Reserve Bank of New Zealand
Te Pūtea Matua

Analytical Notes

Technical appendix to

Measures for Assessing the Sustainability of House Prices in New Zealand.

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This appendix outlines the conceptual framework for the user cost (households) and asset price (investors) models presented in the *Analytical Note*, and how the models were calibrated to New Zealand data.

The user cost and asset price models use information about the benefits and costs of home ownership to estimate an 'intrinsic value' for housing. However, the models are inherently sensitive to their inputs and assumptions and should be considered in the context of a broader range of measures. Alternative calibrations are also shown in the model output section.

The models presented in the *Analytical Note* are fitted to match the historical experience of the imp lied returns on housing. This abstracts away from some issues around the data sources (such as whether the correct rent measure is being used relative to a given house price measure).

Conceptual Model

There are a wide range of modelling techniques to estimate asset prices. For the purposes of measuring house price sustainability, we use a relatively simple model that determines an intrinsic value of house prices as being the discounted value of future net benefits derived from a property.[1] This is equivalent to a 'user cost' model traditionally used literature to estimate house prices (see Miles and Monroe, 2019; O'Donovan & Stephens, 2009; Hargreaves, 2008; and Poterba, 1984 as examples). In the model, the long-run user cost value of a house is defined as:[2]

$$(1)\quad User\ cost\ value = \frac{Benefits\ of\ ownership}{discount\ rate + costs\ of\ ownership - expected\ capital\ gains}$$

To develop the model for assessing house values in New Zealand, we make the following assumptions around investor and household behaviour:

1. Potential rent on a property approximates the benefits of owning the property. By extension, the housing market is in equilibrium when households are indifferent between renting and home ownership. That is, the benefits of owning a given property is equal to the potential rent on that property.

2. The costs of housing are expressed as a share of the benefits of ownership (potential rent in equilibrium) rather than as a share of property value as traditional user cost models assume. This is because the relationship between costs and rents is more stable in the New Zealand context.

3. Buyers do not have foresight over structural changes in the economy. This means the future expectations for interest rates used to discount cash flows are assumed to be equal to the neutral risk-free rate plus debt and equity premiums *at the date of purchase*.[3] Any subsequent changes in the neutral rate are therefore considered to be unexpected shocks.

1 This type of model is effectively equivalent to a Gordon-Growth Model (Gordon 1962). While the result is similar to a user cost model, a Gordon-Growth Model is derived using the closed-form solution of future cash flows that follow a geometric series pattern. In contrast, a user cost model estimates the fair-value by deriving the rate of substitution between housing and other consumption goods based on a household's utility function.

2 This equation is derived from the assumption that the cost of housing equal to the price multiplied by: the discount rate, plus costs as a share of property value, less expected capital gains.

3 The neutral risk-free rate is the short-term central bank policy rate that is neither expansionary nor contractionary. The neutral risk-free rate in this paper is the Reserve Bank average estimate for the neutral OCR.

4. The price a property would be expected to sell at would be the discounted future net benefits at the date of sale (i.e. the same estimate approach of pricing at date of original purchase). This allows the model to be derived in a closed-form solution, similar to a Gordon Growth Model. [4] The model also assumes that there is no capital gains tax, which in the New Zealand context is analogous to buyers holding the property for long enough that the tax does not apply.

The models presented in this *Note* make some technical adjustments to the strict user cost model by incorporating short-term factors as well. This means that the model estimate internalises the full 'pathway' of underlying drivers (interest rates and growth rates) towards the medium and long-term outlooks.[5]

$$(2)\ Value_0 = \frac{1-\left(\frac{1+g_{sr}}{r_{sr}-g_{sr}}\right)^6}{1-\left(\frac{1+g_{sr}}{r_{sr}-g_{sr}}\right)} * Net\ benefits\ + \left(\frac{1+g_{sr}}{1+r_{sr}}\right)^5 * \left(\frac{1}{r_{lr}-g_{lr}} * Net\ benefits\right)$$

Short-term outlook Long-term outlook

Where r_{sr} and r_{lr} are the short and long-term discount rates respectively. The short-term discount rate reflects the forward path of interest rates and required investor returns over the next five years. The long-term discount rate reflects the level that interest rates and required investor returns will be when the risk-free rate is at its neutral level. These incorporate any costs that are expressed as a share of house prices. g_{sr} and g_{lr} describe the short-term (five year) and long-term expectations for capital gains. The $Net\ benefits$ are the benefits of ownership less any costs that are expressed relative to these benefits and after any tax.

Calibration of Model

Net Benefits

It is common in user cost and models to measure costs as a share of house prices. This has the advantage of simplifying analysis, particularly for comparative statics. However, the relationship between costs, namely maintenance and council rates, and house prices has become volatile and unreliable in the New Zealand context. This is largely due to the fact that: rates are not directly related to property prices (although prices are the distributional mechanism); and house prices have been increasing due to higher land values rather than building costs which relate more directly to maintenance costs. [6]

To overcome this issue, the user cost and asset price models incorporate these costs as a share of rents rather than house prices, which is more stable. The baseline model deducts 15 percent of pre-tax rental income to represent maintenance costs, and 10 percent to represent rates costs. It is important to note that the 15 percent for maintenance costs are the long-term average costs. In practice, this would be reflected on profit through small actual maintenance costs plus an assumed depreciation rate on the property-structure and chattels.

4 With a constant growth rate in cash flows, the sum of future cash flows becomes a geometric sequence and the 'limit' can be simplified to closed form using $\sum c * x^{i-1} = c * \frac{1}{1-x}$ where $i \in \mathbb{Z}^+$.
In practice, while this assumes the asset is held in perpetuity, if the purchaser were planning to sell the asset at a later point, they would (theoretically) get the same present value of the asset.

5 This equation is based on a closed form solution for a geometric sequence (in this case the future net benefits), and holds so long as r – g > 0.

6 Some user models assume a 'depreciation cost'. As these generally relate to 'wear-and-tear' of a property, such costs are assumed to be captured through maintenance costs.

In addition to these costs, property management fees for property investors are assumed to be set at 8 percent of pre-tax rent.

In both models the benefits is rents. For investors, rents represent the cash flow income from the investment. For households, rents represent the savings they are receiving from not renting. Unfortunately, there are a number of data limitations with rents. In particular, as there has been declining home ownership over the past decades, median rents do not align with a consistent quality of housing (such as median or lower quartile houses). To overcome this issue, the model uses rents and house prices that control for some quality changes (see Table A2).

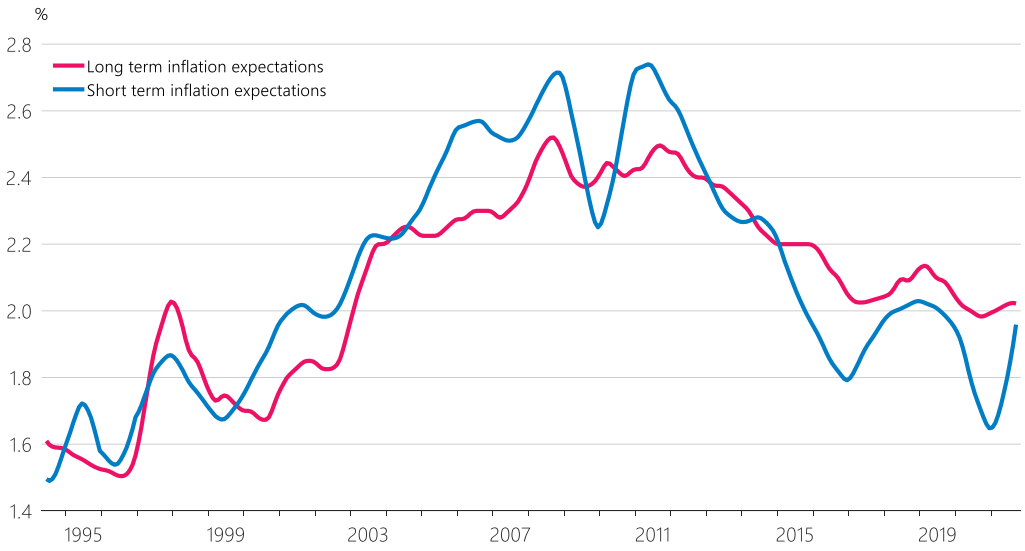
Table A1: Cost assumptions

Cost	Baseline assumptions
Maintenance / depreciation	15 percent of pre-tax rent
Council rates	10 percent of pre-tax rent
Property management (investors only)	8 percent of pre-tax rent

Calibration of Growth Rates / Capital Gains

The expected growth rates in the baseline model ('*g*') is derived by: the 12-month rolling average expected inflation at the time of purchase; plus the geometric mean growth rate from 1994 to 2021 for real rents, which is 1.3 percent. This implicitly ties capital gains to the growth in cash flows, which is a necessary assumption to result in a stable rental yield for a given interest rate.

Figure A.1: Inflation expectations (12 month rolling average)[7]



Source: RBNZ estimates, author's calculations

7 See Table A2 for data sources

Calibration of Discount Rates

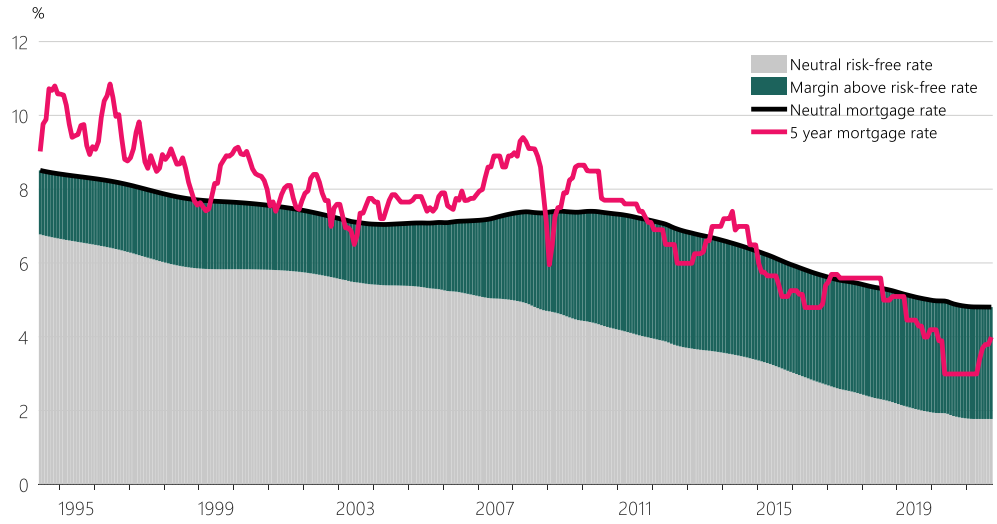
The discount rate used in the model is equivalent to a weighted-average cost of capital (WACC). The cost of debt is the mortgage rate, and the cost of equity is the term deposit rate. There is also a risk premium, ρ, to reflect the additional risk of investing in housing. The model assumes that the marginal investor is leveraged up to 60 percent and the marginal owner-occupiers up to 80 percent. The top marginal tax rate is assumed for investors, with the exception of the recent top tax bracket. Owner-occupiers also face taxes for their term deposit returns.[8] As noted earlier, the discount rate for the short-term component incorporates the forward path for the next five years, and the long run discount rate is based on estimates are neutral mortgage rates and required returns.

$$r = LVR * (1 - \tau) * r_{mortgage} + (1 - LVR) * (1 - \tau_{td}) r_{term\ deposit} + \rho$$

To estimate the neutral mortgage rate, the spread of the 5-year mortgage rate over the 5-year government bond rate is assumed to represent the mortgage rate spread above the risk-free rate. As this series is volatile, a Hodrick-Prescott filter derives the trend of the spread and this is applied to the neutral risk-free rate to estimate long-term mortgage rates. The 5-year mortgage rate is used for the short-term debt rate.

For term deposit rates, the long-term rate is estimated using a similar approach. The filtered spread between six-month term deposit rates and six-month swap rates are applied to neutral risk-free rates. For the short-term rates, a five-year term deposit rates is constructed using six-month term deposit rates and an assumed forward path of term deposit rates towards neutral term deposit rates.[9]

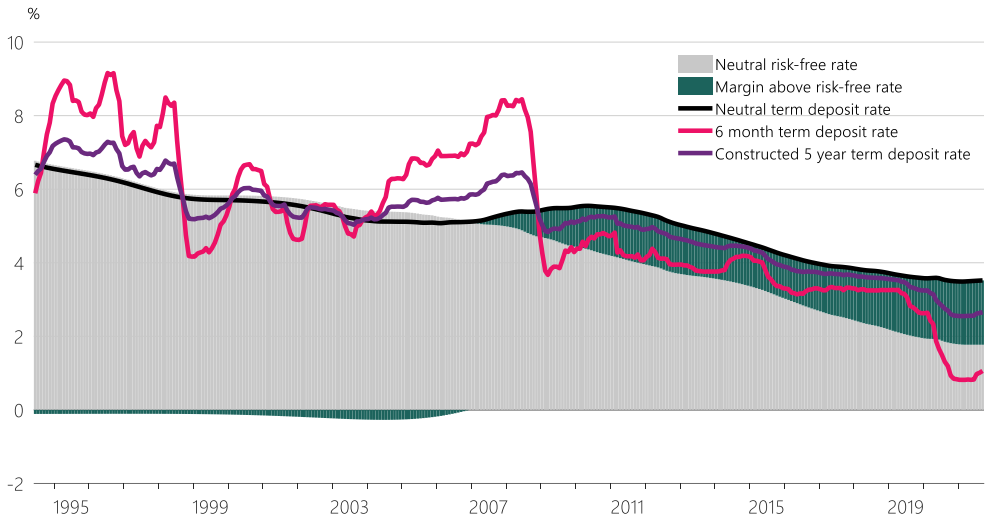
Figure A2 Neutral mortgage rate estimates



Source: Interest.co.nz, RBNZ *Standard statistical return survey*, RBNZ estimates, author's calculations

8 The 33 percent tax rate is assumed from 2020 onwards, instead of the top marginal tax rate of 39 percent, for investors and owner-occupiers.
9 This forward path assumes a linear increase in six-month term deposits towards the neutral term-deposit rate over three years, and then the neutral term-deposit rate over the next two years.

Figure A3: Neutral term-deposit rate estimates



Source: Interest.co.nz, RBNZ *Standard statistical return survey,* RBNZ estimates, author's calculations

The risk-premium is calibrated by minimising the error terms between model outputs and actual house prices from June 1994 to December 2004 and January 2013 to September 2021. For households this risk-premium is 1.20 percent, and for investors it is 1.52 percent. Observations between 2005 and 2012 are excluded as this includes a period where house prices are assumed to be unsustainable. An alternative calibration below includes all observations.

Model Estimates

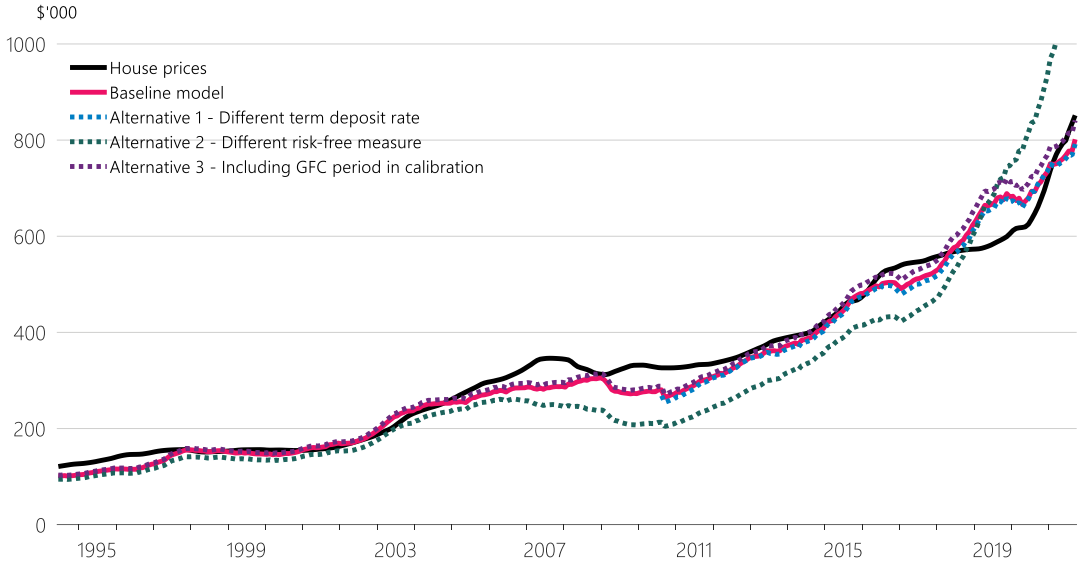
Alongside the baseline calibration described above, a range of alternative calibration approaches are shown for the *asset price* model for investors below. The first alternative uses a 5-year constructed term deposit rate based on the forward path of market-implied swap rates, which is available back to 2011. This shows very little difference from the baseline calibration, suggesting that the model is robust to assumptions around the short-term term deposit rate.

The second alternative calibration uses a neutral risk-free rate based on derived 5-year forward 5-year government bond rates (filtered through a Hodrick-Prescott). This model is much more sensitive, and suggests that house prices were significantly overvalued for over ten years and are now significantly undervalued. This is likely due to the influence of market factors, and recently quantitative easing, on long-term government bond rates. The periods of significant over- and under-valuation suggest that this model is not appropriate for estimating prices over the past 20 years. The baseline model uses the neutral OCR for the neutral risk-free rate from 2003 onwards instead.

The third alternative calibrates the model includes observations between 2005 and 2012 when estimating the risk premium. This results in a slightly higher estimate of house prices. However, it still suggests that house prices around the GFC were unsustainable.

The baseline model is the preferred calibration as it provides estimates over a long period, produces results that broadly align with actual prices over the past 30 years, and are not biased by the period of overvaluation around the GFC.

Figure A4: Model outputs for baseline and alternative calibrations



Source: QV, author's estimates

Table A2: Key data sources

Input / variable	Data source
Rent	To control for changes in the quality of rental properties associated with changing home ownership, house prices and rents are derived from index changes. Rent measures uses the Rental Price Index flow measure prior to 2006, and a composite index constructed from the MBIE geometric mean rent (seasonally adjusted) and Consumer Price Index measures for rent. The composite measure places weightings on the MBIE geometric mean rent and the Consumer Price Index rent to match the Rental Price Index measure from 2006 to 2021. The rent index is based to the December 2006 MBIE geometric mean rent.
House prices	House prices are the QV quarterly house price index, based to the median house price in January 2006. For the last three months, where the data is not available, prices are derived using the REINZ monthly house price index.
Median income	Median income is based on Statistics New Zealand's *Linked Employer-Employee Data*. Where data is unavailable, the change in total gross earnings is used to estimate forward median incomes.
Neutral risk-free rate	The neutral risk free rate is derived from the Reserve Bank mean estimates of the neutral OCR from 2003. Prior to 2003, the change in the trend of the five-year forward five-year government bond rate is used to estimate back the risk-free rate to 1990. The trend in the five-year forward five-year government bond rate is derived using a Hodrick-Prescott filter
Long-term inflation expectations	Long-term inflation expectations uses the Aon Hewitt seven-year CPI inflation expectations measure from 1993 to 2017, and then the Reserve Bank survey of ten-year inflation expectations for businesses.
Short-term inflation expectations	Short-term inflation expectations are estimates from the RBNZ inflation expectations curve for the next five years, based on surveys of businesses and professional forecasters.

References

Gordon, M. (1962), The investment, financing, and valuation of the corporation. The Review of Economics and Statistics, 44(1), 37-51.

Hargreaves, D. (2008). The tax system and housing demand in New Zealand. Reserve Bank of New Zealand Discussion Paper Series, No. 06.

Miles, D., & Monro, V. (2019). UK house prices and three decades of decline in the risk-free real interest rate. Bank of England Staff Working Paper, No. 837.

O'Donovan, B., & Stephens, D. (2009). Tax and house prices. Westpac Institutional Bank.

Poterba, J. M. (1984). Tax Subsidies to Owner-Occupied Housing:An Asset-Market Approach. The Quarterly Journal of Economics, 99(4), 729-752.