Preliminary

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

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Abstract: The post-1980 downward trend in the U.S. saving rate and the recent consumption boom and bust have been attributed to changes in the supply of credit and the liquidity of housing wealth, factors which are not directly observed. Our indexes of unsecured consumer credit availability and the liquidity of housing wealth address this gap. The liquidity of housing wealth is estimated as a common unobservable state in a jointly estimated, non–linear state space model of consumption and mortgage refinancing. The resulting credit augmented, life cycle model of consumption shows that financial innovations and frictions play critical roles in the booms and busts in U.S. consumption.

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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.,* 2011; Case and Shiller, 2008; while Slacalek, 2009 documents similar cases in other countries), there is no consensus regarding the details and size of these credit and wealth effects.

For example, theory implies that large estimated housing wealth effects likely reflect an increase in the liquidity of housing wealth (Carroll and Kimball, 2005; Aron *et al*., 2012) that enables otherwise credit constrained households to borrow against housing equity. Consistent with this collateral view of "housing wealth effects," a number of cross-section studies have found that consumption is much more sensitive to housing wealth among families that are most apt to be credit constrained (Browning, et al., 2008; Disney and Gathergood, 2011; Hurst and Stafford, 2004; and Mian and Sufi, 2011a, b). 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 (Muellbauer and Murphy, 1990; Miles, 1992). Macroeconomic forecasters have found MEW series useful in gauging U.S. consumer spending (e.g., Duca, 2006; Greenspan and Kennedy, 2008). However, the main reason may be that MEW tracks the evolution of credit availability and the sensitivity of consumption to housing collateral. Exogenous, hard to predict, changes in credit supply and the liquidity of housing wealth can make MEW, and thereby consumption, prone to large shifts. Indeed, prior to the 1986 tax changes which made home equity loan interest tax deductible, the ratio of MEW to income barely changed in response to large swings in real home price appreciation (Figure 1). But after 1986, the two series become more positively correlated. The advent of new mortgage products, especially those increasing access to and lowering the costs of refinancing mortgages, enabled households to withdraw more housing equity via cash-out mortgage refinancing. Through this channel, MEW became more sensitive to housing wealth, having implications for cash flow and leverage effects on consumer spending.

We explore these effects using an econometric models based on solved-out consumption specifications, which allow for short- and long-run effects of credit availability and wealth. In this framework, the non-income impact of the crisis on consumption can be gauged through two channels: the availability of unsecured consumer credit and the availability of mortgages for accessing housing collateral. Innovations in mortgage and other related products may increase the liquidity of housing wealth, thereby raising the m.p.c. (marginal propensity to consume) 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 Muellbauer (2007) and Duca and Garrett (1995).

To model the second channel, we track the evolution of major wealth components and the liquidity of housing wealth, estimated as a common unobservable factor or state–in a jointly estimated, non-linear state space model of consumption and mortgage refinancing. *Inter alia*, 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*). *HLI* only enters the consumption function interacted with housing wealth, so it may be interpreted as the evolving m.p.c. of housing wealth. *HLI* enters the refinancing equation both as on its own and interacted with interest rate variables that measure the incentive to refinance. *HLI* is inversely related to the (unobserved) pecuniary and other costs of refinancing, which have fallen over time, lowered barriers to and costs of withdrawing housing equity via cash-out mortgage refinancing (e.g. Bennett, *et al.*, 2001). MEW activity reflects a combination of mortgage refinancing, home equity borrowing, and the roll-over of capital gains when existing homeowners change homes. Greenspan and Kennedy (2008) show that the principal component of active MEW is cash-out refinancing, so the two series move closely together. In our paper, the liquidity of housing wealth (*HLI*) is estimated from a two equation model of consumption and mortgage refinancing, rather than a three equation model including MEW, because the economic determinants of refinancing are more directly observable, and because MEW is harder to measure than refinancing.

Our credit augmented consumption function allows for innovations in consumer credit and the liquidity of housing wealth. As a result the estimated version of this model has a better fit, more stable coefficients, and more plausible short and long-run properties than other consumption functions. We find that financial innovations have altered the housing wealth (or more precisely, the housing collateral) and unsecured 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, which combined with the large falls in house and equity prices, induced a sharp drop in consumption to income ratio and rise in the savings ratio.

In the next section, we outline our credit augmented consumption function. Section 3 describes our measures of unsecured consumer credit availability. In Section 4 we set our refinancing equation and show how the index of housing liquidity (*HLI*) is estimated in our two equation model of consumption and mortgage refinancing activity. The refinancing results and our estimated *HLI* are discussed in Section 5. Section 6 discusses our consumption function results, while Section 7 looks the gains from of estimating housing liquidity from refinancing activity, along with 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. Section 8 concludes.

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

This section reviews the implications of the evolution of consumer credit availability and housing wealth liquidity in a solved-out consumption function. The Euler equation approach has the attraction of simply specifying consumption with first difference terms that do not appear, to require tracking structural factors, but in fact omits important long-run relationships involving wealth and credit frictions. As Campbell and Mankiw (1989) and Muellbauer (2010) *inter alia* show, empirical aggregate Euler equations violate the martingale condition implied by simple theory. In contrast, our modernized Ando-Modigliani style consumption specification encompasses the rational expectations permanent income hypothesis but incorporates 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 real per capita consumption c is given by:

$$c_t = \phi A_{t-1} + \omega y_t^P \tag{2.1}$$

where y^p is permanent real non-property income and A is the real net wealth, both in per capita terms. Letting y be current real income and using the approximation $\left(y^P - y\right)/y \approx \ln\left(y^p/y\right)$ and some algebra yields:

$$\ln c_t = \alpha_0 + \ln y_t + \gamma\, A_{t-1}/y_t + \ln\left(y_t^P/y_t\right) \tag{2.2}$$

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

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

where K is the horizon and η is a discount factor. 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:

$$\ln c_t = \alpha_0 + \ln y_t - \alpha_1 r_t - \alpha_2\theta_t + \alpha_3(E_t \ln yperm_t - \ln y_t) + \gamma\, A_{t-1}/Y_t + \varepsilon_t \tag{2.4}$$

More realism can be added by adding habits (or rational inattention) 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 more borrowing in anticipation of future income), or *HLI* could enter interacted with HSG/Y, which would reflect a larger housing collateral effect. Finally, a consumer unsecured (non-mortgage) credit conditions index (CCI) may also affect consumption.

All of this implies the following equilibrium-correction model for consumption:

$$\begin{aligned}\Delta\ln c_t \approx\ & \lambda\,(\alpha_{0t} + \ln y_t - \ln c_{t-1} + \alpha_{1t} r_t + \alpha_2\theta_t + \alpha_3(E_t \ln yperm_t - \ln y_t) + \alpha_4 CCI_t + \alpha_5 HLI_t \\ & + \gamma_1\, NLA_{t-1}/Y_t + \gamma_2\, IFA_{t-1}/Y_t + \gamma_3\, HSG_{t-1}/y_t + \gamma_4 HLI \times HSG_{t-1}/Y_t) \\ & + \beta_1\Delta\ln y_t + \beta_2\Delta nr_t + \beta_3\Delta ur_t + \ldots + \varepsilon_t\end{aligned} \tag{2.5}$$

where the term in brackets is equilibrium minus actual consumption, λ is the speed of adjustment toward long-run equilibrium and the γ's are the m.p.c.'s of the wealth components. The m.p.c of housing wealth varies with the liquidity of housing wealth.

The m.p.c.'s 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 and borrowers face penalities for not meeting debt obligations (see Mian and Sufi, 2011a,b; Mishkin, 1976, 1978; and Muellbauer and Lattimore, 1995). 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. 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 by total real consumption expenditures excluding imputed housing services because it is more plausible to find a positive classical wealth effect when excluding 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 small impact of temporary taxes on permanent income. Similarly, we adjust non-property income for temporary tax changes using BEA estimates of their impact on disposable income.[1] We track income uncertainty using the contemporaneous 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

[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.

growth after 1968) with two drivers (details are in Appendix A). These are the 4-quarter change in the 3-month Treasury bill yield (to track monetary policy) and the Michigan index of consumer expectations of future economic conditions. Permanent income was constructed with three alternative quarterly discount rates, 0.025, 0.05 and 0.1. As there is little difference in fit between the last two, a discount rate of 0.05 ($\eta = 0.95$) was chosen.

The real interest rate (*r*) is the Federal Reserve Board's user cost of capital for autos (the real interest rate on finance company auto loans plus auto depreciation). To track short run credit effects such as large inter-temporal shifts in auto sales induced by changes in auto interest rate incentives, we include the change in the nominal auto loan interest rate (*nr*). Using Flow of Funds data, liquid assets (*NLA*) are the sum of deposits and credit market instrument minus consumer (*CDEBT*) and mortgage (*MDEBT*) debt. Housing assets (*HA*) are gross housing assets, while illiquid financial assets (*IFA*) equal all other household assets. We also include an oil shock dummy for when oil supply constraints induced a fall in economic activity.[2] The last two variables are the credit conditions (*CCI*) and housing liquidity (*HLI*) indexes, discussed below.

3. The Unsecured Consumer Credit Conditions Index (*CCI*)

We construct a levels index of unsecured consumer credit conditions (*CCI*) index using data from the Federal Reserve's Senior Loan Officer Opinion Survey of 60 large banks which 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.* (2012), is negatively correlated with 1994-2010 survey data on changes in credit standards on non-credit card consumer loans.

We first adjust the willingness to lend index for the identifiable effects of interest rates and the macroeconomic outlook by estimating an empirical model based on screening models. In

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

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).

We include 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 (*RegQ*) measures the degree to which Regulation Q interest rate ceilings reduced banks' ability to attract deposits (Duca, 1996; Duca and Wu, 2009) and thereby raised banks' shadow cost of loanable funds in an era before the loan sales and mortgage-backed securities markets became deep. 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 money market deposit accounts, which boosted deposits (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:

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

$$- \underset{(2.43)}{2.80}\, RegQ_t^{*} - \underset{(10.48)}{47.56}\, CrControl_t^{**} - \underset{(2.95)}{4.93}\, Libor\ Spread_t^{**} - \underset{(2.68)}{20.38}\, Lehman_t^{**} \qquad (2.6)$$

where t-statistics are in parentheses, $R^2 = 0.80$, $AR(1) = 0.75^{**}$ (14.78), equation standard error = 9.09, LM(2) = 0.59 and Q(24) = 20.46. The coefficients are significant with the expected signs. Reassuringly, coefficients hardly change in samples before the financial crisis started in August 2007 and its peak effects on interbank lending 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 then chained into a levels index, based on its correlations with the growth rate of real consumer loan extensions at banks, and normalized (see Figure 2).

CCI has several notable shifts. It dips below 0 in the credit crunch of 1966, before rising in a series of shifts to its peak of 1 in 2007 q3. *CCI* rises during the 1970s, punctuated by declines or pauses that coincide with Reg Q-induced disintermediation in 1970, 1973-74 and in the late 1970s and early 1980s. The index rose much following deposit deregulation through 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 appliances.

Other signs confirm a general increase in the ability of households to borrow. The timing and 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 outstanding balances and partly serve as a means of incurring debt (Figure 3). The relationship is less tight using a broader definition covering credit cards without this debt feature or which are usable at a particular retailer. For example, in 1970, 51% of families had cards using the broader definition, but only 16% had cards with general debt features. By 2001, this gap had 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.

CCI drops during banks' transition to meeting tougher capital standards under Basel I. 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.

4. The Index of Housing Liquidity (*HLI*) and Mortgage Refinancing

A housing liquidity index should track the non-directly observable extent to which financial innovations have made it easier and less expensive for Americans to refinance their mortgage at a lower rate and/ or borrow against the equity in their homes. Such latent effects allow for ease of mortgage equity withdrawals, enhancing the impact of housing wealth on consumption. We estimate these latent effects by estimating mortgage refinancing activity with controls for observable interest rate incentives to refinance and by estimating a housing liquidity index (*HLI*) in a system of equations with a latent variable – the liquidity of housing wealth, *HLI*

- that is interacted with other variables.[3] The systems approach is used because it uses more information, and permits more precise estimation of *HLI*. The *HLI* interactions capture parameter variation over time in a parsimonious and economically meaningful way.

We employ the Kalman Filter to estimate the latent *HLI* in a non-linear state space model of system (Table 1) consisting of consumption (eq. 2.5) and mortgage refinancing equations (eq. 2.7 and 2.8 below). The state space approach is appealing as it is more objective than an alternative 'spline' approach that employs more judgment. Nevertheless, similar *HLI* estimates arise using either approach. 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 cover 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:

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

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:

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

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

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 negatively affect 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, $(HSG_{t-1}-MDEBT_{t-1})/Y_t$, 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 factors.

5. Refinancing Results and *HLI* Estimates

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

5.1. Refinancing Equation Results

Results for the refinancing model in Table 2 are sensible. The model has a good fit and the residuals are relatively clean.[4] In order of the variables, after the lagged dependent variable, are three interest rate incentive terms. The 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

[4] There is some evidence of heteroscedasticity, likely reflecting big Iraq war-related outliers in 2003.

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 reflects 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 significant t and t-1 dummies for mortgage interest rates being within 10 basis points of their lowest level over the prior 30 quarters. The t-2 lag of *Low* is negative and significant likely reflecting an unwinding or payback effect. Also significant is the TED spread (*Libor Spread*), with the expected negative sign.

The lower interest rate expectations term interacted with a post-1981 dummy is marginally significant, suggesting that the advent of adjustable rate mortgages (ARMs) induced refinancing between fixed and adjustable rate mortgages. Ostensibly, households could obtain ARMs during periods of high interest rates 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, 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 decline in risk-adjusted housing wealth lowering the demand for mortgages.

5.2 The Estimated Housing Liquidity Index (HLI)

The *HLI* series is estimated using the nonlinear, two-equation state space model set out in Table 1. The state variable is only identified up to scale so the normalization we use means that *HLI* may be interpreted as the m.p.c. of housing wealth.

HLI has contours that are consistent with developments that likely affected the liquidity of housing (Figure 5). The *HLI* falls in the 1973-74 credit crunch, when binding Regulation Q ceilings hurt the ability of intermediaries to fund consumer and mortgage credit. The *HLI* rises a little in the late 1970s, coinciding with steps taken to deregulate bank deposits at a time when the mortgage-backed securities market was under-developed (Duca, 1996). The timing also coincides with the rise of second mortgages (Seiders, 1979). Afterward, *HLI* is flat for several years, before rising in the late 1980s, when financial sector productivity rose which lowered the costs of financial intermediation (Duca, 2005). *HLI* plunges in the early 1990s credit crunch, when Basel 1 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.[5] *HLI* begins to recover in 1993 near when Congress pressured Fannie Mae and Freddie Mac to expand mortgage lending. Increased mortgage securitization also occurred via home equity loans and cash-out mortgage refinancing. *HLI* surges between the late 1990s and mid-2000s, consistent with: declines in mortgage refinancing costs (Bennett, *et al.*, 2001); findings that proceeds from cash-out mortgage refinancings partially funded consumer spending (Canner *et al.,* 2002); and cross-section consumption results (Hurst and Stafford, 2004). *HLI* recedes in the late 2000s after the U.S. housing market peaked. 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,

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

and a weaker economy. Nevertheless, the state space model estimated 3.8% maximum m.p.c. out of housing wealth is notably lower than other estimates. For example, Carroll, *et al.* (2011) find that the housing wealth m.p.c. rose to about 9 percent in the late 1990s. However, their estimate may convolute the roles of unsecured consumer credit constraints and housing collateral as suggested by the high significance of our CCI in our estimated consumption function.[6]

6. Consumption Function Results

Estimates of the consumption function are presented in Table 3. 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.* (2012) (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 equilibrium level.) Illiquid financial assets including pension and stock market wealth have an estimated m.p.c. of 0.019, 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

[6] Carroll *et al's* (2011) estimates also predate upward revisions to housing wealth in the Flow of Funds accounts.

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 2-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, reflecting the importance of financial innovations in consumer and mortgage finance.

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 ratio of consumption to non-property income 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 3, 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 5 percentage points to the combination of declines in housing wealth and 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 arise from the writing off of bad debts. It is likely that further deleveraging by households and a bottoming out of house prices, along with some recovery in consumer credit availability will induce a recovery in consumption. The timing will also likely depend on movements in the *CCI*, *HLI*, house prices, and other asset prices.

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.

7. One and Two Equation Estimates of *HLI*

One may estimate a time varying housing liquidity index, *HLI*, using a state space model of the consumption function without simultaneously estimating the refinancing equation. One advantage of a single equation approach is its simplicity. Another is that it avoids any contamination from using a mis-specified refinancing equation. The disadvantage is that there additional information on the latent *HLI* may be gleaned by jointly modeling mortgage refinancing with consumption, since exogenous changes in *HLI* drive both variables. To address this empirical issue, we estimated an alternative single-equation consumption function (Table 3).

The two approaches have important similarities and differences. Estimates of the non-time varying consumption parameters are similar, as are the contours of the housing liquidity indexes. Both rise in the late 1990s, coinciding with the advent of cash-out mortgage refinancing (Canner, Dynan, and Passmore, 2002; Figure 1), before declining some after 2006 (Figure 5).

Nevertheless, there are some differences. First, the *HLI* from the 2-equation state space model is more consistent with a collateral role for housing wealth. 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 from models that omit 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 non-housing consumption dominated. The 2-equation *HLI* series 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) and tighter capital regulation (Basel 1). Abstracting from the Basel 1-related dip of the early 1990s, the *HLI* from the two-equation model rises to about 1 percent by 1994, likely reflecting greater 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 9. Thus, 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 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.

This approach, combined with our disaggregation of net wealth components, has important implications for the downswings that follow consumption booms fueled by rising house prices and mortgage borrowing, such as those of the late 1990s and mid-2000s. As a result of the increases in the liquidity of housing wealth during the late 1990s, the moderate increases in house prices then and the sharper rises of the mid-2000s induced greater mortgage borrowing that at first boosted consumption. During the early phases of such consumption booms, the positive impact of rising housing wealth overwhelms any drag from higher debt. Later, when real house prices stopped rising, the drag from previously built up debt predominates, giving way to reduced consumption and deleveraging. A fallback in housing liquidity has exacerbated the negative payback effect of the house price boom of the mid-2000s. The negative payback or deleveraging phase arises in our model, which disaggregates net wealth, because net liquid assets have a higher estimated m.p.c. (15%) than gross housing wealth (4% at the peak). This feature of our framework, combined with slow recoveries in consumer credit availability in these episodes, helps account for why consumption was slow to recover early in the recovery of the early 2000s before house prices surged, and why consumption has been slow to recover during the current recovery after plunging during the Great Recession.

8. 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. In addition, by explicitly modeling the factors driving the long run evolution of the consumption-to-income ratio, our LIVES approach accounts for important parameter shifts in the basic responses of consumption to wealth, credit, and income shocks. Consequently, by not ignoring long-run information by detrending and linearizing, our approach avoids the parameter instability that often plagues conventional linear VARs, especially during the recent recession.

Consistent with our credit-augmented life-cycle/permanent income approach, we find that 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 became more complete during the 1980s, while the liquidity of housing wealth rose in the late 1990s. Our results imply that differences in the timing of these innovations are 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., the LIBOR-OIS spread) and by other elements that may have longer-term 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.

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 a model for mortgage refinancing activity that includes 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 two-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 mortgages. We show how gleaning information from refinancing 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 the changing sensitivity of mortgage refinancing activity interest rate incentives to replace old mortgages and 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 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.[7] 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 asset price declines associated with declines in credit and mortgage availability, the latter of which also reflect tighter credit standards on mortgages for home purchases as shown by Duca, Muellbauer, and Murphy (2011a). Recent swings in consumer credit standards partly owe to shifts in LIBOR spreads that have affected the inter-bank lending market which helps banks 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.

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

Appendix A: Modeling Income Expectations

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.

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

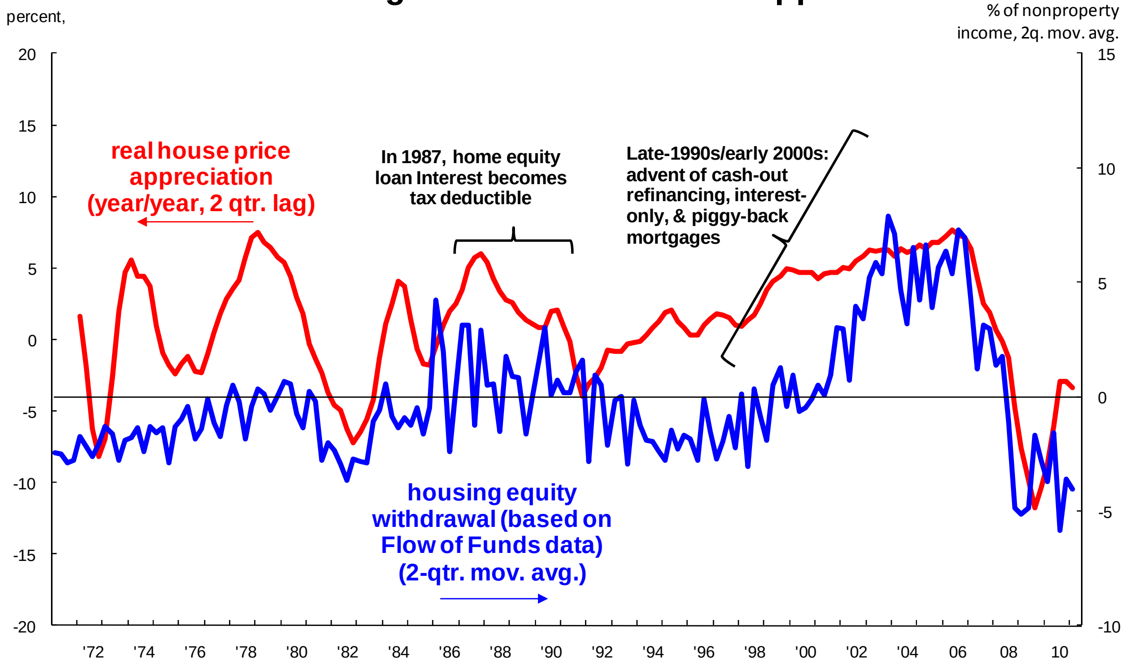


Figure 2: Consumer Credit Availability Rises Much from 1970 to Mid-1990s, Rises During Recent Boom then Falls Back

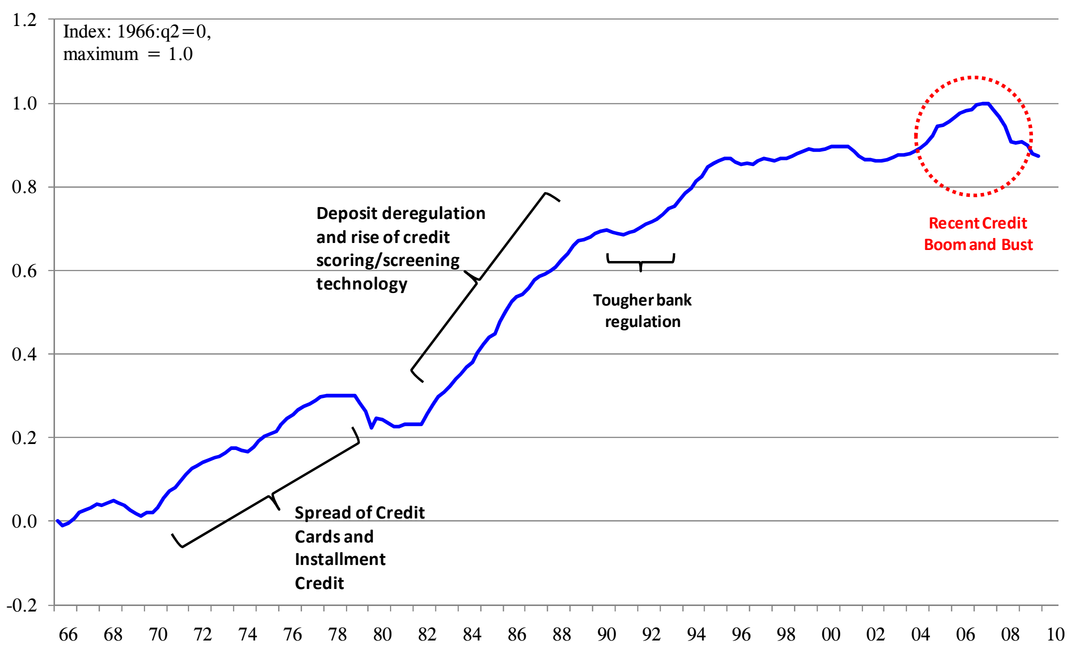
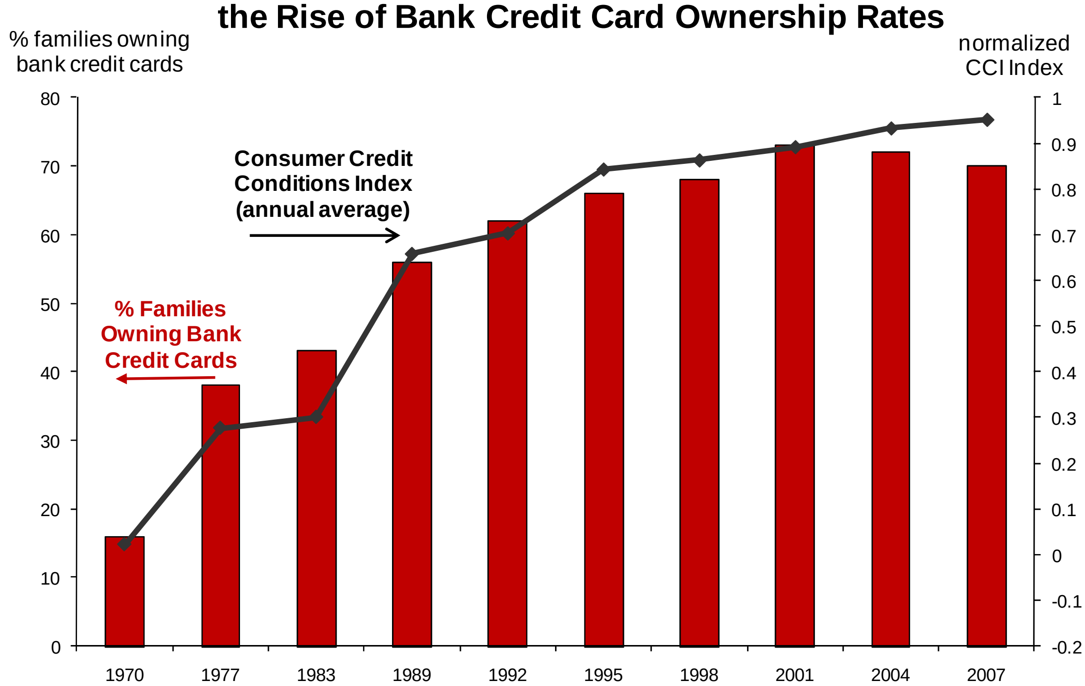


Figure 3: The Consumer Credit Conditions Index Tracks the Rise of Bank Credit Card Ownership Rates



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

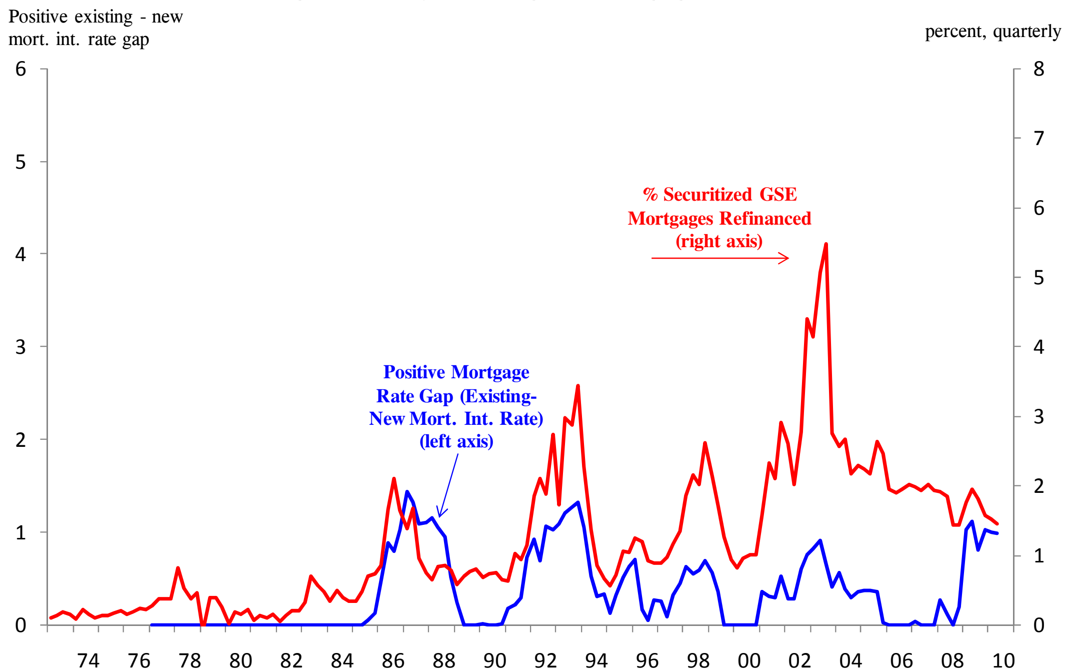


Figure 5: Estimated M.P.C.'s out of Housing Wealth From State Space Models

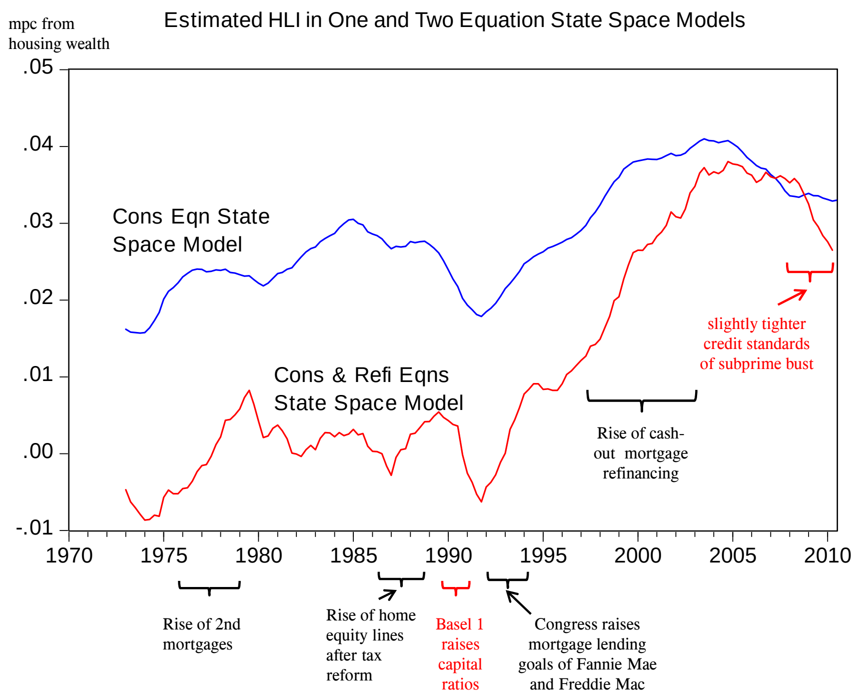


Figure 6: Actual and fitted values of log permanent income/actual income.

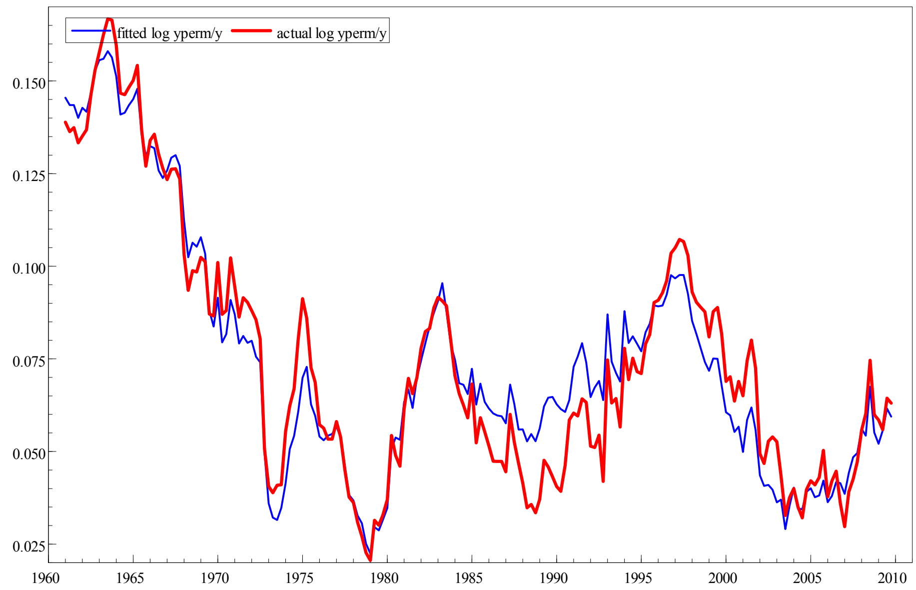


Figure 7: Long-run Equilibrium Relationship in Credit-Augmented Model Tracks the Fall in the Consumption-to-Income Ratio Since the Financial Crisis

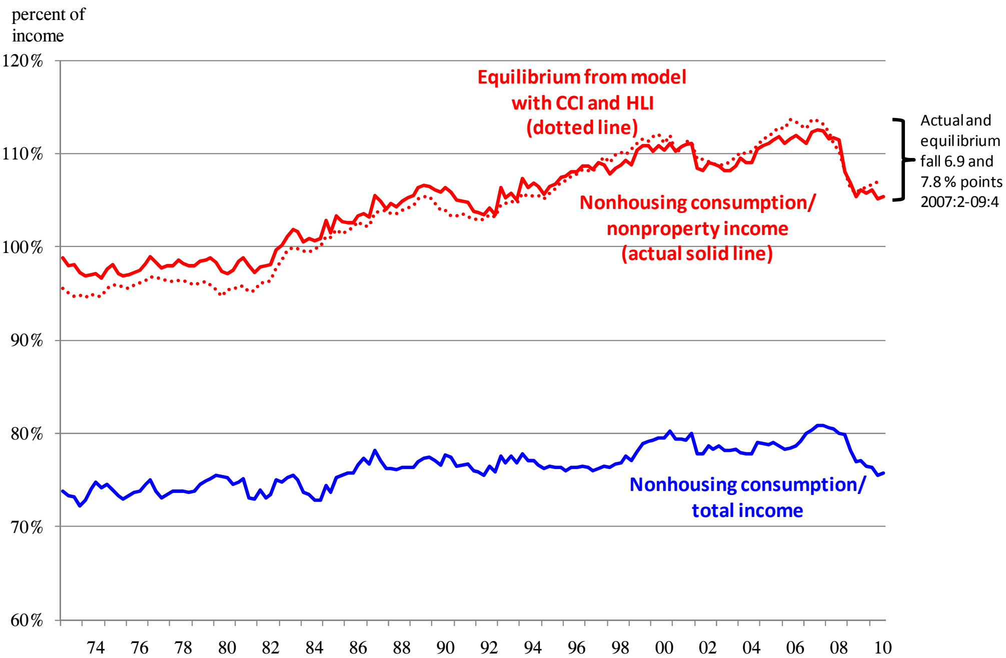


Figure 8: Estimated Equilibrium Components of Log Ratio of NonHousing Consumption to NonProperty Income

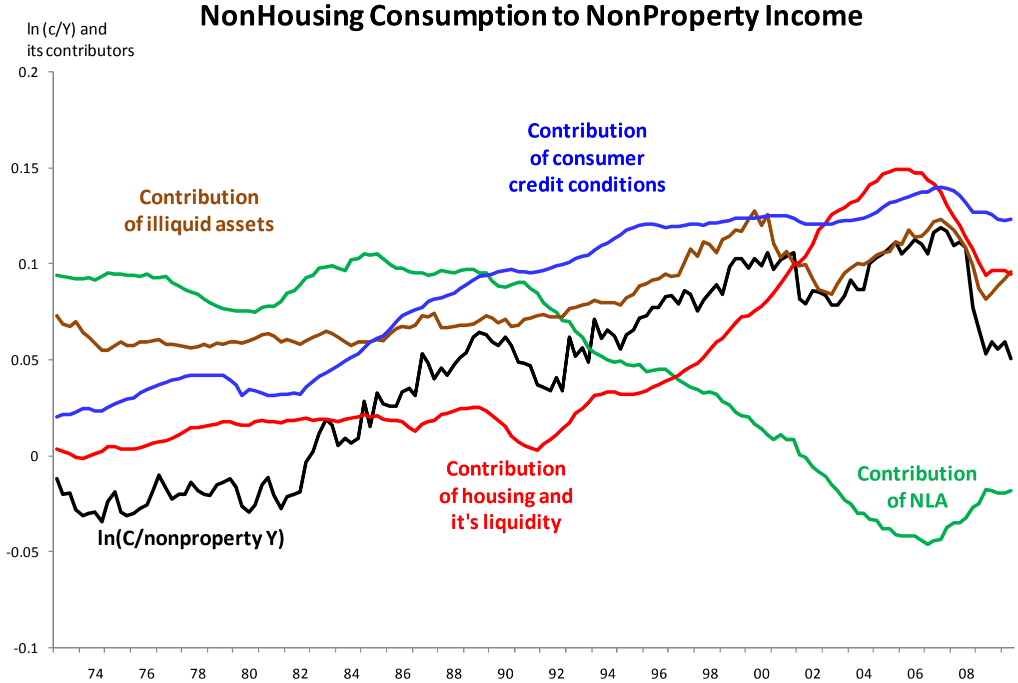


Figure 9: Two-Equation State Space Models Yield More Precise HLI Estimates Having Smaller Standard Errors

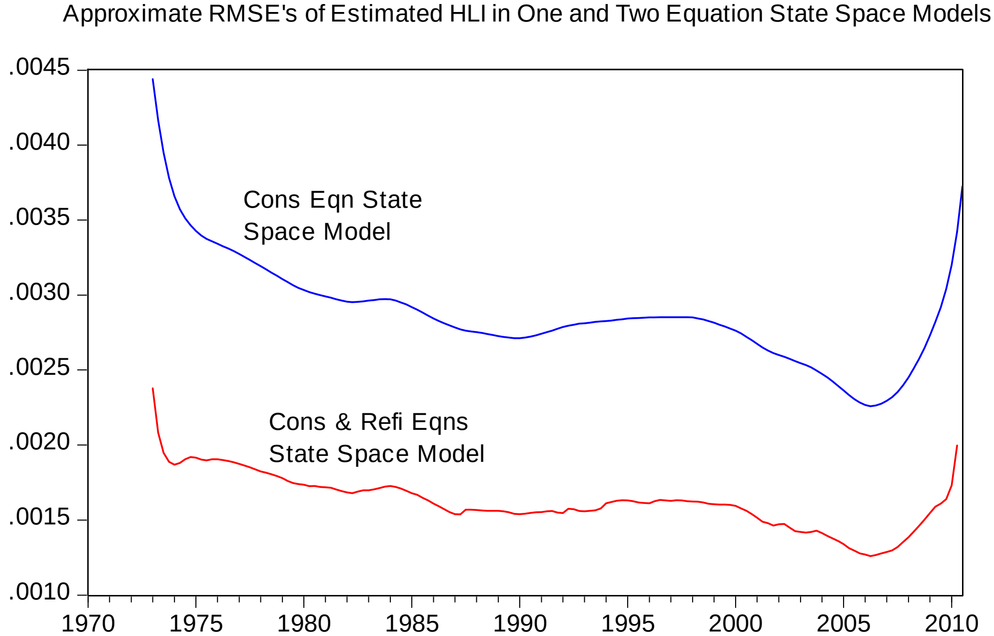


Table 1: The Two Equation State Space Model

1. Consumption Function:

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

2. Refinancing Equation:

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

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

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. $\widehat{\ln} \, y^p_{t+1} - \ln y_t$ is the OLS fitted value of $\left(\sum_{s=1}^{K} \eta^{s-1} \ln(y_{t+s}/y_t) \right) / \left(\sum_{s=1}^{K} \eta^{s-1} \right)$, 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: Two-Equation State Space Models Estimates of the Refinancing Equation

Dependent variable: *refi* (refinancing share)
Sample: 1973 q1 - 2010 q2

		Coefficient	t-Stat
$z_t'\delta$ Part of Refi Equation			
Positive Interest Rate Gap_t		0.300**	3.67
Positive Interest Rate Gap_{t-1}		0.289**	2.64
Positive Interest Rate Gap_{t-2}		-0.342**	-4.20
$Payback_t$		-0.132**	-7.01
Interest Rate Low_t		0.169*	2.45
Interest Rate Low_{t-1}		0.168**	2.98
Interest Rate Low_{t-2}		-0.098*	-2.46
Libor – T bill $spread_t$		-0.092**	-3.70
1981 Smoothed step $dummy_t$ × expected interest rate $fall_t$		0.171+	1.96
Net housing $wealth_{t-1}$ / $income_t$		0.089	1.57
Lagged refi rate		0.644**	12.11
$HLI + HLI \times z_t'\delta$		34.47**	5.99
Log Likelihood	568.49	R^2	0.971
AIC	-7.22	SIC	-6.68

Notes: The superscripts **, * and + denotes significance at the 1%, 5% and 10% levels, respectively. The refinancing equation is $refi_t = rr_1 refi_{t-1} + rr_2 HLI_t + z_t'\delta + rr_2\left(HLI_t \times z_t'\delta\right) + v_t$ with:

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

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:

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

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

Sources: Estimated mpc's for the UK from Aron, et. al (2011, (column 4, table 1)), U.S. (2 equation state space) from Duca, Muellbauer, and Murphy (this paper), and Australia from Muellbauer and Williams (2011).