Housing Market Dynamics and the GFC:
The Complex Dynamics of a Credit Shock

Arthur Grimes and Sean Hyland

Motu Working Paper 13-12
Motu Economic and Public Policy Research

October 2013

Author contact details

Arthur Grimes
Motu Economic and Public Policy Research & University of Auckland
arthur.grimes@motu.org.nz

Sean Hyland
Motu Economic and Public Policy Research
sean.hyland@motu.org.nz

Acknowledgements

We thank the Department of Building and Housing (now Ministry of Business, Innovation and Employment) for commissioning and funding the housing market model on which this research is based, with special thanks to Andrew Coleman, James Kerr and Alex Collier who contributed to the completion of that model. Any errors and views expressed are solely the authors' responsibility.

Motu Economic and Public Policy Research

PO Box 24390
Wellington
New Zealand

Email	info@motu.org.nz
Telephone	+64 4 9394250
Website	www.motu.org.nz

 ISSN 1176-2667 (Print), ISSN 1177-9047 (Online).

Abstract

We analyse the multiple channels of influence that GFC-induced credit restrictions had on New Zealand's subnational housing markets. Our model isolates dynamics caused by impacts on the supply and the demand sides of the market. These dynamics are compared to those caused by a migration shock, a more common form of housing shock in New Zealand. We focus on the impacts on two outcome variables: house prices and housing supply; both shocks cause substantial cyclical adjustments in each variable. Similar cyclical dynamics could complicate the conduct of macro-prudential policies which are designed to affect bank credit allocation.

JEL codes

E51; R21; R31

Keywords

House prices, housing supply, credit restrictions, GFC, migration

Contents

1. Introduction

Housing markets around the world were affected significantly by the Global Financial Crisis (GFC). Real house prices in New Zealand fell by 15.3% (between 2007Q2 and 2011Q2), and remained 9.5% below their peak in 2012Q4. In other countries, including Ireland, Spain and the United States, the reduction in house prices was substantially greater (International Monetary Fund, 2012). Over the same period, new housing construction across New Zealand plummeted, with residential housing consents across the country falling by 56%. After describing a model of regional housing markets in New Zealand, we analyse the multiple channels of influence that the GFC had across subnational housing markets and plot the resulting dynamics caused by the GFC-induced credit shock, focusing on price and construction. The dynamics caused by this shock are compared to those of a migration-induced population shock, which is a more common form of housing shock within New Zealand.

The *prima facie* importance of both population and credit shocks in driving house prices is illustrated in Figure 1, using national level data for New Zealand. Population changes (driven primarily by net international migration flows) are highly correlated with house price changes throughout most of the period from 1990 to 2012. However, house prices fell substantially in 2008 following the onset of the GFC (indicated by the dashed line) at a time when population flows would normally suggest flat or modestly growing house prices. The downturn in house prices after the GFC appears long-lasting, with a pronounced double dip in prices following 2007. The GFC resulted in a sharp rise in banks' non-performing loans (NPLs) as a ratio of total bank assets (Figure 2); a standard credit channel operating through banks' balance sheets implies that banks will have restricted credit while the NPL ratio was elevated (Claus and Grimes, 2003).

This paper contributes to the understanding of the dynamics of housing markets, building on the prior work of Pain & Westaway (1997), Glaeser & Gyourko (2006), Glaeser et al (2008), Grimes & Aitken (2010) and Van Nieuwerburgh & Weill (2010). Our incorporation of the link between credit markets and the housing market is especially important in light of the recent adoption across a range of countries of macro-prudential policy tools designed, in part, to affect outcomes in the housing market (Lim et al, 2011). We show that the dynamic responses of housing markets to changes in credit supply are complex and potentially very long-lived. Similar dynamic responses may greatly complicate the conduct of macro-prudential policies designed to affect bank credit allocation.

The model that we use for our simulations, the New Zealand Regional Housing Model (NZRHM), provides a framework to analyse the impacts of key exogenous influences on housing market outcomes. The NZRHM (as in Grimes and Hyland, 2013; henceforth GH) is a revised and updated version of the model in Grimes and Aitken, 2010 (henceforth GA) that modelled housing supply and house prices across New Zealand territorial local authorities (TLAs). The NZRHM models house prices and new housing supply (via new dwelling consents), extending the framework and updating the data used by GA. In addition, the NZRHM models both residential vacant land (lot) prices and average rents. All housing market variables are modelled at the TLA level, across 72 TLAs within New Zealand, using quarterly data from the early to mid 1990s to 2011.

The four modelled variables are co-determined, and are further influenced by a range of exogenous influences. Each of the four modelled relationships has a long term equilibrium component (cointegrating vector) that shows the value to which the modelled variable will tend, given the values of the exogenous variables (including policy variables) in the system. Values of the exogenous variables differ across TLAs and so each TLA – while driven by the same underlying economic forces – has differing housing market outcomes reflecting its area-specific developments. This use of regionally varying data is important in identifying the responses of the modelled variables to the independent influences.

In addition, the model is estimated with a dynamic (error correction) component that shows how each endogenous variable moves on a quarterly basis, relative to the equilibrium.

Recent changes in other variables may impact the dynamic adjustment path, potentially causing some initial movements away from equilibrium. Price expectations, for instance, may cause housing market adjustments that lead to temporary deviations in outcomes away from equilibrium, and we explore this factor in our simulations.

The simulated dynamics are the result of shocks to the model using the (former) Manukau TLA as our focus. Importantly, however, the dynamics would be very similar when applied to other TLAs. The first shock is an exogenous shock to population, simulated as an immigration surge into the TLA of a magnitude reflecting the observed "abnormal" population increase in the Manukau TLA between the 2001 and 2006 censuses. The abnormal increase is taken to be the actual percentage increase in the Manukau population over that period (expressed quarterly) in excess of the average quarterly rate of population growth across New Zealand over a prolonged period. This shock causes housing demand (and hence house prices) to jump, which in turn induces an increase in housing supply. However, the population shock also reduces land availability per person, and as such land prices increase. This increases the replacement cost of housing and results in a permanently higher number of people per dwelling. Our analysis suggests it takes nine years for the housing supply to equilibrate following the exogenous increase in demand, where the dynamics of adjustment primarily reflect supply rigidities. An additional dynamic impact arises from the modelled (extrapolative) expectations process which magnifies the price dynamics caused by the supply rigidities.

The effect of a migration flow on local housing markets is thereafter used as a yardstick for the second shock that we consider; a cut to credit supply, driven by an exogenous and prolonged increase in the NPL ratio of New Zealand registered banks. This proxy is chosen as it is a pre-determined variable that is likely to cause banks to change their lending criteria. The NPL ratio is not driven by changes to credit demand so can be considered an exogenous indicator of credit restrictions emanating from the supply side of the finance sector. Unlike the population shock, our data do not enable us to observe regional variations in the credit cycle.

Thus our simulations of the impact of a change in the NPL ratio should be interpreted as the housing market impacts that arise from an increase in the NPL ratio plus any other factors correlated with that increase (e.g. a generalised increase in risk aversion in the economy) that are omitted from our model.

Tighter credit restrictions have two effects in the model. First, they reduce some borrowers' access to credit, which reduces the amount that will be bid for a house, placing downward pressure on house prices. Second, they reduce developers' access to credit, which is required to construct new houses, thereby reducing the housing supply response to a given set of price signals. This latter effect temporarily reduces housing supply, resulting in upward pressure on house prices. Thus credit restrictions place opposite pressures on house prices. Our model enables us to consider both influences separately or together, thereby disentangling the complex dynamics that a credit shock has on housing markets.

The simulated credit shock mirrors the jump (and subsequent decline) in New Zealand banks' NPL ratio after the GFC. The countervailing effects of the shock on housing demand and housing supply result in complex dynamics as a result of the shock to credit supply. The demand effect, which dominates, causes house prices to fall substantially almost immediately after the shock. The subsequent shortage of supply that this creates (due to reduced incentives for construction whilst other variables remain at baseline levels) causes prices to bounce back so that house prices exceed their baseline level after four years. Eventually, the price rise (relative to baseline) mirrors the initial degree of price decline. The cycle in house prices is damped but the effects of the shock on house price dynamics are still apparent fifteen years after the shock's onset.

One over-arching conclusion across the two simulations is that housing markets are slow to adjust to shocks causing disequilibria, so that exogenous shocks have very long lasting effects. Specifically, we find that an increase in population leads to a prolonged period of upward pressure on prices (houses, land and rents). Full adjustment takes nine years for the modelled population shock. Similarly, tighter credit restrictions following a GFC-sized shock lead to a very prolonged and highly cyclical adjustment in house construction and prices, reflecting both the demand and supply effects emanating from the credit market.

The rest of the paper is structured as follows. Section 2 briefly outlines the key equations within NZRHM. Section 3 describes the impacts of the population shock and teases out the roles of supply rigidities and the expectations setting process in affecting dynamic adjustment. Section 4 outlines the impacts of the credit supply shock, disentangling the supply-side versus the demand-side impacts of the increased credit restrictions. Section 5 compares the simulation results and discusses what they may imply for actual housing markets and policies.

2. The Model

The New Zealand Regional Housing Model (NZHRM) comprises four key relationships explaining: house prices, house construction (and hence dwelling stock), residential land (lot) prices, and rents. The model is estimated across all 72 TLAs in mainland New Zealand (keeping the newly amalgamated Auckland TLAs as separate authorities, and incorporating the former Banks Peninsula TLA as part of Christchurch City). All modelling uses quarterly data extending from the early to mid 1990s to 2011Q2.[1]

Data availability influences the choice of variables included in the model specification and constrains the modelling to assume a single homogeneous housing market within each TLA; thus we do not differentiate between housing of different quality within a TLA. The same housing market relationships (e.g. functional form and elasticities) are assumed to operate across all TLAs. Specific features of individual TLAs are included by incorporating TLA-specific values for exogenous influences (e.g. population) and through inclusion of TLA fixed effects and TLA-specific time trends. Identification, for instance of the impact of a population shock on house

[1] The initial date varies across long run equations due to data availability on covariates.

prices, is assisted by the fact that at any point in time population dynamics vary across TLAs. Hence impacts of population changes can be identified separately from the impacts of macro variables that are correlated with population at the national level.

Two of the four key relationships are based on the model in GA, specifically a supply equation for new houses and a demand equation. The supply equation is based on a Tobin's Q approach to investment so that new housing construction responds positively to a deviation between house prices and the full cost of producing a new house, where the cost includes both construction and land costs. The demand equation, which is based on a consumer optimisation model, takes the supply of houses (dwellings) as given in the short run and therefore takes the form of a house price equation.

The third relationship in NZRHM is an equation determining residential lot (vacant section) prices, based on a bargaining game between landowners and developers. This relationship is included since lot prices influence the supply of new dwellings (and hence long run house prices). The fourth relationship is an equation determining residential rents. Changes in rents (driven, for instance, by rental subsidy changes) can affect the return to housing ownership; as a result we treat rents and house prices as an inter-related system. Other variables are treated as exogenous to this system of equations. These variables include: population, building construction costs (at the national level), incomes, interest rates and credit restrictions, and housing-related policy variables (e.g. development contributions and accommodation supplement).

Our dataset covers all 72 TLAs in mainland New Zealand and is estimated using data available from the early to mid 1990s (depending on the equation) to 2011Q2. Given the time series properties of this dataset, the equations are modelled using panel cointegration and error correction approaches. This enables us to identify long run equilibrium relationships between variables and to model the dynamics of adjustment towards the long run equilibrium following shocks to the system. The recursive nature of the model enables us to simulate the effects of an individual shock as it feeds through to multiple variables in the model over time (taking the values of exogenous variables as given).

The existence of a long run equilibrium (cointegrating) equation is implied by a stationary estimated long run residual. We use the Im-Pesaran-Shin (IPS) and Levin-Lin-Chu (LLC) panel unit root tests to test for stationarity (versus the null hypothesis of a unit root) of the residual from the long run equation. The LLC test assumes that the same time series processes operate across TLAs whereas the IPS does not make this restriction. For this reason, the IPS is our preferred test. We note however, that neither the IPS nor the LLC test is strictly appropriate to test the stationarity of a residual obtained using estimated parameters. We therefore supplement these tests with the requirement that the residual from the cointegrating regression be strongly significant ($p<0.01$) in the error correction equation.[2] The results of such an approach supports the existence of a long-run relationship for each endogenous variable.

Each long run equilibrium equation is supplemented by a short run (error correction) equation. The latter equation tests whether changes in the variable of interest respond significantly to the lagged disequilibrium term (i.e. to the lagged residual from the cointegrating equation). A significant response to the lagged disequilibrium term is required to establish that the variable of interest does adjust towards equilibrium following a shock. The error correction equations also include other (stationary) variables to model the dynamics of adjustment. All variables in the error correction equations are lagged to avoid endogeneity (simulataneous determination) problems.[3]

The cointegrating equations all include area (TLA) fixed effects, which allow for a different constant term for each TLA reflecting (unchanging) local conditions. Three of the four equations (i.e. excluding the house price equation) also include time fixed effects reflecting national developments. For the house price equation we instead include TLA-specific time

[2] Our estimation software (Stata) does not incorporate panel cointegration tests.
[3] Endogeneity is not an issue in the cointegrating regressions given the super-consistency property of coefficients on non-stationary variables in such regressions.

trends to reflect unobserved deterministically trending factors applicable to housing demand in specific TLAs (e.g. income and consumption per capita, and changing preferences towards certain amenities within that TLA). The short run equations do not include separate area or time fixed effects (or time trends) given that these are incorporated into the long run relationships. No spatial interactions between TLAs have been incorporated.

All long run equations are estimated by ordinary least squares (OLS) given the super-consistency properties of OLS estimates with non-stationary variables. The short run equations are estimated through a seemingly unrelated regression (SUR) model.[4] The estimation period is given by the equation with the shortest time span for data (1996Q4-2011Q2). Table 1 defines all variables used in the long and short run equations. Only non-stationary variables are included in the long run equations and only stationary variables are included in the short run equations.[5] Tables 2 and 3 provide the long run and short run equation estimates respectively.

The house price (housing demand) equation is based on the theoretical outline derived in Pain and Westaway (1997) and, more succinctly, in GA. The latter's derivation of this equation is reproduced in the Appendix. House prices, in the long run, are determined by the demand for housing relative to the existing supply of dwellings. The latter is pre-determined in the short-run by the stock of houses at the end of last quarter (with new supply being unable to react to new information within a quarter). Housing demand (and hence house prices) is affected positively in the long run by a rise in population relative to the existing dwelling stock, incomes[6] and governmental support for owner-occupiers.[7] House prices are affected negatively in the long run

---

[4] GH also estimated the short run equations using OLS. They used the Prais-Winston estimate of the autoregressive parameter in the residuals to test for residual autocorrelation, and compared OLS with Newey-West standard errors to examine whether the specification was free of heteroskedasticity and autocorrelation. In one case, the short run equation for housing supply, the specification of the dependent variable is chosen so as to avoid problems of autocorrelation that would otherwise be present.

[5] GH provide detailed definitions of all variables, their derivation and their sources, and test all variables for a unit root.

[6] TLA-specific income trends are captured in the long run equations through inclusion of deterministic time trends with TLA-specific coefficients; short run income changes are captured through inclusion of the relevant per capita Regional Economic Activity index calculated by the ANZ/NBNZ.

[7] Government support for owner-occupiers is captured through inclusion of the real (CPI-adjusted) level of accommodation supplement paid to eligible owner-occupiers.

by the user cost of capital (interest rates less extrapolative expectations of house price inflation[8]) and by bank credit restrictions. Such restrictions may conceivably take a variety of forms including a higher home equity requirement (lower loan to value ratio), tighter covenants on debt servicing ratios, or stricter criteria on borrower eligibility (Claus and Grimes, 2003). Rather than modelling each of these directly (given the lack of data on each), we include the banking system's proportion of loans that are non-performing (impaired loans plus those at least 90 days overdue). This variable is predetermined at any given time; a higher ratio is likely to cause banks to adopt stricter loan criteria during the period that the banks are working to reduce their NPL ratio. Thus we take the banks' NPL ratio as our underlying variable that proxies the restrictiveness of banks' credit rationing policies.[9] In addition to the long run determinants, changes in (real) rents impact positively on house prices in the short run.

The housing supply equation is based on the theoretical outline in GA, with key elements also reproduced in the Appendix. In accordance with a Tobin's Q approach to investment, additions to the dwelling stock occur when it is profitable for builders/developers to build new dwellings. Thus new construction responds positively to increased house prices, but is affected negatively by rises in residential lot prices and/or construction costs. New construction may be restricted by tighter credit conditions which reduce the ability of builders/developers to access the finance required to purchase land, materials and labour for housing construction even when Tobin's Q is greater than unity. In the short run, housing construction also responds positively to expectations of rising housing market prices. The dynamics of adjustment incorporate non-linear and asymmetric adjustment coefficients with especially strong adjustment as the Q ratio rises well above unity.

---

[8] Consistent with GA, all price expectations variables in the model are based on extrapolation of the past three years' rate of price growth in a TLA (or nationally for national variables).

[9] We do not have similar information on non-performing loans of other parts of the financial system, although finance company loan impairments could be particularly important for the availability of credit to developers. The NPL variable will be correlated with non-performing loans from other financial intermediaries, so will pick up some of these effects, albeit imperfectly.

Lot prices are set as a result of a bargaining game between landowners (farmers) and developers who act as intermediaries for the ultimate homebuyer. Suppose a farmer owns lot-sized farm land, which is valued at the farmland price. The developer can prepare the land for residential use through incurring development costs (a function of construction costs) and paying a development contribution to the council (levied under the Local Government Act, and/or a financial contribution levied under the Resource Management Act)[10, 11]. The minimum lot price that allows for non-negative profits for converting farmland to residential land is, therefore, the land's value as farmland plus the sum of development costs and development contributions.

In a TLA with perfectly elastic supply of farmland and all development occurring at the periphery of an urban area, this expression will determine the residential lot price, PL. However, some residential lot development may occur through subdivision within an urban area, especially where planning controls or geographical constraints inhibit expansion at the urban periphery (Grimes and Liang, 2009; Saiz, 2010). As house prices tend to their replacement cost in the long run, new lots cannot be sold to a developer for more than the level of house prices less construction costs for a new house. The lot price will be higher the closer the lot is located to the city centre (or other sought-after amenity); and, for any chosen lot, this convenience yield will be higher the greater is the pressure on population in the area. We therefore hypothesise that the average urban lot price may rise above the minimum lot price according to: (a) the level of house prices less construction costs for a new house, and (b) the impact of population pressures on land for new housing development in the presence of residential land constraints (Grimes and Liang, 2009). In the absence of explicit regulatory measures, we hypothesise that the current population level relative to that in 1991 (when current TLA boundaries were set) provides an indicator of relative land constraints. Consistent with this bargaining game approach, our

---

[10] Our data for this variable only starts with the start of the development contribution regime in 2002Q3. Dummy variables are included in the equations to account for this data discontinuity.

[11] See Palmon and Smith (1998) for a discussion of the ways that development contributions can affect property prices.

estimated long run equation finds that the real residential lot price is set as a function of real farm prices, real development plus financial contributions per housing consent, real house prices and the interaction of house prices with population growth relative to the 1991 population level (which has an additional positive short run effect).[12]

As in Grimes and Aitken (2007), rents are set so as to provide landlords with a market yield, given the level of house prices. The total real yield to landlords equals the rental yield plus expected real capital gains on the house; thus (in accordance with our long run estimates) rental yields fall as expected capital gains rise while rents rise in response to increases in both house prices and interest rates. Rents (relative to house prices) are also estimated to rise, in the short term, as the rate of government rental assistance (accommodation supplement) rises; we find no evidence of a long run effect of this variable on rents, consistent with a market in which there is a high supply elasticity of new landlords (Coleman and Scobie, 2009).

3. Population (Migration) Shock

We subject the NZRHM, as characterised in Tables 2 and 3, to two separate shocks. These shocks are conducted over a fifteen year window for a single TLA, Manukau, which is a major area of housing growth in the south of Auckland, but the shocks could equally be applied to any other TLA. The simulated shock outcomes are compared to a baseline without the shock.[13] For each simulation, we present four graphs comparing simulated versus baseline results, in the nature of an impulse response function. The first graph shows the time-path of the shocked variable. The second and third graphs show the paths of the housing stock and housing investment (consents) respectively, while the fourth graph shows the path of house prices. The population, housing stock and house price graphs are presented in terms of percentage deviation

[12] The influence of real construction costs (a national variable) is captured through the time fixed effects.
[13] The baseline is the predicted path of each variable.

from baseline, while the housing consent graph (and, in the next section, the credit restrictions graph) are presented in terms of percentage point deviation from baseline. For conciseness, we do not include the corresponding land price and rent graphs but the responses of these variables feed into the responses of the supply and price variables that are shown.

The first shock, and that considered in this section, is an exogenous shock to population, simulated as a migration surge into the TLA of a magnitude reflecting the actual "abnormal" population increase in the Manukau TLA between the 2001 and 2006 censuses. Over the 1991 to 2006 period, the New Zealand population experienced an average quarterly growth rate of 0.23%. By contrast, the growth rate in the Manukau city population between 2001 and 2006 was 0.76% per quarter (0.54% per quarter[14] higher than the long run New Zealand population growth rate). This was the highest inter-censal expansion of population in any of New Zealand's main city TLAs over our estimation period. Our chosen shock is a simulation of the impact on a TLA housing market if its simulated population growth rate is 0.54% per quarter above its baseline rate for a period of five years beginning in period 0, dropping back to its baseline growth rate from quarter 20 onwards. We begin by using the full estimated model to simulate the effects of this shock, where the results are discussed in section 3.1. However, part of the dynamic response arises as a result of the extrapolative expectations mechanism embedded within the model. To establish the role of the expectations variables versus other impacts on the dynamics of the system, section 3.2 presents results with the expectations effects 'turned off'.

3.1. Population Shock (Including Extrapolative Expectations)

As a result of the 20 quarter (net) migration surge, the population level in the simulation is permanently above baseline from the start of period 0 onwards. From quarter 20 onwards population is 11.2% above baseline. The increase in population, in the presence of adjustment

[14] Rounding causes the difference to be 0.54% per quarter rather than 0.53%.

costs that prevent the rate of new housing investment from keeping pace with the migration surge, places upward pressure on house prices as the ratio of population to the housing stock rises. The sustained increase in house prices becomes embedded in expectations of further capital gains in housing which contributes to a reduction in the (perceived) user cost of capital. The reduction in the user cost of capital temporarily exacerbates the increase in house prices. Consequently, house prices exceed the baseline case by a maximum of 23.6% in the 22nd quarter. Importantly, the population increase also places upward pressure on residential lot prices (through the interaction term between population and house prices).

The increase in house prices drives Tobin's Q above unity (since building costs are assumed not to rise, and lot prices do not increase sufficiently to cause the total development cost increase to outweigh the house price increase). The increase in the Q ratio causes housing investment to increase, with the path of the housing investment rate broadly mirroring the path of house prices. The peak expansion in housing investment coincides with that of house prices; housing investment rate is 0.6 percentage points above baseline 22 quarters after the initial shock.

The increased housing investment causes the housing stock to increase gradually throughout the first nine years of the simulation. The fact that the stock is increasing materially for a further four years beyond the end of the migration surge indicates the lags involved in meeting the residential needs of an abnormal increase in the population. When construction exceeds the increases in population we find house prices start returning towards baseline. House prices are approximately equivalent to their baseline level after ten years. However, the reduction in house price deviations from baseline after the fifth year sets in train a slight downward overshoot of house prices; this effect is again exacerbated through the (negative) expected capital gains channel.

The equilibrium condition in the supply equation suggests that long run house prices increase by 22% of the long run increase in lot prices (holding construction costs constant), where the latter rises due to the added population pressure. The resulting increase in long run real house prices causes a reduction in demand for housing (relative to the population), so the final increase in the housing stock is less than the increase in population. After fifteen years, the housing stock in the model has increased by 9.2% compared with the 11.2% increase in population. Thus there is a permanent increase in the number of people per dwelling following the migration surge as a result of pressure on residential land prices.

One key finding of the simulation, other than the directions and magnitudes of effects, is that a five year migration surge (of a scale recently witnessed in New Zealand) causes a ten year house price cycle, with slight cyclical echoes stretching beyond ten years. Thus a population shock has a long term impact on the housing market (and broader economy) over the course of an extended cycle.

3.2. Population Shock (Excluding Extrapolative Expectations)

The previous simulation uses the full estimated model to simulate the dynamics associated with a (net) migration inflow. Part of the dynamic adjustment is due to the incorporation of extrapolative expectations in the model. In order to understand the role attributed to expectations, we decompose the dynamics into variation attributed to our specification of expectations and all other factors (dominated by the rigidities in the adjustment of the housing stock). Specifically, Figure 4 depicts the impact of the same net migration inflow if expectations were formed independent of the shock, i.e. where the growth in house and land prices is expected to be that under the baseline. Such expectations are consistent with a situation where agents (erroneously) believe that house prices follow a random walk with drift, in which case an agent's best prediction of tomorrow's house price is today's house price plus a constant growth rate.

The lower right panel of Figure 3, when compared to that of Figure 4, indicates a degree of self-fulfilment in expectations of house price growth; house prices increase further if future growth rates in prices are anticipated to be similar to those currently than would be the case without extrapolative expectations. Without the expectations channel, house prices exceed baseline levels by a maximum of 18% in the 22nd quarter compared with the maximum 24% over baseline under the alternative scenario. Importantly, without extrapolative expectations, the convergence towards the new long run house price level is characterised by less cyclicality and volatility. House prices in this scenario do not fall below baseline levels, rather the difference decays monotonically from the maximum to remain 6.7% above baseline at the end of our simulation period.

The reduced spike in house prices results in a reduced incentive for developers to construct new homes in the early stages of the simulation period, but also results in a reduced incentive to cut back on construction as house prices fall from their peak. The result is that the quarterly housing investment rate exceeds baseline by 0.44 percentage points in the 22nd quarter, thereafter fluctuating around 0.05 percentage points above baseline. Given that house prices are still above the baseline level at the end of the simulation window, housing investment remains above baseline fifteen years after the onset of the shock.. The peak in the housing investment rate is 0.16 percentage points below the maximum under the scenario incorporating extrapolative expectations. Hence, without the extrapolative expectations channel, the housing stock level is slower to equilibrate following the change in population and is still increasing in response to the shock at the fifteen year mark. After fifteen years, the housing stock in the scenario without extrapolative expectations is 0.9 percentage points lower than in the simulation with expectations incorporated.

Collectively, the two previous simulations suggest the extent to which expectations on both the demand and supply sides affect the housing market. A scenario which allows for expectations to be extrapolative on the demand side, while conforming to baseline growth expectations on the supply side, differs little from the outcomes in subsection 3.1. This situation might arise if developers act only in response to observed, rather than expected, disequilibria whereas buyers have extrapolative expectations. On the demand side of our model, price expectations flow through to long run housing demand (and hence to house prices) via the user cost of capital, with additional short run effects through the setting of rents. These channels, especially through the user cost of capital, therefore appear to be the dominant form of transmission of extrapolative expectations to housing outcomes.

While the expectations effects are material, they are dominated in magnitude by the impacts of the supply rigidities. Approximately one quarter of the peak house price increase in the first simulation arises from the expectations channels. Thus the qualitative result from the first simulation – that house prices follow a substantial cycle in response to a population shock – is robust to alternative expectations mechanisms. Furthermore, a larger price spike brings forward construction of extra new dwellings. Without a full understanding of the sources of the supply rigidities, we cannot conclude whether a faster or slower construction response is welfare-improving, but the dynamic patterns of response, and how they are affected by the expectations channel, are clarified by our simulations.

4. Credit Restrictions Shock

The second shock that we simulate is a cut to credit supply, driven by a prolonged exogenous increase in banks' NPL ratio. The increase mirrors the jump (and subsequent decline) in the NPL ratio of New Zealand banks' after the GFC. We simulate the impacts of the tighter credit restrictions initially with the demand side channel operating only, then just with the supply side channel operating, and finally with both channels operative. This enables us to decompose the full effects of the credit channel on the housing market into its two competing sources.[15]

In each case, the same shock is considered. The average NPL ratio over the period 1996Q1 to 2008Q3 was around 0.6%, albeit varying with the state of the economy (Figure 2). In 2008Q4, this ratio jumped markedly above 0.6%, and by 2011Q1 had reached a peak of 2.11% before subsiding to 1.36% in 2012Q4. The ratio in 2012Q4 was similar to that at the start of the series in 1996Q1. As such, we use the (smoothed) rate of decline in the ratio of 5% per quarter from 1996Q1 to 1999Q4 to project forward the path for the NPL ratio beyond 2012Q4. The result (as depicted in the first quadrant of Figures 5 to 7) is that the NPL ratio is elevated relative to baseline for a total of 32 quarters, peaking 1.51 percentage points above baseline 10 quarters after the onset of the shock.

4.1. Credit Restrictions (Housing Demand Channel Only)

Figure 5 shows the impacts of the shock to the NPL ratio on the housing market where we activate only the housing demand (house price) channel. Thus, in the housing supply equation, we hold the NPL ratio at its baseline path while we use the simulated path of NPLs in the house price equation; housing supply still reacts to house prices and therefore reacts indirectly to the NPL shock.

The reduction in credit supplied to prospective house purchasers constrains bids on the margin and leads to a significant fall in the house price level (relative to baseline), with a peak fall of 7.7% eight quarters after the start of the shock. This fall compares with an actual peak to trough fall in national (New Zealand) real house prices after the onset of the GFC of 15.3%, implying that credit restrictions accounted for approximately half of the fall in real house prices. (Other factors, such as falls in real incomes, are held constant in our simulation.) The fall in

[15] We do not further decompose the effects into those emanating from expectations and other mechanisms as the insights from Section 3.2 apply equally to this scenario; extrapolative expectations increase the amplitude of price and construction responses.

house prices reduces the profitability associated with new housing construction. As a result, housing investment is below the baseline level for 18 quarters following the start of the shock whilst the housing stock is below baseline for almost 8 years, with a peak fall relative to baseline of approximately 1%.

The erosion of the per capita housing stock via reduced investment, however, places upward pressure on house prices. Thus house prices gradually return to baseline and then overshoot baseline by almost 8% seven years after the onset of the shock. This price increase reverses the housing investment shortfall, with investment exceeding baseline from quarters 19 to 43, thereafter remaining just below baseline through to the end of our fifteen year simulation. The higher investment rate, caused by the house price overshoot, leaves the housing stock slightly above (but returning to) baseline from quarters 33 onwards.

The nature of the cycle in house prices and new construction mirrors the shape of the actual cycle witnessed since the GFC. House prices initially fell in the post-GFC period and new housing construction collapsed. Subsequently, house prices have increased sharply (particularly in the country's largest city, Auckland,[16] where housing construction has fallen well behind population growth) and new construction activity is underway.

4.2. Credit Restrictions (Housing Supply Channel Only)

Figure 6 shows the impacts of the shock to the NPL ratio on the housing market when we activate only the housing supply (new housing consents) channel. In the house price equation, we hold the NPL ratio at its baseline path while we use the simulated path of NPLs in the housing investment equation; house prices react to changes in supply and so react indirectly to the NPL shock.

[16] Christchurch has its own construction and price surge as a consequence of its earthquakes in 2010 and 2011. GH examine the specific case of post-earthquake housing outcomes in Christchurch.

The credit restrictions reduce new housing investment as developers face reduced access to credit. As a result, housing investment remains below baseline for almost three years and the housing stock is below baseline for approximately five years. The result of the supply shortfall (with other factors held constant) is an increase in house prices consequent on the credit shock. However the peak house price increase is just 0.7%, with the small size of the increase mirroring the subdued nature of the housing supply responses. Overall, while the impact on house prices through the housing supply channel is in the opposite direction to that through the demand-side channel, the supply-side effect is the smaller of the two.

4.3. Credit Restrictions (Both Channels)

With both channels operating, the dynamics in house prices are similar to those from just the demand channel (Figure 7). House prices fall below baseline by a maximum of 7.5% in the 8th quarter, before rising to a peak of 7.2% above baseline after 26 quarters. The housing supply response is magnified relative to the demand case since both the supply and demand channels cause an initial reduction in new housing investment. Investment is below baseline for four years after the onset of the shock while the housing stock remains below baseline for seven years, with a maximum reduction of 1.2% relative to baseline. As the per capita stock falls (given exogenous population growth) prices increase thereby inducing new supply. Housing investment consequently rises above baseline for a period of six years before tracking just below its baseline level.

In contrast to the dynamics of the NPL ratio, which is characterised by a rapid rise to a peak ratio followed by a continuous decline until the ratio returns to baseline, the housing market displays marked cyclical behaviour. As expected, the credit shock causes a reduction in house prices and construction activity, but it also sets in train the prerequisites for a housing boom, even while the NPL ratio is still above its baseline level. Thus house prices and new house construction both peak approximately six years after the onset of the credit shock at which time the NPL ratio is still 0.24 percentage points above its baseline level. The complex dynamics of the housing market – in which the housing dynamics differ materially from the dynamics of the underlying shock – are therefore illustrated clearly through this simulation.

5. Conclusions

The New Zealand Regional Housing Model (NZRHM) provides a framework to analyse the impacts of key policy and exogenous influences on housing market outcomes. It models four key variables within local housing markets: house prices, housing supply (new dwelling consents), residential vacant land (lot) prices, and average rents. The four modelled variables interact with each other in a system of long run (equilibrium) and short run (dynamic) equations.

We use the model to simulate the effects on TLA housing markets of two separate exogenous shocks. The first is a permanent population shock (temporary migration surge) which mirrors the actual "abnormal" increase in population experienced by Manukau between 2001 and 2006. The shock increases house prices, as new supply falls short of the increased population. The higher prices in turn induce new housing investment, resulting in a higher path for the housing stock. However, the rise in the housing stock falls short of the rise in population owing to a permanent increase in land prices caused by population pressures; the housing stock rises by 9.2% after fifteen years, compared with the 11.2% increase in population. Furthermore, there is a major cycle of nine to ten years (i.e. starting at baseline, rising to a peak in house construction and house prices, and then back to baseline), with indications of a small cyclical effect thereafter. Approximately three-quarters of the amplitude of the cycle is explained by price reactions in the face of supply rigidities; the remainder is due to the effects of extrapolative price expectations magnifying the price responses following past changes in observed house prices.

The second shock is a prolonged increase in the restrictiveness of credit provided by the financial system. The source of the credit shock is an exogenous increase in banks' non-performing loans which causes them to increase the stringency of their lending criteria. The size of the shock mirrors the actual rise in NPLs experienced by New Zealand banks after the GFC. The shock has a direct negative effect on housing supply (as developers find it more difficult to access credit for new developments), while also having a direct negative effect on house prices as prospective purchasers curtail their bids for houses. The house price reduction induces a further decrease in new housing investment. The result of the two influences is that the housing market exhibits marked dynamics in which prices and construction initially fall below baseline and then rise to a peak above baseline of a similar magnitude to the initial trough. This cycle continues in a damped fashion even beyond the end of our fifteen year simulation period.

In absolute terms, the (actual) population shock has a greater impact on construction outcomes relative to baseline than the (actual) credit shock. Housing investment rises to a peak above baseline of approximately 0.6 percentage points for the population shock whereas the peak rise is 0.16 percentage points for the credit shock. Similarly, the peak house price rise relative to baseline with the population shock is 24% whereas the peak change following the credit shock is 7.5%. However the trough to peak changes under the credit shock are closer to the population shock, with a trough to peak rise in housing investment of approximately 0.3 percentage points and a trough to peak rise in house prices of approximately 15%.

One overarching conclusion from these simulations is that shocks cause long-lived dynamics within the housing market. Whilst extrapolative expectations of future house price growth increase the amplitude of the housing cycles, the key reason for the prolonged dynamics is the time that it takes to achieve a material change in the dwelling stock through new construction. The population simulation shows that the stock takes approximately nine years to almost fully respond to a population increase spread smoothly over five years. There are therefore prolonged upward impacts on house prices in the model (as well as on lot prices and rents), with a significant cycle in the rate of new dwelling construction. The cyclicality of housing market adjustments is even more apparent in the credit shock simulation, where even after fifteen years the cyclical effects remain pronounced.

Thus, given the institutional settings that exist in New Zealand, market participants and policy-makers should expect even temporary shocks that impact on housing markets to have a prolonged impact on those markets. Consistent with the work of Kydland and Prescott (1982), these fluctuations in the "time to build" new capital equipment (of which housing is an example) can potentially have major effects on the cyclical behaviour of the wider economy. As discussed by the New Zealand Productivity Commission (2012), policy-makers may therefore need to consider how the responsiveness of housing supply to demand shocks can optimally be increased in order to reduce the cyclicality and prolonged nature of responses to the myriad of shocks that hit the housing market. Furthermore, complex and unforeseen housing market dynamics may arise through the use of macro-prudential policy tools, complicating the use of tools such as loan-to-value ratio limits. This possibility will necessitate continued close monitoring of housing supply and price developments, and their causes, to ensure that undesired price or supply effects do not eventuate in subsequent years.

References

Claus I. & A. Grimes. 2003. "Asymmetric Information, Financial Intermediation & the Monetary Transmission Mechanism: A Critical Review", New Zealand Treasury Working Paper 03/19, Wellington: Treasury.

Coleman A. & G. Scobie. 2009. "A Simple Model of Housing Rental and Ownership with Policy Simulations", Motu Working Paper 09-08, Wellington: Motu.

Glaeser E. & J. Gyourko. 2006. "Housing Dynamics". NBER Working Paper 12787, Cambridge, MA: National Bureau of Economic Research.

Glaeser E. & J. Gyourko & A. Saiz. 2008. "Housing Supply and Housing Bubbles", *Journal of Urban Economics* 64(2), 198–217.

Grimes A. & A. Aitken. 2007. "House Prices and Rents: Socio-Economic Impacts and Prospects", Motu Working Paper 07-01, Wellington: Motu.

Grimes A. & A. Aitken. 2010. "Housing Supply, Land Costs and Price Adjustment", *Real Estate Economics* 38(2), 325-353.

Grimes A. & S. Hyland (with A. Coleman, J. Kerr and A. Collier). 2013. "A New Zealand Regional Housing Model". Motu Working Paper 13-02, Wellington: Motu.

Grimes A. & Y. Liang. 2009. "Spatial Determinants of Land Prices: Does Auckland's Metropolitan Urban Limit Have an Effect?", *Applied Spatial Analysis and Policy* 2, 23–45.

International Monetary Fund, 2012. "World Economic Outlook: Growth Resuming, Dangers Remain". *World Economic and Financial Surveys*, April 2012.

Kydland F. & E. Prescott. 1982. "Time to Build and Aggregate Fluctuations", *Econometrica* 50, 1345–1370.

Lim C., F. Columba, A. Costa, P. Kongsamut, A. Otani, M. Saiyid, T. Wezel & X. Wu. 2011. "Macroprudential Policy: What Instruments and How to Use Them?", IMF Working Paper WP/11/238, Washington DC: International Monetary Fund.

New Zealand Productivity Commission. 2012. *Housing Affordability Inquiry*. Wellington: NZPC.

Pain N. & P. Westaway. 1997. "Modelling Structural Change in the UK Housing Market: A Comparison of Alternative House Price Models", *Economic Modelling* 14(4), 587–610.

Palmon O. & B. Smith. 1998. "New Evidence on Property Tax Capitalization", *Journal of Political Economy* 106(5), 1099–1111.

Saiz A. 2010. "The Geographic Determinants of Housing Supply", *Quarterly Journal of Economics* 125(3), 1253–1296.

Van Nieuwerburgh S. & P-O. Weill. 2010. "Why Has House Price Dispersion Gone Up?", *Review of Economic Studies* 77(4), 1567–1606.

Appendix: Derivation of Long Run Demand and Supply Equations

Long run housing demand equation

GA consider an economy with N_t identical individuals at time t, each of whom derives utility from real non-housing consumption (cx_t) and housing services (θh_t) where h_t is the individual's housing stock and θ is the ratio of the individual's housing services to housing stock.[17] In each period, the individual earns y_t; the individual's real wealth, w_t, can be allocated between h_t and real financial assets (f_t). The prices of the housing stock and non-housing consumption are PH_t and PC_t respectively; their ratio is denoted $g_t = PH_t/PC_t$, and $\dot{g}_t$ is the expected rate of change of g between t and $t+1$. The real after-tax return on f_t is r_t; the real return on h_t equals the real rate of capital gain ($\dot{g}_t$) less the rate of depreciation (κ) and less the foregone rate of earnings (or the after-tax cost of borrowing), r_t, on the real housing capital ($g_t h_t$). Thus the intertemporal constraint for the state variable, w_t, is given by (1):

$$w_{t+1} = (1 + r_t)(w_t + y_t - cx_t) + (\dot{g}_t - r_t - \kappa)g_t h_t \quad (1)$$

In each period, the individual has a constant relative risk aversion utility function that is separable in non-housing consumption and housing services; thus the individual's value function in t (with ρ being the discount factor) is given by:

$$V_t = \{ [({cx_t}^{1-\delta} + (\theta ht)^{1-\delta}) / (1-\delta)] + \rho V_{t+1}(w_{t+1})\} \quad (2)$$

Taking the ratio of the first order conditions for (2) with respect to cx_t and h_t respectively, yields the optimum ratio of housing stock to consumption for the individual:

$$h_t/cx_t = \theta^{(1-\delta)/\delta}\, UC_t^{-1/\delta} g_t^{-1/\delta} \quad (3)$$

where: $UC_t \equiv (r_t - \dot{g}_t + \kappa)/(1 + r_t)$ is the real user cost of capital for housing.

Aggregating (3) over all N_t individuals and solving for g_t, we obtain:

$$g_t = \theta^{1-\delta} \left(\frac{Nt}{Ht}\right)^{\delta} CX_t^{\delta}\, UC_t^{-1} \quad (4)$$

Expressing g_t as PH_t/PC_t, adding regional subscripts to relevant variables, and taking logs yields expression (5) for the equilibrium house price:

$$\ln\left(\frac{PH_{it}}{PC_t}\right) = (1-\delta)\ln\theta - \delta\ln\left(\frac{H_{it}}{N_{it}}\right) + \delta\ln\left(\frac{Cons_{it}}{N_{it}}\right) - \ln UC_{it} \quad (5)$$

where: $Cons_{it}$ is total non-housing consumption in i at t.

[17] Lower case letters denote individual-level variables; upper case letters denote the corresponding aggregate variables or variables faced identically by all individuals.

Equation (5) forms the basis for the long run house price equation in Table 2 where $\ln UC$ is replaced by UC (multiplied by a coefficient), per capita consumption is proxied by TLA-specific time trends, and credit restriction and accommodation supplement terms are added as additional variables impacting respectively on per capita consumption and on the effective user cost of capital.

Long run housing supply equation

We assume that a builder seeks to build a new house where the house sale price exceeds the full cost of developing and building a new house. Total costs are a function of building costs and residential lot (vacant land) costs plus builders' financing costs. We further assume that some substitutability exists between land and structures for a given level of utility for the ultimate purchaser, but that both sets of inputs are required for any development to proceed. Accordingly, we adopt a divisia index for total costs in TLA i at time t (TC_{it}) as a function of residential land costs (PL_{it}) and (national) building costs (PB_t) with weights summing to one. In addition, real financing costs (i_t^r) must be borne by the developer. Thus, we postulate:

$$TC_{it} = [e^{\lambda_i} PL_{it}^{\beta} PB_{it}^{1-\beta}](1 + i_t^r)^{\gamma} \quad (6)$$

where λ_i incorporates TLA-specific cost factors and γ reflects the holding period between the builder raising finance and selling the house. In equilibrium, house prices equal total costs so that $\ln(PH_{it}) = \ln(TC_{it})$. Using this equilibrium condition, and rearranging (6), we obtain the long run relationship:

$$ln\left(\frac{PH_{it}}{PB_{it}}\right) = \alpha - \beta\, ln\left(\frac{PB_{it}}{PL_{it}}\right) + \lambda_i + \lambda_t + \varepsilon_{it} \quad (7)$$

where λ_t incorporates the finance cost term and any other national factors affecting the equilibrium relationship. If (7) forms a cointegrating vector then it is valid to model housing consents relative to the housing stock (a stationary variable) as a function of the (stationary) residual from equation (7).

Tables and Figures

Table 1: Data Definitions

Variable	Definition	Source
AS^{O-Real}	Accommodation Supplement; real value to eligible homeowners	MSD
AS^{R-Rate}	Accommodation Supplement; rate paid to eligible renters	MSD
DC_HC_i	Development contributions per housing consent	DBH, SNZ
H_i	Dwelling stock	SNZ
HC_i	Housing consents	QVNZ
i^m	1 year mortgage interest rate	RBNZ
N_i	Population	SNZ
NPL	Credit restrictions (banks' non-performing loan ratio)	RBNZ
PB	Residential construction cost index	SNZ
PC	Consumer price index	SNZ
PF_i	Farm price per hectare	QVNZ
PH_i	House price	QVNZ
PL_i	Residential lot price	QVNZ
R_i	Average rent	DBH
REA_i	Regional economic activity index	ANZ/NBNZ
UC_i	Real user cost of capital	RBNZ, SNZ

Notes:
ANZ/NBNZ=ANZ/National Bank of New Zealand; DBH=Department of Building and Housing (now MBIE); MSD=Ministry of Social Development; QVNZ=Quotable Value New Zealand; SNZ=Statistics New Zealand; RBNZ=Reserve Bank of New Zealand.

Series with an i subscript have TLA-specific data; non-subscripted variables are national.

A supercript G added to a price variable denotes an expectations measure for the rate of change in the variable where the rate of (extrapolative) expectation is based on data for the 3 years up to the the last quarter.

Table 2: Long Run Equations

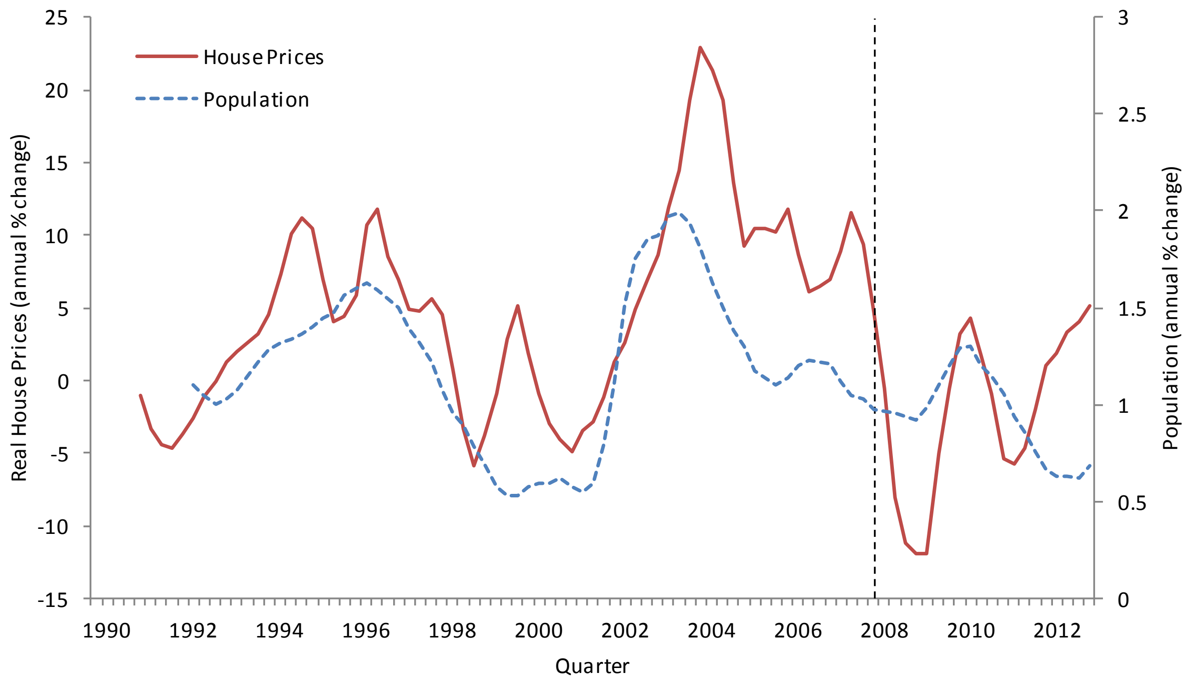
	House Prices	Housing Supply	Lot Prices	Rents
	$\ln\left(\frac{PH_{it}}{PC_t}\right)$	$ln\left(\frac{PH_{it}}{PB_{it}}\right)$	$\frac{PL_{it}}{PC_t}$	$\frac{R_{it}}{PH_{i,t-1}} - i_t^m$
$Constant$	9.7634***	4.0169***		0.0007
	(0.1334)	(0.0184)		(0.0008)
$\ln(H_{it}/N_{it})$	-2.1854***			
	(0.2015)			
UC_{it}	-0.0498***			
	(0.0014)			
CR_{it}	-0.0146***			
	(0.0052)			
AS_{t-1}^{O-Real}	0.0160***			
	(0.0007)			
$\ln(PB_{it}/PL_{it})$		-0.2162***		
		(0.0047)		
PF_{it}/PC_{it}			0.1401***	
			(0.0389)	
$(DC_{it}\_HC_{it})/PC_t$			0.3792***	
			(0.0764)	
PH_{it}/PC_{it}			0.3607***	
			(0.0146)	
$(PH_{it}/PC_t) \times \ln(N_{it}/N_{i,1991})$			0.4278***	
			(0.0192)	
$PH_{i,t}^G$				-0.2274***
				(0.0069)
Obs	4320	6192	5832	5328
	1996Q3-2011Q2	1990Q1-2011Q2	1991Q1-2011Q2	1993Q1-2011Q2
$\overline{R^2}$	0.9544	0.9531	0.9824	0.9285
Area fixed effects included	Y	Y	Y	Y
Time fixed effects included	N	Y	Y	Y
Area specific time trends included	Y	N	N	N

Table 3: Short Run Equations (SUR Estimates)

	House Prices	Housing Supply	Lot Prices	Rents
	$\Delta\ln\left(\frac{PH_{it}}{PC_t}\right)$	$\frac{HC_{it}}{H_{it-1}} - 0.6\frac{HC_{i,t-1}}{H_{it-2}}$	$\Delta\frac{PL_{it}}{PC_t}$	ΔR_{it}
$Constant$	0.0080*** (0.0009)	0.0014*** (0.0001)		111.8199*** (7.5179)
$\varepsilon_{i,t-1}$	-0.1585*** (0.0069)		-0.1866*** (0.0092)	
$\Delta\ln(H_{i,t-1}/N_{i,t-1})$	-0.4339 (0.2764)			
$\Delta\ln(REA_{i,t-1}/N_{i,t-1})$	0.2694*** (0.0537)			
$\Delta UC_{i,t-1}$	-0.0018 (0.0012)			
ΔCR_{t-1}	-0.0703*** (0.0056)	-0.0009*** (0.0002)		
ΔAS_{t-1}^{O-Real}	0.0051*** (0.0005)			
$\Delta\ln(R_{i,t-1}/PC_{t-1})$	0.0274*** (0.0083)			
$\varepsilon_{i,t-1}^{+}$		0.0002 (0.0014)		
$(\varepsilon_{i,t-1}^{+})^2$		0.0227*** (0.0072)		
$\varepsilon_{i,t-1}^{-}$		0.0038*** (0.0013)		
$(\varepsilon_{i,t-1}^{-})^2$		-0.0006 (0.0061)		
$\Delta PH_{i,t-1}^{G}$		0.0079* (0.0047)		
$\Delta PL_{i,t-1}^{G}$		0.0001 (0.0026)		
$\Delta PB_{i,t-1}^{G}$		0.0913*** (0.0243)		
$\Delta(PH_{i,t-1}/PC_{t-1} \times \ln(N_{i,t-1}/N_{i,1991}))$			0.6050*** (0.0607)	
$PH_{i,t-1} \times \varepsilon_{i,t-1}$				-0.1130*** (0.0093)
$\Delta R_{i,t-1}$				-0.3716*** (0.0145)
$\Delta(PH_{i,t-1} \times PH_{i,t-1}^{G})$				0.0192*** (0.0061)
$\Delta(PH_{i,t-1} \times AS_{t-1}^{R-Rate})$				0.0106*** (0.0020)
Obs (1996Q4-2011Q2)	4248	4248	4248	4248
$\overline{R^2}$	0.1915	0.049	0.1022	0.2168

Notes: $\varepsilon_{i,t-1}$ is the lagged residual from the corresponding long run equation.
No area fixed effects, time fixed effects or area specific time trends are included in the short run specifications.

Figure 1: Real House Prices, Population and the GFC, New Zealand



Note: The dashed vertical line indicates the onset of the GFC.

Figure 2: Ratio of Non-performing Loans to Total Assets (%), NZ Registered Banks

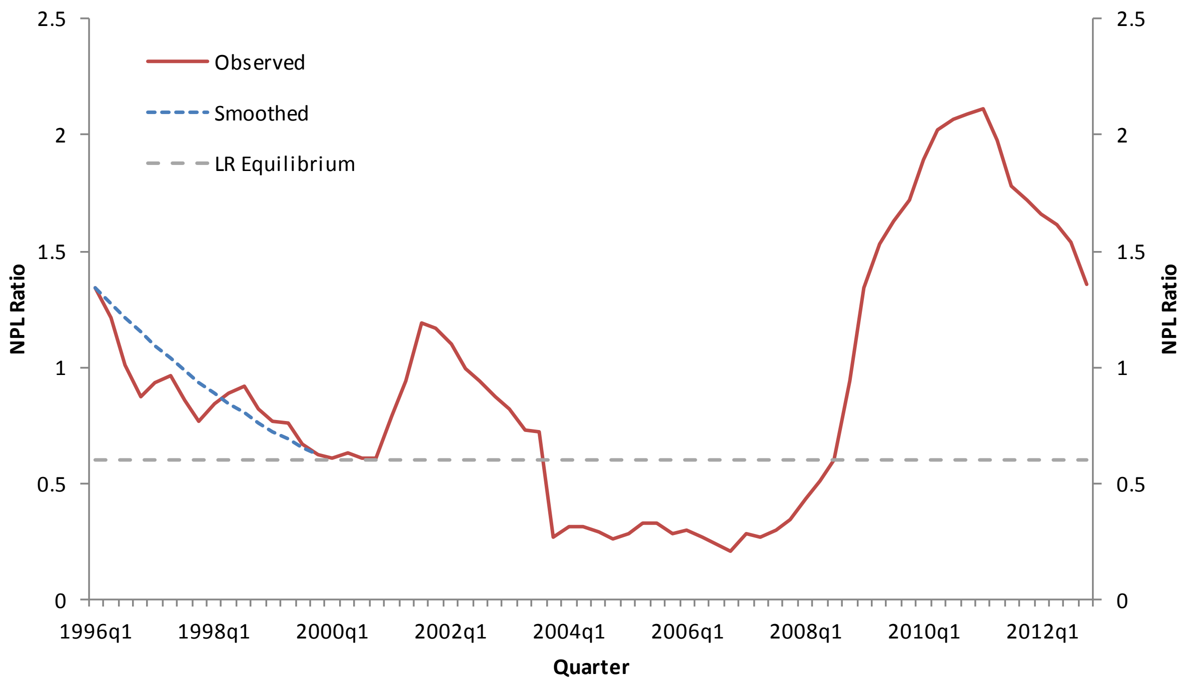


Figure 3: Simulation of Population Shock (including extrapolative expectations)

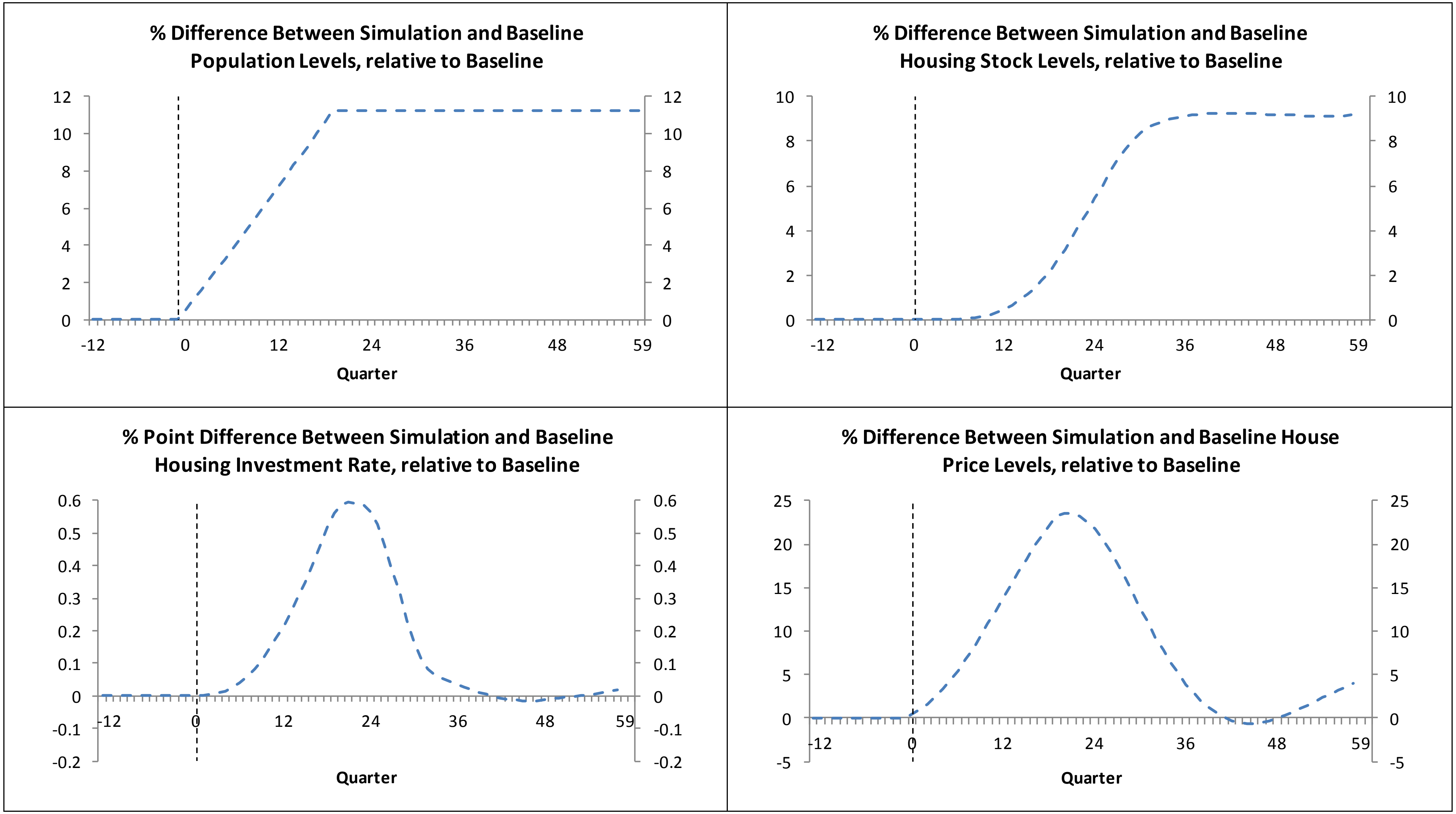


Figure 4: Simulation of Population Shock (excluding extrapolative expectations)

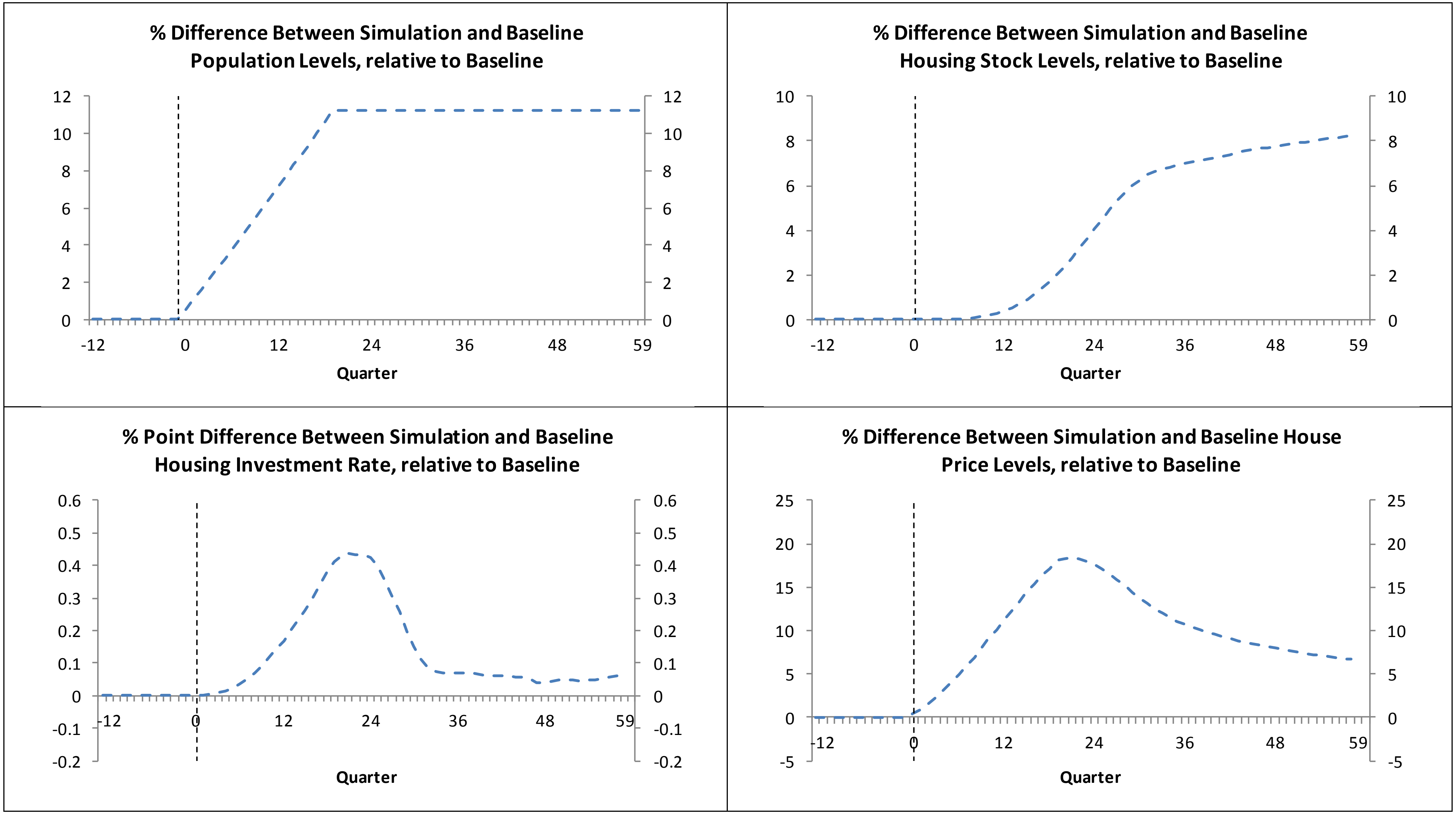


Figure 5: Simulation of Credit Shock (Demand Side Only)

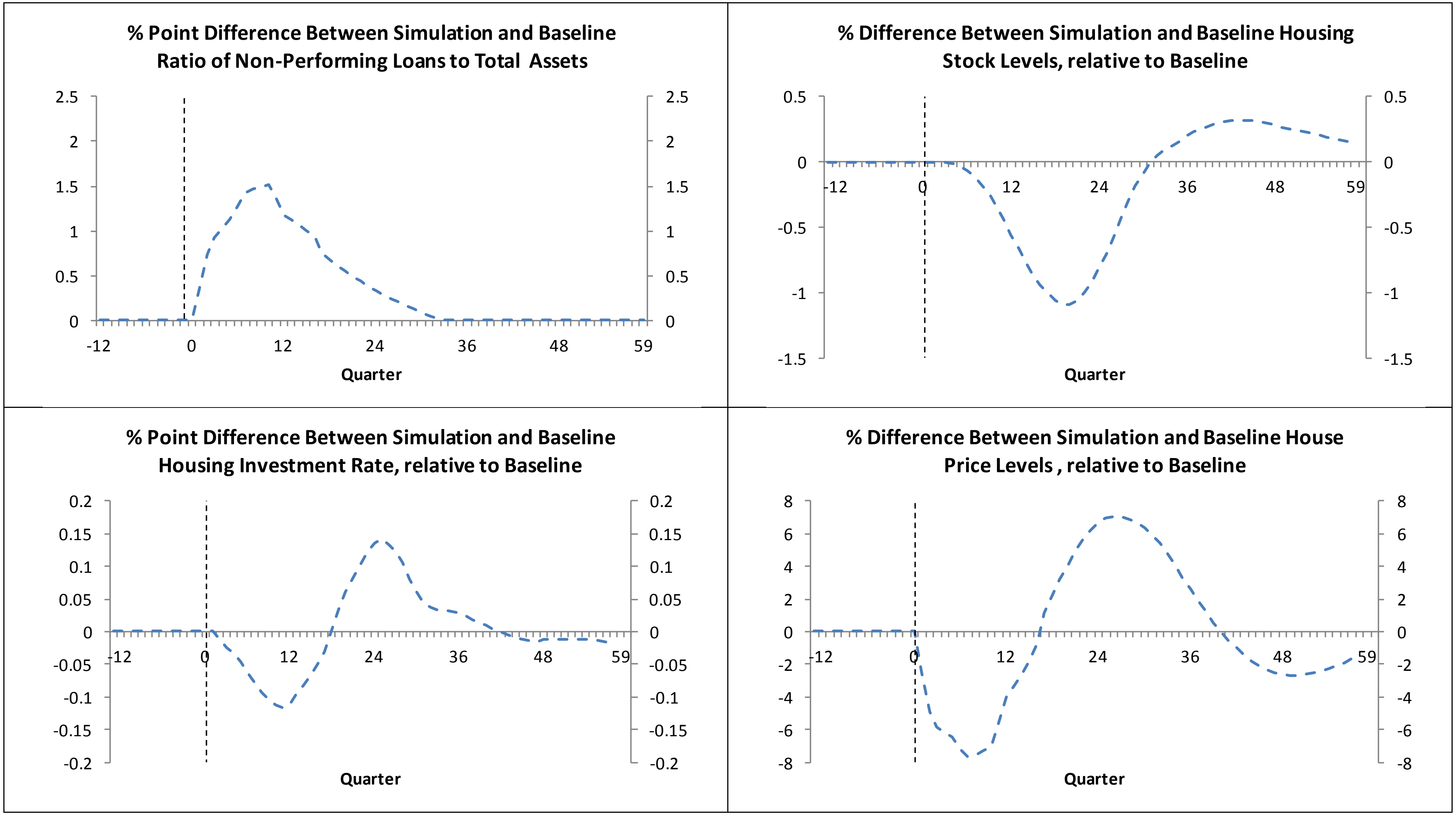


Figure 6: Simulation of Credit Shock (Supply Side Only)

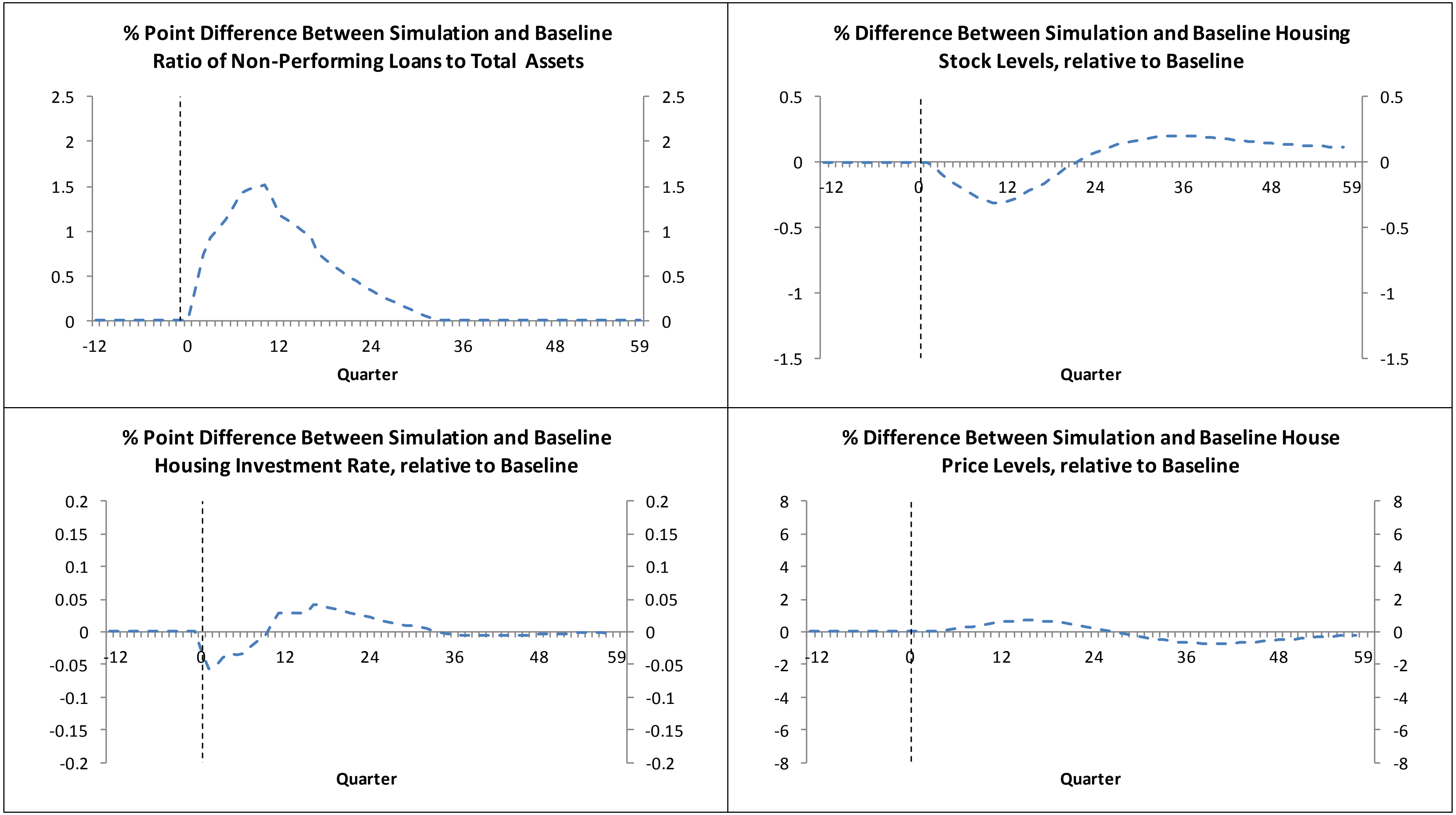
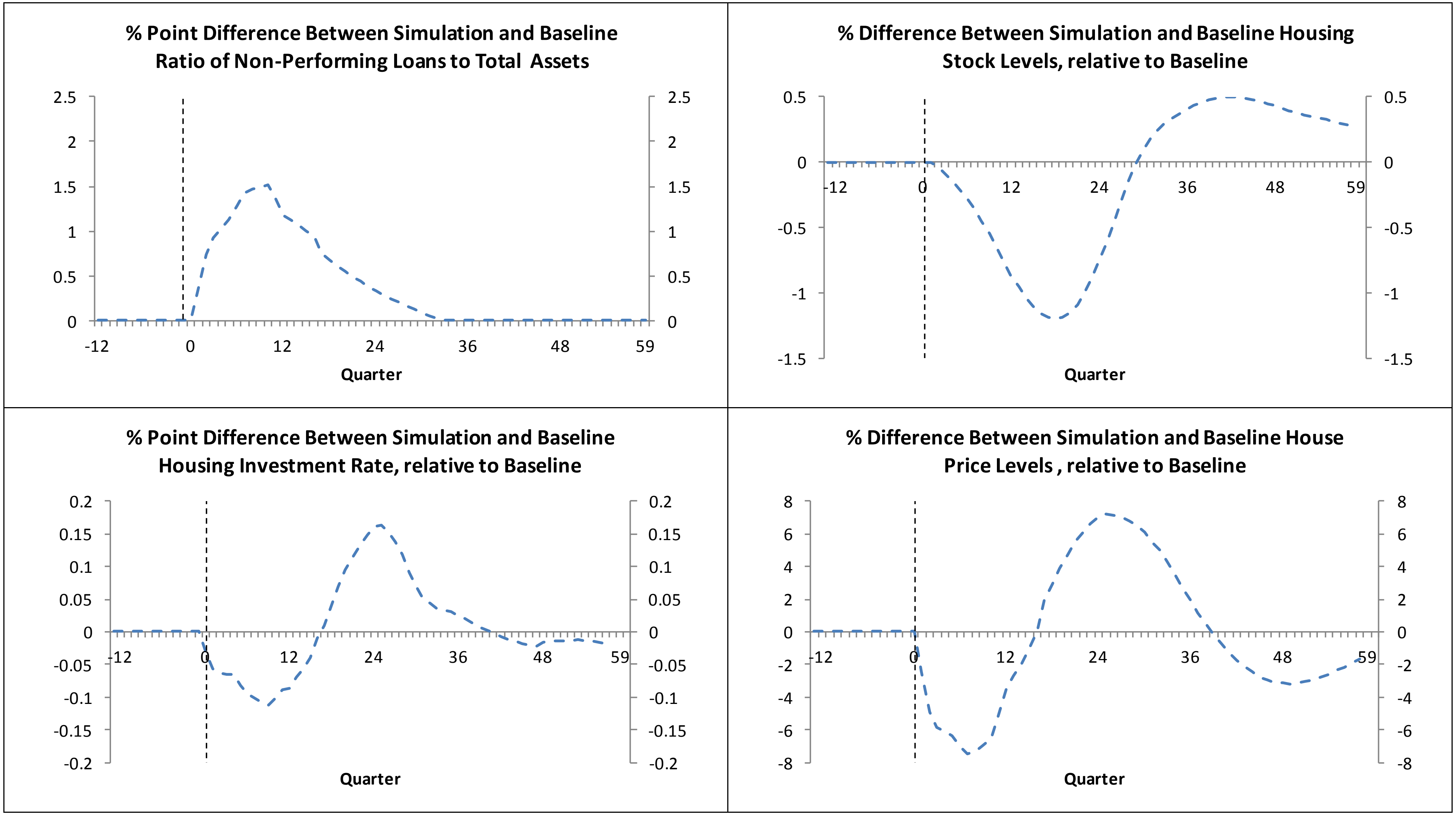


Figure 7: Simulation of Credit Shock (Both Channels)



Recent Motu Working Papers

All papers in the Motu Working Paper Series are available on our website www.motu.org.nz, or by contacting us on info@motu.org.nz or +64 4 939 4250.

13-11 Anastasiadis, Simon and Suzi Kerr. 2013. "Mitigation and Heterogeneity in Management Practices on New Zealand Dairy Farms".

13-10 Grimes, Arthur and Sean Hyland. 2013. "Passing the Buck: Impacts of Commodity Price Shocks on Local Outcomes".

13-09 Allan, Corey, Arthur Grimes and Suzi Kerr. 2013. "Value and Culture."

13-08 Maré, David C., and Richard Fabling. 2013. "The Incidence and Persistence of Cyclical Job Loss in New Zealand".

13-07 Grimes, Arthur, and Nicholas Tarrant. 2013. "A New Zealand Urban Population Database".

13-06 Fabling, Richard, and David C. Maré. 2013. "Firm-Level Hiring Difficulties: Persistence, Business Cycle and Local Labour Market Influences".

13-05 Crichton, Sarah, and David C. Maré. 2013. The Impact of Wage Subsidies on Jobseekers' Outcomes and Firm Employment".

13-04 Crawford, Ron, and David C. Maré. 2013. "Investigation of Options for a New Longitudinal Household Survey: Issues and Options Paper".

13-03 Dixon, Sylvia, and David C. Maré. 2013. "The Costs of Involuntary Job Loss: Impacts on Workers' Employment and Earnings".

13-02 Grimes, Arthur, and Sean Hyland, with Andrew Coleman, James Kerr and Alex Collier. 2013. "A New Zealand Regional Housing Model".

13-01 Fabling, Richard, and Lynda Sanderson. 2013. "Export Performance, Invoice Currency, and Heterogeneous Exchange Rate Pass-Through".

12-14 Motu Economic and Public Policy Research. 2012. "Roadmap for Implementing a Greenhouse Gas Emissions Trading System in Chile: Core Design Options and Policy Decision-Making Considerations".

12-13 Fabling, Richard, Arthur Grimes and David C. Maré. 2012. "Performance Pay Systems and the Gender Wage Gap."

12-12 Kerr, Suzi. 2012. "The Economics of International Policy Agreements to Reduce Emissions from Deforestation and Degradation."

12-11 Coleman, Andrew. 2012. "Pension Payments and Receipts by New Zealand Birth Cohorts, 1916–1986."

12-10 Tímár, Levente. 2012. "Spatial and Temporal Responses to an Emissions Trading System Covering Agriculture and Forestry: Simulation Results from New Zealand."

12-09 Grimes, Arthur, Les Oxley and Nicholas Tarrant. 2012. "Does Money Buy Me Love? Testing Alternative Measures of National Wellbeing."

12-08 Woods, Darian, with Andrew Coleman. 2012. "Price, Quality, and International Agricultural Trade."

12-07 Olssen, Alex, Wei Zhang, David Evison, and Suzi Kerr. 2012. "A Forest-Profit Expectations Dataset for New Zealand, 1990–2008".

12-06 Kerr, Suzi, and Alex Olssen. 2012. "Gradual Land-Use Change in New Zealand: Results from a Dynamic Econometric Model".

12-05 Abramitzky, Ran, and Isabelle Sin. 2012. "Book Translations as Idea Flows: The Effects of the Collapse of Communism on the Diffusion of Knowledge".

12-04 Fabling, Richard, and David C. Maré. 2012. "Cyclical Labour Market Adjustment in New Zealand: The Response of Firms to the Global Financial Crisis and its Implications for Workers".