Financial Innovations: An Alternative Explanation to the Great Moderation

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Abstract

This paper argues that the sustained decline in the volatilities of real variables over the past two decades in the United States can be partially attributed to financial innovations in the late-1970s. Prior to these changes, households faced significant transaction costs, which deterred them from fully adjusting their portfolios every period. Advances in information technology and financial deregulation decreased transaction costs, facilitating portfolio re-balancing and increasing household participation. Higher household participation decreases the volatility of interest rates, which in turn contributes to smoothing investment and consumption. When changing from a portfolio sluggishness of five quarters to three quarters my model can account for almost 25 percent of the observed decline in the volatilities of output, consumption, and investment.

Keywords: Great Moderation, Financial Innovation, Sluggish Portfolio Adjustment, Monetary and Technology Shocks.

JEL classification: E41, E47

1. Introduction

Over the past two decades, the U.S. economy has experienced a sustained decline in the volatility of several real variables resulting in what Stock and Watson (2002) call the Great Moderation. The literature seems to agree about the size of the Great Moderation and when it started. Table 1 reports the volatilities for inflation, interest rates and the growth rates of output, consumption, investment, and real balances. The first row corresponds to the volatilities for the period 1960-1983 while the volatilities for the other terms are normalized by those of the former period. Clearly, real variables are at least 50 percent less volatile after 1984 than before.[1] For example, the volatility of output growth declined by two-thirds in the post-1984 sample. Furthermore, real balances have become more volatile during the 1980s.

Yet academics disagree about the driving forces behind the Great Moderation. The decline in volatilities has been attributed to better monetary policy (Clarida, Gertler, and Gali, 2000), less volatile productivity shocks and commodity prices (Justiniano and Primiceri, 2006; and Stock and Watson, 2002), and unknown forms of good luck reflected in smaller forecast errors (Stock and Watson, 2002). This paper proposes that financial innovations during the late-1970s and early-1980s were important contributors to the Great Moderation.

Goldfeld and Sichel (1990), Dynan, Elmendorf, and Sichel (2005), Justiniano and Primiceri (2006), and Urban and Quadrini (2007) have previously highlighted the potential smoothing effects of financial innovations.[2] For example, Dynan et al. (2005) provide compelling evidence, which indicate that financial innovations played a key role in reducing the volatility of economic activity. Their findings suggest that advances in information technology and financial deregulation may have significantly lowered the cost of financial transactions (such as deposits, withdrawals, bond issuing, assessment and pricing of risk),

[1] Following the findings in Sims and Zha (2004), my model sets 1984 as the year when the smoothing of the economic activity started. For comparison purposes, I normalize the pre-1984 volatiles to 1.

[2] For an early discussion on the effects of financial innovation on the economy, see Pierce (1984).

making easier for households to re-balance their portfolios, widening household participation in financial markets, and ultimately enhancing the ability of households and firms to borrow funds. Section 2 of this paper describes financial innovations that have provided better access to financial markets by households, enabling them to adjust their portfolios more quickly to news in the market, and as a consequence more efficiently smoothing out consumption and investment.

My model, as detailed in Section 3 of this paper, implements the financial innovation hypothesis by assuming that households divide their money holdings into two parts: money for consumption purchases and money for financial investment. The transaction costs for a household to re-optimize her money holdings are modeled using time-dependent rules. This modeling technique yields nontrivial heterogeneity across households since money for purchases (and therefore consumption) depends upon the frequency of portfolio re-balancing. To control for household heterogeneity, I propose a methodology that is related to the heterogeneous price setting literature (see, for example, Altig, Christiano, Eichenbaum, and Linde, 2005; Christiano, 2004; Woodford, 2005). This method involves approximating choice variables such as individual consumption with a linear function of the source of heterogeneity, which in this case is individual money holdings.

The increased flexibility of portfolio re-balancing made possible by financial innovations has two consequences. First, a lower cost of making a portfolio adjustment results in a larger fraction of households adjusting their money balances every period. Hence, for a given change in money supply, interest rates have to move by a smaller amount before enough households accept the extra funds. The resulting less-volatile interest rates in turn reduce the volatility of the return on capital and decrease uncertainty in the economy.[3] The second consequence is that households can more freely adjust their allocation of monetary resources to consumption purchases. The combined effect of these two factors is a reduction in the volatility of consumption.

[3] Utility maximization by households requires that the rate of return on capital co-move with the interest rate. Therefore, the volatility of the latter directly affects that of the former.

Section 4 of this paper discusses how my model confirms the just described effects for different degrees of portfolio sluggishness by computing the volatilities for several nominal and real variables. Moving from high portfolio sluggishness, in which households re-balance their portfolios on average every five quarters, to moderate flexibility (portfolios are reviewed every 3 quarters) can account for roughly one-fourth of the decline in the volatilities of output, consumption, and investment. Moreover, the model explains 20% of the decline in inflation and almost half of the increase in the volatility of real balances.

By allowing household portfolio sluggishness to decline in discrete steps, the effects of financial innovation on the stochastic properties of my model can be easily tracked. This approach is an improvement over existing papers in the literature that usually study the effects of financial sophistication using two states of nature: complete and incomplete markets (see, for example, Baxter and Crucini 1995).

2. Financial Innovations in U.S.

Without any doubt, advances in computer and information technology have been the main source of innovation in financial markets. Some of the most important innovations happened during the late 1970s and early 1980s. Examples include the production of Intel's 16-bit microprocessor, the 8086, and the introduction of the first personal computers: the Apple II in 1977, the IBM PC in 1981 and the Commodore 64 in 1982. These advances in turn had significant affects on the banking sector. First, automated teller machines (ATMs) and electronic fund transfers (EFTs) became a standard in the industry.[4] As a consequence, customers could deposit and withdraw money more quickly and at a reduced fare compared to person-based transactions. Second, financial institutions gained access to statistical software that greatly simplifies credit risk assessment (VisiCalc, introduced in 1979, was the first spreadsheet for personal computers). This newly acquired ability enabled not only banks but also other players in the financial industry to lend money more

[4] Although, the first ATMs and ETFs were introduced in the 1960s, it was not until the early 1980s when they truly became key players in the banking industry. For example, the number of ATMs rose from less than 10,000 terminals in 1978 to roughly 324,000 in 2001 (Sienkiewicz 2002)

efficiently. Firms also benefited from the new risk valuation techniques as they progressively gained access to a market for high-risk debt.[5]

A second important source of innovation in financial markets has been major changes in banking legislation at the beginning of the 1980s. The Depository Institutions Deregulation and Monetary Control Act (DIDMCA) was introduced in 1980, which allowed, among other things, NOW and sweep accounts nationwide; eliminated interest rate ceilings on deposits and usury ceilings on loans; and increased deposit insurance to $100,000 per account. Two years later, Congress passed the Depository Institutions Act (Garn-St. Germain), which permitted depository institutions to offer money market deposit accounts (MMDAs). Together, these laws fostered greater integration between capital and credit markets and therefore led to better access to financing (see, for instance, Justiniano and Primiceri, 2006; Campbell and Hercowitz, 2004; Dynan et al., 2005).

An additional source of financial sophistication was the introduction of new banking products and interstate banking both aimed to boost banks profits. For example, in 1975 California allowed lending institutions to issue adjustable-rate mortgages, characterized by low initial interest rates, which made them very popular among house owners. With respect to branching, states such as Maine and Massachusetts introduced new legislation (1975 and 1982, respectively) that permitted out-of-state companies to buy banks in those states. Finally, the Chicago Board of Trade introduced in the mid 1970s the concept of financial derivatives.

Intuitively, the previous arguments suggest important improvements in the financial sector. However, we may wonder whether these innovations ultimately translated into higher participation of households in the financial markets. Fortunately, Vissing-Jorgensen (2002) provides such evidence. Using data from the PSID, she estimates that the annual cost for participating in the stock market declined by 43 percent between 1984 and 1994. Consistent with this decline in costs, she finds household participation in the stock market

[5] Dynan et al. (2005) reports 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.

increased from 28 to 44 percent for the same period. Her results, therefore, indicate that transaction costs declined and households traded more frequently. Furthermore, the timing of her study nicely relates to the early 80s financial innovations previously described. In Section 3, I provide further evidence supporting the notion that financial sophistication did indeed increased household participation.

In summary, in the late 1970s and early 1980s the U.S. economy was hit by important innovations in the financial industry. Ultimately, those innovations facilitated financial transactions by increasing the variety of instruments and services available to households and decreasing the cost per transaction.

3. Model

The basic framework of my model is that of Altig, Christiano, Eichenbaum, and Linde (2005, henceforth ACEL). Their formulation is rich enough to capture the business cycle properties of key variables after monetary and technology shocks.[6]

3.1. Households

The model features a continuum of households, indexed by $j \in (0, 1)$. Before any uncertainty is revealed, households have access to insurance provided by perfectly competitive firms. After learning the current state of nature, households make decisions regarding consumption, investment, capital, and labor supply. Simultaneously, households allocate their beginning-of-period cash between deposits at the bank and cash to be used for consumption transactions. The model assumes that households face a Calvo probability every time they optimize transaction balances.

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

[6] Their model has become the baseline formulation in the monetary economics literature. For example, Schmitt-Grohe and Uribe (2005) use a version of ACEL to formulate optimal monetary policy. Justiniano and Primiceri (2006) extend ACEL's formulation to incorporate stochastic volatility.

households choose consumption, labor, capital, investment, and real balances based on the following maximization problem

$$\max_{\substack{c,M,Q\\k,w}} E_t^j \sum_{l=0} \beta^l [\log(C_{j,t+l} - bC_{t+l-1}) - \psi_L \frac{h_{j,t+l}^2}{2}] \tag{1}$$

subject to

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

Here, E_t^j is the time t expectation operator conditional on the information set of household j; $b > 0$; $\psi_L > 0$; and S is a function reflecting the costs associated to adjusting the investment portfolio. This function is assumed to be increasing and convex satisfying $S = S' = 0$ and $\varkappa \equiv S'' > 0$ in steady state. A_i is household i's net cash inflow from the insurance markets. The term Υ is an investment-specific shock. In the household's constraint the following notational and timing conventions hold: $w_{j,t}$, $M_{j,t}$, and $Q_{j,t}$ denote the beginning of period nominal wage, stock of money and nominal balances of household j. The quantity $(x_t - 1)M_t^a$ is a lump-sum transfer made to household j by the monetary authority, and x_t is the gross growth rate of the stock of money, M_t^a. The quantity R_t is the gross interest rate paid by the financial intermediary to households. My model does not index consumption and investment to reflect the complete markets assumption. Finally, my model displays external habit persistence.

Money is introduced into the model is by assuming that the purchase of goods requires the payment of transaction services. These transaction costs depend on individual velocity, $V_{j,t} \equiv p_t C_{j,t}/Q_{j,t}$, through the function η with positive first and second derivatives.[7]

[7] This way of modeling money originated in Sims (1994) and has been applied widely. See Schmitt-Grohe and Uribe (2005) and Altig et al. (2004) for examples.

3.1.1. Money Holdings Setting

The main assumption in the basic formulation (1) comes from time-dependent portfolio adjustment; agents re-optimize their money balances, Q, infrequently, similar in spirit to the price- and wage-setting models of Woodford (2003) and Christiano, Eichenbaum, and Evans (2005). This friction is likely to capture two important aspects of the economy. First, it measures the degree of access to financial and banking services enjoyed by households. Prior to the widespread use of ATMs, electronic banking, and the branching liberalization of the early 1980s, households spent an important amount of resources managing their accounts. For example, money deposits and withdrawals had to be made during business days as banks were closed on weekends. Consequently, households had limited access to such services, which is parsimoniously captured in the model by infrequent portfolio re-balancing.

Second, the time-dependent assumption captures the costs faced by households when assessing the uncertainty surrounding the economy and the financial system. The presence of large costs make harder for households to determine the state of the economy and in particular the risk exposure of banks. As a consequence, households may opt to limit their participation in financial markets. Moreover, households may keep real balances for purchase purposes as well as for precautionary savings. The computer and banking revolution of the 1980s most likely contributed to decrease those costs and ultimately increase household participation in financial markets.

We can also think of the portfolio friction as indirectly capturing the infrequent participation of trading agents in the equity market reported by Vissing-Jorgensen (2003). As before, I interpret this infrequent re-optimization as the result of costs faced by households. The basic idea is that in the presence of these costs, households fully optimize their portfolio only periodically, and follow simple rules for changing their portfolio at other times. The type of costs I have in mind are those associated with optimization (e.g., costs associated with information gathering, decision making, negotiation, and communication). The sluggish portfolio adjustment idea is formalized in assumption 1.

Assumption 1: Only a fraction, $1 - \xi_{po}$, of randomly chosen households is allowed to re-optimize their balances every period. The rest of the population follows a rule outlined in Assumption 2.

Notice that a decline in ξ_{po} implies more frequent portfolio adjustment or higher household participation in the financial system. Hence, financial sophistication is captured in the model by such drops in the Calvo probability. The literature on portfolio choice provides little guidance regarding how to model inactive households.[8] One possibility is that they follow a rule of thumb. As in the Calvo pricing literature, my model assumes that inactive households increase their monetary holdings at the rate of inflation.

Assumption 2: If a household is not allowed to re-optimize today, then her money holdings are adjusted according to the rule $Q_{i,t} = \pi g_c Q_{i.t-1}$, where π represents the steady state economy-wide inflation, and g_c is the growth rate of consumption in steady state.

The presence of g_c in the indexation rule implies that there are no distortions from portfolio dispersion along the steady state growth path.

Assumption 3: There exists insurance provided by competitive companies. Moreover, agents can contract upon any uncertainty, including that created by Calvo, with the insurance companies.

This last assumption, which has been extensively used in the Calvo pricing literature (see Erceg, Henderson, and Levin 2000 and Woodford 2003), aims to reduce the degree of heterogeneity across households resulting from time-dependent portfolio adjustment. A consequence of this market completeness is that households value an extra dollar equally: $\lambda_{j,t} = \lambda_{j',t}$ for households j and j', where λ is the budget multiplier (for more details see the technical appendix to Christiano, Eichenbaum, and Evans 2005). By employing this assumption, I focus on the direct effects of the Calvo friction on consumption and money balances.

To derive the optimal money holdings for household j that can re-optimize at time t,

[8]For an authoritative survey see Campbell and Viceira (2002).

take the FONC for Q_t:

$$0 = \left[-R_t + 1 + \eta'(V_{j,t}) \left(\frac{p_t c_{j,t}}{Q_{j,t}} \right)^2 \right] + E_t^j \sum_{l=1}^{\infty} (\xi_{po}\beta)^l \frac{\lambda_{t+l+1}}{\lambda_t} \left[\begin{array}{c} (-R_{t+l}+1)(\pi g_c)^l + \\ \frac{\left(\eta_{j,t+l}^t\right)'}{(\pi g_c) l} \left(\frac{p_{t+l} c_{j,t+l}}{Q_{j,t}} \right)^2 \end{array} \right], \tag{2}$$

where $\eta_{j,t+l}^t \equiv \eta(V_{j,t+l}^t)$, $V_{j,t+l}^t \equiv \frac{p_{t+l} c_{j,t+l}}{(\pi g_c)^l Q_{j,t}}$ and E_t^j is the expectation operator upon the event that household j does not re-optimize her money balances after period t.[9] The Lagrangian multiplier, λ, is not indexed (reflecting my assumption of insurance markets).

In the absence of time-dependent portfolio adjustment, the optimal condition for money balances requires that the cost of an extra unit of balances, R_t, equal the benefits of the decrease in the transaction cost: $R_t = 1 + \eta'(V_t) \left(\frac{p_t c_t}{Q_t} \right)^2$. No extra costs or gains arise under these circumstances because households can choose a new portfolio freely in the next period. In contrast, with time-dependent portfolio adjustment, the costs and benefits of an extra unit of money balances extends well beyond the current period because with positive probability households must retain their current nominal balances, indexed by inflation, next period. In the second period, losses come from the foregone interest income $\pi g_c R_{t+1}$.[10] On the other hand, gains come from the savings on transaction costs, $\pi g_c + \frac{\left(\eta_{t+1}^t\right)'}{\pi g_c} \left(\frac{p_{t+1} c_{t+1}}{Q_t} \right)^2$. Because these costs and gains arrive during the next period with probability ξ_{po}, they must be discounted using the household's stochastic discount factor, $\xi_{po}\beta \frac{\lambda_{t+1}}{\lambda_t}$. The combination of these terms corresponds to the second element of equation (2). This argument can be extended readily to subsequent periods.

Deriving a tractable money demand equation from equation (2) presents two challenges. First, as in the Calvo pricing literature, the conditional expectation $E_t^j \left(\eta_{j,t+l}^t \right)' \left(\frac{p_{t+l} c_{j,t+l}}{Q_{j,t}} \right)^2$ must be evaluated only across those histories in which household j

[9] As shown in Woodford (2005), the operator E_t^j delivers different results compared to the most common expectation operator E_t which integrates across all states of the nature.

[10] The indexation rule stated in Assumption 2 implies that money balances, Q, grow at rate πv in steady state. Hence, there is an extra term in front of the interest rate.

has not re-optimized her money balances. However, her consumption, $c_{j,t+l}$, depends on all continuation histories including those in which the household can re-optimize her balances. Second, in spite of the insurance market assumption, the presence of the transaction function η implies that consumption is still heterogeneous across agents. As contingent markets equate the marginal utility of wealth across households,

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

for households j and j'. Because money holdings differ across households, so too does consumption.

To manage these complications, my model extends the procedure outlined in Woodford (2005). First, to remove the nonlinear terms, my model takes a log-linear approximation of equation (2) about steady state. The proposition proved in the appendix shows that this equation does indeed admit a first-order Taylor approximation under mild assumptions. Second, because only active households absorb additional funds in the market after a monetary shock, then other things equal, velocity of active households is smaller than that of inactive households. The only source of this differential lies in the sluggish adjustment setup. Thus, individual velocity must be a function of economy-wide velocity plus a term that depends on individual money holdings relative to economy-wide money balances. Therefore, I guess and verify that, as a log-linear approximation, the velocity for household j is:

$$\widehat{V}_{j,t} = \widehat{V}_t^* + \Psi \widehat{\left(\frac{Q_{j,t}}{Q_t^*}\right)},$$

where Ψ is a coefficient to be determined and $\widehat{V}_t^*$ is the economy-wide velocity.[11] Note that this solution is valid under the first-order Taylor approximation used to solve equation (2), and is accurate up to an error term of order $o\left(||\varepsilon||^2\right)$.[12] By combining equations (2) and

[11] It is not difficult to show that this method can be extended to handle heterogeneous labor supply in an economy displaying non-separable utility.

[12] This factor represents all terms that are of second order or higher in the deviations of the variables from their steady state.

(3), the aggregate money demand equation and the coefficient Ψ are given by (the result is shown in a technical appendix available upon request):

$$\begin{aligned} \widetilde{R}_t &= c_1 \widehat{V}_t^* + c_3(\widehat{\pi}_t + \widehat{g}_{c,t}^* + \widehat{V}_{t-1}^*) + E_t[c_2(\widehat{V}_{t+1}^* - \widehat{g}_{c,t+1}^* - \widehat{\pi}_{t+1})], \\ \Psi &= -\frac{\rho}{\rho + \tau}. \end{aligned} \quad (4)$$

Here the reduced-form coefficients, c_i and τ, depend on the structural parameters; starred variables correspond to aggregate variables; ρ is the coefficient of risk aversion; and ν is the growth rate of consumption. In equation (4), the gross interest rate, $\widetilde{R}_t$, represents deviations of the interest rate from its steady state value. The negative coefficient in front of relative money balances confirms the suspicion that households with larger money holdings have smaller individual velocities.

3.1.2. Wage Setting

Each household is a monopolistic supplier of a differentiated labor service, say $h_{j,t}$. Households sell these labor services to a competitive firm that aggregates labor and sell it to intermediate firms. The technology used by the aggregator is

$$L_t = \left[\int_0^1 h_{j,t}^{1/\lambda_w} dj \right]^{\lambda_w}, \quad 1 \leq \lambda_w < \infty.$$

It is straightforward to show that the relation between the labor aggregate and the wage aggregate, W_t, is given by

$$h_{j,t} = \left[\frac{W_t}{w_{j,t}} \right]^{\frac{\lambda_w}{\lambda_w - 1}} L_t.$$

Some households do not change nominal wages (with exogenous probability ξ_w). In those cases, wages are set according 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 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 is a neutral technology shock defined below.

3.2. Firms

The economy consists of two types of firms: final-good firms and intermediate-good firms. The former behave competitively while the latter enjoy some monopoly power. At time t, a consumption good, Y_t, is produced by a perfectly competitive firm. This good is produced by combining a continuum of intermediate goods indexed by $i \in [0, 1]$, according to the technology

$$Y_t = \left[\int_0^1 y_t(i)^{1/\lambda_f} di \right]^{\lambda_f},$$

where $1 \leq \lambda_f < \infty$ measures the degree of substitutability between intermediate goods, $y_t(i)$. Perfect competition implies that the final-good firm takes output and input prices as given.

My model assumes that each intermediate-good firm, i, has monopoly power in the supply of good i. This good is produced using the technology

$$y_t(i) = \max \left\{ k_t(i)^\alpha (z_t h_t(i))^{1-\alpha} - \phi z_t^*, 0 \right\},$$

where $0 < \alpha < 1$, $h(i)$ and $k(i)$ denote labor and capital used by firm i, and ϕ is a fixed cost that guarantees profits are zero in steady state. Firms rent capital and labor in perfectly competitive factor markets. Furthermore, firms must borrow the wage bill in advance from a financial intermediary at the gross interest rate, R_t. Finally, intermediate-good firms set prices in a Calvo fashion. That is, in each period, a firm revises its price with an exogenous probability $1 - \xi_p$. If this firm does not re-optimize its price, then its price is updated according to the rule: $P_t(i) = \pi_{t-1} P_{t-1}(i)$, where π_{t-1} is inflation over the previous period.

The log-deviation of growth rate of z and Υ, $\widehat{\mu}_z$ and $\widehat{\mu}_\Upsilon$, follow $AR(1)$ processes: $\widehat{\mu}_{z,t} = \rho_z \widehat{\mu}_{z,t-1} + \varepsilon_{z,t}$, $\widehat{\mu}_{\Upsilon,t} = \rho_\Upsilon \widehat{\mu}_{\Upsilon,t-1} + \varepsilon_{\Upsilon,t}$, where $0 < \rho_z < 1$ and $\varepsilon_{z,t}$ and $\varepsilon_{\Upsilon,t}$ are uncorrelated over time and with all other shocks in the economy.

3.3. Monetary and Fiscal Policy

My model adopts a parsimonious representation for monetary policy:

$$\begin{aligned} \widehat{x}_t &= \widehat{x}_{z,t} + \widehat{x}_{M,t} + \widehat{x}_{\Upsilon,t}. \qquad (5) \\ \widehat{x}_{M,t} &= \rho_M \widehat{x}_{M,t} + \varepsilon_{M,t}, \\ \widehat{x}_{z,t} &= \rho_{xz} \widehat{x}_{z,t-1} + \varsigma_z \varepsilon_{z,t} + \varsigma_z^1 \varepsilon_{z,t-1}. \\ \widehat{x}_{\Upsilon,t} &= \rho_{x\Upsilon} \widehat{x}_{\Upsilon,t-1} + \varsigma_\Upsilon \varepsilon_{\Upsilon,t} + \varsigma_\Upsilon^1 \varepsilon_{\Upsilon,t-1} \end{aligned}$$

Here, x represents the gross growth rate of money, M_{t+1}^a / M_t^a. The disturbance ε_M denotes a shock to monetary policy, whereas ε_z is a neutral technology shock. The terms σ_M and σ_z denote the standard deviation of those shocks, respectively. The term $\widehat{x}_{z,t}$ captures the response of the monetary authority to an innovation in neutral technology. In addition, the term $\widehat{x}_{\Upsilon,t}$ describes the response of monetary policy to an innovation in capital embodied technology. An accommodative monetary policy like (5) improves a model's predictions with respect to the effects of technology shocks (see, for example, ACEL). Finally, the government adjusts lump sum taxes to ensure that its intertemporal budget constraint is satisfied.

In the experiments outlined in Section 4, I analyze the effects of financial innovation by assuming that every aspect of the economy except the portfolio selection part remains unchanged. Hence, the monetary policy described in equation (5) is best suited for the experiment as money growth targeting is likely to be a good approximation of the Fed's policy prior to the financial innovations of the early 1980s (see, Walsh, 2003, and Friedman and Kuttner, 1996).

3.4. The Loan Market

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

$$w_t H_t = x_t M_t - Q_t.$$

3.5. Parameterization

Since my formulation is a modified version of ACEL, I borrow most of the parameter values and shock processes from their study. Table 2 reports the parameters used in this study. A crucial parameter in my specification is the Calvo probability of money adjustment: ξ_{po}. Unfortunately, the related literature offers little guidance on how to choose that parameter. One possibility is to resort to Vissing-Jorgensen's (2002) study about investors' preferences. However, setting ξ_{po} to match her findings is a poor approximation as my study does not directly model the stock market. A second possibility is to use the ad hoc values suggested in Atkeson et al. (2003).[13]

A final possibility is to directly estimate the money demand equation (4). In the accompanying paper entitled "Time-Dependent Portfolio Adjustment: Yet Another Look at the Dynamics of the Demand for Money," I estimate different versions of (4) via GMM. This partial information approach is perfectly suited for I am solely interested in the dynamics of money demand. The results there suggests that money demand has become more flexible over time. Furthermore, the estimates consistently indicate that the Calvo probability has declined from roughly 0.80 during the 70s and early 80s to around 0.70 in the last part of the 80s and 90s. Facing this evidence, I use three Calvo probabilities $\xi_{po} = 0.67$, 0.75, and 0.80, corresponding to different degrees of financial innovation with the lowest probability reflecting the highest degree of financial innovation. Interestingly this selection is consistent with the values suggested in Vissing-Jorgensen and Atkeson et al.

[13] Vissing-Jorgensen (2002) estimates that households re-balance their portfolios on average every year and half. Alvarez et. al. (2003) assume re-balancing times between 18 and 36 months.

4. Results: Financial Sophistication and the Great Moderation

This section explores the affects that a decrease in the Calvo probability for portfolio adjustment has on the volatility of several economic variables. As described in Section 3, a decrease in this probability is equivalent to a decline in the costs associated with portfolio re-balancing, which is the result of the financial innovations described in Section 2. To isolate the effects that such innovations had in the U.S. economy, I propose the following experiment: First, I choose three Calvo probabilities $\xi_{po} = 0.67$, 0.75, and 0.80. Next, I feed the model with the monetary, neutral technology, and investment-specific shocks estimated in ACEL. Finally, I compute the standard deviations for interest rates, inflation, and the growth rates of real balances, consumption, investment, and output. I repeat this procedure for each Calvo probabilities.[14]

4.1. Baseline Case

Figure (1) displays the resulting model-simulated paths of the deviations from steady state for the interest rate and the growth rates of consumption, investment, and output. Solid lines correspond to very infrequent portfolio adjustment, $\xi_{po} = 0.80$, whereas starred lines show the variables' response with more frequent adjustment, $\xi_{po} = 0.67$. Note that interest rates are more responsive as portfolio adjustment becomes more infrequent. This result is expected since higher Calvo probabilities imply lower participation in the financial market. Suppose, for example, that the monetary authority increases the money supply, either from a shock to its monetary policy or because of its response to a technology shock; then interest rates must decline by a lot to induce the few households present in the market to take the extra money. If the Calvo probability is low, more households are willing to take the additional funds, requiring a smaller drop in the interest rate.

With infrequent portfolio re-balancing, households cannot fully smooth out consumption

[14] Similar results were obtained if instead we resort to Cooley and Prescott's (1994) method of simulating the model 100 times with each simulation of length 180, the structural shocks drawn from distributions $N(0, \sigma)$, and then reporting the average standard deviations for each variable.

as money for transaction purposes has already been determined in the past. Consequently, consumption and output are very volatile. However, as portfolio re-balancing becomes more frequent, households transfer volatility from consumption to real balances. The right upper panel of figure (1) confirms this intuition. Alternatively, optimal behavior by households relates the growth rate of consumption to interest rates.[15] Increasing portfolio flexibility decreases the volatility of interest rates that, through the first order conditions, implies smoother consumption. A second consequence of smaller volatility in consumption is that prices and therefore inflation fluctuate less.

Utility maximization by households requires that the rate of return on capital co-moves with the interest rates.[16] Other things equal, a decline in the volatility of the latter is accompanied by smaller volatility in the former. Because the return on capital drives investment, more frequent portfolio re-balancing should be followed by a drop in the volatility of investment. Figure (1) shows exactly this decline. Finally, through the resource constraint, $y_t = c_t + i_t \Upsilon_t^{-1}$, less volatile consumption and investment imply smaller fluctuations in output. This result is confirmed in the left upper panel of figure (1). To further confirm the smoothing of output, figure (2) displays the impulse responses of output growth to the three shocks. Notice that with high portfolio inflexibility, output is more reactive (volatile) to those shocks.

Table 3 reports the volatility of the variables for three different degrees of financial innovation. To facilitate comparison with the data, the volatilities for the moderate and low degrees of portfolio inflexibility, $\xi_{po} = 0.75$ and $\xi_{po} = 0.67$, respectively, are expressed relative to that of the highest portfolio sluggishness, $\xi_{po} = 0.80$. There are three clear features in Table 3. First, moving towards portfolio flexibility drives down the volatility of output and investment by 25 percent and that of consumption by 17 percent. Almost half of the total decline happens when households move from adjusting their portfolio on average

[15] Suppose for a moment that there is no cost involved in buying goods, $\eta = 0$, and no habit formation, $b = 0$. Then, combining the optimal conditions for consumption and that for money holdings, $c_{t+1}/c_t = \beta R_{t+1}/\pi_{t+1}$.

[16] Abstracting from costly adjustment in capital, optimal behavior equates the return of capital with the real interest rate, i.e., $r^k_{t+1} + 1 - \delta = \frac{R_t}{\pi_{t+1}}$. Here, r^κ is the return on capital and δ is the rate of depreciation.

every five quarters, $\xi_{po} = 0.80$, to every four quarters, $\xi_{po} = 0.75$. This occurs because the largest increase in the fraction of active households happens from the initial decline in the Calvo probability.

The second notable regularity is that the volatility of real balances increases by 36 percent. This increase is more notorious than the decline in the volatilities of real variables. This prediction is probably an overstatement of reality. To see why, note that during the 1980s households' holdings of money (currency plus checking accounts) accounted for roughly half of M1 (numbers based on the Federal Reserve Board's Flow of Fund Account). Hence, the volatility increase for real balances in Table 3 explains at most half of the observed decline.

Third, interest rates become smoother as the Calvo probability declines. These last results are expected because the interest rate and money holdings are the variables that mainly absorb monetary and technology shocks in the presence of portfolio inflexibility. Therefore, a substantial jump in those variables is required to restore equilibrium after the monetary authority injects additional funds into the economy.

Yet the results must be interpreted carefully. ACEL report that monetary and technology shocks combined explain roughly 50 percent of the variance of output, consumption, investment, and inflation at the business cycle frequencies. Moreover, a comparison of the results in Tables 1 and 3 indicates that my model delivers less volatility than the data. Indeed, output growth had a volatility of 1.1% for the period 1960-1983 while my model predicts a volatility of 0.42% for a Calvo probability of $\xi_{po} = 0.80$; recall that the highest portfolio stickiness in my formulation is assumed to capture the characteristics of the pre-1984 period. An implication of these observations is that the change in the volatilities reported in Table 3 captures at most half of the variations found in the data. Consequently, when moving from a portfolio sluggishness of roughly five quarters to three quarters, the model accounts for almost one-fourth, or 25% percent, of the decline in the volatilities of output, consumption, and investment. In the next section I explore how other frictions present in the model affects its volatility predictions.

4.2. The Role of Other Frictions

The baseline model includes several additional frictions on top of the sluggish portfolio adjustment assumption. To check whether the results of the previous section are an artifact of the extra frictions, I repeat the simulations but excluding price and wage stickiness, habit formation, and adjustment costs in investment. The columns labeled No Nominal Frictions in Table 4 display the findings from the new scenario. As before, the volatilities are expressed relative to that of the highest portfolio sluggishness, $\xi_{po} = 0.80$. A quick look at the new results reveals that they are in line with the findings from the baseline model, i.e. higher portfolio flexibility implies smoother real variables. However, we note that the smoothing of output, consumption and inflation is less notorious relative to those in Table 3 while nominal variables become more volatile. For instance, moving portfolio adjustment from every 5 quarters to 3 quarters decreases the volatility of output by 18 percentage points (compare this result to the 25 percent decline found in the baseline scenario). These findings are hardly surprising because in the absence of sluggish price and wage adjustment the model is closer to displaying Modigliani's (1963) *classical dichotomy.* In other words, monetary shocks now induce fluctuations mostly in nominal variables.

In my formulation, firms must pay the wage bill in advance (see Section 3.2). Hence, interest rate affect the economy through its direct influence on households as well on firms. To evaluate the effect of the wage-in-advance assumption, I repeat the experiment outlined in the previous section but I suppress that assumption. The columns labeled No Wage in Advance corresponds to this new case. As before, the results are qualitatively consisted with those derived from the baseline scenario. Some important departures are: 1) the increase in the volatility of real balances is less notorious while the drop in the variability of interest rates is stronger than in the baseline case, and 2) there is a stronger decline in the volatility of consumption (10 percentage points more than in the baseline case). To understand this result, recall that when firms do not borrow the wage in advance, households must absorb all additional funds after a monetary shock; hence, interest rates must drop considerably. Portfolio flexibility allows more households to assimilate the monetary shock inducing smoother interest rates, which in turn reduces the volatility of bank and capital returns. Ultimately, consumers translate more certain returns into smoother consumption patterns.

Finally, I consider the effects of a monetary policy implemented in the form of the Taylor rule

$$R_t^4 = \left(R_{t-1}^4\right)^{\rho_r} \left[\pi_t^{\rho_\pi} \left(\frac{Y_t}{Y_{t-1}}\right)^{\rho_y}\right]^{1-\rho_r} \varepsilon_t^m, \tag{6}$$

where, ε^m corresponds to a monetary shock. The values for ρ_r, ρ_y, and ρ_π are taken from Clarida, Gali, and Gertler (2000). The last three columns in Table 4 displays the standard deviations for the same variables previously studied. Similar to the benchmark model, the volatilities of consumption, interest rates, and inflation drop following the increase in the degree of financial sophistication in the economy. The decline, however, is smaller than the one experienced with the money growth rate rule. This is likely a consequence of the extra persistence induced by the Taylor rule on interest rates. On the other hand, investment becomes slightly more volatile after the change in the Calvo probability.

The results from the Taylor rule case suggest that the size of the moderation predicted by my model is somehow sensitive to the monetary policy in place. However, this conclusion must be taken cautiously as the results of Lubik and Schorfheide (2004) indicate that monetary policy was passive prior to 1980 ($\rho_\pi < 1$). Such findings might obscure the analysis because of the presence of sunspot equilibria in the model. Furthermore, the experiment outlined at the beginning of Section 4 analyzes the effects of financial innovation by assuming that every aspect of the economy except the portfolio adjustment part remains unmodified. Consequently, a money growth rule as in equation (5) is best suited for the experiment for such rule provides a better description of the Fed's policy prior to the financial innovations of the early 1980s (see, Walsh, 2003, and Friedman and Kuttner, 1996).

5. Concluding Remarks

This paper provides a potential explanation of the observed change in the second moment properties of consumption, investment, output, and interest rates. The idea is simple: Financial innovations of the late 1970s helped to increase household participation in financial markets, which decreased the volatility of interest rates and therefore consumption. This paper models financial innovation by changing the Calvo probability that agents face every time they want to optimize their money holdings. In particular, I argue that financial innovations have made banking transactions easier, which is equivalent to a decrease in the Calvo probability. My model can explain up to 25 percent of the observed declined in the volatilities of real variables. These results indicate that financial sophistication did indeed contribute to smoothing consumption and output. The fact that the model accounts for only part of the decline in the volatilities indicates that factors like better monetary policy and smoother shocks are also preponderant contributors to the Great Moderation.

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Table 1:

Standard Deviations

	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
1984-2001[a]	0.44	0.52	0.53	0.31	0.50	1.35
1960-2001[a]	0.81	0.84	0.83	0.91	0.81	1.19

Data Source : *Altig et al.*(2004)

Annual growth rates for output, investment, consumption, and real balances

Annual changes for interest rates and inflation

[a] *Volatilities expressed as a fraction of those for the period* 1960 − 1983

Table 2:

Parameter Values

β	α	δ	ψ_L	λ_w	μ_z	μ_x	V	η	λ_f
0.99	0.36	0.025	1	1.05	1.00	1.017	0.45	0.036	1.01
b	ρ_Υ	σ_Υ	ρ_{xz}	$\varkappa$	ρ_m	σ_m	ρ_z	σ_z	ς_z
0.72	0.24	0.30	0.33	3.28	−0.03	0.33	0.90	0.07	3.00
ξ_w	ξ_p	σ_η					ς_z^1	ς_Υ	ς_Υ^1
0.72	0.82	1					1.42	0.25	0.13

Table 3

Standard Deviations:

	Model with Static Indexation		
ξ_{po}	0.80 (5 quarters)	0.75[a] (4 quarters)	0.67[a] (3 quarters)
σ_m	0.32	1.27	1.36
σ_y	0.42	0.88	0.75
σ_c	0.19	0.92	0.83
σ_i	1.01	0.87	0.73
σ_π	1.03	0.90	0.71
σ_r	2.16	0.85	0.65

[a]*Volatilities expressed as a fraction of those for* ξ_{po}=0.80

Table 4

Standard Deviations

	No Nominal Frictions			No Wage in Advance			Taylor Rule		
ξ_{po}	0.80 (5 quarters)	0.75[a] (4 quarters)	0.67[a] (3 quarters)	0.80 (5 quarters)	0.75[a] (4 quarters)	0.67[a] (3 quarters)	0.80 (5 quarters)	0.75[a] (4 quarters)	0.67[a] (3 quarters)
σ_m	0.87	1.16	1.33	0.80	1.06	1.08	0.24	1.18	1.50
σ_y	0.24	0.92	0.82	0.28	0.82	0.71	0.36	0.97	0.96
σ_c	0.19	0.95	0.88	0.16	0.83	0.73	1.02	0.90	0.81
σ_i	0.38	0.86	0.74	0.57	0.84	0.74	0.75	1.01	1.05
σ_π	2.55	0.83	0.67	0.75	0.80	0.68	9.82	0.94	0.87
σ_r	1.26	0.78	0.55	3.66	0.63	0.37	11.13	0.94	0.88

[a]*Volatilities expressed as a fraction of those for* ξ_{po}=0.80

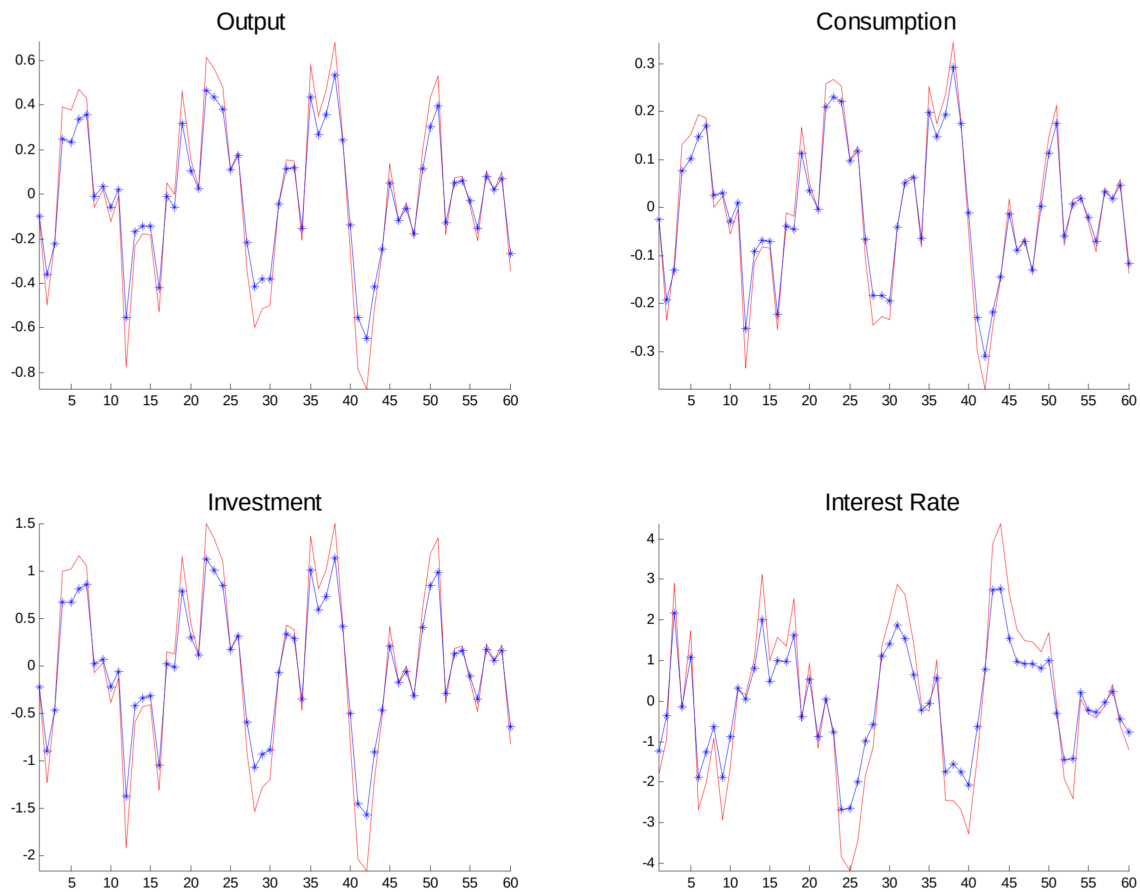

Figure 1: Simulated paths several variables. Note: $\xi = 0.80$ (solid lines) and $\xi = 0.67$ (starred lines).

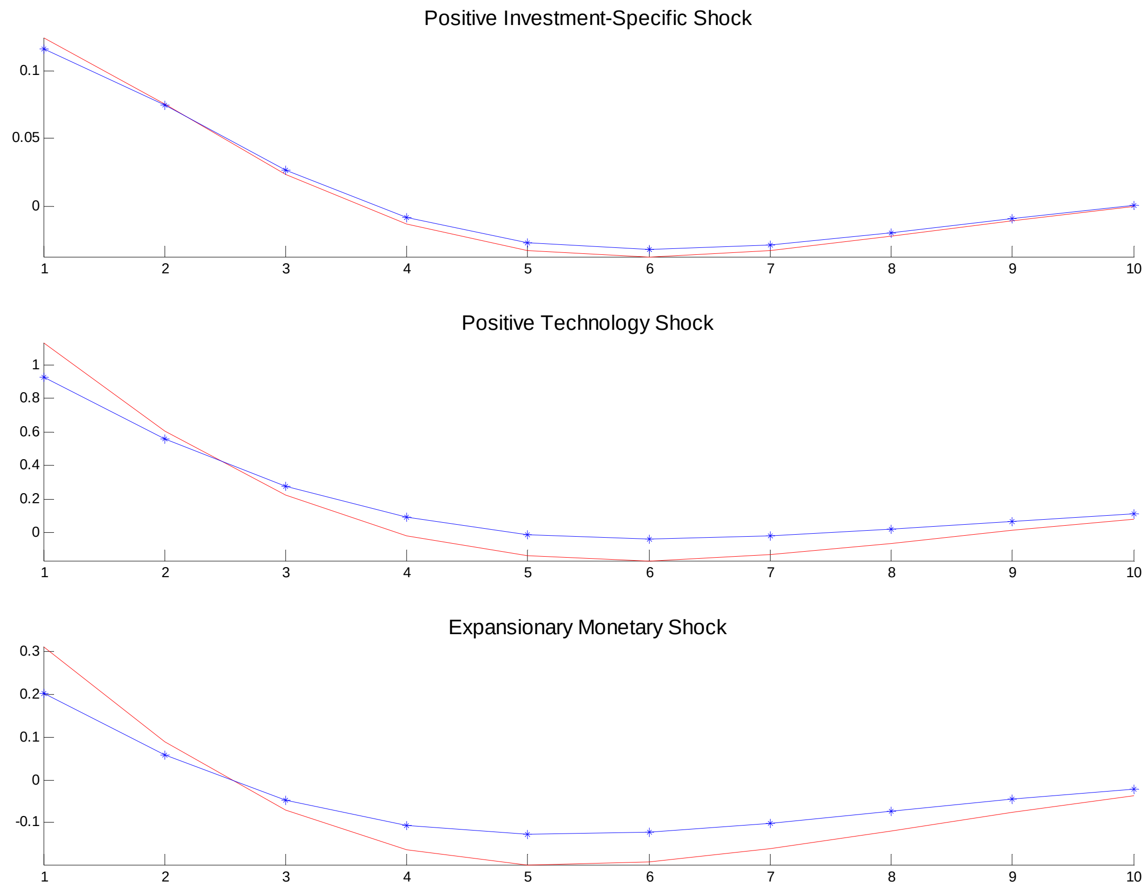

Figure 2: Impulse Responses for Output Growth. Note: $\xi = 0.80$ (solid lines) and $\xi = 0.67$ (starred lines).