The Financial Labor Supply Accelerator

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Abstract

When minimum equity stakes in durable goods constrain a household's debt, a persistent wage increase generates a liquidity shortage. This temporarily limits the income effect, so hours worked grow. This is the financial labor supply accelerator, which links labor supply decisions to limits on household borrowing. This paper examines its implications for the comovement of hours worked and household debt by comparing model-generated data with evidence from the PSID. The drastic deregulation of household debt markets in the early 1980s effectively reduced required equity stakes in durable goods. Since then, the estimated regression effect of mortgage debt on hours worked, interpreted as comovement rather than causality, has dropped dramatically. Analogous estimates from model-generated data display a quantitatively comparable fall after a calibrated reduction in equity requirements.

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1 Introduction

In PSID data, hours worked and household debt expand and contract together. The Monetary Control and the Garn-St. Germain Acts of 1980 and 1982 triggered a comprehensive deregulation of the mortgage market that reduced the required equity stakes of households in their durable good. From then through at least 2005 the coefficient from regressing hours worked on household debt (and appropriate life-cycle and demographic control variables) fell substantially. This paper documents these facts and examines them through the lens of a model where households face an occasionally binding equity requirement on their durable goods arising from minimum down payments and accelerated debt amortization.

The model we use is a version of Campbell and Hercowitz (2009), in which households are home owners. According to the model, an unanticipated persistent wage increase generates a *shortage* of funds for financing the (now larger) desired stock of durable goods. This liquidity shortage induces the household to expand labor supply and use the higher earnings to fund the equity requirements. This is the eponymous financial labor supply accelerator. With zero equity requirements no liquidity shortage is generated, and so hours remain constant following the wage increase.

We use this framework to consider two regimes: One with high equity requirements, calibrated to the period prior to 1983, and another with low equity requirements, calibrated to the period afterwards. Artificial data generated by the model mimics the decline in the comovement between hours worked and household debt following financial liberalization, which effectively reduces equity requirements.

Existing empirical results about the relationship between labor participation and mortgage debt motivate our work. Fortin (1995) finds a positive contribution of the outstanding mortgage balance to probit estimates of Canadian female labor force participation rates. Del Boca and Lusardi (2003) study the link between the mortgage market and female labor market participation in Italy following financial liberalization triggered by the European unification in 1992. Comparing 1989 to 1993, they find higher female participation along with a sharp increase in the proportion of new homeowners with a mortgage. We make two contributions to this literature. First, we use the PSID (which begins well before the Carter-Reagan financial reforms and extends to the recent past) to document how the link between household debt and labor supply has evolved in the United States. Second, we interpret this evolution with an intertemporal substitution model of labor supply with borrowing constraints.

The rest of the paper is organized as follows. Section 2 provides basic statistics on hours worked and mortgage debt. Section 3 presents the model and discusses the main theoretical prediction about equity requirements and financial acceleration of labor supply. In Section 4 we calibrate the model and compute it's quantitative predictions. Section 5 reports the empirical results and compares them to the model's predictions, and Section 6 concludes with a discussion of the results' macroeconomic implications.

2 Motivating Evidence

In this section we present basic statistics about mortgages and hours worked from the PSID. The sample consists of households with two adults headed by a person of 65 years of age or less, during the period 1968 to 2005. The top 2 percentiles of dividend and interest income are excluded. Hours worked are the sum of the head's and wife's annual hours. The debt is dated at the PSID interviews, around April, and hours worked refer to the total in the previous calendar year. Hence, in terms of a standard dynamic model, the debt can be interpreted as an "end-of-period" stock which reflects a current decision.

We express mortgage debt in hours of work by dividing the balance by the hourly wage of the family head; hence, we can easily compare mortgages in different years and with hours worked. Because of the possibility of measurement errors in dividing total labor income into hours and hourly wages, we use whenever possible the lagged hourly wage in order to prevent an artificial positive correlation between mortgage debt and hours.[1]

Table 1 shows the basic statistics for the 1969-1997 period, for which the PSID surveys are annual; hence, the lagged wage to deflate the debt is available. Table 2 includes also the waves though 2005, which are biannual. For this table, the debt is deflated by the current wage. The statistics in both tables are organized by decades.

The top panels in the two tables show the well known fact that during this period hours worked and mortgage debt trend up; the debt, however, much faster.

For the second moments in the second and third panels we first filter each variable using a panel regression with year effects, and the household head's age, age squared, school years and race. As usual, we denote this "random effects", given that the household's characteristics are modelled as partially observable and partially unobservable, or "random". For comparison, we also include the results with fixed-effects (plus age squared).[2] We conjecture that fixed effects filter too much: households who are in the sample for a few years, (the average number

[1]Both mortgage debt and the hourly wage are expressed in constant dollars by dividing them by the consumption expenditure index in NIPA.

[2]Linear age is spanned by the fixed effects and the year dummies.

Table 1: Descriptive Statistics from the Annual PSID

	1969–1979	1980–1989	1990–1997
Mean of			
Hours Worked	2899	3187	3395
Mortgage Debt	1417	1893	2334
Standard Deviation/Mean of			
Hours Worked			
Raw Data	1057	1119	1134
Random Effects Residual	1035	1082	1092
Fixed Effects Residual	753	750	716
Mortgage Debt			
Raw Data	2238	2844	3699
Random Effects Residual	2182	2738	3622
Fixed Effects Residual	1847	2054	2404
Correlations of Hours Worked and Mortgage Debt			
Raw Data	0.175	0.214	0.179
Random Effects Residuals	0.139	0.164	0.141
Fixed Effects Residuals	0.064	0.061	0.048
Household-Year Observations	20,383	27,342	23,380

Note: For this table, all observations of households' mortgage debts were scaled by the household head's wage *from the previous survey*. Thus, mortgage debts are in units of hours worked. Please see the text for further details.

Table 2: Descriptive Statistics from the Complete PSID

	1970–1979	1980–1989	1990–1999	2001–2005
Mean of				
Hours Worked	2922	3223	3451	3605
Mortgage Debt	1318	1791	2275	3427
Standard Deviation/Mean of				
Hours Worked				
Raw Data	1036	1087	1087	1096
Random Effects Residual	1016	1056	1047	1081
Fixed Effects Residual	745	743	709	750
Mortgage Debt				
Raw Data	2156	2782	3665	4787
Random Effects Residual	2101	2684	3574	4764
Fixed Effects Residual	1814	2079	2525	3315
Correlations of Hours Worked and Mortgage Debt				
Raw Data	0.151	0.184	0.162	0.137
Random Effects Residuals	0.156	0.171	0.151	0.164
Fixed Effects Residuals	0.099	0.084	0.080	0.091
Household-Year Observations	21,889	28,816	27,822	9,135

Note: For this table, all observations of households' mortgage debts were scaled by the household head's wage *from the present survey*. Thus, mortgage debts are in units of hours worked. Please see the text for further details.

of years in the panel underlying Table 2 is 7.0) may have during most or all these years an interesting temporary behavior—unrelated to age, schooling and race—which the fixed effects filter out.

The results in both tables and filtering procedures are similar qualitatively, although different quantitatively. The largest results are from Table 2, which is based on a longer sample, and the random effects estimates. Comparing the 2000s to the 1970s, the correlation between hours worked and debt in the last panel goes up slightly—from 0.156 to 0.164. Hence, the tightness of the comovement between mortgage debt and hours worked does not change much. However, the important change is the sharp decline in dispersion of hours worked relative to the dispersion of debt. In the 1970s, the hours/mortgage ratio of standard deviations is $1016/2101 = 0.484$, and towards the 2000s this ratio goes down to $1081/4764 = 0.227$.

This can be visualized as flattening of a fitted regression line in a scatter plot of the two variables, where hours worked is on the vertical axis and mortgage debt on the horizontal axis. The interpretation of this regression has nothing to do with causality; it only indicates the strength of the comovement of hours worked with mortgage debt. Because the debt is expressed in hours worked, the regression coefficient has a simple interpretation: How many more hours households decide to work when they decide to expand mortgage debt.

We can easily compute regression coefficients from these preliminary statistics and compare the first to the last decade. The regression coefficient equals the correlation coefficient times the hours/debt ratio of standard deviations: It is $0.156 \times 0.484 = 0.076$ in the 1970s, and $0.164 \times 0.227 = 0.037$ in the 2000s. The implications of these coefficients can be illustrate in the following example. Consider a household with two adults working regular full-time hours, i.e., 4000 hours a year together. In a given year, they decide to take a mortgage equal to one-year worth of their income, i.e., 4000 hours worth of mortgage. The coefficient for the 1970s says that the household will work an additional $4000 \times 0.076 = 304$ hours that year. For the 2000s, the comparable calculation is $4000 \times 0.037 = 148$ hours. Repeating this calculation using the estimates from Table 1, for the 1969-1997 sample, and using the fixed effects residuals provides the other extreme in terms of the magnitude: 104 hours for the 1970s, and 56 hours for the 1990s.

The message, however, is the same from both Tables. For the same mortgage decision, households seem to increase hours by less in the 1990s and 2000s than in the 1970s. In this paper we study this behavior in the context of lowering equity requirements, which diminish the liquidity needs at times of updating the housing stock.

3 The Model

The model is a partial equilibrium version of Campbell and Hercowitz (2009). It characterizes the choices of a single infinitely lived household that faces a collateral constraint on its borrowing. This constraint has typical features of household loan contracts in the United States. First, debt collateralized by homes and vehicles is almost 90% of total household debt.[3] Here, we make the assumption that all debt is collateralized by durable goods. Second, debt contracts require the borrower to have an equity stake in the collateralized good: An initial equity share, corresponding to the minimum down payment, and an increasing equity share, as the term of the loan contracts is much shorter than the useful life of the good. We use the model to derive the implications of lowering equity requirements.

The preferences of the household are described by

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ (1-\theta) \ln C_{it} + \theta \ln S_{it} + \omega \ln (1 - N_{it}) \right\}, \quad 0 < \beta < 1, \tag{1}$$

where C_{it} is non-durable consumption, S_{it} is the stock of durable goods, and N_{it} is the fraction of available time spent working. We assume that the household is impatient, i.e., the discount factor satisfies $\beta R < 1$, where R is the constant gross interest rate.

Denoting net financial assets at the beginning of the period with A_{it}, and the idiosyncratic wage rate with W_{it}, the household's budget constraint is

$$C_{it} = W_{it} N_{it} + R A_{it} + (1-\delta) S_{it} - A_{it+1} - S_{it+1}, \tag{2}$$

where $0 < \delta < 1$ is the depreciation rate of durable goods.

The individual wage rate follows the exogenous process

$$\log W_{it} = \rho \log W_{it-1} + \varepsilon_{it}, \quad 0 < \rho \leq 1, \ Var(\varepsilon_t) = \sigma^2. \tag{3}$$

Debt is constrained by the collateral value of the household's durable goods. A simple specification of collateral value is

$$V_{it} = (1 - \pi) S_{it}, \tag{4}$$

[3] Using data from the 2002 Survey of Consumer Finances, Aizcorbe et al. (2003) report that borrowing collateralized by residential property account for 81.5% of households' debt in 2001 (Table 10), and installment loans, which include both collateralized vehicle loans and unbacked education and other loans, amounts to an additional 12.3%. 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% of total household debt, and, hence, collateralized debt (by homes and vehicles) is almost 90% of total household debt.

where π is a required equity share —an exogenous parameter—corresponding to the down-payment rate. Limiting borrowing to the value of collateral yields

$$A_{it+1} \geq -V_{it+1}. \tag{5}$$

A household purchasing a durable good subject to (4) and (5) will pay back the loan's principle as the good depreciates. To see this, multiply both sides of (4) by $(1-\delta)$ and subtract the result from the same equation for $t+1$ to get

$$V_{it+1} = (1-\delta)\, V_{it} + (1-\pi)\left(S_{it+1} - (1-\delta)\, S_{it}\right). \tag{6}$$

Hence, the specification in (4) implies that the collateral value depreciates at the rate δ. If the borrowing constraint binds, this requires that the debt be amortized at the same rate. In fact, amortized mortgages and typical automobile loans require the borrower to repay the loan principle at a faster rate than this, so that the borrower's equity share rises over time. We embody this fact into the model by requiring that a good's collateral value depreciates faster than the flow of services it generates. This replaces the first instance of δ in (6) with the depreciation rate of a durable's collateral value, ϕ.

$$V_{it+1} = (1-\phi)V_{it} + (1-\pi)\left(S_{it+1} - (1-\delta)\, S_{it}\right). \tag{7}$$

This perpetual-inventory collateral accumulation equation reduces to (4) if $\phi = \delta$. When $\phi > \delta$, the required equity share for a given purchase increases as the good ages. This mimics a typical feature of most loan contracts in the United States: An equity share that starts with a down payment and increases over time as debt amortizes more rapidly than the goods depreciate. The parameters capturing this feature are the initial equity share $0 \leq \pi < 1$, and the rate of repayment $\phi \geq \delta$ which determines equity accumulation.

Suppressing from now on the index i, the household chooses sequences of C_t, S_{t+1} and A_{t+1} to maximize the utility function in (1) subject to the sequences of constraints in (2), (5) and (7), and the initial stocks V_0, A_0 and S_0. Expressing the Lagrange multipliers on the four constraints with Ψ_t, $\Psi_t\Gamma_t$ and $\Psi_t\Xi_t$, the first-order conditions for optimization are

$$\Psi_t = \frac{(1-\theta)}{C_t}, \tag{8}$$

$$\Gamma_t = 1 - \beta R E_t \frac{\Psi_{t+1}}{\Psi_t}, \tag{9}$$

$$\Xi_t = \Gamma_t + \beta(1-\phi)E_t \frac{\Psi_{t+1}}{\Psi_t}\Xi_{t+1}, \tag{10}$$

$$1-\Xi_t(1-\pi)=\frac{\beta\theta}{(1-\theta)}\frac{C_t}{S_{t+1}}+\beta(1-\delta)E_t\frac{\Psi_{t+1}}{\Psi_t}-\beta(1-\delta)(1-\pi)E_t\frac{\Psi_{t+1}}{\Psi_t}\Xi_{t+1}, \quad (11)$$

$$\frac{\omega}{1-N_t}=\Psi_t W_t. \quad (12)$$

The multiplier on the budget constraint in (8), Ψ_t, represents the marginal value of current resources. In (9), Γ_t is the deviation from the standard Euler equation, which is positive when the borrowing constraint currently binds, and thus measures the current marginal utility from additional borrowing at the optimum.

Iterating (10) forwards yields Ξ_t as a present value of the current and future values of Γ_t. Hence, even if the equity constraint does not bind currently, i.e., $\Gamma_t=0$, Ξ_t is positive if the constraint is expected to bind sometime in the future. Therefore, Ξ_t can be interpreted as the price of an asset which allows the holder to marginally expand its debt in the future—or the marginal utility from liquidity.

Equation (11) characterizes optimal durable good purchases. If the borrowing constraint never binds, i.e., $\Xi_t=\Xi_{t+1}=0$, then this equation equates the purchasing cost of the durable good—the marginal cost of current resources—to it's marginal utility plus it's discounted resale value. When Ξ_t and Ξ_{t+1} are positive, the purchasing cost of the durable good is lower because it provides $1-\pi$ of collateral, whose liquidity value is that times Ξ_t. The resale price of the durable good is correspondingly lower as well.

The optimal condition for hours worked in (12) is standard. The borrowing constraint does not alter the intertemporal equality of the rate of substitution between consumption and leisure to the wage. The financial effect on the labor supply condition works via consumption. Here, consumption does not reflect permanent income only as for the unconstrained household, but also the availability of liquidity.

3.1 Steady State

We next characterize the deterministic steady state, focusing on the effects of changing the equity requirement parameters π and ϕ on hours worked.

From equation (9), the Lagrange multiplier on the borrowing constraint is

$$\Gamma=1-\beta R>0, \quad (13)$$

and thus the borrowing constraint binds at the steady state. This has two implications. First, from (7) and (5), the debt/durable stock ratio is

$$\frac{-A}{S}=\frac{(1-\pi)\delta}{\phi}. \quad (14)$$

Second, from (13) and (10) the marginal value of collateral is

$$\Xi = \frac{1-\beta R}{1-\beta\left(1-\phi\right)} > 0. \tag{15}$$

Using then (11) and (15) we obtain the ratio of durable to nondurable consumption:

$$\frac{S}{C} = \frac{\beta\theta/\left(1-\theta\right)}{\left[1-\beta\left(1-\delta\right)\right]\left[1-\frac{(1-\pi)(1-\beta R)}{1-\beta(1-\phi)}\right]}. \tag{16}$$

To complete the set equations for determining hours worked at the steady state, the budget constraint can be rewritten as

$$\frac{C}{WN} = \frac{1}{1+\left(R-1\right)\frac{-A}{S}\frac{S}{C}+\delta\frac{S}{C}}, \tag{17}$$

and the optimal condition for hours as

$$\frac{1-N}{N} = \frac{\omega}{1-\theta}\frac{C}{WN}. \tag{18}$$

This set of equations can be used to examine the long-run implications of changes in equity requirements. Lowering π or ϕ increase both S/C and $-A/S$ in (14) and (16). Hence, $C/\left(WN\right)$ decreases from (17), and N goes up according to (18). The intuition for these results involves substitution and income effects. Reducing equity requirements lowers the effective cost of durable goods, and thereby induces a shift from leisure to durable goods. It also generates higher debt in the new steady state, which induces a further decline in leisure, along with durable and nondurable consumption.

3.2 Financial Factors and Labor Supply

To elaborate on how the financial accelerator works, we address here the effect of a wage change on labor supply. To simplify this discussion we assume that the borrowing constraint always binds—which from Section 3.1 holds around the steady state—and $\phi = \delta$, i.e., the equity-requirement share is constant over time. These assumptions imply that the borrowing constraint, the condition for optimal purchases of durable goods, and the budget constraint can be written as

$$A_{t+1} \geq -\left(1-\pi\right)S_{t+1},$$

$$\pi = \frac{\beta\theta}{(1-\theta)} \frac{C_t}{S_{t+1}} + \beta \frac{C_t}{C_{t+1}} R \left(\pi - \frac{R-1+\delta}{R} \right), \tag{19}$$

and

$$W_t N_t + R \left(\pi - \frac{R-1+\delta}{R} \right) S_t = C_t + \pi S_{t+1}. \tag{20}$$

When $\pi = (R-1+\delta)/R$, the down payment equals the user cost of durable goods as usually defined. In this case there are no equity requirements because the down payment covers only the interest and the depreciation costs, and thus the outstanding debt next period equals the depreciated durable good. When $\pi > (R-1+\delta)/R$, there are positive equity requirements. These increase both the current cost and the continuation value of durables goods in (19), as well as the value of the current stock S_t in the budget constraint (20).

We now analyze the labor supply response to a wage change by comparing the effects under zero equity requirements and positive equity requirements. In the first case, $\pi = (R-1+\delta)/R$, and thus the three equations (19), (20) and the labor supply condition

$$N_t = 1 - \frac{\omega}{1-\theta} \frac{C_t}{W_t} \tag{21}$$

become a system for solving C_t, S_{t+1} and N_t as functions of W_t. From these three equations it follows that C_t and S_{t+1} should move proportionally to the wage, while N_t remains unchanged. Note that this holds regardless of whether the wage change is permanent or transitory. Intuitively, the household behaves as if disconnected from the capital market, while having access to a perfect rental market for durable goods. In this situation, all current income is spent on consumption of nondurable and renting durable goods at their user cost—as equation (20) indicates when $\pi = (R-1+\delta)/R$.

This situation is similar to that of an unconstrained household with zero assets who faces a permanent wage change: The substitution and the income effects on labor supply fully cancel each other out. The difference is that here, these results obtain for a wage change of any persistence. This follows from the binding borrowing constraint, which makes future wage behavior irrelevant.

When $\pi > (R-1+\delta)/R$, the proportional increase of C_t and S_{t+1} with N_t remaining constant is not a feasible response to a wage increase. The second term on the right-hand side of (**??**) equals the household's equity in its durable goods stock. Its presence makes the adjustment of C_t and S_{t+1} to the wage change gradual. Correspondingly, the ratio W_t/C_t during the process is higher than in steady state, implying from the condition for labor (21) that N_t is temporarily high.

4 Quantitative Implications

In this section we report first the calibration of the model. Then, we present impulse responses to illustrate the financial accelerator mechanism. We complete this section by estimating statistics from artificial panel data generated by the model, which are used to interpret our actual panel data estimates.

We solve the model using a rolling certainty-equivalence solution. The procedure solves period by period the current decisions given the current innovation to the wage and the other state variables, taking the expected future path of the wage as certain. The solution for each period requires the computation of the expected future path of all variables, including the Lagrange multipliers. Hence, the solution at a given period involves the simultaneous computation of when the constraints are expected to bind in the future.

For computing impulse responses, the model needs to be solved only once. For generating an artificial panel data set, the solution is applied sequentially for the number of time-series periods, and this repeatedly for each of the households in the cross-section size.

4.1 Calibration

The length of the period is one year, given the frequency of the PSID surveys. The calibration follows Campbell and Hercowitz (2009). For the high equity-requirement regime, the initial equity share, π, is 0.16, and the rate of repayment, ϕ, is 0.126. For the low equity-requirement regime, $\pi = 0.11$, and $\phi = 0.0744$. The other parameters are: depreciation rate $\delta = 0.04$, durable goods utility parameter $\theta = 0.37$, time-preference factor $\beta = 1/1.06$ and gross interest rate, $R = 1.04$. The calibrated rate of impatience, therefore is 2 percent. Given the other parameters, ω is set so that hours worked at the steady state equal 0.3. The result is $\omega = 1.93$.

We calibrate the parameters of the wage process, ρ and σ^2 based on results by Meghir and Pistaferri (2004). They find that labor income growth is a sum of a permanent component and an $MA(1)$ component with coefficient -0.26. They include also an error-in-measurement component, which is not relevant for calibrating the wage process in the present model. According to their estimates (Table III, second panel, pooled sample) the variance and serial correlation of labor income growth, excluding error-in-variables, are 0.0613 and -0.118.[4] We cannot adopt these values directly because hours worked is endogenous in our model. Ideally,

[4] These numbers are computed from Meghir and Pistaferri's estimates as follows: The variance of the permanent shock and the transitory shock are $\sigma_p^2 = 0.0313$ and $\sigma_e^2 = 0.03$. Hence, the variance of income growth is 0.0613. Because the temporary shock is $MA(1)$ with coefficient θ, i.e., $e_t = \varepsilon_t + \theta\varepsilon_{t-1}$, the variance of the shock is $\sigma_e^2 = \left(1+\theta^2\right)\sigma_\varepsilon^2$, and thus $\sigma_\varepsilon^2 = \sigma_e^2 / \left(1+\theta^2\right)$. The serial correlation coefficient corresponds

we would calibrate the ρ and σ so that the model delivers the two statistics above for the variance and serial correlation of labor income growth. This would require simulating data sets from the model sequentially, searching for values of ρ and σ until convergence of the two statistics of income growth to the target. Because this is extremely time consuming, we follow in this version of the paper the following procedure. We first adopt $\rho = 1$, i.e., innovations are permanent, which can in principle produce negative serial correlation of labor income growth because of the temporary labor response. Then, we set σ so the variance of labor income growth in the simulated high equity-requirement regime equals 0.06. This produces $\sigma = 0.17$. The resulting serial correlation coefficients of labor income growth for the two regimes are -0.054 and -0.076, which are lower but not far from the target.

4.2 Impulse Responses

Here we illustrate the labor supply accelerator by comparing impulse responses to a permanent wage increase of one percent in the calibrated high and low equity-requirements regimes.

Let us consider first the first four graphs in Figure 1, which show percentage deviations from steady state. The responses under low equity requirements—the dashed lines—are closer to the theoretical responses under zero equity requirements discussed in Section 3.2: Nondurable consumption, the durable stock and the debt, increase at a rate closer to one percent, while hours worked are closer to remain constant. The weaker liquidity shortage under low equity requirements makes possible to adjust durable and nondurable consumption faster, while increasing hours worked by less.

The over-shooting of the debt is due to the accelerated repayment feature ($\phi > \delta$). New durable goods can carry more debt than older durable goods; hence, following the new purchases, the temporarily younger durable stock allows impatient agents to borrow more than in steady state.

The last two graphs show the absolute deviations of the debt and hours worked from steady state values. Because steady state debt almost doubles from the high to the low equity-requirement regimes, the absolute deviation for the latter regime is larger, in spite of being lower in percentage terms. For hours worked, the steady state increase is only 3.5%, and thus the deviations in the low equity requirement regime are smaller in both units.

The impulse responses reflect the variables' volatilities. Hence, expressing the deviations

to $\frac{\theta\sigma_\varepsilon^2}{\sigma_p^2+\sigma_e^2} = \frac{\theta\sigma_e^2/\left(1+\theta^2\right)}{\sigma_p^2+\sigma_e^2} = -0.117\,82$, given their estimate $\theta - 0.2566$.

Table 3: Regression Coefficients of Hours Worked on Debt from Model-Generated Data

	Coefficient	t-statistic
High Equity Requirements	0.088	62.7
Low Equity Requirements	0.044	59.0

in absolute terms facilitates contrasting the impulse responses with the actual volatilities in Tables 1 and 2. There, from the 1970s to the 1990s or 2000s, the volatility of the debt relative to hours increased. The same happens here when moving from high to low equity requirements. In the data, however, both volatilities increase, while for the debt it does much more. Here, according to the two last graphs in Figure 1, the volatility of the debt does increase, but the volatility of hours decrease. A comprehensive comparison of the model to the data is reported in Section

4.3 Regression Analysis with the Model's Data

Here we focus on the key quantitative comovement of hours worked with the debt. We compute regression coefficients from the model, which in Section 5 we compare to the actual data counterparts.

In the sample up to 1983, there are 5.75 observations per household with all the data required.[5] In the 1984-1997 period, this number is 5.36. Based on these averages, we simulate both regimes by generating panel data with 6 years of time series. The number of simulated households is 300. The results are similar when using smaller number of households.

Table 3 reports the regression coefficients of hours worked on end-of-period debt for the two equity requirement regimes. As with the actual data, the debt is expressed in hours worked by dividing it by the lagged wage. Because all households are identical, there are no other variables, or fixed effects, to control for. The coefficient for the high equity requirement regime is 0.088, and half this size in the low equity requirement regime. Hence, the main implication of the model is that lowering equity requirements weakens the comovement of hours worked with debt: For the same change in debt, hours move in the second regime much less than in the first.

[5] In the first sample there are 52000 observations and 9000 clusters, and in the second, 35791 observations and 6677 clusters.

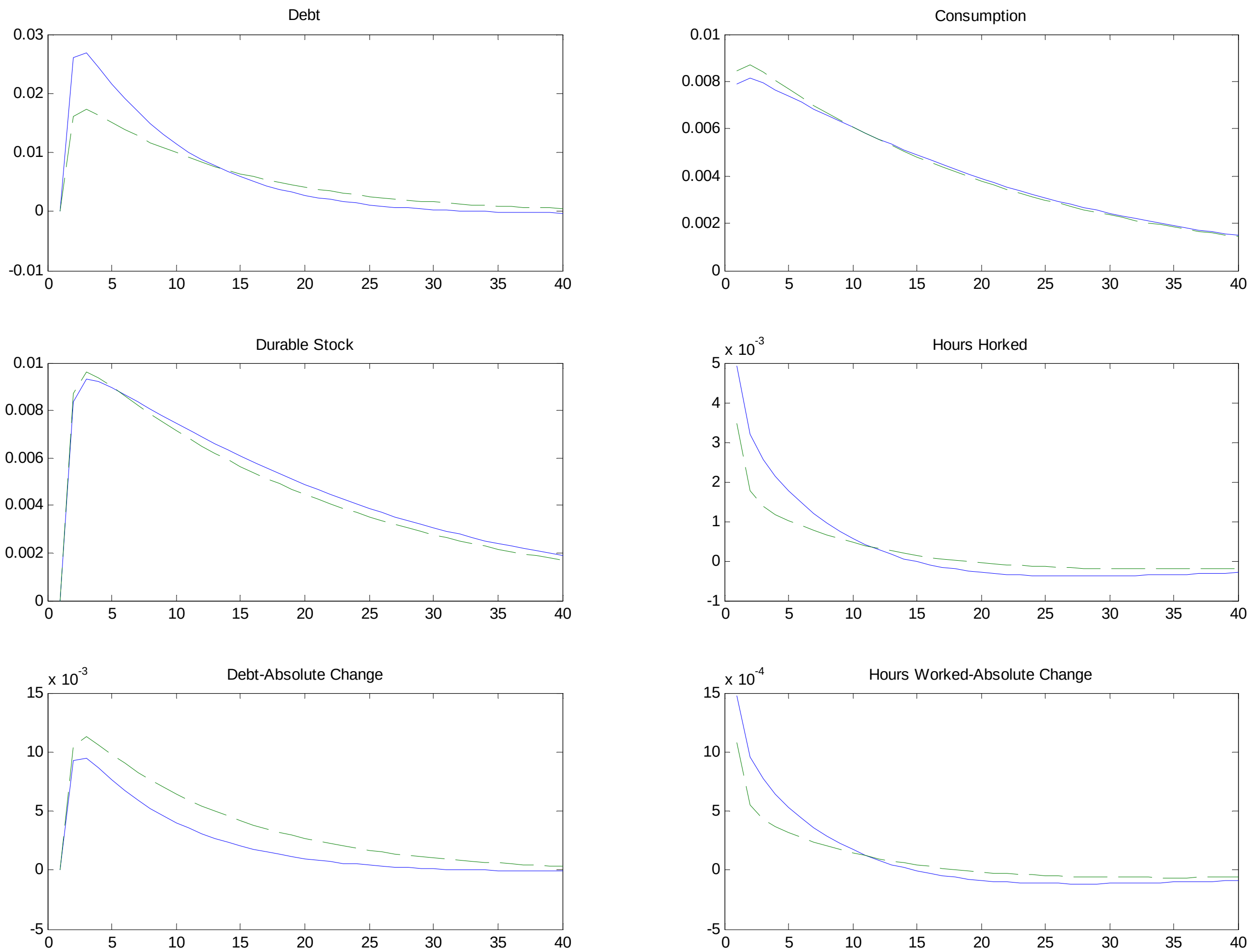

Figure 1: Impulse Response Functions

Notes: The full and dashed lines correspond to the high- and low-equity requirement regimes. The first four responses are percentage deviations from the corresponding steady states, and the last two are absolute deviations.

5 Comparison with the Evidence

To compare the model with the evidence we contrast the coefficients from the model in Section 4.3 for the two equity requirement regimes to comparable coefficients estimated with PSID data. In this section we describe first the data used, and then report the estimates.

5.1 The Data

PSID data is particularly attractive in the present context because they include labor market variables, mortgages and nonlabor income, covering well the periods before and after 1982. The main sample used is 1968-1997 for which the observations are annual. We also use the sample extended to 2005, with biannual observations from 1997 onwards.

We consider households with a "head" and a "wife" (married or unmarried partner) whose head is 65 years old or younger, that are not in the top 2 percentiles of the dividend and interest income distribution. Deleting the top 2 percentiles of the nonlabor income distribution follows the presumption that these households do not fit the characterization of impatient. In any event, as reported in Juster et al. (1999), the few richest households are not represented in the PSID.

Nominal variables are deflated by the consumption price index from NIPA, base 2000.

The empirical counterparts to the model's variables for household i in year t are:

N_{it}	total annual hours (sum of household head's and spouse's),
W_{it}	household head's real hourly wage (yearly average),
B_{it+1}	real mortgage balance at the end of the year.

We deflated nominal variables by the price index for personal consumption expenditures from the National Income and Product Accounts. Other variables from the PSID we employ are the household head's age, years of schooling, and race.

A basic problem with this data set is the possibility of errors in the allocation of total labor earnings to hours and hourly wages. Such errors generate an artificial positive correlation between hours worked and the ratio of any variable to the current wage. To avoid this problem whenever possible, we use the lagged wage. Hence, we express the debt in terms of hours worked by dividing B_{it+1} by W_{it-1}.

PSID surveys are conducted in the spring of year $t+1$ (around March-April). Hours and wage correspond to the period January-December of year t, while mortgage balance refers to the time of the interview. The ideal end-of-period mortgage balance would correspond to December of year t. However, the delay from December to March-April is consistent with the spirit of the model, that the liquidity constraint induces households to work more first to pay then for the equity requirement associated with borrowing.[6]

5.2 Econometric Results

We estimate regression coefficients of annual hours worked on mortgage debt with PSID data, and interpret them using the model's counterparts in Section 4.3 for the high and low equity-requirement regimes. However, we do not impose, ex-ante, specific sample periods to match the theoretical regimes. The deregulating legislation in 1982 could be taken as a dividing date, but there was increasing financial distress prior to 1982 and gradual implementation of the deregulation since then. Hence, we allow for year-specific coefficients by interacting the coefficient of the debt with a polynomial of time. Mortgage debt is expressed in hours of work, and the regressions include also the household head's age, age squared, school years dummies, and race dummies. The PSID does not have data on automobile debt; hence, we perform the estimation with mortgage debt only. We use alternatively two samples periods, 1970-1997 and 1969-2005. In the first period, PSID surveys are annual and hence the lagged wage, used to deflate mortgage debt, is available. The second period includes also biannual observations after 1997. For this sample, we use the current wage to deflate the debt.

Details of these regressions are reported in Table 4. We chose the order of the time polynomial for the debt to be three; a forth order polynomial produces the same pattern of coefficients over time. The coefficients of the debt by year are shown in Figures 2 and 3 along with 95 percent confidence intervals.

Let us focus first on Figure 2, which reports the coefficients from the random effects regression. In the lower panel, the debt is deflated by the current wage. Hence, the coefficients should be biased upwards if there are errors-of-measurement in the division of labor income into hours worked and hourly wages. It is unclear, though, if this bias should affect the pattern of coefficients over time which is at the focus of our analysis. The coefficients clearly

[6] We deleted unreasonably extreme observations according to the following criteria: 1. Real mortgage balance which is 5 times lower or higher than the balances in the adjacent years, provided that the absolute differences are larger than the average mortgage size in that year. 2. We applied two subsequent filters to hourly wages. First, we eliminated wages which are more or less than 10 standard deviations (in logs) from the average wage for the middle 50 percentiles in that year. Not including the lowest and highest 25 percentiles prevents extreme observations from distorting the average around which the band of acceptable values is computed. Second, we deleted hourly wages less than half of the federal minimum wage (Source: http://www.dol.gov/ESA/minwage/chart.htm#footnote), and more than 200 dollars of 2000. 3. Annual hours worked of more than 4000 per adult.

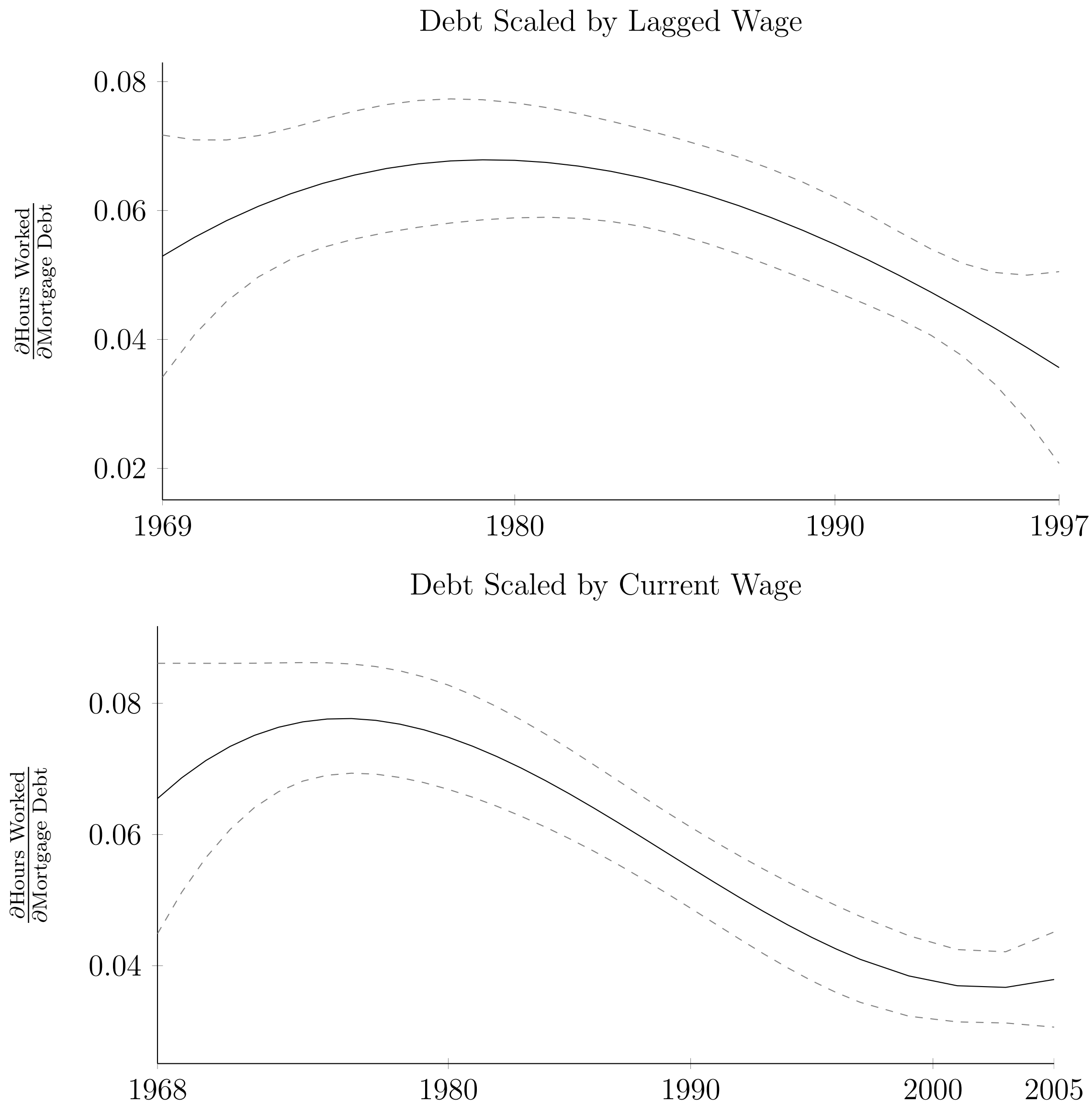

Figure 2: Estimated Coefficients from Random Effects Regressions

Note: Each panel plots the derivative of hours worked with respect to mortgage debt as a function of calendar time from the random effects regression estimates reported in Table 4. Confidence intervals with 95 percent coverage probability accompany each reported point. Please see the text for further details.

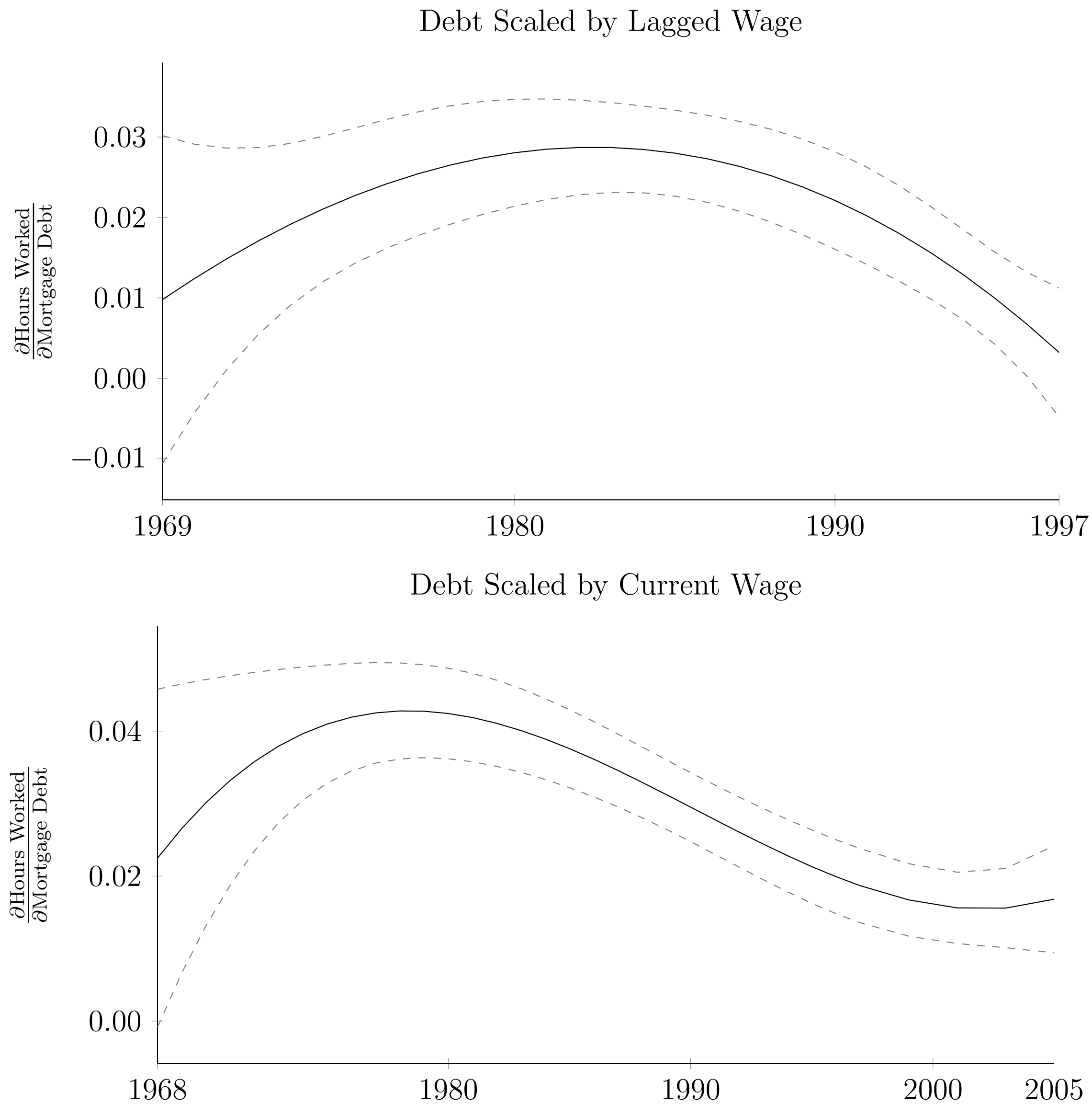

Figure 3: Estimated Coefficients from Fixed Effects Regressions

Note: Each panel plots the derivative of hours worked with respect to mortgage debt as a function of calendar time from the fixed effects regression estimates reported in Table 4. Confidence intervals with 95 percent coverage probability accompany each reported point. Please see the text for further details.

Table 4: Estimated Regression Coefficients

	Random Effects				Fixed Effects			
	1969–1997		1968–2005		1969–1997		1968–2005	
	Estimate	t-Statistic	Estimate	t-Statistic	Estimate	t-Statistic	Estimate	t-Statistic
Mortgage Debt								
$\times 1$	0.050	4.13	0.065	6.23	0.007	0.55	0.022	1.89
$\times t$	0.128	1.10	0.127	1.71	0.106	1.03	0.161	2.19
$\times t^2$	-0.246	-0.78	-0.373	-2.46	-0.118	-0.46	-0.375	-2.69
$\times t^3$	0.077	0.31	0.219	2.43	-0.030	-0.16	0.208	2.62
Age	79.795	16.29	69.515	16.95				
Age^2	-1.058	-17.74	-0.912	-18.03	-1.374	-20.17	-1.012	-17.57
Household Head's Education								
High School	173.647	7.49	169.170	8.38				
Some College	267.354	10.03	254.076	11.09				
College	215.539	6.91	197.761	7.38				
Post College	235.579	6.26	205.602	6.04				
Household Head's Race								
Black	-1.935	-0.09	9.672	0.51				
Other Minority	-132.073	-3.02	-195.078	-5.94				
Root Mean Squared Error	1,061		1,035		739		731	
R^2	0.107		0.113		0.568		0.558	

Table 5: F-statistics

	Random Effects				Fixed Effects			
	1969–1997		1968–2005		1969–1997		1968–2005	
	F-Statistic	p-value	F-statistic	p-value	F-Statistic	p-value	F-Statistic	p-value
1968			0.28	0.59			2.08	0.15
1969	1.54	0.21	0.10	0.75	2.71	0.10	1.72	0.19
1970	1.47	0.23	0.00	0.94	2.97	0.08	1.35	0.24
1971	1.30	0.25	0.05	0.83	3.20	0.07	0.99	0.32
1972	1.04	0.31	0.29	0.59	3.35	0.07	0.63	0.43
1973	0.70	0.40	0.81	0.37	3.36	0.07	0.33	0.57
1974	0.37	0.54	1.71	0.19	3.18	0.07	0.10	0.75
1975	0.13	0.72	3.05	0.08	2.81	0.09	0.00	0.98
1976	0.01	0.91	4.89	0.03	2.29	0.13	0.09	0.77
1977	0.02	0.90	7.19	0.01	1.72	0.19	0.43	0.51
1978	0.11	0.74	9.81	0.00	1.18	0.28	1.08	0.30
1979	0.28	0.60	12.57	0.00	0.74	0.39	2.08	0.15
1980	0.49	0.48	15.23	0.00	0.40	0.53	3.45	0.06
1981	0.75	0.39	17.62	0.00	0.17	0.68	5.12	0.02
1983	1.41	0.24	21.26	0.00	0.00	0.99	9.01	0.00
1984	1.83	0.18	22.54	0.00	0.05	0.83	10.99	0.00
1985	2.35	0.13	23.54	0.00	0.18	0.67	12.88	0.00
1986	2.99	0.08	24.35	0.00	0.42	0.52	14.62	0.00
1987	3.80	0.05	25.03	0.00	0.78	0.38	16.20	0.00
1988	4.84	0.03	25.64	0.00	1.31	0.25	17.63	0.00
1989	6.21	0.01	26.24	0.00	2.07	0.15	18.93	0.00
1990	7.99	0.00	26.87	0.00	3.15	0.08	20.14	0.00
1991	10.29	0.00	27.57	0.00	4.71	0.03	21.29	0.00
1992	13.04	0.00	28.38	0.00	6.97	0.01	22.44	0.00
1993	15.83	0.00	29.31	0.00	10.18	0.00	23.60	0.00
1994	17.74	0.00	30.43	0.00	14.50	0.00	24.81	0.00
1995	17.77	0.00	31.75	0.00	19.54	0.00	26.11	0.00
1996	15.87	0.00	33.33	0.00	23.82	0.00	27.52	0.00
1997	13.02	0.00	35.23	0.00	25.36	0.00	29.06	0.00
1999			40.09	0.00			32.47	0.00
2001			46.21	0.00			35.54	0.00
2003			50.58	0.00			35.17	0.00
2005			43.88	0.00			26.70	0.00

decline since the early 1980s, and stabilization appears to occur in the 2000s. This is allowed for only in the longer sample.

Prior to the early 1980s there is an increasing pattern at times of mounting financial distress. However, this positive slope is not statistically significant, while the decline afterwards is. This follows from Table 5, which shows the F-statistics of the null-hypotheses that the coefficient in a particular year is the same as for 1982. For the random effects columns in this table, the coefficients in the increasing part are insignificantly different from the coefficient in 1982. However, after 1982, the coefficients in the shorter sample are significantly lower starting from 1987. In the longer sample, the decline starts in 1976, and the coefficients since then are significantly different from that in 1982.

In terms of the comparison with the model, the coefficients prior to 1982 are about 0.06, declining to below 0.04 in 1997. The model's coefficients for the high and low equity requirements are 0.088 and 0.044. Hence, the model captures, although more dramatically, these changes in the comovement of hours worked with debt.

In Figure 3, the fixed effects coefficients have a similar pattern as in Figure 2, but the size of the coefficients is smaller. The columns in Table 5 for the fixed effects estimation present the same path of statistical significance as for the random effects estimates.

6 Concluding Remarks

In the mechanism studied here, households wish to expand their stocks of durable goods following a persistent wage increase, but they lack the funds for the required minimum equity stakes. We label the resulting increase in labor supply "the financial labor supply accelerator." This differs from the usual financial accelerator applying to firms. There, it is an *increase* in the availability of funds which induces constrained firms to expand economic activity. This difference is due to the margin households face and firms do not: The allocation of time across activities generating funds or utility. A shortage of funds induces constrained households to give up leisure. In a macro model where both firms and households face liquidity constraints, positive productivity shocks are likely to produce simultaneously an increase in the availability of funds to the firms, and a shortage of funds for the households—via equity requirements. Hence, it seems that the present and the standard financial accelerators operate in the same direction. A positive interaction between these two mechanisms seems an interesting aspect to explore.

The main macroeconomic implication of this paper is the possible link between the present mechanism and macroeconomic volatility, and in particular with the "great moderation" from the early 1980s until August 2007. The role of financial innovation for explaining this phenomenon through firms' financial considerations was addressed recently by Jerman and Quadrini (2009). They focus on increased flexibility in equity financing as the mechanism generating greater stability. We focus on enhanced possibilities in the mortgage market which effectively reduce equity requirements. With lower equity requirements, productivity shocks generate smaller labor supply responses by collateral constrained households, and thus more moderate aggregate fluctuations. We addressed the degree to which the financial changes contributed to the reduction in macroeconomic volatility in Campbell and Hercowitz (2006) using a general equilibrium framework incorporating the present mechanism, and we plan to continue that investigation.

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