



**CoreLogic**

# CoreLogic New Zealand Residential Property Index Series

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# Overview

The CoreLogic New Zealand Residential Property Index Series is designed to provide a reliable and consistent benchmark for the New Zealand residential real estate market. The market includes residential properties and is defined as houses, flats, apartments, lifestyle, and land.

The hedonic imputation approach (based on hedonic regression) to calculate residential property value indices is the preferred method for compiling a constant quality dwelling value index in New Zealand. Hedonic regression is a statistical technique that measures the relationship between the values of residential real estate and the observed values of its characteristics, for example, attributes encompassing its geographic location and property features, such as number of bedrooms and bathrooms, etc. [1]. The hedonic imputation index model essentially estimates the value of every property each week, using the coefficients derived using hedonic regression, and describes the movements in the value of the residential real estate portfolio.

The hedonic imputation model operated by CoreLogic utilises comprehensive information on the attributes and characteristics of residential properties to measure quality-adjusted changes in property values over time and impute the value of all dwellings based on observed characteristics. The hedonic imputation method has the advantage of controlling for compositional bias that may exist in other indices (for example, in a median sales index) [2]. The hedonic index model is trained using an exponential weighting scheme with a 360-day decay period. Weighting the regression allows the model to impute more timely valuation estimates. The index is further enhanced by revising the most recent 12 months of growth in a rolling window as new sales and listing data become available. This improves the historical accuracy of the index backseries and reduces index drift.

In addition to the hedonic index series, a set of additional indices, including stratified median, SPAR and repeat sales indices, are produced. Accompanying metrics such as rolling mean and median of various periods are also available.

In order to establish a summary of best practices for house price index calculation, the Statistical Office of the European Union (Eurostat) coordinated in 2013 the development of the Residential Property Price Indices Handbook [1]. The handbook proposes a comprehensive presentation and analysis of the methodologies to date and has been widely used as a reference document by financial institutions and legislators [3, 4, 5]. While more recent reviews expand on index construction [6], they do not revolutionise best practices, so the Eurostat paper remains the most comprehensive overview of index methodologies. A similar study by the Reserve Bank of New Zealand (RBNZ) [14] also echoes the advantages of the Hedonic method, where high-quality data and sufficient processing power are available. CoreLogic New Zealand has adhered to its guidelines when

implementing indices methods appropriate to the New Zealand market while introducing improvements wherever possible.

## 1. Index Series

The CoreLogic New Zealand hedonic Index provided six different levels of geographical area: country, region, territorial authority (TA), suburb (and locality), postcode, and major city. This geographical division is based on information available on StatsNZ, and is consistent with the existing New Zealand Market Trends product (introduced in 2023), and can be cross-referenced. Each index can be subcategorised according to any region and property attribute combination, and additional subindices can be generated at request.

A broad suite of indices is produced for listings, sales, and rents using different methodologies, such as simple tiered median, repeat observation, and hedonic imputation. Table 1 summarises the indices produced.

| Index Method       | Index Name                                | Dataset |       |          |             |
|--------------------|---|---------|-------|----------|-------------|
|                    |   | Sales   | Rents | Listings | Properties* |
| Hedonic            | Hedonic Index (sales)                     |         |       |          | ✓           |
|                    | Hedonic Index (asking price)              |         |       |          | ✓           |
|                    | Hedonic Index (rents)                     |         |       |          | ✓           |
|                    | Tiered High/Mid/Low Hedonic Index (sales) |         |       |          | ✓           |
|                    | Rental Yield (rent-to-sales)              |         |       |          | ✓           |
|                    | Rental Yield (rent-to-asking price)       |         |       |          | ✓           |
|                    | Total Return (sales plus rents)           |         |       |          | ✓           |
|                    | Deciles Hedonic Index (sales)             |         |       |          | ✓           |
| Stratified Median  | Stratified Median Index                   | ✓       | ✓     | ✓        |             |
| Repeat Observation | Repeat Sales Index                        | ✓       |       |          |             |
|                    | Repeat Rents Index                        |         | ✓     |          |             |
| Median             | 1 Month Median Index                      | ✓       | ✓     | ✓        |             |
|                    | 3 Month Rolling Median Index              | ✓       | ✓     | ✓        |             |
|                    | 6 Month Rolling Median Index              | ✓       | ✓     | ✓        |             |
|                    | 12 Month Rolling Median Index             | ✓       | ✓     | ✓        |             |
| Mean               | 1 Month Mean Index                        | ✓       | ✓     | ✓        |             |
|                    | 3 Month Rolling Mean Index                | ✓       | ✓     | ✓        |             |
|                    | 6 Month Rolling Mean Index                | ✓       | ✓     | ✓        |             |
|                    | 12 Month Rolling Mean Index               | ✓       | ✓     | ✓        |             |

\* Properties here meaning that the indices are based on value imputations of the properties

## 2. Index Maintenance

### 2.1. Weekly Valuation

Residential property value indices and accumulation (total return) indices based on the hedonic imputation method are calculated weekly. The property value indices measure the weekly movement in imputed values. The accumulation index series measures the weekly movements in residential property values with the full reinvestment of rental income (also calculated based on the hedonic imputation method). Weekly results are never directly revised; however, when the month-end results are revised, weekly results are normalised to keep the weekly and monthly indices in line. This process involves distributing the delta between the original month-end result and the revised result evenly across each day of the month. This way, intra-month trends are broadly preserved while all reported indices are maintained uniformly.

### 2.2. Selection Rules

All properties known to exist on the index date will be eligible to be included in the index from the initial month after the property was added to the CoreLogic database. CoreLogic defines a total of five property types, and they are based on property categories issued by the District Valuation Roll (DVR). More details of CoreLogic property types will be discussed in section 3.3.

### 2.3. Base Date

All CoreLogic New Zealand Hedonic Indices have a baseline value of 100 as of 31/01/2018. The starting date for all hedonic indices is also set at 31/01/2018. However, based on data availability, this will vary greatly for different series and geographies.

### 2.4. Index Rebalancing

The portfolio is rebalanced monthly to account for the addition or removal of stock from the residential property portfolio over the preceding month. Changes in property attributes (for example, a change in the recorded number of bedrooms for a property) are handled by fixing attributes such as those most recently observed at that index date when calculating growth between two periods. This ensures that value estimates imputed at each time are treated as having the same attributes, eliminating bias in growth estimates due to changes in the underlying properties. In cases where a property cannot be valued using the hedonic imputation method, for example, if there are no relevant observed sales during the period, it will be removed from the index until a value can be imputed from the arrival of new sales data.

## 2.5. Eligibility Factors

CoreLogic maintains comprehensive property and attributes datasets, populated via sales and listings time-series data. Sales data includes recent sales data from real estate agencies and confirmed sales data from the District Valuation Roll (DVR). In combination, CoreLogic is able to support an accurate property dataset backed up by timely and comprehensive attributes, sales, and listing histories. Due to these rich datasets, CoreLogic can use hedonic regression, a data-intensive method, to produce a compositionally adjusted hedonic index that runs in real-time.

The entire known residential property dataset is used as the population for the index model for a given index run date. Similarly, all sales and listings are used. Appropriate filters are in place for incomplete records, missing values and extreme values.

## 2.6. Data Assumptions and Limitations

There are some limitations with the data available for the production of a hedonic index

1. Data quality issues can reasonably be expected in property databases, as the data is derived from various sources and in different formats.
2. Whilst sophisticated techniques exist to ensure that addresses can be matched across multiple data sources, it is recognised that errors can arise.
3. There is no completely reliable point-in-time property type identifier. Therefore, there may be instances where it is not possible to tell when a property identifier changed, for example, when a house was built on vacant land. This is sometimes possible through the known sale data obtained from the DVR but is not always reliable.
4. The population of properties and their attributes is expected to change from one day to the next, either due to data quality improvements or the arrival of new data on sales and listings.

## 2.7. Index Revision

Despite the timeliness of the datasets, transactions will inevitably be ingested after the monthly index growth rates are published. As a result, the index can be retrospectively improved by recalculating index growth once coverage of transactions has increased. To capture this increased breadth of historical data, the last 12 months of the index will be routinely revised. This ensures the index can be reported in real time while maintaining the most accurate possible backseries. A revisionary index process also means that changes in data can be addressed in the underlying dataset and erased from the index as they are identified.

## 3. Index Construction

The CoreLogic New Zealand hedonic index is specifically designed to track weekly value changes in the residential property market [2]. It is a constant quality value index for the stock of residential housing at a particular time.

Repeat observation and stratified median methodologies are also available as part of the indices suite. Further comparable metrics, such as several simple median and mean metrics complementing the more complex methodologies, are also available.

The steps taken in calculating the hedonic index are:

1. Obtain historical sales over the preceding 360 days;
2. Apply filters and obtain attributes and variables to estimate value function;
3. Estimate value function;
4. Apply value function estimate to the population of properties in the valuation portfolio;
5. Identify the composition adjusted portfolio;
6. Calculate the index.

The hedonic regression coefficients are calculated at the TA level, but index metrics are produced at geographic levels specified in Section (1).

### 3.1. Data Cleaning and Standardisation

CoreLogic applies conventional data cleansing and maintenance techniques to standardise property data to produce robust model results. Common methods include:

1. Select overlapping attributes from sources with greater established expertise and credibility
2. Select an analogous substitute when attribute values are missing
3. Identify a low-risk method to impute missing attribute values
4. Simplify attributes with high dimensionality using mathematical techniques, such as k-means clustering

Specific data cleansing and maintenance rules are applied to sales and listing data, ensuring the provision of quality data in the model training process.

## 3.2. Outlier Detection

Outlier detection is divided into two parts, including input data outlier detection and property estimated value outlier detection. But their principles are almost the same.

1. Outlier filter conditions for absolute values:

For sales data, the sales price must be greater than \$1,000 and less than \$100,000,000; For rental listing data, the rental price per week must be greater than \$30 and less than \$5,000. These filters are consistent with the NZ Market Trends product.

2. Percentage filter conditions:

For each TA area with a sales/listing volume greater than 50 in the past year and each region with a sales/listing volume greater than 100, we remove the lowest 2.5% of sales/listing in the area and remove the highest 2.5% of sales/listing in the area.

3. Output data outlier detection:

We use the above two methods to detect outliers for each property's estimated sales and rental price. We also took the same approach in Australia to ensure that for each property, the growth rate between last month's and this month's valuations was not too high.

## 3.3. Segmentation

### 3.3.1. Region Segmentation

The training process is segmented geographically at the TA and region levels using geolocation information sourced from DVR and LINZ, and the index results are produced at country, region, TA, major cities, suburb, and postcode level.

Properties with valid TA or region information are excluded from the process, CoreLogic also applies the following custom definitions:

For region level, we combine the Tasman, Nelson, and Marlborough regions into one region called Tasman Nelson Marlborough.

Major cities in CoreLogic definition are metropolitan areas that consist of one or more TAs:

| Major City Name   | TAs  |
|-------------------|--|
| Auckland          | Rodney(TA004), North Shore(TA005), Waitakere(TA006), City(TA007), Manukau(TA008), Papakura(TA009), and Franklin(TA010) |
| Wellington        | Porirua City(TA044), Upper Hutt City(TA045), Lower Hutt City(TA046), Wellington City(TA047)                            |
| Dunedin           | Dunedin City(TA071)  |
| Christchurch City | Christchurch City(TA060)   |
| Hamilton          | Hamilton City(TA016)   |



### 3.3.2. Property Type Segmentation

CoreLogic defines a total of five property types: houses, flats, apartments, lifestyles, and land. They are developed based on the Property Category defined in the Rating Valuations Rule published by LINZ. All five property types are used in the Hedonic model training process.

Only variables relevant to the property type are used in model training. Some TA's or regions may have insufficient sale data for Apartment and Lifestyle property types, and to overcome the limitation, we apply the following rules to combine multiple property types for model training in those areas:

1. If the past year's apartment sales volume is less than 200, train the regression using a combination of apartments and flats sales.
2. If the past year's lifestyle sales volume is less than 200, train the regression using a combination of lifestyles and house sales.

CoreLogic generates a hedonic index for each of the five property types. We also generate a combined total index incorporating all property types, except land.

### 3.4. Hedonic Imputation Index

There is no uniformity in the application of hedonic regression, and it can suffer from omitted variable bias if an important hedonic attribute is missing. As long as sufficient data is available for all hedonic attributes, the hedonic imputation method is generally the best technique for constructing a constant quality residential property value index [14].

The hedonic index requires that all properties' actual prices are known to calculate the movement in values. However, in each period, not all properties are sold. Therefore, their values must be imputed based on sales observed for a given geographic level, property type and period. The hedonic imputation method estimates the values (or listed values in the case of sales listing and rental indices) of all properties for each period. If the value of property  $i$  cannot be imputed; for example, if there aren't enough sales in the geographic level for that period, the value of property  $i$  is imputed from the sample based on the higher geographic level wherever possible. In such a case, transaction data from the Region level would be used to impute the values of properties that could not be established using only TA transaction data.

The hedonic regression formula is shown in Equation (1). It gives the least squares estimate of the log price (or asking rental price in the case of the rental index) of a property at a particular time, conditional on the information available and controlling for its most statistically significant observable attributes [8]. Listings data are used to calculate equivalent rental and accumulation indices but not in sale price indices. In the case of the rental index, sales are substituted by rental asking prices found in the listing data.

$$\ln P_i^t = C_0^t + \sum_{k=1}^K C_k^t X_{ik}^t + \varepsilon_i^t \quad (1)$$

where:

$P_i^t$  = sale price (or listing price) of property  $i$  ( $i = 1$  to  $N^t$ ) in period  $t$

$X_{ik}^t$  = transformation of the hedonic variable  $k$  for property  $i$  in period  $t$

$C_0^t$  to  $C_k$  = numerical coefficients to be estimated

$\varepsilon_i^t$  = (zero mean) residual error term for property  $i$  in period  $t$

The calculation of the hedonic index value is shown in Equation (2). The hedonic index is market value weighted and adjusts as new properties enter or exit the portfolio, reflecting when properties were constructed, demolished or added to the residential database. In the case of a weekly index, the rebalancing is performed weekly to reflect changes in the level of property stock. All properties are revalued for the previous index date. This technique ensures that the population of properties (and their attributes) of properties are consistent between two consecutive index dates and that the effect of time only is captured in the index. When valuing both the current and prior month, the attributes are fixed as those observed for the more recent month; this formulation is known as a Paasche index. This index is revised every month for the 12 months following release routinely.

$$I_{IMP}^t = I_{IMP}^t \times \frac{\sum_{i=1}^{N^t} \hat{P}_i^t}{\sum_{i=1}^{N^t} \hat{P}_i^t} \quad (2)$$

where:

$I_{IMP}^t$  = sale price (or listing price) imputation index at period  $t$

$I_{IMP}^t$  = sale price (or listing price) imputation index at the index run date prior to period  $t$

$\hat{P}_i^t$  = imputed price (or listing price) of property  $i$  at period  $t$

$\hat{P}_i^t$  = imputed price (or listing price) of property  $i$  at the index run date prior to period  $t$

$N^t$  = number of properties at period  $t$  with valuations possible for period  $t$  and the prior period

### 3.4.1. Variable Selection

We use different hedonic index training formulas for different property types. Each formula contains a slightly different set of attributes. To ensure the rationality of the formula we selected, we adopt the following steps:

1. We calculate the correlation coefficients between all attribute values and sales prices and select attributes with significant correlation into our model.

2. We ensure the selected attributes come from a reliable data source and that ongoing support is assured.
3. We remove attributes that have too little coverage.

The hedonic variables and their transformations are shown in Table 3.

**Table 3. Hedonic variables and their transformations**

| Hedonic Variable     | Description  | Transformation  |
|----------------------|--|---|
| <b>Floor area</b>    | Total floor area in square metres  | Transformed to a log value, it is winsorised at the 5 <sup>th</sup> and 95 <sup>th</sup> percentiles for floor area in the TA area.   |
| <b>Bathrooms</b>     | The most recent recorded bathroom count (including ensuites) at the time of the recorded sale or listing.  | This variable is winsorised at the 5 <sup>th</sup> and 95 <sup>th</sup> percentiles for bathrooms (including ensuites) in the TA area and is represented as a factor.<br>If the bathroom count is smaller than 1 or is null, set it equal to 1. |
| <b>CV percentile</b> | The percentile rank of the CV (capital value) of this property is relative to all other properties of this type within the same TA. The higher the rank, the more expensive the property is compared to all others in the same TA. | No transform  |
| <b>Category</b>      | Category code for the property. Combination of PropertyTypeCode, decade built and construction quality. E.g. RF198B which is a combination of 'RF' (Property type), '198' decade built and 'B' (construction quality).             | For property, only extract the construction quality.<br>For land, only extract the last letter of the property type code.   |
| <b>Car spaces</b>    | The most recent recorded car space count at the time of the recorded sale or listing, or the number of main roof garage if the number of car spaces is zero.   | This variable is winsorised at the 5 <sup>th</sup> and 95 <sup>th</sup> percentiles for car spaces in the TA area and is represented as a factor.<br>If car space is null, set it equal to 0.   |
| <b>Bedrooms</b>      | The most recent recorded bedroom count at the time of the recorded sale or listing.  | This variable is winsorised at the 5 <sup>th</sup> and 95 <sup>th</sup> percentiles for bedrooms in the TA area and is represented as a factor.<br>If bedroom is null, set it equal to 0.   |
| <b>Levels</b>        | No. of levels in the property.   | It is represented as a factor.<br>If the level is larger than 1, set it to 2.<br>If the level is null, set it to 1.   |
| <b>Building site</b> | Total area covered by the property in square meters.   | Transformed to a log value. It is winsorised at the 5 <sup>th</sup> and 95 <sup>th</sup> percentile for building site in the TA area.   |
| <b>Decade built</b>  | The most recently recorded decade built where available.   | It is represented as a factor.<br>If decade built is missing, use the year built to calculate decade built. If it is before 1980 or is null, set it to 1980.  |
| <b>CSI</b>           | Class of Surrounding Improvements from DVR   | It is represented as a factor, including from 1 to 5 levels.<br>If it is null, set it to 3.   |

|                                 |  |   |
|---------------------------------|--|---|
| <b>House type</b>               | AP-Apartment, BN-Bungalow (Post war), CN-Contemporary, CT-Cottage, PB-Pre-war Bungalow, QB-Quality Bungalow, QO-Quality Old, RB-Bach, SB-Spanish Bungalow, SR-State Rental, TC-Terrace Apartments, TH-Townhouse, UN-Unit, VL-Villa | It is represented as a factor. If it is null, set it to Unknown. QB, QO, and CN belong to level 3. BN, TH, PB, VL, UN, RB, SR, and SB belong to level 2. All the others belong to level 1. Details of how to define the group are in section 3.1.1.   |
| <b>Land area</b>                | The total size of the parcel is in square metres.  | Transformed to a log value. It is winsorised at the 5 <sup>th</sup> and 95 <sup>th</sup> percentile for land area in the TA area.   |
| <b>Wall construction</b>        | The most recently recorded description for materials in external walls.  | It is represented as a factor. If it is null, set it to Unknown. "Glass", "Malthoid/Fab", and "Stone" belong to level 3. "Plastic", "Mix.Material", "Solid Stone", "Tile Profile", "Brick Veneer", "Concrete", "Fibre Cement", "Solid Brick", "Weatherboard", "Roughcast,etc", and "Stone Veneer" belong to level 2. All the others belong to level 1.            |
| <b>Apportionment</b>            | Current apportionment codes are used when there are multiple rates assessments for a property - in this case there is 1 parent record and multiple children records.   | It is represented as a factor. If it is 1 or 2, set it to 1, means it is a children record of other property. For other values, set it to 0.  |
| <b>Ownership type</b>           | Type of the Property Ownership   | It is represented as a factor. If the ownership type includes lease, set it as leasehold, otherwise, set it as freehold.  |
| <b>Bedrooms<br/>Bathrooms</b> / | The ratio of the number of bedrooms to bathrooms.  | This variable is binary and indicates whether there are more bathrooms than bedrooms after winsorisation.   |
| <b>Time Fraction</b>            | Period fraction indicating when the property was sold (or listed in the case of the listing or rent indices) within period t.  | The period fraction is shown in the following formula:<br>$F_i^t = \frac{\text{date}(P_i^t) - \text{date}(t_{start})}{\text{date}(t_{end}) - \text{date}(t_{start})}$<br>$\text{date}(P_i^t)$ = date of sale (or listing) of property $i$ in period $t$<br>$\text{date}(t_{start})$ = start date of period $t$<br>$\text{date}(t_{end})$ = end date of period $t$ |

### 3.5. Accumulation Index (total returns)

The accumulation index assumes that daily rental income is reinvested into the hedonic index daily [10]. Transaction, taxation and ownership costs associated with purchasing and owning residential property are not considered (along with individual tax concessions). A gross rental yield is calculated. It is assumed that all properties are rented; therefore, the weekly rental income can be estimated from the hedonic imputation rental model which is based on advertised weekly rents. If the rent of property  $i$  cannot be imputed using the hedonic imputation model, for example if there are no listings in period  $t$ , the rent of property  $i$  is imputed from the hedonic index for the region above. The imputed weekly rents are converted to daily values and reinvested into the weekly house value index (assuming an actual/365 day count convention). In line with the hedonic index it is necessary to ensure that the population of properties (and their attributes) is consistent between consecutive index dates. The accumulation index is shown in Equation (3).

$$I_{TR}^t = I_{TR}^{\hat{t}} \times \sum_{i=1}^{N^t} \frac{\hat{P}_i^t + \hat{R}_i^t}{\hat{P}_i^{\hat{t}}} \quad (3)$$

where:

$I_{TR}^t$  = sale price total return index at period  $t$

$I_{TR}^{\hat{t}}$  = sale price total return index at the index run date prior to period  $t$

$\hat{P}_i^t$  = imputed price (or listing price) of property  $i$  at period  $t$

$\hat{P}_i^{\hat{t}}$  = imputed price (or listing price) of property  $i$  at the index run date prior to period  $t$

$\hat{R}_i^t$  = imputed daily rent of property  $i$  at period  $t$

$N^t$  = number of properties at period  $t$  with valuations possible for period  $t$  and the prior period

### 3.6. Repeat Sales Index

In line with the hedonic indices described previously, the repeat sales index measures the average change in home price in a particular geographic area. Bailey et al. introduced the repeat sales method in 1963, and there are several implementations of the methodology, the best known of which is the S&P CoreLogic Case-Shiller Home Price Index.

The main variable used for index calculation is the price change (sale pair) between two arms-length transactions of the same property [11]. Thus, the repeat sales method aims to capture pure price changes across different time periods but does not control for a change in quality (which can account for a significant part of the variability between two sales of the same property) [12]. A dummy variable regression model is estimated on the pooled data (sales pairs) across the sample period [1]. So, the estimated growth rate in any period is determined by the prices of properties sold in that period and by the prices of

properties for which consecutive transactions occurred on either side of that period [12]. By design, the method is revisionary, and the most recent periods are subject to larger revisions, as the properties that changed hands in a period constitute a relatively small proportion of the total number of sale prices that will eventually affect the index in that period.

If we have a sample of houses that transacted more than once over the sample period  $t = 0, 1, \dots, T$  (with  $0 \leq s < t \leq T$ ), the sales pairs are pooled together and the model is estimated with the standard repeat sales Equation (4).

$$\ln(P_n^t/P_n^s) = \sum_{t=0}^T \gamma^t D_n^t + \mu_n^t \quad (4)$$

where:

$P_n^t$  = Price of property  $n$  at the end of period  $t$

$P_n^s$  = Price of property  $n$  at the end of period  $s$

$D_n^t$  = Dummy variable equals to 1 in the period that the second sale occurs, -1 in the period that the first sale occurs, and 0 otherwise

$\gamma^t$  = Coefficient for period  $t$

$\mu_n^t$  = error term for property  $n$  during period  $t$

Under the classical assumption that the errors have a zero mean and constant variance, the repeat sales formula shown in Equation (4) can be estimated by the OLS regression. The coefficient for each period can be taken to represent the cumulative growth in property prices since the first period. Therefore, the repeat sales index from period 0 to period  $t$  can be obtained by exponentiation of the coefficients  $\gamma^t$  as in Equation (5).

$$P_{RS}^{0t} = \exp(\gamma^t) \quad (5)$$

### 3.7. Stratified Median Index

Stratified median price series are also implemented as part of the CoreLogic New Zealand Residential Property Index Series. Stratification is a process for creating qualitatively similar subsets of dwellings. Unique price series are created for these subsets, which are then aggregated to estimate strata-adjusted price movements in the overall market. The strata definitions used to classify properties into subsets are based on price, geography, and interactions of these variables.

The stratified median for different property types groups statistical regions by their long-term median transaction price within a higher-level statistical region. Sales transfers are grouped by property type, TA area and five-year median price within each transfer's Region area. The TA areas are ranked and grouped by deciles of equal numbers (the first decile may contain more TA areas if an equal number of TA areas cannot be determined

for each decile). The stratified median for a particular region (Region level or above) is the weighted mean of the log return of each strata within that region (weighted by volume of sales).

Stratified medians are simple to calculate and provide the price of the middle-ranking property observed to sell in a given measurement period. Further, rather than selecting the 50th percentile (i.e., the median) from whatever properties are observed to sell over a particular measurement period, other percentiles, such as the 25th or 75th percentile, can equally be selected using the same method to create other percentile series.

The major shortcoming of the median (or any other selected percentile) price series is that they do not represent changes in the value of the residential property market portfolio. Median prices do not track the same properties over time. It is most unlikely that any properties observed selling in one period will be the same as those selling in the next measurement period when examining quarterly or monthly median price series. By way of example, in one period, the median-priced house observed may happen to be a three-bedroom home, and in the next period, it may be a four-bedroom home. Further, in order to provide useful statistics, one needs to aggregate a sufficiently large number of property sales over what can be long periods of time. As such, the publication frequency of the median price series is often limited to quarterly, although CoreLogic does offer a monthly median series (in addition to many other frequencies).

The fact that median or other percentile-based series cannot be used to track changes in the value of a market portfolio does not make them wrong: they simply have different applications than hedonic indices. For example, median price series are useful in answering economic policy questions about housing affordability [13].

## 4. Index Governance

### 4.1. Index audit

In 2017 the consultancy KPMG was engaged to audit the hedonic index (Australia). The purpose of the collaboration was to determine that the implementation of the index was in line with the methodology CoreLogic Australia had retained for the daily index.

In addition to the audit of the implementation, the model was subject to an academic review. The purpose of such an academic review was twofold:

- i. Ensure that the revisionary hedonic imputation model was in line with leading research and industry best practices;
- ii. Establish that the variables (features) used in the model were appropriate as intended in the methodology.

These audits were conducted prior to both weighting the hedonic regression, and revising the hedonic index in a rolling 12 month window. Due to the similarities in methodologies and code base, the Australian audit holds relevance for the NZ Hedonic index production.



## 4.2. Index Announcements

Announcements concerning changes in the indices models will be communicated periodically in line with continuous improvement initiatives.

## 4.3. Recalculation Policy

Beyond the standard 12 months of revision, there may be occasions where the indices need to be recalculated. This may occur when material changes to the historic data set have been implemented or where errors are detected in the base level data or outputs. Any errors that arise will be corrected immediately and the changes reflected in the relevant index. Any significant recalculations will be alerted within the Index Announcements.

## 4.4. Index Dissemination

CoreLogic indices are available via subscription and a number of portals. Please contact CoreLogic for further information.

## 4.5. CoreLogic Model Governance

CoreLogic has a formal governance program in place for all analytic models. The objective of this program is to (1) establish a model risk management policy and governance program over all CoreLogic models; (2) provide guidance to help CoreLogic business units and mitigate risks arising from customer reliance on computer-based models; and (3) define key model development, testing, validation and monitoring processes and best practices. The program is modelled on published Office of the Comptroller of the Currency bulletins, including "Supervisory Guidance on Model Risk Management" (OCC 2011-12) and "Third-Part Relationships" (OCC 2013-29).

The hedonic imputation index method has been reviewed by the CoreLogic Model Governance committee and approved for client use. This committee maintains oversight on all models approved for client use and require regular reviews of these models to ensure continued compliance.

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