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INTEGRATING EVOLVING CREDIT MARKET ARCHITECTURE INTO FLOW OF FUNDS BASED MACRO-MODELS

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In 2013 all ECB publications feature a motif taken from the €5 banknote.

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Abstract

After the global financial crisis, there is greater awareness of the need to understand the interactions between the financial sector and the real economy and hence the potential for financial instability. Data from the financial flow of funds, previously relatively neglected, are now seen as crucial to the data monitoring carried out by central banks. This paper revisits earlier efforts to understand financial-real linkages, such those of Tobin and the Yale School, and proposes a modeling framework for analysing the household flow of funds jointly with consumption. The consumption function incorporates household income, portfolios of assets and debt held at the end of the previous period, credit availability, and asset prices and interest rates. In a general equilibrium setting, these all have to be endogenised and since households make consumption and housing purchase decisions jointly with portfolio decisions, there is much to be gained in modeling a household sub-system of equations. Major evolutionary structural change – namely the evolving credit architecture facing households – is handled by our 'Latent Interactive Variable Equation System' (LIVES) approach. A by-product is improved understanding of the secular decline in US saving rate, as well as of the household financial accelerator. Moreover, the models discussed in this paper offer new ways of interpreting data on credit, money and asset prices, which are crucial for central banks.

JEL Codes: B22, E21, E44, E51, G11.

Key Words: Finance and the real economy, financial crisis, consumption, credit constraints, household portfolios.

Non-technical summary

After the global financial crisis, there is general awareness, see the report on the first two years of the macro-prudential research network, ECB (2012), of how standard macroeconomics as practiced up to 2008 had failed to understand the interactions between the financial sector and the real economy and so failed to grasp the potential for financial instability. Data from the financial flow of funds, neglected previously, are now seen as crucial to the data monitoring carried out by central banks. This paper revisits earlier efforts to understand financial-real linkages, such as those of the Yale tradition, as the back-ground to new approaches to model linkages between the flow of funds and the real economy. These new approaches throw fresh light on how to interpret data on money and credit.

Tobin and Brainard (1963) had anticipated the bank lending channel of monetary transmission as later highlighted by Bernanke and Blinder (1988) and Bernanke and Gertler (1995). Brainard and Tobin's 1968 stylised paper on pitfalls in financial modeling included three sectors (governments, private sector and banks), a set of seven financial assets and focused on investment (rather than consumption) as the key interaction between the financial sector and the real economy. In the 1970s, the Yale school introduced consumption with a systems approach to household flow-of-funds analysis, see Backus and Purvis (1980).

However, in the 1970s and part of the 1980s, monetarism, by focusing on the link between the money supply and inflation, offered a simpler, deceptively elegant view which crowded out the more complex portfolio balance view. The latter required a more structural approach, as it entailed modeling portfolio choices across a wider range of assets relevant for savings behaviour and real-financial linkages. The more recent fad of real business cycle theory, including its New-Keynesian DSGE incarnations, eclipsed any substantive role for money and credit and essentially assumed a 'passive' financial sector.

The financial accelerator was introduced into this DSGE framework by Bernanke *et al*. (1999). However, the financial friction in this model has a simple one-period form and applies only to firms through costly monitoring carried out by banks. Roles for households, housing and mortgage markets, as well as feedbacks via the asset base and potential solvency of the banking sector are missing. Iacoviello (2005) introduced housing and a new financial friction, a maximum loan to value ratio at which patient households are willing to lend to impatient households. However, the model lacks a banking sector, mortgage default, the possibility of house prices overshooting as well as positive aggregate housing equity withdrawal. It therefore cannot capture the US subprime trigger of the global financial crisis.

The financial accelerator then operating had four major linkages. The first was via the collapse of construction. In the second, consumption fell as collateral values dropped and credit contracted. In the third channel, a negative feedback loops operated through the banking sector as rising bad loan books and risks of bank insolvencies, amplified by a liquidity crisis, led to a sharp credit contraction. Fourthly, rising risk spreads in credit markets also contributed to the credit contraction. The induced decline in economic activity fed back negatively on home values, amplifying the initial shocks.

As consumption accounts for around 70 per cent of US GDP, the household channel played a central role in the crisis. To understand it, a credit-augmented life-cycle consumption function is discussed, generalising the work of Ando and Modigliani (1963), Friedman (1957, 1963) and Tobin and Dolde

(1971). The combination of wealth and credit effects, in conjunction with accounting for how financial innovation has shifted key financial-real linkages, is necessary to understand the behaviour of consumption. Consumption is explained by household income, portfolios of assets and debt held at the end of the previous period, credit availability, and asset prices and interest rates.

In a general equilibrium setting, these all have to be endogenised. Since households make consumption and housing purchase decisions jointly with portfolio decisions, there is much to be gained in modeling a household sub-system of equations for such data as was the intent of Backus and Purvis (1980), but incorporating the evolving credit architecture facing households. The credit channel is incorporated via variations in constraints on down-payments and on home equity withdrawal. As an implication of the model, the impact of rising house prices on consumption is likely to be negative in countries with less active mortgage markets and without home equity loans (e.g. Italy) where saving would have to increase to satisfy the down-payment constraint. The opposite holds for countries like the U.S., the U.K. or Australia, where easy availability of home equity loans made housing into a more liquid asset and higher housing collateral values boosted spending.

The demand for housing as a stock is jointly determined with non-housing consumption. Given the existing stock of the previous period, this can then be used to derive an equation for house prices as an inverted demand equation, taken as part of the equation system for the household sector. Since shifts in the ability of home-owners to borrow against accumulated housing equity are not observable directly, a latent variable represents such shifts. This has consequences throughout the equation system and potentially enters both as an intercept shift and in interaction with key variables such as housing wealth hence the acronym 'latent interactive variable equation system' (LIVES).

The outcome of such a modeling effort is illustrated with some of the authors' recent work on the US which well explains booms and busts in consumption, mortgage refinancing, housing equity withdrawal and in house prices, as well as long-run changes in the household saving rate. Clear evidence of the dramatic consequences of the shifts in US financial architecture imply that constant, linear SVARs and DSGE models which fail to incorporate such shifts will yield non-robust findings and cannot be 'structural' in the sense of the Cowles Foundation definition. Evidence for other countries of consumption functions with a similar structure and similar parameter estimates suggests that the credit augmented consumption function discussed in this paper is closer to being 'structural'.

Strategic aggregation of household flow of funds data should make possible tractable macro-econometric models that better incorporate real and financial sector linkages, useful for assessing financial stability. This addresses earlier criticism of the Tobin-Brainard approach as being too unwieldy for policy making purposes, which was part of the monetarist appeal of focusing on one type of liquid asset, money. In this sense, a tractable, Tobin-type portfolio approach toward modeling the household sector restores broad money to its proper, but not dominant place along with debt, stock market and housing wealth.

Links with other subsector models in a tractable general equilibrium framework should focus on modeling strategic sectors, rather than attempting to model the entire flow of funds matrix. Because such frameworks are more comprehensive than standard models, they offer the possibility of synthesizing key insights from Tobin's portfolio balance approach with asymmetric information (Stiglitz and Weiss, 1981), the investment financial accelerator (Bernanke *et al*., 1999), the household financial accelerator and instabilities arising from systemic risks (Adrian and Shin, 2010).

1. Introduction

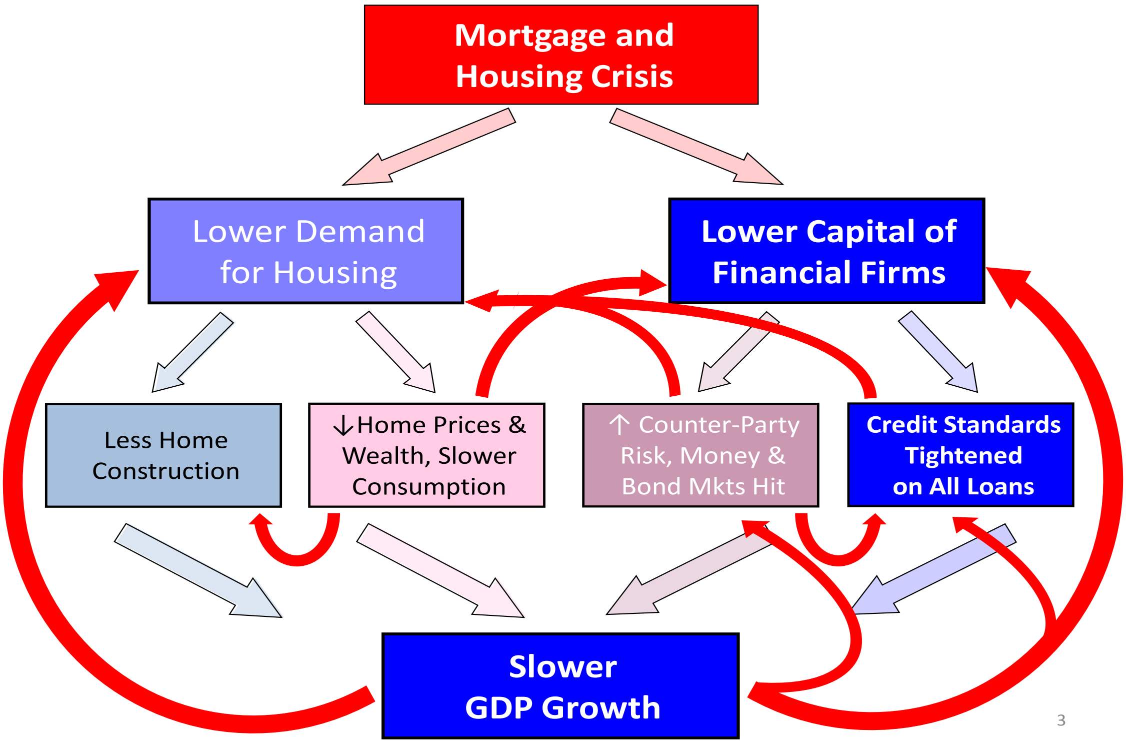
After the global financial crisis there is now general awareness, particularly at central banks, of how standard macroeconomics as practiced up to 2008 failed to understand the interactions between the financial sector and the real economy and so failed to grasp the potential for financial instability. Data from the financial flow of funds, previously relatively neglected, are now seen as crucial to the data monitoring carried out by central banks. This paper revisits earlier efforts to understand financial-real linkages, such as those of the Yale tradition. Early work by Tobin and Brainard (1963) had anticipated the bank lending channel of monetary transmission as later highlighted by Bernanke and Blinder (1988) and Bernanke and Gertler (1995). Brainard and Tobin's 1968 stylised paper on pitfalls in financial modeling included three sectors (governments, private sector and banks), a set of seven financial assets and focused on investment (rather than consumption) as the key interaction between the financial sector and the real economy. In the late 1970s, the Yale school brought households and therefore consumption into the frame with a complete systems approach to household flow-of-funds analysis, see for example the important paper by Backus and Purvis (1980).

However, in the 1970s and throughout much of the 1980s, monetarism, by focusing on the link between the money supply and inflation, offered a simpler and deceptively elegant view which crowded out the more complex portfolio balance view of Tobin, Brainard, Backus and Purvis. The former view had the simplicity of a reduced-form approach, while the latter required a more structural approach, as it entailed modeling portfolio choices across a wider range of assets relevant for savings behaviour and real-financial linkages. The subsequent fad of real business cycle theory, including its New-Keynesian incarnations in 'micro-founded' DSGE, eclipsed any substantive role for money and credit and essentially assumed a 'passive' financial sector.

The financial accelerator was introduced into this DSGE framework by Bernanke *et al.* (1999). However, the financial friction on which this model is based has a simple one-period form and applies only to firms through costly monitoring carried out by banks. Roles for households, housing and mortgage markets, as well as feedbacks via the asset base and potential solvency of the banking sector were missing in this initial version of the financial accelerator. Iacoviello (2005) introduced housing and a new financial friction, a maximum loan to value ratio at which patient households are willing to lend to impatient households. However, the model lacks a banking sector, mortgage default, the possibility of house prices overshooting as well as of housing equity withdrawal being positive in aggregate. It therefore cannot capture the US subprime crisis which triggered the global financial crisis.

Figure 1 below presents some of the mechanisms and feedbacks which operated in this crisis. From left to right, it illustrates the linkages via construction, whose collapse amounted to about three percentage points of GDP cumulated over three years (see Duca, Muellbauer, and Murphy, 2010), and secondly, via consumption, as collateral values dropped and credit contracted. The third and fourth channels track the negative feedback loops via credit markets and the banking sector more generally, through credit contraction triggered by rising bad loan books, risks of bank insolvencies and risk spreads. In turn, the decline in economic activity feeds back negatively on home values, amplifying the initial shocks.

Figure 1 The financial accelerator operating in the US subprime crisis



As consumption accounts for around 70 per cent of US GDP, this second channel played a central role in the crisis. Indeed, in the Great Recession, the saving rate rose by four percentage points, as consumption fell four per cent more than income, in sharp contrast to a relatively flat saving rate in prior U.S. recessions. Consumption also plays a key role in economic upswings of the business cycle, where negative feedbacks become positive feedbacks. As noted in our related paper (Duca, Muellbauer, and Murphy, 2012b), the post-2009 recovery in US consumption has been uncharacteristically weak. This unusual behaviour can be accounted for in a credit-augmented life-cycle consumption function, generalising the work of Ando and Modigliani (1963), Friedman (1957, 1963) and Tobin and Dolde (1971). The combination of wealth and credit effects, in conjunction with accounting for how financial innovation has shifted key financial-real linkages, is necessary to understand the behaviour of consumption.

Such a consumption function conditions consumption on household income, portfolios of assets and debt held at the end of the previous period, credit availability, and asset prices and interest rates. In a general equilibrium setting, these all have to be endogenised. However, since households make consumption and housing purchase decisions jointly with portfolio decisions, there is much to be gained in modeling a household sub-system of equations for such data as was the intent of Backus and Purvis (1980). Doing so seriously means facing the challenge of handling major evolutionary structural change in econometric modeling – namely the evolving credit architecture facing households. A by-product of this is improving our understanding of the secular decline in the US saving rate. Moreover, the models discussed below offer new ways of interpreting data on credit, money and asset prices, which are crucial for central banks.

The chapter is structured as follows. Section 2 discusses the contribution of the Yale school to understanding financial-real economy linkages and the role of money. It suggests some additional pitfalls in financial modeling, particularly dealing with financial innovation and consequences of deregulation, as well as with expectations, in addition to those highlighted by Tobin and Brainard. Section 3 discusses key changes in the US credit market architecture.

Section 4 summarises the background and motivation for our credit-augmented life-cycle consumption function. A key element is the introduction of shifts in credit availability in both unsecured household credit and in mortgage credit and the consequent induced behavioural shifts. The credit channel is incorporated via variations in down-payment constraints and home equity withdrawal. As an implication of the model the impact of rising house prices on consumption is likely to be negative in countries with less active mortgage markets (as in Italy and other continental European housing finance systems) where saving would have to increase to satisfy the down-payment constraint. The opposite holds for countries like the United States, the United Kingdom or Australia, where easy availability of home equity loans made housing into a more liquid asset and higher housing collateral values boosted spending.

Section 5 introduces this consumption function into a larger system which endogenises key portfolio choices made by households such as changes in mortgage debt, mortgage refinancing, housing equity withdrawal or its counterpart, given changes in the mortgage stock, the acquisition of residential housing. The demand for housing as a stock is jointly determined with non-housing consumption. Given the existing stock of the previous period, this can then be used to derive an equation for house prices as an inverted demand equation, which can be incorporated as part of the equation system. Since shifts in the ability of home-owners to borrow against accumulated housing equity are not observable directly, we introduce a latent variable to represent such shifts. This has consequences throughout the equation system and potentially enters both as an intercept shift and in interaction with key variables such as housing wealth. This is why the acronym ‘latent interactive variable equation system’ (LIVES) describes such an equation system.

To illustrate the outcome of such a modeling effort, we summarise some of our recent work on the US which well explains booms and busts in consumption, mortgage refinancing, housing equity withdrawal and in house prices, as well as long-run changes in the household saving rate. Section 7 concludes and discusses how the Flow of Funds Accounts can be strategically integrated into tractable macro-econometric models that better incorporate real and financial sector linkages and are useful for assessing financial stability.

2. The Yale school and the flow of funds

To analyse interactions between the financial system and the real economy Brainard and Tobin proposed a system-wide general equilibrium approach. In their famous 1968 paper on ’pitfalls in financial model building’ they set out, for a closed economy, the sectoral balance sheets and propose a stylised system of equations for modeling them. In their framework there are three sectors: government, commercial banks, and the private sector, and seven endogenous assets. The private sector holds demand deposits, time deposits, treasury bonds, loans and equities. One equation is specified for each asset, as a function of four interest rates, current income and total wealth. Banks hold net free reserves, loans and treasury bonds, each holding a function of demand and time deposits and interest rates. It is assumed that the short-run dynamics of asset holdings are governed by partial adjustment.

Some interest rates are market determined, others, policy variables. Tobin’s q is part of the model providing a role for equity yields. The key interaction between the financial sector and the real economy in Brainard and Tobin’s stylised model occurs via business investment. Consumption implicitly is just a function of after-tax income. Thus, the yield on equities is a key component of the vector of four endogenous interest rates. The equity yield, or the stock market price, depends on the economy’s portfolio composition, policy instruments, productivity shocks and so on in a reduced form relationship with (presumably) quite complex dynamics.

Brainard and Tobin emphasise the accounting consistency for the holdings by banks with the private sector, given overall balance sheet constraints. They argue that the main pitfall in financial modeling at the time was the widespread failure to impose explicitly the financial identities in model building, so missing the complex interdependencies of the whole system. Tobin (1969) contrasts somewhat more 'monetarist' special cases, with money and equities as the only assets, with a multiple asset model. In the real world, where capital is heterogeneous, and asset demands depend on expectations, attitudes to risk and estimates of risk, Tobin concludes: "there is no reason to think that the impact (of monetary policies or other financial events) will be captured in any single exogenous or intermediate variables, whether it is a monetary stock or a market interest rate".

In Tobin (1981), he expands on this theme in assessing the monetarist counter-revolution, and also the then new classical economics. Solow (1983) elegantly summarized the Tobin view as follows:

> "in a world with a complex set of portfolio preferences, financial institutions, and paper assets (some with fixed and some with market-determined yields), monetary theory and monetary policy are not well represented by a model in which an undifferentiated "M" is exogenously varied by means of helicopter drops, and idealized helicopter drops at that. Instead, money supplies actually change in the course of transactions between the Treasury and the public, or between banks and the non-bank public, in which at least one other asset besides money must change hands.….in such a world, with consumers having finite lifetimes and finite horizons, and inter-temporal markets less than perfectly transparent, financial policies will have real effects in as long a run as actually matters."

The effects of quantity constraints had long been on Tobin's mind. In earlier work, Tobin and Brainard (1963) had discussed the effects of interest rate ceilings and reserve requirements on the bank lending or credit channel of monetary transmission, in some ways anticipating Bernanke and Blinder (1988) and Bernanke and Gertler (1989). Interestingly, credit constraints were central to Tobin's return to integrating consumption behaviour into his multi-sector view of the economy. In the same year as Modigliani (1971) had emphasized the importance of wealth effects on consumption for monetary transmission, Tobin and Dolde (1971) analysed monetary transmission and wealth effects on consumption when some households either cannot borrow or face an external finance premium (interest rates on loans exceed those on assets). However, there is still no housing market or mortgage debt in this model. Their micro-simulation model, with much heterogeneity, implied that a single wealth budget constraint in estimated systems of household behaviour (for example, Saito, 1977; Blake, 2004), was inappropriate.

Building on the work of Tobin and his co-authors, Backus and Purvis (1980) integrated consumer expenditure with portfolio decisions. They analysed quarterly US household Flow of Funds data in a complete systems approach with partial adjustment of asset stocks to long-run equilibrium levels, but did not make the mistake of assuming a single wealth budget constraint. One of their key points, a highlight of Purvis (1978), is that disaggregated assets, not just net worth, are needed to model consumption and this is strongly supported by their empirical evidence. Although some of their empirical findings look anomalous[1], there are hints of interesting findings. For example, estimated marginal propensities to consume (m.p.c.'s) out of liquid assets and (minus) consumer credit are far larger than those out of stock market wealth or indeed out of housing.

While Backus and Purvis emphasise pitfalls from not taking an integrated approach to portfolio and consumption determination, three further pitfalls in financial modeling are even more serious. These arise from neglecting structural changes in the financial system, particularly associated with changes in credit availability to households, uncertainty and the treatment of expectations. The last two issues and the endogeneity of asset prices were tackled in the quite different approach of Breeden (1979) in the consumption CAPM framework, but at the cost of assuming efficient and complete asset markets (and so, for example, no credit constraints), rational expectations, and the existence of a representative consumer. This approach fits naturally with DSGE models that treat finance as a 'passive' adjunct to the real economy. However, there is a developing literature of asset pricing models with time-varying risk premia, see Campbell *et al*. (2011), which potentially might be able to capture at least some aspects of interactions between finance and the real economy.

After the early 1980s, the literature analysing Flow of Funds systems is fairly limited. Blake (2004) is a rare exception. He focuses on the system properties of the Deaton-Muellbauer 'almost ideal demand system' using a common net worth constraint (ignoring the Backus and Purvis insight), but partially accounting for credit market innovation, as measured by a debt/income proxy.

Most empirical macro studies over the past few decades, however, have tended to ignore the importance of financial architecture for macro modeling. For example, the large and predominant VAR literature on empirical links between money, credit and business cycles tends to find unstable relationships. This instability arises because these frameworks do not distinguish demand influences from the impulse and propagation effects of financial innovation on the supply of credit. Recognizing this shortcoming, the profession is now reexamining how Flow of Funds data can be incorporated into models of the macroeconomy and financial stability, partly to make sense of the severe recession associated with the housing and financial crisis.

3. Addressing vast changes in US credit market architecture since the mid-1960s

Before one can estimate the full impact of the crisis through the four channels highlighted in Figure 1, a time series framework needs to address the vast changes in US credit market architecture since the mid-1960s, otherwise estimates will be contaminated by mis-specification bias. Underlying declines in information costs, changes in regulation, and regulatory avoidance gave rise to four major shifts in household credit market structure: (1) a fourfold increase in credit card ownership rates from 15 per cent in 1970 to over 60 per cent by 1992; (2) the increased securitization of mortgages by Government Sponsored Enterprises (GSE's, mainly Fannie Mae, Freddie Mac, and Ginnie Mae) which lowered the costs and stabilized access to prime mortgages; (3) an increased ability to tap housing equity among homeowners; and (4) the boom and bust in subprime mortgages in the 2000s (Duca, Muellbauer, and Murphy, 2011, 2012a, 2012b).

As will be reviewed later, the first development spawned a decline in the precautionary need to save and an accompanying decline in the personal saving rate during the 1980s, while the second – coupled with the deregulation of deposit interest rates – primarily had the effect of eliminating Regulation Q induced disintermediation, and thereby stabilized residential construction during much of the Great Moderation period. The third development – the increased liquidity of housing wealth – mainly occurred in the late 1990s and early 2000s. It had the effect of amplifying the impact of the boom and bust in US house prices during the mid- and late 2000s, respectively, which stemmed from an unsustainable easing of credit standards for first time home-buyers, most pronounced for subprime borrowers, followed by a great retrenchment.

In this way, the shifts in household credit market architecture had ramifications for aggregate consumption and thereby the macro-economy.

The changes in household finance were spawned by a mixture of deregulation and technological advances. Improved information technology coupled with the deregulation of deposit rates allowed a large increase in the availability of consumer credit, particularly evident in a large rise in credit card ownership rates during the 1980s and early 1990s (Duca, Muellbauer, and Murphy, 2012b). During the late 1990s, falling transaction costs for refinancing mortgages, coupled with tax reform favoring mortgage over consumer debt and moderate house price appreciation, fostered a boom in mortgage equity withdrawal. Much of this was through 'cash-out' mortgage refinancings, in which households replaced higher interest rate old mortgages with new mortgages having higher principal balances. Along with the advent of home equity lines of credit encouraged by the tax reform in 1986, this set the stage for consumption to be boosted and then battered by the recent boom and bust in US house prices. Duca, Muellbauer, and Murphy (2011, 2012a) show how the bubble in US housing was driven by swings in mortgage credit standards associated with the subprime mortgage boom and bust. This type of finance surged owing to improvements in the ability to sort nonprime borrowers using credit scoring and the rise of private-label mortgage backed securities. The latter were the predominant means of funding nonprime mortgages deemed too risky to be held in portfolio by banks or to be packaged into standard mortgage-backed securities (MBS) whose investors are insured against default on underlying prime mortgages by Fannie Mae or Freddie Mac.

The funding of subprime mortgages via private-label MBS reflected the rise of structured finance in the early to mid-2000s, which stemmed from the confluence of several regulatory and financial product developments. On the surface, private-label mortgage backed securities provided protection against default risk to investors through either being packaged into CDOs and/or being enhanced with derivatives such as CDS. The demand for the former was bolstered by (1) capital inflows from foreigners who bought investment grade-rated private-label MBS, (2) increased demand from Fannie Mae and Freddie Mac under greater Congressional mandates to buy these securities to bolster homeownership rates, (3) increased demand from commercial banks owing to favorable capital requirement treatment of investment grade MBS under Basel 2, (4) increased demand from the rise of structured investment vehicles and other capital requirement avoidance vehicles, and (5) the SEC increasing the maximum leverage ratio ceilings on the brokerage units of investment banks. The increased use of derivatives like CDS owed in part to key changes in derivatives laws. As argued by Roe (2011) and Stout (2011), the Commodity Futures Modernization Act of 2000 induced a major expansion of derivatives by not only deregulating the derivatives market, but also by making derivative contracts enforceable and giving derivatives contracts prior claims on collateral enforceable before a court decided which claims to honor in the event of a business bankruptcy.

The coalescing of these factors allowed more subprime and Alt-A (another type of nonprime) mortgages to be originated in the early 2000s, which lowered the downpayment constraints and other credit standards facing first-time home-buyers. Duca, Muellbauer, and Murphy (2011, 2012b) show that the average down-payment for first-time home-buyers fell from about 12 per cent in the mid- to late 1990s to about 6 per cent at the height of the subprime boom. By increasing the share of potential first-time buyers who can qualify for a mortgage, this change increased the overall effective demand for owner-occupied housing. As stressed in an overview of the housing and financial crisis (Duca, Muellbauer, and Murphy, 2010), this can create substantial excess demand for existing homes because housing markets are thinly traded – the annual turnover rate for homes is usually 5-6 per cent versus around 100 per cent for stock traded on the NYSE. As a result, an easing of credit standards spawns increases in house prices. This, in turn, increases expected house price appreciation, which has a bubble-builder effect of lowering the real user cost of mortgage credit and thereby amplifying the initial price increases induced by easier credit standards.[2]

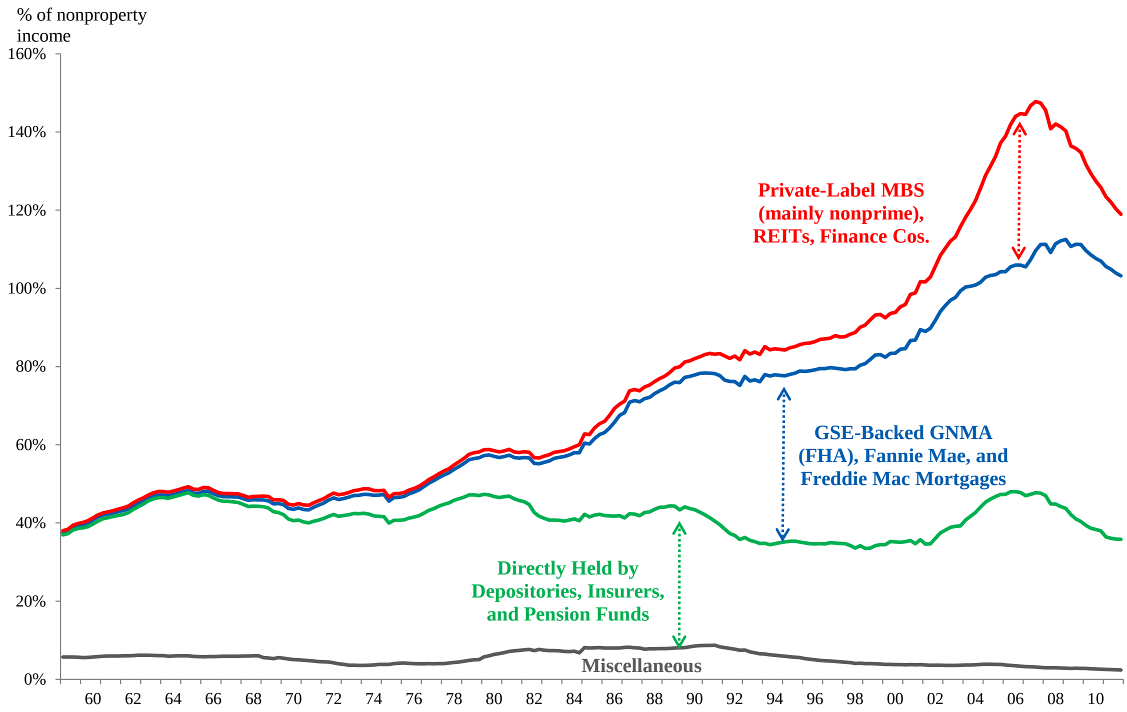
The increases in housing wealth, amplified by a higher liquidity of housing, induced greater consumer spending. The resulting increase in house prices also raised the relative price of existing to new homes (increasing Tobin's q for real estate capital), spurring a construction boom. In this way, innovations lowering the credit barriers to home purchases by potential first-time homebuyers and to mortgage equity withdrawals by established home-owners triggered the housing and consumption boom of the early to mid-2000s. The underlying innovations were, however, not sustainable.

The increases in house prices induced by the easing of mortgage credit standards initially disguised the high risks to investors of holding subprime MBSs. If a subprime borrower encountered difficulty in meeting mortgage payments, higher house prices enabled them to either sell their home and pay off the mortgage) or obtain larger mortgages against the more highly valued collateral. But when US house prices stopped rising, newer subprime borrowers were no longer bailed out by higher house prices and the subprime losses started rising.[3] Unexpected losses led investors to realize the high risk of private-label MBSs, and the subsequent lack of demand led to a collapse in nonprime originations, a tightening of mortgage credit standards and ensuing falls in housing demand and house prices (Duca, Muellbauer, and Murphy, 2010). These, in turn, triggered reversals in housing construction and consumption, the latter of which are discussed in more detail in Section 4.

Before turning to consumption, there are some important distinctions among the types of assets securitized that have relevance for assessing financial stability and the stability of housing markets. Figure 2 illustrates the salient features of the evolving structure of the US mortgage market since 1959, with the shares of home mortgage debt classified into mortgages directly held in portfolio by depositories, conventional (mainly prime) and Federal Housing Administration mortgages securitized or held directly by government sponsored enterprises (GSE's, mainly Fannie Mae, Freddie Mac, and Ginnie Mae), and mortgages either securitized into private-label MBSs or directly held by intermediaries (real estate investment trusts, REITs, and finance companies) that depend on non-government insured debt to fund their mortgage holdings. All of these holdings are scaled in Figure 2 by non-asset income of households to abstract from trends in real income growth and inflation.

The ratio of depository mortgage debt-to-income was relatively flat during the 1980s and early 1990s, when the mortgages backed by the GSE's surged. This was not accompanied by massive, nationwide mortgage problems, reflecting that the GSE's securitized prime conventional mortgages and or, in the case of Ginnie Mae, securitized FHA mortgages, had ceilings on the size of individual mortgages and their debt payment-to-income ratios. The main problems arose with the rise of private-label MBSs (and REIT/finance company held mortgages) in the 2000s because they funded nonprime mortgages, and thereby funded a weakening of credit standards that fueled the housing bubble. As Duca, Muellbauer, and Murphy (2012b) note, the rise and fall of loan-to-value ratios for first-time homebuyers was linked to the rising and then falling shares of private-label MBS securities. So the systemic risks arose not so much from securitization in general, but rather from a particular type of funding which was used to fund high risk mortgages.[4] The latter's rise was associated with an unsustainable easing of mortgage credit standards, which ended and reversed abruptly when the non-government insured funding sources for this type of credit dried up when the default risk on underlying nonprime mortgages rose and the liquidity risk of the private label MBSs soared. The resulting reversals in effective housing demand and house prices hurt not only construction, but also consumer spending.

Figure 2 The evolving funding of US home mortgages



Sources: Flow of Funds, Bureau of Economic Analysis, and authors' calculations.

4. A credit- and financial innovation-augmented consumption framework

These implications of shifting financial architecture for portfolio, financial frictions, and financial innovation effects on consumption can be analyzed in a life-cycle consumption function that is augmented for credit constraints and disaggregated wealth effects that can vary over time depending on financial innovations. Recall that the basic rational expectations, permanent income hypothesis (REPIH) model implies that real per capita consumption c depends on expected real per capita permanent (non-property) income (y^p) and net wealth (A):

$$c_t = \varphi A_{t-1} + \omega y_t^p \tag{4.1}$$

Using the approximation $(y^p\text{-}y) / y \approx \ln (y^p/y)$ and some algebra yields the following log-linearisation:

$$\ln c_t = \alpha_0 + \ln y_t + \gamma A_{t-1}/y_t + \ln (y_t^p/y_t)$$
(4.2)

where $\gamma=\phi/\omega$ and $\alpha_0 = \ln \omega$. Permanent income can be measured by a discount-weighted moving average of forward expected income. If we also allow for the effects of the real interest rate r, and a measure of income uncertainty θ, the REPIH model becomes:

$$\ln c_t = \alpha_0 + \ln y_t + \alpha_1 r_t + \alpha_2 \theta_t + \alpha_3 (\ln y^p_t - \ln y_t) + \gamma A_{t-1}/y_t + \varepsilon_t \tag{4.3}$$

Unlike Euler equations originally stressed by Hall (1978), this solved-out, long-run consumption function does not throw away long-run information on income and assets, whose recent importance has partly induced Hall (2011) to reconsider long-run wealth effects in his recent analysis of US consumption.

Equation (4.3) embodies three critical, overly restrictive assumptions. First, it implicitly assumes that credit constraints do not exist or if they do, that they are constant over time and thus empirically can be captured by a time-invariant estimated constant. Second, it assumes that all components of net wealth have about the same impact on consumer spending. This ignores evidence that the marginal propensity to consume out of gross liquid assets minus debt differs from that out of illiquid, non-housing assets, and for two good reasons. Illiquid assets are primarily hard to access pension wealth and directly held stock wealth, the latter of which is highly concentrated among the very rich for whom the m.p.c. out of illiquid assets is likely to be low, reflecting the concavity of consumption in wealth (Carroll and Kimball, 1996). In addition, 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). Another important consideration is that housing wealth effects need not have the same-sized m.p.c. as the other two wealth components since housing is both a consumption good as well as a store of value, see Aron *et al*. (2012). The third overly restrictive, major assumption of the basic REPIH model is that key parameters – particularly on wealth components – are constant over time. In doing so, it implicitly assumes that financial innovations, particularly regarding down-payment constraints and the liquidity of housing wealth, have not altered consumption or its relationship with housing wealth.

The first two sorts of shortcomings can be addressed with two direct modifications. First, to handle changes in the availability of consumer credit which largely act as a shifting constant, the intercept term is allowed to vary with a measure of consumer credit conditions, see below. Second, 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 (*HA/y*). Thirdly, several other parameters, particularly the m.p.c. out of housing wealth, can be allowed to vary over time. These changes yield a credit-augmented, Friedman-Ando-Modigliani consumption function, which can be estimated using the following model, a special case of an equilibrium correction model:

$$\Delta \ln c_t = \lambda\{\alpha_{0t} + \alpha_{1t} r_t + \alpha_2 \theta_t + \alpha_{3t} \ln (y^p_t / y_t) + \gamma_1 NLA_{t-1}/y_t + \gamma_2 IFA_{t-1}/y_t$$

$$+ \gamma_{3t} HA_{t-1}/y_t + (\ln y_t - \ln c_{t-1})\} + \beta_1 \Delta \ln y_t + \beta_2 \Delta nr_t + \beta_3 \Delta ur_t + \varepsilon_t \qquad (4.4)$$

where the term in brackets is equilibrium minus actual consumption, λ is the speed of adjustment toward long-run equilibrium, γ's are the m.p.c.'s of wealth components, and short-run terms are included for changes in current income ($\Delta \ln y$), nominal consumer loan interest rates (Δnr), and the unemployment rate (Δur). Four parameters have been given time-subscripts to reflect relaxation in credit conditions: the intercept term $\alpha_{0t,}$ (because of a reduced precautionary motive and a reduced impact of down-payment constraints), the real interest rate coefficient α_{1t} (because of potentially greater ability to engage in intertemporal substitution), the coefficient on expected income growth α_{3t} (because future income should matter more when borrowing is easier), and the m.p.c. out of housing wealth γ_{3t} (because of increased access to home equity loans). Equation (4.4) reduces to a basic REPIH variant assuming that wealth should not be disaggregated ($\gamma_1 = \gamma_2 = \gamma_3 = \gamma$), that none of the parameters vary over time and excluding the short-run terms. These restrictions are easily rejected in Aron *et al*. (2012) and Duca, Muellbauer and Murphy (2012a) which find, for the US that the intercept term and the m.p.c. out of housing wealth shifted dramatically. The latter reflects the fact that mortgage equity withdrawals have become more sensitive to house price appreciation (Duca, Muellbauer, and Murphy, 2010) and that US consumption has become more sensitive to housing wealth (for example, Carroll *et al*., 2011, Slacalek 2009, and Duca, Muellbauer, and Murphy, 2012a).

Assuming that the m.p.c. of housing wealth is constant and positive also ignores some important and often overlooked aspects of aggregate 'housing wealth' effects. In a complete, perfect markets world, gross housing wealth does not have a positive effect – and may even have a negative effect – on non-housing consumption, because a higher relative price of housing implies a higher relative cost of imputed housing services (rent) which effectively reduces the real amount of income available for non-housing expenditure, see Muellbauer (2007). However, in a world where some homeowners may otherwise face consumer credit constraints, the ability to borrow against housing may result in a positive observed m.p.c. of gross housing wealth for aggregate consumption. This 'collateral' view of housing is consistent with mounting micro evidence that consumption is much more sensitive to housing wealth among families who would likely be credit constrained absent borrowing against their housing equity (Browning *et al*., 2008; Disney and Gathergood, 2011; Hurst and Stafford, 2004; and Mian and Sufi, 2011a, b). And there are plausible reasons why the collateral role has changed over time, being enhanced by innovations such as the advent of home equity lines of credit following tax preferences given to mortgage over consumer credit in the Tax Reform Act of 1986 (Maki, 2001) and by the advent of home equity withdrawals via 'cash-out' mortgage refinancings during the late 1990s and early 2000s (Canner *et al*., 2002) that followed or accompanied declines in the costs of refinancing mortgages (Bennett *et al*., 2001).

5. A latent interactive variable equation system for consumption and household portfolios

As noted in the introduction, incorporating a Friedman-Ando-Modigliani style consumption function (such as eq. 4.4) in a general equilibrium setting necessarily implies endogenising portfolio flows and asset prices. An important step towards developing a full macroeconometric model is to model the subsystem of equations concerned with household expenditure and portfolio decisions. As noted in Section 4, at a minimum, wealth needs to be disaggregated into liquid assets minus debt, illiquid financial assets and housing wealth to coherently model consumption. Figures 3 and 4 display ratios relative to income of the major underlying balance sheet components from the Federal Reserve's Flow of Funds release. Figure 3 shows gross liquid assets (currency, deposits, money market funds…), unsecured consumer loans and mortgage debt. Only during the height of the recent credit boom did debt exceed liquid assets in the aggregate. Figure 4 shows corresponding ratios for non-pension and pension forms of illiquid financial assets and for housing owned by the household sector. The increase in the ratio of pension assets after the 1983 introduction of 401k plans is noticeable, as, of course, are the booms and busts in stock prices as well as the recent one in housing prices.

In addition to the coherence stemming from the common decision structure, modeling the flows behind these balance sheets jointly with consumption has a great advantage in that hard to measure common factors can be absorbed in common latent variables appearing in all or most of the subsystem equations. We have highlighted the importance of shifts in credit conditions. In the US, the Federal Reserve's Senior Loan Officer (SLO) Opinion Survey has tracked credit conditions for unsecured consumer credit from banks since 1966 and for bank mortgages since 1990. Muellbauer (2007), Aron *et al*. (2012) and Duca, Muellbauer, and Murphy (2012a) construct a levels index of unsecured consumer credit conditions from the SLO's diffusion index. The diffusion index tracks changes in banks' willingness to make consumer installment loans since 1966, which is negatively correlated (-0.9) with overlapping data tracking net increases in bank consumer credit standards based on survey questions since the mid-1990s. The estimated effects of changes in real interest rates, the macroeconomic outlook (using the index of leading economic indicators), and consumer loan quality are netted out from the diffusion index, before it is converted into a levels index (*CCI*). Movements in *CCI* in Figure 5 are highly and positively correlated with intermittent estimates of the rising share of households having credit cards following deposit deregulation and the rise of credit scoring, with *CCI* falling during credit crunches, following the Basel 1 Accord, and during the recent crisis.

Figure 3 The components of net liquid assets as ratios to income

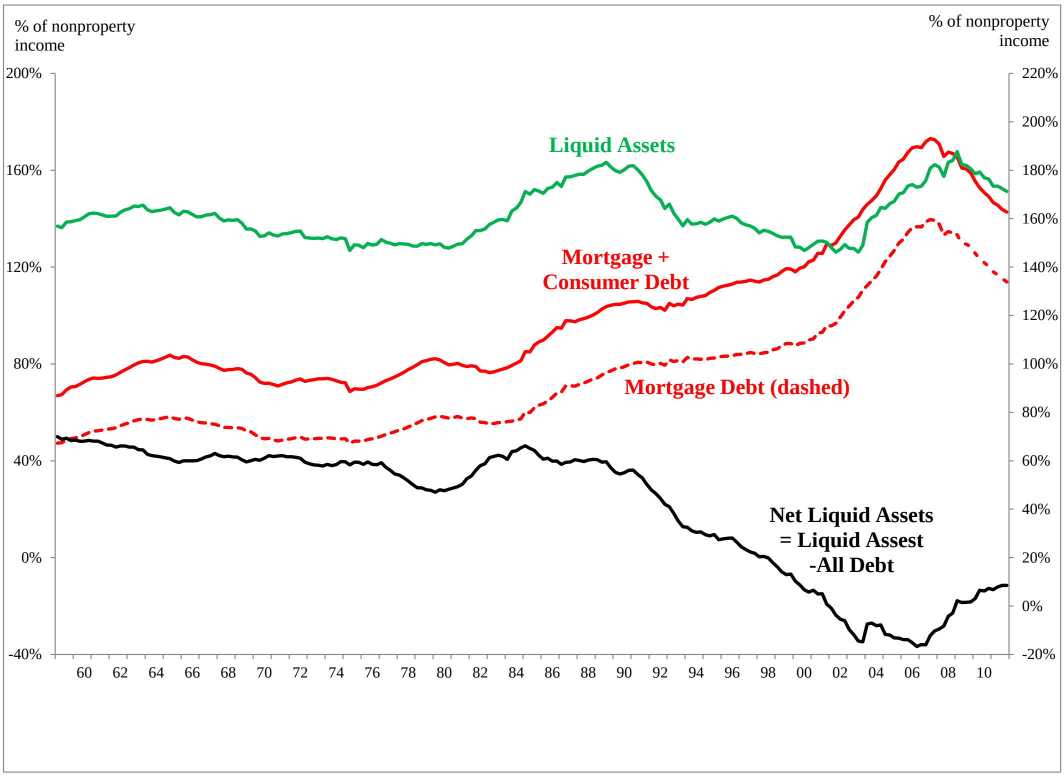


Figure 4 Housing and illiquid financial assets as ratios to income

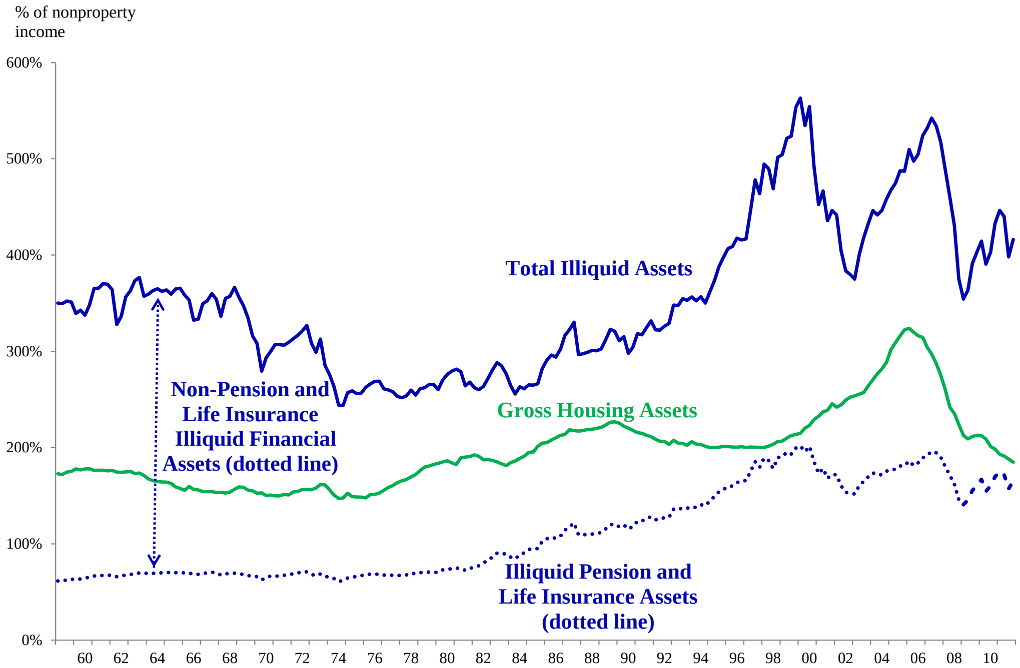
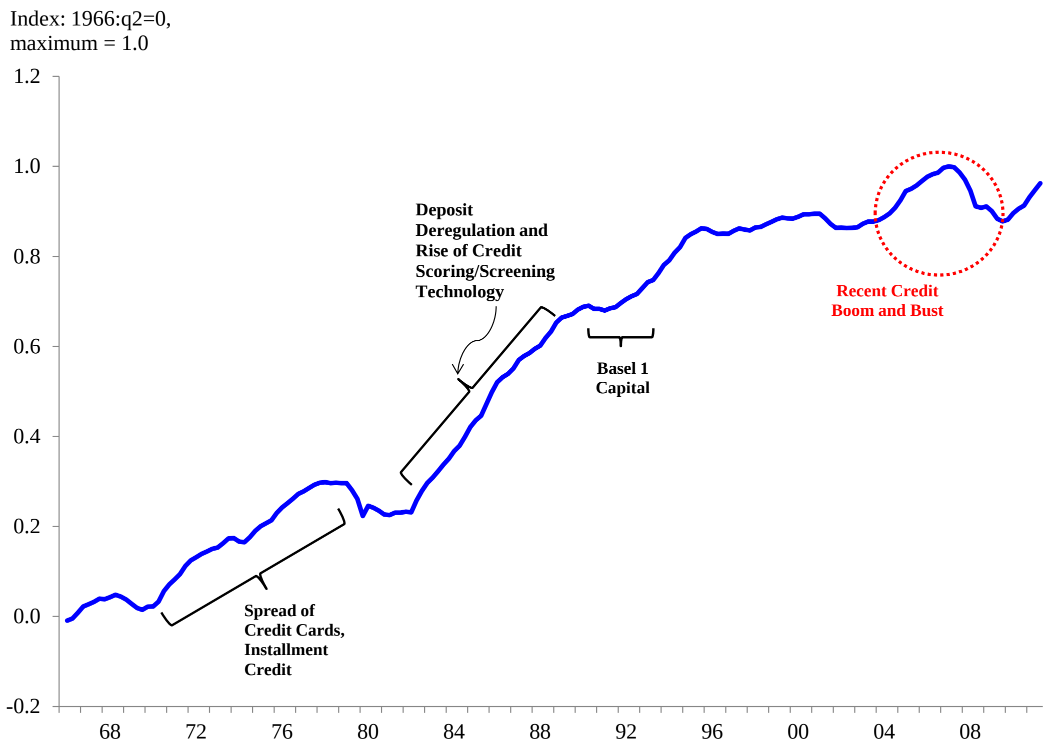


Figure 5 Consumer Credit Conditions Index



Unfortunately, the corresponding diffusion index for bank mortgage loans only begins in 1990Q3 and breaks in 2007, when prime, subprime and non-traditional begin to be distinguished. It suggests a major decline in availability of bank mortgage credit in 1990Q4 to 1991Q2, and major declines in availability of subprime credit from 2007Q1 and in prime credit from 2007Q4. Private label securitisations of mortgages, discussed in Section 3, will be not be reflected in the index which therefore is liable to understate the rise in mortgage credit availability leading up to the credit crunch beginning in 2007. Instead, we use a latent variable intended to capture the varying spendability of housing wealth linked to changing access to home equity and changing refinancing costs. This housing liquidity index (HLI) is jointly estimated in a system containing the consumption function in eq. (4.4).

In a two-equation variant of the system, Duca, Muellbauer, and Murphy (2012a) use the Kalman filter to extract HLI as a stochastic trend in a state space model for consumption and the mortgage refinancing rate. The refinancing share *Refi* is the per cent share of GSE securitized mortgages refinanced in one quarter, which peaked at 6 per cent at its 2003Q3 peak, when rates on new mortgages hit a record low relative to the average rate on outstanding fixed rate loans.

The specification of the refinancing equation takes the basic form with intercept and interaction effects:

$$Refi_t = \beta_1 Refi_{t-1} + \beta_2 F(X_t) + \beta_3 HLI_t + \beta_4 HLI_t\, F(X_t) + \varepsilon_t \quad , \qquad (5.1)$$

where *HLI* is the common factor and F(*X*) contains a constant and economic factors affecting the incentives to refinance.

The consumption equation is given by eq. (4.4) above where the time-varying intercept is defined by $\alpha_{0t} = \alpha_0 + \alpha_{01}CCI_{t-1}$ and the time varying m.p.c. out of housing wealth by $\gamma_{3t} = \gamma_3 HLI_t$. Broadly similar results are obtained using a smooth spline function in place of the filtered stochastic trend. In different variants of the system, we have added equations for the mortgage stock, housing equity withdrawal and house prices, using an inverted demand function approach. House prices are the asset price which is the most endogenous to the behaviour of households, which is a good reason for including it in the household equation subsystem. The housing liquidity index HLI enters relevant equations potentially both through an intercept effect and interaction effects, for example to capture the shifting role of housing collateral in the mortgage stock and equity withdrawal equations. To complete the system, we need equations for liquid assets (close to household broad money holdings), unsecured consumer debt, and the acquisition of illiquid financial assets.

The long-run part of the consumption equation corresponding to equation (4.4) estimated on quarterly US data for 1971Q4 to 2011Q1 from a four-equation variant[5] of the system is as follows:

$$\begin{aligned}
\log(c_t / y_t) \approx\ & \underset{(6.2)}{0.131} + \underset{(7.7)}{0.089CCI_{t-1}} - \underset{(-6.4)}{0.0047r_t} + (\underset{(6.7)}{0.49} + \underset{(1.3)}{0.35HLI_t})E_t \log(y^p / y)_t \\
& + \underset{(7.6)}{0.101NLA_{t-1} / y_t} + \underset{(8.6)}{0.017IFA_{t-1} / y_t} + \underset{(5.4)}{0.055(HLI_{t-1})HA_{t-1} / y_t} \\
& (t - ratios)
\end{aligned} \qquad (5.2)$$

In this variant and as shown in Figure 6, *HLI* is given by a smooth spline plus the change in the scaled 10-year US treasury minus Aaa-rated corporate bond yield spread as an indicator of a general risk premium.

Note that there is also a modest (and not very significant) interaction effect in equation (5.2) with *HLI* multiplying the log ratio of permanent to current income, suggesting a somewhat larger role for income growth expectations as home equity finance becomes more easily accessible.[6] While consumption in this equation is conditional on end of previous period portfolios, asset prices and current income, many useful insights into both long run trends and short to medium term policy issues can be obtained from a graphical decomposition of the long run solution for the log ratio of consumption to non-property income.

It is worth noting that equation (5.2) has attractive co-integration properties. There are six I(1) variables in equation (5.2). These are:

$\log(c_t / y_t)$, CCI_t, NLA_t / y_t, IFA_t / y_t , $(HLI_t)HA_t / y_t$ and $E_t \log(y^p / y)_t$.

A Johansen co-integration analysis yields just one co-integrated vector. The adjustment coefficient for log *c/y* is highly significant while those for *NLA/y, IFA/y,* and *(HLI)(HA/y)* are not. This confirms the validity of the consumption function interpretation.[7]

Figure 6 The time varying m.p.c. out of housing wealth, proportional to HLI

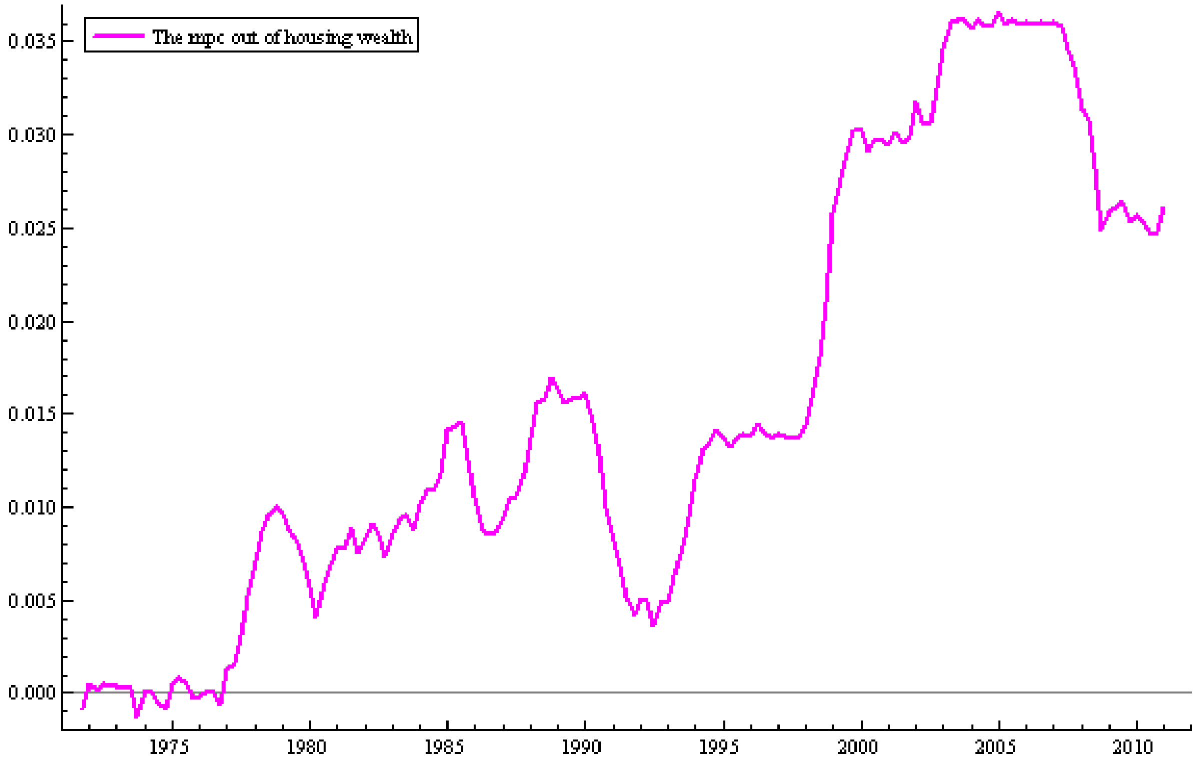
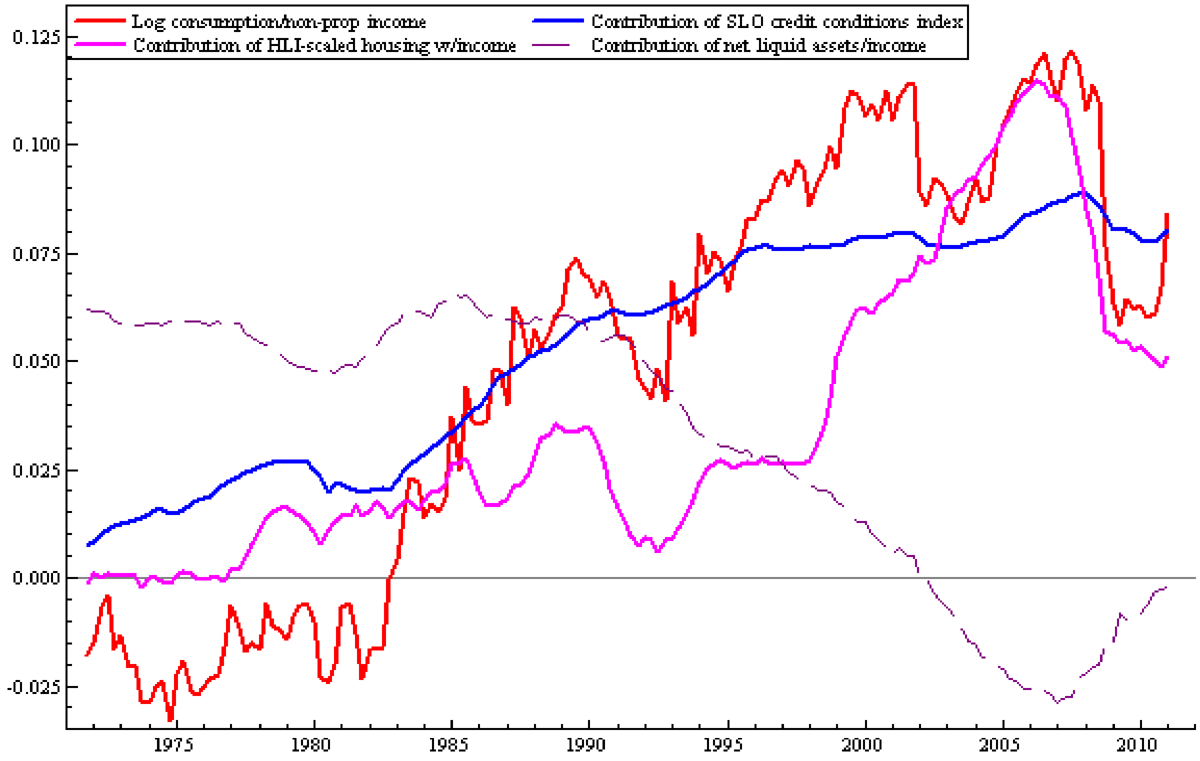


Figure 7 shows the main contributions of credit related variables to long- and short-run fluctuations in the consumption-to-income ratio. The liquidity-weighted housing wealth effect accounts for much of the rise of the consumption-to-income ratio from the early 1990s to 2007 and its subsequent collapse. The longer run contribution of the CCI based on the Senior Loan Officer Survey is also evident. It is striking, however, by how much the build-up in debt, revealed in the decline in the net liquid asset to income ratio, depresses the consumption-to-income ratio. One might call this the 'pay-back effect' of credit market liberalization. At first, consumption rose in the mid-2000s as the positive effects of increases in *CCI and HLI* on consumption in conjunction with the interactive positive effects of increases in house prices from an easing of mortgage credit standards for buying homes initially outweighed the damping effect of higher debt. Later, when *CCI* or *HLI* had stopped rising or fell, the negative effects of higher debt on consumption predominated. This is important empirical evidence for the vulnerability of households to high debt levels: while asset prices and access to new credit are subject to sudden declines, it is hard to pay back debt in the short run.

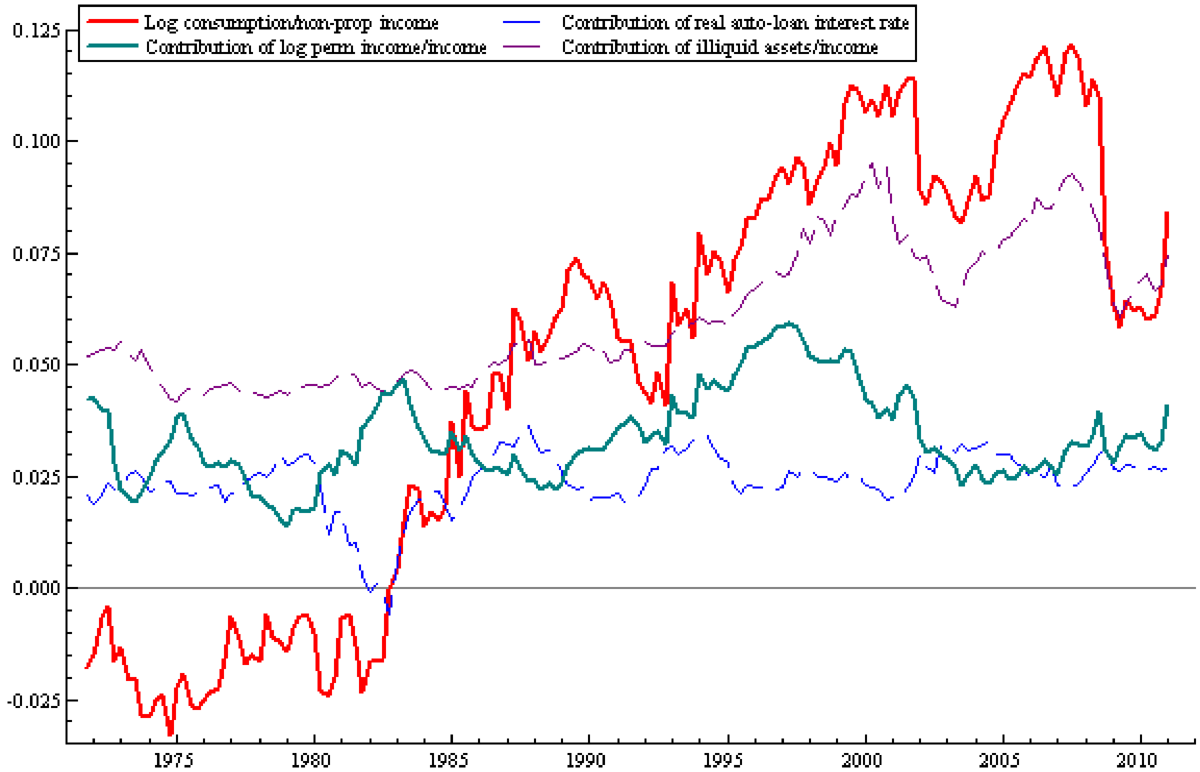
Figure 7 Estimated contributions of CCI, housing wealth and net liquid assets to the consumption/income ratio



Nevertheless, since the trough in 2007, household deleveraging, a mix of reduced borrowing, increased paying back of debt and defaults, see Brown *et al.* (2011) and Dynan (2012), has substantially reversed the decline in the net liquid asset-to-income ratio and recently has begun to make a contribution to a recovery in the consumption-to-income ratio, together with a small rise in CCI.

Figure 8 shows the contributions of the remaining part of the long-run determinants of the log consumption to income ratio. These include the real interest rate, showing a notable negative effect on consumption during the early 1980s, but no effect on the long-run trend.

Figure 8 Estimated contributions of real interest rates, permanent income and illiquid financial assets to income to the consumption/ income ratio



The fitted contribution of expected income growth as measured by the log ratio of permanent to current income made a sizable contribution to the rise of consumption relative to income from the late 1980s to the late 1990s but not in the 2000s.[8] Again, there is hardly any effect on the long-run trend. The ratio of illiquid financial assets to income has a more notable effect both on the trend and on the cyclical variations in the consumption to income ratio: note the long upswing to 2000, the effect of the collapse of the dotcom bubble and the subsequent recovery of the stock market in the mid-2000s, followed by the renewed decline in the global financial crisis, and the partial recovery since.

The much larger estimated m.p.c. for net liquid assets than for gross housing assets or illiquid assets highlights the importance of modeling wealth in a more disaggregated way, as Brainard and Tobin (1968), Purvis (1978) and Backus and Purvis (1980) emphasised. It is also consistent with micro-economic evidence by Gross and Souleles (2002). The low m.p.c. for stock market wealth is partly due to the other controls, including income growth expectations, and consistent with arguments by Poterba (2000). And the financial instability arising from the recent housing and financial crisis highlights the importance of identifying destabilizing developments in household finance (Aron *et al*. 2012; Duca, Muellbauer, and Murphy (2010). Such steps have the potential to help economists identify the sources of unsustainability, whether they are asset price bubbles or busts, or unsustainable levels of debt or exposures to risky assets. For example, there are differences in the pace of recovery of consumer credit (not secured by real estate) and mortgage debt in the U.S. (for example, Duca, Muellbauer, and Murphy, 2012), and interpreting the deleveraging process entails sorting out the impact of loan charge-offs from reductions in credit stemming from efforts by households to actively de-lever and the tightening of credit standards by lenders (for example, Brown *et al*., 2010, and Dynan, 2012).

The ECB's report on the first two years of the macro-prudential research network commented as follows: "Theoretical and empirical (network) research illustrates the *transmission of financial instability to the real economy* through constraints on credit supply, credit demand and the disturbing effect of the breakdown of risk-sharing on the consumption plans of households. Empirically identifying credit supply and demand effects and their relative importance remains, however, a challenge."(ECB (2012), p.6. The research discussed in the present paper meets this challenge by proposing and implementing practical methods for such empirical identification. In so doing, new understandings useful for policy are developed of how to interpret data on money and credit.

Clearly, prices of equities need to be incorporated into a larger system beyond the household sector subsystem. The composition of loan funding from the monetary and financial sector could give useful information for endogenising the measures of credit availability to households captured in CCI and HLI. For example, HLI is notably correlated with the rise and fall of the private label MBS share of the mortgage market. It is then important to add linkages back, via negative equity and other economic determinants of loan defaults, such as unemployment, to the asset base of the banking system and spreads in credit markets more generally. The ultimate aim is to have a comprehensive, yet tractable way of incorporating financial accelerator feedbacks, such as those that arose in the recent crisis, as shown earlier in Figure 1.

6. Conclusion

Our time series findings imply that modeling linkages between the financial sector and the real economy are crucial, consistent with recent cross section findings of Mian and Sufi (2011a,b). Econometric results for the US and other countries imply that shocks to intermediation and wealth can undermine macroeconomic and financial stability. Furthermore, the nature of these shocks and their magnitudes reflect the evolution of financial architecture stemming from financial innovations induced by technological advances and regulatory changes.

As a result, both conventional econometric and standard DSGE models that omit important financial linkages are inadequate for modeling and policy purposes. In addition, the interactive and nonlinear effects of financial shocks and the financial propagation of macro shocks in general imply that constant, linear VARs will yield non-robust findings, especially in a world where the financial architecture has shifted over time and sometimes rapidly in response to failed experiments, such as subprime mortgage lending.

For progress in macroeconomics, a return to the Cowles Foundation definition of a 'structural' equation or submodel is needed: this is one whose parameters are stable when there are structural shifts elsewhere in the system, for example, because a policy rule has altered. Our claim is that the consumption function illustrated in equation (5.2) is structural in this sense, particularly because it builds on responses to evolutionary changes in credit market architecture, which is key to understanding trend and cycle in US consumption in the last 40 years. Evidence for other countries of consumption functions with a similar structure and similar parameter estimates, discussed above, substantiates this claim. In recent years the fashion in macroeconomics has been to dismiss any model not built on the foundation of optimizing consumers with rational expectations operating in efficient financial markets as 'not structural'. However, it is clear that such models fail the Cowles Foundation definition of 'structural'. This is particularly clear for aggregate consumption. It has long been known that growth in aggregate consumption fails the unforecastibility test implied by the Euler equation popularized by Hall (1978); see Campbell and Mankiw (1991) and Muellbauer (2010). The representative consumer Euler equation also cannot explain the long-run rise in the ratio of consumption to GDP. This is consistent with the finding by Canova (2012) that DSGE models have difficulties empirically explaining long-run trends and short-run fluctuations from the same mechanisms, and that standard de-trending methods risk seriously distorting the conclusions from these models. The latter is also a conclusion of Fukac and Pagan (2010).

The inadequacy of many macro models to address the housing and financial crisis reflects several shortcomings in financial modeling. Some are the general equilibrium pitfalls emphasized in Brainard and Tobin's (1968) classic article: these include, in particular, that financial identities imply important spillover and interaction effects and that interest rates and asset prices are endogenous. Others reflect that underneath macrofinancial identities, agents face heterogeneous risks and uncertainty (Carroll and Kimbal1, 2007), as well as credit constraints arising from asymmetric information (for example, Stiglitz and Weiss, 1981), with financial innovations implying economically significant structural changes in the role of credit and wealth shocks (Duca, Muellbauer, and Murphy, 2012b) that give rise to non-robust relationships from estimating linear VARs. Another and rather poignant pitfall is overlooking underlying systemic risks that can give rise to 'Minsky moments' in which rapid deleveraging gives rise to asset fire sales that disrupt the real economy (Adrian and Shin, 2009 and 2010, Fisher, 1933, and Gorton and Metrick, 2012). And still another challenge stems from the partial adjustment of not only asset quantities – stressed by Brainard and Tobin (1968) – but also of some asset prices – especially house prices (Duca, Muellbauer, and Murphy, 2011 and 2012a). This implies that macro models should not implicitly drop important financial relationships as being redundant by assuming that arbitrage and the absence of frictions (heterogeneity, search, and transaction or information costs) ensure instantaneous market clearing of prices or even quantities.

Addressing all of these issues is rather daunting, but very much needed given the depth of the Great Recession arising from the recent housing and financial crisis. One starting point could be building macrofinancial models for some key sectors (such as nonfinancial corporate business as well as households) that incorporate major financial linkages and yet are tractable. This addresses some earlier criticism of the Tobin-Brainard approach as being too complex and unwieldy for policy making purposes,[9] which was part of the monetarist appeal of focusing on one type of liquid assets, namely money. In this sense, a tractable, Tobin-type portfolio approach toward modeling the household sector restores broad money to its rightful, but not overweening place along with debt, stock market wealth, and housing assets.

Once developed, such subsector models could be linked in a tractable general equilibrium framework that focuses on modeling strategic sectors, rather than attempting to model the entire Flow of Funds matrix. Because such frameworks are more comprehensive than standard models, they offer the possibility of synthesizing key insights from Tobin's portfolio balance approach with asymmetric information (Stiglitz and Weiss, 1981), the investment financial accelerator (Bernanke *et al*., 1999), the household financial accelerator (Duca, Muellbauer, and Murphy, 2012b; Mian and Sufi, 2011), and instabilities arising from systemic risks (Adrian and Shin, 2010, and Gorton and Metrick, 2012).

Notes

[1] Some of the estimated marginal propensities are far too large (see their Table 1), and are then scaled down in mixed estimation which imposes some priors (see Table 3). It is not possible to deduce, from the estimates presented, the implied propensity to consume out of permanent income, which is too crudely represented by an exponential time trend. It seems likely that this is one of the mis-specifications in the model.

[2] One reason why house price expectations appear to have a backward-looking component is that the housing market is inefficient, with tax breaks largely confined to owner-occupiers rather than a small number of investors owning many homes. High transactions costs induce serial correlation in excess returns, making it sensible to use momentum-based or backward-looking expectations.

[3] The misunderstanding of the dynamic effects of shifts in credit standards on house prices and nonprime mortgage quality partly reflects the limited historical experience with an unsustainable easing of mortgage credit standards.
[4] Although Fannie Mae and Freddie Mac failed, their failure reflected their low capital ratios (3 per cent), the spillover effects of the subprime boom and bust hurting house prices enough to damage even prime mortgages, and their purchases of private-label MBSs (they owned about ¼ of these in the mid-2000s) to meet Congressional goals of raising the homeownership rate.
[5] Five equation variants including a house price equation for a 1979-2009 sample for which we have loan-to-value data relevant for modeling house prices give very similar results. These can be extended back to 1971 treating missing LTV data for 1971-78 as another latent variable.
[6] The evidence for the UK (Aron *et al*. 2012), Australia (Muellbauer and Williams, 2011) and South Africa (Aron and Muellbauer, 2013) indicates that such shifts are larger than in the US. A possible explanation is that individual household income volatility has increased by more in the US so that greater microeconomic uncertainty has partially offset the tendency for future income to play a greater role due to easier access to credit; see Sichel *et al*. (2007) and Hacker and Jacobs (2008).
[7] This contrasts with the finding by Lettau and Ludvigson (2001) that assets rather than consumption adjust to the deviation of log consumption from a linear combination of log income and log net worth. We attribute their conclusion to their adoption of the text-book life-cycle consumption function instead of our credit-augmented generalization which incorporates the vast changes in credit market architecture discussed in Section 3.
[8] Permanent income is defined over a 10 year horizon using a 5 per cent per quarter, (approximately) 20 per cent per annum discount rate to discount future income. Such high discount rates are justified by microeconomic evidence, see for example Hausman (1979). Log permanent income is modelled relative to log current income using trend reversion, a Michigan Survey measure of income expectations and the change in the T-bill rate to capture short term monetary policy.

[9] We acknowledge comments to this effect made to John Muellbauer by Charles Goodhart several years ago.

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