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Abstract

There is widespread agreement that, in the United States, higher house prices raise consumption via collateral or possibly wealth effects. The presence of similar channels in Canada would have important implications for monetary policy transmission. We trace the impact of shifts in non-price household credit conditions through joint estimation of a system of error-correction equations for Canadian aggregate consumption, house prices and mortgage debt. We find strong evidence that, after controlling for income and household portfolios, easier credit conditions raise house prices, debt and consumption. However, unlike in the United States, housing collateral effects on consumption are absent. Given credit conditions, rising house prices increase the mortgage down-payment requirement and reduce consumption, although there is evidence for some attenuation of this effect over the 2000s. We also find that high and rising levels of both house prices and debt since the late-1990s can be mostly explained by movements in incomes, housing supply, mortgage interest rates and credit conditions, suggesting that the outlook for house prices and debt could depend mainly on the future paths of these variables.

JEL classification: E02, E21, E44, G21, R21 and R31
Bank classification: Credit and credit aggregates; Domestic demand and components; Economic models; Financial institutions; Financial stability; Financial system regulation and policies; Housing; Transmission of monetary policy

Résumé

Il est communément admis qu'aux États-Unis, une hausse des prix des logements induit un accroissement de la consommation par le biais d'effets de garantie, et peut-être de richesse. Or, l'existence de tels canaux au Canada aurait des conséquences considérables pour la transmission de la politique monétaire. Nous retraçons les effets de variations des modalités non tarifaires du crédit à la consommation, grâce à l'estimation simultanée d'un système d'équations à correction d'erreurs de la consommation globale, des prix des logements et de la dette hypothécaire intérieurs. Notre analyse, qui tient compte des effets du revenu et des portefeuilles des ménages, nous permet de conclure qu'un assouplissement des conditions du crédit fait augmenter les prix des logements, la dette et la consommation. Toutefois, contrairement à ce qui est observé aux États-Unis, des effets de garantie immobilière ne se font pas sentir sur la consommation au Canada. Dans des conditions de crédit données, le renchérissement des logements resserre les exigences de mise de fond des prêteurs hypothécaires et réduit la consommation, quoique l'on note des signes d'atténuation de cet effet dans les années 2000. Nous constatons en outre que les niveaux élevés et croissants des prix des logements et de la dette des ménages depuis la fin des années 1990 peuvent en grande partie s'expliquer par des variations des revenus, de l'offre de logements, des taux d'intérêt hypothécaires et des conditions du crédit, ce qui donne à penser que les perspectives d'évolution des prix des logements et de la dette pourraient dépendre surtout de la trajectoire future de ces variables.

Classification JEL : E02, E21, E44, G21, R21, R31
Classification de la Banque : Crédit et agrégats du crédit; Demande intérieure et composantes; Modèles économiques; Institutions financières; Stabilité financière; Réglementation et politiques relatives au système financier; Logement; Transmission de la politique monétaire

Non-Technical Summary

What are the interactions between credit markets, housing markets and the real economy? How do these real-financial interactions affect the transmission of monetary policy and determine economic outcomes? How can the buildup of destabilizing forces in house prices and household balance sheets be detected? These are some of the important questions facing policy-makers and researchers in the aftermath of the 2008–09 global financial crisis (Kohn 2009; Poloz 2015).

This paper builds a model of real-financial linkages in the household sector. We explore the long-run drivers of aggregate consumption, national house prices and mortgage debt in Canada over the past three decades and compare our empirical results with findings from other countries. We estimate a credit conditions index (CCI) that accounts for the common long-run variation in consumption, house prices and mortgage debt that is not explained by economic and demographic factors. The estimated CCI matches well with the history of institutional changes in Canada's housing finance system and with growth in household credit aggregates. We show that standard models that exclude controls for credit conditions yield far weaker empirical results.

Canada appears to share similarities with the United States, the United Kingdom, Australia, France, Germany and South Africa in that shifts in credit conditions have real economy effects on consumption as well as effects on household balance sheets. However, we find that Canada differs from the United States, the United Kingdom, Australia and South Africa over most of our sample in that, notwithstanding changes in credit conditions, the dominant effect of higher house prices relative to income is to reduce consumption by increasing the amount of savings required for a mortgage down payment. Canada shares this characteristic with France, Germany and Italy. But we also find some evidence that the negative house price effect was attenuated with easier credit access in the 2000s.

Our results also highlight an important feature about Canada's monetary policy transmission mechanism: a decrease in mortgage interest rates initially raises consumption, but there are some offsetting effects via higher house prices and debt levels that take longer to materialize. Consumption adjusts to changes in interest rates within around 1½ to 2 years, whereas house prices and mortgage debt take closer to 5 years. Finally, we find that the high and rising real house prices and debt levels in Canada since the late 1990s can mostly be attributed to long-run movements in incomes, housing supply, declining mortgage interest rates and increased access to credit. Our evidence suggests that the outlook for Canadian house prices and mortgage debt levels depends on the future paths of these variables.

1. Introduction and motivation

The global financial crisis (GFC or great crisis) showed that interactions between credit conditions, asset prices and real economic variables could play a crucial role in determining economic outcomes. The U.S. foreclosure crisis, the rising volume of bad loans and the falling house prices undermined financial contracts such as mortgage loans and asset-backed commercial paper. This made lenders, investors and consumers more worried about risks. The resulting cuts in lending and spending caused an economic recession and, in turn, a worsening of financial tensions. Extraordinary policy measures, including liquidity injections, exceptionally low policy interest rates and fiscal stimuli, were needed to break an intensifying vicious circle.

Unfortunately, existing macroeconomic models were not very helpful in guiding policies at the time of the crisis, as they allowed for too few linkages between real and financial variables (Muellbauer 2010). A goal of this paper is to build a model that can capture real-financial interactions in the household sector. Other approaches have been developed to capture real-financial linkages in the household sector, including dynamic stochastic general equilibrium (DSGE) models with a housing sector and a financial accelerator mechanism developed by Iacoviello (2005), Iacoviello and Neri (2010), and Christensen et al. (2009). Such models can be useful in thinking about general equilibrium issues but leave out important aspects of reality. For instance, they either exclude the down-payment mechanism and the implied saving behaviour or conflate it with the housing collateral mechanism, without allowing for time variation in either. Also, they may not capture non-linear or time-varying relationships between economic activity and credit conditions.

The starting point for our analysis is the multi-equation approach developed by Muellbauer and Williams (2011) for Australia, Duca and Muellbauer (2013) for the United States, and Aron and Muellbauer (2013) for South Africa. This approach gives partial equilibrium models that are smaller, more tractable and that can be estimated with standard econometric techniques. This multi-equation approach, which endogenizes house prices, has great advantages over single-equation approaches attempting to link consumption and house prices or housing wealth. In determining consumption, house prices and mortgage credit levels (Chart 9.1), our approach takes into account cointegration relationships with wealth (Chart 9.2), income expectations, the housing user cost and interest rates (Chart 9.3). In addition, it produces an index of non-price credit conditions faced by households and incorporates potential interaction effects between credit conditions and economic variables.

A key feature of our multi-equation approach is its ability to capture the credit and monetary policy channels operating on households, for example, via house prices. Life-cycle consumption theory extended to include housing (but not mortgage credit constraints) suggests that, in aggregate, higher house prices probably lower the standard national accounts measure of consumer spending (Aron et al. 2012). However, the credit channel should be crucial to understanding real-world responses of consumption to house prices.

There are two potential mortgage credit constraints. The first is the down-payment constraint whereby mortgage lenders, facing asymmetric information, require borrowers to make a substantial down payment on a home purchase. The second, particularly relevant in fixed-rate mortgage markets, is the home equity constraint. This concerns the terms and costs of extending further secured loans to existing homeowners, enabling home equity withdrawal for consumption or investment purposes. In some countries, home equity loans are either unavailable, or the costs and regulatory arrangements are too high for such loans to be widely used. In countries or periods in which the ratio of the required down payment to home value is high and where home equity loans are unavailable, higher house prices relative to income tend to reduce aggregate consumption, as would-be homebuyers need to save more for a down payment. Moreover, renters are likely to be more cautious about spending, realizing that higher rents tend to follow higher house prices. In countries or periods in which down-payment ratios are small and home equity loans are readily available, aggregate consumption tends to rise with higher house prices. The foregoing has important implications for understanding how credit liberalization is likely to affect mortgage markets, housing markets and consumer spending. It is also important for understanding monetary policy transmission: interest rates have important effects on house prices and debt and hence, indirectly as well as directly, on consumption. The multi-equation (systems) approach used in this paper makes it possible to trace through these mechanisms.

Applying this approach to Canadian data proved challenging because there are four key unobserved variables for which no direct data exist. One is the measure of non-price credit conditions (see Section 2). The other three unobserved variables are housing liquidity (HLI) (see Chart 9.4), housing user cost and investor demand. In addition, there are data challenges for some of the observed variables. For instance, while long samples are required to differentiate between cyclical movements in trending variables and to estimate in levels, some variables are available only on a quarterly basis from the early 1990s. Also, adjustments needed to be made to publicly available data to generate series such as non-property income and disaggregated household wealth. We discuss our approach to these modelling challenges in Section 5.

The main findings of the paper are as follows:

- We estimate a latent variable, a non-price credit conditions index (CCI) (see Chart 9.5), which captures the common long-run variation in consumption, house prices and mortgage debt not explained by economic and demographic fundamentals. The estimated CCI is consistent with the institutional history of Canada's housing finance arrangements and with growth in household credit aggregates (Chart 9.6). Canada shares similarities with the United States, the United Kingdom, Australia, France, Germany and South Africa[1] in that shifts in credit conditions have real economy effects on consumption and on household portfolios.

- We find highly significant speeds of adjustment toward long-run fundamentals in each equation, estimated using quarterly data for 1982Q1 to 2015Q1. Standard models that exclude controls for credit conditions yield far weaker empirical results.

- Canada's institutional arrangements appear to have encouraged home equity lending for investment, contributing to the post-1990s' increases in house prices and mortgage debt, but not consumption. The absence of a detectable housing collateral channel could be due to Canada's conservative mortgage institutions, mostly full-recourse lending, borrowers' exposure to interest rate risk via relatively short mortgage renewal periods, and non-deductibility of mortgage interest for personal residences. Households are then less inclined to borrow to consume housing capital gains.

- In the absence of a housing collateral channel (unlike in the United States, the United Kingdom, Australia and South Africa), higher house prices to income have an overall negative impact on consumption, given credit conditions. This is because the dominant effect is to raise the mortgage deposit requirement and induce higher saving. France, Germany and Italy share this trait. We find some evidence that the negative house price effect was attenuated with easier credit access since the 2000s, implying that in recent years the overall effect of higher house prices on aggregate consumption in Canada was only modestly negative or even zero.

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1. For international evidence and additional references, see Aron et al. (2012) for the United States, the United Kingdom and Japan; Muellbauer and Williams (2011) for Australia; Chauvin and Muellbauer (2013) for France; Geiger, Muellbauer and Rupprecht (2014) for Germany; and Aron and Muellbauer (2013) for South Africa.

- High and rising real house prices in Canada since the late 1990s can be mostly explained by long-run movements in incomes, housing supply, mortgage interest rates and credit conditions. This implies that the outlook for house prices depends largely on the future paths of these variables. For example, mortgage rates will at some point rise from historically low levels. All else being equal, and under certain assumptions, our model suggests that a 100 basis point rise in mortgage rates from, say, 2.5 to 3.5 per cent would decrease real house prices by about 12 per cent over the subsequent 5 years. It is difficult to be overly precise about these estimates and, in practice, higher mortgage rates could be correlated with stronger incomes that could provide some partially offsetting support for house prices. These aspects would need to be taken into account in a more refined projection.

The paper is organized as follows. Section 2 explains the Latent Interactive Variable Equation System (LIVES) methodology. Section 3 outlines the theoretical lineage of the three equations (consumption, house prices and mortgage debt). Section 4 provides the institutional backdrop for the estimations, summarizing the major developments that have affected household borrowing conditions in Canada over the past 30 years. Section 5 summarizes the data and discusses the approaches used for the observed and unobserved variables. Section 6 outlines the empirical results. Section 7 concludes. Four appendices are included with further details about the following: the solved-out consumption function; the income forecasting equation; Canada's housing finance system; and data sources, variable construction and descriptive statistics.

2. Methodology used to estimate latent credit conditions effects

For Canada, time-series data do not exist to measure the non-price impact of continuously evolving credit system regulations and financial innovation on households' access to credit.[2] We use a Latent Interactive Variable Equation System (LIVES) to control for the jointly estimated impact of unobserved shifts in non-price household borrowing conditions, after controlling for economic and demographic fundamentals. The latent variable we estimate is best interpreted as a measure of non-price shifts in households' access to mortgage credit (Chart 9.5). We also explore a proxy to control for shifts in access to home equity loans (Chart 9.4).

2. The Bank of Canada collects data on price and non-price credit conditions in the *Business Outlook Survey* (BOS) and *Senior Loan Officer Survey* (SLOS), but neither survey addresses lending conditions for households. By contrast, in the United States, the Federal Reserve's *Senior Loan Officer Opinion Survey of Bank Lending Practices* provides useful information on unsecured credit conditions since 1966 and on the mortgage market since 1990. However, since much of subprime lending occurred outside the main banks surveyed, the latter gives only a partial picture for the 2000s.

The LIVES method has been developed across several related empirical papers (Muellbauer and Williams 2011; Duca, Muellbauer and Murphy 2015; Duca and Muellbauer 2013; Aron and Muellbauer 2013; Chauvin and Muellbauer 2013; and Geiger, Muellbauer and Rupprecht 2014). We jointly estimate a system of three equilibrium correction models for consumption, house prices and the mortgage stock using full information maximum likelihood (FIML). We hypothesize that the long-run time series in each equation are approximately cointegrated through their possession of an unobserved stochastic trend. This latent influence is germane to all equations in the system and causes an evolving, structural mean-shift (see, for example, Stock and Watson [1988], and Hendry [1997] on co-breaking). There may also be interaction effects between selected regressors and the latent variable or the proxy for access to home equity loans.

Each equation contains the latent variable defined as a spline function composed of a linear combination of smoothed step dummies (discussed below). The spline function has a scaled effect in each equation but its slope coefficients are common and jointly estimated. The function captures time variation in the intercept and, via interaction effects, the parameters of key explanatory variables in each equation. This latent variable approach is somewhat different from the literature on time-varying cointegration (Bierens and Martins 2010; Park and Hahn 1999) in that the time variation in our study has an explicit economic interpretation in each equation. This permits the use of institutional knowledge about developments in Canadian housing finance systems, consumption theory and parameter estimates from comparable international studies in order to impose priors on key parameters in the system (including the slope and scale coefficients of the spline function).

The generalized LIVES approach is

$$\Delta y_{it} = \varphi_i(\alpha_{i0} + \kappa_i CCI_t + \sum_j \acute{\alpha}_{ijt} z^*_{ijt-1} + \sum_p \alpha_{ip} z_{ipt-1} - y_{it-1}) + \sum_q \acute{\beta}_{iqt} \Delta x^*_{iqt} + \sum_v \beta_{iv} \Delta x_{ivt} + \varepsilon_{it} \quad (2.1)$$

where $i \in [c, h, m]$,

$\kappa_i \equiv 1$ for equation $i = h$,

$\acute{\alpha}_{ijt} z^*_{ijt-1} = \alpha_{ij} z^*_{ijt-1} + \alpha^*_{ij} CCI_t(z^*_{ijt-1} - \overline{z_{ij}})$, and

$\acute{\beta}_{iqt} \Delta x^*_{iq} = \beta_{iq} \Delta x^*_{iqt} + \beta^*_{iq} CCI_t(\Delta x^*_{iqt} - \overline{\Delta x_{iq}})$.

Here, y_i is the dependent variable for equation i, φ_i is the corresponding speed of adjustment to equilibrium and α_{i0} is the intercept or autonomous level of the dependent variable. c, h, m denote the three equations in the system. A spline function representing the unobserved variable (CCI) causes a series of shifts in the intercept scaled by κ_i in each equation. There are two types of long-run explanatory variables: z^*_{ij} are long-run explanatory variables that are tested for an interaction with CCI (that is, whether their coefficients, $\acute{\alpha}_{ijt}$, are time-varying with credit conditions, CCI); z_{ip} are long-run explanatory variables that are not interacted with CCI (that is, their coefficients α_{ip} are time-invariant). There are also two types of short-run variables. Δx^*_{iqt} are short-run explanatory variables that are tested for an interaction with CCI (that is, whether their coefficients $\acute{\beta}_{iqt}$, are time-varying with credit conditions). Δx_{ivt} are short-run explanatory variables that are not interacted with CCI (that is, their coefficients β_{iv} are time-invariant). All parameters should, in principle, be uniquely identified[3] with the exception of κ_i, which we set to 1 in the house price equation.

The history of Canadian credit markets (see Section 4 and Appendix 3) suggests rolling, almost continuous changes in institutional arrangements over recent decades. Our general-to-specific approach allows for this possibility. The spline function is defined as a linear combination of smoothed step dummies (SSD). (See Appendix 4.) We first estimate a very general spline function in the system and then simplify it by omitting insignificant dummies. CCI equals the linear combination of the (significant) dummies, where the jointly estimated slope coefficient on each dummy is τ_s. We opt initially to include a dummy every two years (1982Q1, 1984Q1, 1986Q1 and so on) plus an extra dummy around the GFC. We find this strategy is sufficiently general to detect the major latent variable effects on consumption, house prices and debt (see Section 6.4).

$$CCI = \sum_{s=1} \tau_s SSD_s \tag{2.2}$$

We therefore hypothesize that the I(1) long-run variables y_i, z^*_{ij}, z_{ip} are cointegrated subject to a mean-shift for y_i and z^*_{ij} captured by CCI. The system is directly estimated since this approach provides efficient estimation of the long-run relationships (Banerjee et al. 1986; Kremers et al. 1992), such as those between consumption, income and wealth;[4] or between house prices, incomes per house and the user cost. The strong significance of the long-run parameters and of the speeds of adjustment implies, and is implied by, cointegration. We apply standard cointegration tests on the parsimonious estimated models as robustness checks (see Section 6.5).[5]

3. In practice, where data have insufficient independent variation, estimates of interaction effects can be quite imprecise and then all but the most economically relevant parameters can be omitted.
4. For example, Craigwell and Rock (1995) estimate a solved-out consumption function using Canadian data and find a single cointegrating vector (they use the unemployment rate as a proxy for liquidity constraints).
5. To be precise, because models with interaction effects fall outside the standard linear cointegration framework, linear cointegration tests are applied to versions of the model without interaction effects.

3. Theoretical models of consumption, house prices and mortgage debt

This section sets out the theory underpinning the long-run consumption, house prices and mortgage debt specifications that are used to estimate the CCI-inclusive system.

3.1. Consumption

The cornerstone of the consumption model is the Ando-Modigliani-Brumberg-Friedman "solved-out" consumption function whereby an Euler equation solution is substituted into the inter-temporal budget constraint (see Muellbauer and Lattimore 1995). The solved-out approach permits estimation in levels, thereby retaining long-run information on consumption, income and assets, and is adaptable for policy evaluation.

The classical solved-out function is

$$c_t = \frac{1}{\omega} W_t = \left(\gamma^* A_{t-1} + y_t^p\right). \tag{3.1}$$

Aggregate consumption (c) depends on household lifetime net worth (W) scaled by the per period inverse marginal propensity to consume out of lifetime wealth, $1/\omega$ (see Appendix 1). W consists of the end-of-period household real net asset endowment (A_{t-1}) and the present value of permanent non-property household gross disposable income (y^p). The marginal propensities to consume out of these are, respectively, $\gamma^*$and 1. Non-property income (y) refers to labour income plus net transfers. Since $\gamma^*$is the return on net assets (embodying property income such as dividend, rent and interest), it is appropriate to exclude property income from other measures of household income used in the consumption function (Blinder and Deaton 1985). All variables are real per capita levels.

Linearizing in logs, Equation (3.1) becomes

$$\ln c_t/y_t \approx \alpha_0 + \gamma A_{t-1}/y_t + \psi E_t \ln(y_t^p/y_t) \tag{3.2}$$

where the log consumption to income ratio ($\ln c_t/y_t$) is composed of three elements. First, there is (time-invariant) autonomous consumption share, α_0. Second, there is the ratio of net household wealth (at end of period t-1) to income, A_{t-1}/y_t, scaled by the marginal propensity to consume out of assets ($\gamma = \gamma^*$). Assets are assumed to be homogenous such that $\gamma = \bar{\gamma}$ for all asset types. Third, there is the expected log ratio of permanent to current non-property income, $E_t \ln(y^p/y_t)$, scaled by (ψ) to allow for a generalization of the strict permanent income hypothesis. $\ln(y_t^p/y_t)$ can be approximated by a weighted moving average of forward-looking income growth rates (Campbell 1987), where k is the time horizon and δ is the discount factor applied to future income (see Appendix 2):

$$\ln(y_t^p/y_t) = \left(\sum_{s=1}^{k} \delta^{s-1} \ln y_{t+s}\right) / \sum_{s=1}^{k} \delta^{s-1}) - \ln y_t. \qquad (3.3)$$

The discount factor δ is assumed to be well below $1/(1+r)$ where r is a risk-free real rate of interest. Together with $\psi < 1$, this reflects the theories, under income uncertainty, of liquidity-constrained consumption of Deaton (1991) and of precautionary saving of Carroll (2001). Both authors argue that many households discount future income more heavily than in the simple textbook model.

The dynamic version of Equation (3.2) is

$$\Delta \ln c_t \approx \varphi(\alpha_0 + \gamma A_{t-1}/y_t + \psi E_t \ln(y_t^p/y_t) + \ln(y_t/c_{t-1})) + \lambda \Delta \ln y_t \qquad (3.4)$$

where φ is the speed of adjustment to equilibrium and $\Delta \ln y_t$ is the change in log current income. The latter term allows for some time-invariant proportion of households (λ) that are constrained by myopia, liquidity constraints, inattentiveness or use of rules-of-thumb (Campbell and Mankiw 1989, 1991; Gali, Lopez-Salido and Valles 2004; Reis 2006). Equation (3.4) assumes no shifts in the age structure of the population or other factors; constant real interest rates; homogenous net assets ($\gamma = \bar{\gamma}$); and that credit constraints are time-invariant and only affect consumption by determining the proportion of Keynesian consumers, λ.[6] Note that equations (3.2) and (3.4) are homogenous of degree one such that doubling income and assets doubles consumption.

To generalize the model, including introducing controls for time-varying credit access and allowing marginal propensities to consume of assets to vary by asset type, we augment Equation (3.4):

$$\Delta \ln c_t \approx \varphi(\alpha_0 + \kappa_c CCI_t + \acute{\alpha}_{1t} r_{t-1} + \gamma_1 NLA_{t-1}/y_t + \gamma_2 IFA_{t-1}/y_t + \acute{\gamma}_{3t} HA_{t-1}/y_t + \acute{\alpha}_{2t} \ln(hp_{t-1}/y_{t-1})$$
$$+ \acute{\psi}_t E_t \ln(y_t^p/y_t) + \ln y_t/c_{t-1}) + \acute{\lambda}_t \Delta \ln y_t + \acute{\beta}_{1t} \Delta ue_t \,. \qquad (3.5)$$

Here, the autonomous consumption share now includes the intercept (α_0) and a credit conditions index (CCI) with coefficient κ_c; r is the real household borrowing rate; NLA_{t-1}/y_t is the ratio of net liquid assets (cash and

6. Income endogeneity is almost irrelevant given the long-run unity restriction imposed on $\ln y_t$ and since long-run movements in A_{t-1}/y_t are dominated by movements in the numerator. Geiger, Muellbauer and Rupprecht (2014) found that "instrumenting the income denominator makes virtually no difference to the estimated coefficients on asset to income ratios." In a wider system, income, asset prices and the portfolios held by households at the end of the previous quarter are, of course, endogenous. Nevertheless, important insights for policy and for short-term forecasting can be obtained from the partial system. Note that λ turns out to be statistically zero in CCI-inclusive estimations for Canada.

cash-like assets less household debt) to non-property income; IFA_{t-1}/y_t is the ratio of illiquid financial assets (financial assets less liquid assets) to income; HA_{t-1}/y_t is gross housing assets to income; $\ln(hp_{t-1}/y_{t-1})$ is the log ratio of real house prices to income; $E_t\ln(y_y^p/y_t)$ is the log ratio of permanent to current income (see Appendix 2); and Δue is the change in the unemployment rate as a proxy for income uncertainty (Kimball 1990). Time subscripts on key parameters denote the form $\acute{\alpha}_{jt}z = \alpha_j z + \alpha_j^* CCI_t(z - \overline{z})$, where $\acute{\alpha}_{jt} = \alpha_j + \alpha_j^* CCI_t$ is the total coefficient on (de-meaned) explanatory variable z subject to potential non-linear parameter shifts due to CCI. If there are no parameter time shifts ($\alpha_j^* = 0$), then $\acute{\alpha}_{jt} = \alpha_j$.

We now explain Equation (3.5) in more detail. The intercept comprises $\alpha_0 + \kappa_c CCI_t$, where the latter term controls for fluctuations in long-run $\ln c/y$ due to (unobserved) shifts in household credit access, particularly mortgage credit access. Due to imperfect information, real interest rates do not perform a Walrasian auctioneer's role in clearing the credit market. Rather, lenders rely on non-price constraints such as down payments ("the skin in the game"), debt servicing capabilities and other screening technologies—that evolve through time—to mitigate default risk. As mortgage credit access evolves, households without collateral may need to forego more or less current consumption to save for a deposit. This affects long-run $\ln c/y$ and its obverse, the household savings rate. Movements in log real house prices to income ($\ln hp/y$) could be partially offsetting because, notwithstanding changes in credit availability, higher house prices could still necessitate larger deposits and therefore more saving by younger households hoping to enter the housing market.

Whereas equations (3.1), (3.2) and (3.4) assume homogenous assets, Equation (3.5) adopts a three-part disaggregation of household net worth whereby the marginal propensity to consume out of assets depends on liquidity and credit access. This disaggregation is possible by virtue of working with asset levels relative to income rather than log levels (see Appendix 1). Liquid assets and debt can be used to buffer against unanticipated income fluctuations and may therefore have a higher marginal propensity to consume (MPC) compared with other asset types (Otsuka 2004). Subject to the state of mortgage market liberalization, housing collateral could also be used as a buffer stock (Miles 1992; Parkinson et al. 2009). Muellbauer and Williams (2011) and Aron et al. (2012) find that countries with deep mortgage markets and easier access to home equity loans,[7] such as Australia, the United Kingdom and the United States, have a positive housing-wealth MPC that drifts upward as credit conditions become easier. Households with existing housing wealth can spend some of

7. Other things being equal, access to home equity loans tends to be easier with floating-rate mortgages since there is no prepayment risk for lenders when the interest rate alters.

their capital gains through refinancing or drawing against home equity loan products that became popular through the latter half of the 1990s.[8]

Life-cycle/permanent income hypothesis theory predicts that, in the absence of credit effects, price-induced housing-wealth effects on aggregate consumption are small or possibly negative (Muellbauer 2008).[9] Empirical evidence suggests that countries with shallow mortgage markets (conservative down-payment requirements) and no home equity loans, such as Japan (Aron et al. 2012), France (Chauvin and Muellbauer 2013) and Germany (Geiger, Muellbauer and Rupprecht 2014) exhibit negative housing-wealth effects. The foregoing discussion motivates a three-fold disaggregation of household net worth (see Chart 9.2): net liquid assets (NLA, defined as cash and short-term deposits less household debt); illiquid financial assets (IFA, defined as financial assets less liquid assets and therefore mostly directly held pension assets, life insurance and securities); and gross housing assets (HA), where the latter is potentially subject to a parameter shift with access to home equity loans.

A further consideration is that easier credit access could facilitate greater inter-temporal consumption smoothing. In Equation (3.5), this would imply a positive drift in the coefficient on expected future income growth ($\acute{\psi}_t$), a negative drift on the coefficient for (time-varying) real interest rates ($\acute{\alpha}_{1t}$), a downward drift toward zero on the current income growth coefficient as the proportion of non-life-cycle hypothesis (LCH) consumers declines ($\acute{\lambda}_t$), and an upward drift toward zero on the change in the unemployment rate coefficient ($\acute{\beta}_{1t}$) for the same reason.[10] Equation (3.5) includes the current income growth term, but the proportion of non-LCH consumers ($\acute{\lambda}$) is now more attributable to "rules of thumb," myopia or lack of sophistication since liquidity constraints are already embodied in CCI.

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8. For Canada, this remains an open question. For example, Bailliu, Kartashova and Meh (2012) and Kartashova and Tomlin (2013) examine post-1999 household survey data. The former study finds that growth in residentially secured debt (what they call "home equity extraction") positively affected consumption and home renovation investment. The latter study finds that house prices are positively associated with homeowners' non-mortgage debt and that, in turn, non-mortgage debt positively contributes to non-housing consumption. Both studies interpret their findings as evidence of a positive link between house prices/debt and consumption. However, an alternative interpretation of their evidence is that shifts in credit access (for mortgages and/or consumer credit) are *jointly* affecting consumption, house prices and debt in a manner similar to CCI.

9. This is because higher house prices induce a negative income effect that offsets or, under reasonable assumptions, dominates the positive wealth impact. The observed effect on aggregate consumption is actually the net of these effects.

10. However, an increased debt level increases household vulnerability and may neutralize these potential shifts of coefficients. In Section 6.1, we also show a version of Equation (3.5), adding controls for demography since life expectancy and population age structure could also affect consumption (Bosworth 2012; Bosworth, Burtless and Sabelhaus 1991).

Finally, it is important to recognize that all of the above are testable hypotheses. Under the following six testable restrictions, Equation (3.5) reduces to the classical model in Equation (3.4): (i) $\kappa_c = 0$ so that $\alpha_0 + \kappa_c CCI_t = \alpha_0$; (ii) $\gamma_1 = \gamma_2 = \acute{\gamma}_{3t} = \bar{\gamma}$; (iii) $\acute{\alpha}_{1t} = \alpha_1$; (iv) $\acute{\psi}_t = \psi$; (v) $\acute{\lambda}_t = \lambda$; and (vi) $\acute{\beta}_{1t} = \beta_1$. To preview the findings set out in Section 6.1, we can reject hypotheses (i) and (ii) but not (iii), (iv), (v) (in fact, $\hat{\lambda}$ is statistically zero in CCI-inclusive estimations) and (vi).

3.2. House prices

This section explains the functional form of the house price equation. We follow a supply-and-demand approach to determining house prices. In this approach, the housing demand function is

$$\ln hs = \alpha_0 + \alpha_1 \ln y - \alpha_2 \ln rent + \sum \alpha_f D \quad (3.6)$$

where hs is housing services (measured by the real per capita net dwelling stock); y is household real per capita non-property income; $rent$ is the price of housing services;[11] and D is a vector of other factors that shift the demand curve. The income elasticity is α_1 and the own-price elasticity is α_2. An efficient housing market where households optimize the rent versus own decision, in the absence of credit constraints, implies that $rent = hp.ucc$, where hp is the real house price and ucc is the real housing user cost of capital. We can therefore invert the housing demand function as

$$\ln hp = (\alpha_0 + \alpha_1 \ln y - \ln hs + \sum \alpha_f D)/\alpha_2 - \ln ucc. \quad (3.7)$$

The real housing user cost (ucc) can be represented, at least theoretically, as

$$ucc = r^* + t + c + dep + risk - E_t(\dot{hp}/hp) \quad (3.8)$$

where the real after-tax opportunity cost is r^*; property tax costs are t; transaction costs amortized over the ownership period are c; depreciation costs are dep; the risk premium required to compensate home ownership is $risk$; and, as an offset to these costs, expected housing capital gains are $E_t(\dot{hp}/hp)$.

The inverse housing demand function in Equation (3.7) has several useful characteristics. First, it has a clear consumption theory foundation. Since the stock of established housing is large relative to the flow of net new supply, supply can be assumed to be fixed except in the long run. The housing supply process is $\mathrm{H_t} =$

11. $rent$ is unobserved, since we can only impute the price of housing services that owners charge themselves. Market rent data are not a good proxy, given that the characteristics of owned and rented homes are different.

$(1-\delta)H_{t-1} + C_t$ where H is the stock of housing, δ is depreciation and C is gross new completions. In the steady state $H_t = H_{t-1}$ so C is simply constant at the replacement rate ($C = \delta H$).[12] Since C_t is extremely small relative to H_t, and is itself a function of construction already in progress, housing supply at any point in time is mostly determined by H_{t-1}. This implies that, except in the long run, changes in house prices can be attributed to disequilibrium between demand and supply, caused predominately by shifts in demand.

Second, our approach has recourse to international literature that can provide plausible ranges of values for key parameters. (For the United Kingdom, see Buckley and Ermisch 1982; Meen 1990, 1996, 2000, 2002; Miles 1992; Meen and Andrew 1998; Muellbauer and Murphy 1997; Cameron, Muellbauer and Murphy 2006. For the United States, see Poterba 1984, 1991; Mankiw and Weil 1989. For Australia, see Tu 2000; Oster 2005; Abelson et al. 2005; Williams 2009; Muellbauer and Williams 2011.) Time-series evidence suggests that the income elasticity of housing demand (α_1) should be around 1 and the own-price elasticity (α_2) between about (minus) 0.5 and 1, implying that the elasticity of house prices to income, given the stock, (α_1/α_2) should lie between 1 and 2.

We augment Equation (3.7) to test for potential credit conditions effects and for a nominal interest rate effect[13]

$$\ln hp_t \approx h_0 + \kappa_h CCI_t + h_2(h_1 \ln y_{t-1} - \ln hs_{t-1}) + h_3 \ln ucc_{t-1} + h_4 \ln i_{t-1} + \sum h_f D_{t-1} \qquad (3.9)$$

where the intercept is h_0; CCI is a credit conditions index controlling for latent shifts in borrowing conditions, particularly mortgage down-payment requirements;[14] y is real per capita non-property income; hs is real per capita net dwelling stock; i is the nominal mortgage borrowing rate; D is a vector of other long-run demand-side variables; and ucc is the real housing user cost. The parameter $\kappa_h \equiv 1$ is the direct long-run effect of CCI on housing demand normalized to 1 to uniquely identify the components of CCI (see Section 2); the income elasticity of housing demand is $h_1 = \alpha_1$; the inverse own-price elasticity of housing demand is $h_2 = 1/\alpha_2$; h_3 is the elasticity of real house prices with respect to the real user cost and is freely estimated to allow for the

12. In the national accounts, Statistics Canada treats δ as a constant 2 per cent per annum.
13. Standard mortgage amortization contracts fix periodic repayments in nominal terms; while, due to asymmetric information, lenders impose repayment/income-based borrowing tests. The interaction of these two institutional features may give rise to nominal interest rate effects beyond the real rate effects occurring through the user cost. All else being equal, a fall in inflation and nominal rates raises the maximum qualifying loan size for a given repayment/income ratio. See Kearl (1979), Debelle (2004) and Ellis (2005).
14. The fact that most home purchases involve mortgage finance implies that credit conditions should be a key demand-side influence on house prices, as emphasized by Schembri (2015). We also estimate a model that includes, in addition to CCI, a measure of access to home equity loans, often used by property investors to partly fund the down payment for a conventional mortgage.

possibility that, even in the long run, households do not fully optimize the rent versus own decision (i.e., h_3 does not equal -1 as implied by Equation 3.7); h_4 is the elasticity of real house prices with respect to the nominal mortgage rate; $h_f = \alpha_f/\alpha_2$.

Additional explanatory variables in D could include measures of demographic change, investor demand and housing liquidity. Key gaps in the Canadian data are the lack of data on investor housing purchases, including by foreign investors,[15] and investor mortgage demand. These are important omissions because domestic buy-to-let homeowners could be more sensitive to portfolio considerations, such as net rental cash flow, vacancy risks and prospective relative asset class total returns. Conversely, foreign investors might be less sensitive to domestic economic conditions and policy settings. We explore some of these aspects in Section 6.

3.3. Mortgage debt

This section outlines the specification for the mortgage stock equation. The mortgage debt equation is difficult to ground because consumption theory has little to say about debt levels. The rational expectations permanent income hypothesis (REPIH) with a representative household contains a single, homogenous, net assets term. In practice, households' motivations for holding debt may include the following: human capital investment in education or training; buffering against unexpected income fluctuations; borrowing against anticipated higher future incomes; financing the purchase of lumpy consumer durables, house purchases or home renovations; offsetting suboptimal compulsory pension saving arrangements; and portfolio investment in assets for which the risk-adjusted expected returns are greater than the cost of borrowing (Brueckner 1994).

Credit conditions could be an important determinant of mortgage debt, given asymmetric information (Miles 1992; Brueckner 1994; Leece 1995, 2004; Meen 1990, 1996). Higher incomes, expected incomes, wealth and lower borrowing costs may also be important. Mandatory pension contributions could induce higher mortgage demand as households seek to offset excess savings.[16] Debt levels also appear influenced by demographic changes (Crawford and Faruqui [2012] provide cross-sectional evidence for Canada).

We explored a range of possibilities but settled on a relatively simple long-run mortgage debt specification

15. Ley and Tutchener (2001) highlight the gateway role of several Canadian cities for immigration and international investment flows.
16. The Canada Pension Plan (CPP) compulsory contribution rate has doubled since the mid-1990s (Lammam, Palacios and Clemens 2013).

$$\ln ms_t \approx m_0 + \kappa_m CCI_t + m_1 \ln y_{t-1} + m_2 \ln i_{t-1} + m_3 \ln(HA_{t-1}/y_t) \qquad (3.10)$$

where ms is real per capita mortgage stock (excluding residentially secured personal lines of credit);[17] y is real per capita non-property income; i is the nominal mortgage rate; and $\ln(HA_{t-1}/y_t)$ is the log ratio of housing assets (at end-period t-1) to income. The intercept is m_0; κ_m is the coefficient on CCI; m_1 is the income elasticity; m_2 is the elasticity with respect to nominal interest rates; and m_3 is the elasticity of real per capita mortgage debt with respect to the ratio of housing assets to income.

4. Institutional background to the estimations

This section provides an overview of the institutional backdrop to the empirical estimations. We first discuss some of the main characteristics of Canada's system of household finance. We then summarize major changes that have affected non-price credit conditions (price conditions are explicitly controlled for in the model) since the early 1980s. A more detailed background is provided in Appendix 3.

The Canadian household credit market is national—i.e., lending conditions and products are similar across the country—and is largely dominated by domestic lenders, especially by a few large banks. Mortgage credit represents about two-thirds of that market. Governments can influence non-price credit conditions by changing the terms and conditions for access to mortgage credit insurance, by changing the regulation of lending institutions, or through fiscal incentives. Non-price credit conditions can also be influenced by financial innovations and by developments, such as the GFC, affecting risk perception.

Canada's housing finance system is considered conservative (Klyuev 2008) or prudent (Schembri 2014) by international standards, and it functioned well during the GFC and subsequent recession (Crawford, Meh and Zhou 2013).[18] Schembri (2014) and Crawford, Meh and Zhou (2013) explain that Canada's rigorous regulatory and supervisory framework, coupled with targeted government guarantees of mortgage insurance and securitization products, has a significant impact on mortgage underwriting standards and on the types of

17. Canada measures secured personal lines of credit (PLCs) as consumer rather than mortgage debt, even though about half of such loans are secured by housing. Secured PLCs grew from approximately 7 per cent of consumer credit in the mid-1980s to 50 per cent by 2011 (Crawford and Faruqui 2012). Much of this increase occurred after the mid-1990s, coinciding with the proliferation of home equity loan products.
18. See also Crawford and Faruqui (2012), Kiff (2009) and Traclet (2005). The relative prudence of Canada's housing finance system is reflected in the fact that non-prime mortgages represented about 5 per cent of outstanding mortgages in Canada in 2005, compared with 20 per cent in the United States, and in the fact that mortgage delinquency rates are structurally lower compared with in the United States (Schembri 2014).

mortgage products available.[19] Moreover, certain institutional features may incline households to be cautious in their use of debt. First, most mortgages are subject to full legal recourse.[20] In contrast, a number of U.S. states (Arizona, California, Oregon, etc.) have non-recourse laws; non-recourse mortgages are more prevalent in that country. Second, mortgage interest on a personal residence is not tax deductible in Canada, whereas it is in the United States. Third, about three-quarters of Canadian mortgages are fixed for a period of 5 years or less and the rest are at floating rates, exposing borrowers to greater interest rate risk than in the United States where mortgages are typically fixed for 30 years.[21]

However, Canada's relative prudence does not imply that credit conditions are invariable. Schembri (2015), for example, notes that a broader set of borrowers and lenders have become involved in mortgage finance due to financial liberalization and innovation since the mid-1990s.

We see five distinct periods in the evolution of non-price credit conditions since the early 1980s.

1. A period of easing from 1982 (the beginning of our sample) to 1988. A 1980 amendment to the *Bank Act* allowed banks to have mortgage loan subsidiaries (Freedman 1998), stimulating the supply of mortgage loans. Non-price credit conditions also became easier as the effects of the 1981–82 recession on risk aversion subsided. In addition, there was a marked reduction of yearly inflation from above 12 per cent to around 4 per cent (Chart 9.3), which eased access to credit (Debelle 2004).
2. A period of tightening between 1989 and 1992. This was reflected in tighter bank regulation, including the implementation of the provisions of Basel I and reduced maximum leverage ratios, and heightened risk aversion due to the early 1990s recession.
3. A period from 1992 to about 1999 that we see as undetermined. There were some developments consistent with easier credit conditions (e.g., inflation fell to around 2 per cent, recovery from the early 1990s recession), but others consistent with tighter credit conditions (e.g., reduced competition in the credit market, Asian and Russian crises).

19. Lascelles (2010) provides another good primer on the Canadian mortgage market.
20. Creditors holding non-recourse mortgage loans are prevented from seizing other assets or incomes from borrowers in the event of a default if the proceeds from the sale of the house are not sufficient to pay off the loan and associated legal costs. Recourse loans have the opposite implications. Two provinces, Alberta and Saskatchewan, have a sizable proportion of non-recourse mortgages (Bank of Canada 2015).
21. Kiff (2009) discusses the reasons for this difference.

4. A period of easing from 2000 to 2007. Access to government-backed mortgage insurance was facilitated, markets for mortgage-backed securities developed rapidly, bank regulation eased (lower capital ratios) and new participants entered the household credit market (increased credit supply).
5. A period of tightening from 2008 to now. This was caused by the GFC, by more stringent bank regulations, and by a series of moves to tighten access to mortgage insurance. These tightening developments were partially offset, during the worst of the GFC, by Bank of Canada and government interventions (liquidity injections and fiscal stimuli) to reduce market tensions.

To preview the results set out in Section 6.4, we find that our estimated CCI is broadly consistent with this prior information and is well-correlated with growth in household credit aggregates (see Charts 9.5 and 9.6).

5. Data, variables and specifications

5.1 Data for the observed and unobserved variables

This section provides an overview of the variables and data used to test the specifications for consumption (Equation 3.5), house prices (Equation 3.9) and mortgage debt (Equation 3.10) as outlined in Section 3. The sample contains 133 quarterly observations from 1982(1) to 2015(1). Appendix 4 provides further detail on variables' construction and sources (Table 14.1) and summary statistics (Table 14.2).

There are two types of data, observed and unobserved, and formidable challenges surrounding each. For observed data, the source for the data is predominately national accounts (CSNA 2012), flow of funds money and credit aggregates, and interest rate data from Statistics Canada and the Bank of Canada. We generate a measure of non-property income, essentially net labour income plus net transfer components of household gross disposable income excluding net property income (Blinder and Deaton 1985). Another important issue is the trade-off between data quality and sample length. We estimate in levels because the long-run relationships between variables-in-levels are of most interest to policy-makers (e.g., the appropriate level of real house prices given interest rates, incomes, housing supply, credit access and so on). Because we estimate in levels, a multi-decade quarterly sample is necessary to identify multiple inflection points in trending levels variables such as $\ln c/y$, wealth, house prices, debt, CCI and demographics. The trade-off is that, for some time series, quarterly data are available only from the 1990s and must be spliced with earlier data of lower quality (for example, house prices before 1999)[22] or lower frequency (for example, household wealth before 1990).

For unobserved variables, we generate proxies. The four unobserved variables are the credit conditions index (CCI) for mortgage credit access in all equations;[23] an index of housing asset liquidity (HLI) for access to home equity loans; and the real housing user cost and investor demand in the house price equation. CCI is a jointly estimated latent variable (see Section 2 and Chart 9.5). For HLI (Chart 9.4), we use a four-quarter moving average of the ratio of home equity lines of credit (HELOCs) to mortgage credit. The ratio is set to 0 before 1996Q1 and rebased by subtracting the 1996Q1 value of the series thereafter, since we assume HELOCs were not available in Canada before this time. The real housing user cost is real opportunity costs facing households, plus other ownership costs, less a weighted average of lagged house price growth terms.

Finally, for the house price equation, we explore two variables that could capture in part the role of housing investor demand: a four-quarter moving average of the ratio of immigration from Asia to total immigration; and HLI. The former variable appears to capture the uneven flow of Asian immigrants and soon-to-be house seekers into gateway cities[24] such as Toronto and Vancouver where housing supply is tighter, thereby pushing up national house prices. It might also capture investor demand to the extent that the foreign capital flows into Canadian real estate are linked to family migration from parts of the world where property rights are considered less secure.[25] The second investor proxy is HLI, incorporating the notion that domestic buy-to-let investors have benefited from easier credit access since HELOCs became widely available after about 1996. HLI is also added to the mortgage debt equation on the grounds that HELOC debt and mortgage debt may be complementary.

5.2 Overview of the empirical specifications

This section briefly summarizes the empirical specifications set out in tables 10.1 to 10.4. We present four versions of the system: two versions of the system excluding CCI—one is a “classic” solved-out consumption

22. See Appendix 4.
23. To some extent, the CCI may capture the latent effects of changes in consumer credit access also, since we have not separately controlled for the latter in the consumption equation. We assume mortgage credit access is the dominant latent impact being captured through CCI in the system.
24. See Ley and Tutchener (2001).
25. For example, immigration from Hong Kong was about 10 to 20 per cent of the total yearly migrant intake in the decade preceding the British Government’s 1997 handover to China. Many immigrants were business owners. By 1999, Hong Kong immigration had dropped to less than 1 per cent of the Canadian migrant intake.

model, and the other allows for disaggregated wealth, varying real interest rates and income uncertainty; and two CCI-inclusive systems—one that is relatively simple and another that adds HLI and demography. We find that CCI-inclusive models are markedly superior to CCI-exclusive models.

Consumption equation

Equation (3.5) specifies a long-run relationship between the log ratio of real per capita aggregate consumption ("consumption") to real per capita non-property gross disposable income ("income"); real interest rates; log expected permanent income to current income (see Appendix 2); the ratio of net liquid assets (liquid assets less debt) to income; illiquid financial assets (financial assets less liquid assets) to income; gross housing assets to income, potentially subject to a shift in HLI representing shifts in access to home equity loans; the log ratio of real house prices to income, potentially subject to a shift in CCI; and CCI.[26] We also test the long-term change in the child-to-adult population ratio. In the short run, the model includes lagged consumption growth, current income growth, the change in the unemployment rate, and a differenced impulse dummy for the temporary displacement effect on consumption of the imposition of a goods and services tax (GST) in 1991Q1.

House price equation

Equation (3.9) specifies a long-run relationship between log real national house prices; log real per capita non-property income; the log real per capita net dwelling capital stock; the log nominal mortgage borrowing rate; the log real housing user cost of capital; a four-quarter moving average of the ratio of immigration from Asia to total immigration; the CCI; and the HLI. We also test for age demographics effects. The short-run dynamics include autoregressive terms, the delta unemployment rate, a Q4 seasonal dummy for pre-1988 house price data only (0 thereafter), a differenced impulse dummy for an outlier in 1983Q1 and another for 1987Q2.

Mortgage stock equation

Equation (3.10) specifies a long-run relationship between log real per capita mortgage stock (excluding residentially secured personal lines of credit); log real per capita non-property income; the log nominal

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26. Again, to some extent, the CCI may capture the latent effects of changes in consumer credit access as well since we have not separately controlled for the latter in the consumption equation.

mortgage borrowing rate; log gross housing assets to income; the CCI; and the HLI. In the short run, the empirical model includes the change in the unemployment rate.[27]

6. Results

6.1. Consumption equation results

Estimation results for the long-run consumption equations are set out in Table 10.1. In Column (1), we estimate Equation (3.4). This is the "classic" solved-out consumption equation with habits, constant interest rates, homogenous net assets and no income uncertainty. The speed of adjustment is around 11 per cent per quarter and estimates for net worth and income growth expectations are highly significant. However, the marginal propensity to consume (MPC) out of net worth is low at about 0.02 and the coefficient on income growth expectations is 1.7. The fact that the latter is well above 1 (meaning that households are consuming in excess of the discounted value of expected future income growth) suggests an important omitted variable such as access to credit. Time-invariant liquidity constraints are incorporated via inclusion of a current income growth term with coefficient λ in the short-run dynamics (not shown in the table). Estimated λ is 0.13 (t-stat = 3.0), suggesting that a constant 13 per cent of households are Keynesian consumers.

Column (2) relaxes the previous model by allowing for time-varying interest rates; a three-fold disaggregation of household net worth; income uncertainty (by adding the change in the unemployment rate to the dynamics); and lagged consumption growth (also in the dynamics, to account for durable goods stock-building). The speed of adjustment improves to 14 per cent but, overall, the results remain suggestive of omitted credit channel effects.[28] Real interest rates are not significant. The coefficient on income growth expectations is 1.2. The point estimates for the MPC out of different asset decompositions are 0 for net liquid wealth and gross housing wealth (neither are significant) and 0.04 for illiquid financial wealth (t-stat = 2.4).[29] In the dynamics (not shown), the coefficient on current income growth ($\hat{\lambda}$) is lower at 0.09 (t-stat = 2.1).[30]

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27. We include two lagged autoregressive terms in the CCI-exclusive model but then omit them in the CCI-inclusive specifications since they are not significant.
28. A speed of adjustment of 0.14 implies that its takes about 4 years for 90 per cent of a shock to consumption to dissipate. This is twice as long as conventional wisdom would suggest, given monetary policy lags of around 1½–2 years (see, for example, www.bankofcanada.ca/core-functions/monetary-policy).
29. A recurring feature of the Canadian results is the lack of precision around the coefficients for housing wealth and net liquid assets, since both of these variables are trending variables with few inflection points. However, there have been

In Column (3), we estimate Equation (3.5) that incorporates controls for shifts in household borrowing conditions. That is, compared with Column (2), we have added the CCI and log real house prices to income. CCI can be interpreted as the jointly estimated long-run impact of the relaxation of mortgage down-payment constraints (and possibly also consumer credit constraints) on consumption. The effect of CCI is partially offset by the extent to which higher house prices relative to income raise the deposit required to enter the housing market; and by the fall in net liquid assets relative to income, resulting from the rise in debt made possible by more relaxed credit conditions. With these two additional controls, Column (3) shows a dramatic improvement compared with Column (2). The speed of adjustment more than doubles to around 34 per cent per quarter (t-stat = 5.7). The equation standard error is lower at 0.0042 and the adjusted R squared is 0.61. The coefficient on expected income growth is now much more plausible at 0.8 (t-stat = 5.8). In the dynamics (not shown), current income growth is less important ($\hat{\lambda}$ drops to 0.08, t-stat = 1.8).

Column (4) provides the CCI-inclusive system plus controls for housing liquidity and demographics. Compared with Column (3), the consumption equation adds the long-term change in the ratio of children-to-adult population and an interaction effect between the CCI and the (de-meaned) log real house price to income ratio.[31] The equation standard error is lower at 0.0040 and the adjusted R squared is 0.65. The speed of adjustment is 43 per cent per quarter (t-stat = 6.4). This estimate implies that it takes about five quarters for 90 per cent of a shock to the long-run consumption-to-income ratio to disappear. This is consistent with the generally accepted time frame of monetary policy effects on real variables and similar to estimates for Australia (Muellbauer and Williams 2011) and for the United Kingdom and the United States (Aron et al. 2012). A likelihood ratio test confirms Column (4) is superior to Column (3), and both models are clearly superior to CCI-exclusive approaches in columns (1) and (2).

Consumption is positively affected by easier credit (CCI) but negatively affected by higher house prices relative to incomes, since the former decreases the need to save for a mortgage down payment while the latter increases it. The estimated coefficient on CCI ($\hat{\kappa}_c$) is normalized by the house price equation and is well-determined (t-stat = 3.6): all else being equal, if CCI has a +1 per cent long-run impact on real house prices, it has a +0.19 per cent impact on the long-run consumption-to-income ratio. The coefficient on log real house

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several booms and busts in Canadian financial assets over the past 30 years so we had no difficulty pinning down the coefficient on illiquid financial assets to income at around 0.02–0.04 in all estimations.

30. Also introduced in Column (2) is the delta unemployment rate, with coefficient -0.7 (t-stat = -3.2).

31. We have also added controls for housing liquidity and demographics to the other equations in the system.

prices to income is -0.15 (t-stat = 1.8). We allow for time variation in this parameter in Column (4), whereas in Column (3), we hold it time-invariant.[32] The coefficient on log house prices to income therefore shifts from -0.15 when CCI = 0 to about -0.02 at peak CCI. In other words, roughly 85 per cent of the negative impact of high house prices (given incomes) on consumption is attenuated by easier non-price credit access.[33]

Real household borrowing rates have significant and negative effects as expected. We tested but did not find a significant positive coefficient on deposit interest rates for Canada, unlike in Germany (Geiger, Muellbauer and Rupprecht 2014). This is not surprising since Canadian households are net borrowers. The coefficient on expected income growth is 0.7 (t-stat = 6.5), consistent with the view that, if some households are myopic or face credit constraints, current income as well as permanent income should matter for consumption.[34] Demographic change is proxied by the long-term change in the child-to-adult population, with a modestly significant positive coefficient.[35]

We maintain a restriction of 0.07 for the coefficient on the trend-like net assets to income term, aligned with the freely estimated coefficient in Column (3).[36] The marginal propensity to consume (MPC) out of illiquid financial assets is around 0.02 (t stat = 2.9).[37] The housing-wealth coefficient is statistically zero. We tested but found no significant interaction effect between housing wealth and HLI. The evidence thus suggests there is no standard housing-wealth effect or housing collateral channel for Canada. These findings differ from those of Kartashova and Tomlin (2013); Bailliu, Kartashova and Meh (2012); and Pichette and Tremblay (2003). However, none of

32. In Column (4), we allow for some attenuation of the negative log house price-to-income effect by interacting that term (de-meaned) with the CCI and defining the coefficient as some fraction of the non-interacted coefficient. Its total coefficient is therefore $\alpha_{2t} = \alpha_2 - \alpha_2^* \alpha_2 CCI_t$. We estimate α_2^* to be 1.4 (t-stat = 2.7) times the non-interacted coefficient.
33. We cannot be too precise about the degree of attenuation. For example, we could also accept (via a likelihood ratio test) a model with an imposed restriction that the log house price to income coefficient is fully offset at peak CCI.
34. We tested interaction effects with CCI for real interest rates and expected income growth but these were insignificant.
35. The intuition is that, in comparing steady states, an economy with a lower child/adult ratio will have a broadly similar aggregate household consumption-to-income ratio. But, in the transition to a lower ratio, falls in child-related expenditure will temporarily lower the consumption to income ratio.
36. A likelihood ratio test confirms this is a valid restriction. For Column (3), we also tested the validity of the common coefficient restriction on net liquid assets to income by decomposing the variable into the ratio of liquid assets to income and household debt to income. The coefficient on the former is 0.09 (t-stat = 2.4) and the latter is -0.05 (t-stat = -1.2). A likelihood ratio test confirms no statistically significant difference in system log likelihood by imposing a common coefficient on net liquid assets to income.
37. Note that financial wealth excludes households' claims on the Canada or Quebec Pension Plans. We tested public pension plan assets (the sum of Canada and Quebec Pension Plan assets) separately and as part of illiquid financial assets. The results suggest there are negligible wealth effects from public pension plan assets.

these studies include controls for credit conditions that positively and jointly affect consumption, house prices and debt.[38]

Charts 9.7a and 9.7b decompose the long-run consumption equation for Column (4) in Table 10.1. The charts depict the estimated long-run coefficient multiplied by the explanatory variable. While not a general equilibrium, the charts help to visualize through time the partial equilibrium contributions of each variable to the level of log consumption to income. In the 1980s, easier credit access contributes positively to log consumption to income, partly offsetting the negative impact of rising down-payment requirements caused by higher log house prices to income. The 1990s rise in log consumption to income is mainly explained by higher income expectations, rising financial wealth, lower real interest rates and positive demographic effects. From the late 1990s, flat or declining log consumption to income is attributable to a heavy drag from household indebtedness, moderating income expectations and a rising deposit requirement caused by rising house prices. These factors are partly offset by modest further shifts in credit access and by falling real interest rates.

Charts 9.8a and 9.8b further decompose the model in level and growth terms. Chart 9.8a shows the residual of the cointegrating relationship for consumption, which is strongly stationary for models 3 and 4.[39] This reflects our finding that consumption quickly adjusts to long-run fundamentals within about 1½ years, consistent with the widely accepted time frame of monetary policy real effects. By contrast, the CCI-exclusive models 1 and 2 show wide and persistent deviation between actual consumption and the fitted long-run solution because they exhibit a much longer adjustment horizon of around 4 to 5 years. Chart 9.8b shows quarterly growth in real consumption per capita. About two-thirds of the quarterly variation is explained by our model, most of which is attributable to the equilibrium correction dynamics.

Canada is therefore very different from the United States, where Aron et al. (2012) and Duca, Muellbauer and Murphy (2015) report that the interaction effect of HLI with the housing-wealth-to-income ratio is highly significant in the U.S. consumption equation and implies a coefficient of around 0.05 on the housing-wealth-to-income ratio at the peak value of HLI, and with no offsetting negative effect from house prices/income. Their estimates imply that the combination of rising HLI and rising house prices/income up to 2007 and the

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38. Another reason for Pichette and Tremblay's (2003) finding could be that they restrict the coefficient on housing wealth to be minus that on mortgage debt.

39. The long-run equation residual is typically negative at time t-1 since the regression coefficient-weighted means of the other variables, including the change in the dependent variable, net to a positive value.

subsequent decline of both accounts for much of the variation in the U.S. consumption-to-income ratio from 2000 to 2014. In contrast, Canada's more conservative housing finance arrangements appear to have discouraged housing equity withdrawal for consumption purposes such that there is no housing collateral effect.[40]

6.2. House price equation results

A key finding of this paper is that, in contrast with other studies for Canada (Bauer 2014; Igan and Loungani 2012; *The Economist* 2014),[41] we find that movements in the long-run variables explain most of the movements in house prices. We do not find evidence of persistent, unexplained misalignment. Actual house prices in 2015Q1 are close to their equilibrium value, defined as the sum of the fitted contributions of the long-run explanatory variables (Chart 9.9a). This is not to say Canadian house prices are not historically high, but rather that they have risen along with the evolution of the long-run equilibrium, for example, due to the significant decline in mortgage interest rates and the increased availability of mortgage credit. Equivalently, quarterly house price growth is mostly attributable to equilibrium adjustment dynamics (Chart 9.9b). Our model explains about two-thirds of house price dynamics over the 1982–2015 period.[42]

Estimation results are set out in Table 10.2. Columns denoted (2), (3) and (4) correspond to the same system shown for the consumption equation in Table 10.1 (we omit Column [1] for brevity). We restrict the inverse housing demand elasticity (h_2) with respect to price to 1.8 and the income elasticity (h_1) to 1 (discussed below). Column (2) shows the long-run house price equation without controls for credit access. The speed of adjustment is low at 3.8 per cent per quarter (t-stat = 1.9). This implies, rather implausibly, that it takes about 15 years for house prices to adjust to long-run movements in incomes, interest rates and so on. Coefficients on the long-run

40. Our findings are consistent with Crawford, Meh and Zhou's (2013) view that Canada's institutional arrangements provide incentives for households to pay down debt and build equity. Bailliu, Kartashova and Meh (2012) offer micro-level evidence that residentially secured debt has been used to invest in home renovations. Since 2000, over roughly the same period in which HELOCs became widely available, renovation investment activity has increased from 1.5 to 2.6 per cent of GDP. Klyuev and Mills (2006) also offer some evidence that, unlike the United States, the United Kingdom and Australia, Canada has not witnessed substantial home equity withdrawal (although it is unclear whether the other countries' definition of mortgage debt properly accounts for HELOCs).

41. These studies omit many of the controls we find important (e.g., user cost, housing supply, credit conditions). Given these omissions, it is not surprising that the IMF house price model for Canada shows six out of eight coefficients are insignificant, including the equilibrium speed of adjustment, and the model R-squared is only 0.12.

42. As explained in Section 3.2, changes in house prices in the short to medium run can be interpreted as reflecting disequilibrium between demand and supply caused predominantly by shifts in demand. This is because supply in the short to medium run is highly inelastic (flows of net new housing supply are very small relative to the established stock).

variables are poorly determined, indicative of omitted variable bias. The poor empirical performance of CCI-exclusive models makes sense because most home purchases involve access to credit.

Column (3) shows the CCI-inclusive house price equation. The speed of adjustment is now strongly significant at 10 per cent per quarter (t-stat = 4.4), implying that it takes about 5 years for 90 per cent of a shock to house prices to disappear. This 5-year time frame seems much more consistent with Canada's housing finance arrangements.[43] The equation standard error is lower at 0.015 and the adjusted R squared is now 0.61.
In Table 10.2, we show the restrictions on h_2 and h_1 being maintained, which reduces the number of free parameters in the system and thereby helps pin down estimates for the consumption equation. Freely estimated, h_2 is 1.6 (t-stat=2.5) and inverting this coefficient gives (minus) the elasticity of housing demand with respect to price of 0.6.[44] The freely estimated income elasticity is 0.98 (t-stat = 4.3). The restrictions on h_2 and h_1 are therefore acceptable and in line with the international evidence (see Section 3.2). The estimates roughly imply that doubling real incomes, given the housing stock, raises real house prices by a multiple of three to four.

Column (4) shows the CCI-inclusive model plus controls for housing liquidity and demographics. The speed of adjustment and model fit are unchanged relative to Column (3). The combined coefficient on the two interest rate terms is also unchanged at around -0.5. The elasticity with respect to the user cost is around -0.3 (t-stat = -2.2), much less than the strict theoretical prediction of -1 in Equation (3.7) (i.e., an efficient market model where households optimize the rent-own decision in the absence of credit constraints). The elasticity on the nominal borrowing rate is around -0.2 (t-stat = -1.9). This means that a 100 basis point rise in nominal mortgage rates from, say, 2.5 to 3.5 per cent would reduce long-run house prices by about 7 per cent over the subsequent 5 years. If the real user cost increased as well (assuming unchanged inflation, constants and real capital gains expectations at 2.5 per cent), the combined impact would be around -12 per cent over the subsequent 5 years.[45]

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43. Countries that feature mostly floating-rate mortgages tend to exhibit even faster adjustment speeds. For Australia, where roughly three-quarters of mortgages are at floating rates, the estimated adjustment speed is 24 per cent per quarter, implying that 90 per cent of a shock to house prices disappears after about 2 years (Muellbauer and Williams 2011).
44. This is broadly similar to estimates for other countries. Time-series estimates include -0.5 to -0.6 for the United Kingdom (Meen 1996; Meen and Andrew 1998; Cameron, Muellbauer and Murphy 2006); -0.56 for Australia (Muellbauer and Williams 2011); -0.68 for Germany (Geiger, Muellbauer and Rupprecht 2014); -0.65 for France (Chauvin and Muellbauer 2013).
45. It is difficult to be overly precise about these estimates and, in practice, the rise in mortgage rates could be gradual and correlated with stronger incomes that could provide some partially offsetting support for house prices. Other determinants

Column (4) includes the housing liquidity index as a proxy for the non-price relaxation of credit access for buy-to-let investors. The interpretation is that HELOCs make it easier for investors to find the required deposit to obtain mortgages for their investment properties by withdrawing equity from their existing home(s).[46] Since HELOCs are more expensive than mortgages, they seem to be more of a complement than a substitute for mortgages. Column (4) also includes a small negative impact from the working-age (15–64 years) to total population ratio (the obverse dependency ratio). The interpretation is that households with children or retirees have modestly higher space requirements per person, raising demand for housing. Many retirees live in single-person households and are unable to benefit from scale economies available to couples, especially couples without children. Another long-run variable is the annual average ratio of immigration from Asia to total immigration (lagged two quarters) as discussed in Section 5.1. The coefficient on this variable is 1.2 (t-stat = 3.6).

In the short run (not shown in table), we found significance on two autoregressive terms, outlier and pre-1988 seasonal dummies. The change in the unemployment rate is not significant. We tested housing supply dynamics by adding the lagged four-quarter change in log real net dwelling stock per capita ($\Delta_4 \ln hs_{t-1}$) to the dynamic specification. The coefficient is not significant, indicating that Canadian housing supply dynamics have no significant impact on national house prices in the short run.

Charts 9.10a and 9.10b decompose the long-run solution in levels. There is a heavy drag on real house prices before about 1997 due to declining real incomes per house. Other factors work to offset this. Easier mortgage credit conditions during the 1980s and a rising composition of immigration from Asia that continued into the 1990s (notably from Hong Kong) contribute positively to house prices. House prices decline and level off after 1990 due to higher user cost and nominal mortgage rates, ongoing declines in incomes per house and tighter credit conditions. Demographics (measured by the obverse dependency ratio) are a slight drag on house prices from about 1994 to 2010. The rise in house prices from 1997 is explained by the cessation of the drag from incomes per house (in other words, long-run changes in income and supply have been mostly offsetting); lower housing user cost; lower nominal mortgage rates; growing use of home equity loans (HLI); and further easing in mortgage credit access around 2002 and 2006 that were interrupted by the GFC.

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of house prices could also change (including capital gains expectations within the user cost). These aspects would need to be taken into account in a more refined projection.

46. Bailliu, Kartashova and Meh's (2012) micro-level evidence suggests HELOCs have also made renovation investments easier to undertake.

6.3. Mortgage debt equation results

Results for the long-run mortgage stock equation are set out in Table 10.3. Columns denoted (2), (3) and (4) correspond to the same systems shown for tables 10.1 and 10.2 (for brevity, we omit Column [1]).[47]
For Column (2), the absence of any role for interest rates seems counterintuitive and suggestive of misspecification.[48] Column (3) shows the CCI-inclusive mortgage stock equation. The freely estimated income elasticity is close to 1, so we maintain a unity restriction to reduce the number of free parameters in the system. The estimated speed of adjustment doubles to 0.12 (t-stat = 6.2), implying that it takes just under 5 years for 90 per cent of a shock to real per capita mortgage debt to disappear. The fact that *both* house prices and mortgage debt adjust to their long-run drivers within about 5 years is consistent with Canada's housing finance arrangements.

Columns (3) and (4) clearly improve upon the CCI-exclusive results. Relative to Column (3), Column (4) adds the HLI. There is little difference in model fit. The equation standard error is slightly lower at 0.006 and the adjusted R squared is now 0.56. The coefficient on the CCI is well-determined at 0.5 (t-stat = 4.6). This implies that, all else being equal, if CCI has a +1 per cent long-run impact on real house prices, it has approximately half that impact on the long-run mortgage-debt-to-income ratio, given the housing-wealth-to-income ratio. The elasticity with respect to nominal interest rates is -0.11 (t-stat = -2.5).[49] All else being equal, a 100 basis point (40 per cent) rise in nominal interest rates from current levels (2.5 per cent) would reduce real mortgage debt per capita by about 4 to 5 per cent over the subsequent 5 years. Finally, we add HLI as an additional control for the relaxation of credit access for buy-to-let investors. HLI has a coefficient of 0.9 (t-stat = 1.8). As previously discussed, HELOCs appear to be more of a complement than a substitute for mortgages.[50]

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47. For all mortgage stock equations, we impose a minus unity constraint on current inflation when the dependent variable is formulated in real terms, meaning that the dependent variable in the dynamic specification is the delta log nominal mortgage stock per capita. This is an acceptable, simplifying restriction since the freely estimated coefficient on current inflation (if included among the short-run regressors) is -1.0 (t-stat = -5.3).
48. If the housing assets elasticity (m_3) is restricted to 0.4 (a statistically acceptable restriction for models 3 and 4 but not 1 and 2), results in Column (2) are somewhat more plausible notwithstanding the absence of credit controls. The speed of adjustment is 0.04 (t-stat = 3.3) and the interest elasticity is well-determined at -0.22 (t-stat = -4.2).
49. We also tested for income expectations and the housing user cost. Neither effect was significant.
50. In the short run, two lags of the autoregressive term are significant when the CCI is omitted but are otherwise not significant. They were omitted from the models estimated in columns (3) and (4). Although we retained the delta unemployment rate as a proxy for income uncertainty, its coefficient is not significant.

Chart 9.11 decomposes the long-run mortgage solution for Column (4). Aside from the early 1980s and early 2000s, mortgage debt/income in Canada has risen steadily over three decades. The rise is explained by significantly lower nominal mortgage rates, especially since the mid-1990s; increased access to mortgage credit (CCI) and HELOC credit (HLI); and rising housing wealth. It is important to recognize that responses in the mortgage stock to credit conditions and interest rates, given the housing-wealth-to-income ratio, understate the full response that would include the indirect effects operating via housing wealth.

Chart 9.12a plots the residual of the cointegrating relationship, which is clearly stationary for models 3 and 4, and reflects our finding that mortgage debt adjusts to long-run fundamentals within about 5 years.[51] In contrast, because they exhibit an adjustment horizon roughly twice as long, the CCI-exclusive models 1 and 2 show wide and persistent deviation between actual debt and the fitted long-run value. Chart 9.8b shows quarterly growth in real mortgage debt per capita. A little more than half of the quarterly variation is explained by our model, most of which is attributable to the equilibrium correction dynamics.

6.4. The estimated CCI results

The jointly estimated latent variable, CCI, captures the common long-run variation in consumption, house prices and mortgage debt that is not explained by economic and demographic controls. For comparison purposes, we maintain the same parsimonious CCI specification for columns (3) and (4) and omit the most insignificant dummies.[52] Results are detailed in Table 10.4 and plotted in Chart 9.5. Columns (3b) and (4b) show the more generalized CCI. Log likelihood tests comparing columns (3) and (3a), and columns (4) and (4a), respectively, confirm that the five restrictions on the parsimonious CCI used in columns (3) and (4) are acceptable.

The estimated CCI matches the priors for the shape of CCI well (see Section 4 and Appendix 3) and is well-correlated with growth in household credit aggregates (Chart 9.6). The CCI rises strongly during the 1980s,

51. The long-run equation residual is typically negative at time t-1 since the regression coefficient-weighted means of the other variables, including the change in the dependent variable, net to a positive value.

52. We retained all post-GFC dummies, given that these estimates may be of interest to policy-makers. Given clear priors about the GFC, we added an extra dummy for 2007Q3 and lagged the 2008 dummy so that it commences in 2008Q4. Tightening is the prior for 2008Q4 but the coefficient is positive, partially offsetting the larger negative effect beginning in 2007Q3. This combination suggests overall tightening, but with more pronounced temporary effects in the worst part of the crisis. The partial offset may reflect the counter-crisis policy measures mentioned in Section 4. Given the priors, we also lagged the 2012 dummy to commence in 2012Q4. Two dummies may be influenced by other effects: the 1988 dummy appears to capture some of the omitted demographic effects in Column (3); and the 2004 dummy, appears to capture some of the omitted HLI effect in Column (3). Both of these dummies are statistically zero in Column (4).

coincident with banks' establishing mortgage loan subsidiaries and disinflation, before retrenching and flattening in the aftermath of the recession in the early 1990s and the implementation of Basel I. The CCI, together with HLI, rises substantially during the 2000s with the strongest increase occurring around the 2006 relaxation of mortgage insurance rules. The CCI indicates tightening around the 2007–09 credit crisis, offset by counter-crisis policy measures in 2009. The CCI drifts slightly lower in the post-crisis years, suggesting that changes to mortgage insurance rules and other regulations have made mortgage credit only marginally less easy to obtain, at least as far as we can detect in terms of their impact on consumption, house prices and debt.

There are good reasons to view CCI as a key long-run control and as capturing the latent impact shifts in access to credit. First, the counterfactual approach, to omit controls for non-price credit conditions, is tantamount to assuming full information shared by lenders and borrowers and unchanging credit markets cleared by interest rates. Yet it is widely accepted that asymmetric information about borrower default causes lenders to impose non-price borrowing constraints (Flemming 1973; Jaffee and Russell 1976; Stigliz and Weiss 1981, 1992; Stiglitz 1999; Williamson 1986; Miles 1992; Brueckner 1994; Leece 1995, 2004; and Meen 1990, 1996.) The GFC shows that shifts in these non-price credit conditions do impact financial stability and real activity.

Second, CCI plays a plausible, consistent role across all three equations. To our knowledge, this is the first study of its type in Canada, but our results can be compared with evidence from other countries that use direct (e.g., loan officer survey data) and indirect (e.g., latent variable) methods to control for credit conditions effects.[53] For Canada, the CCI is well-corroborated by the history of institutional developments (Section 4; Appendix 3). Schembri (2015) also highlights that mortgage credit conditions have been positively affected by financial liberalization and innovation and are an important demand-side contributor to rising Canadian house prices:

> The trend in advanced economies from the mid-1990s until the crisis has been toward higher maximum loan-to-value ratios, longer amortizations for mortgage borrowers and more flexible funding arrangements for mortgage lenders in terms of covered bonds and mortgage securitization. The assessment and diversification of mortgage credit risk have also improved. As a consequence, a broader set of borrowers and lenders has become involved in obtaining and providing mortgage finance.

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53. See Aron et al. (2012) for the United States, the United Kingdom and Japan; Muellbauer and Williams (2011) for Australia; Chauvin and Muellbauer (2013) for France; Geiger, Muellbauer and Rupprecht (2014) for Germany; and Aron and Muellbauer (2013) for South Africa. For example, the U.S. CCI is a transformation-to-levels of a diffusion index from the Federal Reserve's *Senior Loan Officer Opinion Survey of Bank Lending Practices* that tracks the willingness of 60 large banks to make consumer installment loans. A U.S. HLI can also be derived using the LIVES method (Duca, Muellbauer and Murphy 2015). CCI differs from country to country due to idiosyncratic changes in housing finance regimes.

Third, omission of the CCI in models (1) and (2) sees deterioration in the long-run solutions. Arguably, instead of our CCI, one could try to control for credit access shifts by adding a few dummies to the long-run solutions in individual equations. However, we see this approach as ad hoc and less intuitive than our general-to-specific LIVES method, which exploits the *common* impact of shifting credit conditions on consumption, house prices and mortgages. Choosing the "right" dummies would be arbitrary and difficult because Canada's regulatory environment and the pace of financial innovation are almost continuously (and non-linearly) evolving.

Fourth, consumption equations often rely on the current log income term growth to capture the (time-invariant) proportion of non-LCH or liquidity constrained consumers (Campbell and Mankiw 1989, 1991). However, this sees credit constraints as all about limits on consumption smoothing and ignores the fact that mortgages dominate debt and that quite different types of credit constraints then arise. Inclusion of the CCI addresses shifts in these more important constraints and makes the current income growth term redundant.

Finally, while we have taken care to ensure CCI is plausibly representing non-price shifts in credit access, there remains the possibility that CCI is partly picking up some other omitted controls (e.g., shifts in unsecured consumer credit access, housing stock composition, or persistent mismeasurement of one of the included controls). Arguably, CCI could also partly capture non-fundamental long-run influences or "irrational exuberance" jointly affecting consumption, house prices and debt (i.e., a common influence on these three dependent variables not explained by economic or demographic controls or by identifiable changes in credit market technologies or regulations). However, the relative stability since the early 1990s of CCI in Model 4 (i.e., after separately controlling for the spread of HELOCs) argues against this interpretation. Furthermore, the user cost term already incorporates exuberance based on recent appreciation and has a disproportionately large effect as user cost tends to zero. The finding of econometrically robust and economically sensible long-run solutions also suggests such issues could be relatively minor.

6.5. Robustness checks

We conducted robustness checks for parameter stability, systems estimation methodology, sensitivity to income measurement, and cointegration. Results are available on request. First, the CCI-inclusive systems were estimated over the periods 1982Q1 to 2005Q4 and 1992Q1 to 2015Q1. The former sample excludes the GFC while the latter excludes the poor-quality house price data from the 1980s. We also recursively estimated (step-wise) the house price equation parameters from 2006Q1. System estimates appear stable across subsamples and are around or within a standard error of their full sample estimate. The main cost of omitting observations is that coefficient estimates for the highly trend-like variables are less efficient.

Second, the results are not sensitive to the systems estimation methodology. We found minimal differences in the results for models 1 to 4 using seemingly unrelated regression (SUR) estimation as compared with full information maximum likelihood (FIML) estimation. Third, we use non-property income as our income metric for the reasons discussed in Section 3.1. We tested adding the log ratio of property to non-property income in each of the long-run equations. The coefficients are statistically zero and the system log likelihood is unchanged, so our results are not sensitive to the choice of income metric.[54]

Finally, we performed Johansen cointegration tests on each equation for Column (3) of tables 10.1 to 10.3.[55] For the consumption equation, the endogenous variables (with one lag) in the vector auto-regression (VAR) are the log consumption to income ratio, real interest rates, expected permanent income growth, net liquid assets to income, illiquid financial assets to income, the log house prices to income ratio and CCI. Current income growth and the outlier dummies are treated as weakly exogenous.[56] At the 1 per cent level, the trace test finds two cointegrating vectors. One is close to the long-run solution reported in Column (3) of Table 10.1 and the other could be interpreted as an equation for log house prices (albeit missing controls for the user cost and income per house). Consumption reacts only to the first vector.

For the house price equation, the endogenous variables (with three lags) in the VAR are log real house prices, log real income per house, log nominal mortgage rates, the log user cost and CCI. The immigration variable and the outlier dummies are treated as weakly exogenous. At the 1 per cent level, the trace test finds two cointegrating vectors. The first is close to the long-run solution reported in Column (3) of Table 10.2. The second could be interpreted as a relationship between the log real user cost and log nominal mortgage rate. House prices react only to the first vector.

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54. National accounts measurement issues may also contribute to the insignificance of property income. Canada offers a range of tax-sheltered savings arrangements, for example, compulsory public pension plans; employment insurance; private and employer-based registered retirement savings plans (RRSPs); tax-free savings accounts (TFSAs); and registered education savings plans (RESPs). Capital income accruing inside these shelters does not count toward household (property) income. Capital income is counted on withdrawal (except for TFSAs), at which time it is counted as non-property income.
55. Column (3) can be considered a reasonably close approximation to Column (4).
56. We tested weak exogeneity by finding the lagged residual from the long-run equation insignificant in a regression for current income growth.

For the mortgage stock equation, the endogenous variables (with one lag) in the VAR are the log real mortgage stock to income, the log nominal mortgage rate, log housing wealth to income and CCI.[57] At the 1 per cent level, the trace test finds two cointegrating vectors. The first approximates the long-run solution reported for mortgage debt in Column (3) of Table 10.3. The other could be interpreted a relationship between debt and CCI. All the I(1) variables react to the first vector. CCI reacts to the second vector as well as to the first. This implies that housing wealth to income, the mortgage rate and CCI are all endogenous. This seems obvious for housing wealth to income but it is plausible that the mortgage rate and CCI react to household indebtedness.

We interpret this last finding as follows. While there are long-term exogenous drivers of CCI such as financial innovations and regulatory changes unrelated to the economic cycle, our results also suggest that CCI tends to decline after periods of rising debt/equity, debt/income and debt servicing ratios. The evidence points to the existence of a countercyclical policy feedback in which Canadian regulators tend to tighten (ease) mortgage regulations in response to higher (lower) leverage and debt servicing ratios. This would imply that, notwithstanding Canada's high-quality lending practices and conservative screening of individual borrowers, there has been a trend toward easing in mortgage credit access but with a policy feedback rule that mitigates excesses.

57. The residual of the long-run equation is marginally significant when included in a regression for the change in log nominal income per capita. Even so, the coefficient is tiny so we treat the change in log income as weakly exogenous.

7. Conclusion

Canada shares similarities with the United States, the United Kingdom, Australia, France, Germany and South Africa in that shifts in non-price credit conditions have real economy effects on consumption and on household portfolios. Our estimated latent variable (CCI) has a profile consistent with prior qualitative information about specific changes in Canadian credit market architecture and is well-correlated with growth in credit aggregates. Its robust significance and role in improving the estimates of the other long-run influences offers strong evidence that credit conditions jointly influence Canadian house prices, mortgage debt and consumption. The exclusion of controls for credit conditions yields much weaker empirical results and is non-intuitive given that credit markets are intrinsically imperfect.

Canada's institutional arrangements appear to have encouraged home equity lending for investment (including buy-to-let purchases and home renovations), contributing to increases in house prices and mortgage debt post 1990s, but not to increases in consumption. Canada differs from the United States, the United Kingdom, Australia and South Africa in that, given credit conditions, higher house prices to income have an overall negative impact on consumption (by necessitating greater saving for a mortgage deposit). France, Germany, Italy and Japan share this trait. There is some evidence that Canada's negative house-price-to-income effect was attenuated with easier credit access since the 2000s. The reluctance of households to borrow to consume housing capital gains could be due to Canada's conservative housing finance arrangements, for example, relative to the United States (Schembri 2014); the fact that most Canadian mortgages are subject to full recourse; the fact that borrowers are exposed to interest rate risk due to short mortgage renewal periods; and the fact that mortgage interest on a personal residence is not tax deductible (see Section 4 and Appendix 3).

Our results also highlight an important feature of Canada's monetary policy transmission mechanism: a decrease in borrowing rates initially raises consumption, but there are some negative offsetting effects via higher house prices and debt levels that take longer to materialize. Consumption adjusts to changes in interest rates within around 1½ to 2 years, whereas house prices and debt levels take closer to 5 years. Finally, high and rising real house prices and debt levels in Canada since the late 1990s can be mostly explained by long-run movements in incomes, housing supply, mortgage interest rates and credit conditions. This suggests that the outlook for Canadian house prices and mortgage debt levels depends mainly on the future paths of these variables.

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9. Charts

Chart 9.1: Log levels of the dependent variables

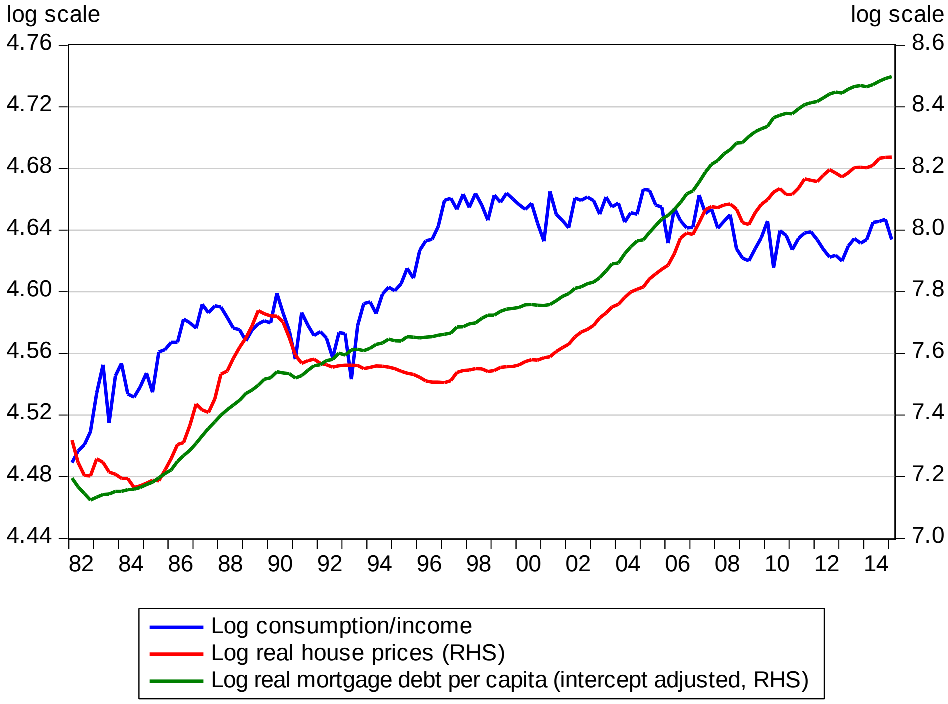


Chart 9.2: Ratios of household wealth components to annualized income

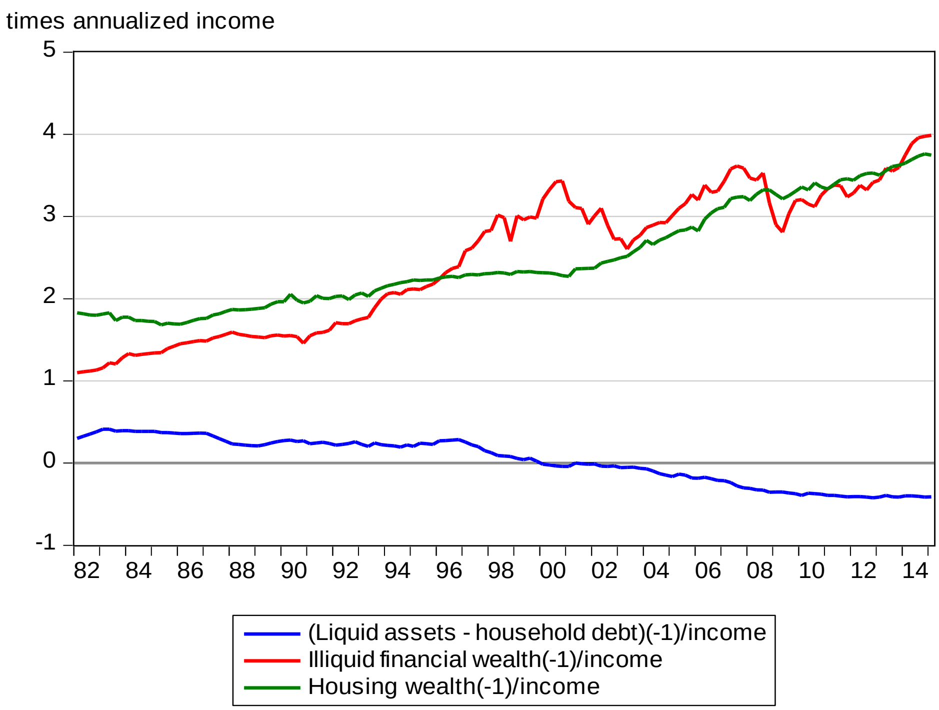


Chart 9.3: Interest rates in Canada

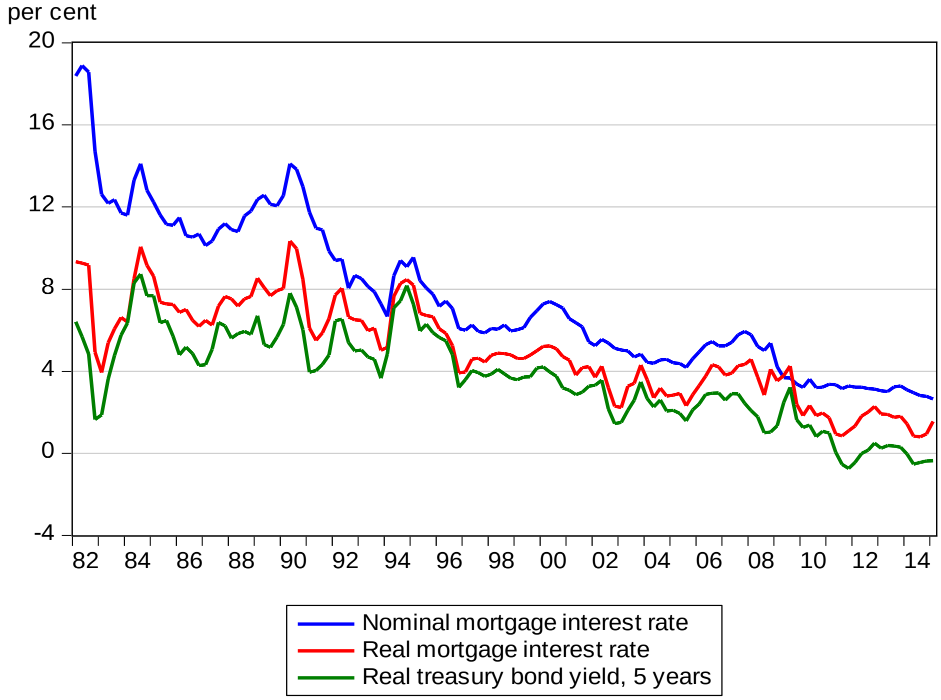
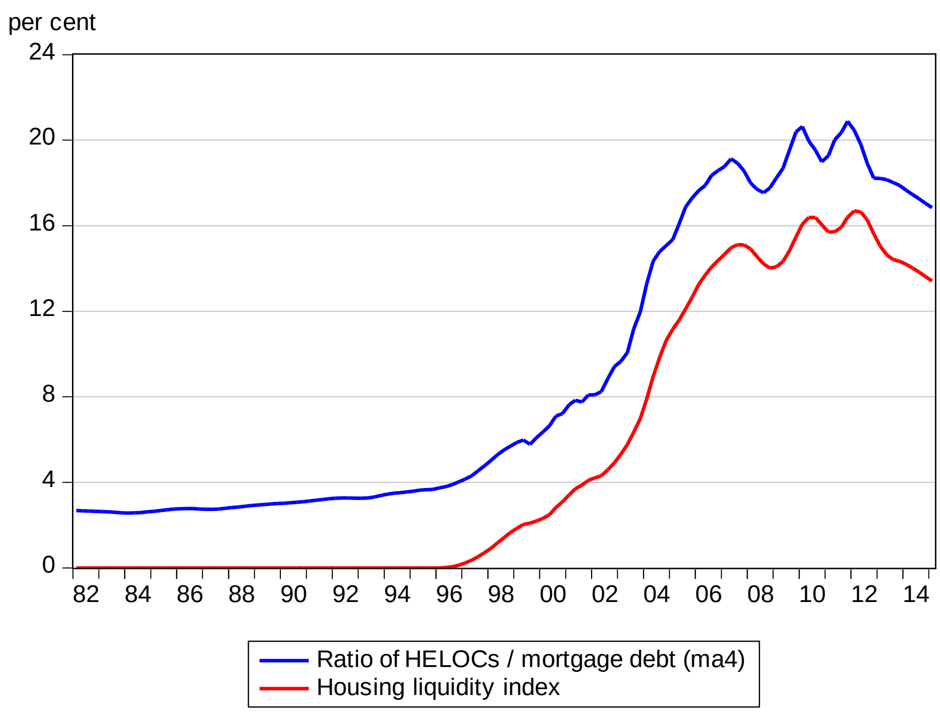


Chart 9.4: Housing liquidity index (HLI)



Note: The housing liquidity index is defined as the four-quarter moving average of the ratio of home-equity lines of credit (HELOC) debt to mortgage debt, set to 0 before 1996Q1 and rebased by subtracting the 1996Q1 value from subsequent values.

Chart 9.5: Credit conditions effects

(long-run contribution to house price and mortgage debt levels in a partial equilibrium)

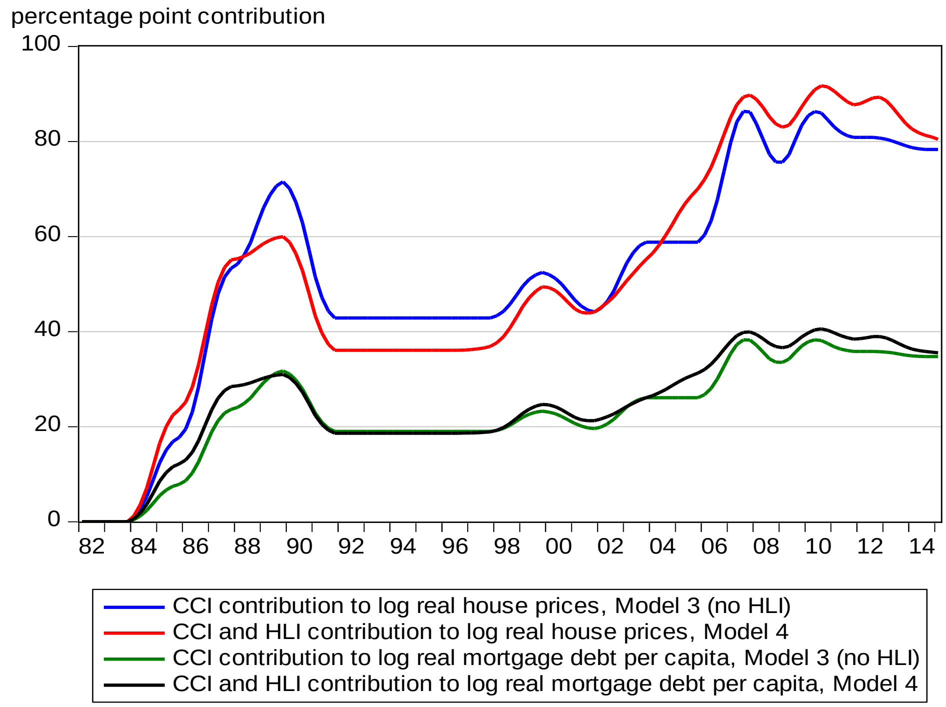
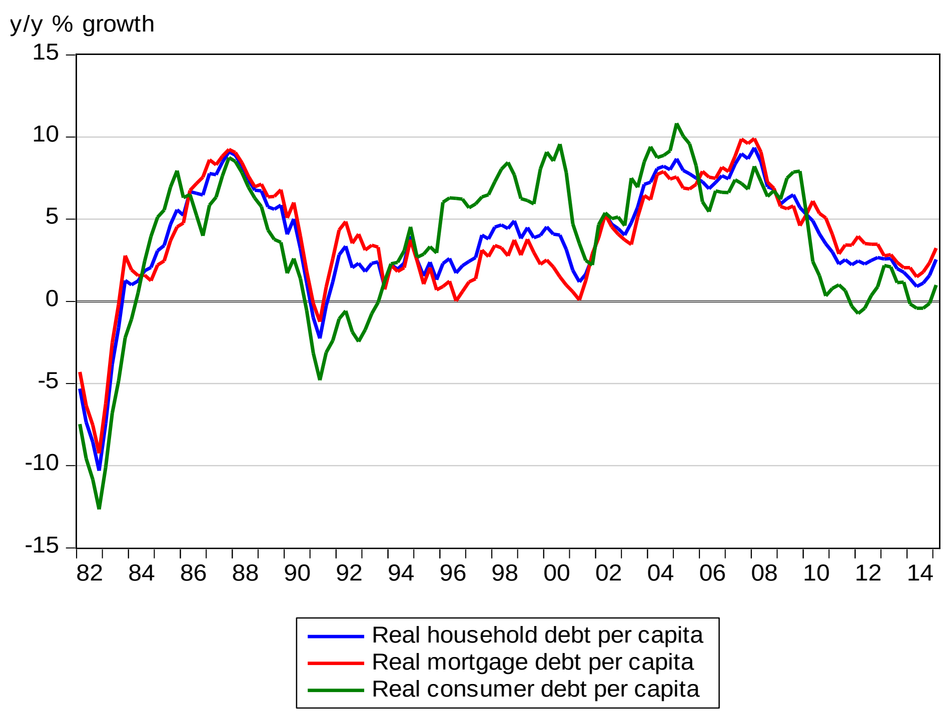
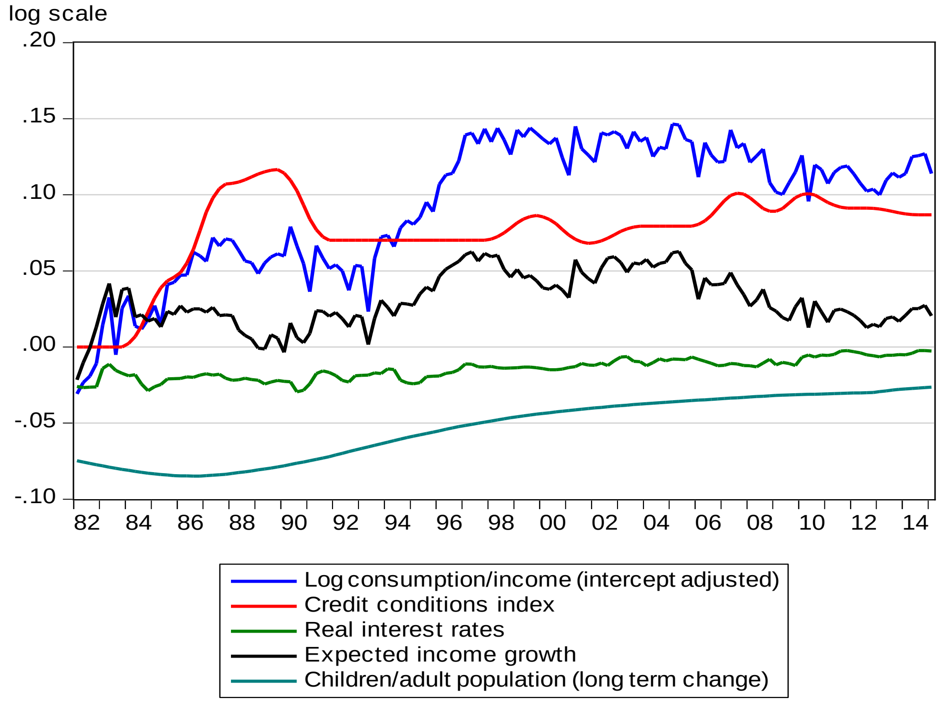
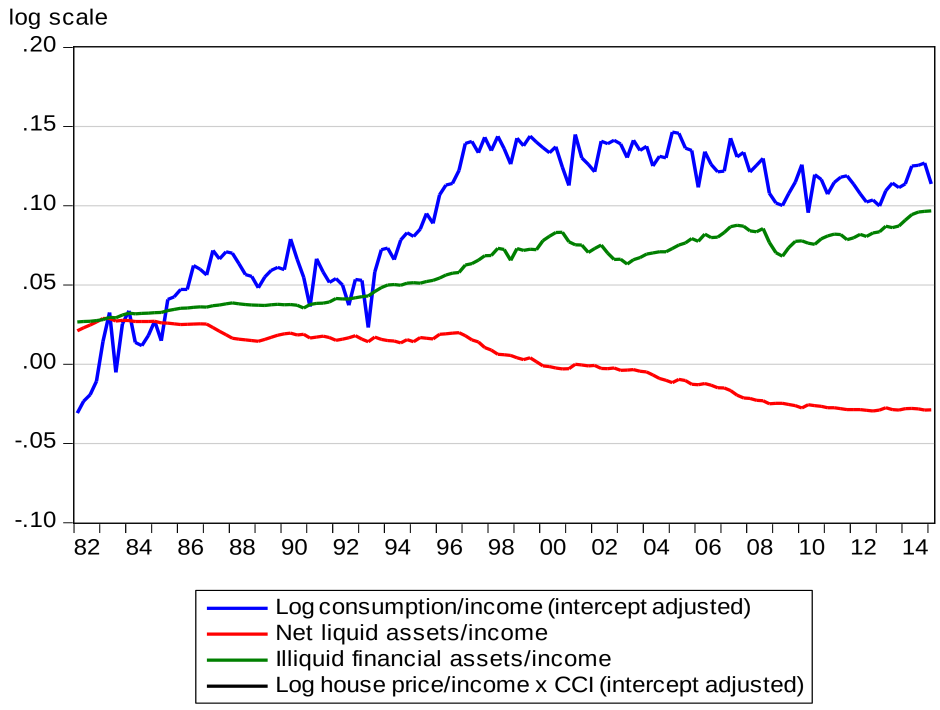


Chart 9.6: Estimated CCI is well-correlated with growth in household credit aggregates



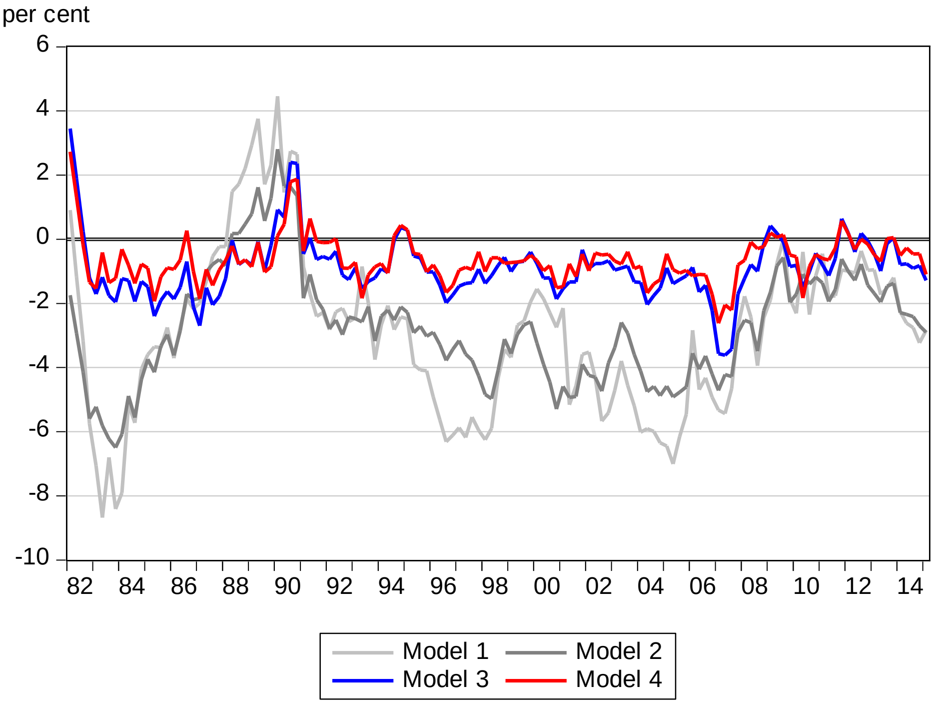
Charts 9.7a and 9.7b: Decomposing the long-run solution for log consumption/income





Note: The charts above show the explanatory variables multiplied by their estimated long-run coefficient (Column 4, Table 10.1). Between two points in time, all else being equal, multiplying the change in the y-axis value for a variable by 100 gives its approximate percentage point long-run contribution to the change in the dependent variable in a partial equilibrium.

Chart 9.8a: Residual of the long-run solution for log real consumption per capita



Note: The cointegration residual is defined here as actual log real consumption per capita (at time t) minus the fitted long-run equation set out in columns (1) to (4) in tables 10.1 to 10.4.

Chart 9.8b: Actual versus fitted real per capita consumption growth (Model 4)

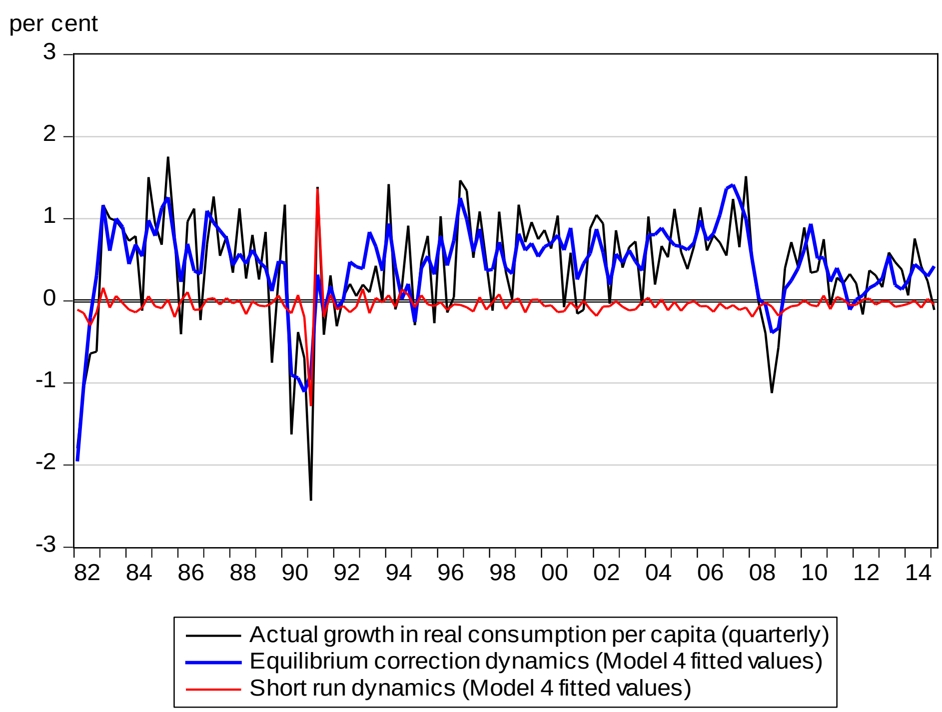
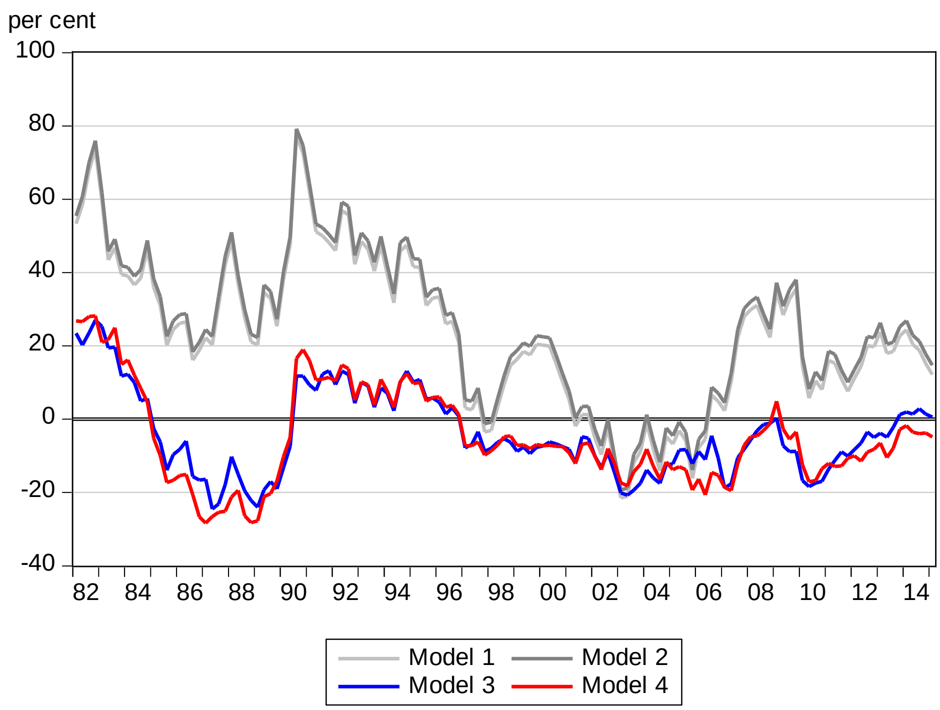
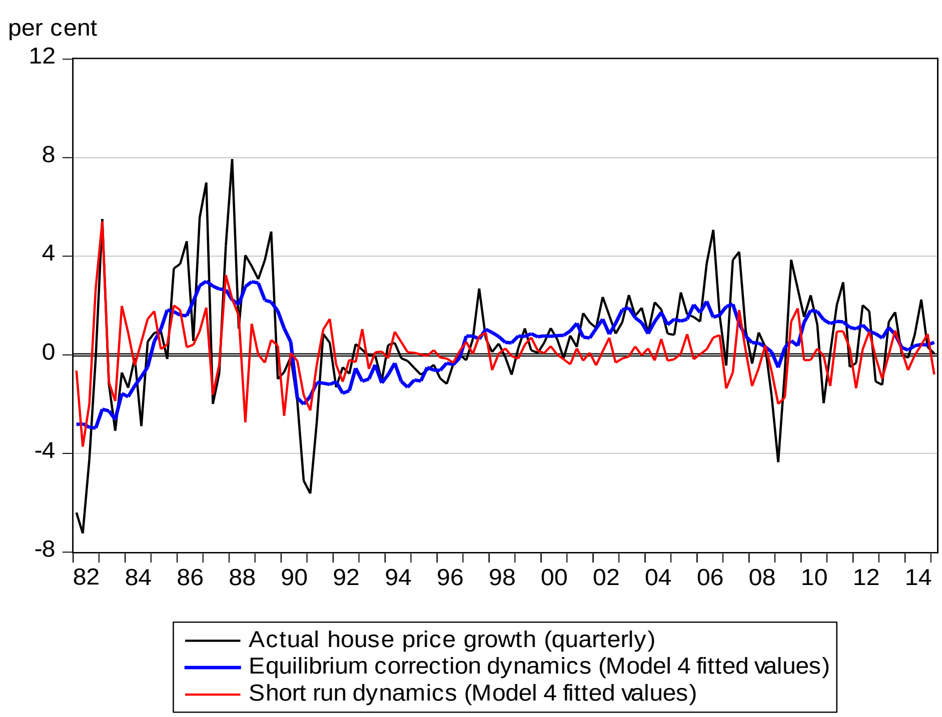


Chart 9.9a: Residual of the long-run solution for log real house prices

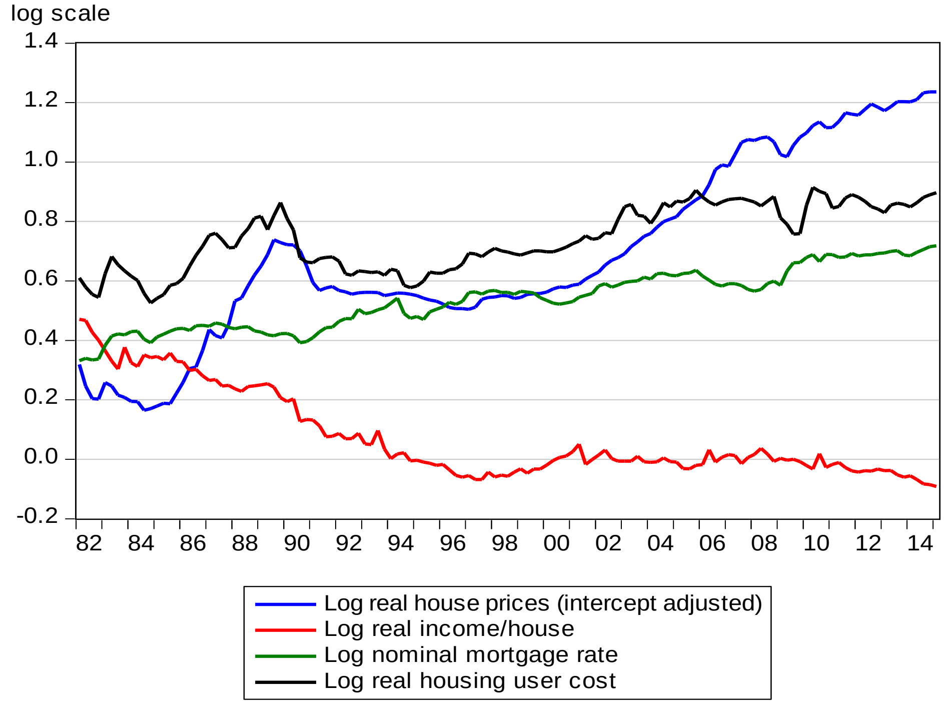


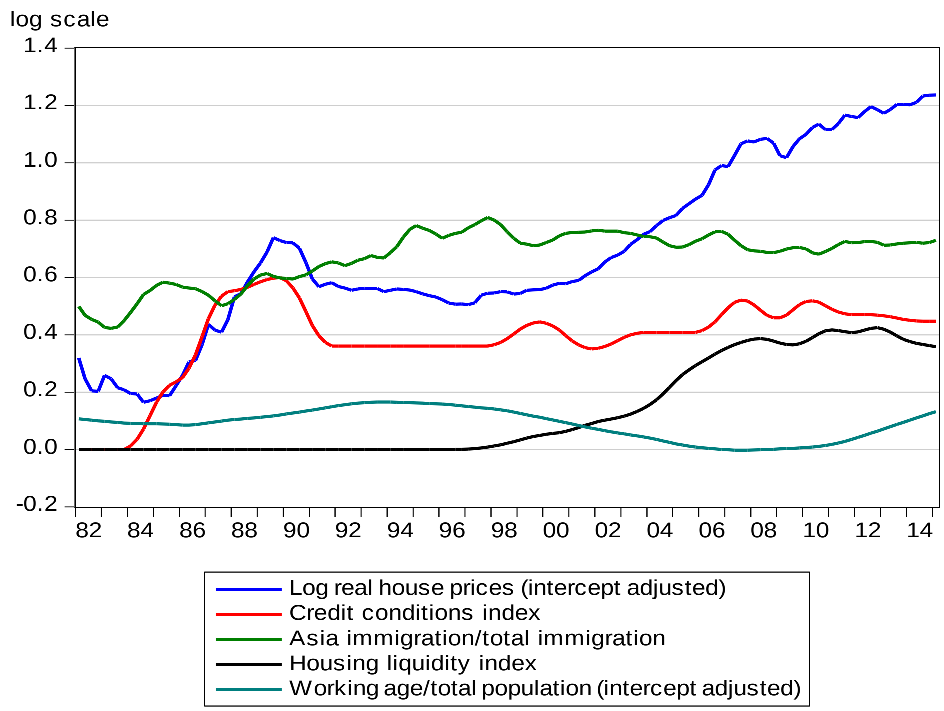
Note: The cointegration residual is defined as actual log real house prices (at time t) minus the fitted long-run equation set out in columns (1) to (4) in tables 10.1 to 10.4. Models (3) and (4), which include controls for credit, suggest house prices in 2015Q1 are around 0 to 5 per cent below their model-fitted value. For models (1) and (2), which exclude credit controls, house prices in 2015Q1 are around 12 to 15 per cent above their model-fitted value.

Chart 9.9b: Actual versus fitted real house price growth (Model 4)



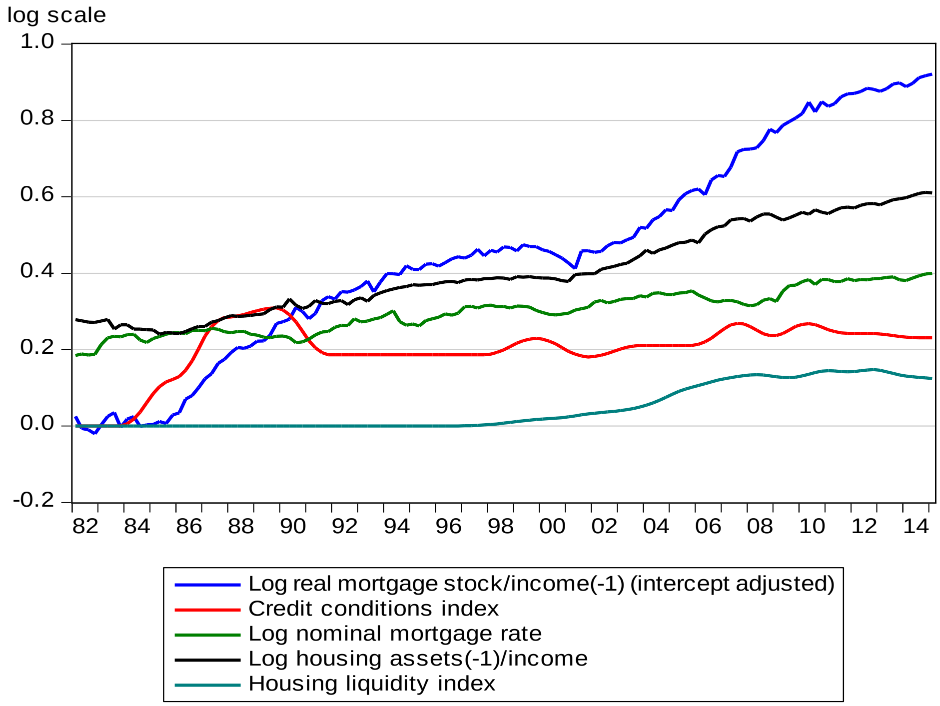
Charts 9.10a and 9.10b: Decomposing the long-run solution for log real house prices





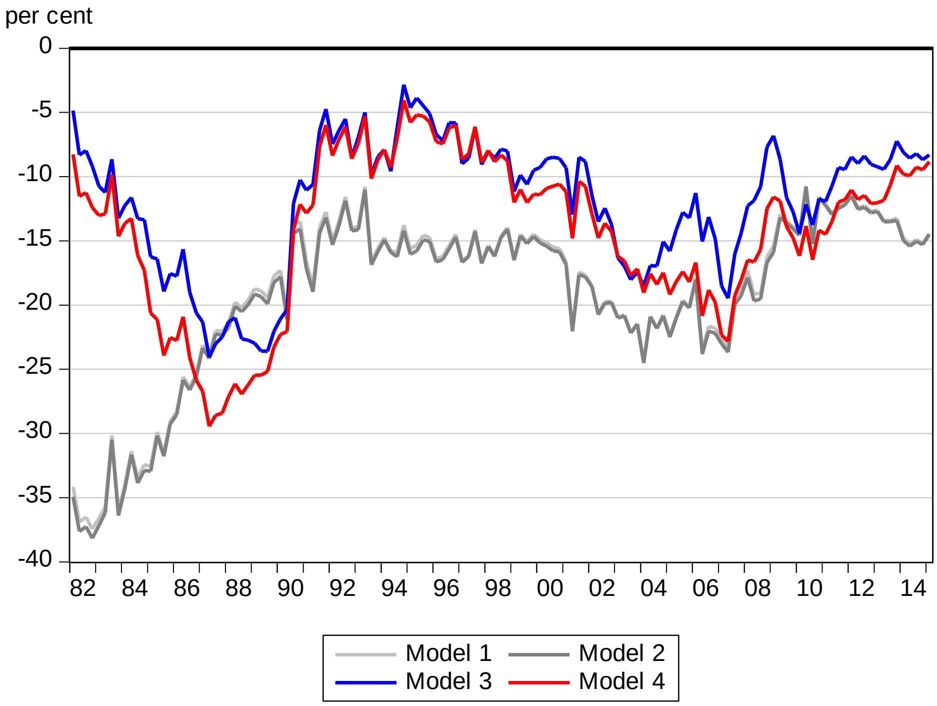
Note: The charts above show the house price equation explanatory variables multiplied by their estimated long-run coefficient (Column 4, Table 10.2). Between two points in time, all else being equal, multiplying the change in the y-axis value for a variable by 100 gives its approximate percentage point long-run contribution to the change in the dependent variable in a partial equilibrium.

Chart 9.11: Decomposing the long-run solution for log real mortgage stock per capita



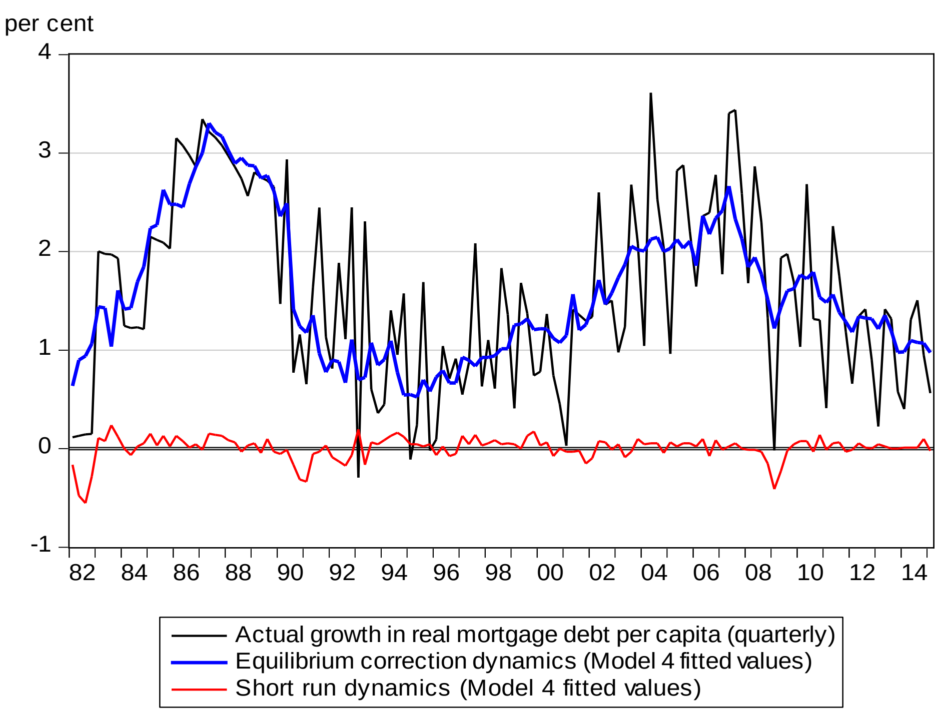
Note: The charts above show the mortgage stock equation explanatory variables multiplied by their estimated long-run coefficient (Column 4, Table 10.3). The dependent variable is re-parameterized to incorporate the unity constraint on lagged log income. Between two points in time, all else being equal, multiplying the change in the y-axis value for a variable by 100 gives its approximate percentage point long-run contribution to the change in the dependent variable in a partial equilibrium.

Chart 9.12a: Residual of the long-run solution for log real mortgage debt per capita



Note: The cointegration residual is defined here as actual log real mortgage debt per capita (at time t) minus the fitted long-run equation set out in columns (1) to (4) in tables 10.1 to 10.4, both multiplied by 100.

Chart 9.12b: Actual versus fitted growth in real mortgage debt per capita (Model 4)



10. Tables

Table 10.1: Estimates of the long-run solution for Canadian consumption

Dependent variable = $\Delta \ln c_t$ Sample: 1982Q1–2015Q1 Sample size: 133 quarterly obs		(1) No credit access effects	(2) No credit access effects	(3) Simple credit access effects	(4) Credit access, HLI & demography
Long-run coefficients for $\ln(c/y)_t$	*Symbol*				
Speed of adjustment	φ_c	0.111 (3.5)	0.136 (4.2)	0.338 (5.7)	0.431 (6.4)
Constant	α_0	4.471 (197.1)	4.551 (52.0)	6.502 (7.8)	7.095 (5.0)
Credit conditions index, CCI_t	κ_c	-	-	0.156 (3.4)	0.194 (3.6)
Real interest rate, r_{t-1}	α_1	-	0.087 (0.2)	-0.248 (-1.4)	-0.286 (-1.9)
Forecast future income growth, $E_t \ln(y_t^p/y_t)$	ψ	1.699 (4.8)	1.187 (3.6)	0.845 (5.8)	0.695 (6.5)
Net total household wealth to income, A_{t-1}/y_t	$\gamma_1 = \gamma_2 = \gamma_3$	0.019 (3.3)	-	-	-
Net liquid wealth to income, NLA_{t-1}/y_t	γ_1	-	-0.038 (-0.5)	0.068 (2.1)	0.07
Illiquid financial wealth to income, IFA_{t-1}/y_t	γ_2	-	0.039 (2.4)	0.035 (3.7)	0.024 (2.9)
Housing wealth to income, HA_{t-1}/y_t	γ_3	-	-0.026 (-1.0)	-	-
Log real house prices to income, $\ln(hp/y)_{t-1}$	α_2	-	-	-0.118 (-2.5)	-0.147 (-1.8)
CCI x log real house prices to income, $CCI_t\,(\ln(hp/y)_{t-1} - mean(.))$	α_2^*	-	-	-	1.409 (2.7)
Long-term change in child/adult population, $child/adpop - ma120(.)$	α_3	-	-	-	0.457 (2.1)
Diagnostics					
Equation standard error		0.0053	0.0049	0.0042	0.0040
Adjusted R^2		0.356	0.451	0.606	0.646
DW		1.68	1.94	2.07	2.11
System log likelihood		1367.46	1381.12	1444.56	1453.13

The table shows coefficients (t-ratios). The estimated generalized credit-augmented consumption function is

$$\Delta \ln c_t = \varphi_c(\alpha_0 + \kappa_c CCI_t + \alpha_1 r_{t-1} + \psi E_t \ln(y_t^p/y_t) + \gamma_1 NLA_{t-1}/y_t + \gamma_2 IFA_{t-1}/y_t + \gamma_3\, HA_{t-1}/y_t + \gamma_3^* HLI_{t-1}(HA_{t-1}/y_t - mean(.)) + \alpha_2 \ln(hp/y)_{t-1} - \alpha_2^* \alpha_2 CCI_t(\ln(hp/y)_{t-1} - mean\,(.)) + \ln y_t/c_{t-1}) + \lambda \Delta \ln y_t + \beta_1 \Delta \ln ue + \beta_2 \Delta \ln c_{t-1} + \beta_3 (I1990q4 - I1991q1) + \varepsilon_t$$

In Column (1), $A_{t-1}/y_t \equiv NLA_{t-1}/y_t + IFA_{t-1}/y_t + HA_{t-1}/y_t$, which imposes the restriction $\gamma = \gamma_1 = \gamma_2 = \gamma_3$. In columns (3) and (4), γ_3 is insignificant and is set to zero. Column (4) adds demography. For parsimony, in Column (4), the insignificant parameter λ is set to zero. For all equations, outliers are captured by $I1990Q4$ and $I1991Q1$, which are impulse dummies defined as 1 in that quarter and 0 otherwise. Note that Column (4), with λ relaxed, simplifies to Column (1) under the testable restrictions: $\gamma = \gamma_1 = \gamma_2 = \gamma_3$; $\kappa_c = \gamma_3^* = \alpha_2 = \alpha_2^* = \beta_1 = \beta_2 = 0$.

Table 10.2: Estimates of the long-run solution for Canadian house prices

Dependent variable = $\Delta \ln hp_t$ Sample: 1982Q1–2015Q1 Sample size: 133 quarterly obs		(2) No credit access effects	(3) Simple credit access effects	(4) Credit access, HLI & demography
Long-run coefficients for $\ln hp_t$	*Symbol*			
Speed of adjustment	φ_h	0.038 (1.9)	0.104 (4.4)	0.105 (3.1)
Constant	h_0	15.225 (22.3)	17.327 (73.6)	23.296 (4.3)
Credit conditions index, CCI_t	κ_h	-	1.0	1.0
Inverse own-price elasticity, $\ln hs_{t-1}$	h_2	1.8	1.8	1.8
Log real income per capita, $\ln y_{t-1}$	h_1	1.0	1.0	1.0
Log real user cost, $\ln ucc_{t-1}$	h_3	-0.703 (-1.9)	-0.220 (-1.7)	-0.314 (-2.2)
Log nominal mortgage rate, $\ln i_{t-1}$	h_4	-0.397 (-1.6)	-0.282 (-3.0)	-0.200 (-1.9)
Share of immigration from Asia, $aimmig(ma4)_{t-2}$	h_5	2.540 (2.3)	0.948 (3.0)	1.213 (3.6)
Housing liquidity index, HLI_{t-1}	h_6	-	-	2.572 (2.3)
Working-age population (15–64yrs) / total population	h_7	-	-	-8.928 (-1.1)
Diagnostics				
Equation standard error		0.0155	0.0145	0.0146
Adjusted R^2		0.555	0.610	0.607
DW		1.83	2.01	2.02
System log likelihood		1381.12	1444.56	1453.13

The table shows coefficients (t-ratios). The generalized credit-channel augmented house price equation estimated in Column (4) is

$$\Delta \ln hp_t = \varphi_h(h_0 + \kappa_h CCI_t + h_2(h_1 \ln y_{t-1} - \ln hs_{t-1}) + h_3 \ln ucc_{t-1} + h_4 \ln i_{t-1} + h_5 aimmig(ma4)_{t-2} + h_6 HLI_{t-1} - \ln hp_{t-1})$$
$$+ h_7 \Delta \ln hp_{t-1} + h_8 \Delta \ln hp_{t-2} + h_9 \Delta_2 \ln ue_{t-1} + h_{10}(I1983q1 - I1982q4) + h_{11}(I1987q2 - I1987q3) + h_{12} Q4(pre1988) + \mu_t.$$

Outliers are captured by $I1982Q1$, $I1983Q1$, $I1987Q2$, and $I1983Q1$, which are impulse dummies defined as 1 in that quarter and 0 otherwise. $Q4(pre1988)$ is a seasonal dummy that equals 1 in quarter 4 in 1982 through 1987, and 0 in quarter 4 from 1988 onward.

Table 10.3: Estimates of the long-run solution for Canadian mortgage debt

Dependent variable = $\Delta \ln nms_t$ Sample: 1982Q1–2015Q1 Sample size: 133 quarterly obs		(2) No credit access effects	(3) Simple credit access effects	(4) Credit access, HLI & demography
Long-run coefficients for $\ln ms_t$	*Symbol*			
Speed of adjustment	φ_m	0.059 (4.0)	0.122 (6.2)	0.104 (6.5)
Constant	m_0	0.393 (2.9)	0.178 (2.8)	0.245 (2.6)
Credit conditions index, CCI_t	κ_m	-	0.443 (6.9)	0.516 (4.6)
Log real income per capita, $\ln y_{t-1}$	m_1	1.0	1.0	1.0
Log nominal mortgage rate, $\ln i_{t-1}$	m_2	-0.027 (-0.3)	-0.154 (-5.5)	-0.111 (-2.5)
Log housing wealth to income, $\ln HA_{t-1}/y_t$	m_3	0.890 (5.5)	0.4	0.462 (2.5)
Housing liquidity index, HLI_{t-1}	m_4	-	-	0.894 (1.8)
Diagnostics				
Equation standard error		0.0074	0.0063	0.0063
Adjusted R^2		0.377	0.549	0.556
DW		1.80	1.97	2.12
System log likelihood		1381.12	1444.56	1453.13

The table shows coefficients (t-ratios). The generalized credit-augmented mortgage stock equation estimated in Column (4) is

$$\Delta \ln ms_t = \varphi_m(m_0 + \kappa_m CCI_t + m_1 \ln y_{t-1} + m_2 \ln i_{t-1} + m_3 \ln(HA_{t-1}/y_t) + m_4 HLI_{t-1} - \ln ms_{t-1})$$
$$+ m_5 \Delta \ln p_t + m_6 \Delta \ln ms_{t-1} + m_7 \Delta \ln ms_{t-2} + m_7 \Delta \ln ue + v_t.$$

Note that m_5 is not statistically different from -1 so we re-parameterize the dependent variable as delta log nominal mortgage debt per capita: $\Delta \ln nms_t = \Delta \ln ms_t + 1.\Delta \ln p_t$. For columns (3) and (4), m_6 and m_7 are not significant and are set to zero.

Table 10.4: Estimates of the long-run parameters for the credit conditions index (CCI)

Smoothed step dummy (SSD) *Sample: 1982Q1 – 2015Q1*	*Sign prior (see Section 4)*	(3) Simple credit access effects	(3a) Unrestricted CCI	(5) Credit access, HLI & demography	(5a) Unrestricted CCI
SSD 1982Q1	Easing (+)	-	0.052 (0.4)	-	0.096 (0.7)
SSD 1984Q1	Easing (+)	0.177 (3.0)	0.142 (2.5)	0.236 (2.9)	0.226 (2.7)
SSD 1986Q1	Easing (+)	0.356 (4.6)	0.362 (5.1)	0.315 (3.8)	0.297 (3.7)
SSD 1988Q1	Easing (+)	0.182 (2.6)	0.183 (2.3)	0.050 (0.8)	0.021 (0.3)
SSD 1990Q1	Tightening (-)	-0.287 (-3.6)	-0.262 (-3.2)	-0.239 (-3.3)	-0.229 (-3.3)
SSD 1992Q1	Tightening (-)	-	0.003 (0.1)	-	-0.034 (-0.7)
SSD 1994Q1	No prior	-	0.005 (0.1)	-	0.005 (0.1)
SSD 1996Q1	No prior	-	-0.005 (-0.1)	-	0.022 (0.6)
SSD 1998Q1	No prior	0.096 (1.6)	0.086 (1.4)	0.084 (1.5)	0.064 (1.2)
SSD 2000Q1	Easing (+)	-0.083 (-1.5)	-0.071 (-1.4)	-0.095 (-2.0)	-0.098 (-2.1)
SSD 2002Q1	Easing (+)	0.147 (3.1)	0.102 (1.9)	0.058 (1.7)	0.050 (1.2)
SSD 2004Q1	Easing (+)	-	0.090 (1.1)	-	0.003 (0.1)
SSD 2006Q1	Easing (+)	0.298 (4.4)	0.274 (3.5)	0.123 (2.3)	0.122 (2.3)
SSD 2007Q3	Tightening (-)	-0.161 (-2.0)	-0.182 (-2.2)	-0.090 (-1.6)	-0.110 (-2.1)
SSD 2008Q4	Tightening (-)	0.157 (1.5)	0.161 (1.4)	0.092 (1.7)	0.098 (1.7)
SSD 2010Q1	Tightening (-)	-0.073 (-0.8)	-0.065 (-0.7)	-0.063 (-1.3)	-0.066 (-1.3)
SSD 2012Q4	Tightening (-)	-0.025 (-0.5)	-0.002 (-0.04)	-0.023 (-0.7)	-0.022 (-0.6)
Consumption eq. CCI coefficient	κ_c	0.156 (3.4)	0.179 (3.3)	0.194 (3.6)	0.190 (3.6)
Mortgage stock eq. CCI coefficient	κ_m	0.443 (6.9)	0.435 (7.0)	0.516 (4.6)	0.526 (4.4)
System log likelihood		1444.56	1447.68	1453.13	1455.29

The table shows coefficients (t-ratios). $CCI = \sum_{s=1} \tau_s SSD_s = \tau_1 SSD1982q1 + \tau_2 SSD1984q1 + \ldots + \tau_{17} SSD2012q4$.
SSD is an ogive dummy taking the value 0 up until quarter t-1, then 0.05, 0.15, 0.3, 0.5, 0.7, 0.85, 0.95 and remaining at 1 thereafter.

11. Appendix 1: Further background on the solved-out consumption function

We employ a version of the Ando-Modigliani-Brumberg-Friedman solved-out consumption function similar to that exposited in Aron et al. (2012). The life-cycle model of consumption is

$$c_t = \frac{1}{\omega} W_t = \left(\gamma^* A_{t-1} + y_t^p\right). \qquad \text{(A1.1)}$$

Aggregate consumption (c_t) depends on household lifetime net worth (W_t) scaled by the per period inverse marginal propensity to consume out of lifetime wealth, $1/\omega$.[58] Net lifetime wealth consists of the end-of-period real net asset endowment (A_{t-1}) and permanent non-property[59] household gross disposable income (y_t^p), where the marginal propensities to consume out of these are, respectively, γ^* and one. All variables are real per capita. With some manipulation:

$$c_t = (\gamma^* A_{t-1} + y_t + y_t^p - y_t) \qquad \text{(A1.2)}$$

$$c_t / y_t = (\gamma^* A_{t-1}/y_t + 1 + (y_t^p - y_t)/y_t) \qquad \text{(A1.3)}$$

Note that $\ln(\gamma^* A_{t-1}/y_t + 1) \approx \gamma^* A_{t-1}/y_t$ since $\gamma^* A_{t-1}/y_t$ is small, and also $\ln y_t^p/y \approx \ln{(y^p - y_t)}/y_t$. Linearising in logs:

$$\ln c_t/y_t \approx \ \gamma A_{t-1}/y_t + \ln(y_t^p/y_t) \qquad \text{(A1.4)}$$

This formulation is helpful because assets enter as ratios to income rather than log ratios. This is a better approximation for explaining log consumption, particular when splitting net worth into sub-components—avoiding the problem that the log function is not defined for negative quantities, such as net liquid assets. It therefore permits estimation of differing marginal propensities to consume out of asset classes based on liquidity or credit access (Aron et al. 2012). The empirical version of the classical solved-out consumption function (with perfect foresight) is as follows, where α_0 could be different from 0 and ψ different from 1 to relax somewhat the strictest form of the permanent income model.

$$\ln c_t/y_t \approx \alpha_0 + \gamma A_{t-1}/y_t + \psi \ln(y_t^p/y_t) \qquad \text{(A1.5)}$$

58. For example, in a simple two-period set-up, 1/ω is 1/[1 + 1/(1+r)] in the case of quadratic preferences and $1/[1+(1/(1+\varsigma)^{\sigma})(1/(1+r)^{1-\sigma}]$ in the case of constant elasticity of substitution preferences, where r is the real interest rate, ς is the subjective discount rate and σ is the elasticity of inter-temporal substitution. Simplifying assumptions treat r, ς, σ and age demography as constants.

59. Again, non-property gross disposable income (y) refers to labour income plus net transfers. Since γ^* is the return on net assets (that is, it embodies property income such as dividend, rent and interest), it is appropriate to exclude property income from the household income measure in the consumption function (Blinder and Deaton 1985).

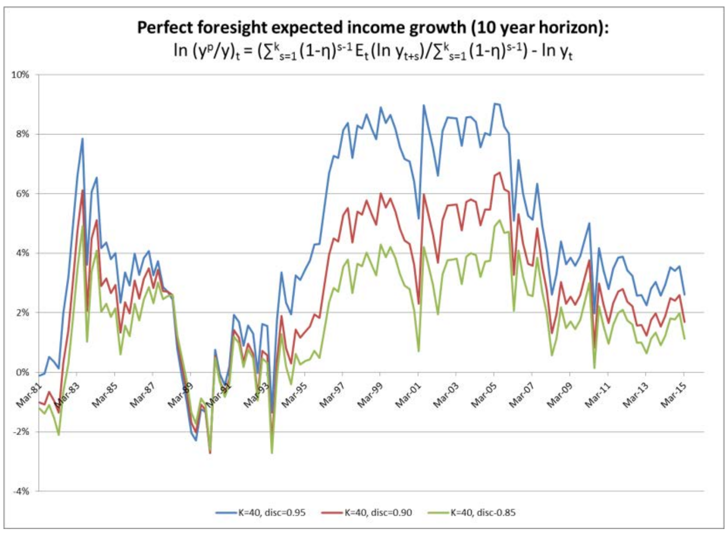
12. Appendix 2: Permanent income forecasting model

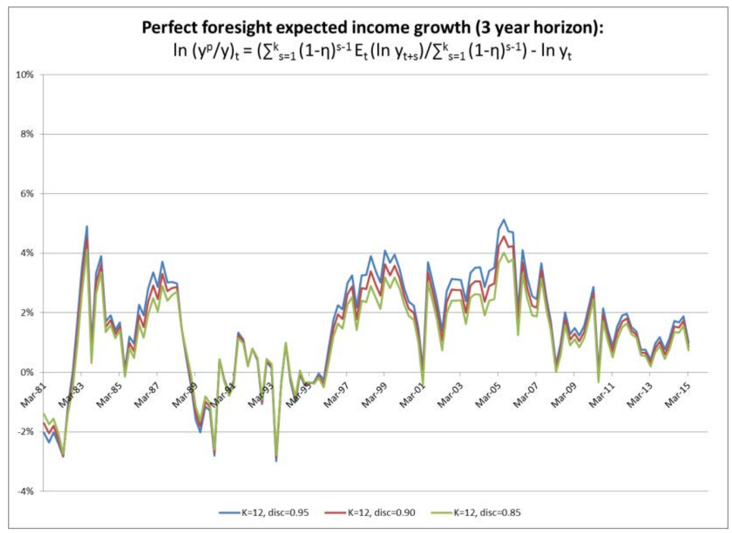
The solved-out consumption function requires an explicit forecasting process for real per capita household non-property gross disposable income (y). First, following Campbell (1987) we define $\ln(y_t^p/y_t)$ as a weighted moving average of forward-looking income growth rates with horizon (k) and discount rate (δ):

$$\ln(y_t^p/y_t) = \left(\sum_{s=1}^{k} \delta^{s-1} \ln y_{t+s}\right) / \sum_{s=1}^{k} \delta^{s-1}\right) - \ln y_t. \tag{A2.1}$$

We extrapolate income per capita growth beyond 2015Q1 at around 0.2 per cent per quarter[60] and assume that households look ahead to incomes over the next 10 years (k = 40) with a quarterly discount factor of δ = 0.95. The latter means that income received four quarters hence is worth four-fifths of its value today. Alternative assumptions for k and δ are also plotted in charts 12.1 and 12.2.

Charts 12.1 & 12.2: Actual values of $\ln(y_t^p/y_t)$ under different assumptions for (k) and discount factor (δ)





The representations above assume that households have perfect foresight about the path of future income (relative to current income). To relax this assumption, we rely on a forecasting model that embodies the notion that the deviation of log permanent income to current income (the dependent variable) is explained by deviation of log current income around a trend, augmented by some forward-looking economic variables (see also Chauvin and Muellbauer 2013; Geiger, Muellbauer and Rupprecht 2014). As such,

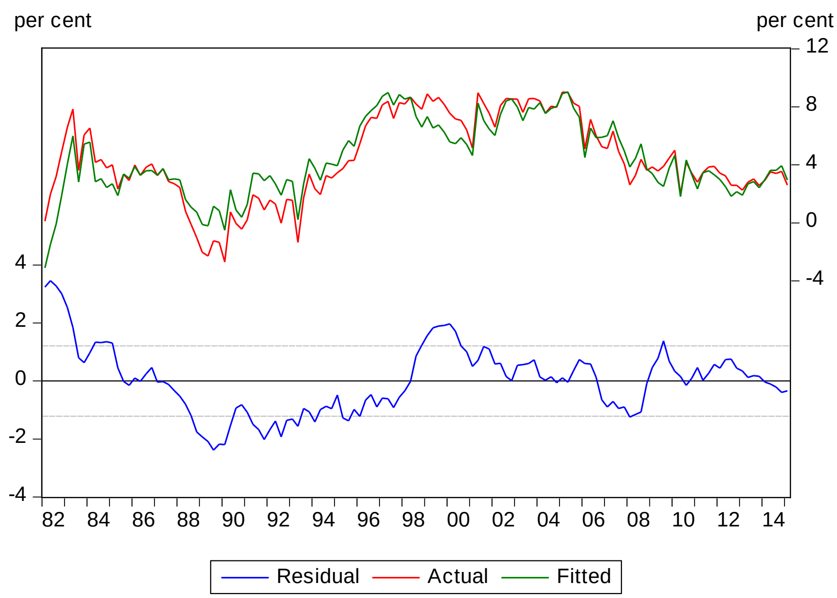
60. We extrapolate income growth per capita for the period from 2015Q1 to 2017Q4 using the Bank of Canada's potential output projection (*Monetary Policy Report*, October 2015) and Statistics Canada's population projection. The longer-run GDP per capita growth projection is based on assuming an unchanged growth rate for labour productivity after 2017, a projection of trend labour input (number of hours worked) done with the Bank of Canada's Integrated Framework (Pichette et al. 2015) and, again, Statistics Canada's population projection.

temporary falls in current income relative to the trend will raise expected future income growth relative to current income. Explanatory variables include log current real per capita non-property income; a full sample trend; The Conference Board of Canada's consumer confidence index; the terms of trade; the log ratio of the working-age population (persons 15–64 years) to total population to capture the idea that the working-age population is a key determinant of output; the four-quarter change in log nominal mortgage interest rates and some lags of delta log income. See Table 12.1 and Chart 12.3.

Table 12.1: Estimates for the household income forecasting equation

Dependent variable = $\ln(y_t^p/y_t)$ Sample: 1982Q1–2015Q1 Quarterly observations: 133	(1) *Coefficient (t-ratio)*
Constant	-8.031 (-12.1)
trend (full sample)	0.002 (19.4)
$\ln y_t$	-0.754 (-15.4)
consumer confidence index, ma4	0.001 (9.2)
Log terms of trade$_{t-1}$, ma4	0.149 (3.6)
Log (working-age/population)	1.0
$\Delta_4 \ln i_t$	-0.028 (-3.4)
$\Delta \ln y_t$	-0.123 (-1.2)
$\Delta \ln y_{t-1}$	-0.070 (-0.6)
$\Delta \ln y_{t-2}$	-0.046 (-0.4)
$\Delta \ln y_{t-3}$	-0.028 (-0.3)
Equation standard error	0.0121
Adjusted R^2	0.827
DW	0.096

Chart 12.3: Plot of fitted and actual values of $\ln y^p/y_t$ ($k = 40$, $\delta = 0.95$)



13. Appendix 3: History of Canadian household credit market institutions and features

The Canadian household credit market is national—i.e., lending conditions and products are similar across the country—and largely dominated by domestic lenders, especially by a few large banks. Mortgage credit represents about two-thirds of the household credit market. Since the 1967 amendment to the *Bank Act,* there has been no ceiling on interest rates on loans in Canada.

The residential mortgage credit market is relatively conservative; indeed, it was criticized by Klyuev (2008) for being too conservative. Canadians typically sign 5-year, fixed-rate mortgages that are rolled over with new 5-year, fixed-rate contracts for the life of the mortgage—typically 25 years (the amortization period). There are, however, a range of products, with variable-rate mortgages representing about one-third of outstanding mortgages.[61] By comparison, in the United States, the typical mortgage is a fixed-rate 30-year mortgage. An implication of this is that Canadian lenders can more easily match liabilities and assets, which reduces the interest rate risk they face and increases the interest risk faced by borrowers.[62]

Most Canadian mortgages are subject to full legal recourse, which significantly reduces the incentive for households to default when they are faced with negative housing equity.[63] In contrast, a number of U.S. states (Arizona, California, Oregon, etc.) have non-recourse laws and non-recourse mortgages are more prevalent in that country. Another difference is that mortgage interest on a personal residence is not tax deductible in Canada, whereas it is in the United States.[64]

By federal law, financial institutions regulated by the Office of the Superintendent of Financial Institutions (OSFI, the main regulator of financial institutions) are allowed to extend conventional mortgages up to a certain amount (presently 80 per cent) of the value of a residential property. For high-ratio mortgages, i.e.,

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61. HELOCs, for instance, are typically at floating rates.

62. There are considerable differences across countries (Lea 2010). For instance, medium-term fixed-rate mortgages are the dominant instrument in Canada, the Netherlands and Switzerland. Long-term fixed mortgages dominate in the United States and (to a lesser extent) France, while Australian mortgages are typically floating rate. Mortgage markets are not constant. For instance, during 2004–06, between 30 and 35 per cent of U.S. mortgages were hybrid adjustable-rate mortgages with short- to medium-term initial fixed rates reverting to variable rates after the end of the fixed-rate period. The relative importance of these instruments has greatly declined since then.

63. Alberta and Saskatchewan have a sizable proportion of non-recourse mortgages (Bank of Canada 2015).

64. Note, however, that financial manoeuvres are possible around this constraint (see, for instance, *Globe and Mail* 2013). But such manoeuvres can be risky and are likely used by few households.

mortgages where the down payment is less than 20 per cent of the value of the property, mortgage insurance is required. Over 50 per cent of mortgages on the balance sheet of financial institutions are insured.[65] This insurance is provided by mortgage insurers approved by the Minister of Finance and supervised by the OSFI.[66] The Canada Mortgage and Housing Corporation (CMHC), a federal agency, is the largest mortgage insurer, with about 75 per cent of the market (two private insurers account for about 25 per cent of the market). The federal government provides explicit 100 per cent coverage on CMHC net claims on insured mortgages (90 per cent in the case of the two private insurers). Government interventions in the credit market have often entailed influencing mortgage insurance parameters, for instance, by requiring that the loan-to-value ratio should not exceed a certain amount or that the loan's amortization period should not exceed a certain number of years.

We see five distinct periods in the evolution of credit conditions.

I. Easing in 1982–88; contributing factors include the following:

- A 1980 amendment to the *Bank Act* allowed banks to have mortgage loan subsidiaries (Freedman 1998). By stimulating the supply of mortgage loans, this likely caused a gradual easing of credit conditions.
- There was a deep recession in Canada in 1981–82, which made lenders more prudent. Lenders' risk aversion eased as the effects of the recession subsided.
- Inflation fell from above 12 per cent in 1981 to around 4 per cent in the mid-1980s. This made it easier to access mortgage credit (Debelle 2004).
- In response to a very weak housing market, fiscal measures were adopted to facilitate access to housing. For instance, the Canada Homeownership Stimulation Plan, introduced during the 1982 downturn, provided cash grants to help with house purchases.
- The Canada Mortgage and Housing Corporation (CMHC, the main mortgage insurance provider) introduced Mortgage Backed Securities in 1986, which improved the liquidity of the

65. The insurers charge the lender a premium for insurance that protects the lender in case of borrower default. Typically, a lender will pass this cost on to the borrower (Allen 2011). Premiums have moved over time, both up and down. These changes may not have had much impact on borrowers, however, given that the premiums can be borrowed and do not count against loan-to-value ratios.

66. A difference from the U.S. situation before the GFC is that government-sponsored enterprises such as Fannie Mae and Freddie Mac only benefited from implicit government guaranties and subsequently had less supervision. They could therefore engage in riskier activities (Crawford, Meh and Zhou 2013).

secondary mortgage market and widened the sources of funding. This likely stimulated credit supply.

- The above measures were partly compensated for by the fact that, in 1983, the federal government raised the minimum down payment that mortgage borrowers had to provide from their own resources to qualify for mortgage insurance (from 5 to 10 per cent).

II. Tightening in 1989–92:

- The 1988 Basel Accords were implemented between 1989 and 1992. They likely constrained credit supply in general, and thus households' access to finance.[67]

- The OSFI-imposed maximum leverage ratio for large banks was reduced to 20 in 1991 (30 before). Banks had reduced their leverage ratio to below 20 before the new limit was officially adopted (Crawford, Graham and Bordeleau 2009).

- There was increased uncertainty and risk aversion related to the 1990–91 recession, to which banks likely responded by restricting access to credit.

III. Unclear in 1992–99:

- In 1992, an amendment to the *Bank Act* allowed chartered banks to enter the trust business, which they did largely through acquisitions. This led to an increase in large institutions' share of that market.[68] This could have reduced competition and therefore made credit supply tighter.[69]

- The Asian, Russian and Long Term Capital Management (LTCM) crises made lenders more prudent.

But …

- Inflation fell to around 2 per cent (the Bank of Canada inflation-targeting framework was adopted in 1992).

- The banks/trusts mergers could have led to cost savings that would have reduced the cost of financing (Freedman and Goodlet 1998).

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67. Van Roy (2008) and Allen (2004) report evidence that bank risk-weighted capital ratios increased during that period.
68. For instance, Allen (2011) reports that the "Big 8" share of that market went from around 60 per cent in 1994 to around 80 per cent in 1997–98 (see Chart 1 of their paper).
69. However, Allen (2011) reports that other factors may have increased competition during that period, in particular, the increased use of mortgage brokers.

- The federal government introduced the Home Buyers' Plan (HBP) in 1992, allowing Canadians to withdraw up to $20,000 from their Registered Retirement Savings Plans to finance house purchases.
- Also in 1992, CMHC introduced the First Home Loan Insurance program that allowed first-time homebuyers to purchase a home with as little as 5 per cent for down payment. This likely had a significant positive impact on access to mortgage credit.
- There were also financial innovations, such as credit scoring and Internet banking, which facilitated lending and access to credit (Freedman and Goodlet 1998).

IV. Easing from 2000 to mid-2007

- In 2000, the maximum leverage ratio imposed by OSFI was raised from 20 to 23 for some banks, which likely caused an easing in lending conditions.
- CMHC introduced the Canada Mortgage Bond (CMB) program in June 2001. This greatly stimulated securitization (Schembri 2014) in Canada (Chart 9.5), which facilitated financing of mortgage loans, and possibly access to housing finance.
- Home equity lines of credit were quickly becoming more popular (Crawford and Faruqui 2012), which made it easier for households to leverage the value of their house.
- Access to mortgage insurance was made much easier. For instance, insurance on 40-year amortization and insurance on mortgages with zero down payments became available.
- New players entered the market (Wells Fargo Financial, PMI Canada, etc.), which increased the supply of mortgage credit.
- However, the events of September 2001, the crashing of the tech bubble and the U.S. recession may have made lenders more careful around 2001, partly compensating for the above-mentioned factors.

V. Tightening since mid-2007

- In the summer of 2007, lenders became more risk averse and global liquidity became scarcer, in large part because of uncertainty about the value of certain financial market instruments (in particular, asset-backed commercial paper), which caused Canadian banks financing costs to increase. In response, banks tightened credit conditions.
- Starting in September 2007, lenders who had gradually been gaining market shares in the higher-risk mortgage market (for instance, Money Connect, PMI Canada and Accredited Home Lenders Canada) started exiting the market or tightening their credit conditions.

- Starting in July 2008, the government tightened the rules for qualifying for mortgage insurance. In particular, it gradually reduced the maximum amortization period (now 25 years) and imposed a maximum LTV ratio of 95 per cent for new purchases (80 per cent for mortgage refinancing and purchases of investment properties). It also imposed debt-service ratio limits; and borrowers must satisfy these limits based on rates for 5-year fixed-rate mortgage if they select a variable-rate mortgage or a term that is shorter than 5 years (Schembri 2014).
- These tightening developments were partially offset, during the worst of the GFC, by Bank of Canada interventions to ensure money-market liquidity and by the Federal Government Insured Mortgage Purchase programs that allowed mortgage lenders to sell NHA MBS to CMHC to obtain an additional source of liquidity. The program started in October 2008 and ended in March 2010.
- More recently (2013–14), the government imposed mortgage insurance caps on CMHC and private mortgage insurers and raised mortgage insurance fees and premiums. These measures will constrain the government's exposure (Schembri 2014). CMHC started limiting insurance supply (for instance, it eliminated mortgage insurance for second homes).
- Also, in response to the GFC, bank regulators have tightened capital and liquidity standards. The phase-in of Basel III capital rules began in 2013. Canada implemented these changes in January 2013, ahead of the Basel III timeline. The phase-in of Basel III's liquidity rules begins in 2015.

14. Appendix 4: Regression variables, data sources and descriptive statistics

Table 14.1: Description of the regression variables and data sources

Sample period: 1982Q1–2015Q1
Sample size: 133 quarterly observations

Consumption equation			
Variable name	***Symbol***	***Description***	***Sources***
Real per capita aggregate consumption (dependent variable)	c	Real household final consumption expenditure (v62305724) divided by population (see below)	Statistics Canada
Real per capita household non-property gross disposable income	y	Nominal non-property household gross disposable income (quarterly) divided by household final consumption deflator (v62307259) divided by population. To back-cast the 1980Q1–1980Q4 consumption deflator series, we apply the growth rate of v498179/v1992044 to the 1981Q1 value of v62307259. Nominal non-property gross disposable income is household gross disposable income (v62305981) less net property income (v62305959) plus (net transfers paid to government (v62305975)*net property income/gross disposable income).	Authors' calculations and Statistics Canada
Credit conditions index	CCI	$\mathrm{CCI} = \sum_{s=1} \tau_s \mathrm{SSD}_s = \tau_1 \mathrm{SSD1982Q1} + \tau_2 \mathrm{SSD1984Q1} + \ldots + \tau_{17} \mathrm{SSD2012Q1}$ where SSD is smoothed step dummy. Each dummy is created by defining a step dummy taking the value 0 before time t-1 and 1 from time t onward; then take a four-quarter moving average, and take a five-quarter moving average. The result is a smoothed step dummy (SSD) taking the values 0.05, 0.15, 0.3, 0.5, 0.7, 0.85, 0.95 and 1 over eight quarters, then remaining at 1. Such a smooth transition function is often called an "ogive."	Authors' calculations Jointly estimated impact on consumption, house prices and total mortgage stock.
Real household borrowing rate	r	Nominal effective mortgage borrowing rate less four-quarter change in log household consumption deflator (see above). Nominal effective mortgage borrowing rate is a quarterly average of a weighted average of rates applying to mortgage debt, calculated at the Bank of Canada (int'effmortrate).	Statistics Canada Bank of Canada unpublished series
Log permanent income growth to current income	$\ln(y_t^p/y_t)$	Per Campbell (1987): $$\ln(y_t^p/y_t) = \sum_{s=1}^{k} \delta^{s-1} \ln y_{t+s} \Big/ \sum_{s=1}^{k} \delta^{s-1} - \ln y$$ where k is the forecasting time horizon, δ is the household discount rate, and y is real per capita non-property gross disposable income (see above). We assume $k = 40$ and $\delta = 0.95$. We extrapolate income per capita growth beyond 2015Q1 at around 0.2 per cent per quarter. We extrapolate income growth per capita for the period from 2015Q1 to 2017Q4 using the Bank of Canada's potential output projection (*Monetary Policy Report*, October 2015) and Statistics Canada's population projection. The longer-run GDP per capita growth projection is based on assuming an unchanged growth rate for labour productivity after 2017, a projection of trend labour input (number of hours worked) done with the Bank of Canada's Integrated Framework (Pichette et al. 2015) and, again, Statistics Canada's population projection. See Appendix 2 for further discussion.	Authors' calculations and Statistics Canada

Net liquid assets to income	NLA_{-1}/y	Household liquid assets minus debt (at t-1), divided by quarterly nominal non-property income. Liquid assets are cash-like instruments defined as households' Canadian currency and deposits plus foreign currency and deposits plus short-term paper plus other receivables. Canadian currency and deposits are post-1990 household Canadian currency and deposits (v6269395) from Statistics Canada, spliced with pre-1990 household currency and deposits market value constructed at the Bank of Canada (depdhca). Since pre-1990 data are annual, linear interpolation is used to construct quarterly data. Foreign currency and deposits are post-1990 household foreign currency and deposits (v6269395) from Statistics Canada, spliced with pre-1990 household foreign currency and deposits market value constructed at the Bank of Canada (depfhca). Since pre-1990 data are annual, linear interpolation is used to construct quarterly data. Short-term paper is post-1990 data from Statistics Canada (v62693938), spliced with pre-1990 data constructed at the Bank of Canada (v52229272). Since pre-1990, data are annual, linear interpolation is used to construct quarterly data. Other receivables are post-1990 data from Statistics Canada (v62693965), spliced with pre-1990 data constructed at the Bank of Canada (v52229278). Since pre-1990 data are annual, linear interpolation is used to construct quarterly data. Household debt is post-1990 household liabilities (v62693968) from Statistics Canada, spliced with pre-1990 household liabilities market value constructed at the Bank of Canada (tliabhca). Since pre-1990 data are annual, linear interpolation is used to construct quarterly data. Also, we subtract trade payables liabilities (v62693999, tradphca).	Statistics Canada Bank of Canada unpublished pre-1990 series
Illiquid financial assets to income	IFA_{-1}/y	Household financial assets less liquid assets (at t-1), divided by quarterly nominal non-property income. Financial assets are post-1990 household total financial assets (v62693932) from Statistics Canada, spliced with pre-1990 market value financial assets constructed at the Bank of Canada (fassethca). Since pre-1990 data are annual, linear interpolation is used to construct quarterly data. Financial assets include privately held life insurance and pension wealth but exclude the unrealized value of claims on the Canada Pension Plan, Quebec Pension Plan, Old Age Security Program, Guaranteed Income Supplement Program and Employment Insurance Scheme. Liquid assets are described above.	Statistics Canada Bank of Canada unpublished series
Housing assets to income	HA_{-1}/y	Sum of residential structures plus land (at t-1), divided by quarterly nominal non-property income. Residential structures are post-1990 household residential structures (v6263922) from Statistics Canada, spliced with pre-1990 structures market value series constructed at the Bank of Canada (resshca). Since pre-1990 data are annual, linear interpolation is used to construct quarterly data. Land is post-1990 household land (v62693930) from Statistics Canada, spliced with pre-1990 land market value constructed at the Bank of Canada (landhca). Since pre-1990 data are annual, linear interpolation is used to construct quarterly data.	Statistics Canada Bank of Canada unpublished series
Housing liquidity index proxy	HLI	Four-quarter moving average of the post-1996Q1 ratio of residentially secured personal lines of credit (SPLC) divided by non-SPLC mortgage debt ($splc/mdebt$). SPLC (also known as home equity lines of credit, HELOC) is the estimated SPLC share of consumer credit multiplied by the consumer credit series (etsfinstat'estconscr) from the Greys, taken as a quarterly average. The estimated SPLC share is the post-2012Q1 Greys' actual share (etstdsadmin'tds.rl4.obk.v2331 / etsfinstat'estconscr), spliced with the growth rate in the estimated SPLC share from internal Bank of Canada CFM data from 1999Q1 to	Statistics Canada Canadian Monetary and Credit Aggregates and Interest Rates, Bank of Canada Data and Statistics Office (also known as the

		2011Q4, spliced with the growth rate in the estimated SPLC share from Crawford and Faruqui (2012, Chart 10) from 1986Q1 to 1999Q1, spliced with a pre-1986Q1 share generated by back-casting using the average 1986 growth rate in the SPLC share. Because home equity loan products largely did not exist before the late-1990s, we set the pre-1996 $SPLC/mdebt$ series to 0 and rebase the later series by subtracting from it the 1996Q1 value.	Greys) Crawford and Faruqui (2012), Chart 10 Bank of Canada unpublished series
Real house prices to income	hp/y	Real house prices series (see below) / real non-property income per capita. Real non-property income is non-property income (see above) divided by household consumption deflator (v62307259).	Statistics Canada Authors' calculations
Unemployment rate	ue	Unemployment rate (v2062815), 15 years and over.	Statistics Canada
Population	pop	Population (v1), seasonally adjusted using X12 in EViews.	Statistics Canada
Child-to-adult population ratio, deviation from 30-year moving average	$child/adpop - ma120(.)$	Children 0–14 years plus 0.8*children 15–19 years divided by adult population, minus 120 quarter moving average ratio. Data are obtained from 1950Q4. The 0.8 weight on children 15–19 years reflects their partial participation in the workforce and therefore reduced degree of dependency. This could be time-varying in a more refined analysis.	OECD
House price equation			
Variable name	***Symbol***	***Description***	***Sources***
Real house prices (dependent variable)	hp	Nominal national house price series divided by household consumption deflator (v62307259). The national house price series is a composite series comprising data from three sources: Teranet-National Bank (a repeat sales index) from 1999; Royal LePage (data are partially compositionally adjusted by property type) from 1988 to 1999; and Multiple Listing Service (MLS) before 1988. MLS data rely on transaction-based realtor data and are quite volatile because they are not adjusted for the composition of sales values that are transacted in each period. We try to at least partly correct for possible measurement error using seasonal/impulse dummies in the house price equation.	Conference Board, Royal LePage, Teranet-National Bank Bank of Canada composite series (teranet_hist)
Real per capita household non-property gross disposable income	y	See above.	See above
Real per capita housing stock	hs	Real dwelling net capital stock divided by population (see above). Real year-end net capital stock of single and multiple dwellings (v28368488) from Statistics Canada, rebased to 2007 for consistency with CSNA2012, then interpolated to quarterly data using a matched last cubic spline.	Statistics Canada
Nominal mortgage borrowing rate	i	See above.	See above
Real housing user cost	ucc	Real opportunity cost plus constants less expected house price appreciation. Real opportunity cost is w * real mortgage rate + $(1 - w)$ * real after-tax long government bond yield. w is set at 0.8, giving a greater than equal weight on mortgage rates faced by the marginal buyer. The real after-tax nominal bond rate is nominal bond rate x (1- average income tax rates from CANSIM Table 202-0501) less four-quarter change in log household consumption deflator (v62307259). Real mortgage rate is nominal mortgage borrowing rate (see above) less four-quarter change in log household consumption deflator (v62307259). Constants are assumed to equal 8 per cent, being the sum of depreciation, property	Authors' calculation and Statistics Canada

		taxes, transaction costs and non-interest homeownership risk compensation. Households' expectations about future housing capital gains are assumed to be extrapolative based on a weighted average of past house price growth with an extra weight on more recent growth rates. See for example Shiller (2007), Chauvin and Muellbauer (2013), and Gelain and Lansing (2014). We assume a 0.1 weight on growth over the past year, a 0.4 weight on average annual growth over the past 4 years, and a 0.5 weight on average annual growth over the full sample (around 2.5 per cent).	
Asia immigration share (ma4)	$aimmig(ma4)$	Four-quarter moving average of the ratio of total Asia immigration (v27) to total immigrants (v16). v16 was discontinued by Statistics Canada in 2013Q2, so we generate the series directly using immigration arrivals by country data obtained from Citizenship and Immigration Canada.	Statistics Canada Citizenship and Immigration Canada
Housing liquidity index	HLI	See above.	See above
<u>Total mortgage stock equation</u>			
Variable name	***Symbol***	***Description***	***Sources***
Real per capita mortgage stock (dependent variable)	tms	Mortgage debt (excluding residentially secured personal lines of credit) divided by household consumption deflator (see above). Post-1990 mortgage debt (non-SPLC) is v62693988) from Statistics Canada, spliced with a pre-1990 series constructed at the Bank of Canada (morlhca) interpolated to quarterly data using linear interpolation.	Statistics Canada Bank of Canada unpublished series
Nominal mortgage rate	i	See above.	See above
Real per capita household non-property gross disposable income	y	See above.	See above
Log housing assets to income	$\ln HA_{-1}/y$	See above.	See above
Housing liquidity index	HLI	See above.	See above
<u>Income forecasting equation for fitted $E_t \ln y^p/y$</u>			
Variable name	***Symbol***	***Description***	***Sources***
Log permanent income growth to current income (dependent variable)	$\ln y^p/y$	See above.	See above
Real per capita household non-property gross disposable income	y	See above.	See above
Consumer confidence (ma4)	$cconf(ma4)$	Four-quarter moving average of consumer confidence index (CBISA_q), seasonally adjusted, quarterly average.	The Conference Board of Canada
Terms of trade	tot	Terms of trade (v61992664), 2007 = 100.	Statistics Canada
Working-age population to	wa/pop	Working-age population (v66971) is persons aged 15–64 years, both sexes.	Statistics Canada

total population		Annual population (v466668) is interpolated to quarterly using a cubic spline.	
D4 log nominal mortgage borrowing rate	$\Delta_4 \ln i$	Four-quarter change in log nominal mortgage rate.	See above

Table 14.2: Summary statistics

Sample period: 1982Q1–2015Q1
Sample size: 133 quarterly observations

Variable	Mean	Standard deviation	Maximum	Minimum
$\ln c$	-5.2656	0.1757	-4.9771	-5.5606
$\ln y$	-9.8754	0.1425	-9.6121	-10.0916
$\ln c/y$	4.6126	0.0440	4.6665	4.4892
r	0.0506	0.0237	0.1034	0.0081
$\ln(y_t^p/y_t)$	0.0439	0.0291	0.0902	-0.0270
$\mathrm{E}_t \ln(y_t^p/y_t)$	0.0439	0.0256	0.0903	-0.0311
LA_{-1}/y	1.1792	0.0741	1.3433	1.0652
CR_{-1}/y	1.1481	0.3180	1.7327	0.6994
NLA_{-1}/y	0.0310	0.2791	0.4127	-0.4221
IFA_{-1}/y	2.4822	0.8503	3.9867	1.0100
HA_{-1}/y	2.4790	0.6278	3.7624	1.6826
$HLI\ proxy$	0.0512	0.0648	0.1669	0.0000
$\ln hp/y$	17.5670	0.1735	17.560	17.199
$\ln hp$	7.6901	0.3063	8.2365	7.1648
$\ln hs$	-3.2436	0.2027	-2.9009	-3.6194
$\ln i$	-2.7013	0.4981	-1.6667	-3.6337
ucc	0.0990	0.0341	0.1871	0.0542
$\ln ucc$	-2.3709	0.3421	-1.6761	-2.9149
$aimmig$	0.5603	0.0754	0.6809	0.3438
$\ln ms$	-8.8203	0.4091	-8.1026	-9.4755
$\ln HA_{-1}/y$	0.8774	0.2452	1.3251	0.5203
$cconf$	9.2890	20.111	130.375	48.883
$\ln tot$	4.5000	0.0766	4.6923	4.3981
wa/pop	0.6847	0.0060	0.6948	0.6760
$\ln(wa/pop)$	-0.3789	0.0087	-0.3642	-0.3716
$child/adpop$	0.3318	0.0414	0.4239	0.2667
$child/adpop - ma120(.)$	-0.1166	0.0449	-0.0576	-0.1856
ue	0.0850	0.0174	0.1297	0.0593
$\Delta \ln c$	0.0041	0.0066	0.0176	-0.0243
$\Delta \ln y$	0.0031	0.0122	0.0476	-0.0356
$\Delta \ln hp$	0.0064	0.0233	0.0794	-0.0724
$\Delta \ln ms$	0.0096	0.0106	0.0324	-0.0284
$\Delta \ln i$	-0.0149	0.0674	0.2602	-0.2425
Δue	-0.0001	0.0037	0.0017	-0.0073