 0.75,$ and 0.67 . The first and last values are the pre-
 421 and post-1984 GMM estimates, respectively. They are intended to capture the state of the
 422 economy before and after the financial innovations. Next, for each Calvo probability, simulate
 423 the model outlined in Section 3 using the monetary, neutral technology, and investment-
 424 specific shocks reported in ACEL. Finally, compute the theoretical standard deviations for
 425 real and nominal variables and compare them to the empirical ones.¹²

426 Table 4 reports the theoretical volatilities for different degrees of financial innovation (base-
 427 line model). To facilitate comparison with the data, the volatilities are reported relative to
 428 that of the highest portfolio sluggishness, $\xi = 0.84$. Two clear patterns emerge from this exer-
 429 cise. First, interest rates are substantially more volatile as portfolio adjustment becomes less
 430 frequent. To understand this result, note that large Calvo probabilities reduce participation
 431 in financial markets, since only a small fraction of households re-balance portfolios. Hence,
 432 following an expansionary monetary policy, interest rates must decline by a large amount to
 433 induce the few households active in the market to take the extra money. This large drop
 434 translates into substantial interest rate volatility. As the Calvo probability declines, more
 435 households are able to accept the additional funds, requiring a smaller drop in the interest
 436 rate, i.e., smoother time paths.

437 The second pattern is that moving toward portfolio flexibility drives down the volatility
 438 of output and investment growth by 34% and that of consumption growth by 23%; such
 439 drops correspond to two-thirds of those found in the data (Table 1). It was already argued
 440 that smooth consumption results from households' ability to optimize their portfolio more
 441 frequently. Optimality in turn requires that the rate of return on capital co-moves with
 442 interest rates.¹³ Other things equal, a decline in the volatility of the latter is accompanied
 443 by a smaller volatility in the former. Because the return on capital drives investment, more

¹²Guerron-Quintana (2007b) discusses alternative ways to conduct this experiment.

¹³Abstracting from adjustments in capital, optimal behavior equates the return of capital with the real interest rate, i.e., $r_{t+1}^k + 1 - \delta = \frac{R_t}{\pi_{t+1}}$. Here, r^k is the return on capital and δ is the rate of depreciation.

444 frequent portfolio re-balancing must be followed by a drop in the volatility of investment.
 445 Finally, the resource constraint, $y_t = c_t + i_t$, indicates that less volatility in consumption and
 446 investment delivers smaller fluctuations in output.

447 To gauge the effects of additional portfolio flexibility, Figure (2) displays simulated paths
 448 for interest rates and growth rates of output, consumption, and real balances under three
 449 scenarios: 1) The pre-financial innovation era characterized by high portfolio inflexibility,
 450 $\xi = 0.84$ (starred lines), 2) The post-financial innovation period with flexible portfolios, $\xi =$
 451 0.67 (solid lines), and 3) The same as in case 2 but with shocks 30% smaller (thick, dotted
 452 lines). To make the comparison meaningful, the shocks are common across the simulations.
 453 For convenience, the horizontal axis has been labeled with the years 1980 through 2000.
 454 The simulations for the last two cases start in 1984 to represent the beginning of the Great
 455 Moderation.

456 This counterfactual exercise shows that a) if portfolio stickiness had stayed at its pre-
 457 financial innovation levels, the economy would have remained highly volatile; b) the decline in
 458 the probability of portfolio adjustment found in the data indeed has contributed to smoothing
 459 the economy; and c) the smoothing comes at the expense of more volatile real balances. This
 460 third result precisely confirms the workings of the model: portfolio flexibility allows households
 461 to transfer volatility from consumption to money. It is reassuring to see that real balances
 462 have indeed become more volatile in the data. Scenario 3 reveals that when combining flexible
 463 portfolios and smaller shocks, the model predicts an even stronger smoothing of the economy.
 464 This last case is what most likely has happened over the past decades in the U.S.

465 Yet the results must be interpreted carefully. ACEL report that monetary and technology
 466 shocks combined explain around 50% of the variance of real and nominal variables at business
 467 cycle frequencies. Indeed, output growth had a volatility of 1.1% for the 1960-1983 period,
 468 while the model predicts a volatility of 0.42% for a Calvo probability of $\xi = 0.84$; recall this
 469 high probability corresponds to the pre-1984 period. An implication of these observations is
 470 that the change in the volatilities reported in Table 4 captures at most half of the variations
 471 found in the data. Consequently, when moving from a portfolio sluggishness of roughly 6

472 quarters to 3 quarters, the model accounts for one-third of the decline in the volatilities
 473 of output, consumption, and investment. In terms of real balances, the model predicts an
 474 increase in volatility of 50%. This prediction is probably an overstatement of reality because
 475 of the explanatory power of the model. Factoring in this effect implies that the model predicts
 476 a volatility increase for real balances of 25%, which is roughly two-thirds of the rise observed
 477 in the data (see Table 1).

478 The baseline model includes several assumptions in addition to the sticky portfolio adjust-
 479 ment assumption. To check whether the results are an artifact of the extra frictions, I repeat
 480 the simulations but exclude price and wage stickiness, habit formation, and adjustment costs
 481 in investment. The columns labeled No Nominal Frictions in Table 4 display the findings from
 482 the new scenario. As before, the volatilities are expressed relative to that of the highest port-
 483 folio sluggishness, $\xi = 0.84$. The new results are in line with those from the baseline model,
 484 i.e., a more flexible portfolio implies smoother real variables. Yet, the smoothing of output
 485 and consumption is smaller relative to those in the baseline scenario, while the smoothing of
 486 nominal variables is stronger. For instance, moving portfolio adjustment from every 6 quar-
 487 ters to 3 quarters decreases the volatility of output by 24 percentage points (compare this
 488 result to the 34% decline found in the baseline scenario). These findings are hardly surprising
 489 because in the absence of sluggish price and wage adjustments, the model is closer to dis-
 490 playing Modigliani's (1963) classical dichotomy. In other words, monetary shocks now induce
 491 fluctuations mostly in nominal variables.

492 Goldfeld and Sichel (1990), and Dynan et al. (2005) have previously highlighted the
 493 potential smoothing effects of financial innovations. However, these authors provide only
 494 indirect arguments about the effects of financial sophistication on the Great Moderation.
 495 Hence, my results can be seen as providing a formalization of their intuition. More important,
 496 this paper is closely related to those of Jermann and Quadrini (2007) and Mertens (2007).
 497 The first paper argues that financial innovations improved debt and equity financing in the
 498 business sector. Consequently, firms can dampen the effects of asset price shocks, which in
 499 turn translate into smoother production plans. Our studies share the feature that flexible

500 financial markets allow agents (households or firms) to transfer volatility from the real side to
501 the financial sector of the economy (from consumption to real balances in my case, and from
502 production to equity/debt in theirs).

503 Mertens (2007) shows that in the presence of deposit rate ceilings banks do not have
504 incentives to lend resources to firms. With low financial intermediation, his study continues,
505 firms fail to fully smooth out production. Hence, his results suggest that the removal of
506 interest rate caps (the introduction of the DIDMCA legislation in 1980) contributed to the
507 Great Moderation. Our studies both predict an increase in the volatility of real balances
508 and a smoothing of economic activity following more flexible financial markets. However, the
509 channels behind the moderation are different; his study attributes it to increased flexibility
510 in financial intermediation (reflected by the absence of interest rate caps), while my study
511 gives an essential role to flexibility on the household side of the economy (more frequent
512 portfolio re-balancing). In summary, my study complements the existent literature on financial
513 innovations.

514 **6. Concluding Remarks**

515 This paper has expanded the field's understanding of money demand in three ways. First,
516 I put forth a micro-founded dynamic money demand equation. To derive this equation, I show
517 that the tools from price-setting models can help manage the heterogeneity on the economy's
518 household side. The second contribution is to show that my model of money demand simulta-
519 neously accounts for low short-run interest elasticities and high long-run elasticities of money
520 demand. Estimates of these elasticities are in line with the findings in the literature. Finally,
521 this paper offers a simple explanation for the change in real balances, output, and consump-
522 tion volatility after 1984. Given estimates from the pre- and post-1984 samples, consumption
523 and output have been smoother since the financial innovations of the late 1970s facilitated
524 portfolio re-balancing.

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Table 1:
Summary Statistics of the Great Moderation in U.S. 1960 - 2005

	σ_y	σ_c	σ_i	σ_π	σ_r	$\sigma_{m/p}$
1960-1983*	1.14	0.57	4.37	2.76	3.88	4.16
1984-2005**	0.44	0.52	0.53	0.31	0.50	1.35
1960-2005**	0.81	0.84	0.83	0.91	0.81	1.19

NOTES: Standard deviations of 1) annual growth rates of output (y), consumption (c), investment (i), and real balances (m/p), and 2) annualized interest rates (r) and inflation (π). Data sources described in Section 4 in main text.

* Volatilities expressed in percentage points.

** Volatilities expressed as a fraction of those for the period 1960-1983

Table 2:
Parameter values for DSGE model used in simulations in Section 5

β	α	δ	ψ_L	μ_z	μ_x	ξ_w	ξ_p
Discount Factor	Capital Share	Depreciation	Labor Utility	Growth Rates		Calvo Probabilities	
0.99	0.36	0.025	1	1.00	1.017	0.72	0.82
b	ρ_γ	ρ_m		\varkappa	σ_m	σ_γ	σ_z
Habit Formation	Persistence Parameters			Cost of Invest	Volatility Parameters		
0.70	0.24	-0.03	0.90	3.28	0.33	0.30	0.07
λ_f	λ_w	ς_z^1	ς_γ	ς_γ^1	ς_z	ρ_{xz}	V
Elasticity Goods and Labor		Monetary Rule Parameters			Velocity		
1.01	1.05	1.42	0.25	0.13	3.00	0.33	0.45

NOTES: Values taken from Altig et al. (2005) and Christiano et al. (2005)

Table 3: GMM Estimates of the Money Demand Equation
 $\tilde{R}_t = \phi_1 \hat{V}_t^* + \phi_3 (\hat{\pi}_t + \hat{g}_{c,t}^* + \hat{V}_{t-1}^*) + E_t[\phi_2 (\hat{V}_{t+1}^* - \hat{g}_{c,t+1}^* - \hat{\pi}_{t+1})]$
Sample: 1960:I - 2005:IV

ϕ_1	ϕ_2	ϕ_3	ζ_{short}	ζ_{long}	η	η''	ξ	J_T
1.59 (0.72)	-0.70 (0.36)	-0.88 (0.35)	1.04 (0.40)	13.16 (3.34)	0.054 (0.54)	0.00 (2e-4)	0.77 (2e-3)	0.14
Sample: 1960:I - 1983:IV								
ϕ_1	ϕ_2	ϕ_3	ζ_{short}	ζ_{long}	η	η''	ξ	J_T
0.91 (0.42)	-0.45 (0.21)	-0.44 (0.21)	3.00 (1.72)	16.67 (3.92)	0.051 (0.24)	0.00 (1e-4)	0.84 (0.19)	0.27
Sample: 1984:I - 2005:IV								
ϕ_1	ϕ_2	ϕ_3	ζ_{short}	ζ_{long}	η	η''	ξ	J_T
1.47 (0.53)	-0.46 (0.29)	-0.95 (0.27)	0.42 (0.11)	4.72 (1.23)	0.034 (0.07)	0.004 (5e-4)	0.67 (0.01)	0.87

NOTES: Instruments are a constant and two lags of interest rates, growth rate of consumption, and velocity. Standard errors are in parenthesis and J_T is the p-value of Hansen's overidentification test. Data described in Section 4 in main text.

Definitions: R interest rate, π inflation, g_c^* growth rate of consumption, ζ semi-elasticity of money demand η and η'' transaction cost parameters, and ξ money demand Calvo probability.

Table 4: Volatilities from DSGE model with different Portfolio Stickiness

	Baseline Model			No Nominal Frictions		
ξ	0.84* (6 quarters)	0.75** (4 quarters)	0.67** (3 quarters)	0.84* (6 quarters)	0.75** (4 quarters)	0.67** (3 quarters)
$\sigma_{m/p}$	0.20	1.35	1.53	0.71	1.30	1.45
σ_y	0.42	0.78	0.66	0.27	0.84	0.76
σ_c	0.20	0.86	0.77	0.21	0.86	0.85
σ_i	1.14	0.77	0.65	0.44	0.74	0.63
σ_π	1.09	0.85	0.67	3.04	0.70	0.56
σ_r	2.41	0.76	0.58	1.54	0.64	0.45

NOTES: Standard deviations of 1) annual growth rates of output (y), consumption (c), investment (i), and real balances (m/p), and 2) annualized interest rates (r) and inflation (π).

* Volatilities expressed in percentage points.

** Volatilities expressed as a fraction of those for $\xi = 0.84$

Figure 1: Plots of velocity (defined as the log of nominal consumption to money), interest rates, the Great Moderation, and some financial innovations

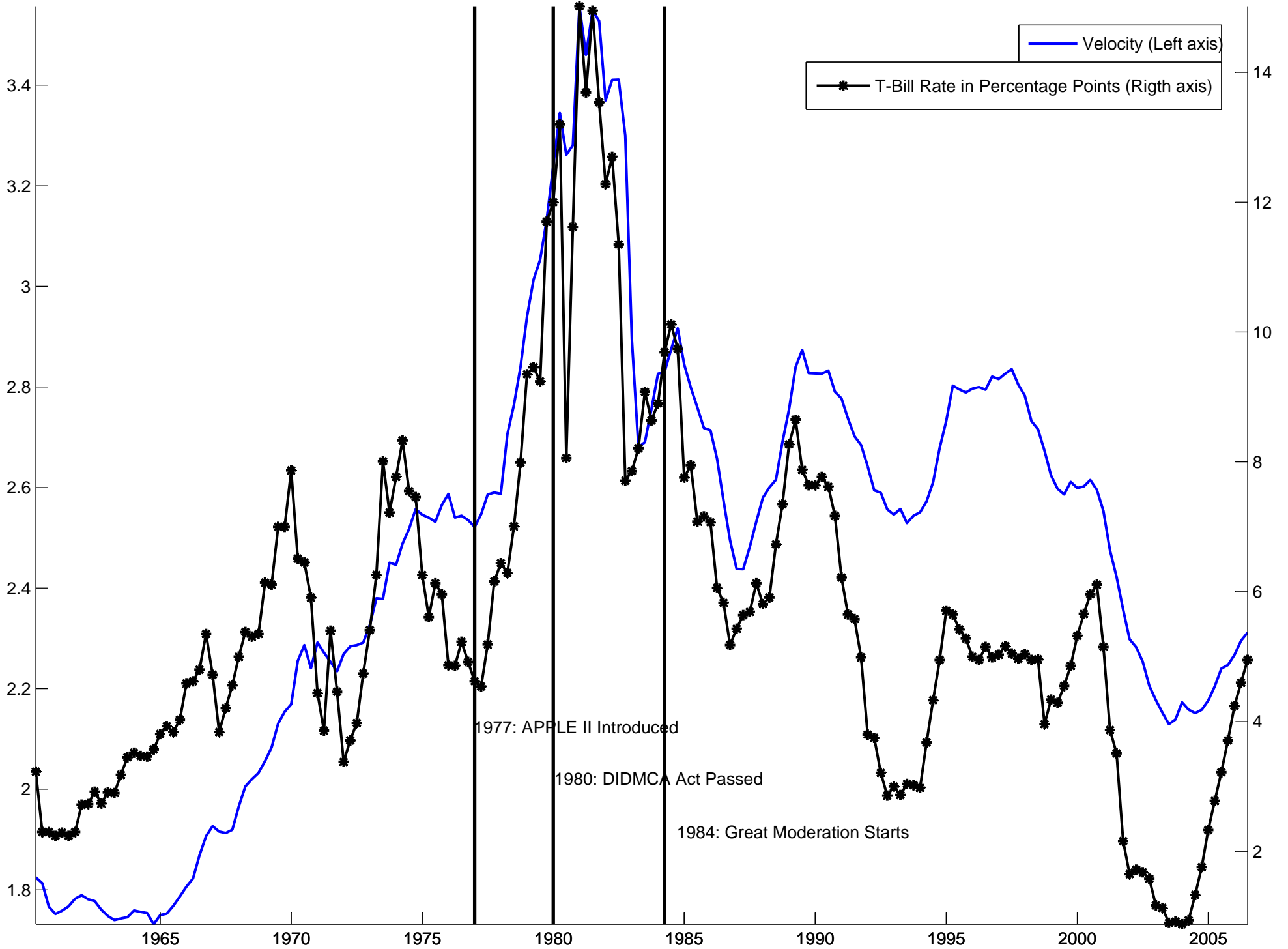


Figure 2: Simulated Paths DSGE Model with Different Portfolio Stickiness: High (Starred line), Medium (solid line) and Medium with small shocks (dotted line). Annualized levels for interest rates and annual growth rates for output, consumption and real balances

