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The Financial Labor Supply Accelerator

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Abstract

The financial labor supply accelerator links hours worked to minimum down payments for durable good purchases. When these constrain a household's debt, a persistent wage increase generates a liquidity shortage. This limits the income effect, so hours worked grow. The mechanism generates a positive comovement of labor supply and household debt, the strength of which depends positively on the minimum down-payment rate. Its potential macroeconomic importance comes from these labor supply fluctuations' procyclicality. This paper examines the comovement of hours worked and debt at the household level with PSID data—before and after the financial deregulation of the early 1980s which reduced effective down payments—and compares the evidence with results from model-generated data. The household-level data displays positive comovement between hours worked and debt, which weakens after the financial reforms. An empirically realistic reduction of the model's required down payments generates a quantitatively similar weakening.

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1 Introduction

In the standard model of labor supply based on intertemporal substitution, temporary wage increases expand both labor supply and assets. Hence, one might hypothesize that households repay debt when labor supply is high. Figure 1 examines this prediction with aggregate data and shows the opposite: Household debt (including mortgages and automobile loans) deflated by the chain-weighted price index for GDP and aggregate hours, both HP-filtered, display a clear and strong *positive* comovement.

Figure 1 suggests that the standard model of labor supply fails to characterize households' use of financial markets over the business cycle. In this paper, we present a model that generates positive comovement between hours worked and household debt with occasionally-binding minimum down-payment requirements for purchases of durable goods. These motivate households to raise labor supply when increasing debt. We denote the resulting expansion of hours worked the *financial labor supply accelerator.* To assess its empirical credibility, we calibrate the model's parameters and compare its predictions with observations of household choices from the Panel Study of Income Dynamics. We find that the positive comovement of hours worked and debt manifests itself in within households across years even after controlling for household fixed effects and calendar-year effects. The calibrated model economy quantitatively reproduces this. In the data, the connection between the two variables weakens after the financial reforms of the 1980's. An empirically realistic reduction of the model's required down payments generates a quantitatively similar weakening.

The model embodies two salient features of most household debt in the U.S.: durable goods serve as collateral, and new borrowing requires a minimum down payment. When the minimum down-payment constraint binds, a persistent wage increase generates a shortage of funds to finance the desired durable goods purchases. In the financial accelerator models of Bernanke and Gertler (1989); Kiyotaki and Moore (1997); Bernanke, Gertler, and Gilchrist (1999); credit-market imperfections amplify the fluctuations of borrowing-constrained firms' demand for factors of production. Unlike with firms, a *shortage* of household funds expands economic activity. Nevertheless, the traditional financial accelerator and that we consider here can complement one another. A persistent technology shock that increases firms' earnings and thereby triggers the traditional financial accelerator, should also raise wages. Then, the financial labor supply accelerator ensures that a given wage increase brings forth more hours worked. This labor supply response further raises output and strengthens the traditional financial accelerator by generating even more earnings for borrowing-constrained firms.

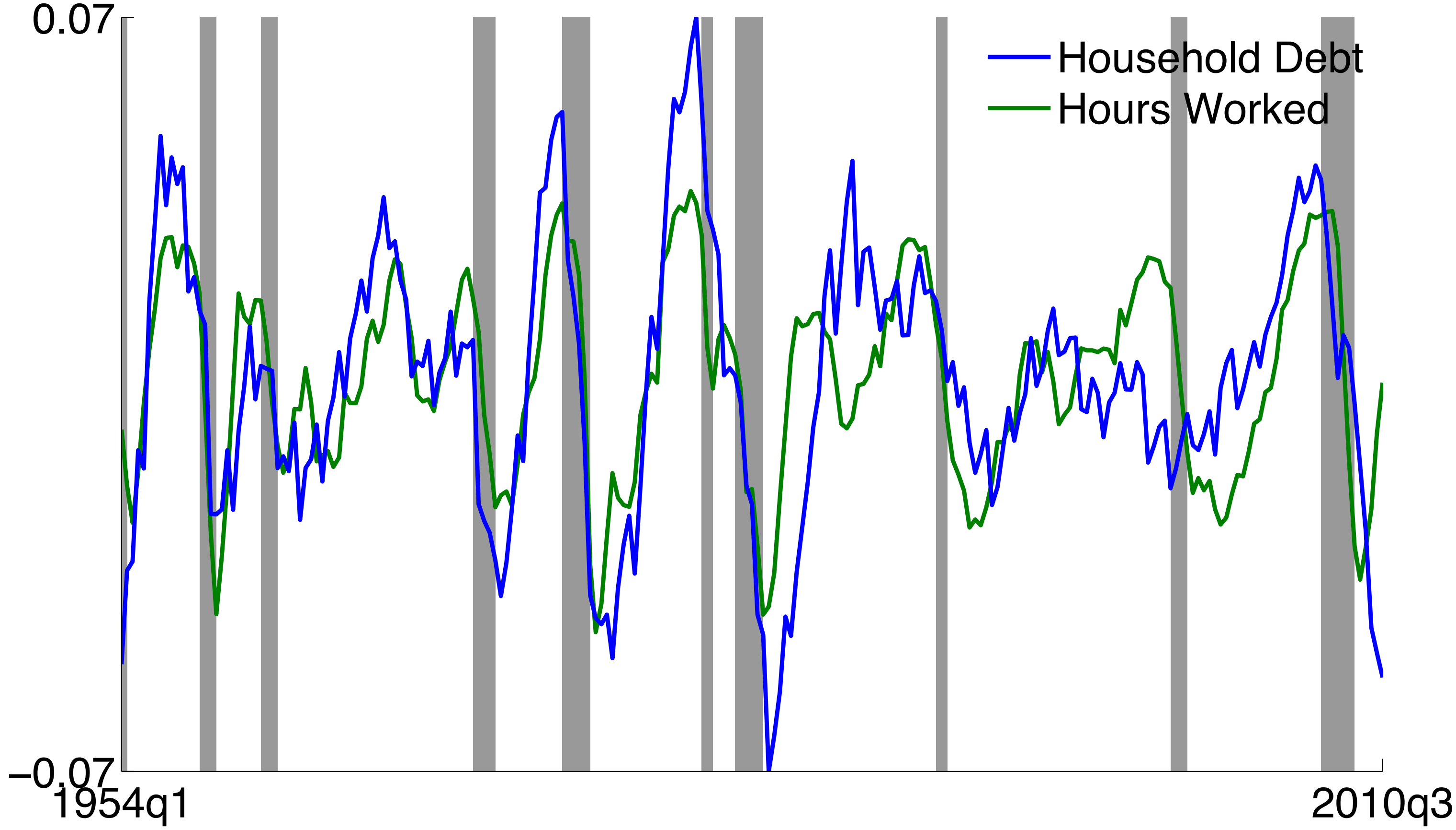

Figure 1: HP Filtered Hours Worked and Real Household Debt

When the down-payment rate exactly equals the user cost of durable goods – as defined by Jorgenson (1963)– then our model draws no meaningful distinction between nondurable consumption goods and the service flow of durable goods. Hence, there is no financial labor supply accelerator. In general, reducing required down payments weakens the accelerator, so periods of "easy credit" should display weaker comovement between hours worked and household debt. In fact, the comovement between the two series in Figure 1 weakened noticeably after the early 1980s. Their correlation before 1983:I is 0.86, and it equals 0.51 thereafter. This coincides with the comprehensive deregegulation of household credit markets brought about by the Monetary Control Act of 1980 and the Garn-St. Germain Act of 1982. As documented in Campbell and Hercowitz (2009b), required down payments on durable goods (particularly on owner-occupied homes) fell substantially in the wake of deregulation. As noted above, we show in this paper that the household-level comovement of hours worked and debt fell at about this time.

We are not the first to study the association between labor supply and household debt. Fortin (1995) found a positive contribution of the outstanding mortgage balance to Canadian female-labor force participation rates. Del Boca and Lusardi (2003) studied the link between mortgage markets and female labor force participation in Italy following a financial liberalization that lowered required down payments for mortgages in 1992. Comparing 1989 to 1993, they found higher female participation along with a sharp increase in the proportion of new homeowners with a mortgage. These observations are consistent with our model's long-run predictions for labor supply following a permanent reduction in required down payments. We build on these previous empirical results in three ways. First, we use observations from the frequently-studied U.S. economy. Second, we use panel data covering years both before and after financial deregulation to examine how the comovement between work and debt changes within a household over time. Finally, we compare our empirical results with those constructed from data generated by a quantitative model of the financial labor supply accelerator. When calibrated using actual down-payment rates from before and after the early 1980s, model-generated simulations mimic the level of comovement between hours worked and debt and its change following credit market deregulation well.

The rest of the paper is organized as follows. The next section presents the model and discusses its primary theoretical predictions. In Section 3, we calibrate the model and compute its impulse responses. In the calibration, we pay particular attention to the down-payment rates and the parameters of the exogenous wage process. These match down payments from observed loan contracts and the evolution of labor earnings in the PSID as reported by Meghir and Pistaferri (2004). The impulse responses quantitatively illustrate the theoretical predictions of Section 2. Section 4 documents the comovement of hours worked and mortgage debt in the PSID data and its changes over time. It then compares these results with those from data generated by the calibrated model. Section 5 concludes with a discussion of the financial labor supply accelerator's potential macroeconomic implications.

2 The Model

In Campbell and Hercowitz (2009b), we considered a general equilibrium economy with two infinitely-lived households, a patient saver and an impatient borrower. Differences between their discount rates motivated lending from the saver to the borrower, but borrowing must be collateralized with durable goods. In that model's steady state, the interest rate equals the saver's rate of time preference, the collateral requirement limits the borrower's debt, and equity in durable goods required by loan contracts represents all of the borrower's wealth. As in Becker (1980)'s analysis of intertemporal trade between households with heterogeneous discount rates, the saver holds all of the borrower's debt and the economy's other wealth. Accordingly, we interpret the two households as stand-ins for the wealthy and the home-owning middle class.[1] In this paper, we examine the decision problem of the less-patient borrower in greater detail, taking as given a constant interest rate that is less than the household's rate of time preference.[2]

The model's constraint on household borrowing has two features typical 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 assume that durable goods collateralize all debt. Second, debt contracts require the borrower to hold an equity stake in the collateralized good. We use the model to derive the implications of lowering equity requirements.

The household enjoys the consumption of three goods, nondurable consumption (C_t), the

[1] Renters can be thought of as even more impatient households, who prefer not to hold the equity required for home ownership. Such renters consume their entire labor income each period, so their labor supply will be invariant to the wage if they have preferences consistent with balanced growth.

[2] Holding the interest rate constant is consistent with this paper's stated goals: Explain the operation of the financial labor supply accelerator and document evidence for its presence in household-level data.

[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.

service flow from durable goods (S_t) and leisure ($1 - N_t$). The utility function equals

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ (1-\theta) \ln C_t + \theta \ln S_t + \omega \ln(1 - N_t) \right\}.$$

Here, $0 \leq \theta \leq 1$ and $\omega > 0$.

The household participates in a labor market, a durable goods market, and a market for one-period debt. Current nondurable consumption serves as the numeraire in all of them. The household can sell time in the labor market in return for the wage W_t. This evolves stochastically and is the sole source of uncertainty in the model. We specify its stochastic process below. The household can purchase or sell durable goods at the constant price of 1. The household's net durable goods purchases in year t equal $S_{t+1} - (1-\delta)S_t$. The household's borrowing in year t for repayment in year $t+1$ equals B_{t+1}. The market interest rate $R < 1/\beta$ is constant over time. Taken together, the household's trades in year t must satisfy the budget constraint

$$C_t + RB_t + S_{t+1} = W_t N_t + (1-\delta) S_t + B_{t+1}. \tag{1}$$

In Kiyotaki and Moore (1997), producers must collateralize their debts with productive capital and own part of that capital outright. Similar requirements constrain the debts of our model household: All debts must be collateralized by durable goods, and borrowers face a minimum down payment rate π. These requirements limit the debt to

$$B_{t+1} \leq (1-\pi) S_{t+1}. \tag{2}$$

Kiyotaki and Moore (1997) motivate a similar restriction on producers' debts with a model of optimal contracting subject to costly repossession. While it is obvious that repossession of durable goods is also costly, the history of household credit markets reviewed in Campbell and Hercowitz (2009b) strongly suggests that federal government housing and banking policies kept minimum down payments high from the end of the Korean War until the early 1980s. Deregulation expanded access to credit in part by allowing minimum down payments to fall. Below, we will model this liberalization with an exogenous reduction of π.

Note that in principle, there is an indeterminacy in the determination of gross debt. When the borrowing constraint is slack the household can carry "free wealth" from t to $t+1$ by paying down its debts, by buying securities, or by some combination of these two. In the first case, the household holds all of its wealth as equity in its durable goods stock, so its gross debt equals B_{t+1}. In the second case, the household sets its borrowing to equal the repossession value of its collateral, $(1-\pi)S_{t+1}$. When (2) binds this problem is not present because these two values are equal. How the household resolves this *portfolio indeterminacy* has no bearing on its consumption, wealth, and labor supply decisions; so we proceed assuming that the household accumulates wealth by paying down its debts. Our specification of the budget constraint in (1) reflects this resolution. [4]

The household's choices of consumption, work, and debt maximize utility given its initial wealth, $(1-\delta)S_0 - RB_0$, and the sequence of budget and borrowing constraints in (1) and (2). We denote their corresponding Lagrange multipliers with Ψ_t and $\Psi_t\Gamma_t$. With this notation, Γ_t can be interpreted as the rate of return from increasing the stock of available collateral. Since $\Psi_t > 0$, Γ_t equals zero when the borrowing constraint is slack and is positive when it binds. The first-order necessary conditions and relevant complementary-slackness conditions for utility maximization are (1), (2), and

$$
\begin{aligned}
\Psi_t &= \frac{(1-\theta)}{C_t}, && (3)\\
\frac{\omega}{1-N_t} &= \Psi_t W_t, && (4)\\
\Gamma_t &= 1-\beta R\mathbb{E}_t\frac{\Psi_{t+1}}{\Psi_t}, && (5)\\
1-\Gamma_t(1-\pi) &= \frac{\beta\theta}{(1-\theta)}\frac{C_t}{S_{t+1}}+\beta(1-\delta)\mathbb{E}_t\frac{\Psi_{t+1}}{\Psi_t}, && (6)\\
\Gamma_t &\geq 0, && (7)\\
\Gamma_t((1-\pi)S_{t+1}-B_{t+1}) &= 0. && (8)
\end{aligned}
$$

In the standard model with unlimited intertemporal substitution, Ψ_t equals the utility value of additional lifetime income. Here, Ψ_t measures the utility of additional income received in any year between the present and the next time the borrowing constraint binds.[5] The borrowing constraint leaves the optimal condition for hours worked in (4) untouched. The financial labor supply accelerator operates through the effects of the borrowing constraint on nondurable consumption.[6]

[4]However, the portfolio indeterminacy's resolution does determine which measure of household debt we compare with the data. We show below that our conclusions from comparing model-generated observations with data from the PSID are robust to selecting different resolutions to this indeterminacy.

[5]The expectation that a borrowing constraint will bind effectively shortens the household's planning horizon. Campbell and Hercowitz (2009a) describe the quantitative implications of this situation.

[6]In Fisher (2007), durable goods complement time spent in the market, and so they directly shift the

Equation (5) is the first-order condition for optimal debt. If the borrowing constraint does not bind in year t, then $\Gamma_t = 0$ and (5) reduces to the standard Euler equation. Otherwise, the collateral value Γ_t equals the Euler equation's violation. Equation (6) characterizes the optimal purchases of durable goods. If the borrowing constraint does not bind in year t then it equates the cost of purchasing a durable good to the marginal rate of substitution between C_t and S_{t+1} plus the purchase's expected discounted resale value. It has a similar interpretation when the borrowing constraint binds, but the expansion of collateral that accompanies the purchase lowers the effective price by $(1-\pi)\Gamma_t$.[7]

2.1 Steady State

To place our analysis of short-run fluctuations into context, we begin the model's analysis with the long-run predictions from its steady state given the wage W. These are three: the borrowing constraint binds, hours worked are invariant to the wage level, and reducing π raises the household's hours worked.

To see that the borrowing constraint holds with equality in the steady state, examine Equation (5) with $\Psi_t = \Psi_{t+1}$.

$$\Gamma = 1 - \beta R > 0, \tag{9}$$

which follows from the assumption of impatience.

The wage has no long-run influence on hours worked, because the household's preferences obey the balanced growth restrictions of King, Plosser, and Rebelo (1988) in which the income effect of a permanent wage change exactly offsets its substitution effect. We obtain the result as follows. First, replace Γ_t in Equation (6) with its steady state value to get the ratio of S to C.

$$\frac{S}{C} = \frac{\beta\theta/\left(1-\theta\right)}{\beta R\left(\frac{R-1+\delta}{R}\right) + \pi\left(1-\beta R\right)} \tag{10}$$

"labor supply curve." Our analysis sticks with preferences that are additively separable in durable goods and hours worked to keep the exposition of the financial labor supply accelerator as simple as possible.

[7]Equation (6) can be rewritten as

$$\Psi_t = \beta\theta\frac{1}{S_{t+1}} + \beta\left(1-\delta\right)E_t\Psi_{t+1} + \Psi_t\Gamma_t\left(1-\pi\right).$$

In utility terms, the price of purchasing this asset equals the standard present value of payoffs—the first two terms on the right hand side—plus its collateral value. The latter is positive only when the Lagrange multiplier of the collateral constraint is positive. This valuation of a collateralizable asset is basically the same as in Fostel and Geanakoplos (2008).

Raising either the minimum downpayment rate, π, or the usual user-cost of durable goods, $(R-1+\delta)/R$, lowers S/C. Second, replace B in the steady state budget constraint with $(1-\pi)S$ and use (10) to replace S itself with $C \times S/C$. Manipulating the result gives us consumption as a share of total labor earnings.

$$\frac{C}{WN} = \frac{1}{1 + \left[(R-1)(1-\pi) + \delta\right] \frac{S}{C}} \tag{11}$$

Finally, we can write the steady-state version of the labor supply condition (Equation (4)) as

$$\frac{1-N}{N} = \frac{\omega}{1-\theta} \frac{C}{WN}. \tag{12}$$

Inspection of (10) and (11) shows that $C/(WN)$ depends on neither W nor N, so N is a simple function of the model's other parameters. Hence, increasing W leaves N unchanged. Furthermore, the household's steady-state choices of C, S, and B are all linear in W.

It is also straightforward to derive the implications of lowering π for hours worked. This reduces the effective price of durable consumption relative to nondurable consumption, so S/C rises. The budget constraint therefore requires $C/(WN)$ to fall, which (through (12)) raises N. At the same time the reduction of π also induces households to increase B, so the model predicts that lower required down payments leads to both higher hours worked and higher debt in the new steady state.

Demographic changes and labor-market innovation undoubtedly influenced long-run labor supply in the U.S. However, it is worth noting that hours worked and household debt per U.S. adult have both a clear upward trend since the time of the financial deregulation in the early 1980s, which lowered effective down payments. Furthermore, Del Boca and Lusardi (2003) found that the Italian financial liberalization of 1992 (which lowered mortgages' minimum down payments) coincided with expansions of both female labor market participation and the proportion of households with a mortgage. Hence, the model's long-run predictions are consistent with the available evidence.

2.2 Financial Factors and Labor Supply

Although the household's borrowing constraint always binds in the nonstochastic steady state, sufficiently large shocks (or unusual initial conditions) can cause it to go slack. Household-level wage fluctuations are typically large, so the model's quantitative analysis requires us to account for the possibility that the borrowing constraint binds only occasionally. Nevertheless, we can develop qualitative intuition regarding the financial labor supply accelerator by looking at the household's responses to small shocks that keep its choices near their steady state values. In this special case, we can write the budget constraint as

$$W_t N_t + R\left(\pi - \frac{R-1+\delta}{R}\right) S_t = C_t + \pi S_{t+1}. \tag{13}$$

The left-hand side sums two sources of funds, labor earnings and the equity remaining after selling the durable goods stock and liquidating all debts. The right-hand side has two uses of funds, nondurable consumption and the required down payments for the purchase of next year's stock of durable goods. We also rewrite the first-order necessary condition for optimal durable goods purchases in (6) as

$$\pi = \frac{\beta\theta}{(1-\theta)} \frac{C_t}{S_{t+1}} + \beta R \mathbb{E}_t \frac{C_t}{C_{t+1}} \left(\pi - \frac{R-1+\delta}{R}\right). \tag{14}$$

This equates the current resource cost of augmenting the durable goods stock, π, with the marginal rate of substitution between nondurable consumption and the service flow from durable goods next year plus the discounted expected value of the resulting equity on hand.

The user cost of durable goods is the lowest choice of π that is possibly consistent with incentive-compatible debt repayment, because then the value of a depreciated durable good exactly equals the value of the debt. With π at this lower bound, the model's near-steady-state dynamics are trivial. The two equations above and the labor supply condition in (4) become a system involving only three unknowns, C_t, S_{t+1} and N_t. The solution leaves N_t at its steady-state value and has both C_t and S_{t+1} respond proportionally to the wage change. Intuitively, the household's expenditures are identical to those of one that can rent its durable goods stock at the user cost. This effectively disconnects the household from capital markets, and the resulting combination of "rule-of-thumb" consumption behavior (as defined by Campbell and Mankiw (1989)) with balanced-growth preferences yields no fluctuations in hours worked *whether wage shocks are permanent or transitory.*[8] In this sense, all of our model's predicted labor supply movements arise from the financial market imperfections that raise π above $(R-1+\delta)/R$.

The second term on the right-hand side of (13) equals the household's equity in its durable goods stock. It is positive when $\pi > (R-1+\delta)/R$, so the proportional increase of C_t and S_{t+1} with N_t remaining constant following a wage increase becomes infeasible. We can gain intuition for this case by setting β to zero so that C_t/S_{t+1} is constant. The budget constraint

[8]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. Here, this occurs even if the wage change is temporary.

then requires both expenditures to rise gradually. The ratio W_t/C_t rises temporarily, so the labor-supply condition (4) requires N_t to also rise temporarily. This response exemplifies the financial labor supply accelerator.

3 Quantitative Implications

Further exploration of the model requires a quantitative investigation. For this, we choose values for the model's parameters to match salient observations from the U.S. economy. After presenting our calibration choices, we explore the model's dynamics by examining a household's responses to permanent and transitory wage shocks.

3.1 Calibration

The calibration of the model's parameters proceeds in two steps. First, we choose values for all parameters but those governing the evolution of wages. In this, we closely follow Campbell and Hercowitz (2009b). We consider two values for the required downpayment π, 0.16 and 0.11. In that paper, we chose these values to match typical down payments on home purchases and new cars observed in the Survey of Consumer Finances and Federal Reserve Statistical Release G-19. The higher number applies to the period before the financial deregulation of the early 1980s, and the lower one comes from the years 1995 and later.[9] The rate of durable good depreciation is 4 percent, which is the appropriately weighted average of depreciation rates for residential structures and vehicles. We set the constant interest rate to 4 percent, and we set the household's discount rate to approximately 6 percent. We chose the utility share parameter θ to match the household's steady-state expenditure share on durable goods with the analogous share from the U.S. National Income and Product Accounts.[10] The resulting value of θ equals 0.40. We set ω, the utility parameter on leisure, so that the household's hours worked in the steady state equal thirty percent of the time endowment. The resulting value of ω is 2.23.

[9] Campbell and Hercowitz (2009b) consider the transition between the two regimes from the early 1980s until the middle 1990s in detail.

[10] For this, we measure "durable goods expenditure" with the sum of Personal Consumption Expenditure on Durable Goods and Residential Investment. Total expenditure adds Personal Consumption Expenditures on Nondurable Goods and Services less Housing Services to this. For the calibration, we chose θ so that the average ratio of durable to nondurable expenditure calculated from 1969 through 1982 matched the value given by (10). For this, we set π to 0.16. Calibrating θ using the analogous procedure with data from the period following the early 1980's financial reforms yields very similar results.

With these parameters set, we can proceed to calculate the model household's optimal behavior given any stochastic process for the wage. We seek to compare the model's generated data to observations from the PSID, so we choose the wage process to match features of a simple model of earnings estimated by Meghir and Pistaferri (2004) with those data. It decomposes the logarithm of earnings into mutually independent permanent and transitory components.

$$E_t = E_t^P + E_t^T$$

The permanent component E^P follows a random walk with a normally distributed innovation, and the transitory component follows a first-order moving average.

$$\begin{aligned}
\Delta E_t^P &\sim N(0, 0.177^2) \\
E_t^T &= \varepsilon_t^T + 0.2566 \times \varepsilon_{t-1}^T \\
\varepsilon_t^T &\sim N(0, 0.173^2/(1+0.2566^2))
\end{aligned}$$

Meghir and Pistaferri obtained these estimates from observations covering 1967 through 1992.[11] We choose a similar permanent-transitory decomposition to govern log wages in our model,

$$\begin{aligned}
\ln W_t &= \ln W_t^P + \ln W_t^T \\
\Delta \ln W_t^P &\sim N(0, \sigma_P^2) \\
\ln W_t^T &= \varepsilon_t^T + \lambda \varepsilon_{t-1}^T \\
\varepsilon_t &\sim N(0, \sigma_T^2).
\end{aligned}$$

Since the model household's hours worked are invariant to the wage *in the long run*, the permanent component of the household's earnings reflects $\ln W_t^P$. Accordingly, we set σ_P^2 to the long-run variance of earnings, 0.0313.

We expect fluctuations in hours worked to contribute to transitory earnings fluctuations, so we use simulated earnings observations to choose σ_T^2 and λ. The simulations use the model's rolling certainty equivalence solution. This takes initial values of S_t, W_t^P, ε_t^T, and ε_{t-1}^T and calculates the household's optimal choices given the expectation that no further wage shocks will occur. These calculations allow the borrowing constraint in (2) to bind only occasionally. The first-period choices from this are saved as "data", and the procedure is

[11] See the first column of the second panel in their Table III. Since the PSID collects information on the prior year's labor earnings, these observations correspond to the PSID waves from 1968 through 1993.

Downpayment	π	β	$R-1$	θ	δ	ω	σ_P	σ_T	λ_T
High	0.16	0.94	0.04	0.40	0.04	2.23	0.177	0.080	0.412
Low	0.11								

Table 1: Calibrated Parameter Values

begun again in the next period with the state updated using the calculated choices and the period's innovations to the wage process.

The calibration itself employs simulations of 2000 households for twenty years. Each of these starts at the nonstochastic steady state. We discard the first ten observations. With the last ten, we calculate transitory earnings as $E_t^T \equiv \ln W_t^T + \ln N_t$. We choose σ_T^2 and λ so that the simulations' variance and first-order autocorrelation match those implied by the estimates of Meghir and Pistaferri.[12] The values of σ_T and λ chosen are 0.080 and 0.412. When combined with a constant labor supply, these parameters yield a transitory earnings variance equal to about one quarter of our calibration target. Thus, labor supply variation dominates transitory earnings fluctuations in our model.

For reference, Table 1 records the calibrated values of all the model's parameters.

3.2 Responses to Wage Shocks

Our first use of the calibrated model is to calculate the responses to the calibrated permanent and transitory wage shocks beginning at the nonstochastic steady state. Since the wage shocks are "large" and our calculations account for possible nonlinearities in the solution, we calculated the responses to both positive and negative shocks. Figure 2 plots the calculated optimal paths of Γ_t, C_t, B_t, and N_t for both values of π. That for Γ_t is expressed as 100 times its deviation from steady state. The other three appear as percentage deviations from the initial steady state. For all simulations, the shock occurs only once, and the household (rationally) expects no further wage disturbances.

The figure's top panels give the variables' responses to the permanent wage shock, and the bottom panels correspond to the $MA(1)$ transitory shock. The mechanism studied in this paper can be best illustrated by the effects of permanent shocks on Γ_t. On impact, a positive shock *increases* the multiplier. That is, a permanent wage increase worsens the liquidity shortage in the short run. This in turn leads to a higher labor supply. Lowering the

[12] The target variance of E_t^T equals 0.03, while the target first-order autocorrelation is 0.2407.

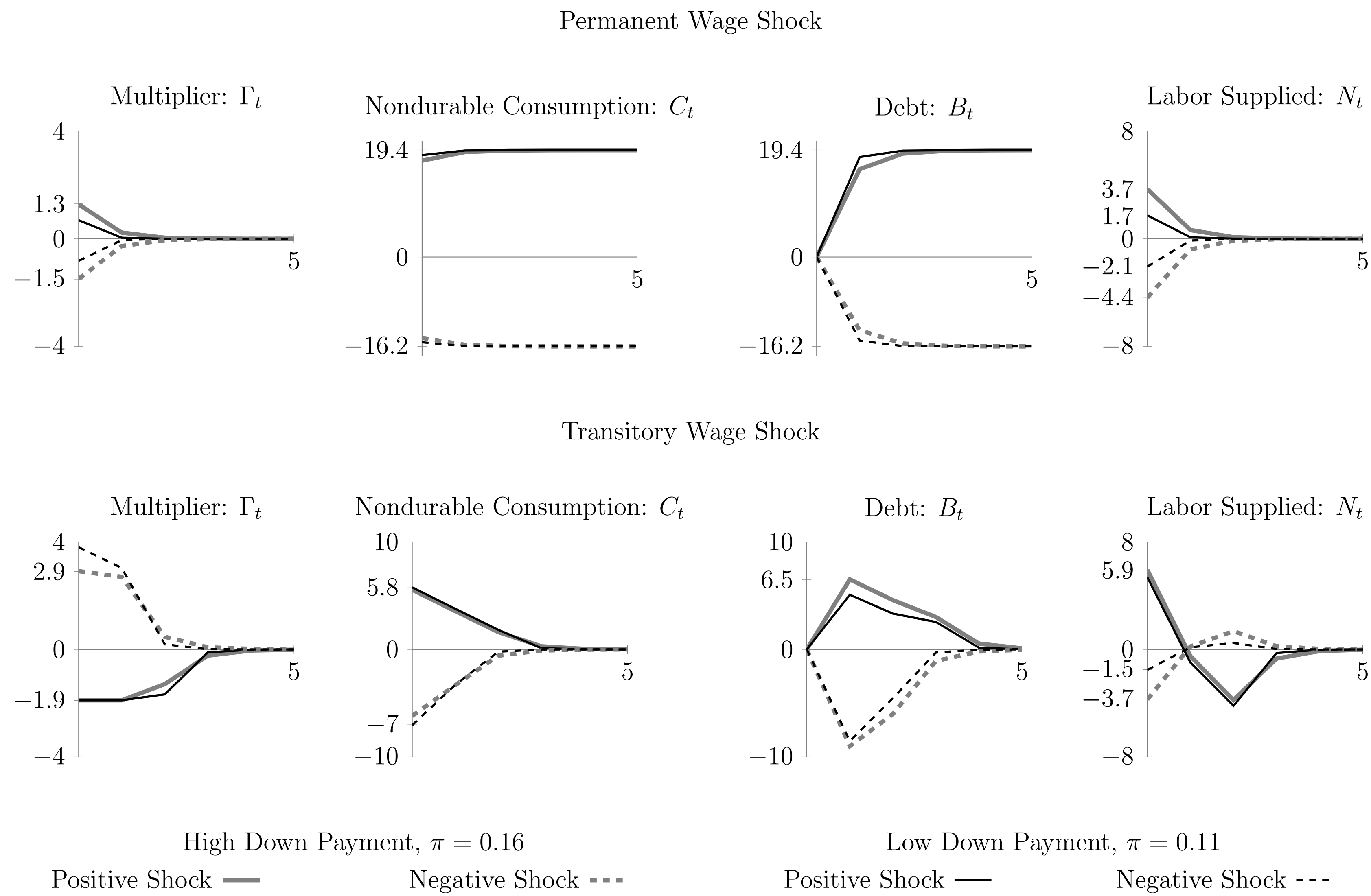

Figure 2: Model Responses to One-Time Wage Shocks Starting from the Nonstochastic Steady State

The horizontal axes given the number of years since the shock, beginning at zero. For the multiplier, the vertical axis plots the difference from its steady-state value times 100. For the remaining variables, the vertical axes plot deviations from initial steady-state values in percentage points. Please see the text for further details.

down-payment rate from 0.16 to 0.11 reduces the need for funds and therefore dampens the effect of the permanent shock on Γ_t. Changing the sign of the permanent shock generates responses that are almost mirror images of the originals. This is because the borrowing constraint always binds in both simulations.

Temporary wage shocks move Γ_t in the opposite direction of their permanent counterparts, so those simulations embody the standard intuition that borrowing constraints become less important in good times. A positive shock reduces the multiplier for a number of periods. Indeed, the calibrated magnitude of the shock is sufficient to bring Γ_t to zero. Turning the borrowing constraint slack shuts off the financial accelerator, so the size of the down payment influences the simulations little.[13] The negative temporary shock simultaneously increases Γ_t and reduces the size of the optimal stock of durable goods. Thus the household repays part of its debts. The higher π, the larger the amount of funds freed by this repayment, and thus the weaker is the tightening of the constraint. This is illustrated by the lower graph for Γ_t, where the multiplier increases less when $\pi = 0.16$ than with $\pi = 0.11$.[14]

In the long run, a positive permanent wage shock of one-standard deviation raises S_t, C_t, and B_t by 19.4 percentage points. The analogous negative shock lowers these variables by 16.2 percent in the long run.[15] As expected, the debt does not immediately jump to its new steady state level. Reducing required down payments considerably quickens this adjustment. The gradual response of B_t and its dependence on π do not depend on the sign of the permanent shock. In the four simulations with the permanent shocks, the borrowing constraint always binds, so the evolution of debt mimics that of S_t. Nondurable consumption also adjusts gradually. The responses to positive shocks are 17.5 and 18.5 percent with the high and low values of π. This incomplete adjustment manifests itself as a delay in the wage increase's income effect on labor supply. Hours worked expand 3.7 percent in the period of the wage increase when $\pi = 0.16$, and they return in about two years to their steady-state value. Lowering π cuts this response in half.

In both of the experiments with positive *transitory* wage shocks, the borrowing constraint does not bind for the first two years. Over this horizon, the household smooths its consump-

[13] We attribute the small differences between the simulations to differences in initial wealth.

[14] Although it turns the borrowing constraint slack, also the positive temporary shock generates positive comovement of labor supplied and debt. This is a result of the binding constraint prior to the shock. As the household's only initial asset is required equity, financing the desired additional durable goods requires borrowing. This would be unnecessary, at least partially, for an unconstrained household, i.e., one with positive free assets.

[15] The effects of positive and negative shocks have different long-run magnitudes because we use exact percentage-point changes instead of logarithmic deviations.

tion response and the usual intertemporal substitution effects on labor supply dominate. The borrowing constraint always binds after the negative transitory wage shocks. The initial wage is 7.7 percent below its original value, but nondurable consumption only drops 6.2 percent when $\pi = 0.16$ and 7.0 percent when $\pi = 0.11$. We interpret this as the household using some of its home equity to cushion consumption from the wage shock. When there is more home equity, the cushion is larger. Since consumption responds less, hours worked respond more. They decrease by 3.7 percent when down payments are high and -1.5 percent when down payments are low.

One might suspect that simulations of the model beginning at its nonstochastic steady state do not represent the model's behavior well, because the calibrated wage process features large shocks. We examined this speculation with 2000 simulated household histories for each down-payment regime. We used the durable goods stock, debt, and lagged transitory shock from each simulation's first year (following the 10 pre sample years) as initial conditions for the calculation of the impulse responses reported in Figure 2. Averaging the resulting responses across simulations yields Figure 3, which shares Figure 2's format. The similarity between the two figures is remarkable. Apparently, the nonstochastic steady state is indeed somewhat "typical" of the model's ergodic distribution.[16]

4 Comovement of Hours with Mortgage Debt

As shown earlier in Figure 1, aggregate hours worked and household debt (a) comove positively in general, and (b) this comovement weakens after the early 1980s—a period corresponding to lower down payments. The model's impulse responses in Figures 2 and 3 are consistent with the aggregate evidence: Shocks to the current wage move both hours worked and debt in the same direction, and lowering the required down payment weakens the response of hours more than that of debt. Given the importance of this pattern for the relevance of the financial labor supply accelerator, we investigate here the presence of a similar comovement at the household level with PSID panel data. We then compare the empirical findings with corresponding results from the model's artificial data.

We carried out this investigation estimating the following descriptive regression with the

[16]To examine this issue further, we calculated the percentage of periods in the calibration simulations in which the borrowing constraint binds and the household's average free wealth given that it is slack. For both values of π, the constraint binds in about 31 percent of the periods. However, the average free wealth *given that it is slack* equals only about 4 percent of the household's current wage. In this sense, the household typically remains close to the steady state.

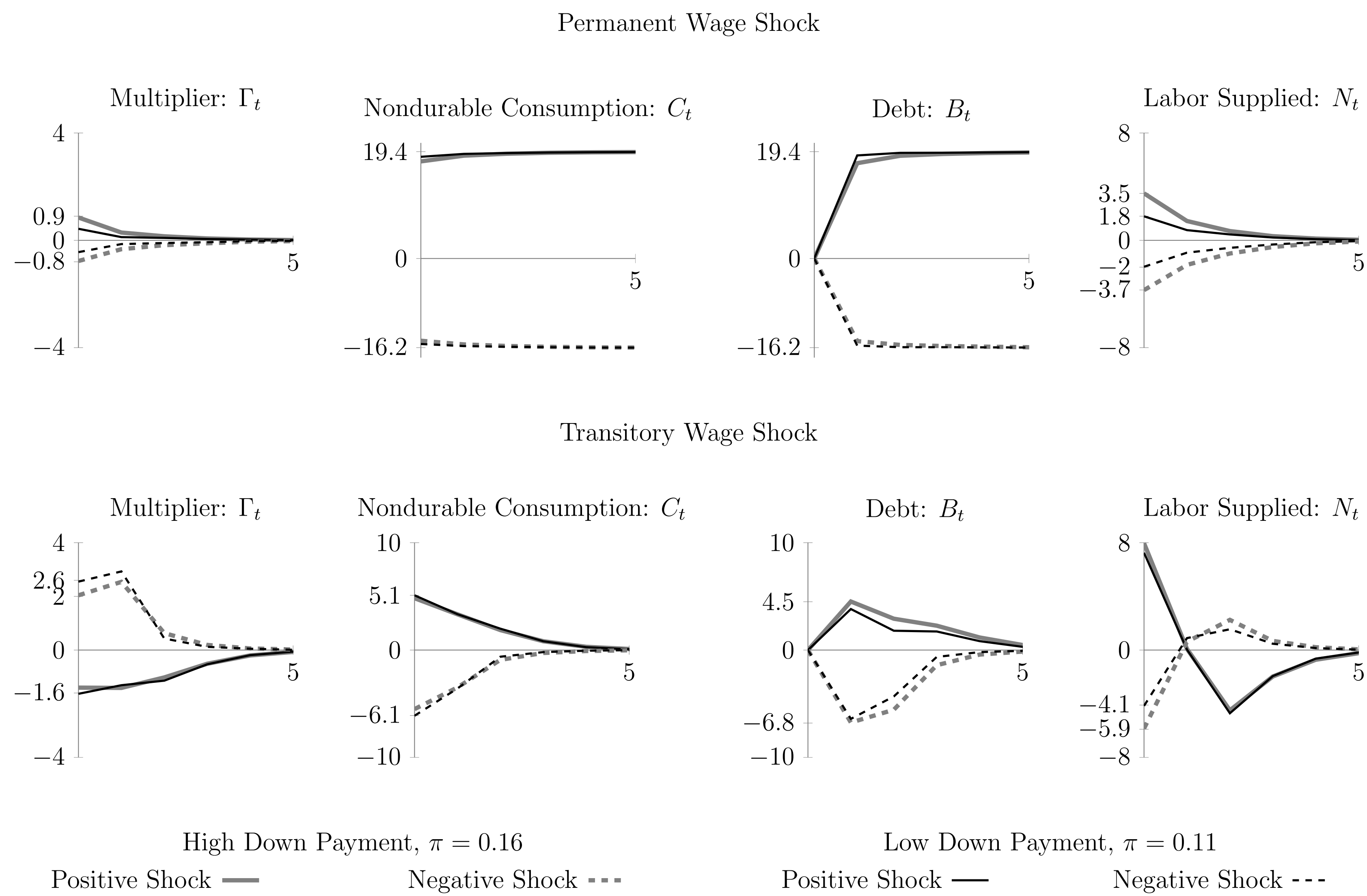

Figure 3: Model Responses to One-Time Wage Shocks Averaged Over Initial Conditions

The horizontal axes given the number of years since the shock, beginning at zero. For the multiplier, the vertical axis plots its level in percentage points. For the remaining variables, the vertical axes plot deviations from initial steady-state values in percentage points. Please see the text for further details.

PSID:

$$N_t^i = \mu_t + \gamma_t D_{t+1}^i/(1000 \times W_{t-1}^i) + \lambda X_t^i + u_t^i. \tag{15}$$

Here, the variables refer to household i in year t: N_t^i is hours worked, D_{t+1}^i is debt at the beginning of the following year, W_{t-1}^i represents the hourly wage in the previous year, and X_t^i is a vector of control variables. We measure N_t^i by summing the Head's and Wife's reports of annual hours in the calendar year prior to the interview in year $t+1$. We use the Head's wage, constructed by dividing reported earnings by reported hours worked, as W_t^i. Mortgage debt at the time of the interview is the only measure of household liabilities consistently present in the PSID. We interpret this as an "end-of-period" stock of debt that reflects the previous year's work, consumption, and saving decisions. We represent this measure of household debt with "D" rather than" B" to emphasize that the resolution of the portfolio indeterminacy we assumed when developing the model does not necessarily characterize the data.

The intercept μ_t varies over calendar time to control for macroeconomic fluctuations, and the vector of individual-specific control variables X_t^i accounts demographic differences across households.

The key variable on the right-hand side of (15) is $D_{t+1}^i/(1000 \times W_{t-1}^i)$.[17] This expresses the household's debt in thousands of hours of work. In the impulse response functions of Figures 2 and 3, shocks to the current wage moved both debt and hours worked in the same direction. Therefore, we expect γ_t to be positive. Lowering the required downpayment rate reduced the response of hours disproportionally more than that of debt, so we also expect estimates of γ_t to be lower for dates after the financial reforms of the 1980s. The time-varying intercept (μ_t) accounts for shocks that are common to all households, so the estimates of γ_t do *not* embody the comovement of aggregate hours worked and household debt displayed in Figure 1.

4.1 Sample Selection

The model describes the decisions of a middle-class household with labor market participation, a substantial stock of leveraged durable goods, and a long planning horizon. So that our sample households are more likely to satisfy these assumptions, we exclude households with either

[17] We use W_{t-1}^i instead of W_t^i in (15) because measurement errors in hours worked can generate a spurious positive correlation between D_t^i/W_t^i and N_t^i.

Sample	Available Years	Observations	Households
Annual	1969–1997	34,164	5,311
Complete	1970–2005	37,292	6,119

Table 2: PSID Sample Sizes

- income from dividends and interest in the current survey's top two percentiles,
- total market work in the previous year less than 1000 hours,
- no mortgage debt in both the current and previous surveys, or
- a Head (as defined in Hill (1992)) under 20 years old or over 50 years old.

Since the model abstracts from life-cycle events such as marriage and divorce, we also require two adults to be present in each of our sample's household-year observations. To mitigate the effects of measurement errors on our results, we excluded observations in which

- either adult's annual hours worked exceeded 4000,
- either adult's measured hourly wage is less than half the current Federal Minimum Wage, or
- either adult's measured hourly wage exceeds $2,000.

Each observation we use has information on hours worked and mortgage debt. Additionally, we require our sample's observations to have information on the Head's age, race, and educational status.

The data covers the period 1968 to 2005. From its inception through 1997, PSID surveys occurred annually. We refer to the resulting set of observations as the *annual* PSID. Thereafter, the survey has been biennial, and we call the observations including these later years the *complete* PSID. To estimate (15) with the complete PSID, we replace the once-lagged wage with the twice-lagged wage. Table 2 reports the number of observations and households in both samples after applying all of our selection criteria.

4.2 Empirical Results

We estimate γ_t in (15) using the Annual PSID observations with two specifications for the control variables in X_t^i. In the *random effects* specification, dummies for the Head's age,

Table 3: Estimates of γ_t in (15) from the Annual PSID

	1969–1979	1980–1989	1990–1997
Random Effects	53	56	31
	(8)	(5)	(4)
Fixed Effects	22	27	9
	(6)	(4)	(3)

Note: For this table, all observations of households' mortgage debts were scaled by the household head's once-lagged wage. Please see the text for further details.

Table 4: Estimates of γ_t in (15) from the Complete PSID

	1970–1979	1980–1989	1990–1999	2001–2005
Random Effects	55	47	33	26
	(6)	(5)	(3)	(3)
Fixed Effects	30	21	11	7
	(5)	(4)	(3)	(4)

Note: For this table, all observations of households' mortgage debts were scaled by the household head's twice-lagged wage. Please see the text for further details.

race, and educational attainment make up X_t^i. The *fixed effects* specification replaces the race and educational attainment dummies with household-specific dummies. In both cases, we restrict γ_t to be constant over three time intervals, 1969–1979, 1980–1989, and 1990–1997. Table 3 reports the estimates of γ_t and their standard errors. Table 4 contains analogous estimates for the complete PSID. For these, we require γ_t to be constant over 1970–1979, 1980–1989, 1990–1999, and 2000-2005.

The results in the two tables are similar, so we focus our discussion on the longer sample in Table 4. Over 1971-1979, the estimated random-effects slope equals 55. That is, a $1,000$ hour increase in mortgage debt (equal to the annual income from a half-time job) is associated with a 55 hour increase in labor supply. The analogous coefficient for the 1980s was basically unchanged, but the coefficients for the 1990's and 2000's are much lower, 33 and 26. Table 1 in Campbell and Hercowitz (2009b) shows that average down payments for home purchases declined substantially only after 1992, so the coefficients declined at about the same time as down payments fell. Replacing the Head's race and education indicators' with household-

Table 5: Estimates of γ_t and $\alpha(A)$ in (16) from the Annual PSID

	$30 \leq$ Age ≤ 39			Adjustment for Age	
	1969–1979	1980–1989	1990–1997	≤ 29	≥ 40
Random Effects	57	59	36	3	-12
	(8)	(6)	(5)	(7)	(6)
Fixed Effects	22	28	14	15	-11
	(6)	(4)	(4)	(6)	(5)

Note: For this table, all observations of households' mortgage debts were scaled by the household head's once-lagged wage. Please see the text for further details.

Table 6: Estimates of γ_t and $\alpha(A)$ in (16) from the Complete PSID

	$30 \leq$ Age ≤ 39				Adjustment for Age	
	1970–1979	1980–1989	1990–1999	2001–2005	≤ 29	≥ 40
Random Effects	52	45	32	25	8	0
	(7)	(6)	(4)	(4)	(5)	(4)
Fixed Effects	22	17	10	8	22	-2
	(6)	(4)	(3)	(4)	(5)	(4)

Note: For this table, all observations of households' mortgage debts were scaled by the household head's twice-lagged wage. Please see the text for further details.

specific fixed effects substantially reduces the coefficients — the estimated coefficient for the 1970s equals 30 — but their decline with time remains. Thus, the later part of our sample, which coincides with a period of low down payments, displays a weaker relationship between hours worked and debt.[18]

Although we have omitted households with older heads (so that households have "long" planning horizons) and have controlled directly for age, one might nevertheless suspect that

[18]Since differencing within households raises any measurement error's relative contribution to total variance, the discrepancies between the random-effects and fixed-effects estimates could arise from measurement error. With this in mind, we have experimented with instrumental variables estimation of the fixed-effects specification using lagged right-hand side variables as instruments. These will be valid so long as the measurement errors are uncorrelated across time for a given household. Although these IV estimates share the sign and declining pattern of those in Figures 3 and 4, they are implausibly large and have very high standard errors.

the empirical relationship between hours worked and debt varies by age. To investigate this, we expand (15) to interact debt with the household head's age. That is

$$N_t^i = \mu_t + (\gamma_t + \alpha(A_t^i))D_{t+1}^i/(1000 \times W_{t-1}^i) + \lambda X_t^i + u_t^i. \tag{16}$$

Here, A_t^i denotes the Head's age and $\alpha(A)$ is an age-specific adjustment to the relationship between household debt and hours worked. For estimation, we constrained $\alpha(A)$ to be constant across the three age groups in our sample, 20–29, 30–39, and 40–49, and we achieve identification by constraining it to equal zero for Heads in their 30's. Tables 5 and 6 report the results.

Both regression specifications applied to both samples indicate that households in the 20's have the strongest comovement of hours worked and debt and that households in their 40's display the weakest effects. This pattern might reflect a concentration of home purchases among the young, but it is not statistically significant in all specifications. Overall, the estimated effects for households with Heads in their 30's resemble the estimates in Tables 3 and 4. We conclude from this that the household-level comovement between hours worked and debt differs little across young and middle-aged groups.[19]

4.3 Comparison with Model-Generated Observations

The comparison of these results with our model proceeds as follows. We begin with simulations of 2000 households starting at the nonstochastic steady state for 20 years holding π at 0.16. Using the same sequences of household-level shocks, we generate analogous simulations with π at 0.11. After discarding the first ten years of each simulation, we estimate ordinary least squares and fixed-effects regressions analogous to those reported in Tables 3 and 4. Table 7 reports the results.

As noted earlier, the proper measure of gross household debt when the borrowing constraint does not bind depends on the shares of debt repayment and security purchases in wealth accumulation. To evaluate the robustness of the results to the particular resolution of this portfolio indeterminacy, we use two distinct measures of household debt. The first follows from the resolution we employed when describing the model, $D_{t+1} = B_{t+1}$. The second

[19]When we expanded our sample to include households with heads between 51 and 65 years old, we found that these estimates of $\alpha(A)$ were *positive* and both economically and statistically significant. Since retirement and the end of life are important considerations for these households, understanding this surprising finding seems to require a life-cycle model with these features. Accordingly, its explanation lies beyond the present paper. In any case, our main empirical results change little if we include these older households in our estimation sample.

Ordinary Least Squares

D_{t+1}	$\pi = 0.16$	$\pi = 0.11$
B_{t+1}/W_{t-1}	57	30
$(1-\pi)S_{t+1}/W_{t-1}$	63	35
B_{t+1}/W_{t-2}	43	25
$(1-\pi)S_{t+1}/W_{t-2}$	45	27

Fixed Effects

D_{t+1}	$\pi = 0.16$	$\pi = 0.11$
B_{t+1}/W_{t-1}	54	29
$(1-\pi)S_{t+1}/W_{t-1}$	62	35
B_{t+1}/W_{t-2}	42	25
$(1-\pi)S_{t+1}/W_{t-2}$	46	28

Table 7: Model-based Regression Coefficients

sets gross household debt at the repossesion value of available collateral, $D_{t+1} = (1-\pi)S_{t+1}$. For each of these, Table 7 reports results for the two scaling options we used above, W_{t-1} and W_{t-2}.

From Table 7 we conclude the following. First, the two resolutions of the portfolio indeterminacy give very similar results. Second, the coefficients obtained when $\pi = 0.16$ are remarkably close to the random-effects estimates from the 1970s and 1980s. That is, the calibrated model reproduces the observed comovement of household debt and hours worked from those decades. Finally, lowering π to 0.11 reduces the estimated coefficient by 17 to 27 hours. This matches the actual reduction from the 1970s and 1980s to the 1990s and 2000s well. Since our calibration used no information on the comovement between hours worked and debt, we find this similarity between the model and data remarkable.

5 Macroeconomic Implications and 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. The positive interaction between these two mechanisms seems to be a promising subject for further study.

The labor supply accelerator works by tightening the collateral constraint, and so delaying the income effect of a wage increase. This allows the substitution effect to dominate in the short run. This effect is stronger the higher the need for funds for down payment requirements. In a standard model of financially unconstrained households, such a wage change would produce little or no change in hours worked.

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 reforms of the household credit markets 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 explored this channel using a general equilibrium framework in Campbell and Hercowitz (2006), and we are continuing that investigation presently.

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