The future of macroeconomics: why central bank models failed and how to repair them

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The consensus that reigned in macroeconomics before the financial crisis has come under renewed attack. New Keynesian 'dynamic stochastic general equilibrium' models until recently dominated macroeconomic and central bank thinking. The failure of these models to capture interactions of finance and the real economy has been widely-recognized since the financial crisis. The models excluded money, debt and asset prices and, importantly, ignored changing credit markets, though the models took some account of price stickiness. These omissions stem from unrealistic micro-foundations for household behaviour when many households face radical uncertainty, and from wrongly assuming that aggregate behaviour mimics a fully-informed 'representative agent'. The wrong implications for aggregate consumption and the economy followed. This also affects more eclectic central bank policy models such as the Federal Reserve's FRB-US model, to which central banks are now increasingly turning to escape the restrictions of New Keynesian DSGE. To repair these, aggregate consumption needs to be jointly modelled with the main elements of household balance sheets, extracting credit conditions as a latent variable. This research highlights the important role of debt and of housing, confirmed by recent micro-economic evidence, and of financial assets and the time and context-dependent role of housing collateral. Rather than 'one-size-fits-all' monetary and macro-prudential policy, institutional differences between countries then imply major differences for monetary policy transmission and policy.

Post-crisis critiques of New Keynesian DSGE models.

The New Keynesian DSGE models, see Clarida et al (1999), that dominated the macroeconomic profession and central bank thinking for the last two decades were based on several principles. The first was formal derivation from micro-foundations, assuming optimising behaviour of consumers and firms with rational or 'model-consistent' expectations of future conditions. For such derivation to result in a tractable model, it was assumed that the behaviour of firms and of consumers corresponded to that of a 'representative' firm and a 'representative' consumer. In turn, this entailed the absence of necessarily heterogeneous credit or liquidity constraints. Another important assumption to obtain tractable solutions was the assumption of a stable long-run equilibrium trend path for the economy. If the economy was never far from such a path, the role of uncertainty would necessarily be limited. Popular pre-financial crisis versions of the model excluded banking and finance, taking as given that finance and asset prices were merely a by-product of the real economy. Second, a competitive

economy was assumed but with a number of distortions, including nominal rigidities –sluggish price adjustment- and monopolistic competition. This is what distinguished New Keynesian DSGE models from the general equilibrium Real Business Cycle models which preceded them. It extended the range of stochastic shocks that could disturb the economy from the productivity or taste shocks of the RBC model. Finally, while some models calibrated –assumed values- of the parameters, where the parameters were estimated, Bayesian system-wide estimation was used, imposing substantial amounts of prior constraints on parameter values deemed 'reasonable'.

In the most scathing of post-crisis critiques, ex-MPC member Buiter (2009) argued that the technical training of economists at central banks was a handicap in the financial crisis:

> 'the typical graduate macroeconomics and monetary economics training received at Anglo-American universities during the past 30 years or so, may have set back by decades serious investigations of aggregate economic behaviour and economic policy-relevant understanding. It was a privately and socially costly waste of time and other resources.
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> Most mainstream macroeconomic theoretical innovations since the 1970s (the New Classical rational expectations revolution[1] associated with such names as Robert E. Lucas Jr., Edward Prescott, Thomas Sargent, Robert Barro etc., and the New Keynesian theorizing of Michael Woodford and many others) have turned out to be self-referential, inward-looking distractions at best. Research tended to be motivated by the internal logic, intellectual sunk capital and aesthetic puzzles of established research programmes rather than by a powerful desire to understand how the economy works—let alone how the economy works during times of stress and financial instability. So the economics profession was caught unprepared when the crisis struck.'

He went on to criticize the complete markets paradigm of the established research programme: 'Both the New Classical and New Keynesian complete markets macroeconomic theories not only did not allow questions about insolvency and illiquidity to be answered. They did not allow such questions to be asked.'

Muellbauer (2010) noted that: 'the recent generation of DSGE models failed to incorporate many of the liquidity and financial accelerator mechanisms revealed in the global financial crisis'. I argued:

[1] See Wren-Lewis (2018) and Hoover (1994) for an illuminating intellectual history of this revolution.

> 'Underlying conceptual reasons for the failure of central bank models of the DSGE type include their typical assumptions about representative agents, perfect information, zero transactions costs, and of efficient markets. For most of these models, with the notable exception of Bernanke *et al.* (1999), and others who also incorporate a financial accelerator for firms… it is as if the information economics revolution, for which George Akerlof, Michael Spence and Joe Stiglitz shared the Nobel Prize in 2001, had not occurred. The combination of assumptions, when coupled with the trivialisation of risk and uncertainty in these supposedly stochastic models, and the linearisation techniques used in their solution, render money, credit and asset prices largely irrelevant. The calibration/estimation methods currently used to apply these models to the data typically ignore inconvenient truths.

Caballero (2010) criticized the 'pretence of knowledge syndrome':

> 'the current core of macroeconomics—by which I mainly mean the so-called dynamic stochastic general equilibrium approach—has become so mesmerized with its own internal logic that it has begun to confuse the precision it has achieved about its own world with the precision that it has about the real one. This is dangerous for both methodological and policy reasons.'

Recently, the debate has been renewed. Romer (2016) shares Cabellero's perspective and is critical of the incredible identifying assumptions and 'pretence of knowledge' in both Bayesian estimation, e.g. Smets and Wouters (2007), and the calibration of parameters in DSGE and real business cycle (RBC) models.

Stiglitz (2018) uses insights from the information economics revolution, to which he made such major contributions, to criticize many aspects of recently fashionable macroeconomics.

Blanchard (2018) points to a number of failings of DSGE models and recommends greater openness to more eclectic approaches. He acknowledges the usefulness of theoretical models with stylized simplifications[2] to explore important macroeconomic issues, but questions whether even the newer generation of DSGE models are suitable as central bank policy models. He recommends the co-existence of this kind of research with work on policy models such as the FRB/US model, Brayton et al (1997), in which economic theory is used more loosely and the data are allowed to speak more freely than in typical DSGEs. The European Central Bank

[2] He usefully distinguishes foundational models making a deep theoretical point, DSGE models designed to explore macro implications of a set of distortions, and 'toy models' such as RBC or simple IS–LM models.

(ECB) is actively developing such models for five major Eurozone economies in its ECB-MC project.

In the forthcoming bumper 14-article issue on the future of macroeconomics in the Oxford Review of Economic Policy, Hendry and Muellbauer (2018) reconsider critiques of the New Keynesian DSGE approach. We discuss econometric methodologies for improving evidence-based macroeconomics and illustrate with a critique of policy modelling at the Bank of England. What follows draws on some of this material.

Micro-foundations built on sand: no representative agent

The first element of the view that New Keynesian DSGE models had the wrong micro-foundations concerns the representative agent assumption. The conditions for exact aggregation of demand functions so that aggregate behaviour corresponds to that of an average household, are very restrictive: demands are linear functions of income and wealth, with households sharing the same marginal propensities[3]. With optimizing behaviour under linear budget constraints, preferences need to have a very specific form, see Deaton and Muellbauer (1980, ch. 6), though, as Muellbauer (1976) showed, there is a more general notion of a representative household than 'average', consistent with slightly more general but still very restrictive preferences.[4] With heterogeneous credit constraints across households, even such restrictions on preferences would be of no help in obtaining exact aggregation. Kirman (1992), Carroll (2000), Hoover (2001) and Stiglitz (2018) are among many criticizing the representative agent assumptions of RBC and New Keynesian macroeconomics.

Instead of representative agent economics, stochastic aggregation theory[5] suggests we can often still make good progress with aggregate data even if behaviour at the micro-level looks different from an aggregate model. An excellent example is Houthakker (1956), who showed that a fixed-coefficient production function, with no substitution, and Pareto distribution of the coefficients at the micro-level, implied substitution at the macro-level as if it arose from an

[3] For example, a marginal propensity to spend out of wealth of 0.04, widely thought to be plausible, would mean that a £100 increase in wealth results in a £4 increase in annual consumer spending.
[4] In this generalization, the distributions of income and wealth, as well as averages, affect aggregate behaviour, see discussion in Deaton and Muellbauer (1980, ch. 6.2).
[5] In contrast with exact linear aggregation, in stochastic aggregation, assumptions on the joint distributions of the data allow aggregate behaviour to be represented by parameters of the distributions, such as means, variances, and covariances.

aggregate Cobb–Douglas technology. The functional form at the micro-level could hardly differ more radically from that at the macro-level. In the literature on lumpy adjustment costs, micro behaviour switches discretely from no adjustment to adjustment when some micro-thresholds are reached. In the aggregate, however, behaviour is smooth, as explained by Bertola and Caballero (1990). A recent applied example of stochastic aggregation comes from models of aggregate mortgage delinquency and foreclosure rates (Aron and Muellbauer, 2016). A key driver is the proportion of mortgages with negative equity: if the distribution of mortgage debt to equity is fairly stable, a shift in the ratio of average debt to average equity shifts non-linearly the fraction of borrowers with negative equity. Since bad loans restrict the ability of banks to extend new credit, negative equity is an important non-linear element in the business cycle feedback loop.

The information economics revolution: incomplete markets

The second element of the critique of the micro-foundations of New Keynesian DSGE models is of their adoption of the complete markets paradigm, implicitly denying the asymmetric information revolution of the 1970s, see the quotations from Buiter (2009) and Muellbauer (2010) above. In these DSGEs, households discount temporary fluctuations in income to maintain spending in the face of shocks, thus providing a stabilizing anchor to the economy, in turn justifying the rational expectation that shocks will prove temporary.

This old-fashioned textbook view of consumption behaviour was challenged by Deaton (1991), Carroll (1992, 1997, 2001), and Aiyagari (1994). Given uninsurable individual income risk and liquidity constraints, the result of asymmetric information, they show that households engage in buffer-stock behaviour to ameliorate income risk and discount expected future income at higher rates than assumed by the textbook model. Moreover, given heterogeneous income processes, heterogeneous liquidity constraints, and heterogeneous asset ownership, there will be considerable heterogeneity in the discount rates used by different households. On average, discount rates applied to expected incomes will be far higher than those of the textbook model.

This has profound implications, as the important paper by Kaplan *et al.* (2016) demonstrates. They contrast two general equilibrium models: a representative agent New Keynesian (RANK) model and a heterogeneous agents New Keynesian (HANK) model, and show that the monetary policy channel works quite differently in the latter. An important feature of their model, which is shared with their earlier papers on fiscal policy in the context of wealthy 'hand-

to-mouth' consumers (Kaplan *et al.*, 2014; Kaplan and Violante, 2014), is that consumers own not only buffer stocks in the form of liquid assets but also illiquid assets, typically earning higher long-run returns. However, there are lumpy transactions costs in trading in and out of such assets and households face borrowing limits.

To keep the HANK model tractable, Kaplan *et al.* (2016) adopt a highly simplified view of housing. A heterogeneous agent model which incorporates somewhat more realistic features of housing and credit markets with important consumption and monetary transmission implications has been developed by Hedlund *et al.* (2016). Both papers imply that since heterogeneous households, facing idiosyncratic micro uncertainty and radical macro uncertainty, discount income expectations with much higher weights on near-term expectations, aggregate behaviour cannot be adequately approximated by RANK models.

The omission of shifting credit constraints, household balance sheets, and asset prices

The asymmetric information revolution of the 1970s provided micro-foundations for the application of credit constraints by the banking system, see Stiglitz (2018) for further discussion. In many countries, shifts in these constraints were among the most important structural changes in the economy; see the example of the US discussed below. Thus, a third criticism of New Keynesian DSGE models, linking closely with the previous, is the omission of debt and household balance sheets, including housing, crucial for understanding, together with shifts in credit availability, consumption, and macroeconomic fluctuations. The US Federal Reserve did not abandon its large non-DSGE econometric policy model FRB/US, but it too was defective in that it also relied on the representative agent permanent income hypothesis, which ignored shifts in credit constraints and mistakenly lumped all elements of household balance sheets, debt, liquid assets, illiquid financial assets (including pension assets), and housing wealth into a single net worth measure of wealth. This is wrong for the following reasons: because housing is a consumption good as well as an asset, consumption responds differently to a rise in housing wealth than to an increase in financial wealth; see Muellbauer (2008) and Aron *et al.* (2012). Second, different assets have different degrees of 'spendability'. It is indisputable that cash is more spendable than pension or stock market wealth, the latter subject to asset price uncertainty and access restrictions or trading costs. This suggests estimating separate marginal propensities to spend out of liquid and illiquid financial assets. Third, the marginal effect of debt on spending is unlikely just to be minus that of either

illiquid financial or housing wealth. The reason is that debt is not subject to price uncertainty and it has long-term servicing and default risk implications, with typically highly adverse consequences.

There is now strong micro evidence that the effect of housing wealth on consumption, where it exists, is much more of a collateral effect than a wealth effect, see Browning et al (2013, Mian et al (2013), Windsor et al (2015), Mian and Sufi (2016) and Burrows (2017). As mortgage credit constraints vary over time, this contradicts the time-invariant housing wealth effect embodied in FRB/US.

The importance of debt was highlighted in the debt-deflation theory of the Great Depression of Fisher (1933).[6] Briefly summarized, his story is that when credit availability expands, it raises spending, debt, and asset prices; irrational exuberance raises prices to vulnerable levels, given leverage; negative shocks can then cause falls in asset prices, increased bad debt, a credit crunch, and a rise in unemployment.

Of structural changes, the evolution and revolution of credit market architecture is often the single most important. In the US, credit card ownership and instalment credit spread between the 1960s and the 2000s. The government-sponsored enterprises—Fannie Mae and Freddie Mac—were recast after 1968 to underwrite mortgages. Interest rate ceilings were lifted in the early 1980s. Falling IT costs transformed payment and credit screening systems in the 1980s and 1990s. More revolutionary was the expansion of sub-prime mortgages in the 2000s—driven by the rise of private label securitization backed by credit default obligations (CDOs) and swaps. The 2000 Commodity Futures Modernization Act (CFMA) made derivatives enforceable throughout the US with priority ahead of claims by others, e.g. workers, in bankruptcy. This permitted derivative enhancements for private label mortgage-backed securities (PMBS) so that they could be sold on as highly rated investment grade securities. A second regulatory change was the deregulation of banks and investment banks. In particular, the 2004 Securities and Exchange Commission (SEC) decision to ease capital requirements on investment banks increased leverage to what turned out to be dangerous levels and further

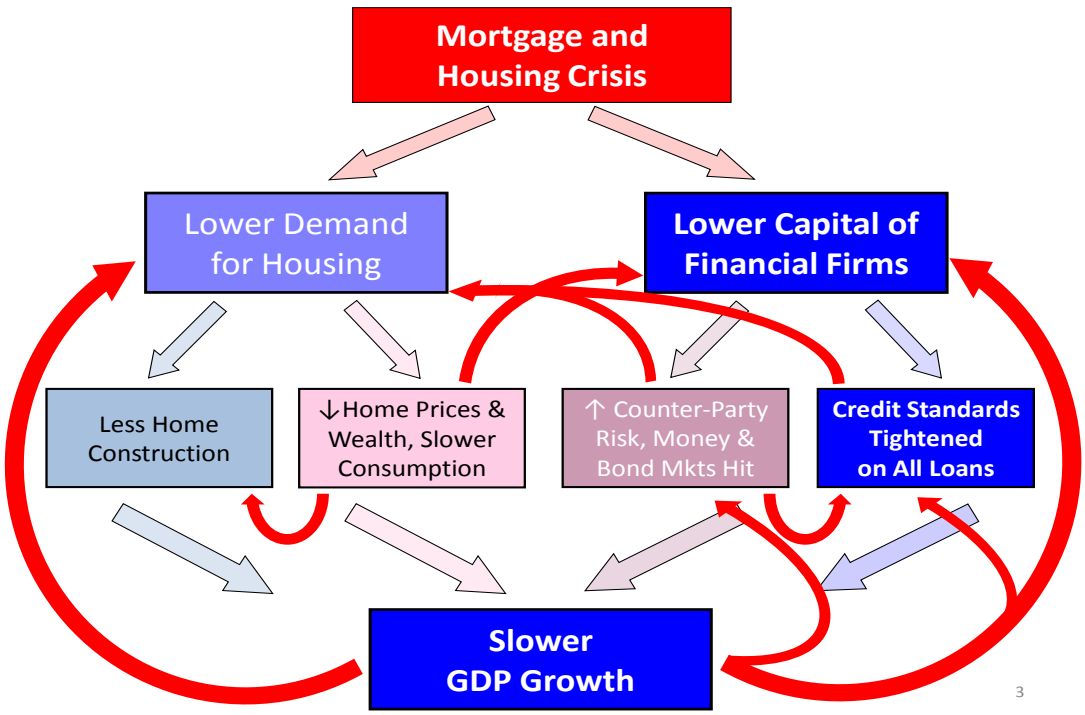
[6] In recent years, several empirical contributions have recognized the importance of the mechanisms described by Fisher (1933). Mian and Sufi (2014) have provided extensive microeconomic evidence for the role of credit shifts in the US sub-prime crisis and the constraining effect of high household debt levels. Focusing on macro-data, Turner (2015) analyses the role of debt internationally with more general mechanisms, as well as in explaining the poor recovery from the global financial crisis. Jordà *et al*. (2016) have drawn attention to the increasing role of real estate collateral in bank lending in most advanced countries and in financial crises.

boosted PMBS; see Duca *et al.* (2016). Similar measures to lower required capital on investment grade PMBS increased leverage at commercial banks also. These changes occurred in the political context of pressure to extend credit to poor.

The missing financial accelerator

In the 1980s and early 1990s, major credit market liberalization occurred in Norway, Finland, Sweden, and the UK, causing credit, house price, and consumption booms which were followed by busts—precursors of the US sub-prime crisis. In the financial accelerator feedback loops that operated in the US sub-prime crisis, falls in house prices increased bad loans and impaired the ability of banks to extend credit. As a result, household spending and residential investment fell, increasing unemployment and reducing incomes, feeding back further on to lower asset prices and credit supply. The following diagram, due to John Duca (see Duca and Muellbauer, 2013), illustrates the feedback loops in the US sub-prime crisis.

Figure 1: The financial accelerator in the US sub-prime crisis



These feedback loops involve non-linearities and amplification. For example, falls in house prices, driving up the incidence of negative equity, cause, via bad loans, a sharper contraction in credit availability than rising house prices cause an expansion of credit availability. Moreover, a contraction in credit availability itself feeds back on to lower house prices. The combination of lower credit availability, which lowers the spendability of housing collateral, even at given house prices, and lower house prices, had a multiplicative effect in lowering consumption in the US sub-prime crisis; see Duca and Muellbauer (2013).

Such mechanisms were entirely missing in New Keynesian DSGE models, and hardly represented in those DSGE models, such as Bernanke *et al.* (1999) which incorporated a financial accelerator only for firms. Iacoviello (2005) and the estimated DSGE model of Iacoviello and Neri (2010) did introduce housing into DSGE. They assume two representative households, patient and impatient, present in a fixed proportion. Patient households apply a loan-to-value constraint when offering mortgage loans to the impatient households, a kind of financial friction. But because of the assumption of infinitely lived or dynastic households, saving for a down-payment, one of the most important saving motives in industrial countries, is omitted. In their closed economy model, without banks and foreclosures, and assuming a frictionless and efficient housing market, transmission and amplification of monetary or other shocks via housing is *extremely* limited. For example, their model implies that aggregate home equity withdrawal, the excess of households' mortgage borrowing over acquisitions of housing, is always negative. In practice, US home equity withdrawal was *strongly positive* for much of the period from 2001 to 2006, and in the peak quarters was of the order of 10 per cent of that quarter's household income. However, this fact and the realized foreclosures, were not in the set of salient data chosen by Iacoviello and Neri for their model calibration. Indeed, for their calibrated model, they compare the correlation between consumption growth and house price growth with and without the financial friction. Without the friction, the correlation is 0.099, the result of the common influence of the shocks[7] on house prices and consumption. With the friction, the correlation rises to 0.123. One would be tempted from this to conclude, but quite wrongly, that financial frictions have little impact on the macroeconomy. This is the opposite of what Figure 1 above implies.

[7] The major shock driving real house prices is a 'preference' shock, which Romer (2016) ironically terms a 'caloric' shock in contrast to the 'phlogiston' of productivity shocks, the major driver of real residential investment in their model.

The failure of rational expectations

The world is usually in disequilibrium: economies are wide-sense non-stationary from evolution and sudden, often unanticipated, shifts both affecting key variables directly and many more indirectly. Technology, globalization, both in trade and in finance, trade union power, credit conditions, monetary and fiscal policy rules and other legislation, social mores, skills, wars, resource and financial crises, climate, demography, health and longevity, and income and asset distributions all change over time. These, and other innovations keep perturbing the economic system in ways that not even rational individuals can foresee (Uber and Airbnb are two recent examples). DSGEs therefore suffer a double flaw: they are making incorrect assumptions about the behaviour of the agents in their model, and are also deriving false implications therefrom by using mathematics that is invalid when applied to real economies.

Structural changes are a key source of forecasting error, as noted above. However, the mathematical basis of DSGEs fails when events suddenly shift the underlying distributions of relevant variables. The 'law of iterated expectations' becomes invalid because an essential, but usually unstated, assumption in its derivation is that the distributions involved stay the same over time. Economic analyses with conditional expectations and inter-temporal derivations then also fail, so DSGEs become unreliable when they are most needed, see Hendry and Mizon (2014).

Dealing with forecast failure

Claiming that forecasts are based on an 'economic theory based model' will not by itself counter any of the causes of forecast failure and associated policy failure unless it can anticipate and model shifts.

Intercept corrections (ICs) in equilibrium correction models discussed by Clements and Hendry (1996, 1999) are a way of getting any forecast 'back on track' *after* a location shift, irrespective of its source, and assuming it is a location shift (so relatively permanent). ICs are not a magic bullet—'forecast' failure will still occur—unless they represent crystal-ball information about the shift that is going to occur. But they can help avoid systematic failure after shifts, if appropriately implemented—as can other devices.[8] After forecast failure, there are still non-

[8] A popular device is differencing the data to eliminate shifts in the mean or omitted non-stationary drivers. Popular 'accelerationist' models of inflation, based on the twice-differenced price level are a symptom of mis-specification: omitting key long-run drivers of inflation, including mean-shifts.

trivial issues about *how* to do intercept correction, e.g., how to separate temporary from permanent components of shifts. There are parallels here with the difficulty forecasters have had in deciding whether and to what degree the UK's capacity output has permanently declined. Forecasting methods that robustify against structural shifts, see Castle et al (2015), can also offer insights into how economic agents might form expectations in a world of shifts and radical uncertainty.

The lack of flexibility of DSGEs

In an efficient market, rational expectations, representative agent framework, the consumption Euler equation is the crucial link between the present and the future and thus the key mechanism for the operation of model consistent-expectations. This makes it the main *straitjacket* of the representative agent DSGE approach. In what follows I advocate its replacement by a solved-out 'credit-augmented' consumption function, incorporating the discounted present value of future incomes, using an average discount rate far higher than in standard textbook permanent income models. Such a replacement has fundamental implications as explicit expectations mechanisms are then needed for the other behavioural equations, also of the solved-out form. This allows a more modular approach, as for example in FRB/US, allowing heterogeneity in expectations between households and firms.

Improving the consumption function: better economic stories

Some central banks did not abandon their large non-DSGE econometric policy models, but these, e.g. FRB/US, were also defective in that they also relied on the representative agent permanent income hypothesis. This ignored shifts in credit constraints and mistakenly lumped all elements of household balance sheets, debt, liquid assets, illiquid financial assets (including pension assets) and housing wealth into a single net worth measure of wealth.

The importance of debt was highlighted in the debt-deflation theory of Fisher (1933) discussed above. A more relevant consumption function for modelling the financial accelerator is thus needed, modifying the permanent income model with shorter time horizons, incorporating important shifts in credit lending conditions and disaggregating household balance sheets into liquid and illiquid elements, debt and housing wealth.

To take into account all the feedbacks, a macroeconomic policy model needs to explain asset prices and the main components of household balance sheets, including debt and liquid assets. This is best done in

a system of equations including consumption, in which shifts in credit conditions, which have system-wide consequences, sometimes interacting with other variables such as housing wealth, are extracted as a latent variable. Duca and Muellbauer (2013) call this a 'latent interactive variable equation system' (LIVES). The availability of home equity loans, which varies over time and between countries – hardly available in the US of the 1970s or in contemporary Germany, France or Japan- and the variable size of down-payments needed to obtain a mortgage, determine whether increases in house prices increase (US and UK) or reduce (Germany and Japan) aggregate consumer spending. In the UK, the down-payment constraint and access to home equity loans has varied over time, with a relaxation in the 1980s, tightening in the early 1990s, followed by a relaxation which ended when the credit crunch began in 2007–8. In turn, the funding for lending scheme, help-to-buy and the recovery in commercial bank balance sheets have led to a more recent relaxation. Modelling of consumption and household balance sheets would help understand these phenomena, debt dynamics, and the implications of debt for consumption, and should be central to the information base for policy formation, within a larger model where the feedback loops can be more fully explored. These shifts have altered the relationship between house prices and consumption. They have also altered the short-term impacts of changes in mortgage rates on aggregate spending.

A graphical illustration below, based on a 2012 update[9] of the UK consumption function explained in Aron *et al.* (2012), gives an indication of how these phenomena played out for consumption. The long-run 'credit-augmented' solution for the log consumption to income ratio generalizes in several respects the textbook permanent income form, which depends on the log ratio of permanent to current income and on the net worth to income ratio. First, it splits net worth into three categories, net liquid assets defined as liquid assets minus debt, illiquid financial assets (stock market and pension wealth), and housing wealth. Second, shifting mortgage credit conditions, measured by a credit-conditions index, has an intercept effect capturing the shifting implications for saving behaviour of variations in the down-payment constraint, and interacts with housing wealth, capturing how access to home equity finance varies with access to credit. Third, the discount rate used to discount expected income growth is higher than the real interest rate to account for income uncertainty and liquidity constraints.

[9] The update was prepared for a presentation by Muellbauer for a December 2012 Bank of England Monetary Policy Roundtable. Up to 2001, the credit conditions index comes mainly from Fernandez-Corugedo and Muellbauer (2006) with three smooth transition dummies capturing later shifts, estimated just from the consumption equation, rather than from a full LIVES system for consumption and household balance sheets.

Moreover, the coefficient on the log ratio of permanent to current income is freely estimated,[10] instead of imposing a coefficient close to one implied by the textbook permanent income model.

Figure 2: Long-run decomposition of log consumption/income into effects of credit conditions, their interaction with housing wealth/income and log permanent/current income.

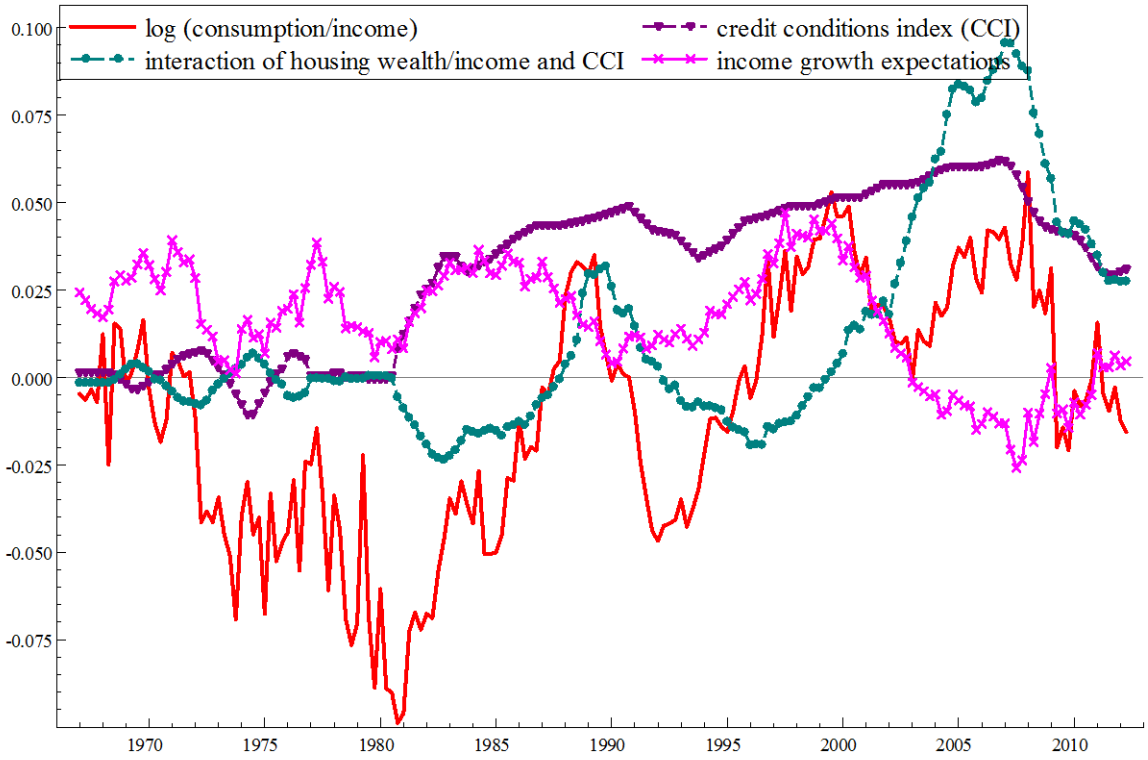
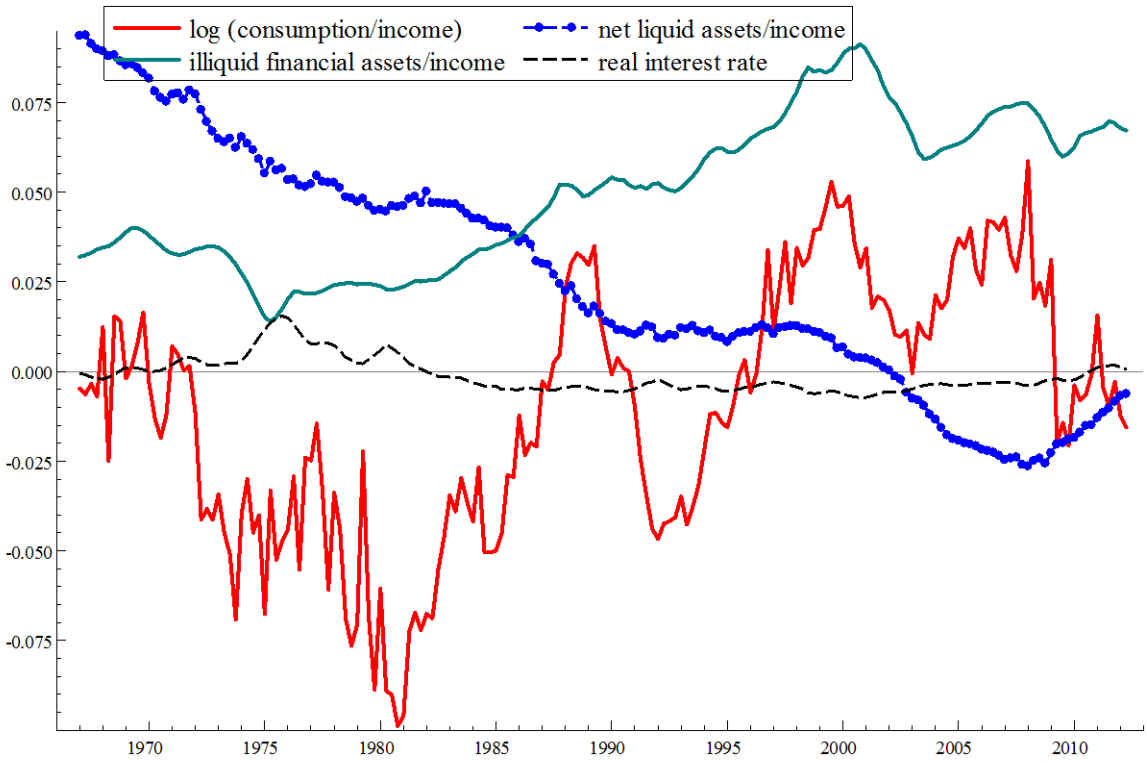


Figure 2 shows a rise from 1980 to 2007 in the log ratio of consumption to income, measured by non-property disposable household income. Some of this is attributable to the rise in the credit conditions index (CCI)—note the jump after 1979 induced by credit market liberalization under Mrs Thatcher. But the interaction effect between CCI and housing wealth/income has even sharper effects and captures much of the time variation. Note that in the 1970s, when credit was heavily rationed, this effect was essentially negligible. In the early 1990s, much of the fall in consumption relative to income is explained by the credit crunch and the decline in house prices, and the combination was even more pronounced after 2008 in the global financial crisis, when the credit crunch was even more severe. However, income growth expectations measured by estimates of log permanent to current income from a forecasting model, also

[10] It also introduces an interaction effect with the credit conditions index, as easier credit access should allow households to be more forward looking.

explain some of the variation in log consumption/income. For example, in the first half of the 2000s, high levels of current income relative to permanent income (low log permanent/current income) offset some of the rise in consumption relative to income that would have been induced by the house price boom. And in the global financial crisis, when current income fell, permanent income does provide some stabilization for the consumption/income ratio. The remainder of the long-run effects are shown in Figure 3.

Figure 3: Long-run decomposition of log consumption/income into effects of net liquid assets/income, illiquid financial assets/income and the real interest rate



The rise in illiquid financial wealth relative to income makes a substantial contribution to the rise in consumption relative to income from 1980 to 2000, and explains some of the decline in the aftermath of the collapse of the dotcom stock market boom in the early 2000s. Crucially important, the other major story told by Figure 3 is the effect of the long-term build-up in debt implied by the decline in liquid assets minus debt, relative to income.[11] This is the pay-back

[11] The estimated model imposes the restriction, empirically supported, that the coefficient on debt equals minus the coefficient on liquid assets. For a range of countries, we find aggregate housing 'wealth' effects of zero or negative before mortgage credit liberalization, the marginal propensity to consume for net liquid assets between 0.08 and 0.16, for illiquid financial assets between 0.015 and 0.03, and speeds of adjustment typically 0.4–0.7 for aggregate consumption, somewhat lower for non-durables, meaning that most of the adjustment takes place within 4 quarters.

for the credit liberalization and boom in asset prices which boosted consumption but built up debt burdens, and illustrates the vulnerability of the household sector to high debt levels when asset prices fall and access to new credit contracts. The estimated long-run effect of real interest rates is relatively small.

The two figures show only long-run effects. The estimated short-run dynamics also reveal two further important effects. One is a highly significant negative effect of the change in the unemployment rate on consumption, also a feature of the Bank of England's pre-DSGE 1999 MTMM consumption function. The second is a negative effect of the change in the nominal borrowing rate, a mix of the mortgage rate and base rate, capturing the asymmetric short-run effect on borrowers compared with savers. This is weighted by the debt/income ratio and also includes an interaction with CCI: for given CCI, a higher debt/income ratio implies a more negative effect of higher interest rates on spending. But with easier access to credit, refinancing is easier when interest rates rise, so softening the impact. The implication is that in 2008–10, when debt/income reached record levels, but access to new credit was very constrained, the impact of lower interest rates on aggregate UK consumption was particularly strong, evidence for monetary policy effectiveness. The Bank of England's 1999 MTMM consumption function also included a negative effect from the rise in the nominal borrowing rate on consumption, but with no account taken of the time variations in the effect.

Of course, such partial equilibrium decompositions tell only part of the story of policy transmission. For example, higher consumption feeds into higher output, higher asset prices, and lower unemployment, adding to the direct channel of transmission. Integration into a larger model of the economy is necessary to capture the full feedback loops, many of which are missing in typical DSGE models such as that currently in use at the Bank of England.

Wider economic and policy insights

There are close parallels between consumption behaviour in the US and the UK, though with mainly fixed-rate mortgages, the response of consumption and house prices to lower interest rates in the US is necessarily slower than in the UK.[12] The above generalization of the textbook permanent income model encompasses the textbook model as a special case with better fit and

[12] Duca and Muellbauer's (2013) version of the US consumption function uses a latent variable to model the shifting responsiveness of spending to housing assets as access to home equity finance has varied, capturing the multiplicative effects of the credit crunch and falling house prices.

parameter stability. It is also an example of the looser, more relevant, application of theory. In contrast to the FRB/US consumption function which incorporates no shifts in credit constraints and aggregates the household balance sheet into a single net worth concept, contradicted by micro evidence, it no longer corresponds to a representative agent optimizing model. The claimed micro-foundations of the FRB/US consumption function do not save it from parameter instability: the estimated speed of adjustment for data up to 2009 of 0.19 falls to 0.10 for recent data. This is clear evidence against treating the FRB/US consumption function as a 'structural' equation in the classical sense of invariant to shifts in the economic environment.

Because of its omissions, the FRB/US model failed to give proper warning of risks faced by the US economy after 2007. At the Jackson Hole conference in 2007, Mishkin (2008) reported the results of FRB/US simulations of a 20 per cent decline in real house prices spread over 2007–8. The standard version of model simulated GDP lower than the baseline by 0.25 per cent in early 2009 and consumption lower by only 0.6 per cent in late 2009 and 2010. The simulations suggested a rapid recovery of residential investment given the lowering of the policy rate in response to the slowing economy. FRB/US failed to include a plausible model of house prices and so also missed the feedback from the credit crunch back on to house prices modelled in Duca *et al.* (2011, 2016). Consistent with this time series evidence, Favara and Imbs (2015) provide strong micro-evidence for the causal link between credit supply and house prices in the US.

Among the findings of the LIVES models for the household sectors of Germany and France are that major shifts took place in French credit conditions compared to Germany's, and these help explain the radically different patterns of house price developments in the two countries. Ignoring post-1980 shifts has catastrophic effects on the French consumption[13] and house price equations and rather less serious ones for Germany. In contrast to the UK, higher house prices relative to income in Germany and France tend to reduce aggregate consumption, other things being equal. The interpretation is that conservative lending practices and high down-payment constraints force many younger households to save for a housing down-payment. Moreover, many renters may be more cautious anticipating that higher rents will follow higher house prices. However, as the French mortgage market has liberalized, so these negative effects of higher house prices relative to income have softened. These findings suggest that monetary

[13] For South Africa, the omission of credit conditions has similarly catastrophic effects for models of consumption and household debt, Aron and Muellbauer (2013*b*).

transmission in Germany is very different from the US and UK, and somewhat different from France.

The three-equation LIVES model for the household sector in Canada of Muellbauer *et al.* (2015) reveals striking differences between Canada and its neighbour in linkages between house prices and aggregate consumption. The ATM-like role of home equity in the US is far smaller in Canada, highlighting the importance of institutional differences. In Canada, unlike in many US states, mortgage contracts are 'full recourse', meaning that defaulters' other assets and income flows can be legally drawn upon by mortgage lenders, and pursued for years. There is no tax relief for mortgage interest payments. The banking sector is concentrated and with compulsory mortgage insurance and federal oversight, lending standards are high, with almost no sub-prime lending.

In Japan, too, high down-payment constraints and conservative mortgage lending practices are factors implying a small negative effect from higher house prices on consumption, given income and other asset prices; see Aron *et al.* (2012). The radically different structure of Japanese household balance sheets compared to those of the US implies that one-size-fits-all ideas derived from the US about monetary policy transmission are wrong, as explained in Muellbauer and Murata (2011). No G7 economy has such a high ratio of liquid assets (mainly bank and post office saving deposits) to income, or such a low rate of stock-market participation (though Germany is not far behind). There is strong empirical evidence that lower real interest rates on deposits *reduce* aggregate consumption in Japan, given income and other asset prices. This explains why aggregate consumption in Japan has failed to respond to low and now negative policy interest rates or, indeed, to forward guidance on higher future inflation: many pre-and post-retirement households can hardly be enthused by the promise that the real value of their liquid assets will be further eroded in the future with the real income stream remaining negative for longer. Lower policy rates transmit to the real economy in other ways, such as the real exchange rate, the stock market, and higher investment including in residential housing, but overall monetary transmission in Japan is almost certainly weaker than in the US.

These insights have applications to the Chinese economy. While mortgage markets have developed a great deal, down-payment constraints are still far more stringent than in the US. The easy assumption that higher house prices in themselves will fuel higher aggregate consumption in China is certainly wrong. The easier credit flows that drive up house prices

stimulate residential construction which creates higher employment and incomes. And though easier credit to households can temporarily stimulate consumption, given house prices, this is offset by the increased saving for down-payments by many younger households induced by higher house prices relative to incomes. When the credit expansion comes to an end, the hit to residential construction will affect employment and income, while still high house prices and high levels of debt constrain consumption. These are major problems for the hoped-for transition of the Chinese economy away from investment and export-led growth to consumption-led growth.

With countries going through major demographic transitions, empirical evidence on the implications is of great relevance. Empirical evidence from the LIVES models for Germany and France, Geiger et al (2016) and Chauvin and Muellbauer (2017), suggest that demographic effects on aggregate consumption *conditional on household portfolios disaggregated into the main asset and debt classes* are small. However, these portfolios, including the important debt components, themselves appear to be quite sensitive to demographic change, implying a slow but important feed-through of demography to household saving rates. Further research on these lines should illuminate the role of demography in the secular stagnation feared by some economists.

Empirical insights not available from micro-cross-sections or short panels include that, contrary to simple textbook models, there is a major role in Germany and France for nominal mortgage interest rates in driving house prices and the mortgage stock. The role of real rates as embodied in 'user cost of housing' increases with leverage. Another is that increased access to unsecured credit reduces demand for liquid assets—ignored by previous research on household demand for money. Finally, evidence for the buffer stock role of both liquid assets and unsecured debt comes from the negative reaction of the former and the positive reaction of the latter to a rise in the unemployment rate.

The careful distinction between the demand for and the supply of credit in LIVES models helps understand the paradox of the frequently found positive correlation between economic growth and credit growth and the negative one with debt levels. Our evidence that, in aggregate, debt has far more negative effects on consumption than stock market or housing wealth have positive effects, has sobering implications for the extended use of monetary policy, including large-scale purchases of government bonds. In the short run, monetary policy, and, of course,

provision of liquidity to banks and other institutions under liquidity stress, are important policy levers. But if extended periods of low interest rates and low returns on safe assets drive up debt/income and prices of risky assets to levels beyond what would be sustainable under moderately higher interest rates, the boost to spending will be reversed later.

Such models, building in disaggregated balance sheets and the shifting, interactive role of credit conditions, have many benefits: better interpretations of data on credit growth and asset prices helpful for developing early warning indicators of financial crises; better understandings of long-run trends in saving rates and asset prices; and gaining insights into monetary transmission for macro and macro-prudential policy. Approximate consistency with good theory following the information economics revolution of the 1970s is better than the exact consistency of the New Keynesian DSGE model with bad theory that makes incredible assumptions about agents' behaviour and the economy. To be blunt the NK-DSGE model was ***not stochastic enough*** – trivialising the role of uncertainty and heterogeneity, ***not dynamic enough*** - missing key lags in relationships, and ***not general equilibrium enough*** – for example, missing the feed-back loops seen in the financial crisis. It was also hardly ***new***, being based on ideas made redundant by the asymmetric information revolution of the 1970s and 80s, and hardly ***Keynesian***, missing the possibility of co-ordination failures in labour and financial markets.

It is possible that, in future, the generation of vast amounts of micro-data from administrative sources rather than surveys subject to selection bias and large measurement errors, may allow quantitative models for the whole economy to be constructed. Ideally, such macro-models would be based on statistically tested models of micro-behaviour, aggregated up from micro-data on millions of households and many thousands of firms. Testing should establish whether such models best assume full information optimizing behaviour at the micro-level or heuristic behaviour rules, see Kahneman (2003), adopted in agent-based modelling approaches. In the absence of such data, there is an important place for policy-relevant models using aggregate data, general enough to be consistent with plausible micro-behaviour and with plausible assumptions about information and market structure. Such models should be able to encompass insights from multiple stylized models, and use aggregate time series data to learn about the relevance of these insights.

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