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Neutral interest rates in the post-crisis period

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NON-TECHNICAL SUMMARY

Broadly speaking, a neutral interest rate is the rate of interest that, over time, is consistent with no over-or-under-utilised resources (a zero output gap) and with inflation being consistent with target (stable inflation). Estimates of neutral interest rates can be used to help central banks think about monetary conditions and to communicate what is happening in the economy and to interest rates. But neutral interest rates are unobservable and difficult to precisely estimate so are best thought of as providing a useful conceptual framework for thinking about monetary policy.

Economic theory suggests neutral interest rates will change over time depending on medium-term trends in future global prospects, productivity growth, population growth and preferences for savings and investment. Shorter-term economic fluctuations can result in the appropriate level of policy interest rates consistent with maintaining stable inflation moving around the neutral interest rate.

Both in New Zealand and across most of the developed world there are signs that the trend decline in neutral interest rates has continued in the years since the global financial crisis. The Reserve Bank of New Zealand has revised down its view of neutral levels for the OCR (or 90-day interest rates), and for retail interest rates that households and firms face, typically proxied by the neutral floating mortgage rate. Our assumed neutral floating mortgage rate has been lowered by less than the reduction in the neutral 90-day rate, reflecting the increased spread that banks are required to pay over the OCR. A lower neutral real interest rate implies that the average level of interest rates over the cycle will be lower than in the past. However, a lower neutral interest rate would not change the expected amplitude of future interest rate cycles.

In recent years, the level of the OCR has remained historically low. The negative output gap has only recently closed and the level of output is still below its pre-crisis trend. In combination with low inflation, the slow recovery could suggest neutral interest rates are even lower. There is a lot of uncertainty around neutral interest rate estimates. One measure which involves estimating the trends of real 90-day interest rates might suggest neutral real 90-day interest rates have fallen further than has previously been adjusted for. However, only time will tell whether such a revision would be appropriate or, indeed, whether a reversal in the recent productivity slowdown might lead to upward revisions in NIRs over time.

This Analytical Note presents background work prepared for the recent speech ‘Shifting gear: why have neutral interest rates fallen’, by Assistant Governor John McDermott, delivered to the New Zealand Institution of Chartered Accountants CFO and Financial Controllers Special Interest Group, Auckland, October 2013.

1. INTRODUCTION

The Official Cash Rate (OCR) has been at historically low levels since early 2009 and retail lending rates have also been low by New Zealand standards. But output is only just beginning to return to a post-crisis trend after a long period with a negative output gap and unemployment is still well above its average of the 2000s.[1] Core inflation measures are still below the midpoint of the target range and there are no signs that, at the current level of the OCR, inflation is about to pick-up dramatically. There are a variety of possible explanations for this situation. It may be that any particular level of the OCR will no longer provide as much stimulus as in the past. Or perhaps it is just that a series of shocks, including the Christchurch earthquakes and European sovereign debt crisis, has held back the recovery. A recession aggravated with financial frictions may simply take longer to resolve. And the high level of the exchange rate could also complicate the picture.

If a given level of the OCR (or of retail interest rates) no longer provides as much stimulus as in the past this might suggest that (unobservable) neutral interest rates (NIRs) have fallen in New Zealand. Whether NIRs have fallen will depend on whether there has been a change in underlying trends in real factors, rather than a change in cyclical conditions. If so, lower interest rates than previously would be consistent, over time, with achieving a zero output gap and inflation within the target band.

The Reserve Bank periodically reviews our estimates of NIRs which are a component of the modelling framework. In this note, we study the concept and review the literature on NIRs in the post-global financial crisis (GFC) period, both in New Zealand and internationally. Specifically, we discuss why NIRs in New Zealand have fallen since the GFC and present some simple empirical results that might shed some light on whether they may have fallen further in more recent years.

2. WHAT ARE NEUTRAL INTEREST RATES?

NIRs were originally defined by Wicksell (1898) for a closed economy as “a certain rate of interest on loans which is neutral in respect to commodity prices, and tends to neither raise nor to lower them.” This definition implies that a NIR is: the rate of interest where desired savings equal desired investment (at least in a closed economy, or for the world as a whole); the rate of interest that equals the marginal product of capital; and the rate of interest that is consistent with aggregate price stability (Amato (2004)). The last definition suggests the NIRs can provide an indication of the level of actual interest rates where monetary policy is neither contractionary nor expansionary. Provided inflation expectations are consistent with

[1] Kendall and Ng (2013) find using Taylor rule estimates that the OCR has been lower than typical before the GFC, given current cyclical conditions.

target, NIRs are equivalent to the policy rate being consistent with keeping real GDP at its potential (zero output gap), in the absence of shocks (Williams (2003)).

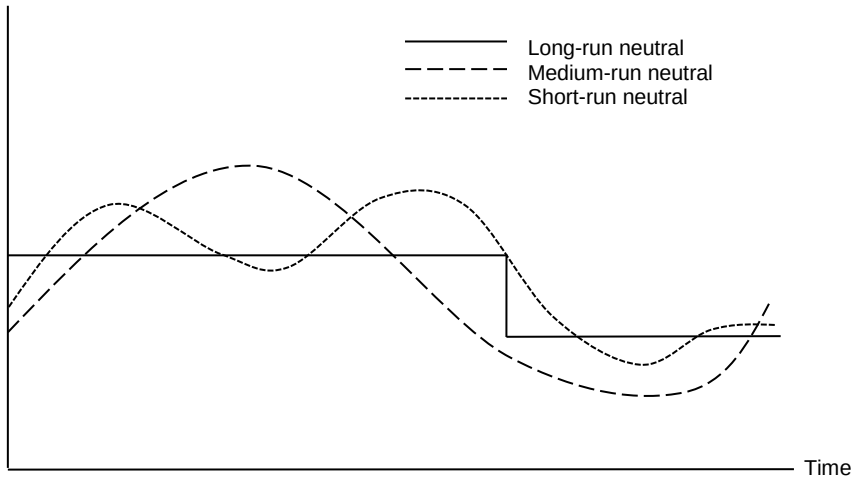
The theoretical foundation of NIRs makes them useful in simple modelling frameworks of the monetary transmission mechanism. Research has suggested that in these frameworks it is equally important to adjust the nominal interest rate in response to changes in the NIRs as it is to adjust the nominal interest rate more than one for one with changes in inflation (and inflation expectations) (Schmidt-Hebbel and Walsh (2009)). This suggests NIRs can be used as a benchmark for interest rates over the forecast horizon. It also means NIRs can be used as a communication device (see for example, Yellen (2005)). As such, reference to estimates of NIRs can help reduce any discrepancy between the market and central bank view of the extent to which interest rates are leaning against or providing stimulus to inflation. If the NIR is changing (or is believed by the central bank to be changing), then this aspect can become more important.

The Wicksellian concept of NIRs is for a closed economy in long-run equilibrium. However, the interpretation of NIRs will be different for open economies and over shorter time horizons. And, in practice it is real interest rates that matter for the effect monetary policy has on inflation so a neutral *real* interest rate (NRIR) is most often used. NIRs are also not observed and can only be estimated with some uncertainty. In modelling applications (although not in central bank deliberations) a NIR is often a mechanical assumption. What follows explains NIRs in more detail.

2.1. TIME HORIZON

The concept of a NIR – a rate consistent with a zero output gap and inflation being consistent with target – varies according to its purpose and time horizon. For example, one can focus on whether the interest rate is appropriate right now, or can focus on where interest rates are now relative to those that are neutral over the monetary policy cycle or in the economy's longer-run equilibrium. These horizons are referred to as the short run, medium run and long run respectively (figure 1).

Figure 1: Neutral interest rates over different time horizons



The time horizon considered will influence how one approaches questions about the level of interest rates consistent with a given level of inflation and output gap, and also whether and why that level has changed. In the following discussion, we use the framework set out in Archibald and Hunter (2001) to understand how the properties of NIRs differ over the short, medium and long run.

2.1.1. SHORT-RUN NEUTRAL

The short-run NIR is the neutral rate which would cause inflation to neither rise nor fall in the one to two years it takes for interest rates to have their full effect on inflation, given the economic environment at the time. The short-run NIR will move, often cyclically, as shocks hit the economy, so is dominated by short-run developments, but will also reflect changes in underlying trends in real factors.

The NIR over the short run tends to be closer to actual policy settings than the longer-run concepts. Holding actual real interest rates above/below the short-run NIR would lower/raise inflation. As such, central banks can use the interest rate gap, the actual interest rate minus the short-run NIR, to provide a real time indication of the stimulus provided by monetary policy (Neiss and Nelson (2003)).

2.1.2. LONG-RUN NEUTRAL

Wicksell's original definition of NIRs applies in a long run sense - what is obtained in the steady-state, which can be thought of as the equilibrium interest rate or 'natural' rate. Economic theory suggests the long-run NIR can vary over time in response to permanent or longer-lasting structural changes in underlying trends of real economic factors such as future global prospects, productivity growth, population growth, and preferences for savings and investment.

The long run concept is less relevant to monetary policy because it is a long-run anchor for interest rates, being the rate that would hold when variables are at their steady-state growth rates, and the economy is in equilibrium. It is thus the rate towards which forecasts eventually should converge. In practice, the economy is never in its steady state, so this anchor is not by itself a direct guide to policy rate settings in response to inflation pressure over the cycle.

In the long run, country real NIRs should converge to global real NIRs in the absence of frictions. But this has not been the case in New Zealand - NIRs have been persistently higher than those in most of the rest of the world (see section 2.3). For

example, the New Zealand NRIR has been persistently higher than the Australian NRIR (as a proxy for the global NRIR) (see figure 14 below).[2]

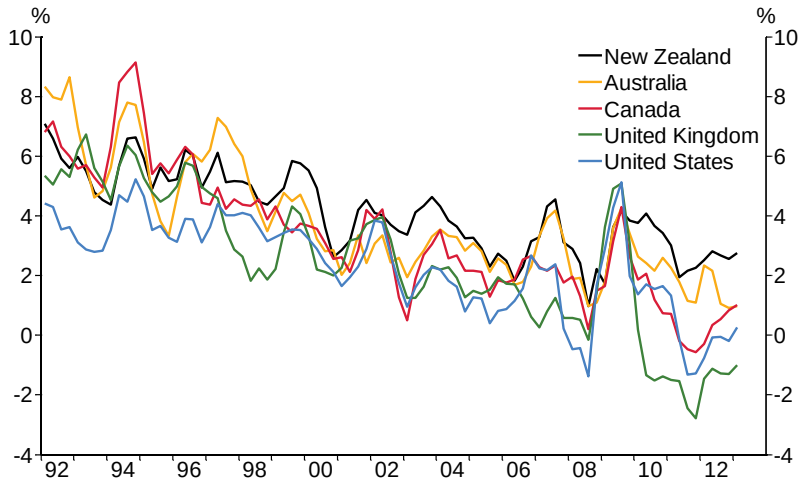
2.1.3. MEDIUM-RUN NEUTRAL

Between the short-run and long-run NIR concepts is the medium run, the time taken for interest rates to have their full effect on inflation, and for interest rates to return other monetary policy-relevant variables, such as the exchange rate, to equilibrium. So the medium-run NIR is the one that is consistent with a zero output gap and inflation consistent with target over a business cycle, without taking account of more-transitory, short-term shocks. A medium run view of NIRs may better represent NIRs in New Zealand (Archibald and Hunter (2001)). The medium-run NIR will tend to converge towards the long-run NIR, but market frictions may cause the two to differ, perhaps for long periods. These frictions include impediments to capital flows such as home bias, capital controls, and country risk premia, and financial frictions such as risk aversion and pricing and financial imperfections. Since the GFC, financial frictions have become more important. These are not included in the Archibald and Hunter (2001) framework, but are discussed in more detail below.

2.2. TIME VARIATION IN PRACTICE

Real interest rates vary considerably over the long run, but over the last 20 years as lower and more stable inflation has become an established feature of advanced economies, a downward trend in real interest rates has been evident (figure 2). This decline in real interest rates is consistent with the general view that NRIRs worldwide have been declining over this time.

Figure 2: Real 10-year government bond rates[3]



[2] Schmidt-Hebbel and Walsh (2009) found that for various countries, except New Zealand, inflation stabilisation over the 1980s and 1990s enabled a lower NIR in the 1990s and 2000s, providing another indication that New Zealand's NIR has been higher than other countries in the past.

[3] Real interest rates in this *Note* are deflated using measures of CPI ex GST for New Zealand and Australia, and measures of CPI for other countries.

There is some formal empirical evidence for declining NRIRs in New Zealand over the pre-crisis period (See Björksten and Karagedikli (2003 a,b), Plantier (2003) in a cross-country context, Basdevant, Björksten, and Karagedikli (2004) and Kirker (2008), summarised in table 1) and internationally (see for example, M'esonnier and Renne (2007) and Garnier and Wilhelmsen (2005)).

Our univariate trend estimates, as discussed later, and work by Kendall and Ng (2013), suggest this trend may have continued in New Zealand in the post-GFC period. Our data also suggest that this downward trend is common among some of our advanced economy trading partners. Recent work by Magud and Tsounta (2013) finds a downward trend in NIRs for Latin American countries and suggests that the trend could reflect stronger domestic fundamentals (lower exchange rate risk and inflation risk premiums, and fiscal consolidation), and easing global financial conditions.

Time variation in NIRs presents additional real time difficulties with estimation. When used in forecasting models it also complicates communication about the meaning of a forecast interest rate track: for example, if the NIR was projected to increase over time, an upward sloping interest rate track might simply be keeping the policy stance neutral, and not even be actively leaning against inflation. A time-varying neutral rate would give an indication of medium-run changes in NIRs as they developed and could allow more flexibility for forecasts and policy rates to take account of changes in the NIR. But this time variation is difficult to measure accurately and using such a measure risks introducing additional noise into interest rate projections. In practice, it is rare for central banks to forecast future changes in neutral rates.

Currently, the cyclical models used by the Reserve Bank to analyse current and expected future inflation pressure exogenously impose a (periodically reviewed) value for NIRs. The use of a constant NIR over the forecast horizon provides simplicity and transparency. Our modelling framework implicitly considers the gap between actual interest rates and NIRs as a measure of monetary policy stance. For quarterly forecast updates a constant NIR is most likely a reasonable approximation, as although neutral may change over the medium to long run, there is unlikely to be a lot of quarter to quarter variation in NIRs (as for any equilibrium or trend concept) compared with the volatility in actual interest rates.

2.3. SMALL OPEN ECONOMY

Wicksell's original definition of NIRs was for a closed economy. For an open economy with access to capital markets, we need to take account of differences between domestic and international conditions when determining neutral, particularly country premia and differences in fundamentals which affect savings and investment which are not eliminated by international capital flows (Archibald and Hunter (2001)).

That New Zealand NIRs have not converged to global NIRs may reflect market frictions. For example, the New Zealand dollar is widely perceived as one of the more volatile currencies among advanced economies (see Chetwin et al (2013), Mabin (2010) and Schmidt-Hebbel (2006)). This volatility may mean investors require a currency risk premium to compensate for the chance the currency may move in an unfavourable direction and erode returns, which moves interest rates higher than otherwise would be the case.

In an open economy, the exchange rate must also be considered in the overall monetary stance because frictions allow the exchange rate to depart from its medium-term equilibrium. The exchange rate itself only affects NIRs indirectly to the extent that it affects the real factors which influence neutral. However, an exchange rate not at its neutral level could impart expansionary or contractionary pressures on the economy. This may require actual interest rates further from NIRs over the short run and medium run to provide an offset.

The high New Zealand exchange rate could also be a function of higher NIRs in New Zealand. This could be the case in the long run because of factors such as currency flows that in turn reflect the need to fund long-standing savings-investment gaps (Reddell, 2013). Or it could just be that investors require a higher marginal product of capital to compensate for risks in New Zealand such as extreme events (Burnside, 2011)).

2.4. ECONOMIC THEORY

Real interest rates matter for cyclical pressure, so when using a forecasting model central banks typically require an estimate of the NRIR. In classic growth models, the NRIR is associated with the long-run equilibrium real interest rate. For example, the Solow model assumes the equilibrium real interest rate is:

$$r = \alpha \frac{\delta+\eta+q}{s} - \delta \quad (1)$$

Where α is the marginal productivity of capital, η is the rate of population growth, s is the savings rate, q is the rate of labour-augmenting technological change, and δ is the rate of depreciation.

Equation (1) suggests NRIRs depend on productivity growth, population growth and changes in preferences for savings. If the capital stock becomes more productive, say because of technological progress, this will raise the marginal product of capital and encourage investment. If savings preferences are unchanged, the rise in the marginal product of capital will raise the equilibrium real interest rate. Higher population growth will increase the number of people in the labour force. This means more investment is needed to provide the necessary capital stock to employ the average labour force. As investment rises, for any given savings preferences, a higher equilibrium real interest rate will be required. If there is a change in preferences and people decide to save less today and consume more instead, a higher interest rate will be required to equate

savings and investment. If preferences for investment are unchanged, then in equilibrium, the equilibrium real interest rate will be higher. Similarly, the Ramsey model assumes the equilibrium real interest rate is determined by productivity growth and the household rate of time preference.

In New Keynesian models, the NRIR is the real interest rate that would apply if all prices were flexible. In this framework, the NRIR is not only determined by the long-term fundamentals of classical models, but also expected growth in the global economy (Galí (2002)).

2.5. UNCERTAINTY

NIRs are unobservable which makes them inherently difficult to estimate using either a bottom-up or a top-down approach: the factors that affect the level of the neutral, such as the average household rate of time preference, are hard to identify; and the level itself is uncertain (see for example, Weber (2006) and Amato (2004) for a discussion of uncertainty). Estimates of NIRs will be subject to model and estimation uncertainty (see for example, Laubach and Williams (2003)). There is also the real-time challenge of estimating unobservables as these must be inferred from the evolution of the economy. Furthermore, in practice central banks set and observe *nominal* rather than *real* interest rates, but require an estimate of NRIRs. Therefore, central banks must consider inflation expectations which are also not directly observable and can vary over time, and must be proxied by, for example, surveys.

Because of uncertainty about the true level of the NIR, other indicators, such as aggregate price inflation and the output gap, have been proposed as close to sufficient statistics for setting policy rates. As explained, both are related to NIRs in different concepts of equilibrium. Aggregate price inflation is more observable than NIRs, but the output gap is also subject to the general problem of unobservable variables.

Since NIRs are not constant, a central bank must consider how often to review the estimate used in forecasting models. Frequent revision – especially when there is a lot of uncertainty in NIR estimates – in principle could risk introducing additional variability into interest rate projections, but might reduce the risk that NIRs reflecting current economic conditions move a long way from that assumed in forecasting models.

Estimating NIRs incorrectly may lead to a period of over-expansionary or over-contractionary policy rate levels. Orphanidies and Williams (2003) suggest the welfare cost of underestimating the extent of mis-measurement in NIRs is greater than overestimating it. Using a policy rule that assumes only a small degree of mis-measurement in NIRs is found to be costly in terms of stabilising inflation and

unemployment in the United States, compared with the inefficiency associated with policy rules that allow for large mis-measurement in NIRs.

As a way to deal with uncertainty about the level of NIRs, central banks can talk about the level of interest rates that would broadly be neutral, rather than conveying precision about the number. The appropriate interest rate setting can instead be described by how expansionary or contractionary monetary policy needs to be, and for how long. Judgement can also be used as a way to recognise uncertainty about the true level of the NIR.

Blinder (1998) suggests the NIR is "most usefully thought of as a concept rather than as a number, as a way of thinking about monetary policy rather than as the basis for a mechanical rule ..." This is consistent with the fact central banks put a lot of effort into understanding cyclical conditions, determining how much pressure there is on inflation and how much interest rates are supporting activity based on a range of explanatory variables.

3. ESTIMATION AND MODELLING

NIRs must be estimated either through various proxies or modelling methods. If the determinants of the NIR were constant over time, taking an average of interest rates over a long period could be used as a proxy (see for example, Bernhardsen and Kloster (2010)) or Reifschneider and Williams (2000)).

The long-run neutrality of money can also be used to help identify the level of NIRs. Money neutrality means that, in the long run, the central bank cannot change real variables, and it is real variables which will directly impact NIRs. In this case either short or long-run actual interest rates would be equivalent to average interest rates (often plus an inflation or liquidity premium).

NIRs can also be proxied using implied long-term forward interest rates (e.g. the second five years in a 10 year bond rate) to the extent that these forward rates are unaffected by cyclical conditions. In the absence of premia, implied forward rates can indicate markets' expectations of interest rates. These rates will be largely unaffected by current conditions and will be more a reflection of future growth and inflation expectations (Bernhardsen and Kloster (2010)), which in turn will reflect structural factors driving NIRs.

In small open economies, NIRs can be proxied by the global NIR plus a country premium. For example, Archibald and Hunter (2001) proxy New Zealand NIRs from estimates of the United States and Australian NIRs and a country premium. In these models, estimates may be biased as there is the possibility that structural parameters, such as time preferences and the inter-temporal elasticity of consumption, could be

hidden within the country premium so that the estimate excludes structural information that should be used to understand the NIR.

But as discussed, NIRs are time-varying and if movements in real factors affecting NIRs are large, long-run averages of interest rates can be a poor predictor (Williams (2003)). Instead, filtering methods such as Kalman filters can be used to allow for time variation (see Laubach and Williams (2003) and Bernhardsen and Gerdrup (2007)).

NIRs can be modelled as the intercept in the Taylor rule, representing the equilibrium interest rate.[4] The intercept in the Taylor rule can be treated as either a constant – as in Kendall and Ng (2013) or as time-varying to take account of changes in determinants of NIRs. For example, Plantier and Scrimgeour (2002) use a state space approach with Kalman filter to get estimates of the intercept in the Taylor rule. NIRs can also be modeled in New Keynesian models. Neiss and Nelson (2003) use a calibrated DSGE model for the UK economy, Kirker (2008) uses a New Keynesian model for New Zealand and Smets and Wouters (2003) use a microfounded model for the euro area.

There are trade-offs in the choice of estimation and modeling technique. Exogenously imposing a value for NIRs is practical for models of the size used in policy formulation. But jointly estimating NIRs in the cycle, such as in Kirker (2008), could be more econometrically efficient. Understanding the theory and conceptual underpinning of NIRs can help to determine an estimation strategy, as well as to interpret the results that are estimated.

4. POST-CRISIS LITERATURE ON NEUTRAL INTEREST RATES

Prior to the GFC, there were indications that NIRs in many countries were falling. For example, the achievement of relatively stable low inflation is likely to have been one factor contributing to lower NIRs. This is because when inflation is higher it is also more volatile, and when inflation is very volatile savers may require a premium on interest rates to compensate for uncertainty about future inflation (which can erode savings). Ageing populations might also suggest NIRs have been falling worldwide if there is a corresponding increase in desired savings across the population as a whole, or if slower labour force growth lowers required investment (Desroches and Francis (2006)).

In the aftermath of the GFC, policy rates in New Zealand and throughout the world were lowered sharply in response to financial disruption and a sudden lowering in expectations for inflation and growth. Interest rates have remained low, but inflation in many advanced economies has not risen rapidly and measures of inflation

[4] Taylor rules can be used to describe the behaviour of central banks in adjusting short-term interest rates in response to economic conditions (see Taylor (1993)).

expectations generally support the idea that despite low interest rates, market participants expect inflation to remain contained.

This situation could reflect a sequence of economic shocks, including the GFC and European sovereign debt crisis, which have held back the recovery worldwide, and are expected to continue to do so for a while yet. An alternative explanation is that there has been a change in underlying trends in real economic factors that determine NIRs, pushing NIRs lower, both in New Zealand and internationally.

In the early post-crisis phase, Bernhardsen and Kloster (2010) analysed whether lower long-run interest rates worldwide reflected the market revising down NIRs. The authors estimated NIRs for selected economies based on proxies of market expectations of future interest rates and expectations of potential growth. Generally, the authors concluded that by 2010 the GFC did not appear to have caused market participants to revise down their long-term interest rate expectations. These authors also found potential growth rates for selected countries – with the exception of the euro area – had not fallen, which loosely speaking would support the idea that NIRs had not fallen by then.

More recently, Bouis et al (2013) found that monetary policy stimulus did not lead to stronger growth in the wake of the GFC for selected OECD countries. Their results suggest lower policy rates may not have provided as much stimulus as in the past because of falls in NIRs as potential output growth declined. The authors propose further reasons why stimulus did not lead to higher growth, including: headwinds provided by balance sheet adjustment of the private sector; the bank lending channel of monetary policy transmission has likely been impaired, with balance sheet adjustments, uncertainty and banks less willing and able to supply credit; and large economic uncertainty and fiscal consolidation.

The GFC has also been associated with high risk aversion and with financial and pricing imperfections which would require central banks to hold policy rates away from neutral to bring the economy back to trend. These frictions could just reflect the position of the economy in the business cycle or could reflect a more fundamental change in underlying behaviour and activity in the longer-run. These frictions could cause the medium-run NIR to fall below long-run equilibrium. Risk aversion and financial and pricing imperfections can come through channels such as expectational errors, risk premia, or credit rationing due to asymmetric information (Amato (2004)). Risk aversion has led to private and public sector deleveraging and increased savings in some countries since the GFC. Furthermore, the importance of secured funding for longer-term borrowing as a result of risk premia and risk aversion has increased the costs of funding relative to the pre-crisis period.

Research has shown that financial frictions can affect NIRs. De Fiore and Tristani (2001) use a model simulation to suggest financial shocks could be responsible for

large enough falls in NIRs to justify a fall of the policy rate to the zero lower bound. In this study the NIR is only affected by real frictions. How the NIR responds to shocks is found to differ between economies with financial frictions and those without such frictions. For example, financial market turbulence has no effect on the NIR in the model without financial frictions, but can cause the NIR to decrease when financial frictions are allowed for. The fall in the NIR is mainly driven by consumption: adverse financial shocks which increase risk and credit spreads result in a decline in output and a substantial fall in investment. The fall in investment opportunities is so large that households initially save less and consume more. But, consumption growth falls over time back to steady-state levels, and this protracted fall drives the fall in the NIR.

It has also been found that changes in spreads due to, for example, rising stress and risk levels, can lower the equilibrium real interest rate in Taylor rules (Curdia and Woodford (2010)). This model can show how the change in the size of the NIR compares to the change in the credit spreads. Using a New Keynesian model with financial frictions, and a baseline Taylor rule adjusted in response to the size of the credit spreads, the authors conclude that including an adjustment for variations in credit spreads can improve Taylor rules which otherwise would tighten too much in response to financial shocks. This adjustment can reduce distortions caused by financial frictions that increase credit spreads. It can also reduce distortions caused by other disturbances such as variations in the size of debt-financed government transfers and taxes. The optimal size of the adjustment in credit spreads depends on the source of variation in the spreads, and is less than one-for-one because the contraction of credit caused by the shock is more persistent than the increase in the credit spread.

Little research has yet been done on the impact macro-prudential tools may have on NIRs, but through channels such as tightening credit conditions, these tools could push NIRs downwards depending on whether the effects are temporary or permanent. Macro-prudential experience in Brazil and Peru suggests these policies do affect NIRs, possibly through their effect on credit conditions (Magud and Tsounta (2013)). These countries had experienced strong capital inflows and thus credit growth. Macro-prudential tools were found in these countries to have lowered NIRs by mitigating the expansionary effect of the credit channel by containing demand for loanable funds. However, it is still unknown, given the short period of macro-prudential implementation in most countries, whether these effects are temporary or permanent in nature. To the extent that macro-prudential tools are used as temporary responses to extremes in credit or asset prices, it is more likely that they are best thought of as changing how far actual policy rates need to diverge from the NIR, rather than as changing the NIR per se.

5. NEUTRAL INTEREST RATES IN NEW ZEALAND

5.1. PRIOR TO THE GFC

NIRs for New Zealand were studied and estimated in a number of papers from the early 2000s until prior to the GFC (mostly done at the Reserve Bank). Table 1 includes estimates of the neutral real 90-day rate for New Zealand from these studies.[5] These papers suggested a range rather than a point estimate, varying considerably (from 3 to 6 percent), and variously assume a constant or a time-varying NIR. Each also presents a range of possible values for the NIR, reflecting the uncertainty around point estimates.

Table 1: Estimates of New Zealand's neutral short-term interest rate

Study	Method	Estimate
Archibald and Hunter (2001)	Historical averages of real interest rates	- 4.3%-5.3% over period 1992-2000
Plantier and Scrimgeour (2002)	State space approach with Kalman filter to get estimates of the intercept in the Taylor rule	- Time-varying - Downward drift over period 1988-2001 - Final estimates 4-6%
Basdevant, Björksten, and Karagedikli (2004)	Taylor rules and other models with Kalman filter	- Time-varying - Declining over period 1992-2001 - Final estimates 3.25-4.25%
Kirker (2008)	Small open economy semi-structural model with Kalman filter	- Stable around 5.25% from 1992-1998 - Drifted downwards to 3% from 1998-2004 - Rose to 4.3% from 2004
Schmidt-Hebbel and Walsh (2009)	Structural model with Kalman filter	- Flat at around 4.5-4.9% since mid-1990s

The range of estimates for the neutral real 90-day rate suggests that if we rely on estimates of the NIR alone – without considering the wider picture of cyclical developments – the level of monetary stimulus any particular OCR provides is uncertain.

Cyclical macro-economic models require an estimate of NIRs, and use a point estimate because these models and their assumptions are predominantly used to provide a useful and tractable simplification of reality. To deal with the risk of false precision in the point estimates, a range of models can be used, along with looking at alternative scenarios, discussions about uncertainty and including application of judgement based on other information about economic conditions.

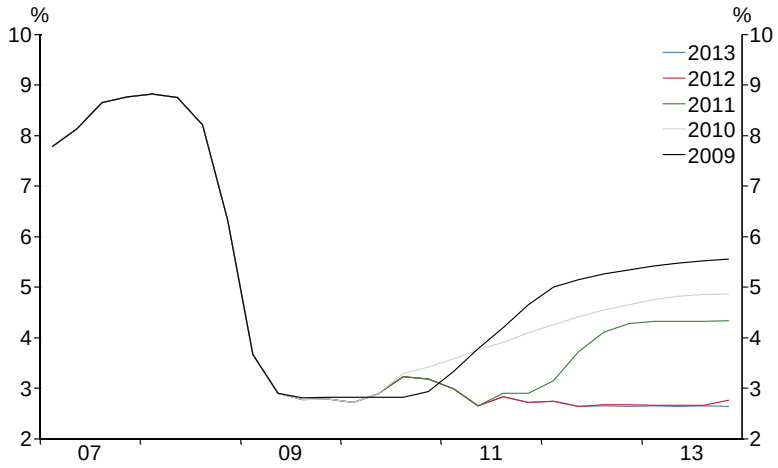
[5] These studies use the real 90-day rate to estimate the neutral real 90-day rate.

5.2. AFTER THE GFC

5.2.1. INDICATIONS NEUTRAL INTEREST RATES HAVE CHANGED

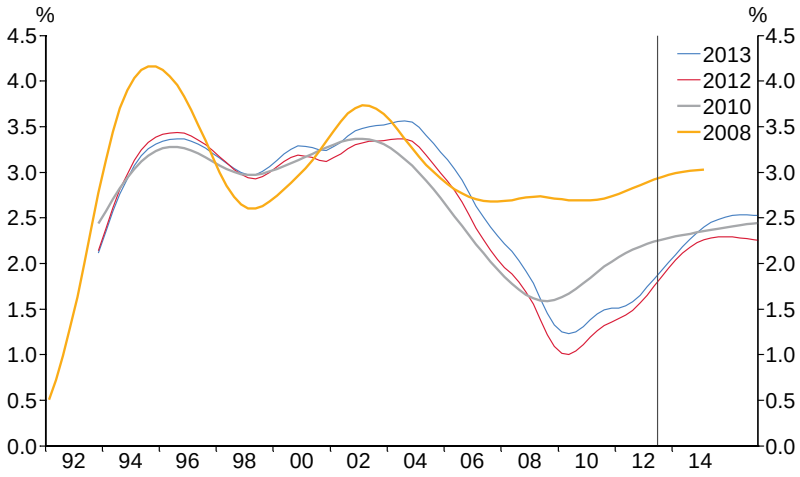
The OCR has been very low for over four years, in spite of projections by the Reserve Bank that interest rates would rise (figure 3), and inflation has also surprised on the downside in New Zealand (see Kergozou and Ranchhod (2013)). In principle, a low OCR combined with low inflation raises the question of whether there has been a change in underlying trends in the New Zealand economy in the post-crisis period which might suggest that NIRs have fallen.

Figure 3: Actual and projected real 90-day interest rates
(September *Monetary Policy Statements*)



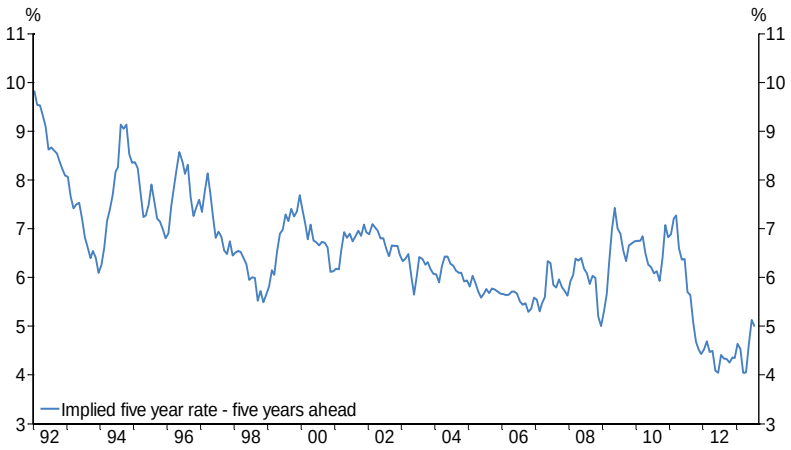
Notably, in New Zealand potential output growth appears to have been lower in the years since the GFC than the Reserve Bank estimated and projected in 2008 (figure 4). And estimates suggest potential output growth since the GFC has been lower than at any other time since the recession of the early-1990s. Potential output growth has fallen in OECD countries (see Appendix A). But does this mean NIRs have fallen?

Figure 4: Projected annual average potential output growth
(September *Monetary Policy Statements*)



One technique that can provide a simple indication of whether NIRs have changed is estimating the nominal implied five year government bond interest rate, five years ahead. This rate did not fall during the recession – consistent with Bernhardsen and Kloster (2010) results – but has subsequently fallen and remains well below previous average levels (figure 5).

Figure 5: Nominal implied five year rate



On average, the implied five year rate over 2010-2013 now sits at 5.4, lower when compared to the average of 7.4 over 1992-1999, even though the inflation target was higher in the 2010-2013 period (table 2).

Table 2: Average nominal implied five year rate

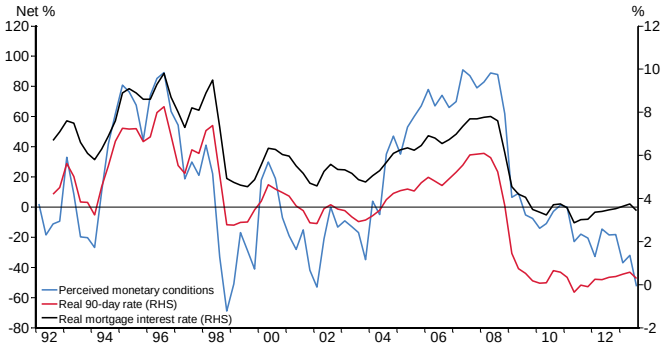
Average 2010-2013	Average 2000-2009	Average 1992-1999
5.4	6.2	7.4

Another way to look at whether NIRs have changed is through the behaviour of simple indicators such the relationship between interest rates and perceptions of monetary conditions.[6] Figure 6 shows the relationship between perceptions of monetary conditions and the real 90-day interest rates is converging. However, the relationship between perceptions of monetary conditions and floating mortgage interest rates, as a proxy for interest rates that firms and households face, has diverged since 2010. This divergence could suggest that NIRs have overshot and may begin rising again. It could also be a reflection of the considerable easing in credit conditions that has been seen. Notably, the relationship between perceived monetary conditions and the real trade weighted index (TWI) has diverged, possibly giving an indication of a change in real economic conditions.

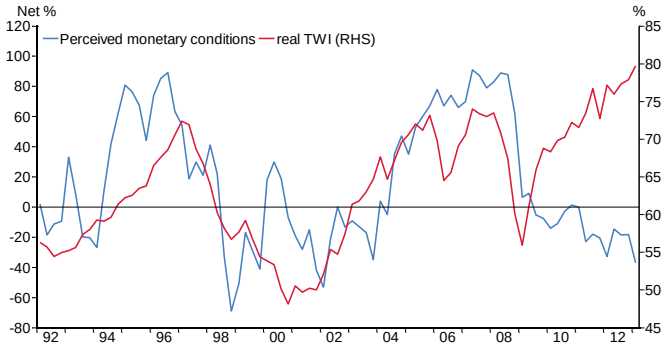
[6] Based on results from the RBNZ survey of expectations question about expectation for monetary conditions at the present moment which provides an indication of the net percent of respondents who see conditions as tight compared to loose.

Figure 6: Perceptions of monetary stance

Perceived monetary conditions and real interest rates



Perceived monetary conditions and the real TWI



Examining underlying trends in real economic factors based on economic theory can also provide an indication of whether NIRs have changed. As described above, NIRs depend on future global prospects, domestic productivity growth, population growth and preferences for savings and investment. Appendix A provides an illustration of how these factors have changed in New Zealand and selected economies. Falls in productivity growth over the last few years in New Zealand, when compared to the two business cycles before the crisis, appear to be the main indication NIRs have fallen in New Zealand. And this story is not unique to New Zealand.

The other factors which influence NIRs have the potential to move in a direction consistent with lower NIRs. But as discussed below, at this stage do not appear to be the beginning of a longer-lasting change in underlying trends in real economic factors that might drive changes in New Zealand NIRs.

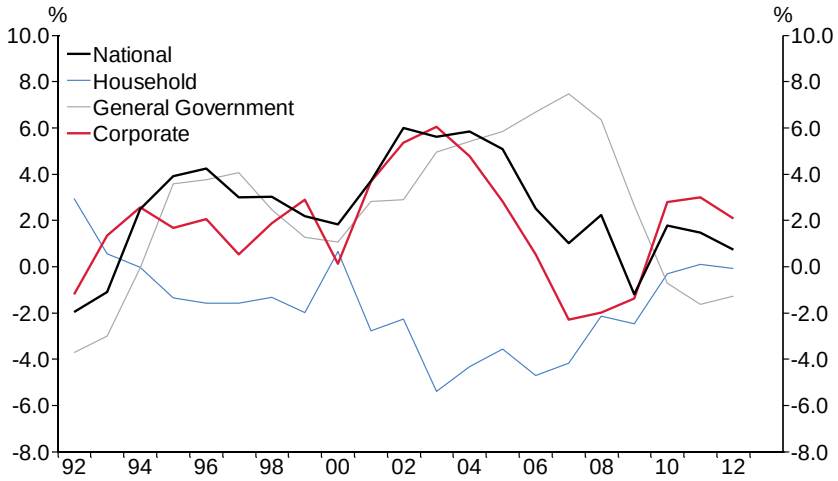
In the aftermath of the GFC, potential output growth in OECD countries fell. However, global GDP growth is expected to remain near its pre-crisis trend so future global prospects would only have a marginal effect on NIRs in New Zealand. If downside risks to global growth eventuate, however, this could affect NIRs.

Global population growth has been trending downwards since the 1960s which might indicate lower global NIRs, while New Zealand population growth has only fallen more recently. Population growth in New Zealand over the last couple of cycles has tended to fluctuate in a way that does not match the apparent movements in NIRs, and the recent fall in population growth is small by the standards of past movements. Swings in population growth in New Zealand (often migration-driven) influence where the OCR needs to be set relative to neutral, but probably have not altered the NIR itself over the last decade.

Changes in the composition of the population could also affect NIRs. To the extent preferences for savings of individuals prior to retirement in an ageing population change, this could put downward pressure on NIRs. There is little evidence in New Zealand at this stage to suggest population ageing is driving a change in NIRs.

Gross national savings, as an indication of preference for savings, rose slightly in New Zealand in the aftermath of the crisis, driven by higher corporate and household savings (figure 7). This probably reflected the household sector trying to reduce debt levels and exposure to financial risk and the corporate sector acting cautiously, retaining a greater share of profits within businesses, even though investment has been subdued. The change in household savings could suggest a change in preferences. And, higher corporate savings could reflect the corporate sector responding cautiously to changed demand and financing conditions.

Figure 7: New Zealand gross savings rates by sector (share of GNI)



Source: Statistics NZ

However, taking the last few years as a whole, gross national savings have not increased relative to the experience in the pre-crisis years. Despite private (household and corporate) savings rising, government savings fell sharply, providing an offsetting effect on gross national savings. Indeed, reduced government savings may have contributed to the increase in private savings. One area of uncertainty in the period ahead is how private savings will respond to the improvement in the fiscal position.

5.2.2. RBNZ REVISIONS TO NEUTRAL INTEREST RATES

In the Reserve Bank modelling framework there is a view of neutral levels for both the OCR, represented by the neutral 90-day rate, and the interest rates that households and firms pay, typically proxied by the neutral floating mortgage rate.

The Reserve Bank has, over time, adjusted the level of the neutral 90-day rate in our forecasting models in response to perceived changes in underlying trends in the economy (figure 8). [7] In the early 2000s, the neutral 90-day rate was revised downwards a total of 75 basis points. This revision reflected an assessment that,

[7] Our neutral rate assumption in the early 2000s, as shown in figure 8, differs from the level of neutral in 2008-2010 because of a change in the forecasting model used. Also, note in FPS neutral is specified in real terms, whereas in NZSIM neutral is specified in nominal terms.

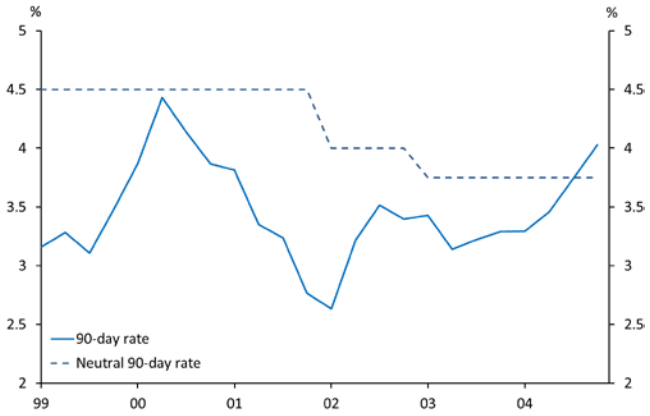
given changing business cycles, it became increasingly unlikely that higher interest rates would be needed in new 'normal' cycles. Both judgement and forecasting models suggested smaller interest rate cycles and hikes were needed to stabilise inflation.

In 2010, the neutral 90-day interest rate was revised down 150 basis points in response to the GFC. High risk aversion was reducing demand for funds and encouraging saving and deleveraging. The neutral floating mortgage interest rate was initially kept unchanged, though was subsequently stepped down by 100 basis points as time and underlying trends in real factors suggested that NIRs for households and firms had fallen.[8] The neutral floating mortgage rate was reduced less than the neutral 90-day rate (raising the spread by 50 basis points to 250 basis points) because the costs of funding in New Zealand rose from around 20-30 basis points above the OCR to around 100-150 basis points above the OCR, in part reflecting the premium banks had to pay on longer-term wholesale and domestic retail funding.[9] This meant the relationship between the OCR and interest rates faced by households and firms changed, causing the 'normal' spread of floating mortgage interest rates relative to the 90-day interest rates to rise.

Figure 8: Stylised view of monetary policy settings in:

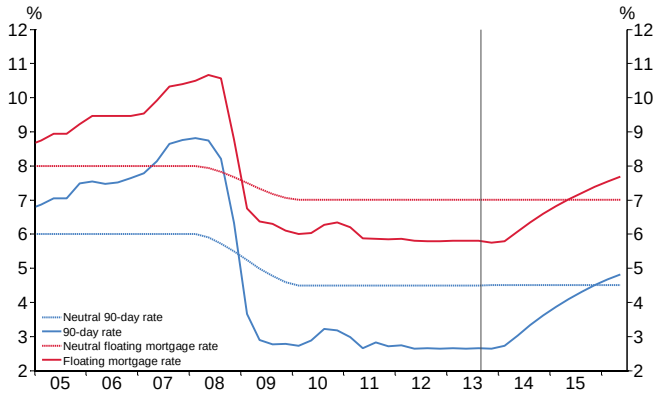
FPS

(real)



NZSIM

(nominal)



The New Zealand experience of rising spreads after the GFC was not uncommon. Figure 9 illustrates that for selected countries after the GFC, a given 90-day interest rate is now consistent with higher mortgage interest rates. For example, in Australia, bank funding costs also rose relative to the policy rate, which Lowe (2012) suggests led to the policy rate being about 150 basis points lower than otherwise.

[8] Measures of credit conditions and growth relative to GDP and labour market conditions needed to be monitored before any changes to neutral floating mortgage rates were made.
[9] Indicative marginal funding spreads remain above pre-crisis levels, but have fallen since 2012.

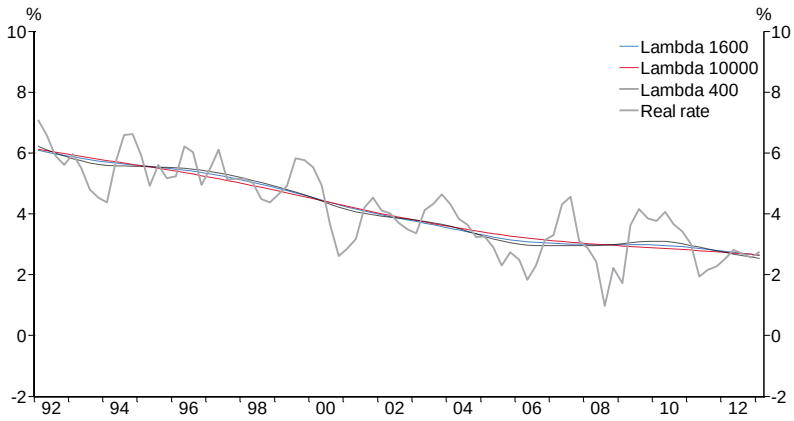
Figure 9: Spread of floating nominal mortgage rates over nominal 90-day rates

5.2.2. INDICATIVE ESTIMATES OF THE NEUTRAL REAL INTEREST RATES

A simple, univariate approach to estimate NRIRs is to estimate trends in real interest rates. We have estimated these trends for 90-day, 10-year and mortgage interest rates for New Zealand and various other countries using a 1992 to 2013 sample. A Hodrick-Prescott (HP) filter has been used with different degrees of stiffness (λ=400,1600,10000) to extract the trend in real interest rates.

New Zealand's real interest rates have been trending downwards since 1992 when low and stable inflation became an established feature of the New Zealand economy, similar to what has been seen in other advanced economies. Figures 10 to 12 show real 10-year, 90-day and floating mortgage rates in New Zealand since 1992, with their HP-filtered trends.[10]

Figure 10: Downward trend in real 10-year interest rates for New Zealand



[10] The real rate used here is the nominal rate minus a measure of CPI that excludes the effects of GST on headline inflation. Using inflation expectations as the deflator shows an even steeper downward trend.

Figure 11: Downward trend in real 90-day interest rates for New Zealand

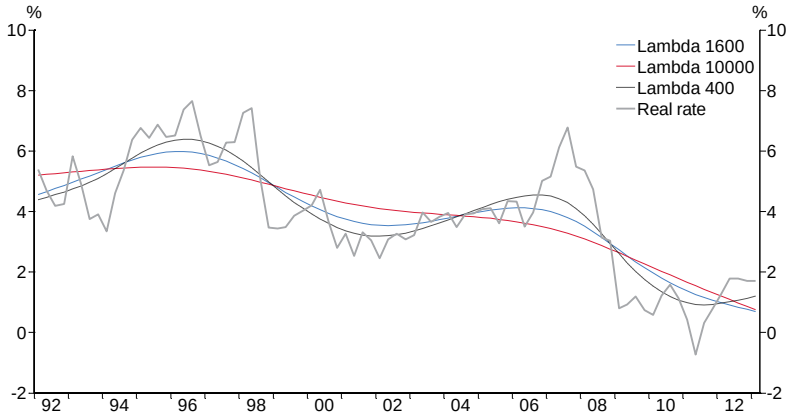
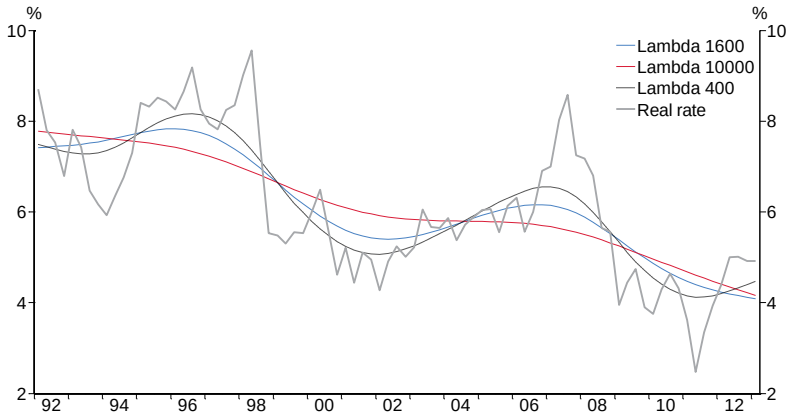
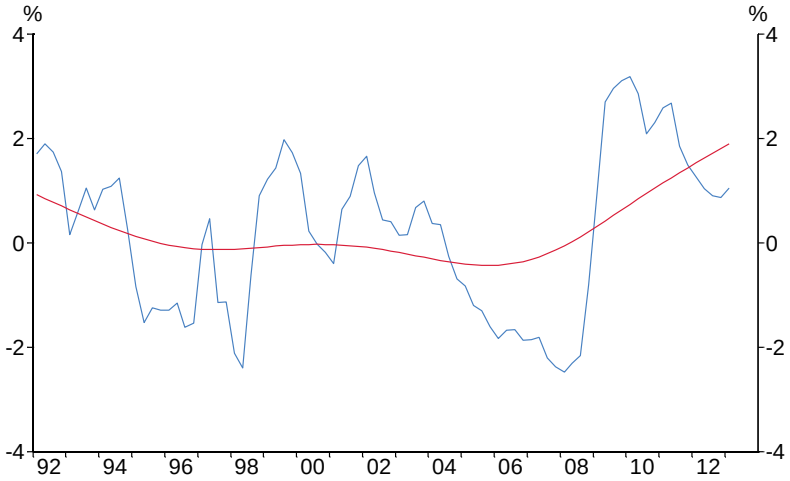


Figure 12: Downward trend in real mortgage interest rates for New Zealand



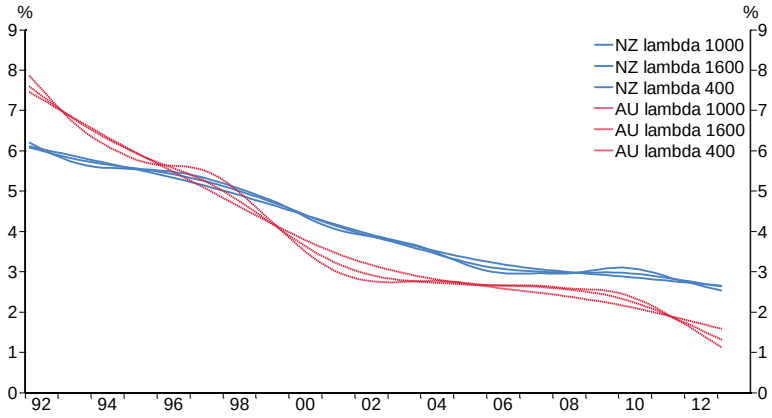
The trend in all three real interest rates is downward (see appendix B for a comparison of trends across the different real interest rates). In particular, real mortgage rates have not trended down as much as real 90-day rates (as would be expected from the rise in spreads). Also, the steady fall in the real 10-year interest rate suggests markets expect that rates will be lower for some time to come. The 10-year interest rate – as an indication of expected returns over a longer period – should largely look through cyclically-weak and cyclically-strong periods, similarly to the implied five year rate. Figure 13 shows the trend in real 10-year rates has fallen since the GFC by less than that in real 90-day rates, likely because of the larger cyclical drop in short-term rates.

Figure 13: Yield curve slope: the trend in real 10-year rates has fallen by less since the GFC than the trend in real 90-day rates



Internationally, the general story has also been one of a decline in real interest rates. Bouis et al (2013) suggests NRIRs in Canada, Japan and in the United Kingdom and United States, may have even turned negative. Appendix C and Appendix D show the downward movement and trends in the various real interest rates in New Zealand and seven other countries – Australia, Canada, Korea, Sweden, Switzerland, the United Kingdom and United States. As in New Zealand, short-term rates have fallen much more in these countries since the GFC than other rates. And again, real 10-year rates have still fallen over an extended period. But as discussed, New Zealand NRIRs appear to be higher than other countries (figure 14).

Figure 14: Trends in real 10-year interest rates: New Zealand compared with Australia

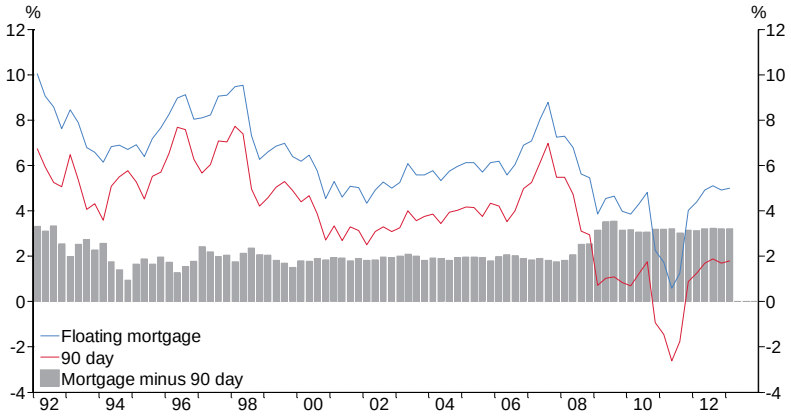


The implications of the decline in NIRs can be illustrated by comparing interest rates implied by a Taylor rule (Bouis et al (2013)). Kendall and Ng (2013) have updated Taylor Rule estimates for the post-GFC period. They found an estimate for the neutral *nominal* interest rate in a Taylor Rule estimation of 6.66 percent over the pre-crisis period 1992Q2-2008Q2. They then estimate the same specifications from 1992Q2-2012Q4 with a dummy for the post-GFC period and find some evidence that neutral nominal interest rates have fallen.

5.2.3. COULD NEUTRAL INTEREST RATES IN NEW ZEALAND HAVE FALLEN FURTHER?

Although there is a lot of uncertainty around NRIR estimates, using this one approach of estimating trends in real interest rates could suggest neutral real 90-day rates may have fallen by around 200 basis points since the crisis, and the spread of real mortgage rates over real 90-day rates appears to have risen by over 100 basis points. Much of this adjustment has already been incorporated into the Reserve Bank of New Zealand modelling framework. However, this measure, if taken in isolation, could suggest that neutral real 90-day rates might have fallen further. The spread of real floating mortgage spreads over real 90-day rates has also risen by more than has been accounted for in the modelling framework (figure 15). Lowering the neutral real 90-day rate could therefore also reflect this higher spread.

Figure 15: Spread of real floating mortgage rates over real 90-day rates



6. COMPLICATIONS IN ESTIMATION AND USE OF NEUTRAL INTEREST RATES

One should be cautious when drawing inferences from the univariate measures of HP filters on interest rates used in this analysis. Univariate measures do not control for the influence of other cyclical conditions on interest rates. Further, the endpoint of the HP-filtered trends is notoriously sensitive to new observations. Consequently, other work may be required to draw conclusions about a narrow range for the NIR.

Other factors can complicate the measurement of NIRs in the post-crisis period. For example, there have been changes in behaviour since the GFC that have affected risk premia in New Zealand. However, the high frequency of changes in sentiment means over the business cycle these changes offer little insight into whether NIRs have changed.

The use of macro-prudential tools in New Zealand could also influence NIRs if they have persistent effects on the relationship between interest rates and the OCR and the relationship between interest rates and saving and investment decisions. For example, to the extent the introduction of the loan-to-value ratio (LVR) affects savings

behaviour over the medium term there would be a marginal impact on NIRs. But LVRs will likely affect demand for the time they are in place, and this is more likely to affect how much stimulus interest rates need to provide. Related to this, there are questions about how quantitative easing and unconventional monetary policy have affected NIRs globally and whether this impact will reverse as these policies are withdrawn over the next few years.

The rise in spreads of 90-day and floating mortgage rates since the crisis has raised the question as to which NIR, either the neutral real 90-day or neutral real floating mortgage rate, is relevant in practice for policy decisions in New Zealand. Historically, the 90-day rate and mortgage rate moved together relatively closely. The floating mortgage rate, as a proxy for interest rates households and firms face would be more relevant for housing, consumption and firm dynamics, but historically the 90-day rate is said to better relate to the exchange rate because it is wholesale returns that matter to wholesale investors. Furthermore, since the GFC the question has been raised of whether the NIR should consider both price stability and financial stability.

Monetary policy can also be operated looser or tighter than neutral would imply. Over the 2000s, Chetwin and Reddell (2012) conclude, with the benefit of hindsight, that policy was probably held too loose [11] – housing strength was underestimated, procyclical fiscal policy was more of a challenge, and low global inflation and falling global interest rates was more a global under-pricing of risk. But policy was operated too loose even relative to the Reserve Bank's estimates of NIRs at the time: one interpretation is that the Reserve Bank acted as if neutral was even lower than the estimate incorporated in the forecasting models.

7. CONCLUDING REMARKS

In this note we reviewed literature on NIRs in the post-GFC period. Research suggests that policy rates worldwide provide less stimulus than in the past. Financial frictions, such as high risk aversion and rising credit spreads that were seen during the GFC, are also found to be able to move NIRs from equilibrium rates for a period of time. However, the question remains whether these financial frictions have become embedded in underlying behaviour and activity. The Reserve Bank has reduced its neutral 90-day rate estimate, partly to reflect rising spreads. Furthermore, falling productivity growth suggests NIRs that households and firms face are lower in the post-crisis period, and neutral floating mortgage rates in the Reserve Bank's framework have been revised downwards to represent this. Lower NIRs would imply that the average level of interest rates over the cycle will be lower than in the past, but will not necessarily suggest a change in the amplitudes of interest rate cycles.

[11] Nominal interest rates did not actually rise above the neutral nominal 90-day rate assumption being used in our model until 2004Q3.

Because it is not directly observable, it is difficult to precisely estimate whether the NIR has changed and what its current level is. However, updated estimates of the trends in real interest rates using post-GFC data suggest average interest rates have fallen over the last cycle and subsequent recession, both in New Zealand and in other economies, and have not recovered subsequently. We use one measure to estimate the current level of the neutral 90-day real interest rate which involves estimating the trends in real 90-day interest rates. This measure might suggest reason for thinking the neutral 90-day interest rate has fallen even further since the revisions made in 2008 to 2010 and would increase the spread between real floating mortgage and real 90-day rates. Only time will tell whether such a revision is appropriate or, indeed, whether a reversal in the recent productivity slowdown might lead to upward revisions in NIRs over time.

Given the gradually changing nature of the economy, there will always be questions about how much stimulus the OCR provides. In practice, central banks should review the level of NIRs periodically to take account of any change in underlying trends in real economic factors because it is difficult to accurately estimate a time-varying NIR. Combining estimates of NIRs with other information about cyclical pressures in the economy and judgement will help inform monetary policy decisions.

REFERENCES

Amato, J. (2004). The role of the natural rate of interest in monetary policy. *BIS Paper*

Archibald, J. and Hunter, L. (2001). What is the neutral interest rate, and how can we use it? *Reserve Bank of New Zealand Bulletin,* 64, 3 pp 15-28

Basdevant, O., Björksten, N. and Karagedikli, Ö. (2004). Estimating a time varying neutral interest rate for New Zealand. *Reserve Bank of New Zealand Discussion Paper Series* DP2004/01.

Bernhandsen, T. and Gerdrup, K. (2007). The neutral interest rate. Monetary Policy Department, *Norges Bank Economic Bulletin* 2/2007 Volume 78, 52-64

Bernhardsen, T. and Kloster, A. (2010). What is the normal interest rate level? Economic commentaries, 1, Norges Bank

Björksten, N. and Karagedikli, Ö. (2003a). Neutral interest rates revisited. *Reserve Bank of New Zealand Bulletin* 66(3): 18-27

Björksten, N. and Karagedikli, Ö. (2003b). Monetary Policy Challenges in New Zealand: how are we different? Presented to the 'analysing the economy for monetary policy purposes' workshop at Reserve Bank of New Zealand, March 2003.

Blinder, A. (1998). *Central banking in theory and practice.* MIT Press

Bouis, R., Rawdanowixz, L., Renne, J., Watanabe, S. and Christensen, A. (2013). The effectiveness of monetary policy since the onset of the financial crisis. *OECD Economics Department Working Papers*, No. 1081,

Burnside, C. (2011). New Zealand's risk premium and its role in macroeconomic imbalances. Paper for RBNZ, The Treasury and Victoria University of Wellington Macroeconomic imbalances - causes and remedies forum, Wellington

Chetwin, W. and Reddell, M. (2012). Monetary policy in the last business cycle: some perspectives. *Reserve Bank of New Zealand Bulletin*. 72, 2

Chetwin, W., Ng, T. and Steenkamp, D. (2013). New Zealand's short- and medium-term real exchange rate volatility: drivers and policy implications. *RBNZ Analytical Note* 2013/03

Curdia, V. and Woodford, M. (2010). Credit spreads and monetary policy. *Journal of Money, Credit and Banking*, Supplement to Vol. 42, 6

De Fiore, F. and Tristani, O. (2011). Credit and the Natural Rate Of Interest. *Journal Of Money, Credit And Banking,* Vol. 43, No. 2–3

Desroches, B. and Francis, M. (2006). Global savings, investment, and world real interest rates. *Bank of Canada Review*

Gali, J. (2008). *Monetary policy, inflation and the business cycle.* Princeton

Garnier, J. and Wilhelmsen, B. (2005). The natural real interest rate and the output gap in the euro area: a joint estimation. Working Paper Series No. 546

Kendall, R. and Ng, T. (2013). Estimated Taylor Rules updates for the post crisis period. *RBNZ Analytical Series* 2013/04

Kergozou, N. and Ranchhod, S. (2013). Why has inflation been low? *Reserve Bank of New Zealand Bulletin.*

Kirker, M. (2008). Does natural rate variation matter? Evidence from New Zealand. *Reserve Bank of New Zealand Discussion Paper Series* DP 2008/17

Laubach, T. and Williams, J. (2003). Measuring the Natural Rate of Interest. *Review of Economics and Statistics*, 85(4), November, pp 1063-1070.

Lowe, P. (2012). What is normal? Address to Australian Business economists Annual Dinner. http://www.rba.gov.au/speeches/2012/sp-dg-051212.html

Orphanides, A. and Williams, J. (2003). Robust monetary policy rules with unknown natural rates. *FRBSF Working Paper #2003-01*

M´esonnier, J. and Renne, J. (2007). A time-varying "natural" rate of interest for the euro area. *European Economic Review*, 51(7), 1768–1784.

Mabin, G. (2011). New Zealand's exchange rate cycles: impacts and policy. New Zealand Treasury Working Paper 11/01.

Magud, N., and Tsounta, E. (2013). Seven questions on the neutral interest rate in Latin America and beyond. *IMF Research Bulletin*, 14, 2.

Neiss, K. and Nelson, E. (2003). The real-interest-rate gap as an inflation indicator. *Macroeconomic Dynamics* 7, 239-262.

Plantier, L. (2003). New Zealand's economic reforms after 1984 and the neutral real rate of interest. Paper presented to the Reserve Bank of New Zealand workshop on Analysing the economy for monetary policy purposes: key issues, 21 March

Plantier, L.. and Scrimgeour, D. (2002). Estimating a Taylor rule for New Zealand with a time-varying neutral real rate. *Reserve Bank of New Zealand Discussion Paper Series,* DP2002/06.

Reddell, M. (2013). The long-term level misalignment of the exchange rate: Some perspectives on causes and consequences. Paper prepared for the Reserve Bank/Treasury exchange rate forum, Wellington 26 March 2013

Reifschneider, D., and Williams, J. (2000). Three lessons for monetary policy in a low inflation era. *Journal of Money, Credit and Banking*, *32* (4), 936-966.

Schmidt-Hebbel, K. (2006). New Zealand's monetary and exchange-rate policy in international comparison. In Testing stabilisation policy limits in a small open economy: 83–144. Reserve Bank of New Zealand, Wellington.

Schmidt-Hebbel, K., and Walsh, C. (2009). Monetary policy and key unobservables: evidence from large industrial and selected inflation-targeting countries. *Central Bank of Chile Working Paper*, 527

Smets, F. and Wouters, R. (2003). An estimated dynamic stochastic general equilibrium model of the euro area. *Journal of the European Economic Association* 1, pp. 1123-1175.

Taylor, J. (1993). Discretion versus policy rules in practice. Carnegie-Rochester Conference Series on Public Policy, 39:195-214.

Weber, A. (2006). The role of interest rates in theory and practice – How useful is the concept of natural real rate of interest for monetary policy? G.L.S Shackle Memorial Lecture 2006. UK: Cambridge Deutsche Bundesbank

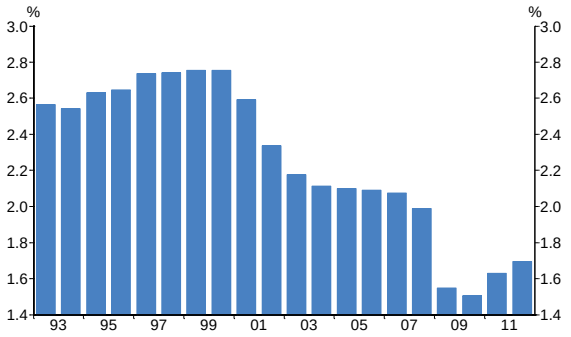
Wicksell, K. (1936). *Interest and Prices* (tr. of 1898 edition by R.F. Kahn). London: Macmillan.

Williams, J. (2003). The natural rate of interest. *FRBSF Economic Letter*, 32

Yellen, J. (2005). Update on the US economy. Speech to a Salt Lake City Community Luncheon. http://www.frbsf.org/news/speeches/2005/1018.html:

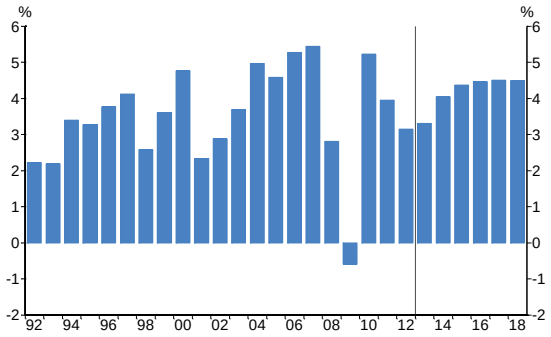
APPENDIX A: INDICATIONS OF POSSIBLE CHANGES IN UNDERLYING TRENDS (SELECTED ECONOMIES)

OECD potential output growth



Source: OECD

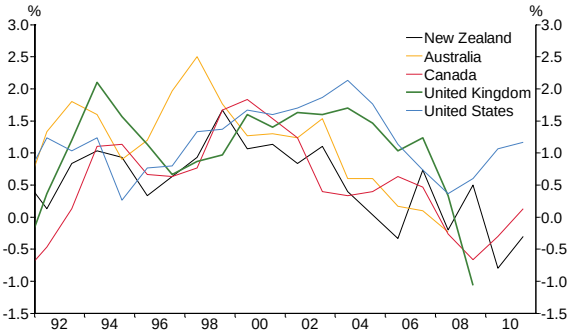
Global GDP growth



Source: IMF *World Economic Outlook*

Multifactor productivity growth

3 year moving average

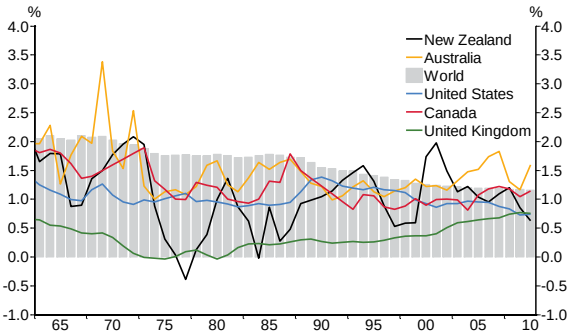


Source: OECD

	Annual % growth		
	1990-1999	2000-2006	2007-2011
Australia	1.44	0.83	-1.00
Belgium	1.04	0.49	-0.98
Canada	0.62	0.79	-0.15
Finland	1.93	2.21	-1.00
France	1.03	1.19	-0.30
Germany	1.09	1.23	0.05
Ireland	3.95	2.09	0.55
Italy	0.60	-0.03	-1.00
Japan	0.95	1.00	0.40
Korea	3.99	2.86	3.28
New Zealand	0.83	0.34	-0.85
Spain	0.62	-0.17	-0.05
Sweden	0.91	2.16	-0.73
Switzerland	-0.67	0.83	-0.47
United Kingdom	0.94	1.49	-2.40
United States	1.04	1.54	0.88

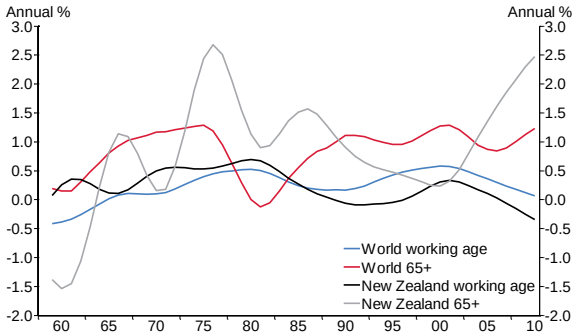
Source: OECD

Population growth



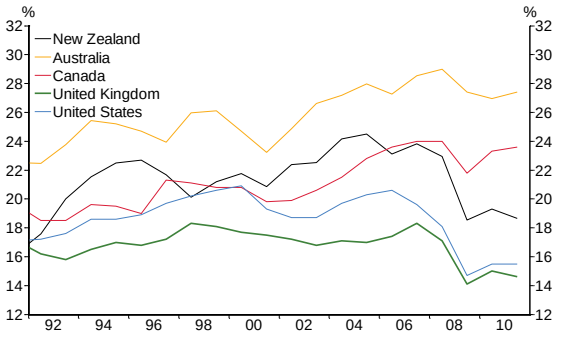
Source: World Bank

Global working age versus 65+ population growth



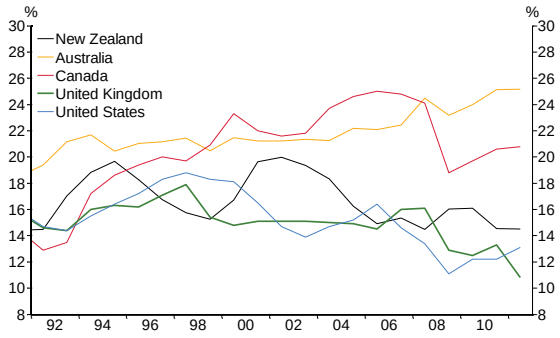
Source: World Bank

Gross investment (percent of GDP)



Source: IMF *World Economic Outlook*

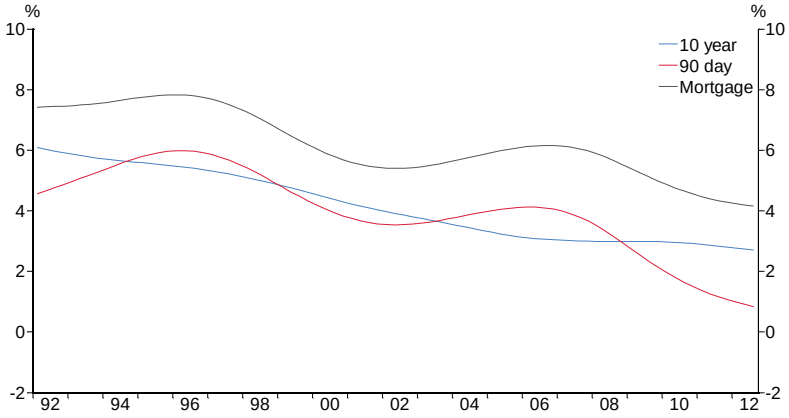
Gross savings (percent of GDP)



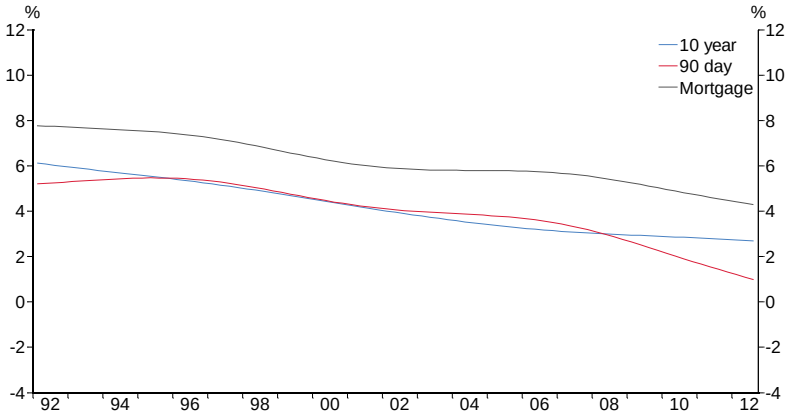
Source: IMF *World Economic Outlook*

APPENDIX B: TRENDS IN VARIOUS NEW ZEALAND REAL INTEREST RATES

λ=1600

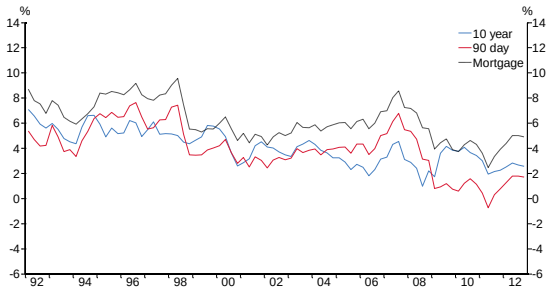


λ=10000

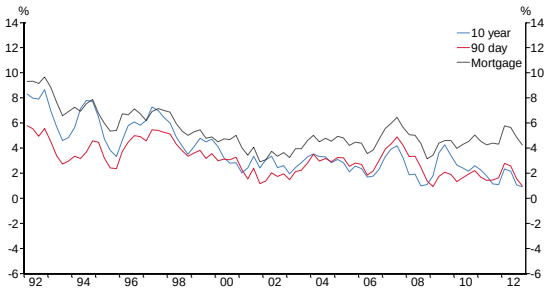


APPENDIX C: MOVEMENTS IN INTERNATIONAL REAL INTEREST RATES[12]

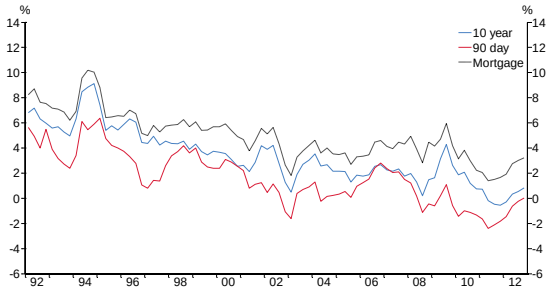
New Zealand



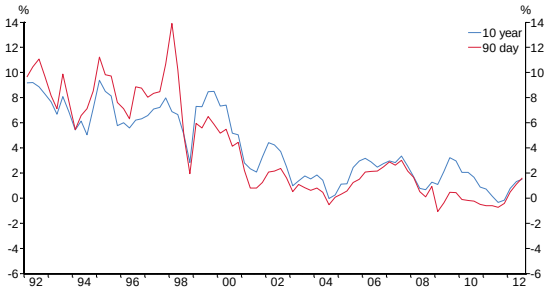
Australia



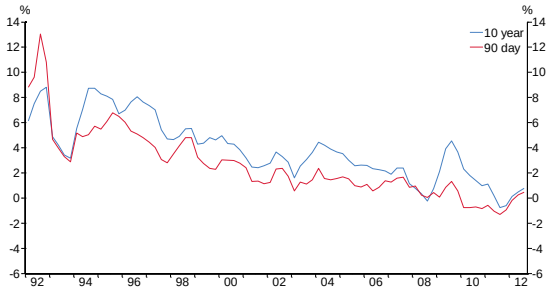
Canada



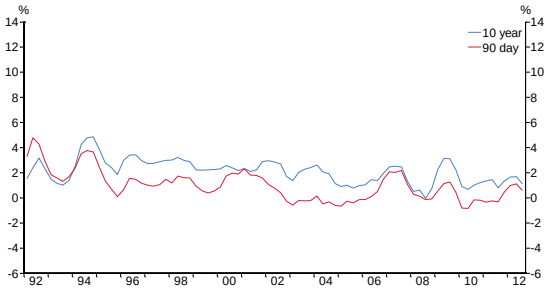
Korea



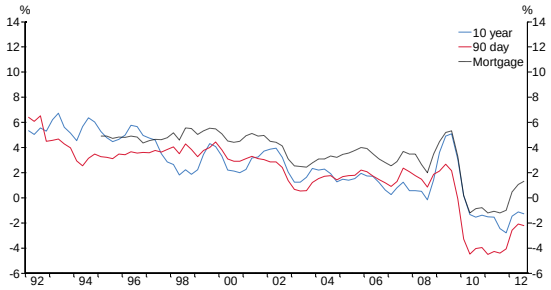
Sweden



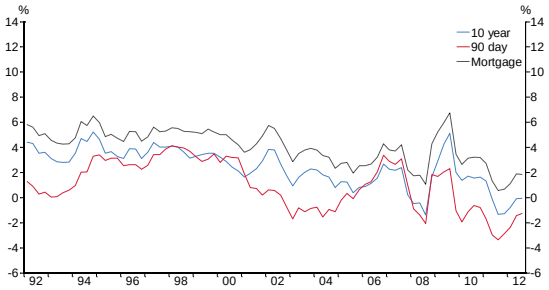
Switzerland



United Kingdom



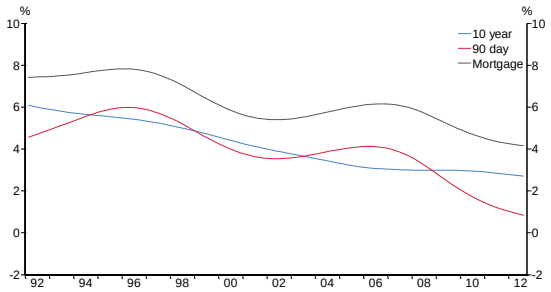
United States



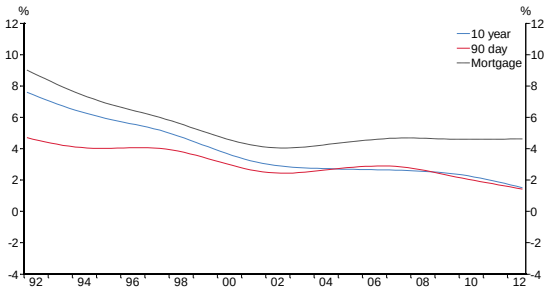
[12] Mortgage rates for these countries are not strictly comparable. From Haver Analytics, these are as follows:
Australia: Bank Housing Loans, Standard Variable Rate
Canada: 5-Year Average Residential Mortgage Lending Rate
Korea: no data
New Zealand: First Mortgage Housing Rate
Sweden: no data
Switzerland: no data
U.K.: Variable Mortgage Rate: Banks and Building Societies
U.S.: Commitment Rate: Conventional 30-Yr Fixed Rate Mortgages, FHLMC.

APPENDIX D: TRENDS IN INTERNATIONAL REAL INTEREST RATES (λ=1600)

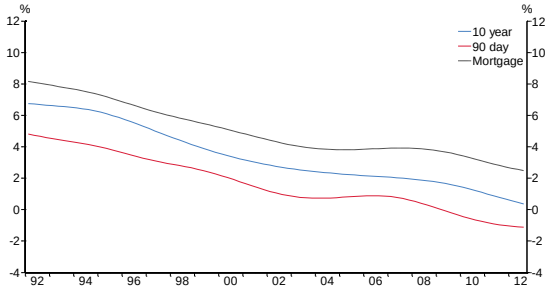
New Zealand



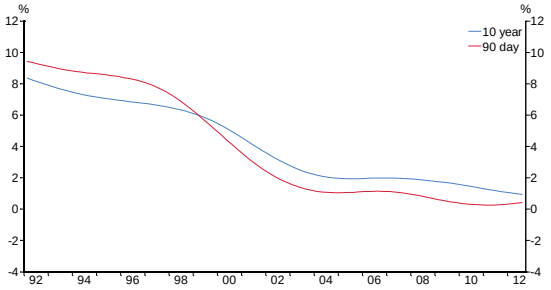
Australia



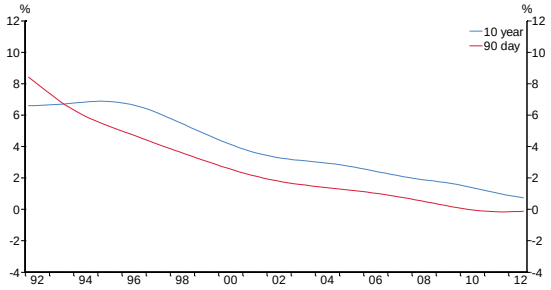
Canada



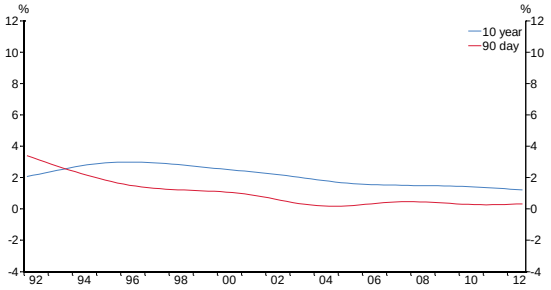
Korea



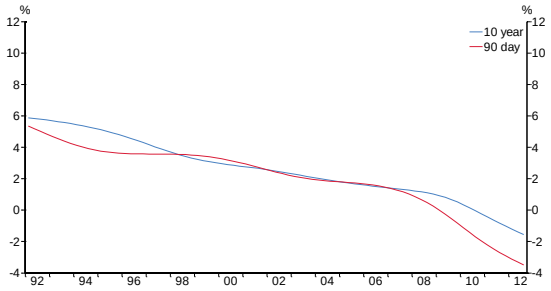
Sweden



Switzerland



United Kingdom



United States