The Role of Collateralized Household Debt in Macroeconomic Stabilization*

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Abstract

Market innovations following the financial reforms of the early 1980s drastically reduced equity requirements associated with collateralized household borrowing. This paper examines the contribution of this development to the macroeconomic stabilization that occurred shortly thereafter. The model combines collateralized household debt with heterogeneity of time preference in a calibrated general equilibrium setup. We use this framework to characterize the business cycle implications of lowering required down payments and rates of amortization for durable goods purchases as in the early 1980s. The model predicts that this reduction of equity requirements can explain a large fraction of the actual volatility decline in hours worked, output, household debt, and household durable goods purchases.

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1 Introduction

This paper examines the implications of the household credit market reforms in the early 1980s for macroeconomic volatility. Homes and other durable goods collateralize most household debt in the United States, and typical debt contracts require the borrower to take an equity stake in the good that serves as collateral. A down payment imposes an initial equity share on the durable good purchased, and the debt's amortization dictates the pace at which the equity share increases. The market innovations that followed the Monetary Control Act of 1980 and the Garn-St. Germain Act of 1982 greatly reduced these equity requirements, and the well known decline in macroeconomic volatility occurred a short time after the reforms.

Because the stabilization was particularly dramatic for residential investment, Stock and Watson (2002, 2003) suggest that these reforms substantially contributed to it. An examination of the behavior of household debt, reported below, supports such a link. Debt starts to accelerate at about the same time that macroeconomic volatility drops, and its standard deviation goes down more than most key aggregates'. This evidence motivates us to measure the effects of households' equity requirements on macroeconomic volatility. For this purpose, we use a tractable quantitative general equilibrium model of business cycles with household debt.

In the model, debt contracts require the borrower to hold an equity stake in the good that serves as collateral, as do most debt contracts in the United States. Equity requirements could be generated by borrowers' inability to commit to repayment combined with costly repossession, as in Kiyotaki and Moore (1997). However, the history of mortgage markets strongly suggests that the large changes in equity requirements follow regulatory changes. Accordingly, our analysis treats equity requirements as exogenous policy choices.

Household debt in the model reflects trade between two households with different rates of time preference, which we label the *saver* and the *borrower*. The saver represents the few very wealthy households who own most assets in the United States, while the borrower represents the other households who owe most debt. Both have infinite lives and the only source of uncertainty is an aggregate productivity shock, so the model incorporates the most salient features of the U.S. household debt market without the complications of intergenerational trade or idiosyncratic risk.

In equilibrium, the borrower owns nothing but the required equity stake in the durable goods that collateralize household debt. When expanding purchases of home capital goods, the borrower must increase labor supply to finance down payments. The higher labor supply persists because of debt repayment. Fortin's (1995) and Del Boca and Lusardi's (2003)

findings that the labor supply of married women increases with their households' mortgage debts supports such a connection between labor supply and household debt. Reducing the equity requirement—by lowering the down-payment rate or extending the term of the loans— weakens the link between durable purchases, debt, and hours worked; and thereby results in lower aggregate variability.

Households' equity requirements generate a transmission mechanism that can be contrasted with the financial accelerator effect for investors in Bernanke and Gertler (1989) or Kiyotaki and Moore (1997). In those models, an exogenous increase in net worth of borrowing-constrained investors is transmitted to higher investment. Iacoviello (2005) extended that framework to include a similar borrowing constraint for households. In his model, a real estate appreciation raises output demand through its effect on households' net worth. The mechanism in this paper works quite differently. Here, it is not the *availability* of internal funds or collateral value that motivates further economic activity, but it is their *shortage*: A shock that increases borrowers' demand for durable goods creates a need for funds to comply with the equity requirements. This in turn induces further economic activity by expanding labor supply. This channel relies on the connection between debt and durable goods purchases, so it does not arise in economies with a fixed minimum for household net worth, such as Krusell and Smith's (1998).

Our analysis of the role of equity requirements in business fluctuations starts with standard preferences and production possibilities. With this specification, output volatility depends primarily on the variance of productivity shocks—as in the basic Real Business Cycle model—because inputs vary relatively little. Hence, lowering equity requirements reduces output's volatility modestly in spite of a substantial stabilization of hours worked. Following King and Rebelo (2000), we then introduce preferences and production possibilities that reduce the size of the exogenous shocks consistent with a given volatility of output. This version of the model predicts that lowering equity requirements substantially reduces macroeconomic volatility.

The remainder of this paper proceeds as follows. The next section reviews the history of household debt markets and the cyclical behavior of household debt. Section 3 presents the model, and in Section 4 the model's steady state is used to analyze long-run responses to a financial market reform. Section 5 builds intuition by analyzing the labor supply decision in partial equilibrium. The quantitative results from calibrated versions of the model are reported in Section 6, and Section 7 concludes.

2 Household Debt in the United States

This section provides context for our analysis by reviewing evidence on household debt in the U.S. economy. It begins with a brief history of credit market institutions and policies and concludes with an analysis of the household debt's cyclical behavior since the Korean War.

Before proceeding, we document two basic aspects of household debt which remain unchanged since the early 1960s. First, the vast majority of household debt is collateralized. According to the Survey of Financial Characteristics of Consumers, homes and vehicles collateralized 85 percent of total U.S. household debt in 1962. The analogous percentage from the 2001 Survey of Consumer Finances is 90 percent. Appendix A details the sources of these observations. Accordingly, the remainder of this paper abstracts from unsecured debt.

Second, according to these two surveys, the middle class owes most collateralized household debt, and rich households hold most of the financial assets. In 1962, households between the tenth and ninetieth percentiles of the wealth distribution owed 79.5 percent of household debt. In 2001, the corresponding figure is 72.7 percent. The funds for the financial sector that directly holds this debt come from wealthy households. Those with wealth above the ninetieth percentile held 54.2 percent of financial assets in 1962 and 72.8 percent in 2001. Thus, most household debt reflects intertemporal exchange between middle class and wealthy households rather than financial trade among the wealthy or lending to the poor. The concentration of assets in a small fraction of households and the distribution of debt across a large fraction of households will be key features of the model presented below.

2.1 A Brief History of Household Credit Markets

Prior to the Great Depression, typical mortgage payments were only interest, and homeowners refinanced their loans' principles every few years. Semer et al. (1986) report that first mortgages had low loan-to-value ratios, but second and third mortgages with higher interest rates were common. For other household durable goods, a multitude of finance companies provided installment credit through retailers (Olney (1991)).

The Great Depression and its aftermath affected these two segments of the household lending market quite differently. Federal involvement in the mortgage market became massive, while other household credit was regulated much less. Deflation during the depression period eroded housing values without affecting nominal balances due at maturity, so many borrowers were unable to find lenders to refinance their loans. The resulting defaults motivated the Hoover and Roosevelt administrations to exercise greater federal control over

mortgage lending.

The Federal Home Loan Bank Act of 1932 and the Home Owners' Loan Act of 1933 established a new environment for mortgage lending based on three regulatory principles. First, regulation constrained savings and loans to raise most of their funds with short-term deposits. Congress intended this to insulate the mortgage market from fluctuations in other financial markets. Second, the federal government became savings and loans' lender of last resort. Finally, long-term *amortized* mortgages replaced the previous interest-only, periodically refinanced mortgages. This reduced the possibility of systemic default risk at the cost of raising borrowers' required equity in their homes.

The maturity imbalance between Savings and Loans' long-term assets and short-term liabilities posed no challenge in a stable monetary environment, but the volatile financial markets of the late 1960s and 1970s pushed many savings and loans into insolvency. By 1980, the Volker monetary policy made the Savings and Loans' regulatory environment unsustainable. The federal government abandoned the New Deal regulatory system with the Monetary Control Act of 1980 and the Garn-St.Germain Act of 1982. Florida (1986), and the articles contained therein describe how this legislation eliminated restrictions on mortgage lending and reintegrated it with other financial markets.

Figure 1 illustrates the implications of credit market regulation since 1954. It plots the ratio of mortgage debt to the value of owner-occupied housing, and the ratio of total household debt to total tangible assets—owner-occupied housing and durable goods.[1] The rapid increase in the early part of the sample reflects the relaxation of residential credit controls near the end of the Korean War. This trend partially reverses in 1966 with the extension of interest rate ceilings on demand deposits (Regulation Q) to Savings and Loans. The ratio declined through the financial volatility of the late 1960s and 1970s. At the end of 1982 the debt-asset ratios start a new dramatic increase. This surge reflects the emergence of the subprime mortgage lending market and households' greater use of home equity loans and mortgage refinancing to cash-out previously accumulated equity. Greater access to refinancing and home equity loans allowed homeowners to delay repayment of mortgage principle, and access to additional subprime mortgages reduced effective down payment requirements. After 1995, the ratios of household debt to tangible assets stabilize at new and higher levels.

Although only the mortgage market underwent dramatic regulatory changes, the automobile loan market also changed substantially. For the 1920s, Olney (1991) reports typical terms

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[1]The source of these observations is the Federal Reserve Flow of Funds Accounts, Table B.100, Balance Sheet of Households and Nonprofit Organizations.

of car loans of 1/3 down and a repayment period of 12-18 months. During the 1972-1982 period, the average figures are 13 percent down and repayment period of 40 months, while in the 1995-2003 period, the corresponding averages are 8 percent down and repayment period of 54 months.[2] Hence, equity requirements in this market eased considerably over time.

2.2 The Cyclical Behavior of Household Debt

The financial developments at the end of 1982 preceded a fast increase in household debt and a dramatic change in its cyclical behavior. Figure 2 shows the fluctuations of total household debt and its comovement with hours worked. Household debt is expressed in real terms by dividing nominal values by the GDP price index, and hours worked is an index of total private weekly hours. Both variables are logged and HP-filtered. The figure shows two phenomena. First, debt's volatility declines dramatically in the early 1980s. Second, debt and hours worked comove strongly until this time. Afterwards, their movements become much less synchronized.

Tables 1 and 2 summarize these data using three sub-periods of the 1954:I–2005:III sample: (1) From the beginning of the sample through 1982:IV—the quarter of the Garn-St. Germain Act's passage—(2) from 1983:I onwards, and (3) from 1995:I onwards.

Table 1 reports the standard deviations of total household debt and mortgage debt along with those of other key macroeconomic variables in these three periods. The standard deviation of total debt declines from 2.8 percent in the period through 1982:IV, to 0.6 percent from 1995:I onwards. The corresponding figures for mortgage debt are 2.3 percent and 0.8 percent. Table 1 also illustrates the decline in general macroeconomic volatility. The standard deviations of hours worked, durable consumption expenditures, nondurable consumption expenditures, and GDP all fall substantially after 1982; and they are even lower from 1995 onwards. As stressed by Stock and Watson (2002, 2003), the decline in investment volatility reflects primarily residential investment: Its standard deviation falls from 12 percent to 2.6 percent, while the standard deviation of nonresidential investment remains essentially unchanged. The final column reports the ratios of the standard deviations in the last period to those in the first. By this measure, household debt, residential investment, and durable goods purchases stabilize the most.

Table 2 quantifies the comovement of hours worked and debt. Prior to 1983, the correlation coefficients of total and mortgage debt with hours worked are 0.86 and 0.82, respectively. These correlations are substantially lower after 1982.

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[2]The source of these observations is Federal Reserve Statistical Release G-19, Consumer Credit.

The levels of per-capita household debt and hours worked also changed. Figure 3 plots their logarithms. Both variables were constructed using the civilian noninstitutional population 16 years and older. Debt starts to accelerate in 1983:I—consistently with the increase in the ratio of household debt to tangible assets from Figure 1—and also hours worked per capita begins then a persistent increase.

The evidence presented in this section indicates that the aggregate volatility decline since the early 1980s was accompanied by a pronounced decline in the volatility of household debt. Furthermore, household debt along with two closely-related variables, residential investment and durable purchases, stabilize the most among the key variables considered. This paper focuses on the possibility that the relaxation of equity requirements on households contributed to the macroeconomic stabilization. For this analysis, we construct a quantitative general equilibrium model with household debt.

3   The Borrower-Saver Model

In this model, household debt reflects intertemporal trade between an impatient *borrower* and a patient *saver*. The saver owns all the productive capital and holds the borrowers' debt. This reflects the fact that in the U.S. economy, few very wealthy households hold most assets, and others owe most of the debt. Durable goods collateralize debt. We model the credit market reform as an exogenous reduction of borrowers' required equity in these durable goods.

Without an equity requirement, the borrower's debt to the saver would increase over time to the maximum level the borrower can service using total labor income. Imposing an equity requirement limits the debt, so the economy possesses a unique steady state with positive consumption by both households. This requirement always limits the borrower's debt if the economy remains close to its steady state; so standard log-linearization techniques can characterize its equilibrium for small disturbances. This is the solution approach we follow below.

Next, we present the economy's primitives, discuss the households' optimization problems, and define a competitive equilibrium.

3.1   Preferences

The preferences of savers and borrowers differ in two respects: One is that savers are more patient, and the other is that savers do not work. The first assumption generates a concen-

tration of assets in a relatively small number of households. This follows Krusell and Smith's (1998) use of heterogeneity in thrift to generate an empirically realistic wealth distribution. Simplicity justifies the assumption that savers do not work. Because there are few savers and because they should each enjoy some of their wealth in the form of leisure, we expect them to contribute little to aggregate labor supply. When we endow savers with the borrowers' intratemporal preferences and calculate the steady state of the model calibrated as described below, savers choose to not work at all unless they represent an inordinately large fraction of the households. Accordingly, we simplify the model by abstracting from their labor supply. In this case, no model statistics except consumption per saver and consumption per borrower depend on the division of households into savers and borrowers.

Borrowers' and savers' specific utility functions are:

$$E\left[\sum_{t=0}^{\infty} \hat{\beta}\left(\theta \ln \hat{S}_t + (1-\theta)\ln \hat{C}_t + \omega \frac{\left(1-\hat{N}_t\right)^{1-\gamma}}{1-\gamma}\right)\right], \quad 0 < \theta < 1, \ \omega > 0, \ \gamma > 0, \quad (1)$$

$$E\left[\sum_{t=0}^{\infty} \tilde{\beta}\left(\theta \ln \tilde{S}_t + (1-\theta)\ln \tilde{C}_t\right)\right], \tag{2}$$

where $\hat{\beta} < \tilde{\beta}$. In (1), $\hat{S}_t$, $\hat{C}_t$, and $\hat{N}_t$ are the borrower's stock of durable goods—assumed to be proportional to its service flow—consumption of nondurable goods, and labor supply. The specification of the last term nests both a logarithmic form ($\gamma = 1$) and Hansen's (1985) linear form ($\gamma = 0$). In (2), $\tilde{S}_t$, and $\tilde{C}_t$ are the saver's consumption of the two goods.

3.2   Technology

The aggregate production function is $Y_t = K^\alpha (A_t N_t)^{1-\alpha}$. Here, Y_t is output, K is a constant capital stock, N_t is labor input, A_t is an exogenous productivity index, and $0 \le \alpha < 1$. The assumption that K is constant simplifies the analysis in an aspect that is marginal in the present context—which focuses on household capital goods. Furthermore, capital stock movements are slow and thus not important for output volatility. We discuss the implications of relaxing this assumption below in Section 6.5. The productivity shock follows the AR(1) stochastic process $\ln A_t = \eta \ln A_{t-1} + \varepsilon_t$, where ε_t is an i.i.d. disturbance with zero mean and constant variance and $0 \le \eta < 1$. We abstract from growth in this paper.

7

Output can be costlessly transformed into nondurable consumption and durable goods purchases. That is, $Y_t = C_t + X_t$. Here, C_t represents aggregate nondurable consumption and $X_t = S_{t+1} - (1 - \delta) S_t$ is aggregate investment in the durable good, which depreciates at the rate δ.

3.3 Trade

All trade takes place in competitive markets. The two households sell capital services and labor to a representative firm and make loans to each other. We denote the rental rate of capital and the wage rate, in units of consumption, with H_t and W_t. Assuming that unbacked state-contingent claims are unenforceable, the only security traded is collateralized debt with a period-by-period adjustable interest rate. The amounts $\hat{B}_{t+1}$ and $\tilde{B}_{t+1}$ are the outstanding debts of the two households at the end of period t, and the corresponding gross interest rate is denoted R_t.

Exogenous equity requirements on the goods that serve as collateral constrain intertemporal trade between borrowers and savers. The equity requirements mimic a typical feature of loan contracts in the United States: An equity share that potentially increases as the good ages. This requirement is closely related to a down payment and a rate of debt amortization. The down payment reflects the initial equity share, and the rate of debt amortization determines its subsequent path. The parameters capturing these features are $0 \leq \pi < 1$, the initial equity share, and ϕ, which governs the speed of subsequent equity accumulation. When a loan is collateralized by a durable good j periods old, the required equity share at the time of the next debt payment is

$$
e_j = 1 - \left(\frac{1 - \phi}{1 - \delta}\right)^j (1 - \pi).
\tag{3}
$$

For newly purchased goods $(j = 0)$, the equity share is just π. As the good ages $(j$ increases), the equity share increases towards one when $\phi > \delta$, and stays constant when $\phi = \delta$. The history of U.S. debt markets reviewed above indicates that the change in households' equity shares in the early 1980s reflected a decision to deregulate. Here, we model this deregulation by lowering π and ϕ.

For a household with positive debt, the total amount of equity at the beginning of period $t + 1$ is $(1 - \delta)S_{t+1} - R_t B_{t+1}$, where the durable stock is adjusted for depreciation and the debt for accumulated interest. This household's required equity in its durable goods stock

sums the equity requirements on the (depreciated) goods of all ages from (3):

$$(1-\delta)S_{t+1} - R_t B_{t+1} \geq (1-\delta) \sum_{j=0}^{\infty} (1-\delta)^j X_{t-j} e_j. \tag{4}$$

If the constraint in (4) always binds for a household, then it has the following recursive representation for the debt:

$$B_{t+1} = \frac{(1-\delta)(1-\pi)}{R_t} X_t + \frac{(1-\phi) R_{t-1}}{R_t} B_t. \tag{5}$$

In (5), the expression $(1-\delta)(1-\pi)/R_t$ is the loan-to-value ratio for new purchases, and $(1-\phi) R_{t-1}/R_t$ is one minus the rate of amortization of the outstanding debt. In this formulation, the equity constraint is expressed as a flexible borrowing constraint, depending on current durable purchases and the outstanding debt.

In this environment, the two households choose asset holdings, consumption of the two goods, and (for the borrower) labor supply to maximize utility subject to the budget and the borrowing constraints. Firms choose their outputs and inputs to maximize their profits.

3.4 Utility Maximization

The condition that the market in collateralized debt must clear implies that the equity constraint binds for one type of household at most. We conjecture that near the steady state it binds for the borrower. After characterizing the steady state, verifying this is straightforward. We now turn to the analysis of the households' utility maximization problems, given this conjecture.

3.4.1 Utility Maximization by the Borrower

We consider first the borrower's problem, given the assumption that the equity constraint in (4) always binds. In this case, its debt is constrained to evolve as

$$\hat{B}_{t+1} = \frac{(1-\delta)(1-\pi)}{R_t} \hat{X}_t + \frac{(1-\phi) R_{t-1}}{R_t} \hat{B}_t. \tag{6}$$

The binding equity constraint also implies that the borrower never purchases productive capital, so the corresponding budget constraint is

$$\hat{C}_t + \hat{X}_t = W_t \hat{N}_t + \hat{B}_{t+1} - R_{t-1} \hat{B}_t. \tag{7}$$

9

Given $R_{-1}\hat{B}_0$ and $\hat{S}_0$, the borrower chooses state-contingent sequences of $\hat{C}_t$, $\hat{X}_t$, $\hat{N}_t$, and $\hat{B}_{t+1}$ to maximize the utility function in (1), subject to the sequences of constraints in (6) and (7).

Denote the current-value Lagrange multiplier on (7) with Ψ_t. If we express the Lagrange multiplier on (6) as $\Xi_t\Psi_t$, then Ξ_t measures the value in units of either consumption good of marginally relaxing the equity constraint.

In addition to the two constraints and the transversality conditions, $\lim_{t\to\infty}\hat{\beta}^t E\left[\Psi_t\right] = \lim_{t\to\infty}\hat{\beta}^t E\left[\Psi_t\Xi_t\right] = 0$, the optimality conditions for this maximization problem are

$$\Psi_t = \frac{1-\theta}{\hat{C}_t},\tag{8}$$

$$1 - \Xi_t\frac{(1-\pi)(1-\delta)}{R_t} = \hat{\beta}E\left[\frac{\theta}{1-\theta}\frac{\hat{C}_t}{\hat{S}_{t+1}} + (1-\delta)\frac{\Psi_{t+1}}{\Psi_t}\left(1 - \Xi_{t+1}\frac{(1-\pi)(1-\delta)}{R_{t+1}}\right)\right],\tag{9}$$

$$W_t = \omega\left(1-\hat{N}_t\right)^{-\gamma}\frac{\hat{C}_t}{1-\theta},\tag{10}$$

$$\Xi_t = 1 - \hat{\beta}E\left[\frac{\Psi_{t+1}}{\Psi_t}R_t\right] + (1-\phi)\hat{\beta}E\left[\frac{\Psi_{t+1}}{\Psi_t}\Xi_{t+1}\frac{R_t}{R_{t+1}}\right].\tag{11}$$

Equation (8) looks familiar, but the equity constraint changes its interpretation. For an unconstrained household, such as the saver, it defines the value of relaxing the intertemporal budget constraint. The borrower cannot freely substitute intertemporally, so Ψ_t represents only the marginal value of additional *current* resources.

A standard condition for optimal investment in durable goods equates the purchase price of a durable good to its immediate payoff (the marginal rate of substitution between durable and nondurable goods) plus its discounted expected resale value. Equation (9) has the same interpretation if we define $1 - \Xi_t(1-\pi)(1-\delta)/R_t$ to be the effective purchase price of the durable good for the borrower. This is the actual price less the benefit from relaxing the borrowing constraint by purchasing an additional unit—which allows borrowing at the maximum loan-to-value ratio.

Equation (10) is the consumption-leisure condition. It has the usual form because it involves only intratemporal substitution, which is not affected by the financial market imperfections.

Setting Ξ_t and Ξ_{t+1} to zero reduces (11) to the standard Euler equation. When the equity constraint always binds, Ξ_t in (11) can be interpreted as the price of an asset which allows

the holder to expand its debt by $(1 - \phi)^j (R_t/R_{t+j})$, $j \geq 0$, in period $t + j$. It equals the payoff to additional current borrowing—the violation of the standard Euler equation—plus the asset's appropriately discounted expected resale value.

3.4.2 Utility Maximization by the Saver

The maximization problem of the saver is standard, but we describe its solution here for the sake of completeness. We impose the ownership of the entire capital stock on the saver, since the borrower never owns capital if (5) always binds. Given the constant stock, $\tilde{K}$, and the initial durable goods and savings in the borrower's household debt, $\tilde{S}_0$ and $-R_{-1}\tilde{B}_0$, the saver chooses state-contingent sequences of $\tilde{C}_t$, $\tilde{X}_t$, and $\tilde{B}_{t+1}$ to maximize utility subject to

$$\tilde{C}_t + \tilde{X}_t - \tilde{B}_{t+1} = H_t \tilde{K} - R_{t-1}\tilde{B}_t. \tag{12}$$

The right-hand side of (12) sums the sources of funds: Capital rental revenue and the value of previous savings. The left-hand side includes the three uses of these funds: Nondurable consumption, purchases of durable goods, and current saving.

We denote the current-value Lagrange multiplier on (12) with Υ_t. The first-order conditions for the saver's problem are

$$\Upsilon_t = \frac{1 - \theta}{\tilde{C}_t}, \tag{13}$$

$$1 = \tilde{\beta} E \left[\frac{\Upsilon_{t+1}}{\Upsilon_t} \left(\frac{\theta}{1 - \theta} \frac{\tilde{C}_{t+1}}{\tilde{S}_{t+1}} + 1 - \delta \right) \right], \tag{14}$$

$$1 = \tilde{\beta} E \left[\frac{\Upsilon_{t+1}}{\Upsilon_t} R_t \right], \tag{15}$$

and the budget constraint (12). Equation (14) is a typical condition for optimal purchases of durable goods, and (15) is the standard Euler equation.

3.5 Production and Equilibrium

The representative firm takes the input prices as given. Letting N_t denote labor input used by the firm, profit maximization implies that

$$W_t = (1 - \alpha) A_t^{1-\alpha} \left(\frac{K}{N_t} \right)^{\alpha}, \tag{16}$$

$$H_t = \alpha A_t^{1-\alpha} \left(\frac{K}{N_t} \right)^{\alpha-1}. \tag{17}$$

11

With the economic agents' maximization problems specified, we define a competitive equilibrium. Given the two households' initial stocks of durable goods, $\hat{S}_0$ and $\tilde{S}_0$, the stock of outstanding debt issued by the borrower and held by the saver, $B_0 = \hat{B}_0 = -\tilde{B}_0$, the predetermined initial interest rate on this debt, R_{-1}, and the initial value of the technology shock, a competitive equilibrium is a set of state-contingent sequences for all prices and the borrower's, saver's, and representative firm's choices such that both households maximize utility subject to the constraints, the representative firm maximizes its profit, the two households' durable goods stocks evolve according to $\hat{S}_{t+1} = (1-\delta)\hat{S}_t + \hat{X}_t$ and $\tilde{S}_{t+1} = (1-\delta)\tilde{S}_t + \tilde{X}_t$, and input, product, and debt markets clear.

4   The Deterministic Steady State

We next characterize the economy's steady state. In light of the substantial increases in the ratio of debt to durable goods and in hours worked after 1982, we focus here on the level effects of changing the equity requirement parameters π and ϕ.

In the steady state, the saver's Euler equation immediately determines the interest rate, $R = 1/\tilde{\beta}$. With R in hand, we calculate the borrower's choices. Equation (11) implies that

$$\Xi = \frac{1 - \hat{\beta}/\tilde{\beta}}{1 - \hat{\beta}(1-\phi)} > 0. \tag{18}$$

Hence, the equity constraint on the borrower binds at the steady state, as conjectured in Section 3.4.

To solve for the steady state we proceed as follows. From (9), the borrower's ratio of durable to nondurable consumption is

$$\frac{\hat{S}}{\hat{C}} = \frac{\theta}{1-\theta} \frac{\hat{\beta}}{(1 - \Xi(1-\pi)(1-\delta)/R)\left(1 - \hat{\beta}(1-\delta)\right)}, \tag{19}$$

and the borrower's budget constraint can be rewritten as

$$\frac{\hat{C}}{W\hat{N}} = \frac{1}{1 + (R-1)\frac{\hat{B}}{\hat{S}}\frac{\hat{S}}{\hat{C}} + \delta\frac{\hat{S}}{\hat{C}}}. \tag{20}$$

To express these two ratios as functions of the primitive parameters we use (18) in (19), and then the resulting expression as well as the debt accumulation constraint (5) into (20).

With the solution for the ratio of consumption to labor income in hand, the optimal labor supply condition (10) determines $\hat{N}$. As $\hat{C}/(W\hat{N})$ declines, labor supply increases. Obtaining W, H, and the rest of the borrower's steady-state choices is then straightforward. The steady-state capital rental rate, the outstanding household debt, and the steady-state versions of (12) and (14) then determine the saver's choices of $\tilde{C}$ and $\tilde{S}$.

The steady state can be used to examine the long-run implications of changes in equity requirements. Lowering π has no impact on Ξ, but it directly increases $\hat{S}/\hat{C}$ and $B/\hat{S}$. Hence, $\hat{C}/\hat{N}W$ decreases from (20), and N goes up according to (10). Intuitively, reducing the down-payment rate lowers the effective cost of durable goods to the borrower and thereby induces a shift from leisure to durable goods. Also, the ratio of household debt to the aggregate stock of durable goods, $B/\left(\hat{S} + \tilde{S}\right)$, the model's counterpart to the ratios plotted in Figure 1, increases as the down-payment rate declines.[3]

Lowering the rate of debt amortization, ϕ, has the same qualitative implications as reducing π. In this case, the decline in the effective cost of durable goods reflects an increase in Ξ. Thus, the changes in the model's steady state following a reduction in equity requirements— lower down-payment and amortization rates—are qualitatively consistent with the long-run changes in hours worked and debt observed in the U.S. economy after 1982. In Section 6.6, we evaluate these effects quantitatively.

5 The Labor Supply Decision

To develop intuition for interpreting the next section's quantitative results, we characterize here the borrower's response to wage changes in partial equilibrium. We compare the borrower's labor supply across two regimes: Zero and positive equity requirements. To sharpen this comparison, we also contrast the borrower's labor supply behavior to a permanent-income consumer's. This analysis demonstrates that labor supply responds only when there is a positive equity requirement.

Assuming that $R_t = R$ and $\phi = \delta$ simplifies this discussion. If the borrower starts off with no assets and no durable goods ($\hat{B}_0 = \hat{S}_0 = 0$), then $\hat{B}_t = \hat{S}_t (1 - \pi) (1 - \delta)/R$ for all

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[3]The ratio $\tilde{S}/B$ declines along with $\hat{S}/B$. The effect on $\tilde{S}/B$ can be shown using the budget constraints of the two households and $HK = \frac{\alpha}{(1-\alpha)}NW$.

$t \geq 1$. Using this, the borrower's budget constraint becomes

$$\hat{C}_t + \left[1 - \frac{(1-\pi)(1-\delta)}{R} \right] \hat{S}_{t+1} = W_t \hat{N}_t + \pi(1-\delta)\hat{S}_t, \tag{21}$$

where the uses of funds appear as nondurable consumption and down payments on the desired stock of durable goods, and the sources of funds are labor income and accumulated equity.

The first-order conditions can be now combined to yield

$$\hat{\beta} \frac{\theta \hat{C}_t}{(1-\theta)\hat{S}_{t+1}} = u + \frac{\pi(1-\delta)}{R} \left[1 - \hat{\beta} E R \frac{\Psi_{t+1}}{\Psi_t} \right], \tag{22}$$

where $u \equiv (R - 1 + \delta)/R$ is the conventionally defined user cost of the durable good. In (22), the marginal rate of substitution between $\hat{S}_{t+1}$ and $\hat{C}_t$ equals the user cost—as it would be for a permanent-income consumer—plus an additional positive term related to the equity requirement. Note here that the term in square brackets is the deviation from the standard Euler equation, which is positive when the equity constraint binds. We consider next the labor supply response to a wage change in two equity requirement regimes.

5.1 Zero Equity Requirements

This case corresponds to $\pi = 0$. Given the assumption that $\phi = \delta$, the equity requirement remains constant at the initial level (zero in this case) for any purchased durable good. The borrower's effective price of durable goods, defined above as $1 - (1-\pi)(1-\delta)/R$, becomes now the conventional user cost. This is also the relevant price in the first-order condition (22). Here, an immediate and full adjustment of $\hat{C}_t$ and $\hat{S}_{t+1}$ to the wage change, while leaving $\hat{N}_t$ constant, simultaneously satisfies both equations and the condition for $\hat{N}_t$ in (10). Therefore, a zero equity requirement eliminates completely the effects of wage fluctuations on labor supply. This result also holds for the more general utility function $\frac{z_t^{1-\sigma}}{1-\sigma} v(1 - N_t)$, where z is a CES aggregator of the two consumption goods and $\sigma > 0$, $v' > 0$, $v'' < 0$. The same feature of these preferences that King, Plosser, and Rebelo (1988) rely upon for balanced growth—exactly offsetting income and substitution effects of permanent wage changes—drives the invariance of labor supply to a wage change when $\pi = 0$.

Here, however, the insensitivity of $\hat{N}_t$ to wage changes holds regardless of their persistence. In other words, the income and the substitution effect of *any* wage change exactly cancel each other. The borrower in this case behaves as a "rule-of-thumb" consumer, who spends all

14

current labor income (on nondurable consumption and on the user cost of the durable stock). Hence, the borrower's reaction under zero equity requirements differs substantially from the permanent-income consumer's, for which the persistence of any change is critical for the strength of the income effect. This difference between the borrower and a permanent-income consumer arises from the borrower's limited access to the financial market. The permanent-income consumer is unconstrained in the financial market, while for the borrower, the zero equity requirement limits debt. The constraint still binds because, as an impatient household, the borrower would like to borrow beyond the total value of its durable goods.

5.2   Positive Equity Requirements

When $\pi > 0$, the presence of the required accumulated equity in the budget constraint (21) makes the proportional adjustment to a wage change infeasible. Hence, the adjustment of $\hat{C}_t$ and $\hat{S}_{t+1}$ must be less than proportional to the wage. The optimal labor supply condition (10) and the decline of $\hat{C}_t/W_t$ then imply that $\hat{N}_t$ rises above its long-run level. This occurs for both permanent and transitory wage changes.

From the borrower's partial equilibrium responses it follows that labor supply fluctuations in the model arise from the required accumulation of equity on durable goods. We now proceed to evaluate this source of business cycle propagation quantitatively.

6   Quantitative Results

To assess the quantitative implications of this framework for macroeconomic volatility, we solve the model and simulate the impact of the empirically relevant changes in household loan markets. We consider first a regime of high equity requirements, for which the parameters π and ϕ are matched to loan observations through 1982:IV. The effects of the financial market reforms in the early 1980s are then assessed by considering a regime of low equity requirements, which is matched to loan observations from the period from 1995:I onwards. As shown in Figure 1, the latter period corresponds to a stabilization of the ratio of household debt to tangible assets after the reforms. We interpret this as convergence of credit markets to the new environment.

6.1 Calibration

Except for π and ϕ, all the parameters are held constant across the two regimes. We consider two alternative values for γ, the parameter governing the elasticity of labor supply. In the baseline case considered first, $\gamma = 1$—i.e., leisure enters utility in logarithmic form. In Section 6.4, we consider also the case of $\gamma = 0$, where leisure enters utility linearly.

The production function elasticity α equals 0.3. The parameters of the exogenous productivity shock process are set as follows. Using the value $\eta = 0.95$ from Hansen and Prescott (2001), σ_ε is calibrated so that the model's standard deviation of output matches its actual counterpart in the 1954:I–1982:IV sample. The resulting value is 0.0078. The same values of η and σ_ε are then used in the simulation of the second regime. The depreciation rate δ is 0.01, the appropriately weighted average of 0.003 for owner occupied residences and 0.031 for cars.[4]

We chose $\tilde{\beta}$ so that the quarterly interest rate is one percent. Because the borrower's discount rate does not influence the interest rate, actual market rates are not useful for its calibration. We set $\hat{\beta} = 1/1.015$, i.e., half of a percentage point higher than the interest rate. This degree of impatience is similar in magnitude to that used by Krusell and Smith (1998). Using a model with 3 levels of time preference, Krusell and Smith calibrate the differences between each type as 0.36%; or 0.72% between the two extremes. We have experimented with various values for this parameter with almost identical results to those reported below.

To calibrate π and ϕ, we utilize observations of automobile loans and mortgages. An average loan-to-value ratio is matched to the model's steady-state counterpart $(1 - \delta)(1 - \pi)/R$. Given the values of R and δ, this equality is used to solve for the initial equity share π. The steady-state amortization rate ϕ is equated to an average repayment rate. The inputs into the calibration of the high- and low-equity requirement regimes are observations from the Federal Reserve Board of loan terms from before 1983 and from 1995 onwards. Appendix B describes the calibration of π and ϕ in detail. The resulting values are 0.16 and 0.0315 for the high equity requirement regime and 0.11 and 0.0161 under low equity requirements. The latter value of ϕ embodies an assumption that the current wide availability of home equity loans and low-cost mortgage refinancing allows homeowners to delay repayment of mortgage principle and so avoid accumulation of equity on their homes.

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[4]The source is "Fixed Assets and Consumer Durable Goods in the United States, 1925-97." The service life of 1-4 units residences is 80 years. Automobiles' service life of 8 years is inferred from the reported non-linear depreciation profile. We used the weights 0.75 and 0.25, which are the shares of the owner occupied residential stock and consumer durable goods stock in the 1954-2004 sample.

The remaining parameters are θ and ω. We chose these simultaneously to match an average share of hours worked of 0.3 and the average share of durable goods expenditure in total households' expenditures in the 1954:I-1982:IV sample of 0.21. To calculate this ratio, we adjusted the NIPA's nondurable personal consumption expenditures by subtracting the imputed service flow of housing. We then added residential investment to personal consumption expenditures on durable goods. Given the other parameters, including the π and ϕ values for the high equity-requirement regime, the unique values of θ and ω that replicate these observations are 0.37 and 1.395. Table 3 summarizes the calibrated parameter values.

6.2 Household Borrowing and Aggregate Dynamics

We begin the quantitative analysis with a description of the two households' simulated decisions in general equilibrium with the model calibrated to the high equity-requirement regime. Figure 4 plots impulse responses of key variables to a positive productivity shock of $1/(1-\alpha)$ percent. All the variables are expressed as percent deviations from their steady-state values. The price responses are not shown since they are similar to those in the standard RBC model: The productivity shock directly shifts up labor demand, so the wage rises and thereafter falls slowly to its steady-state level. The interest rate response has a similar shape, given the increased demand for consumption by both households, but it is very small given their high interest sensitivity.

The individual households' responses illustrate the intertemporal exchange between them. Although the productivity shock increases the rental income from capital, the saver's durable purchases and nondurable consumption reflect the higher interest rate: Durable consumption declines and nondurable consumption trends upwards. Hence, the saver's reaction is to purchase the borrower's debt; helping to finance a surge in the borrower's consumption. As in the partial equilibrium discussion in Section 5, the increase in hours worked by the borrower reflects the equity requirements: Labor supply must increase to satisfy these requirements on newly purchased durable goods.

An important characteristic of this model is that temporarily higher income induces the borrower to *increase* debt—in contrast to the response of a permanent-income consumer, who would save in order to smooth consumption. This arises because borrowing cannot be a vehicle for consumption smoothing for equity constrained households. For them, purchases of durable goods must accompany borrowing.

6.3 Equity Requirements and Aggregate Volatility

We turn now to the paper's main issue: How important is the relaxation of equity requirements for aggregate dynamics? Figure 5 compares the impulse responses of aggregate variables under the two regimes, high and low equity requirements, to the same $1/(1-\alpha)$ percent increase in A_t.

In the low equity-requirement regime, the responses of hours worked and the debt have about half the magnitude of the responses in the high-requirement regime. The response of hours worked reflects the mechanism discussed in Section 5: Moving closer to a zero equity requirement reduces the labor supply reaction to wage movements. The change in the response of the debt follows mainly from the lower repayment rate. If $\phi > \delta$, a young durable good has a lower equity requirement than an old one with the same after-depreciation value to the owner. When a positive shock reduces temporarily the average age of the borrower's durable goods stock, its average equity requirement declines accordingly. Given that the borrower fully exploits borrowing opportunities, the ratio of debt to durable goods overshoots its long-run level. This overshooting is eliminated when $\phi = \delta$, because then age is irrelevant for the required equity share on a durable good. Lowering the equity constraint makes ϕ much closer to δ and greatly reduces debt overshooting.

Figure 5 also shows that the large proportional decline in the response of hours worked produces only a small decline in the response of output. Given the standard utility and production functions, the exogenous productivity shock dominates output dynamics. In the next subsection, we follow King and Rebelo (2000) and introduce preferences and production possibilities that enhance the contribution of labor fluctuations to output.

6.4 A High-Substitution Economy

Here we set $\gamma = 0$ in the borrowers' utility function, leading to Hansen's (1985) utility specification. For savers, the utility function remains the same because there is no labor supply decision.

The production structure is changed to increase the elasticity of output with respect to labor, keeping the income shares of borrowers and savers calibrated at realistic values—which is necessary for the quantitative results. The production function for final goods is

$$Y_t = \left(K^\alpha \left(A_t N_t \right)^{1-\alpha} \right)^{1-\vartheta} M_t^\vartheta, \quad 0 < \alpha < 1, \ 0 < \vartheta < 1, \tag{23}$$

where $M_t = \left(\int_0^1 M(i)_t^\rho \, di \right)^{1/\rho}$ is a composite of intermediate inputs. A profit maximizing

monopoly extracts each input from the ground at a constant marginal cost in units of final output, and savers own all of these monopolies' shares.

We set $\alpha = 0$ and solve for the representative final good firm's optimal level of M_t. Then, we can express its value added as a linear function of labor input, $Y_t = \kappa A_t N_t$, where κ is a constant.[5] The elasticity of output with respect to labor is now unity. However, labor's share in income is less than one because the savers receive monopoly profits. These profits are the difference between total payments to the monopolies and their production costs. It can be shown that savers' share of income is $\nu = (1 - \rho) / (1/\vartheta - \rho)$.

Given that in this economy the non-labor income share is ν, we now calibrate this parameter, and not α, as 0.3. Also σ_ε is calibrated again. As with the baseline economy, we chose its value so the standard deviation of output in the high equity-requirement regime equals the standard deviation of output in the 1954:I-1982:IV period. Given the high-substitution nature of this economy, this parameter is reduced from 0.0078 in the baseline economy to 0.0039. Finally, the requirement that $N = 0.3$ implies that $\omega = 2.77$.

Figure 6 shows the impulse responses for the two regimes in this economy. The difference in output response between the high and low equity-requirement regimes is much more pronounced than for the baseline economy, particularly on impact.

Table 4 presents the standard deviations of HP-filtered data from both economies. The standard deviations for the baseline economy reflect the impulse response functions in Figure 5: The decline in volatility is concentrated in debt and hours.

The results are substantially different for the high-substitution economy, on which we focus henceforth. The last column of Table 4 shows that, except for nondurable consumption, volatility is substantially less in the low equity-requirement regime. For output, the ratio of the standard deviation in the low-requirement regime to its high-requirement counterpart is 0.68. The actual ratio from periods 1995:I-2005:III and 1954:I-1982:IV in Table 1 is 0.53. Hence, the present mechanism can reproduce a large part of the decline in output volatility. Similarly for the debt: The model's volatility ratio is 0.39, while the actual counterparts are 0.21 for the total debt and 0.35 for mortgage debt. The model reproduces the actual finding that the decline in the volatility of the debt is the most pronounced.

The model also accounts for much of the dramatic stabilization of durable purchases. The ratio of standard deviations from the low- and high-requirement regimes is 0.60. The actual ratios for residential investment and durable consumption purchases are 0.22 and

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[5]The same reduced form can be obtained when the production function is $Y_t = (X_t)^\alpha (A_t N_t)^{1-\alpha}$, X_t is capital services determined by $X_t = \min \{H_t K, M_t\}$, and H_t is the rate of capital utilization. In this specification, intermediate inputs, such as energy sources, are a requirement for capital utilization.

0.36. The volatility decline in hours worked is larger in the model than in the data. The model's ratio is 0.54, and in the data it is 0.65. Nondurable consumption stabilizes in the model only modestly: The volatility ratio is 0.93 while the actual ratio is 0.57. However, the model captures the fact that durable purchases and residential investment stabilize more than nondurable consumption, although to an exaggerated extent.

The model qualitatively reproduces the decline in the correlation of hours worked with debt. The correlation goes down from 0.60 to 0.53 compared to actual decline from 0.86 to 0.11 for total debt, and from 0.82 to 0.33 for mortgage debt (Table 2). The larger decline in the data could reflect uncorrelated measurement errors attached to hours worked and the real debt, given that a reduction in the "true" volatility would augment the relative importance of such errors and thereby reduce the estimated correlation.

6.5   Endogenous Capital Stock

We explore here the implications of allowing the capital stock to vary endogenously. A variable capital stock gives the saver an additional avenue for intertemporal substitution. Given the non-labor income share $\alpha(1 - \nu) + \nu = 0.3$, we assume that $\alpha = 0.10$ and hence $\nu = 2/9$. We also set the depreciation rate for physical capital to 0.025 per quarter. The impulse responses from this economy display a well-known problem with models with multiple capital stocks. Immediately following a shock there is a dramatic increase in productive investment along with a similarly strong decline in savers' purchases of durable goods. In the following period the pattern is reversed. This instability reflects the lack of adjustment costs for either one of the stocks. Productive investment is built first all-at-once, and then the durable goods stock is increased. Introducing adjustment costs for at least one of the stocks would alleviate this counterfactual behavior. Our assumption above that the capital stock is constant represents an extreme form of adjustment costs.

The experiment of lowering the equity requirements in this economy yields similar results as those obtained previously with the high-substitution economy. The ratio of the standard deviation in the low equity-requirement regime to its high-requirement counterpart is 0.73, which is somewhat higher than the 0.68 ratio in the previous results. Hours worked also stabilizes somewhat less in this model. The ratio of its standard deviations is 0.52 instead of 0.54. There are two differences between this economy and that considered earlier, short-run curvature in the production function and endogenous capital accumulation. The differences between their results arise from the curvature of the production function. If we choose the same values of α and ν in the high-substitution economy with a fixed capital stock, then

the ratios of standard deviations for output and hours worked are 0.78 and 0.60. When the production function has curvature, stabilizing hours worked makes the equilibrium wage *more* volatile. This partially offsets the original stabilization.

The economy with a variable capital stock and the original economy with a constant capital stock represent two extreme specifications for adjustment costs, none and infinite. Nevertheless, output substantially stabilizes in both economies when equity requirements drop. This leads us to presume that parameterizations of adjustment costs for physical capital that lie between these two extremes will also produce such an endogenous decline in output variance. Extending the model to include business investment with more realistic adjustment costs is therefore of interest, but it lies beyond the scope of this paper.

6.6 Comparison of Level Changes

Figures 1 and 3 indicate that the increase in the ratio of the debt to the durable stock following the reforms in the early 1980s coincides approximately with a trend change in hours worked per capita. The steady-state analysis predicts that both hours worked and the ratio of debt to the durable stock should increase following a relaxation of equity requirements. Here, using the parameter values and the model's steady state, we evaluate these changes quantitatively, and compare them to those from 1954:I-1982:IV to 1995:I-2005:III.

The percentage increase in average hours per-capita across these two sample periods is 5.8 percent. In the baseline economy, the steady-state increase from the high to the low equity-requirement regime is 5.0 percent, and in the high-substitution economy it is 7.2 percent. Hence, the model predicts the order of magnitude of the change in hours worked. Regarding the ratio of total debt to the durable stock, the average ratio for the period 1954:I-1982:IV is 0.34, and for 1995:I-2005:III it is 0.45. The analogous ratios using mortgage debt are 0.32 and 0.42. The corresponding ratios in the high and low equity-requirements regimes (in both model economies) are 0.17 and 0.33. The increase in the ratio of household debt to assets is a fairly direct consequence of the relaxation of the equity constraint. It is more surprising, however, that this financial change can also reproduce the observed increase in hours worked.

7   Conclusion

This paper studies the implications of equity requirements on households for macroeconomic stability. The mechanism works through labor supply—lowering equity requirements weakens the connection between constrained households' durable purchases and their hours worked.

The striking change in the behavior of household debt and hours worked after the financial deregulation of the early 1980s coincided with the macroeconomic volatility decline. We believe that this evidence warrants a focus on the link between household borrowing and labor supply. The quantitative results indicate that weakening this link substantially contributed to macroeconomic stability. Of course, other factors could contribute to the stabilization. McConnell and Perez-Quiros (2000), Blanchard and Simon (2001), Kahn et al. (2002), Stock and Watson (2002, 2003), and Campbell and Fisher (2004) discuss other explanations. One related to ours holds that financial liberalization may affect macroeconomic volatility by increasing households' ability to smooth consumption. However, as Blanchard and Simon (2001) point out, this channel is not a promising route for explaining the greater macroeconomic stability. The volatility of nondurable consumption and services should decline, but the volatility of durable purchases should counterfactually increase—due to easier adjustment towards optimal stocks.

The contribution of lower equity requirements to macroeconomic stability arises in the present model where debt has stable value. That is, there are no inflation shocks which substantially change homeowners equity. This is important to note because low equity requirements also characterized the 1920s, and these arguably contributed to the following Great Depression. In fact, as we discussed above in Section 2, the architects of the New Deal regulatory system sought to stabilize the housing market by imposing equity requirements. The key difference between the 1920s and the time since the 1990s is the monetary stability of the latter period. This makes the present model a much better representation of recent macroeconomic history than of the 1920s and 1930s.

The analysis in this paper abstracts from the implications of the financial reform for welfare. A comparison of steady states reveals nothing in this respect, because the intertemporal substitution that benefits the borrower occurs along the transition path. In a companion paper (Campbell and Hercowitz, 2006), we calculate the transition path for this calibrated economy. The model's transition starts off with previously constrained households cashing out some of the home equity in excess of the new lower requirement. This borrowing surge increases the interest rate. Over time, the debt stabilizes at a higher level while the interest rate returns gradually to it's steady state. The welfare analysis of the calibrated economy indicates that both households gain in terms of discounted utility at the time of the reform, although the saver's gain is much larger than the borrower's because the terms of intertemporal trade move in her favor.

We conclude by noting that the interaction of borrowers and savers in the presence of equity constraints might have interesting implications for the analysis of monetary and fiscal

transmission mechanisms. Lowering the interest rate in a model with standard intertemporal substitution contracts labor supply by reducing the price of current leisure relative to future leisure. In a monetary version of the present model, we expect a lower interest rate to expand labor supply by increasing the demand for durable goods. This mechanism is relevant also for fiscal policies involving temporary redistribution of resources. A temporary transfer of funds from borrowers to savers should lower the interest rate—as the latter attempt to smooth consumption—and hence it should be expansionary. For example, a tax cut for all agents financed by government borrowing—which can be from savers only—should be contractionary in the present setup because it generates a transfer in the opposite direction.

Appendices

A   Measurement of Collateralized Household Debt

This appendix provides the details behind the claim in Section 2 that homes and other durable goods collateralize most household debt in the United States. From the 1962 Survey of Financial Characteristics of Consumers, Projector and Weiss (1966), Table 14, report that homes and real estate secured 77 percent of household debt, and automobiles another 8 percent. Using data from the 2001 Survey of Consumer Finances, Aizcorbe, Kennickell, and Moore. (2003) report that borrowing collateralized by residential property accounted for 81.5 percent of households' debt in 2001 (Table 10), and installment loans, which include both collateralized vehicle loans and unbacked education and other loans, amount to an additional 12.3 percent. Credit card balances and other forms of debt account for the remainder. The reported uses of borrowed funds (Table 12) indicate that vehicle debt represents 7.8 percent of total household debt, and, hence, collateralized debt (by homes and vehicles) represents almost 90 percent of total household debt in 2001.

B   Calibration of π and ϕ

This appendix presents the details underlying the calibrated values of π and ϕ for the two equity-requirement regimes.

Our observations of automobile loan terms come from Federal Reserve Statistical release G.19, which reports the average loan-to-value ratios and repayment periods for automobile loans from 1971 onwards. Over the 1971-1982 sample, the average loan-to-value ratio is 0.87, and the average term of a new car loan is 13.4 quarters. During the 1995:I-2004:II sample, the average loan-to-value ratio for cars is 0.92, and the average term of car loans is 18 quarters.

For mortgage loans, the calibration is based on the Survey of Consumer Finances. The SCF includes the year of home purchase, the equity stake in the home, and the original maturity of the first two mortgages. Our basic measure of the initial equity share is the average equity share of homeowners who purchased their homes within twelve months of the interview date (for the 1983 SCF) or in the interview year (for the 1995 and 2001 SCF's) and who borrowed at least half of the home's value. In the 1983 SCF, there are 104 such homeowners. Their average equity share is 0.2275 with a standard error of 0.0137. In the 1995 and 2001 SCF's, there are 334 and 251 comparable homeowners. Their average equity

shares are 0.1756 and 0.1749 with standard errors 0.0090 and 0.0094. For the same sample in the 1983 SCF, average mortgage term and its standard error are 85.5 and 3.8 quarters. For the 1995 and 2001 samples, the estimates are 102 and 108 quarters, with standard errors of 2.1 and 2.0 quarters.

The fact that the initial equity shares and maturity observations from 1995 and 2001 are very similar supports the assumption that by 1995 the reform of household credit markets was largely complete. We use the average of the two years' observations as our measures of mortgage down-payment rates and terms for the period beginning in 1995.

Because the survey period for the 1983 SCF immediately followed the enactment of the Garn-St. Germain Act, we think of these terms as representative of mortgage terms at the end of the period of substantial financial regulation. To check whether they are typical also prior to the financial reform, we examined the trends in average mortgage terms before 1983, as reported in the Federal Home Loan Bank Board's Monthly Interest Rate Survey. This survey includes only single-family homes, and hence it is more restrictive than the SCF. From 1963, the first available observation, to 1982, this survey reports stable loan-to-value ratios. The average loan-to-value ratio from 1963 to 1982 is 0.73 and this changed little over these twenty years. This average implies an equity share approximately four percentage points higher than we measure with the 1983 SCF. However, when we broaden the SCF sample to include *all* borrowers (i.e., also those who borrowed less than half the home's value), we obtain an almost identical initial loan-to-value ratio of 0.72 with a standard error of 0.02. Hence, the average initial equity share from the 1983 SCF of 0.2275 seems a good estimate for the period before the reform.

In contrast to the stability of the loan-to-value ratio, the average repayment period increased from 85.2 quarters in 1963 to 102.4 in 1982. This increase indicates that the average mortgage term in 1983 is higher than the typical term for the period of interest. Hence, we adjust downwards the 85.5 quarters measure from the 1983 SCF by subtracting half of that increase. The resulting loan term is 76.9 quarters.

We assemble these observations into calibrated values of π and ϕ for the two regimes. For the first regime, we measure the repayment rates of mortgage and automobile debt with the inverse of their average terms to maturity. Then, we calculate ϕ as the weighted average of these repayment rates, where the weights are the average shares of mortgage debt and consumer credit in total household debt over the period. From 1954 through 1982, these shares are 0.7 and 0.3, so the calibrated value of ϕ for the high equity-requirement regime is 0.0315. The financial reforms in the early 1980s substantially widened the options for refinancing and the availability of home equity loans. Given these developments, a household

can practically extend the repayment period to the entire life of the home. Accordingly, we assume that the repayment rate of home loans equals the rate of physical depreciation, 0.003. Refinancing and second loans have never been prominent features of automobile finance, so the terms of new car loans continue to reflect actual equity constraints. As before, we measure the repayment rate of automobile loans with the inverse of their average maturity. Averaging these with the shares of mortgage and consumer credit during the period 1995:I through 2005:III (3/4 and 1/4) yields a value of ϕ of 0.0161 for the low equity-requirement regime.

Similarly, π is a weighted average of the initial equity shares from automobile and mortgage debt. Ideally, the weights would reflect the flow of loans used to purchase new cars and homes. Such observations are not available, so we construct the weights indirectly. In a steady-state version of the model with two durable goods, loans extended in each category should equal the principle repayment rate multiplied by the category's steady-state debt. Given the repayment rates and debt shares used to calibrate ϕ for the period before 1983:I, the implied shares of home and automobile loans in total loans extended are 0.29 and 0.71. The resulting value of π for the high equity-requirement regime is 0.16 (the weighted average of 0.2275 for homes and 0.13 for cars). The average initial equity shares for both automobiles and homes fall by 0.05 from the first to the second sample period. Hence, we set the value of π for the low equity-requirement regime equal to 0.11.

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Table 1: Percent Standard Deviations of HP-filtered U.S. Data[i]

| | Sample Period | | | |
	1954:I-1982:IV	1983:I-2005:III	1995:I-2005:III	Ratio[ii]
Total Debt[iii]	2.77	1.88	0.59	0.21
Mortgage Debt[iii]	2.32	1.76	0.81	0.35
Hours Worked	1.97	1.52	1.29	0.65
Residential Investment	11.99	5.20	2.59	0.22
Nonresidential Investment	5.12	4.79	5.00	0.98
Durable Goods[iv]	5.66	3.07	2.03	0.36
Nondurable Goods & Services[iv,v]	1.14	0.64	0.65	0.57
Output	1.88	1.11	0.99	0.53

Notes: (i) All variables are logged and HP-filtered over the period 1954:I-2005:III. (ii) Ratio of standard deviation for the period 1995:I-2005:III to that for the period 1954:I-1982:IV. (iii) Nominal debt divided by the chain-weighted GDP deflator. (iv) Personal consumption expenditures on the given category. (v) We chain subtracted housing services from personal consumption expenditures on nondurable goods and services.

Table 2: Correlation Coefficients of HP-filtered Hours and Debt[i]

| | Sample Period | | |
	1954:I-1982:IV	1983:I-2005:III	1995:I-2005:III
Total Debt & Hours Worked	0.86	0.45	0.11
Mortgage Debt & Hours Worked	0.82	0.32	0.33

Note: (i) All variables are logged and HP-filtered over the period 1954:I-2005:III.

Table 3: Calibrated Parameter Values

Equity Requirements	π	ϕ	α	η	σ_ε	δ	$\tilde{\beta}$	$\hat{\beta}$	θ	ω
High	0.16	0.0315								
Low	0.11	0.0161	0.3	0.95	0.0078	0.01	$\frac{1}{1.01}$	$\frac{1}{1.015}$	0.37	1.95

Table 4: The Model Economy's Standard Deviations[i]

	Baseline Economy			High-Substitution Economy		
	High[ii]	Low[ii]	Ratio	High[ii]	Low[ii]	Ratio
Debt	2.16	1.03	0.48	1.87	0.72	0.39
Hours Worked	0.66	0.41	0.63	1.34	0.72	0.54
Nondurable Consumption	0.74	0.80	1.08	0.52	0.48	0.93
Durable Purchases	6.25	5.02	0.80	7.36	4.41	0.60
Output	1.88	1.70	0.90	1.88	1.28	0.68

Notes: (i) The entries are population standard deviations of logged and HP-filtered observations. (ii) Equity requirement regime.
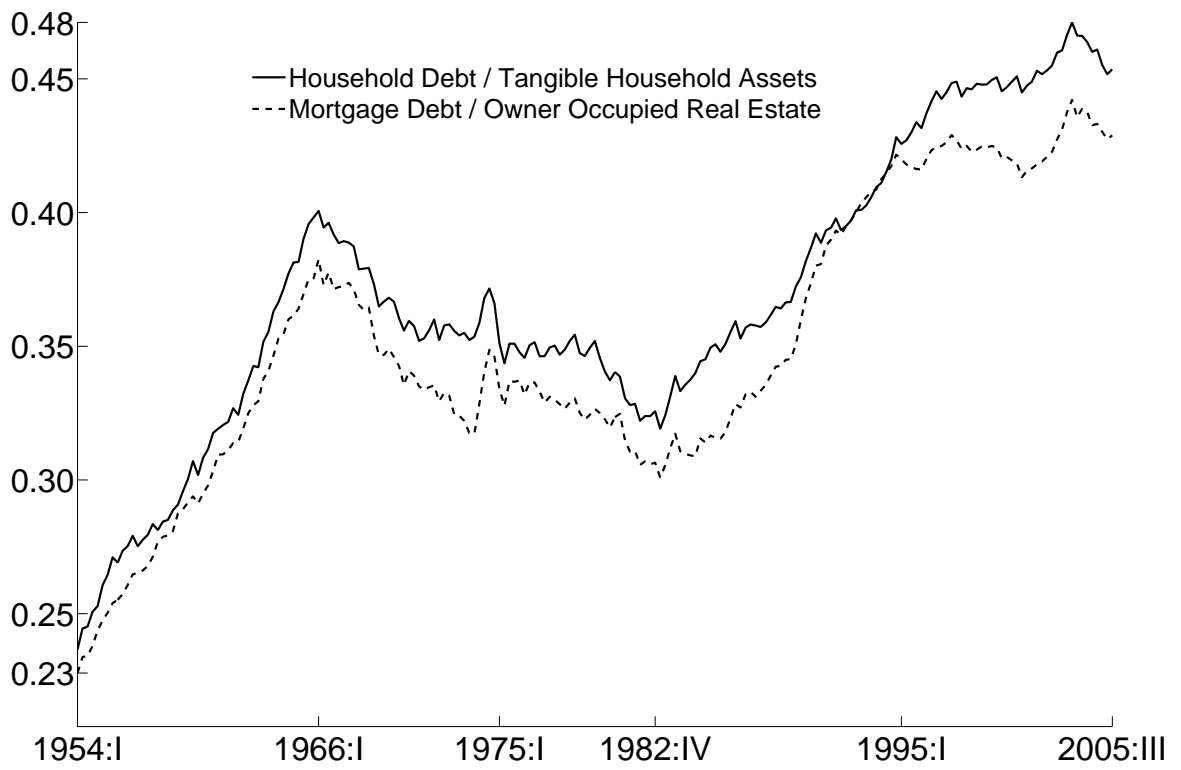
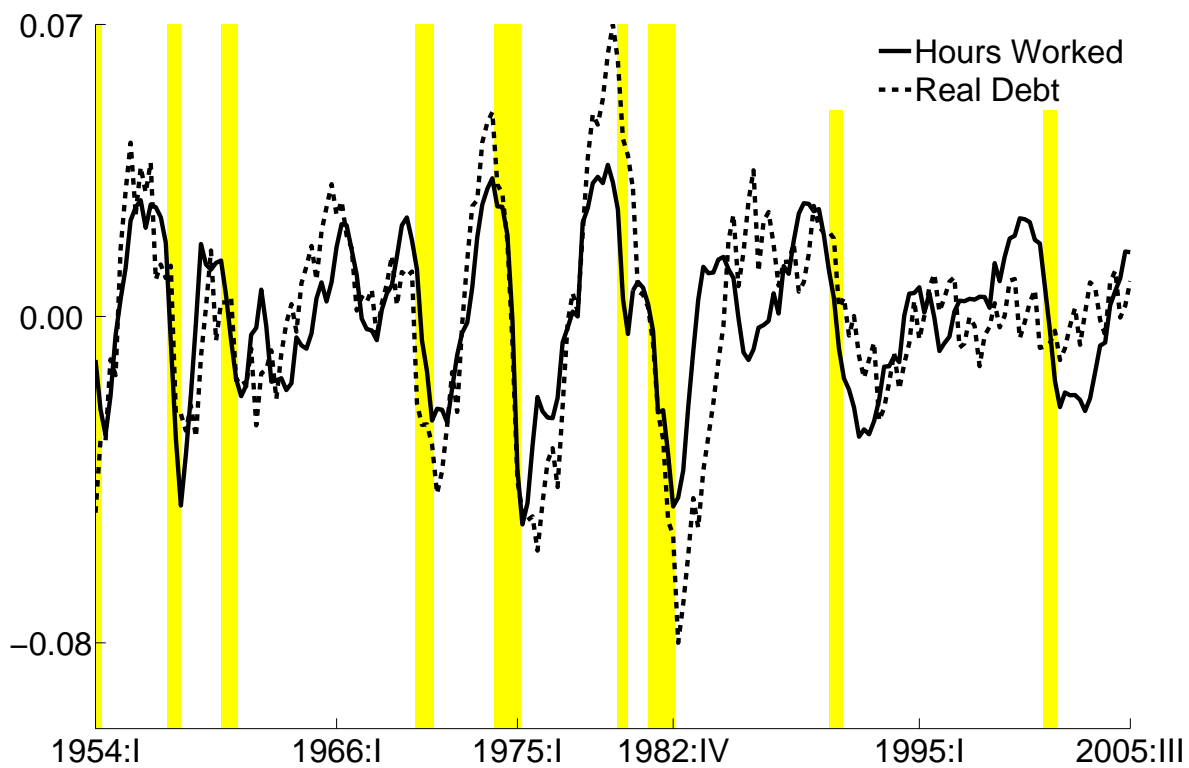Figure 1: Ratios of Households' Debts to their Tangible Assets

Figure 2: HP Filtered Real Household Debt and Hours Worked[i]

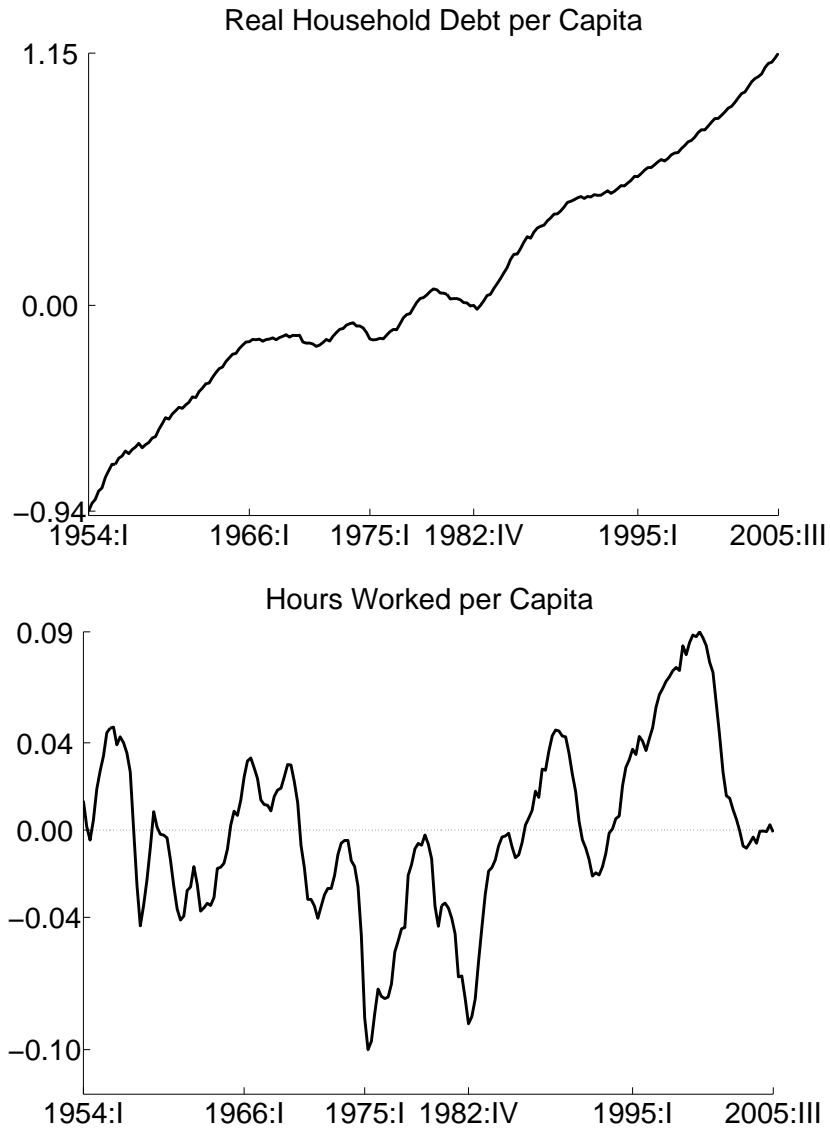Note: (i) Debts and Assets measured at current market values.

Figure 3: Real Household Debt and Hours Worked

Notes: The panels plot the logarithms of per capita hours worked and nominal household debt divided by the deflator for GDP. The average value of hours worked and the value in 1983 of real debt are normalized to zero. See the text for further details.
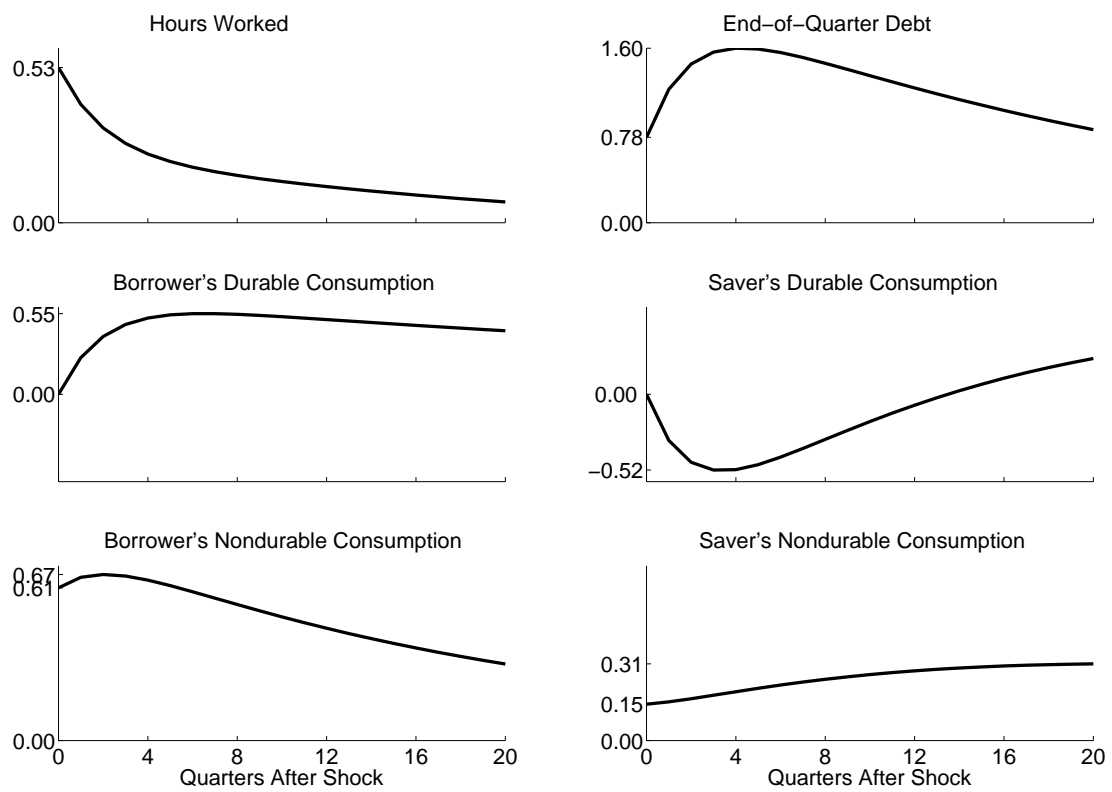
Figure 4: Household Responses with High Collateral Requirements to a Technology Shock
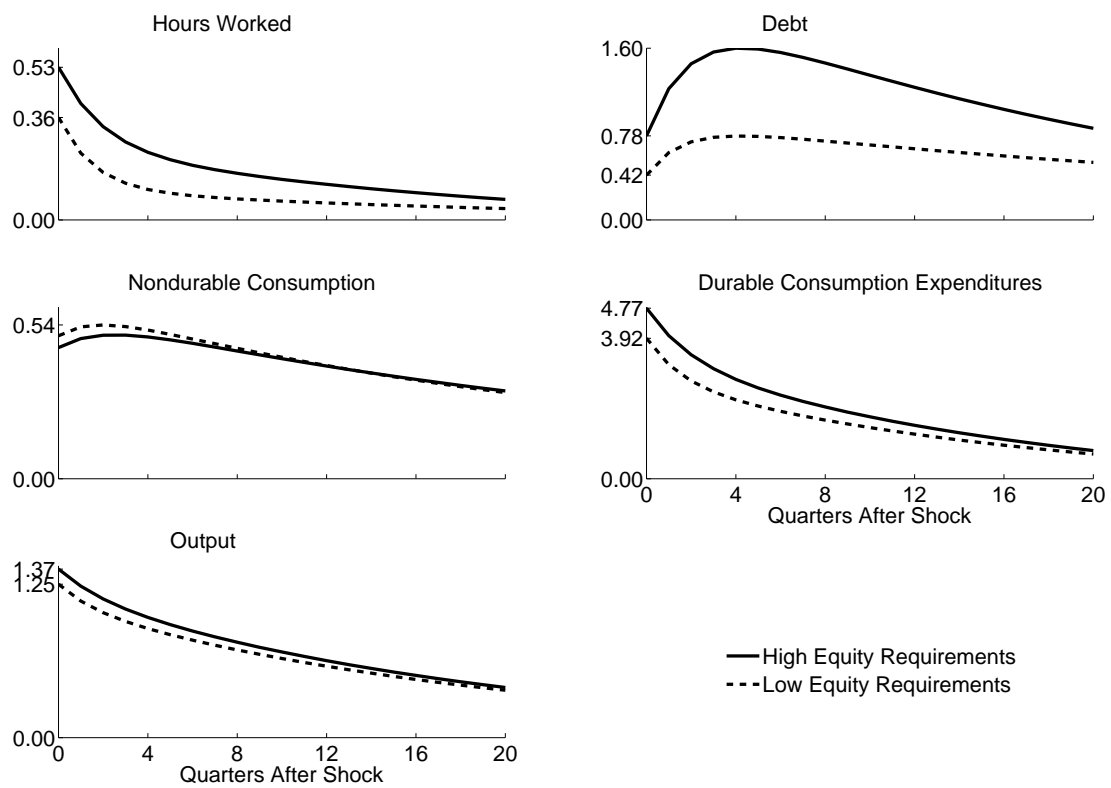
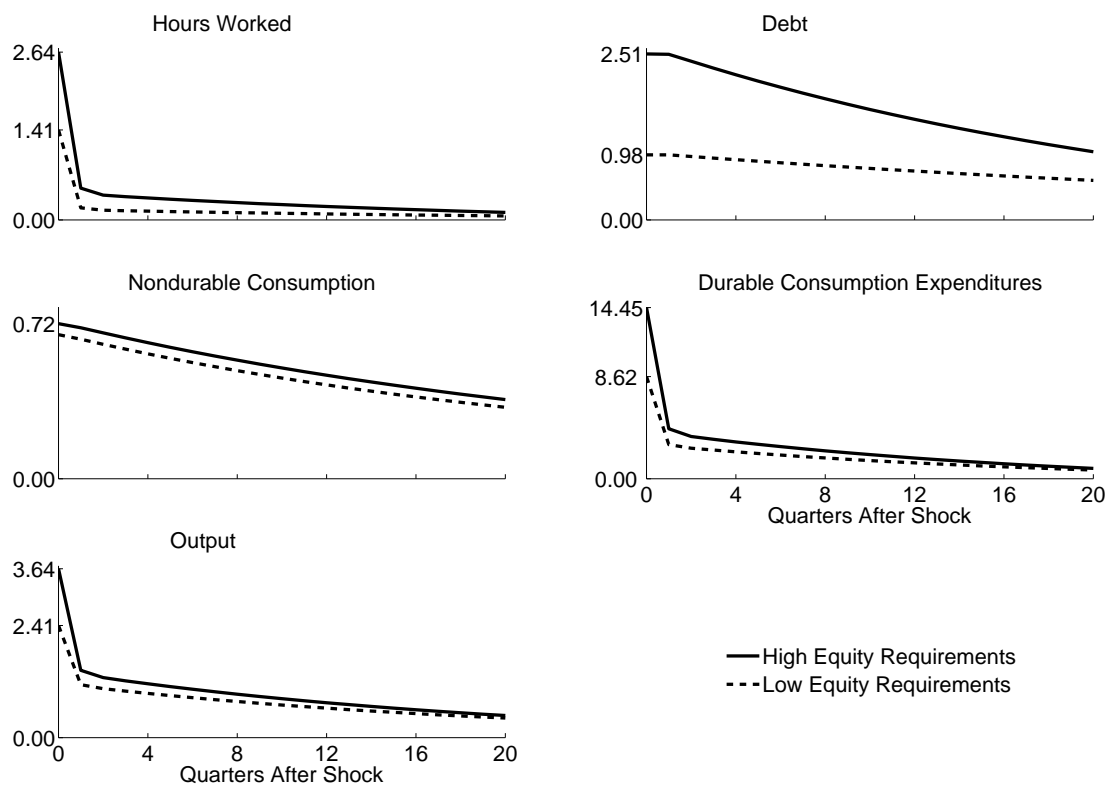Figure 5: Aggregate Responses to a Technology Shock

Figure 6: Aggregate Responses to a Technology Shock in the High-Substitution Economy