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How Financial Innovations and Accelerators Drive Booms and Busts in U.S. Consumption

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Abstract

The post-1980 downtrend in the U.S. saving rate and the recent U.S. consumption boom and bust have been attributed to changes in consumer credit availability and housing wealth liquidity. Because these factors were not directly observable, rigorous time series linkages had not been established earlier. We address this gap by constructing indexes of consumer credit availability and housing wealth liquidity. The indices significantly improve econometric models of consumption, based on solved-out consumption functions. We estimate the liquidity of housing wealth as a common unobservable factor in a jointly estimated, three-equation model of consumption, mortgage equity withdrawal and mortgage refinancing.

JEL Codes: E21, E32, E44, E51

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1. Introduction

The U.S. consumption boom of the mid-2000s and the post-1980 decline in the personal savings rate have been attributed to increases in consumer credit availability and in the liquidity of housing wealth. There has been much concern that declines in wealth—particularly housing—coupled with tighter credit availability will induce a long period of weak consumer spending. Although studies find that the sensitivity of U.S. consumption to housing wealth rose between the mid-1990s and mid-2000s (Carroll *et al.,* 2006; Case and Shiller, 2008; while Slacalek, 2009 documents similar cases in other countries), rigorous time series linkages among these factors have not really been established, partly owing to a lack of data and endogeneity issues.

For example, theory implies that larger-sized housing wealth effects likely reflect an increase in the liquidity of housing wealth (Carroll and Kimball, 2005; Muellbauer and Murphy, 1990; Aron, Muellbauer and Murphy, 2006; Muellbauer, 2007; Aron *et a*l., 2011). This rise has been linked to a greater tendency of families to tap housing wealth via mortgage-equity withdrawals (MEW), which contributed to the early 1990s boom and bust in UK consumption (Miles, 1992; Muellbauer and Murphy, 1990). Macroeconomic forecasters have found such MEW series (e.g., Duca, 2006; Greenspan and Kennedy, 2008) useful in gauging U.S. consumer spending. However, much of the reason may be that MEW tracks the evolution of credit availability and the sensitivity of consumption to housing collateral, which reflect more predictable endogenous factors but also less predictable exogenous ones. The latter make MEW, and thereby consumption, unstable and prone to large shifts. Indeed, a plot of a crude measure of MEW relative to income suggests that prior to 1986 tax changes making home equity loan interest tax deductible, MEW barely changed in response to large swings in real home price appreciation (Figure 1). But after 1986, the two series become more positively correlated. And the advent of new mortgage products, especially the increased access to and decreased expense of refinancing old mortgages with larger ones, increased the ability of households to withdraw housing equity via cash-out mortgage refinancing. Through this channel, MEW became more sensitive to house prices and housing wealth, which also has implications for cash flow and leverage effects on consumer spending.

We do so in econometric models based on solved-out consumption specifications, which allow for short- and long-run effects of credit availability and wealth. Using this framework, the non-income impact of the crisis on consumption can be gauged through two channels: the availability of consumer credit and the availability of mortgages for accessing housing collateral and so increasing the liquidity of housing wealth, which alters the m.p.c. out of housing wealth. We track the first by an index of consumer credit availability derived from the Federal Reserve's Senior Loan Officer Survey, that is adjusted for cyclical and interest rate effects improving upon earlier work by Muellbauer (2007) and Duca and Garrett (1995). This index reflects a mix of exogenous factors, including regulations and the Treasury-Euro-dollar (TED) spread.

In modeling the second channel, we track not only the evolution of major wealth components, but also the liquidity of housing wealth, estimated as a common unobservable factor—a smooth 'spline' function or nonlinear state space component—in a jointly estimated, two- or three-equation model of consumption, mortgage equity withdrawal (MEW), and mortgage refinancing. The consumption equation accounts for income, expectations, and different types of wealth, allowing the impact of housing wealth to depend on the latent housing liquidity index (*HLI*). Another equation models MEW as a function of economic and tax variables, and allows the *HLI*, a proxy for the reduced transaction cost of and greater access to mortgage refinancing, to boost MEW both directly and through its interaction with housing wealth. The third equation estimates the rate of mortgage refinancing, controlling for measurable economic incentives to refinance.

The costs of refinancing (fees and non-pecuniary costs) are not directly observable. Nevertheless, there is evidence that such costs have fallen (Bennett, *et al.*, 2001). *HLI* enters both as a levels effect and interacted with interest rate variables in the refinancing rate equation. The *HLI* is inversely related to refinancing costs, which as they have fallen, have lowered the costs of, and barriers to withdrawing housing equity via cash-out mortgage refinancings.

Modifying estimable consumption functions for innovations in consumer credit and the liquidity of housing wealth yields models with better fits, more stable coefficients, and sensible short- and long-run properties. We find that financial innovations have altered the housing wealth (collateral) and consumer credit channels. In the boom, consumption was boosted by easier consumer credit standards and by an increased liquidity of housing wealth. In the bust these developments partially unwound, and induced a drop in consumption relative to income.

To establish these findings, section 2 discusses how such factors fit into a theoretically grounded consumption function. The third section describes our measure of consumer credit availability, MEW activity, and mortgage refinancing, which are incorporated into a solved-out consumption function. The fourth section presents a system of equations that jointly estimates consumption, MEW, and mortgage refinancing activity. The section discusses the implications for how shifts in wealth, credit availability, and the liquidity of housing wealth contributed to the recent increase in the U.S. personal saving rate that followed a long downtrend over 1980- 2007.

2. Credit Constraints, Housing Liquidity and Consumption – The Linkages

This section first discusses the implications of the evolution of consumer availability and housing wealth liquidity for specifying a solved-out consumption function. The Euler equation approach has the attraction of simply specifying consumption with first difference terms that do not appear, at first glance, to require researchers to track many long-run structural factors. This aspect, however, leaves out many important long-run relationships involving wealth and credit frictions. As shown by Campbell and Mankiw (1989) and Muellbauer, 2010 *inter alia*, empirical aggregate Euler equations violate the martingale condition implied by simple theory. In contrast, the modernized Ando-Modigliani style consumption specification that we use encompasses the rational expectations permanent income hypothesis but incorporates more general wealth and credit channels, passes a number of diagnostic tests and yields sensible coefficients and results.

2.1. A Consumption Function with Wealth and Credit Channels

The perfect capital markets version of the basic life-cycle and permanent income hypotheses (LCH/PIH) implies that consumption, c, is given by:

$$c_t = \gamma A_{t-1} + \lambda^* y^p{}_t \, , \tag{2.1}$$

where y^p = permanent, real non-property income and A= real net wealth, all in per capita terms. Letting y = real non-property income, algebra and the log approximation $\ln(y^p/y)$~$(y^p\text{-}y)/y$ yields:

$$\ln c_t = \alpha_0 + \ln y_t + \gamma^* A_{t-1}/y_t + \ln(y^p/y) \, , \tag{2.2}$$

with $\gamma^* = (\gamma/\lambda^*)$ and $\alpha_0 = \lambda^*$. The log difference between permanent and actual income reduces to a discount-weighted moving average of forward income growth rates (Campbell, 1997):

$$E_t \ln\left(y_t^p / y_t\right) \approx E_t\left(\sum_1^K \eta^{s-1} \ln y_{t+s}\right) \Big/ \left(\sum_1^K \eta^{s-1}\right) - \ln y_t \tag{2.3}$$

Allowing for probabilistic income expectations suggests the introduction of a measure of income uncertainty θ_t, and allows the discount factors in (2.3) to include a risk premium. Making these changes and rearranging yields an expression for the REPIH model:

$$\ln c_t = \alpha_0 + \ln y_t + \gamma^* A_{t-1}/y_t + \alpha_1 r_t + \alpha_2 \theta_t + E_t \ln(y^p_t / y_t) + \varepsilon_t. \tag{2.4}$$

More realism can be added for habits, income uncertainty, and changes in nominal interest rates (*Δnr*). The wealth-to-income ratio can be disaggregated into ratios to income for liquid assets less debt (*NLA/y*), illiquid financial assets (*IFA/y*), and gross housing assets (*HSG/y*). If structural factors alter the liquidity of housing wealth (*HLI*), this could bolster consumption in several ways. *HLI* could enter as an intercept, thereby raising the average propensity to consume out of income, or enter interacted with permanent income growth (as an enhanced collateral role for housing allows young families to borrow more against anticipated income), or *HLI* could enter interacted with *HSG/y*, which would reflect a heightened housing collateral effect. Finally, a consumer (non-mortgage) credit conditions index (*CCI*) may also affect long-run consumption.

Among short-run factors, we control for uncertainty, cash flow and inter-temporal effects, including the change in the civilian unemployment rate *(ur*) as well as the change in the nominal auto loan rate, *Δnr*, with *nr* tracking the powerful, intertemporal effects from temporary sales incentives. We add the interaction between the change in the unemployment rate and the *CCI* to see if greater credit availability reduces the size of the negative impact of unemployment rate changes, suggesting a positive coefficient on this interaction term. All of this implies the following equilibrium-correction model for consumption:

$$\Delta \ln c_t = \lambda\{\alpha_0 + \alpha_1 r_t + \alpha_2\theta_t + \alpha_3 \, E_t \ln (y^p_t / y_t) + \alpha_4 CCI_t + \alpha_5 HLI_t$$
$$+\gamma_1 NLA_{t-1}/y_t + \gamma_2 IFA_{t-1}/y_t + \gamma_3 HLI_t \times HSG_{t-1}/y_t + (\ln y_t - \ln c_{t-1})\}$$
$$+ \beta_1 \Delta \ln y_t + \beta_2 \Delta nr_t + \beta_3 \Delta ur_t + \beta_4 \Delta ur_t \times CCI_t + \varepsilon_t \qquad (2.5)$$

where the term in brackets is equilibrium minus actual consumption, λ is the speed of adjustment toward long-run equilibrium and the γ_i*'s* are m.p.c.'s out of the three wealth components.

These should differ by asset type. The m.p.c. out of net liquid assets should be higher than out of illiquid financial assets or housing wealth, since cash-like assets are more spendable. There are good theoretical reasons for why the m.p.c.'s for illiquid financial assets and housing assets should differ. Most importantly, housing gives direct utility in the form of services implying that there are substitution and income effects not present for financial assets (Muellbauer, 2007, 272-3). The γ_3 coefficient reflects how the evolution of housing wealth liquidity alters the m.p.c. of housing collateral or wealth. Down-payment constraints have been relaxed for housing (Duca, Muellbauer and Murphy, 2011a, b).

Consumption is tracked using total real consumption expenditures excluding imputed housing services. As Muellbauer (2007, pp. 272-3) notes, it is more plausible to find a positive classical wealth effect for this definition of consumption than if consumption included imputed housing services. Income is measured by non-property (labor plus transfer) income, which omits dividends and interest earned on wealth that are embodied in asset prices. As Blinder and Deaton (1985) show, temporary tax changes induce larger deviations in income than in consumer spending, reflecting the smaller impact of temporary tax changes on permanent income. Similarly, we adjust non-property income for temporary tax changes using BEA estimates of their impact on disposable income.[1] To track income uncertainty, we use the contemporaneous

[1] These include the tax surcharges during the Vietnam War, temporary tax cuts in 1975, 2001, 2005, and 2008; but not Blinder and Deaton's estimates for the phase-in of the tax cuts of the early 1980s; details available upon request.

change in the unemployment rate (*Δur*). For expectations of the deviation of permanent from current income, we use a simple model based on reversion to a split trend (with a slow-down in growth after 1968) with two economic drivers. These are the 4-quarter change in the 3-month Treasury bill yield (representing the impact of monetary policy) and the Michigan index of consumer expectations of future economic conditions (having the appeal of being derived from real-time data on actual consumers). Permanent income was constructed with three alternative quarterly discount rates, 0.025, 0.05 and 0.1. There is little difference in fit between the last two and so a discount rate of 0.05 ($\eta = 0.95$) was chosen, implying that consumers have short horizons.

The real interest rate (*r*) is the Federal Reserve Board's user cost of capital for autos, which is the real interest rate on finance company auto loans adjusted for depreciation. To handle short run credit effects, including large inter-temporal shifts in spending on automobiles resulting from changes in auto interest rate sales incentives, we include the change in the nominal auto loan interest rate (*nr*).

Using Flow of Funds data, liquid assets (*NLA*) are defined as the sum of deposits and credit market instrument minus consumer (*CDEBT*) and mortgage (*MDEBT*) debt. Housing assets (*HA*) equals gross housing assets, while illiquid financial assets (*IFA*) equal all other household assets. In addition, we include a dummy for oil price shocks, when the oil crises and constraints on oil deliveries induced a large drop in economic activity.[2] The last two variables are the credit conditions (*CCI*) and housing liquidity (*HLI*) indexes, discussed below.

[2] The oil shock 0/1 dummy is 1 in 1973 q1, 1974 q1, 1979 q2 and q3, as well as 1990 q3.

2.2. Constructing the Unsecured Consumer Credit Conditions Index (CCI)

We construct a levels version of a unsecured consumer credit conditions (CCI) index using data from the Federal Reserve's Senior Loan Officer Opinion Survey, in which 60 large banks report on how their willingness to make consumer installment loans has changed relative to three months prior. This index, which is used in Aron, et al. (forthcoming), is negatively correlated with 1994-2010 survey data on changes in bank credit standards on noncredit card consumer loans.

We first adjust the willingness to lend index for identifiable effects of interest rates and the macroeconomic outlook by estimating an empirical model based on screening models. In such models (see Duca and Garrett, 1995; and the screening model of Stiglitz and Weiss, part IV, 1981), credit standards should be tightened when the real riskless rate rises and the macroeconomic outlook worsens. (Since the willingness to lend index is inversely related to credit standards, these expected signs are reversed in our empirical model.) We track the former by including the first difference of the real federal funds rate (Δrff, the nominal funds rate minus the year-over-year percent change in the overall PCE deflator) and the latter by the two-quarter percent change in the index of leading economic indicators ($\Delta_2 LEI$). To further adjust for factors affecting consumer loan quality, we include the time t year-over-year change in the delinquency rate on bank consumer installment loans ($\Delta_4 Del$, American Bankers Association).

Also included are three regulatory variables. One is a dummy equal to 1 in 1980 q2 when credit controls were imposed and equal to -1 when they were lifted in 1980 q3 (*CrControl*). Another regulatory variable (*RegQ*) measures the degree to which Regulation Q ceilings impinged upon banks' ability to raise small time deposit rates (Duca, 1996; Duca and Wu, 2009) and thereby raised banks' shadow cost of raising loanable funds.[3] The third regulatory variable (*MMDA*) is a dummy equal to one in 1982 q4 and 1983 q1 to control for the re-intermediation effects of allowing banks to offer variable interest bearing money market deposit accounts, which boosted deposits according to money demand models (Duca, 2000).

After Reg Q was lifted, the interbank funding market increasingly became a marginal source of loanable funds, with the 3-month LIBOR normally exceeding the expected 3-month average federal funds rate by about 10 basis points. To control for this, we include the spread between the 3-month LIBOR and 3-month Treasury Bill rates (*Libor Spread*). We also include a dummy (*Lehman* = 1 in 2008 q4) for the failure of Lehman (which was after the 2008 q3 Fed survey). Estimating the model from 1966 q3 to 2010 q4 with an AR(1) correction yields:

$$CR = \underset{(4.51)}{15.27} - \underset{(4.20)}{3.03}\, \Delta rff_t^{**} + \underset{(4.04)}{0.96}\, \Delta_2 LEI_t^{**} - \underset{(2.80)}{12.15}\, \Delta_4 Del_t^{**} + \underset{(3.67)}{26.47}\, MMDA_t^{**}$$

$$- \underset{(2.43)}{2.80}\, RegQ_t^{*} + \underset{(10.48)}{47.56}\, CrControl_t^{**} - \underset{(2.95)}{4.93}\, Libor\ Spread_t^{**} - \underset{(2.68)}{20.38}\, Lehman_t^{**}$$

where t-statistics are in parentheses, $R^2 = 0.799$, AR(1) = 0.751** (t stat.: 14.78), standard error = 9.09, LM(2) = 0.59, and Q(24) = 20.46. The coefficients are significant with the expected signs. It is reassuring that in regressions not shown, coefficients hardly change (especially the *Libor Spread* coefficient) in samples before the start of the financial crisis in August 2007 (when the LIBOR spreads began widening) and the peak effects of the crisis on interbank lending conditions in late 2008. We subtract the estimated impact of changes in the real federal funds rate, leading economic indicators, and the delinquency rate to remove cyclical and interest rate effects, leaving the impact of regulations, Lehman's fall, unusual credit (*Libor Spread*) frictions, and unexplained variation in the adjusted diffusion index (*CRAdj*). The adjusted *CR* index was

[3] Regulation Q was binding before the loan sales and mortgage-backed securities markets became deep.

then chained into a levels index, based on the correlations of the index with the growth rate of real consumer loan extensions at banks, and normalized (see Figure 2).

The *CCI* has several notable shifts and movements. It starts by dipping below 0 in the credit crunch of late 1966, before rising in a series of shifts to its peak of 1 in 2007 q3. *CCI* rises some during the 1970s, punctuated by declines or pauses that coincide with disintermediation induced by binding Regulation Q ceilings around 1970, 1973-74 and in the late 1970s and early 1980s. The index rose a lot following deposit deregulation, all the way up until the imposition of tougher capital standards under Basel 1 in 1990. During this time there were large rises in installment credit, typically used to purchase autos, home furniture and large electrical appliances.

But there were also other signs confirming a general increase in the ability of households to borrow. As shown in Figure 3, the timing and relative shape of the rise in the *CCI* also reflects those of the share of U.S. families owning bank credit cards—cards which do not require full monthly payments of all outstanding balances and which partly serve as a means of taking on debt. The relationship is less tight using a broader definition covering credit cards without this debt feature or which are limited to a particular retailer. For example, in 1970, 51% of families had general cards using the broader definition, but only 16% had cards enabling them to carry balances for more than one month and were usable at more than one retailer. By 2001, the gap between these ownership rates had nearly disappeared. In this sense, the *CCI* picks up the distinction between the impact of credit card technology on transaction and debt services, that latter of which has far more important implications for consumption.

The CCI drops during banks' transition to meeting tougher capital standards under Basel 1. The index then rises moderately until the mid-1990s, by which time the scope for the securitization to alleviate the burden of capital standards had largely been used. The index was relatively flat from the mid-1990s to mid-2000s, an era when financial liberalization affecting households occurred mainly in mortgages, first enhancing the ability to withdraw housing equity from price appreciation and then to buy homes under weaker credit standards. In the mid-2000s the index rose notably, coinciding with the peaking of structured finance that funded much nonprime lending. The index, however, then fell to an extent similar to that seen in the credit crunch of the early 1980s, when consumer durable spending also had fallen sharply.

2.3. Constructing an Index of Housing Liquidity (*HLI*)

A housing liquidity index should track the extent to which financial innovations have made it easier and less expensive for Americans to refinance their mortgage at a lower rate and/ or use the equity in their homes for consumption or other purposes, such as reducing their unsecured debt.. Such effects allow for ease of mortgage equity withdrawals, enhancing the impact of housing wealth on consumption. The housing liquidity index (*HLI*) is constructed using two approaches, both of which involve estimating a system of equations with a latent variable – the liquidity of housing wealth, *HLI* - that is interacted with other variables.[4] The systems approach is used because it is more informative about, and permits more precise estimation of *HLI*. The *HLI* interactions capture parameter variation over time, other than intercept shifts, in a parsimonious and economically meaningful way.

The first approach uses a flexible spline-like function, consisting of smoothed step dummies, which is estimated as a common factor in a three-equation model of the consumption function (eq. 2.5), a mortgage refinancing equation, and a mortgage equity withdrawal

[4] We give this approach the acronym, LIVES, as an abbreviation for latent interactive variable equation system.

equation. The 'spline' function appears as a levels effect (intercept shifter) in the mortgage refinancing and the mortgage equity withdrawal equations, and as interaction effects in all three equations.

The 'spline' function is built up of smoothed step dummies. Consider a step dummy SD_{1972} for 1972, that is 1 from 1972 q1 on and 0 before then. If $SDM4_{1972}$ is the four-quarter moving average of SD_{1972}, then the five-quarter moving average of it (SSD_{1972}) has a smooth S-shaped transition from 0 in 1971 q4 to 1 in 1973 q4. The 'spline' based housing liquidity index, *HLI,* is a linear combination of such smoothed step dummies:

$$HLI_t = \sum_{s=1972}^{t} d_s \times SSD_s \qquad (2.6)$$

Since each *SSD* makes a smooth transition over two years, it is generally sufficient to set the d_s coefficients to zero every second year.

Our priors are that the *HLI* function should not decline except during four credit-crunches. These imply that the d_s's could be negative in 1972/73, in 1979/80, in 1990/91 and in 2007. Negative or insignificant values of the d_s coefficients in other years are set to zero until a parsimonious specification of the 'spline' function, *HLI,* is obtained, consistent with sign priors on key parameters of the other equations. These priors are help identify the 3-equation system. In practice, equation (2.6) is normalized to set *HLI* to zero at its lowest value,[5] and nine parameters are sufficient to characterize the *HLI* function.

The second approach employs the Kalman Filter to estimate the latent *HLI* in a non-linear state space model of a two -equation system consisting of the consumption function (eq. 2.5), and a mortgage refinancing equation (eq. 2.7 and 2.8 below). The state space model is set out in Table 1. The state space approach is appealing since it is more objective than the 'spline'

[5] This occurs in 1975-6 and the normalization is achieved by subtracting the d_{1973} coefficient in equation (2.6).

approach. The the choice of smoothed step dummies ('knots') in the 'spline' approach is more a matter of judgment than of model fit. Nevertheless, the 'spline' approach yields similar estimates, as shown in Figure 5 and in corresponding tables.

2.4 Modeling Refinancing Activity

We track refinancing activity by the share of outstanding mortgages securitized by Fannie Mae, Freddie Mac, and Ginnie Mae that have been refinanced in a quarter (*REFI*). Such mortgages do not include refinancing penalties and we can construct a series that starts in 1970. This series splices direct estimates of mortgage refinancings over 1970-2003 from Anderson and Duca (2007) with mortgage refinancing applications data from the Mortgage Bankers Association to create a series for the period 1970-2010. The splice applies coefficient estimates from log specifications built on the very high correlation of the two series during their period of overlap (1990-2003) to post-2003 applications data to extend the earlier series. The series displays a rising trend and the increasing sensitivity to financial conditions since 1970 (Figure 3).

The specification of the refinancing equation takes the basic form:

$$refi_t = rr_1 refi_{t-1} + rr_2 HLI_t + z_t'\delta + rr_2\left(HLI_t \times z_t'\delta\right) + v_t \qquad (2.7)$$

where *HLI* = the common factor housing liquidity index and $z_t'\delta$ contains a constant and economic factors affecting the incentives to refinance. Since the entire function of variables is shifted by *HLI*, it has both level and interaction effects. The function $z_t'\delta$ is given by:

$$\begin{aligned} z_t'\delta = {} & \delta_0 + \delta_1 Pos\,Gap_t + \delta_2 Pos\,Gap_{t-1} + \delta_3 Pos\,Gap_{t-2} + \delta_4 Low_t + \delta_5 Low_{t-1} + \delta_6 Low_{t-2} \\ & + \delta_7 Payback_t + \delta_8 Libor\ Spread_{t-1} + \delta_9 SSD_{1981,t\text{-}1} \times demeaned\ RateFall_t^e \qquad (2.8) \\ & + \delta_{10}(HSG_{t-1}/Y_t - MDebt_{t-1}/Y_t) + \delta_{11} MortDel_{t-1} + v_t \end{aligned}$$

The vector *z* includes the t to t-2 lags of *PosGap*, which equals the maximum of 0 and the gap between the average interest rate on outstanding (existing) mortgages minus the average interest rate on new mortgages used to purchase existing homes, with the gap scaled by the level of the average interest rate outstanding. The scaling reflects that a given rate gap has a larger percentage effect on house payments when existing rates start out lower. The variable *PosGap* is positive when there is a rate incentive to refinance, and should generally have positive coefficients apart from some dynamic unwinding effects (discussed below). The prevalence of fixed rate mortgages also implies that a given positive value of *PosGap* may not fully account for the possibility that new mortgage rates may appear to be at a low, when there is an additional incentive to lock in a low interest rate. To control for this effect, we include the t to t-2 lags of a dummy, *Low*, which equals 1 if the prevailing average new mortgage rate is at a 30-quarter low.

To further control for strong payback effects and a tendency for refinancing booms to abruptly end, we include the *Payback*, equal to the product of 0/1 dummy for the quarter following a mortgage rate low and the number of mortgage rate lows in the two years up to that quarter. The bigger the second element, the more households have refinanced in the two years leading up to the end of a down-cycle in mortgage interest rates, and the more likely is the payback effect to be more abrupt if mortgage rates rise off a low, as suggested by the sharper falls in refinancing following the two longest refinancing waves of 1992-3 and 2002-3.

Adjustable rate mortgages became available in 1981 with rates usually below fixed rates. The incentive to refinance from fixed to adjustable rates reflects interest rate expectations. We use (demeaned) interest rate expectations interacted with SSD_{1981}, a smoothed step dummy for 1981 to track this effect. The Michigan Survey index of interest rate expectations is a two-quarter moving average, $RateFall^e$, and rises in value when rates are expected to fall.

A higher spread between LIBOR and Treasury rates (*Libor Spread*), which induces lenders to use tighter qualifying standards, might be expected to have a negative effect on refinancing, capturing short term fluctuations in market liquidity not reflected in *HLI*, which by construction is a smooth index of credit supply shifts. In contrast, higher net housing wealth, $(HSB_{t-1}-MDEBT_{t-1})/Y_t$, makes it easier to qualify for refinancing and enhances the demand to refinance to tap housing wealth. We also include the lagged, 60 day mortgage delinquency rate (*MortDel*) to measure the fear or risk that too much debt has been taken. Unlike foreclosure rates which have been distorted by political/regulatory pressure on lenders not to repossess homes, the delinquency rates are more consistent indicators of loan quality over time. Using a full set of variables allows us to strip out from refinancing activity all the effects not associated with financial innovations and to avoid contaminating estimates of *HLI* with endogenous developments.

2.5 Modeling Mortgage Equity Withdrawals

MEW is measured as the net increase in residential mortgage debt minus residential investment (Flow of Funds),[6] and scaled by non-property income. This *MEW/Y* ratio is modeled as a function of demand factors reflecting balance sheet and tax incentives to refinance, weighed against the implicit costs of doing so. MEW and refinancing activity have much in common, because much MEW takes the form of households borrowing more against their houses by refinancing an older mortgage with a new larger one. As Greenspan and Kennedy (2008) note, three forms of MEW are borrowing with second (e.g., home equity) mortgages, using smaller

[6] The more complete Greenspan-Kennedy (2008) measure is too short for our needs, as it misses the 1980s when the ability to refinance rose. As an alternative, we use Kennedy's gross MEW estimates. We use versions of this Kennedy series and a crude measure that nets charge-offs of mortgage debt and intra household sector mortgage flows. The latter are very volatile and appear arbitrary, perhaps reflecting the lack of good data on homeowner-financed mortgages and other private flows.

down-payments, and households not fully rolling over capital gains from selling their old home into the down-payment on their next home purchase. Nevertheless, there are some differences in incentives as balance sheet and collateral issues likely have a greater role in determining MEW volumes.

We model the MEW-to-income ratio as follows:

$$\begin{aligned} MEW_t/Y_t = m_0 + m_1\{&\delta_1 PosGap_t + \delta_2 PosGap_{t-1} + \delta_3 PosGap_{t-2} \\ &+ \delta_4 Low_t + \delta_5 Low_{t-1} + \delta_6 Low_{t-2} + \delta_7 Payback_t\} \\ &+ m_4 CDebt_{t-1}/Y_t + m_5 IFAm4_{t-1}/Y_t + m_6(HSG_{t-1} - MDebt_{t-1})/Y_t \\ &+ m_7 HLI_t + m_8\,(HLI_t \times \text{demeaned } (HSG_{t-1} - MDebt_{t-1})/Y_t) \\ &+ m_9\,(HLI_t \times \text{demeaned } \Delta_8 \ln hp_{t-}) \\ &+ m_{10}\,\Delta ur_t + m_{11} \Delta MortDel_{t-1} + m_{12}\, nr_{t-1} + \text{outlier dummies} + e_t \end{aligned} \tag{2.9}$$

The term in curly brackets reflects the interest rate incentives to refinance mortgages, imposing the same terms as in the refinancing equation (eq. 2.8). Next, are three household portfolio terms, all expressed as ratios to income. Holding the relative cost of consumer versus mortgage loans constant, the larger is consumer debt, the greater is the demand for MEW funding, because of the financial incentive to replace higher interest rate, consumer loans with lower interest rate, mortgage debt. The second portfolio term is the ratio of illiquid financial assets to income. Sign priors on this are unclear. The third portfolio term is the ratio of housing assets, net of mortgage debt to income. In principle, as this rises, MEW should also rise. However, this effect may vary with the liquidity of housing wealth, *HLI*.

HLI also enters the MEW equation as a level effect and interacted with lagged real house price appreciation. Since a higher *HLI* is associated with lower costs of refinancing and withdrawing home equity, both *HLI* terms should have positive signs. The unemployment rate and the lagged mortgage delinquency rate control for uncertainty and variation in the number of householders who qualify for MEW. The nominal rate on auto loans controls for substitution with consumer credit. Finally, we include a number of dummies to control for quarters with large negative outliers. These include dummies for quarters when households and lenders temporarily became highly risk averse following the stock market crash of October 1987, just before the likely onset of the second Gulf War in 2003q1, and just after Lehman Brothers failed in 2008q4. There was an unusual positive outlier in 1990q4, when interest rates fell sharply before the start of the first Gulf War sparked by what proved to be overly pessimistic fears of a deep recession in 1990-91.

2.6 Joint Estimation of a Housing Liquidity Index

The *HLI* estimates are discussed in ths sub-section. Discussion of the individual equation results is postponed to the next sections.. *HLI* is estimated using the nonlinear, two-equation state space model set out in Table 1. We also estimated two and three equation 'spline'-based measures of *HLI,* which are similar to the state space model estimates of *HLI*.[7] The state variable is only identified up to scale so the normalization we used means that HLI may be interpreted as m.p.c. on housing wealth in the consumption function In future work we plan to expand the state space model to a three-equation system.

The state space and 'spline' estimates have similar shapes as shown in Figure 5, and the coefficients in Tables 2A and 2B are consistent with developments that plausibly affected the liquidity of housing. The two estimated *HLI* series fall in the 1973-74 credit crunch, when binding Regulation Q ceiling hurt the ability of intermediaries to fund both consumer and mortgage credit. The housing liquidity indexes rise a little in the late 1970s, coinciding with steps taken to deregulate bank deposits and increase the supply of loanable funds at a time when

[7] The MEW equation is dropped in the two-equation 'spline' model. The resulting HLI estimates are very similar to the estimated from the three-equation 'spline' model, suggesting that the MEW equation conveys little additional information, possibly because the MEW data are too noisy.

the mortgage-backed securities market was under-developed (Duca, 1996). The timing also coincids with the rise of second mortgages (Seiders, 1979, pp. 177-78). Afterward, the estimated *HLI* series are flat for several years. Then, the estimated *HLI* series rise in the late 1980s, when financial sector productivity rose which lowered the costs of financial intermediation (Duca, 2005).

Both indexes then decline sharply during in the early 1990s credit crunch, when the new Basel 1 capital standards imposed higher capital requirements on mortgage loans held in portfolio than on securitized mortgages. This distinction was important because the market for securitized flexible interest rate mortgages and home equity loans was small.[8] The *HLI* series begin to recover in 1993 around the time that Fannie Mae started securitizing loans and stepping up its activity in repackaging mortgages (to aid depositories seeking to reduce their capital requirements for loans held in portfolio). Increased mortgage securitization also occurred via home equity loans and cash-out mortgage refinancing. Both *HLI* series surge between the late 1990s and mid-2000s. The late-1990s' jump is consistent with declines in mortgage refinancing costs (Bennett, *et al.*, 2001); with findings from Canner *et al.* (2002) that proceeds from cash-out mortgage refinancings were partially used for consumer spending; and with the cross-section consumption results of Hurst and Stafford (2004). The *HLI* indexes start receding in the late 2000s after the U.S. housing market peaked. To a large extent, much of this fallback is muted by the inclusion of several variables to control for the endogenous response of lenders to worsening credit quality, weaker house prices, and a weaker economy. Nevertheless, the state space model estimated 4% or so maximum m.p.c. out of housing wealth is considerably lower than other estimates. For example, Carroll, Otsuka, and Slacalek (2011) suggest that that the housing wealth m.p.c. rose to about 9 percent in the late 1990s. However, Carroll *et al.*'s. estimate may

[8] The smaller size of home equity loans relative to home purchase mortgages provided an additional (cost) hurdle.

convolute the roles of unsecured consumer credit constraints and housing collateral.[9] This is suggested by the fact that our separate consumer credit index is highly significant in the estimated consumption function.

3. Refinancing and Mortgage Equity Withdrawal (MEW) Results

Before proceeding to the consumption results, it is instructive to review what the joint estimation model implies for mortgage refinancing behavior.

3.1. Refinancing Equation Results

The results for the refinancing model estimated with the Kalman Filter in Table 2A are very sensible. The model has a good fit and the residuals are relatively clean.[10] Estimates from the three-equation spline are presented in Table 2B. Since these results were similar, we focus the discussion on the refinancing findings estimated using the Kalman Filter to conserve space.

In order of the variables, after the lagged dependent variable, are three interest rate incentive terms. The time t and t-1 lags of the asymmetric mortgage interest rate gap are positive and highly significant. The t-2 lag of the asymmetric mortgage rate gap is negative and significant picking up the tendency for refinancing activity to decline two quarters after surging. The size of its coefficient roughly equals 60 percent of the sum of the positive coefficients on the t and t-1 lags, suggesting that the t-2 coefficient is sensibly interpreted as reflecting the partial unwinding of incentives to refinance earlier. Also reflective of strong payback effects and a tendency for refinancing booms to abruptly end is the highly significant, negative coefficient on the term inter-acting the end of a mortgage rate low with the number of mortgage rate lows in the last two years. The fifth and sixth interest rate incentive terms are the time t and t-1 dummies for

[9] Carroll *et al's* (2011) estimates also predate recent major revisions to the Flow of Funds accounts, which upwardly revised the estimates of housing wealth from 1999 on.
[10] There is some evidence of heteroscedasticity, likely reflecting a big Iraq war-related outliers in 2003.

whether mortgage interest rates are within 10 basis points of being at the lowest level observed over the prior 30 quarters. As expected, these variables are significant. The time t-2 lag of *Low* has a negative and significant coefficient likely reflecting an unwinding or payback effect. Also significant is the TED spread (*liborspd*), with the expected negative sign.

The lower interest rate expectations measure interacted with a post-1981 dummy was marginally significant, suggesting that the advent of adjustable rate mortgages encouraged refinancing between fixed and adjustable rate mortgages. Ostensibly, households could obtain adjustable rate mortgages during periods of high interest rates (like the early 1980s) and then convert to fixed rate mortgages when they expected these rates to fall in the prior quarter. The variable for housing wealth net of mortgage debt was just short of being marginally significant. This may reflect that the aggregate equity stake of families in owner-occupied housing is not informative enough about the distribution of equity stakes and its implications for the ability of families to refinance their mortgages and their demand to do so. Finally, and as expected, the mortgage delinquency rate negatively affects refinancing. This is consistent with higher downside risk to collateral having negative loan supply effects and a reduction in risk-adjusted housing wealth lowering the demand for mortgage debt.

3.2. MEW Equation Results

MEW estimates from the spline model are presented in Table 2C, where all three variables involving *HLI* are at least marginally significant, with the non-interactive *HLI* and *HLI* interacted with house price appreciation are highly more significant. The later is in line with the hypothesis that financial innovations have increased the liquidity of housing wealth and have increased MEW's sensitivity to house price appreciation. The finding is consistent with Canner *et al*. (2002), who show that proceeds from cash-out mortgage refinancings have partly funded consumer spending, in accordance with the cross-section results of Hurst and Stafford (2004). The marginally significant coefficient on net housing assets

Consumer debt has a significant and positive coefficient, reflecting that greater consumer debt provides more incentive to pay down higher interest rates on consumer credit with lower mortgage rate financing. The next term is the ratio to income of illiquid financial assets, for which sign priors are unclear. The statistically significant and negative coefficient likely reflects that as this component of financial wealth rises, households have less need to draw down housing equity, ceteris paribus. This is consistent with evidence (see Duca, *et al.,* 2010) that positive "housing wealth" effects on consumption arise from non-housing wealth and consumer credit constraints that induce the otherwise credit constrained to borrow against housing collateral.

4. Consumption Function Results

4.1 Modeling Income Expectations

Consumer spending accounted for about 70% of GDP in recent years so understanding what drives it is of great importance for policy. Estimating equation (2.5) requires measuring income growth expectations. We choose a subjective discount rate of 5% per quarter as noted above and construct $E_t \ln(y^p{}_t / y_t)$ defined by equation (2.3) taking a horizon of 40 quarters. This is more forward-looking than Friedman's (1963) three-year horizon but less forward-looking than is usually assumed in DSGE models. After 2009 we assume that the historical growth rate resumes from 2010 q1, building in a permanent component of the 'Great Recession.'

$\ln(y^p{}_t / y_t)$ is regressed for 1961 to 2009 on a constant, trend, a 1968 split trend for the productivity slowdown, log y, Δ_4 T-bill yield, and the University of Michigan index of consumer expectations of future economic conditions. Estimating the same equation for 1961 to 2006 results in almost identical coefficients and fit, suggesting the assumptions made about income after 2009 q4 are consistent with the estimated equation. Figure 6 shows the fitted value against the actual value of $\ln(y^p{}_t / y_t)$, given post-2009 assumptions on income. Since 1970, the fitted value has remained in the range 0.02 to 0.1, with a low in 1979 and a high in the late 1990s.

The joint estimation results correspond very well with theoretical priors. An initial general specification was estimated in which the housing liquidity index enters both as an intercept and in interaction with demeaned income growth expectations and housing wealth to income ratio and similarly in the MEW equation. This is compared with a restricted specification in which there is no intercept role for *HLI* in either equation but only interaction effects with income growth expectations and the housing wealth-to-income ratio, *not* demeaned, and the level effect of the housing wealth-to-income ratio is zero. The difference in twice log likelihood between the two specifications is 4.48 and is asymptotically chi-squared. With four restrictions the 5% critical value is 9.49 so that the restricted specification passes easily.

4.2. Consumption Function Estimates

Estimates of the consumption function using the state space and 'spline' approaches are presented in Table 3. As with the refinancing results, the findings are broadly similar, and to conserve space, we focus on the two-equation state space estimates. The speed of adjustment, at 53 percent per quarter, is far larger than in traditional Ando-Modigliani consumption functions. The consumer credit conditions index is highly significant, with the expected positive sign. The change in unemployment, the real interest rate and non-interacted expected income growth variables all have sensible and significant coefficients. The interaction of the change in the unemployment rate and the *CCI* suggests that credit liberalization has reduced the negative impact of short-run increases in unemployment on consumption. In addition, the impact of current income changes is smaller and is barely significant, in contrast to its highly significant role in the consumption model (Table 3) that excludes *HLI* and *CCI* terms.

Of the wealth ratios, net liquid assets have the strongest impact with an estimated m.p.c. of 0.147, somewhat above the UK estimates in Aron *et al.* (2011) (see table 4), but near that for Australia found by Muellbauer and Williams (2011). (M.p.c.'s equal coefficients divided by the speed at which consumption adjusts to its long-run determinants. Illiquid financial assets including pension and stock market wealth have an estimated m.p.c. of 0.019, very close to those found for the UK and Australia, but smaller than common estimates of 0.03 to 0.05 implied by consumption functions conditional on net worth. Part of the reason is that standard models lack controls for income growth expectations and shifts in credit unlike the three papers listed above. In particular for the U.S., the University of Michigan index of expected economic conditions is strongly correlated with stock prices. Our findings accord with Poterba's (2000) point that stock market wealth effects partly embed growth expectations as well as a classical wealth effect.

Compared to the consumption function in the two-equation model, the model omitting *CCI* and the *HLI* interaction with the housing wealth-to-income ratio has a much slower speed of adjustment (9% versus 53%) and a worse fit. The contrast reflects the large effects that financial innovations in consumer and mortgage credit have had on consumption.

{model diagnostic and cointegration results are not ready yet}

Using the two-equation consumption function estimates in Table 2 that includes *CCI* and *HLI*, we decompose how much the equilibrium consumption-to-income ratio fell in response to credit and wealth effects. We use 2007:q2, the quarter before the financial crisis started to disrupt the Libor markets as a pre-crisis benchmark. Between 2007:q2 and 2009:q4, the consumption to non-property income ratio fell 6.9 percentage points. The long-run equilibrium ratio implied by the two-equation system tracks this ratio remarkably well as shown in Figure 7.

Based on the long-run coefficient estimates in Table 3A, the model implies that the long-run equilibrium consumption-to-non-property income ratio fell by 7.8 percent. Of this, 1.7 percentage points was attributable to the fall in *CCI* and about 5 percentage points to the combination of falling housing wealth and declining housing liquidity. The latter is partially offset by about a 2 percentage point rise in the equilibrium consumption-to-income ratio associated with declines in mortgage debt. Some of fallback in mortgage debt stems from voluntary repayment of debt or not taking on new debt; but some will be the result of the writing off of bad debts through foreclosures. It is likely that further deleveraging by households and the bottoming out of house prices, along with the beginnings of a recovery in consumer credit availability will create the conditions for a significant eventual recovery in consumption growth. The timing will also likely depend on the levels of the credit conditions index, house prices, and the housing liquidity index over the next few years.

Figure 8 plots the consumption-to-income ratio and its key long-run drivers: the fitted long-run components due to net liquid assets/income, the consumer credit index and housing wealth/income scaled by the housing liquidity index. The last two account for a major part of the secular rise in the consumption-to-income ratio, as well as its recent sharp fall. However, there is a major offset from the accumulation of debt, a consequence of credit market liberalisation, which pulls down net liquid assets/income. Since the m.p.c. out of net liquid assets is far larger than out of illiquid assets, this offset is substantial. Although higher income growth expectations help explain some phases of the rise in consumption relative to income, such as in the early

1980s and the mid-1990s, they cannot account for the rise after 1997. Also, the scale of variation implies that one cannot base much of a long-run story on this source. These cast doubt on the contention that the rise in U.S. consumption of the 2000-09 decade owed to large increases in expected growth income—if anything, income growth expectations appear to have down-shifted from the 1990s. Another 'long-run' fitted component reveals that the upward trend in illiquid financial wealth accounts for some of the upward drift and cyclical fluctuations in the consumption-to-income ratio. The impact of the real interest rate on auto loans also has little long-run effect, although changes in it help explain short-run dynamics of consumer spending.

5. Advantages of the Multi-Equation Approach

One may estimate a time varying housing liquidity index, *HLI*, using a state space model of the consumption function on its own, i.e. without simultaneously estimating the refinancing equation. One advantage of a single equation approach is its simplicity. The second advantage is that it avoids any contamination from using a mis-specified or poorly specified refinancing equation. The disadvantage is that there additional information on the latent *HLI* may be gleaned by modeling mortgage refinancing as well as consumption, since exogenous changes in *HLI* drive both variables. As this is partly an empirical issue, we estimated an alternative single-equation consumption function and report the results in Table 3.

Comparing the two approaches reveals some important similarities and differences. Estimates of the non-time varying consumption function parameters are similar. In addition the contours of the housing liquidity indexes have similarities. Both rise in the late 1990s, coinciding with the advent of cash-out mortgage refinancing (see Canner, Dynan, and Passmore, 2002, and recall Figure 1), before declining some after 2006 (Figure 9). Nevertheless, there are some differences.

First, the HLI estimates from the two equation state space model are more consistent with the collateral view of the housing wealth effect. The HLI from the one-equation model fluctuates in a range between 1.5 to 3.0 percent between the mid-1970s and mid-1990s, near old consensus estimates for the U.S. from models that do not control for noninterest rate consumer credit conditions. In contrast, the HLI from the two-equation state-space model indicates that the m.p.c. out of housing wealth was slightly negative in the mid-1970s, before the advent of traditional 2nd mortgages in the late 1970s, the introduction of home equity lines in the late 1980s, and the advent of cash-out mortgage refinancing in the late 1990s. The slightly negative m.p.c. in the mid-1970s is from an era in which "active" MEW was not feasible especially given the credit crunch of 1973-74, and when the negative effects of higher house prices on family budgets left less income for nonhousing consumption dominated. The 2-equation *HLI* series then rises to a range around ½ percent in the late 1970s, when traditional (non credit line) second mortgages became more available. It dips during periods of large loan losses (the oil bust of the mid-1980s, commercial real estate bust of the early 1990s, and the subprime crisis of the late-2000s) and tighter capital regulation (Basel 1 in the early 1990s). Abstracting across the regulation-related dip during the early 1990s, the *HLI* from the two-equation model trends up to about 1 percent by 1994. This shift plausibly reflects the rising use of home equity loans. It then jumps dramatically in the late-1990s with the advent of cash-out mortgage refinancing. In these ways, the two-equation *HLI* series is more consistent with institutional changes affecting the collateral role of housing before the late 1990s.

A second difference is that the standard error of the estimated HLI is about 30 percent smaller in the two-equation than in the one-equation model, as shown in Figure 10. In addition to yielding more sensible m.p.c. results in pre-1995 samples, the two-equation HLI estimates are more precise. Given the large swings in both the level and liquidity of housing wealth, this is an important practical advantage, especially given indications that U.S. house prices may not bottom until early 2012 (if not later) as discussed in Duca, Muellbauer, and Murphy (2011b)

A third and final notable difference is that the fit of the consumption equation is also better in the two equation framework, which has a standard error that is about 10 percent lower than from the one-equation state space model, and an adjusted R^2 that is 7 percent higher. Another advantage is that the speed of adjustment is roughly twice as fast in the two-equation model. Given that consumption comprises about 70 percent of U.S. GDP, these factors also illustrate the benefits from using a multi-equation approach to model financial innovation.

6. Conclusion

Assuming that capital markets are perfect under certainty equivalence yields the canonical type of saving function based on the permanent income-life cycle hypothesis. We find that imposing market completeness and certainty equivalence can render consumption models, much as with asset price models, less useful for understanding and tracking cycles and disequilibria. The existence of credit constraints and major shifts in credit availability can imply departures from those highly stylized models, and may explain why traditional models have generally failed to track the recent decline in consumption and the boom that had preceded it.

Consistent with this approach, we find that constructing and adding indexes tracking changes in the availability of consumer credit and the liquidity of housing wealth greatly improve empirical models of consumer spending. These indexes indicate that consumer credit markets were liberalized (became more complete) during the 1980s, while the liquidity of housing wealth rose in the late 1990s. Our results indicate that differences in the timing of these innovations are both statistically and economically important. In addition, adding these channels enables us to gauge the impact of the financial crisis on consumption, via both its short-run effect on some types of financial frictions (e.g., swings in the LIBOR-OIS spread) and by other elements that may have medium-or even long-run effects on credit availability and the ability of homeowners to tap housing equity. Overall, our findings imply that it is important to carefully account for financial liberalization and innovation when modeling consumption behavior.

One particular contribution from this study is its construction of a levels index for the availability of consumer credit. This index is constructed by removing short-run cyclical influences from a diffusion index of the change in bank lending and then scaling the resulting diffusion index using its common sample growth rate versus that of consumer loan extensions relative to income over 1966-82. Including this index notably improves model fit and characteristics (e.g., increase the speed of adjustment). Removing short-term cyclical influences from the index improves on the original version of the index used in Muellbauer (2007), adopted in the President's Economic Report 2010 to model long-run variations in the U.S. saving rate.

Another data contribution of this study is its construction of a time series for the level of housing liquidity. We specify models for refinancing and MEW activity that include many plausible economic control variables, including financial incentives to refinance such as lower interest rates, changing interest rate expectations, and swings in house price appreciation. Using our three-equation system, we extract a common latent index whose trends are consistent with other evidence of major declines in the pecuniary and non-pecuniary costs of refinancing and withdrawing equity from housing. We show how gleaning information from mortgage behavior yields more plausible and less noisy estimates of the m.p.c. of housing wealth. In addition, movements in this index coincide with major shifts in business practices and regulations. In this way, our estimated *HLI* in conjunction with other information sheds light on why, over time, mortgage refinancing activity has become more sensitive to interest rate incentives to replace old mortgages and why MEW activity has become more sensitive to swings in house price appreciation. As a result of underlying financial innovations and incentives from the Tax Reform Act of 1986, the collateral role of housing became enhanced over the years leading up to the recent housing bust, as had the effects of mortgage rate and house price swings on MEW.

The recent combination of large declines in wealth and substantial tightening of mortgage and consumer credit standards has not been seen since the recession of 1974-75, when U.S. consumption was also unusually weak. Our coefficient estimates and calibrations indicate that the equilibrium ratio of consumption (excluding housing services) to non-property income fell by 7.8% between mid-2007 and year-end 2009, in line with actual data.[11] Estimates imply that about one-quarter of the recent rise in the personal saving rate stems from tighter credit standards and, and about three quarters, from wealth effects. The latter not only reflect prior increases in the impact of housing liquidity, but also likely embed asset price declines associated with declines in credit and mortgage availability, the latter of which also reflect tighter credit standards for mortgages used to purchase homes as shown by Duca, Muellbauer, and Murphy (2011a). The tightening of consumer standards partly owes to higher LIBOR spreads that have crippled the inter-bank lending market that had helped fund loans. In this way, our CCI index is affected by financial frictions that are associated with the broader financial and credit crisis of 2007-09.

[11] Because of partial adjustment, the equilibrium ratio falls by somewhat more than the actual ratio over this interval.

In the future, we plan to add further equations to the system: the mortgage stock, the stock of consumer credit and household liquid assets (broad money). Ultimately, indexes of credit conditions could be used to link observable shifts in the composition of loans made by financial sector. This should lead to a more complete understanding of real-financial sector linkages in economies like the U.S.

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Figure 1: Financial Innovations Linked to Increased Sensitivity of MEW to Swings in Real House Price Appreciation

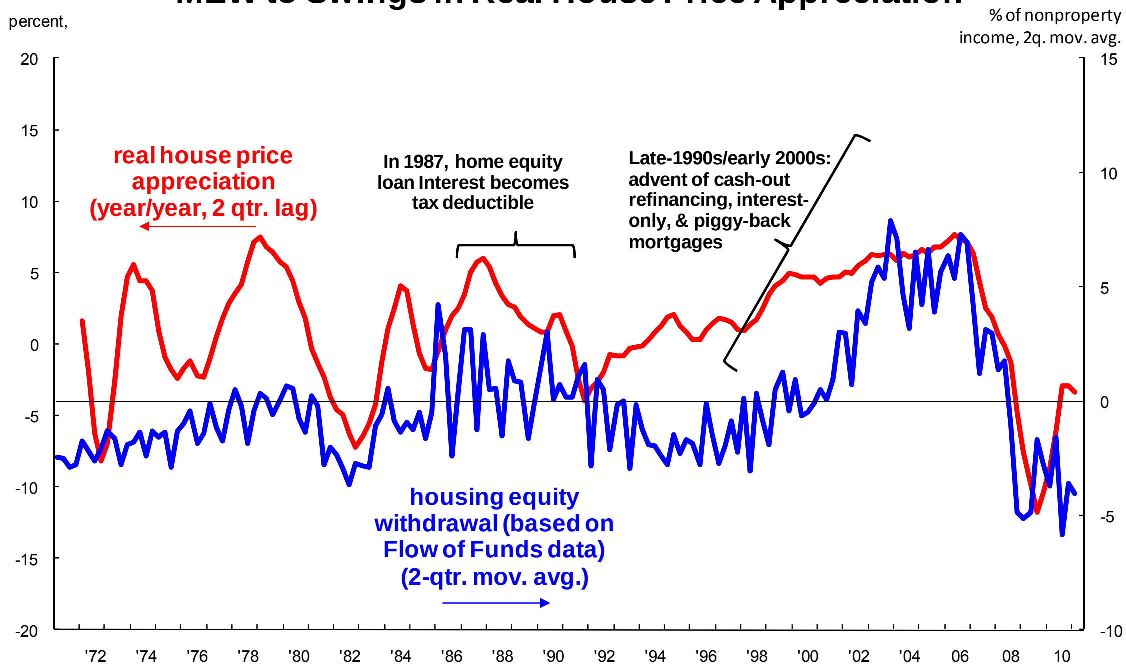


Figure 2: Consumer Credit Availability Rises Much from 1970 to Mid-1990s, Rises During Recent Boom then Falls Back

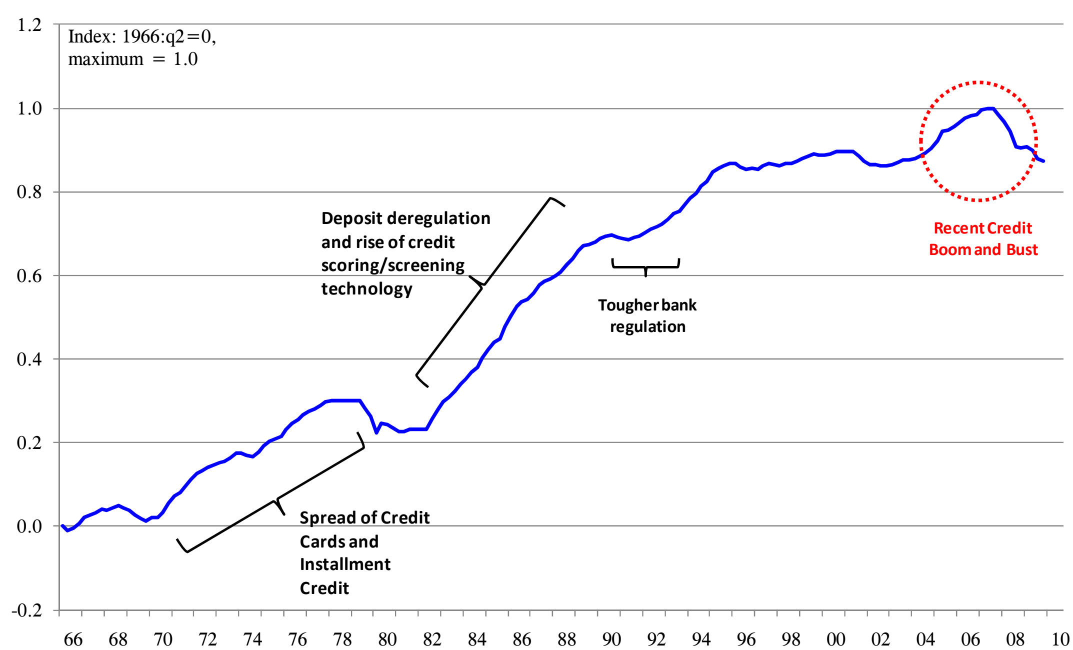
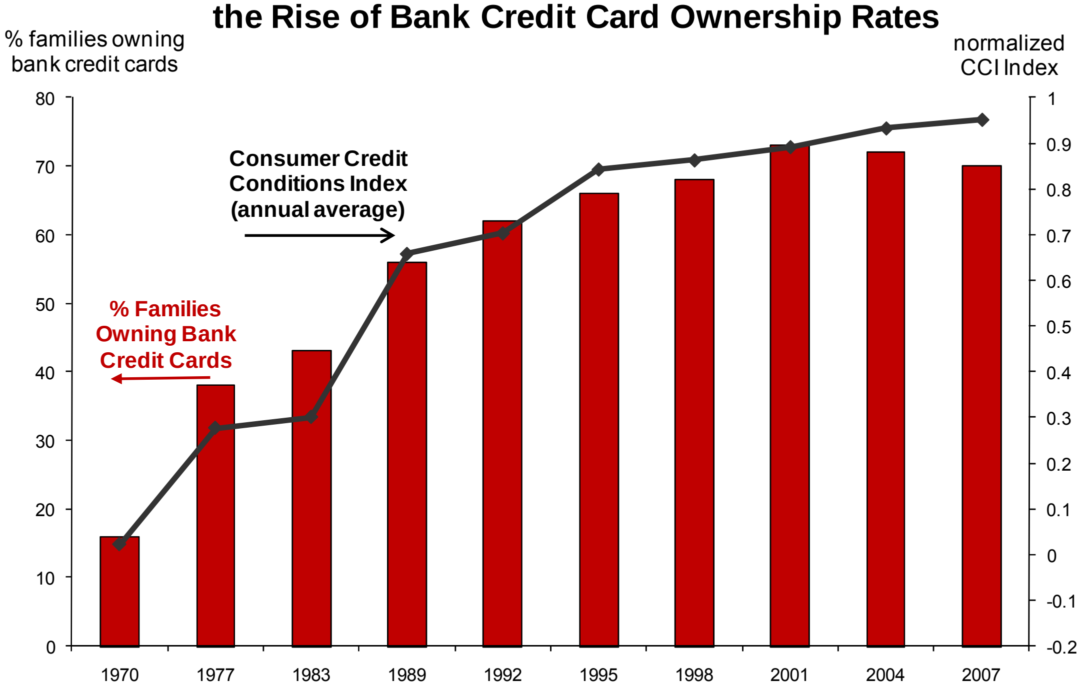


Figure 3: The Consumer Credit Conditions Index Tracks the Rise of Bank Credit Card Ownership Rates



Notes: All credit cards generally excludes cards limited to only one particular retailer. Bank cards are those on which households can carry-over balances. Sources: Durkin (2000), Bertaut and Haliassios (2006) for 1992 data, Bucks, et al., (2007, 2009) for 2001-07, and authors' calculations using Bucks, et al. (2009) figures for bank card ownership in 2004 and 2007.

Figure 4: U.S. Financial and Tax Innovations Linked to Changes in Refinancing Sensitivity to Swings in Mortgage Interest Rates

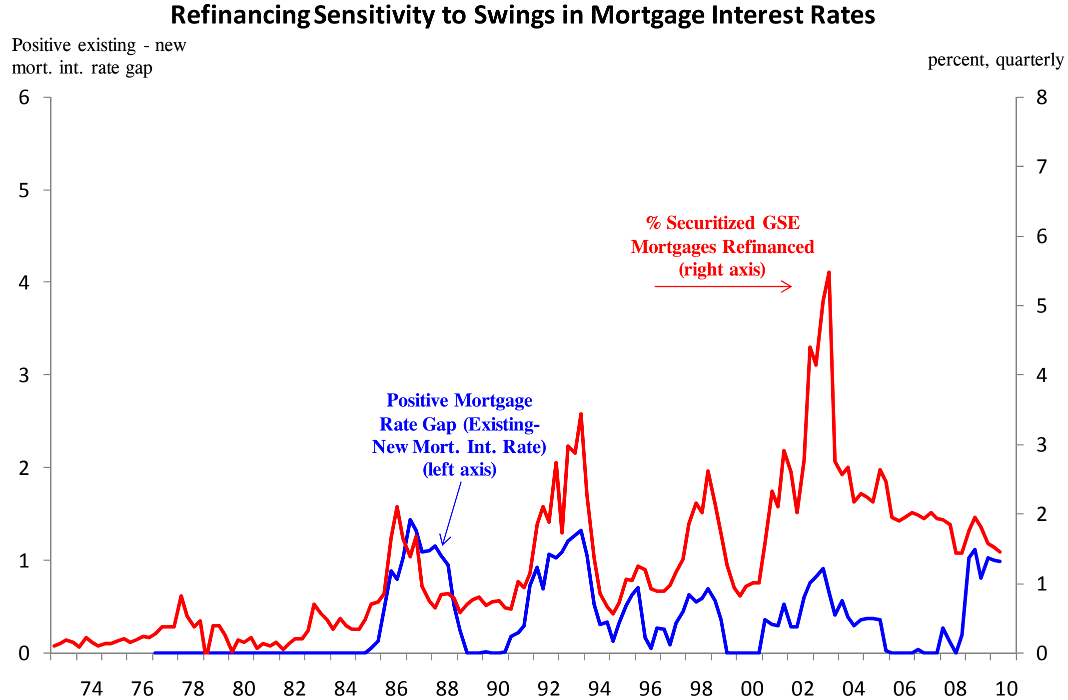
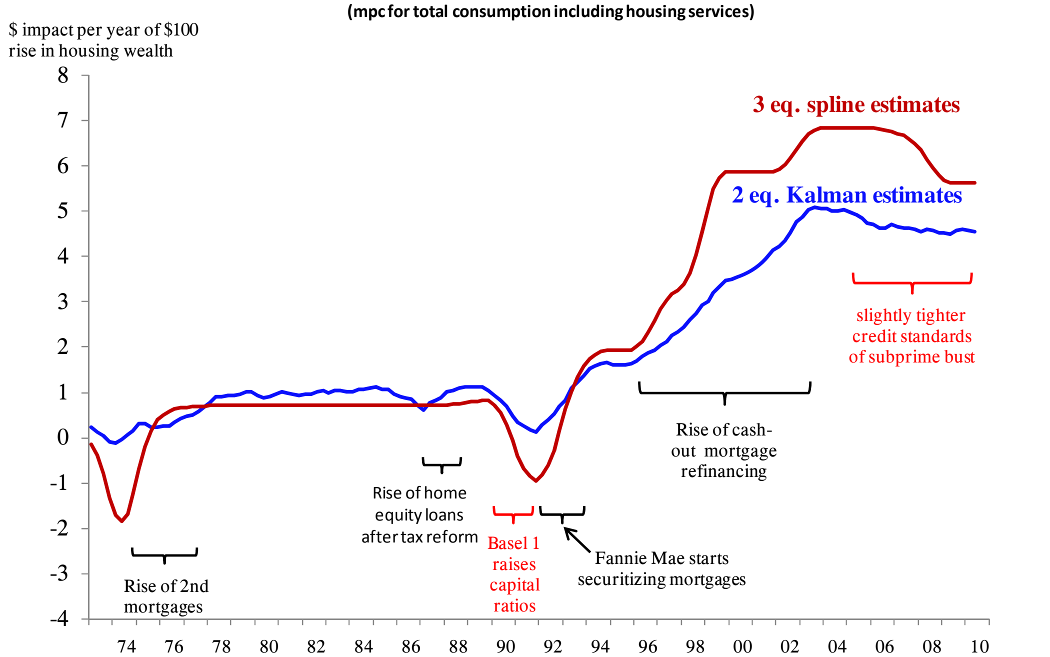


Figure 5: Housing's Wealth Impact on Consumption Soars in Late-1990s, Recedes During the Subprime Bust

(mpc for total consumption including housing services)



Source: "How Financial Innovations and Accelerators Drive U.S. Consumption Booms and Busts," J. Duca, J. Muellbauer, and A. Murphy, March 2011.

Figure 6: Actual and fitted values of log permanent income/actual income.

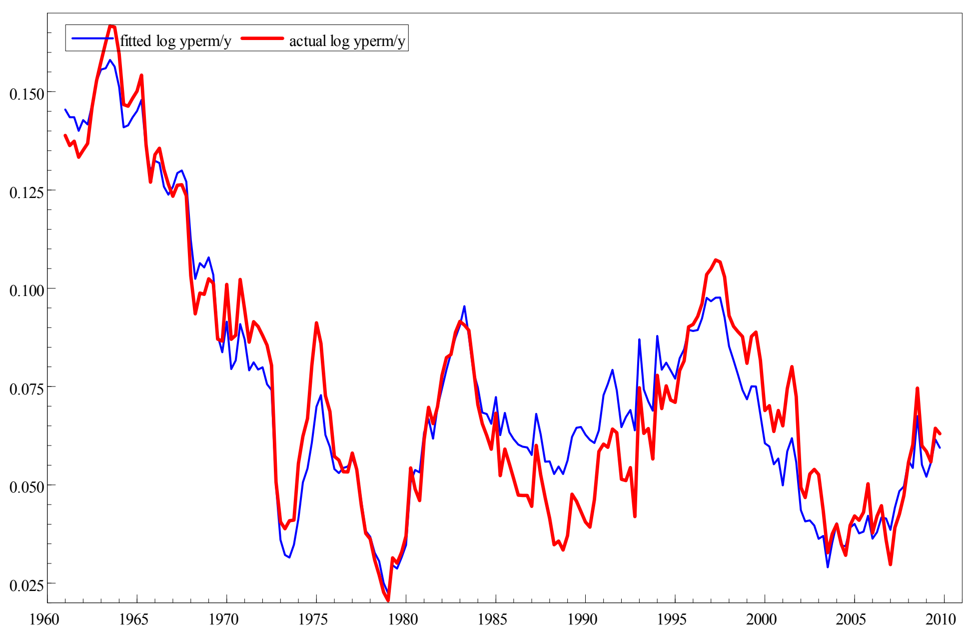


Figure 7: Long-run Equilibrium Relationship in Credit-Augmented Model Tracks the Fall in the Consumption-to-Income Ratio Since the Financial Crisis

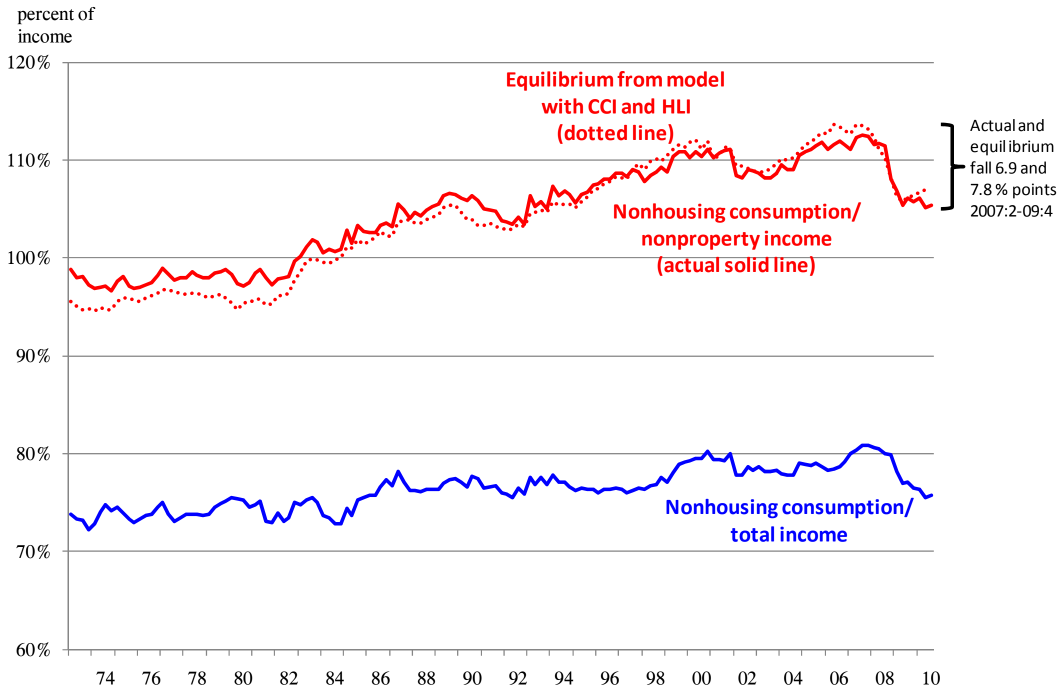


Figure 8: Estimated Equilbrium Components of Log Ratio of NonHousing Consumption to NonProperty Income

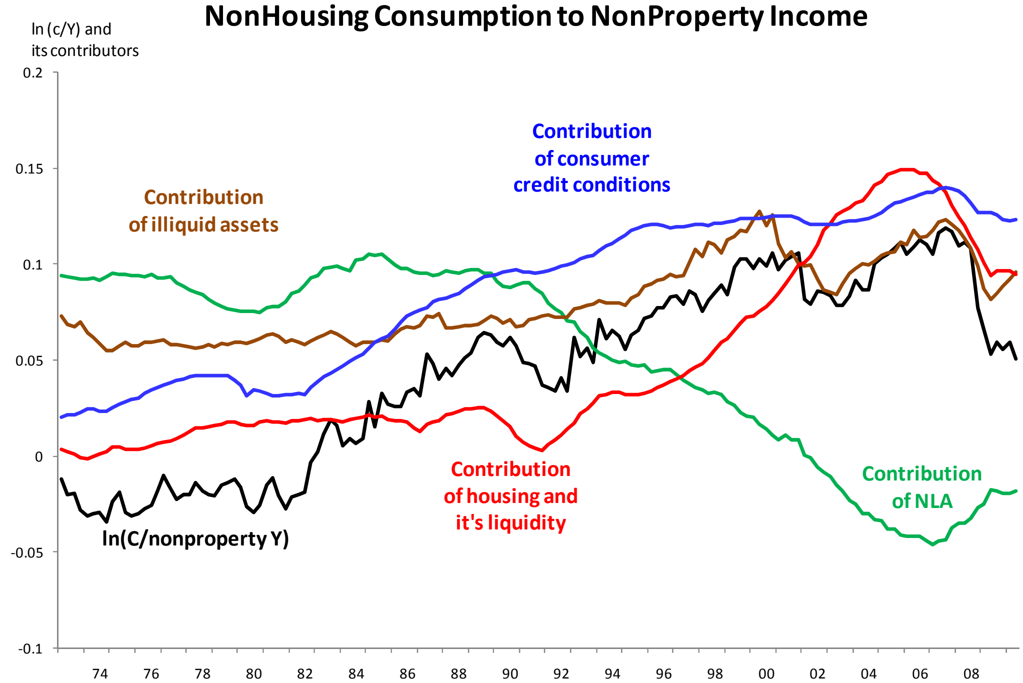


Figure 9: Estimated Wealth Effects From One- and Two-Equation State Space Models

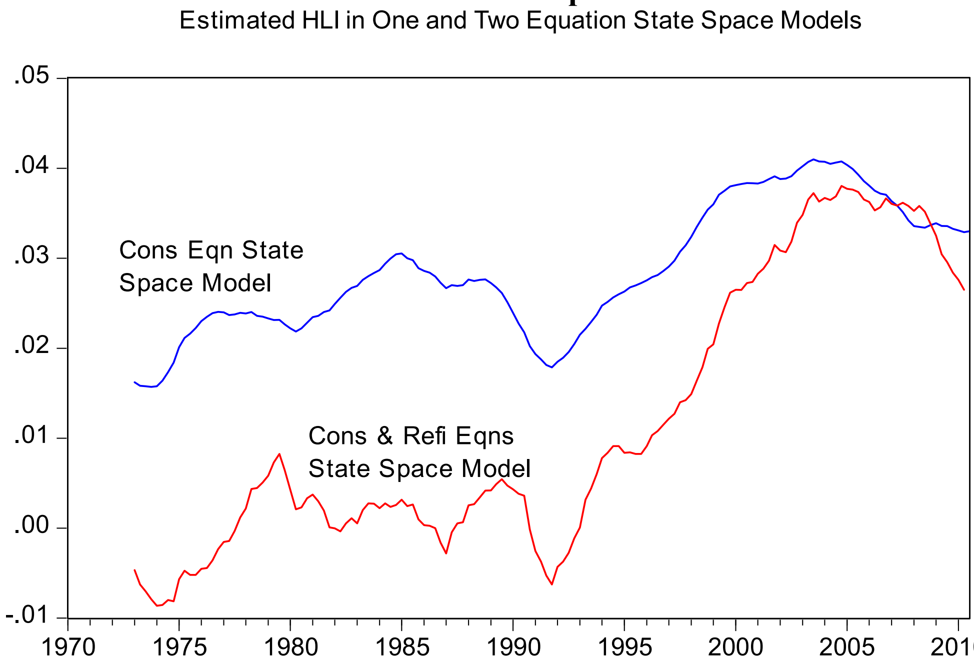


Figure 10: Two-Equation State Space Models Yield More Precise HLI Estimates Having Smaller Standard Errors

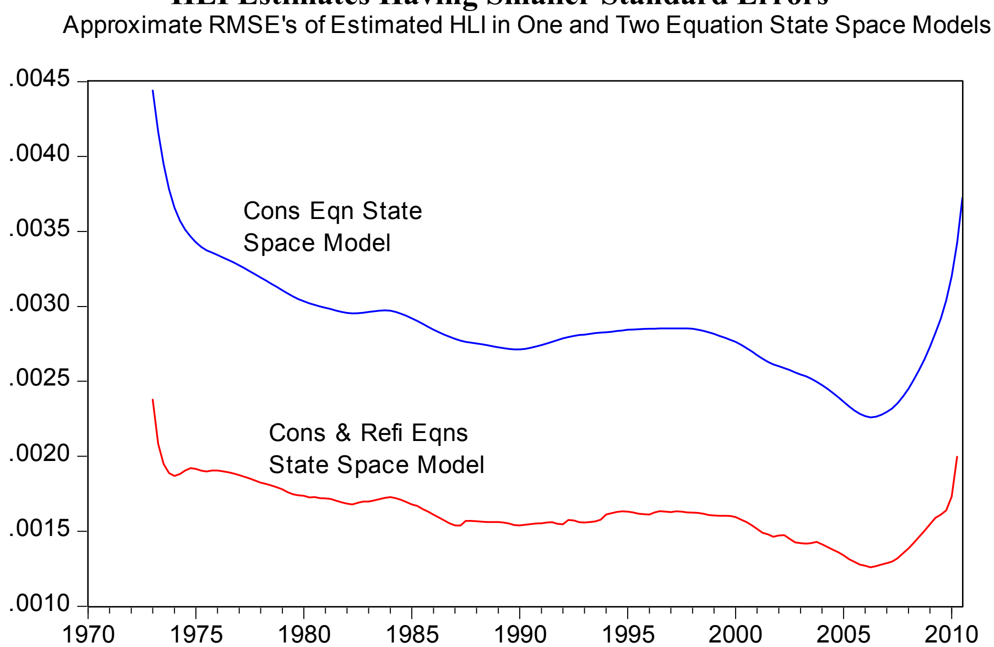


Table 1: The Two Equation State Space Model

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1. Consumption Function:

$$\Delta \ln c_t = \lambda\{\alpha_0 + (\ln y_t - \ln c_{t-1}) + \alpha_1 r_{t-1} + \alpha_2 CCI_t + \alpha_3 (\ln y^p_{t+1} - \ln y_t)$$
$$+ \gamma_1 NLA_{t-1}/Y_t + \gamma_2 IFA_{t-1}/Y_t + \gamma_3 HSG_{t-1}/Y_t + \gamma_4 HLI_t \times HSG_{t-1}/Y_t\}$$
$$+ \beta_1 \Delta \ln y_t + \beta_2 \Delta ur_t + \beta_3 \Delta nr_t + \ldots + u_t$$

2. Refinancing Equation:

$$refi_t = rr_1 refi_{t-1} + rr_2 HLI_t + z_t'\delta + rr_2 (HLI_t \times z_t'\delta) + v_t$$

$$z_t'\delta = \delta_0 + \delta_1 Pos\,Gap_t + \delta_2 Pos\,Gap_{t-1} + \delta_3 Pos\,Gap_{t-2} + \delta_4 Low_t + \delta_5 Low_{t-1} + \delta_6 Low_{t-2}$$
$$+ \delta_7 Payback_t + \delta_8 Libor\ Spread_{t-1} + \delta_9 SSD_{1981,t\text{-}1} \times demeaned\ RateFall^e_t$$
$$+ \delta_{10} (HSG_{t-1}/Y_t - HSG_{t-1}/Y_t) + \delta_{11} MortDel_{t-1} + v_t$$

3. State Equation:

$$HLI_t = HLI_{t-1} + \varepsilon_t$$

Notes: The random error terms u_t, v_t and ε_t are independent, mean zero normal random errors and the normalization $\gamma_4 = 1$ is used. $\ln y^p_{t+1} - \ln y_t$ is the OLS fitted value of $\left(\sum_{s=1}^{K} \eta^{s-1} \ln(y_{t+s}/y_t)\right)\Big/\left(\sum_{s=1}^{K} \eta^{s-1}\right)$, with $K = 40$ and $\eta = 0.95$, in an OLS regression model based on reversion to a split trend (with a slow-down in growth from 1968 on and a small pickup in 1988 which reverses in 1999) and two other explanatory variables - the four-quarter change in the three-month Treasury bill yield and the Thomson Reuters, University of Michigan survey measure of consumer expectations.

Table 2(a): Two-Equation State Space Model Estimates of the Refinancing Equation (1973q1-2010q2)

		Coefficient	*t-ratio*
	z'δ part of refi equation		
***PosGap*(t)**		**0.300****	**3.67**
***PosGap*(t-1)**		**0.289****	**2.64**
***PosGap*(t-2)**		**-0.342****	**-4.20**
***Payback*(t)**		**-0.132****	**-7.01**
***Low*(t)**		**0.169***	**2.45**
***Low*(t-1)**		**0.168****	**2.98**
***Low*(t-2)**		**-0.098***	**-2.46**
Libor – T Bill spread		**-0.092****	**-3.70**
***Ssd81x* Expected interest rate fall**		**0.171+**	**1.96**
Net housing wealth/income		**0.089**	**1.57**
Overall equation			
Lagged refi rate		**0.644****	**12.11**
HLI + HLI × z'δ		**34.47****	**5.99**
Log Likelihood	**568.49**	**R^2**	**0.971**
AIC	**-7.22**	**SIC**	**-6.68**

** (*,+) denotes significance at the 99% (95%,90%) confidence levels.

Table 2(b): Three-Equation 'Spline' Estimates of the Refinancing Equation (1973q1-2010q2)

	Coefficient	*t-ratio*
	z'δ part of refi equation	
***PosGap*(t)**	**0.382****	**3.97**
***PosGap*(t-1)**	**0.184**	**1.56**
***PosGap*(t-2)**	**-0.390****	**-4.50**
***Payback*(t)**	**-0.189****	**-6.53**
***Low*(t)**	**0.221****	**2.94**
***Low*(t-1)**	**0.364****	**4.54**
***Low*(t-2)**	**dropped**	
Libor – T Bill spread	**-0.088****	**-3.20**
	Other Terms	
Constant	**-0.039**	**-0.37**
***Ssd81x* Expected interest rate fall**	**0.195***	**2.25**
Net housing wealth/income	**0.168***	**2.06**
ΔMortgage Delinquency (t-1)	**0.504****	**4.58**
DTaxRefTransition	**-0.971****	**-6.33**
D =1 1993q1, -1 1993q2	**-0.636****	**-4.61**
Dummy 2003q1 2nd Gulf War preamble	**0.483****	**3.11**
Lagged refi rate	**0.637****	**13.31**

**(*,+) denotes significance at the 99% (95%,90%) confidence levels.

Table 2(c): Three-Equation Spline Estimates of the MEW Function (Dependent Variable: $\Delta MEW_{t-1}/Y_t$; sample: 1973q1-2010q2)

	Coefficient	*T-Stat*
Intercept	**0.032^{+}**	**1.71**
Interest rate terms	**0.010^{**}**	**2.70**
Consumer debt/income	**0.244^{**}**	**2.63**
Illiquid financial assets/income	**-0.027^{**}**	**-6.68**
HLI	**0.131^{**}**	**3.96**
***HLI* ×net housing assets/income**	**0.054^{+}**	**1.82**
***HLI* ×house price appreciation**	**0.785^{**}**	**4.67**
ΔUnemployment rate	**-0.009^{*}**	**-2.50**
Δ mortgage delinquency rate	**0.020**	**1.42**
Nominal auto loan rate	**0.006^{**}**	**2.73**
***D1987q4* stock market Crash**	**-0.025^{+}**	**-1.83**
***D1990q4* pre 1stGulf War**	**0.024^{+}**	**1.74**
***D2003q1* pre 2ndGulfWar**	**-0.023^{+}**	**-1.63**
***D2008q4* Lehman failure**	**-0.019**	**-1.32**
Peak m.p.c. housing (2003)	**0.068**	**-**
R^2	**0.73**	

$^{**}(^{*,+})$ denotes significance at the 99% (95%,90%) confidence levels.

Table 3: OLS and State Space Estimates of the Consumption Function

Dependent variable: $\Delta \ln c_t$ (consumption excluding housing services)
Sample: 1973 q1 - 2010 q2

	Basic Equation OLS		One Equation State Space		Two Equation State Space	
	Coeff	t-Stat	Coeff	t-Stat	Coeff	t-Stat
Speed of adjustment (λ)	0.092*	3.16	0.261**	3.27	0.530**	10.06
Long Term Effects:						
Intercept	-0.017	0.95	-0.148+	1.88	-0.110	67.0
Unsecured credit conditions, *CCI*	-	-	0.106*	2.60	0.108	6.44
Lagged real interest rate	-0.0048	1.14	-0.0019	0.82	-0.0021	2.79
Future income growth	0.519*	1.76	0.333*	2.10	0.236	3.67
Net liquid assets / income	0.072+	1.84	0.089+	1.81	0.147	7.76
Illiquid financial assets / income	0.046**	3.57	0.019*	2.27	0.019	5.65
Housing wealth / income	0.050*	2.23	-	-	-	-
HLI x housing wealth / income	-	-	1	-	1	-
Short Run Effects:						
ΔLog income	0.272**	4.77	0.220**	3.38	0.103*	2.05
ΔNominal interest rate	-0.0064**	6.79	-0.0042**	4.55	-0.0036**	5.62
ΔUnemployment rate	-0.0090**	6.61	-0.0057**	4.84	-0.0049**	5.36
Oil shocks dummy	-0.0056*	2.12	-0.0045+	1.78	-0.0081**	6.54
State space housing wealth m.p.c.:						
Maximum smoothed estimate	-		0.041		0.038	
(Rmse)			(0.0024)		(0.0014)	
Equation SE ×100	0.53		0.44		0.40	
Adjusted R^2	0.54		0.67		0.74	
P Values (OLS Regression)*:*						
AR(5)/MA(5)	0.58		0.22		0.11	
Heteroscedasticity	0.00		0.00		0.00	
RESET(2)	0.15		0.24		0.57	
Normality	0.75		0.17		0.25	

Notes: The superscripts **, * and + denotes significance at the 1%, 5% and 10% levels, respectively. The equation SE's, adjusted R^2's and regression diagnostics from the state space models are from OLS regressions, treating the estimated *HLI*'s as given. The general model is:

$$\begin{aligned}\Delta \ln c_t = \lambda\{&\alpha_0 + (\ln y_t - \ln c_{t-1}) + \alpha_1 r_{t-1} + \alpha_2 CCI_t + \alpha_3(\ln y^p_{t+1} - \ln y_t) \\ &+ \gamma_1 NLA_{t-1}/Y_t + \gamma_2 IFA_{t-1}/Y_t + \gamma_3 HSG_{t-1}/Y_t + \gamma_4 HLI_t \times HSG_{t-1}/Y_t\} \\ &+ \beta_1 \Delta \ln y_t + \beta_2 \Delta ur_t + \beta_3 \Delta nr_t + \beta_4 Oil\,Shock_t + u_t\end{aligned}$$

**(*,+) denotes significance at the 99% (95%,90%) confidence levels.

Table 4: Estimated Wealth Effects*

	MPC out of net liquid assets	MPC out of illiquid financial assets	Peak MPC out of housing wealth
U.S. - consumption excluding housing services	0.147	0.019	0.038
U.S. - total consumption	0.163	0.023	0.051
UK - total consumption	0.114	0.022	0.043
Australia - total consumption	0.159	0.022	0.049

*Estimated m.p.c.'s from the preferred models for the UK (column 4 in table 1) from Aron, et. al (2011), U.S. (2 equation state space) from Duca, Muellbauer, and Murphy (this paper), and Australia from Muellbauer and Williams (2011).