Orava Residential REIT – External Audit of Valuation Model

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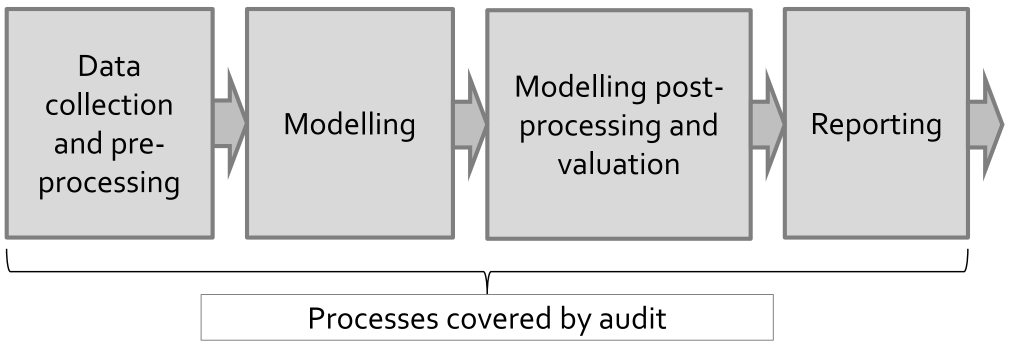
1. The object and contents of the external audit

- Orava Asuntorahasto Oyj, also known as Orava Residential REIT, Orava Rahasto, Orava Funds or Orava, has requested an external audit statement of its automated property valuation models from Realia Management Oy (Realia). There are 123 assets which all are valued with at least one model.
- The purpose of the automated valuation model is to define a market value for the properties owned by Orava. The audit of the model is thus limited to the use of the model for the defining of market value for the aforementioned portfolio at the time of the audit.
- The purpose of the audit is to ascertain independently the true and fair treatment of the data and the results in respect to all parties involved.
- The audit is based on the data and information obtained from Orava and other sources, in part verified against each other. The audit is based on valuation Orava valuation model 2016:06.
- Realia has performed previous external audits, dated 10.6.2012, 16.9.2013, 27.10.2014 and 8.4.2016.
- The audit includes the processes from data collection to result reporting. The following are analysed: the quality of data and other source material; modification and imputing of data; models and their qualities; modelling; and result reporting. The following depicts an approximation of the automated valuation process as followed by Orava Residential REIT.



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2. Regression models in property valuation

- The Orava property valuation model is based on a hedonic multiple linear regression using a transformed log-linear ordinary least squares method.
- The hedonic price model assumes e.g. homogeneity of housing product, market operating under perfect competition and market equilibrium. Although these assumptions involve rough simplifications of reality, the hedonic pricing model is extensively used in housing market research.
- Hedonic modelling using multiple linear regression analysis (MRA) is commonplace and the method is well known and widely applied in the scientific community, as well as outside universities. MRA produces estimates for the individual effects of different housing attributes on prices. As a rule of thumb, in log-linear models, the regression coefficient for a given variable *x* can be interpreted as the expected proportional change in the response variable for unit increase in *x*.
- Log-linear transformation means that the true relationship between dependent and independent variables is assumed multiplicative instead of it being additive. Hence, a non-linear relationship can be modelled using a linear model. Log-linear transformation can also help meeting the data normality requirements posed by the linear regression modelling method.
- Choice of functional form (such as log-linear) is a major empirical problem in hedonic models. Incorrect functional form can lead to inconsistent estimates. Another issue is misspecification of variables, which means that either relevant variables are omitted or irrelevant variables are included in the model.
- MRA makes certain assumptions about the data used in the analysis and the model itself. The credibility and accuracy of the model hinges upon the degree to which these assumptions are met. Most important assumptions are
    - Linear relationship between (possibly transformed) dependent and independent variables.
    - Variables should not show multicollinearity (if one intends to make conclusions from coefficient estimates).
    - Independent, normally distributed error terms.
    - Constant variance of error terms (homoscedasticity).
- Violation of one or more of these assumptions can result in incorrect or misleading outcome of the analysis, although small violations may only have little practical effect. When estimating the quality of the model, much of the effort needs to be directed towards defining the degree and effect of these violations. Hence, in order to justifiable apply MRA, significant level of statistical knowledge is required.
- When using any advanced modelling techniques with real world implications there are often trade-offs between model effectiveness and ease of understanding. Even though MRA makes strong assumptions about the data, it is considered relatively intuitive and it is a standard method in statistics being widely applied and understood. Ease of use reduces the risk of human error in model specification.
- There are many more advanced methods that make fewer assumptions on data and could be used for price estimation instead of MRA. However, these methods, such as artificial neural networks, are more or less of black box nature, which hinders transparency and interpretation of analysis results. MRA results account for each individual variable in the model and come with a rich set of diagnostic tools that help to identify a good or a seriously faulty regression. In the case of Orava, the need for transparency outweighs the benefits that alternative models could provide. Thus, the currently used ordinary least squares MRA model is considered adequate form of modelling.

- The following properties of the model can be considered important in evaluating its performance:
    - Data quality and fit.
    - Statistical significance and unbiasedness of model and its coefficients.
    - Model robustness and lack of structural instability.
    - Validity of other MRA assumptions.
- The above are key properties in establishing the quality of the regression model. Most of them relate at least indirectly to assumptions of multiple linear regression, which highlights the need for thorough understanding of linear regression theory. However, one must also take into account the real world constraints. In real property modelling, the unquantifiable number of variables affecting price formation can prove challenging.
- When the primary use for the model is price estimation, unbiasedness is by far the most important property of the model. A non-biased model would suggest that a sample run for a set of typical properties is likely to achieve a figure, which, on average, is no higher or lower in value than their true price
- Violation of some regression assumptions is more severe than that of some others. For instance, linear dependence is a very strong assumption and linear regression methods cannot capture the true relationship between dependent and independent variables sharing curvilinear relationship. On such occasion, the model coefficient estimates are meaningless. However, even nonlinear dependence over a restricted range can be approximated with a linear model, but problems emerge when one tries to predict values for observations at the edges of (or beyond) the modelling data space. Curvilinear relationships can sometimes be tackled e.g. by variable transformations.
- Another example is heteroscedasticity, which suggests e.g. that there are variables that have not been taken into account or that there may be an underlying misspecification related to functional form of the model. In practice, heteroscedasticity impairs inferences from hypothesis tests while model estimates remain unbiased. Nonetheless most of the problems related to heteroscedasticity are typically seen at the very far reaches of the modelling sets, i.e. in properties with extremely large or small floor area, or properties with exceptional locational attributes.
- If regression residuals do not meet the normality requirement, the usual inference from the model is necessarily not correct. However, for large enough sample size the inference is approximately correct.
- MRA also assumes that data itself is normally distributed. In reality variables are often truncated (e.g. negative values are not possible) and/or skewed. Except for substantial non-normality resulting in outliers, or if there are very few data points, non-normal variables have only little effect on regression.
- Micro-locational aspects are particularly problematic for housing price estimation, while some, such as the size property, are more easily quantifiable. The residuals from hedonic price equations are frequently spatially correlated because models fail to capture many location characteristics, such as proximity to public transportation or schools. Another source of spatial autocorrelation is the fact that neighbourhoods are often developed at the same time, i.e. they share structural characteristics. Spatial autocorrelation results, like many other regression assumption violations, in inefficient model parameter estimates.

3. Automated valuation

- The human intuition and the heuristic ability to weigh in important factors in value formation cannot be overlooked. In addition, while automated models are more likely to consider indications of micro-trends and typical market fluctuations as market evidence for a lasting trend, human intuition is more perceptual to the long-term trend and more likely to attribute weak evidence to a temporary fluctuation in the property cycle.
- The most obvious difference between automated valuation and traditional valuation is in cases of lacking market evidence. Professional valuers are more likely to define market value according to the latest strong market evidence. However, an automated valuation model will typically extrapolate the last known trend even if there is no solid evidence for the continuation of the trend.
- Strength of an automated valuation model is the ability to divide the value into smaller denominators whereby value is created through sums of its parts through hedonic analysis. It is also better at modelling micro-trends that might otherwise go unnoticed.
- Regression analysis requires a functioning market in its typical state. In the event of exogenous events with considerable impact on the market dynamics, for example a severe recession, a traditional valuation is a more suitable method for the defining of market value.
- It is to be noted that the actual, eventual sale price is the market price. However, this market price can be either over- or underpriced compared to the market average. To understand the nature of a market value estimate one should not expect the sales price to be exactly the same as the estimated value as this would be a highly unlikely event due to natural variation in price formation. Therefore, single events of actual sales price evidence cannot be considered a testament to the accuracy of the market value estimate. This is regardless of which specific valuation model or method has been used.
- According to IVS, the definition of market value is the estimated amount for which a property should exchange on the date of valuation between a willing buyer and a willing seller in an arm's-length transaction after proper marketing wherein the parties had each acted knowledgeably, prudently, and without compulsion.
- While both traditional and automated valuation methods are acceptable as long as certain quality criteria are met, they are ultimately alternative views on the same value. Depending on the area under analysis, quality of data and the state of the market, one or the other method may be more accurate. However, as both values are likely to be within acceptable bounds of valuation accuracy, assuming a typical market situation, it is best to take both methods of market value estimation as supporting evidence of true market price.

4. Orava automated valuation model

- As Orava Residential REIT is a holder of assets that can be described as rather typical apartments in relation to the available database, the effect of a relatively small statistical population, possible heterogeneity and the failure in capturing value of potential outliers is somewhat mitigated.
- Due to theoretical and practical challenges in real property modelling and its testing, it is important that a benchmark is used. In the case of Orava Residential REIT, the portfolio is also valued by an independent valuer (Realia, JLL, OPKK) to which the results can be compared, allowing opportunity for the discovery of potential problems.
- The Orava model is a relatively short spanning temporal analysis, a 2-year quarterly based dummy model, where recent data is given sufficient emphasis by default.

Changes since previous audit

- Number of assets has increased from 108 to 123 since last audit.
- Processing of monthly data from Oikotie.fi has been formalized by introducing a detailed automated process to detect anomalies and potential sources of error for further inspection. Typically one fourth of data is examined manually every month by the person responsible for modelling. Processing involves e.g. removal of clearly erroneous observations.
- Division of work within Orava has been adjusted to correspond to the AIFM directive. Responsibilities of valuation work-flow spanning from model development to approval of changes are now more clearly defined.
- An estimate for asset dummy variable has been modelled as a polynomial function of age.
- In addition, some changes have been introduced during the latter half of 2016, but as this audit covers only the valuation model 2016:06, these changes are out of the scope of this audit.

Information on Orava models

- There are 123 assets (defined for the purpose of this audit as combinations of individual apartment assets at a single location) for which value is estimated through modelling. The assets reside in Espoo (8), Forssa (1), Hamina (2), Heinola (2), Helsinki (6), Hyvinkää (3), Hämeenlinna (2), Jyväskylä (5), Järvenpää (3), Kaarina (1), Kerava (2), Kirkkonummi (3), Kokkola (2), Kotka (5), Kuopio (1), Lahti (9), Lempäälä (1), Lohja (2), Mikkeli (1), Naantali (1), Nurmijärvi (2), Oulu (7), Paimio (1), Pori (3), Porvoo (3), Raisio (4), Riihimäki (3), Rovaniemi (6), Salo (1), Savonlinna (3), Sipoo (2), Tampere (6), Tornio (2), Turku (5), Tuusula (1), Vaasa (3), Vantaa (7), Vantaa (1), Varkaus (3).
- There can be more models than there are assets. Some assets with both row house and block of flats apartments are modelled using separate models.
- The models employ ordinary least square linear regression model where the dependent variable has undergone a natural logarithm transformation. The dependent variable is asking price per square meter in all models.
- Independent variables are the following: size in square meters, age, condition, the existence of sauna, time of observation, lot ownership, type of building, approximation of location relative to the primary object of modelling which is based on postal codes and a square kilometre proximity dummy. Asset dummy indicates if observation is from the asset location; own advertisements are removed from the dataset.
- In addition, if single apartments have been sold from the asset location or there is a sales transaction for the apartment being valued, these are included as sales evidence adjusted by the prevailing bargaining range estimate. In practice, transactions are incorporated through asset and apartment dummies.
- The models use asking price data from which an average asking price estimate can be formed.

- Asking price estimate is corrected in post-processing by a bargaining range estimate. This results in a sales price estimate.

Data collection

- Orava Fund has an agreement with Oikotie.fi for data sourcing. The data consist of information for creating real property display ads on Oikotie.fi, filled in by respective property owners or agents.
- The data is downloaded directly from Oikotie.fi once per hour and entered into a database. A dump file is created and downloaded from the database, which is then filtered for the latest month and analysed locally.
- In addition, other sources of data are used to support the quality of available market information. Geocoding information is sourced from Oikotie.fi, and various sources are used to gather sales transaction information and these are included in the modelling as evidence after correcting for the bargaining range estimated (see sections Post-processing / Bargaining range considerations).
- It is possible to automate the data acquisition to remove many of the outliers and data entries with missing information. However, with the data available to Orava, this would lead to a severely truncated dataset with diminished regressional properties. For a sufficiently comprehensive dataset, data entries with missing information need to be imputed requiring additional labour and creating a potential source of bias.
- There is little user discretion in data acquirement process. The process steps of data acquirement have been observed and the quality of the data affirmed by Realia on the computer owned by a member of the Orava organisation in 2012. No discrepancies have been detected in regards to data collection, and the methodology has remained unchanged.

Data pre-processing

- Unrepresentative data is stripped by setting bounds for acceptable values that observations may have, and thus obvious outliers are identified and removed. Each new observation is analysed manually for possible erroneous or missing parameters. Municipal regulated Hitas-properties are removed from the dataset.
- In pre-processing the data, majority of incomplete data is imputed when feasible. This is done with all modelled areas, but paying special attention to areas where observations are scarce. As imputing data is a somewhat arbitrary process and there is a possibility that this would introduce bias if not done with the utmost care. However, for the purpose of a functioning valuation model, imputing is preferable over using a smaller, potentially less representative dataset.
- For imputing missing data, the primary source for the missing inputs are previous validated observations from the same location/building. For the rest of the missing values further information is collected manually using various online services.
- In the source data, building year variable requires careful consideration as it is used ambiguously, referring to building year, renovation year or extension completion year.
- Dummy creation is done according to strict inclusion rule set, which is adhered to throughout the AVM creation process.
- In model valuation of multitenant apartment blocks (multi-storey), only data for multi-storey is used. Should the property under valuation be of any other type, terraced house, semidetached house and detached house data are added to the dataset.

Observed issues

- Even though duplicate ads are removed from the dataset based on ad-id, there may be multiple listings of the same apartment in the dataset. The problem concerns especially new-built apartments that occasionally have several brokers, and thus several ads on Oikotie.fi. These observations are not removed and thus those properties that are typically overpriced and possibly re-listed will be overemphasised. The problem of multiple listing is due to dual challenges of labour intensity and the identification problem; it can be hard to specify whether a re-listed apartment is in fact the same apartment. The inclusion of multiple-listed properties can introduce a bias towards a higher level of modelled asking price compared to the true asking price of the modelling population. The effect of the bias is mitigated by employing the bargaining range adjustment in the post-processing phase.
- Geocoding information from Oikotie.fi can be faulty, although on average it is of good quality. Especially for new-built houses the locational error is in some cases observed to be several kilometres. The issue has been taken into account by introducing decision rules for dropping clearly erroneous observations. However, it is virtually impossible to detect only slightly incorrect data records with locational bias of, say, a couple hundred meters. Thus models capability to deal with micro-locational aspects is diminished to some extent.
- The observing of the process covers data acquisition, data quality checking, imputation of missing data, removal of potential outliers, and finally data entry into the regression. The observation was done to the extent whereby it is possible to ascertain the quality, fairness and objectivity of practices. In particular, special attention was directed to areas where arbitrary measures can be taken.

5. Model and parameter analysis

- A rich set of diagnostic tests were conducted on all the models in order to reveal possible sources of problems and uncertainties. More important than finding poor performing individual models is to detect systematic problems related to model specification. By means of sensitivity analysis it is possible to quantify the expected variation in estimated asset values.

Analysis of models

- A major concern and a source of bias is the available dataset that may or may not be representative of the whole market that the model covers. This issue relates in particular to assets in smaller municipalities where there is a frequent shortage of observations.
- As a rule of thumb, 10-20 observations are needed for each independent variable in linear regression model. Depending on the number of e.g. zip-code dummies, Orava models can have up to 100 variables. Thus, in most cases, approximately 1000 observations are needed so that dataset could be considered sufficient. Most assets reside in bigger municipalities where there is no lack of observations, but several models fall short of this requirement. Dimension reduction techniques, such as Principal Components Analysis, would potentially reduce the need for observations, but regression coefficients would become hard to interpret.
- Besides occasional lack of observations, several datasets contain a significant amount of influential data records and outliers. Influential observations combine discrepancy and high leverage on regression coefficients, and can unduly influence the results of the analysis by distorting the regression surface. Problematic data should not be ignored, but they also should not be automatically deleted. A way to cope with influential observations would be to abandon least-squares estimation in favour of robust estimation, i.e. using for instance least absolute deviations instead of least squares or relying on parametric alternatives.
- Generally, with only a few exceptions, the coefficients of determination (R^2) are on a good level (average 0.82 with standard deviation 0.10), which indicates that data fits the statistical models reasonably well.
- Models' ability to predict unforeseen data was investigated with *k*-fold cross-validation. Those models with possibly too few observations exhibited difficulties to deal with data heterogeneities, whereas larger datasets were clearly better representatives of the market.
- Some models showed signs of structural instability, meaning that model coefficients had different values (in the sense of statistical significance) when the model was estimated using only a portion of the data. This kind of behaviour could not be fully attributed to size of the dataset, and additional explanation to such behaviour could be increased multicollinearity between variables due to data restriction.
- There are no concerns regarding the linearity assumption of the modelling method. Practically all partial residuals behave nicely, thanks to cubic transformations of continuous variables (age and size) and the fact that rest of the independent variables are included as binary dummies.
- Model residuals are not normally distributed, but the big enough number of observations should guarantee that there is little practical effect from non-normality.
- There is strong evidence of some degree of heteroskedasticity in approximately one third of the models. This is a typical feature of log-linear OLS in real estate regressions. The effect of heteroskedasticity appears to be largely contained, but nevertheless remains an additional source of uncertainty.
- There is evidence of a considerable amount of multicollinearity in multiple models, usually with lat-lon dummies and to a lesser degree with other variables. Whilst high levels of multicollinearity may affect the stability of the model to an unknown degree, typically the effect can be considered

non-consequential when the model's sole use is to analyse the dependent variable, in this case price per area.

- Spatial autocorrelation of regression residuals is present in all models. Thus regression parameter estimates are most likely inefficient and their confidence intervals are inaccurate. Nevertheless, parameter estimates remain unbiased. Existence of spatial autocorrelation usually suggests that some predictors are missing from the model. On the other hand, many variables that affect prices are either not available or are virtually impossible to acquire (public transport, recreational possibilities etc.). Another option to account for residual spatial autocorrelation would be to model it explicitly and include it in the linear model.

Analysis of the independent variables

- Model coefficient parameters are analysed. Significance of model coefficients can be tested with null hypothesis that the coefficient is zero, i.e. it has no effect. A low p-value indicates that null hypothesis can be rejected. Typically, p-values ranging 0.05 to 0.20 are considered threshold values below which the coefficient should be for it to be considered non-zero with a sufficient probability. If the value of the parameter has been established in previous models, a high p-value does not directly indicate a non-optimised model. Rather, for the given observations, the coefficient may indeed be close to zero – a useful information on its own – or the unexplained variance may not allow for the successful extraction of weak hedonic signals.
- Recall that many violations of regression assumptions affect coefficient p-values and thus hinder statistical inference.
- Size variable: the variable is significant in all but a few models. This suggests that the size parameter has a strong effect on price formation. There is some multicollinearity present in all models due to the cubic transformation and/or locational dummies. This may cause increased model instability to a small degree.
- Age variable: a cubic transformation has been performed. In most models, at least one of the age variables was significant. Furthermore, in many models all of the age variables, including the polynomial transformation pairs, were significant. There is multicollinearity present between the variables due to the cubic transformation.
- Condition variable: parameters are generally significant and helpful in determining the price estimation. There are some unexpected signs indicating a problem with input in the dataset or the variable is capturing value from an unidentified or unintended source. Also, in some cases the condition variable coefficient estimates do not increase consistently from bad to better. However, the effect on the price formation is typically quite small. In modelling, unexpected but non-significant coefficients can be zeroed without repercussions.
- Sauna variable: In most models, the parameter is significant. Typically, a slight positive coefficient is expected. In some models, the coefficient is negative or non-significant, but more problematically, in some models the positive coefficient is considerably high (over 0.2). In these cases, the sauna dummy can be considered a proxy to apartment's amenities and condition as better outfitted apartments often correlate with the inclusion of a sauna and newer apartments are more likely to have a sauna than older ones.
- Time-variables: the significance is largely dependent on two factors. First is the amount of observations, second is the amount of change in value along the passing of time. The low significance should not be an issue; rather, it is the result of natural price variation in a relatively stable market.
- Latitude and Longitude variable: in many models these two dummy variables were insignificant but with somewhat large coefficient estimates with opposite signs. The two variables span a 1 or 4 km^2 area around the modelled asset and attempt to capture the price level in the proximity of the asset. Relative position within the spanned area is treated linearly,

which makes the model essentially a discrete geographically weighted model.

- Area-variable: due to the possible homogeneity of the postal codes when compared against each other, heterogeneity within the areas, and a small number of observations in respective areas, it is expected that not all area variables pass the significance test.
- Lot ownership: lot ownership has been added to the model to improve value formation due to the ownership status of the lot. In some models, this dummy has been dropped according to pre-set inclusion specification limit of 15 observations and negative sign assumption.
- Sales variables: The use of asset and apartment dummies has proven to be ultimately a good guide towards more accurate pricing. Issues with the use of these dummies may arise when there are only a few sales observations as individual observations may end up having a considerable weight in the model. This is to say that should the observation be clearly under-/overvalued compared to the market average, it will also have a clear impact on the valuation of the asset.
- There is a possibility that sales variables inadvertently capture value that relates to the bargaining range, i.e. difference between actual sales price and asking price that has not been taken into account through bargaining range estimation. As it is not at the discretion of the modeller (Orava) to choose arbitrarily these observations due to reasons of transparency, these kinds of temporary value fluctuations are a regrettable feature of the models. As more sales data are included, these over-/undervalued instances will be gradually averaged out, bringing the model result closer to a market average value.

Sensitivity analysis

- For the purposes of sensitivity analysis, it is identified that the model results are most sensitive to the number of observations, and here we consider the effects of individual observations on the price function formation. The sensitivity analysis is performed by sampling a new dataset from the original one with only two thirds of the observations of the whole dataset. The randomly sampled dataset is used to fit a new model. This procedure is repeated a hundred times and subsequent analysis is made.
- The sensitivity analysis has two purposes: one, it is an estimation of variance due to dataset restriction. Should the model price estimate vary considerably, this is usually a sign of the model being very susceptible to a lack of observational data. Second, the restricted runs provide and estimation of inherent biasness of the model. Should the average estimation value of the runs amount to other than the run of the whole dataset, there is a possibility of a misspecification that is susceptible to the extent of available data.
- Starting from the previous audit, sensitivity runs have been produced using a slightly different method in comparison to audits performed in 2014, 2013 and 2012 and thus the results of this and earlier audits are not directly comparable with each other.
- The sensitivity analysis results table is presented below. The table compares asset valuations with a restricted dataset to that of a full dataset, and includes average difference, maximum/minimum differences along with 20th and 80th percentile differences.
- 25 individual assets were randomly selected and their detailed results are presented in the table. In addition, average values for the whole portfolio are included.
- Some of the models show a possible slight bias based on data selection. Due to data attrition, variance of the modelling run was particularly evident in areas with an already constrained dataset. What is notable,

however, is that by averaging over all hundred iterations, the figure is in most cases very close to that of the full set. Furthermore, on portfolio level non-biasness is practically achieved, as potential negative and positive biases will in part cancel each other out. Thus sample restriction biasness appears to be dataset specific, not inherent to the model, and having a negligible total effect on the portfolio.

- While as a whole, the area data can be considered sufficiently extensive at the moment, the sensitivity nevertheless proves that the model is suffering from an inherent high sensitivity to the number of observation and lies close to the minimum observation boundary. Should the data quality be compromised, i.e. by a reduction of samples, the dataset must be supplemented with additional sources, or the data span of the model should be extended from the current 2 years. On a portfolio level, small changes in the extent of the data can be considered to have an acceptable impact on the quality of the valuation model.

Asset	d(20th perc.)	d(80th perc.)	d(min)	d(max)	d(avg)
Haminan Kaivopuisto	-0.9 %	7.4 %	-7.4 %	15.8 %	3.5 %
Helsingin Koirasaarentie 1	-0.8 %	0.4 %	-4.0 %	2.0 %	-0.2 %
Helsingin Werner	-4.1 %	0.1 %	-5.0 %	0.6 %	-1.6 %
Vantaan Rasinrinne 13	-1.5 %	1.3 %	-3.8 %	4.9 %	0.0 %
Hyvinkään Ryijy	-31.2 %	0.7 %	-34.6 %	3.0 %	-10.0 %
Hyvinkään Ukko-Pekka	-9.7 %	-2.3 %	-14.6 %	4.5 %	-5.7 %
Hämeenlinnan Tervapadankatu 1	-1.7 %	1.3 %	-4.0 %	3.7 %	0.0 %
Kotkan Mällinkatu 6	-3.6 %	4.2 %	-13.0 %	13.0 %	0.1 %
Lahden Vuoksenkatu 4	-0.9 %	0.9 %	-2.0 %	3.0 %	0.0 %
Oulun Alppilan Iiris	-5.3 %	-1.0 %	-9.1 %	2.4 %	-3.4 %
Oulun Jatulinmetsä	-3.4 %	7.9 %	-13.9 %	9.4 %	1.3 %
Porin Pihlavankangas	-2.7 %	2.8 %	-8.0 %	7.1 %	-0.1 %
Porin Huvitus	-2.0 %	0.6 %	-4.4 %	2.8 %	-0.7 %
Porvoon Kaivopolku	-1.8 %	0.9 %	-5.9 %	4.8 %	-0.4 %
Riihimäen Laidunaho	-4.4 %	0.4 %	-11.2 %	4.7 %	-2.0 %
Riihimäen Lovisa	-2.9 %	1.7 %	-20.9 %	6.1 %	-1.6 %
Rovaniemen Laura	-0.5 %	11.4 %	-4.7 %	28.4 %	5.9 %
Rovaniemen Koivula	-3.5 %	1.9 %	-7.8 %	9.4 %	-0.7 %
Savonlinnan Kotipelto	-8.8 %	-1.8 %	-14.0 %	6.4 %	-5.5 %
Savonlinnan Välimäentie 5-7	-3.1 %	3.0 %	-11.0 %	9.5 %	0.0 %
Lindhearst	-2.0 %	2.3 %	-5.2 %	6.1 %	0.2 %
Härmälänrannan Nalle, Tampere	-3.3 %	-0.1 %	-6.1 %	1.3 %	-1.7 %
Tampereen Vuoreksen Emilia	-1.0 %	0.9 %	-3.2 %	3.6 %	0.0 %
Vaasan Aleksander	-2.3 %	4.3 %	-8.1 %	15.8 %	1.0 %
Varkauden Parsius	-1.7 %	5.4 %	-6.1 %	53.0 %	4.7 %
Average (non-weighted)	-4.1 %	2.2 %	-9.1 %	8.8 %	-0.7 %
Portfolio average (non-weighted)	**-3.5 %**	**2.6 %**	**-10.3 %**	**10.8 %**	**-0.3 %**

6. Accuracy and model evaluation

Evaluation of accuracy against independent valuation

- In order to evaluate the accuracy of the Orava model, the model results are compared to property valuations carried out by an independent party. The latest independent valuation is selected. Assets have been valued by Realia Management Oy, JLL or OPKK, whichever valuation has the latest date of value.
- For most independent valuations the value date is the 30th June 2016, but a couple of values date a few months earlier.
- Realia has set the criteria against which to test the accuracy. The criteria have been defined by Realia and accepted by Orava. As no sub-portfolios have been defined by Orava or allocated by Realia, the criteria for sub-portfolios can be ignored.
    - For the whole portfolio, irrespective of the size of the portfolio, the sum of individual asset values must be within 5 % of the sum of asset values as valued by an independent valuer.
    - For a sub-portfolio, the sum of values must be within 7.5 % of the sum of values as valued by an independent valuer.
    - Single property assets (combination of multiple apartments at the same address) must be valued within 15 % of the equivalent valuation by an independent valuer. Of the entire set of property assets, at least 80 % must pass this criteria.
    - Similar to the above 15/80 criterion, 10/60 and 20/90 criteria have been proposed in literature.
- For the Orava 2016:06 models, all above defined criteria are met.
- Orava valuations against independent valuations for 25 random assets, as well as for the whole portfolio, can be seen on the right-hand-side table.

Asset	Orava vs. independent
Haminan Kaivopuisto	5.0 %
Helsingin Koirasaarentie 1	1.0 %
Helsingin Werner	1.2 %
Vantaan Rasinrinne 13	-9.6 %
Hyvinkään Ryijy	5.1 %
Hyvinkään Ukko-Pekka	16.0 %
Hämeenlinnan Tervapadankatu 1	10.7 %
Kotkan Mällinkatu 6	19.8 %
Lahden Vuoksenkatu 4	-0.2 %
Oulun Alppilan Iiris	8.2 %
Oulun Jatulinmetsä	12.2 %
Porin Pihlavankangas	1.6 %
Porin Huvitus	0.5 %
Porvoon Kaivopolku	-22.5 %
Riihimäen Laidunaho	3.9 %
Riihimäen Lovisa	2.3 %
Rovaniemen Laura	-1.1 %
Rovaniemen Koivula	2.8 %
Savonlinnan Kotipelto	-1.0 %
Savonlinnan Välimäentie 5-7	-10.7 %
Lindhearst	10.8 %
Härmälänrannan Nalle, Tampere	3.4 %
Tampereen Vuoreksen Emilia	-5.3 %
Vaasan Aleksander	14.0 %
Varkauden Parsius	-6.2 %
Total	-0.4 %
Portfolio total	**1.8 %**
Portfolio diff. +/- 10 %	**72.4 %**
Portfolio diff. +/- 15 %	**87.8 %**
Portfolio diff. +/- 20 %	**95.9 %**

Note: Positive sign = Orava valuation above independer

Presentation of model evaluation

- The object of the audit is to evaluate whether the automated valuation model is sufficiently accurate and objective for market valuation of the Orava Residential REIT portfolio, a matter of pass or fail. The portfolio valuation model, however, consists of several models and these models furthermore consist of different variables, each with their own properties.
- Thus, the evaluation of the automated valuation model is the evaluation of its parts giving emphasis to critical criteria.
- Four criteria have been defined from which overall scores are derived for each individual model. A heuristic score function was developed for each criterion, and the overall score is obtained as a weighted average of the individual scores.
- 100 score suggests the absense of identified problems.
- The four criteria are the following:
  - **Data quality**: (weight 5)
    Sufficient number of observations,
    Restricted number of influential observations and outliers
  - **Model fit and robustness**: (weight 4)
    Coefficient of determination R^2,
    Ability to handle unforeseen data,
    Structural stability
  - **Regression diagnostics**: (weight 3)
    Validity of linearity assumption,
    Homoscedasticity of residuals,
    Independency and normality of residuals,
    Lack of variable multicollinearity,
    Lack of residual spatial autocorrelation
  - **Valuation** unbiasedness: (weight 5)
    Inherent unbiasedness of the model,
    Insensitivity to dataset restrictions
- Any of the evaluation criteria can become critical to the functioning of the model should the underlying quality be out of the ordinary to a considerable degree. Thus, the weighted score is merely for the reader's consideration and for facilitating the understanding of potential issues.
- Criteria are most likely interrelated. For instance compromised data quality can result in problems regarding model stability.
- The table on the next page shows results for 25 random assets individually, along with results for the whole portfolio. As can be seen from the table, the weighted average total criteria score is 79.[1] The figure works as a benchmark and suggests that there are some issues with the model. While in no terms an absolute baseline, a functioning model ought to receive a score of minimum 70-75 when used for market valuing purposes.
- In terms of individual criteria, biggest problems emerge with the regression diagnostics criterion. Most models do not fully fulfil the regression assumptions, although deviations may not be excessive. However, main problem seems to relate to ill-behaving residuals, which mostly impair statistical inference whereas parameter estimates remain unbiased.

[1] Note: This and the previous audit use different scoring criteria and score functions than those used in audits performed in 2014, 2013 and 2012.

Asset	Criteria weight:	Data quality ●●●●●	Model fit & robustness ●●●●	Regression diagnostics ●●●	Valuation unbiasness ●●●●●	Weighted overall score
Haminan Kaivopuisto		71	100	59	49	69
Helsingin Koirasaarentie 1		100	100	53	100	92
Helsingin Werner		100	100	53	100	92
Vantaan Rasinrinne 13		99	91	53	100	89
Hyvinkään Ryijy		94	73	54	11	58
Hyvinkään Ukko-Pekka		91	69	53	43	65
Hämeenlinnan Tervapadankatu 1		92	76	53	100	84
Kotkan Mällinkatu 6		95	59	87	74	79
Lahden Vuoksenkatu 4		100	82	53	100	87
Oulun Alppilan Iiris		96	83	53	66	77
Oulun Jatulinmetsä		96	71	53	73	76
Porin Pihlavankangas		95	100	80	100	95
Porin Huvitus		94	100	87	100	96
Porvoon Kaivopolku		93	69	53	100	82
Riihimäen Laidunaho		97	74	53	89	81
Riihimäen Lovisa		87	70	53	79	75
Rovaniemen Laura		87	88	65	28	66
Rovaniemen Koivula		87	80	78	100	88
Savonlinnan Kotipelto		74	84	53	45	64
Savonlinnan Välimäentie 5-7		85	47	53	89	72
Lindhearst		83	33	67	100	73
Härmälänrannan Nalle, Tampere		98	100	53	100	91
Tampereen Vuoreksen Emilia		96	78	53	100	86
Vaasan Aleksander		97	92	86	84	90
Varkauden Parsius		80	65	87	24	61
Average (non-weighted)		91	79	62	78	79
Portfolio average (non-weighted)		**91**	**81**	**63**	**77**	**79**
Portfolio lower quartile		**87**	**70**	**53**	**61**	**74**
Portfolio upper quartile		**99**	**93**	**80**	**100**	**88**

7. Post-processing and reporting

Modelling post processing and valuation

- The regressional value estimate is used to attain the asking price value of each apartment where the values of single apartments are aggregated without any corrections for quantity. Should a need arise to divest all apartments in a short period of time a corrective multiplier is required.
- The estimated value is the asking price estimate, including the implied bargaining range. The implied bargaining range is removed by using an estimate of the range, which is then subtracted from the asking price estimate. This estimate of bargaining range has been produced by comparing actual transaction prices from Statistics Finland and data from Oikotie.fi, which are then adjusted by two months for improved match.
- After correcting for bargaining range, no further value modifications are made apart from possible rounding. As the assets are valued as the sum of individual apartments, should the divestment of a large number of apartments take place in the same region or to a single buyer, a correctional discount multiplier should be applied. This multiplier is dependent on the likely buyers' profile and the ability of the local demand to absorb apartments that are put to sale.
- It is acceptable to have a coefficient calibration for the model to reach market valuation estimate. The only such coefficient used is bargaining range, although also condition variables obtained from regression are adjusted, should their values be inconsistent. The average estimated model values are reasonably close to market value valuation by independent parties and therefore no further level-correction is deemed necessary nor appropriate.

Considerations related to the bargaining range

- The bargaining range is the price difference between the asking price and the price for which the property eventually sells for.
- In the model it was identified that there is a potential source of bias in the asking price level related to multiple listings. However, this is mitigated by the estimated bargaining range. The bargaining range is calculated using the modelled asking price and actual sales data for the area. Thus, whatever bias is introduced in the asking price level will be largely removed through employing the bargaining range correction for actual market value. However, care should be taken as this bargaining range is implied and these computational values are applicable to the Orava valuation model only.
- The bargaining range is a considerable source of uncertainty. Should the bargaining range be known with considerable precision, the time-period sufficiently short to mediate changes, and the area divided into relatively homogenous areas and applied only within these areas, many potential problems should not manifest.
- Optimally, the bargaining range would be estimated for each homogenous area. Due to the restrictions imposed by the data quality, the area data is aggregated and subsequently divided into two groups: large cities and smaller cities or towns. For each area model, one of the two bargaining correction ranges is used. The use of averages does not pose problems in valuing at the whole portfolio level.
- Bargaining range estimation has been revisited during autumn 2016. The estimate is formed first on zip-code level and the aggregated to municipality level. The eventual estimate as a function of population is attained by regressing the bargaining range estimates on municipalities' population. In addition, data from 24 months is used instead of the previous 12 months. As this audit focuses on valuation model 2016:06, the changes in bargaining range estimation are out of the scope of this audit.

- The source for the used data for the estimation of bargaining range is Oikotie.fi and Statistics Finland.

Reporting

- From the point of view of this audit, the purpose of reporting is to convey the market value as objectively and accurately as possible at the level of detail and depth deemed suitable considering the audience.
- The following must be stated clearly and objectively:
  - The process in its rudimentary form how the market value estimate is attained.
  - Market value, per individual asset (a combination of apartments at a single location), per portfolio, in local currency and as %-change.
  - Historical data of market value to the extent where potential fluctuations in estimated short-term price trends can be discerned.
  - The current and historical bargaining range estimations.
  - Applicable, easy-to-understand indicators of model quality and their explanations, such as standard errors and goodness of fits.
  - In addition, the inclusion of an audit summary, if available and deemed suitable.
- More detailed information on the models and model formation is available on the Orava Residential REIT website. This information should be considered as complimentary to the analysis made in this audit report. On 20 January 2017, no erroneous information was detected on the website regarding automated valuation processes.
- The auditors have gone through the materials. Orava Residential REIT are committed to reporting objectively and accurately and are in line with the aforementioned reporting criteria.

8. Audit notes

- The audit covers the automated valuation process of assets in their respective areas including a cursory analysis of all models. More detailed analysis results are presented for 25 randomly selected models.
- The previous two audits were performed by a different auditor than the previous ones. This has slightly shifted the emphasis of the audit, although the auditing process itself has remained mostly unchanged. One of the biggest changes is that all the statistical tests made for the models have been performed by the auditor instead of Orava; data and model specifications were delivered by Orava, after which all the models were replicated at Realia by using a different statistical software. As results have been consistent with models built by Orava, any concerns relating to human error in modelling work or software can be ruled out with high probability.
- The number of assets, and thus the number of models, in Orava's portfolio has increased significantly since the audit of 2014. Even though it makes auditing more laborious, a high number of models also helps detecting possible issues in model specification, because the fundamental formulation is common for all models and results can be aggregated over a higher number of models.
- In the audit numerous potential problems were observed. None were severe enough to question whether the model is functional, rather the degree of accuracy. However, the share of the models with severe issues is limited when contrasted against the whole portfolio. In addition, these issues have not been observed to create bias and thus any deviations in models typically cancel each other out when the model results are averaged at portfolio level.
- Identified issues are also considered in the AVM process. No arbitrary changes are made in the formation of AVM processes, but the identified issues are collected and used to improve future versions of the model. According to the observations and analysis made by the auditor, newer models are improvement over the previous models when the purpose is to attain an objective and accurate estimate of market value for the portfolio.

List of attachments

- The inclusion of following attachments is at the discretion of Orava:
  - AVM process charts
  - Employed models
  - Extensive set of statistical tests, descriptions and analyses
  - Detailed process of bargaining range estimate formation
  - Input data description sheet
  - Summary of the audit statement in Finnish

Audit statement

- We have audited the automated valuation model of Orava Residential REIT as of 20 January 2017 and the related data, processes, reporting and work methods at the time of audit.
- A prerequisite for applicability of the model is a normal and functioning market. For the purposes of this audit, a normal and functioning market is defined as a market situation where predictability to a conventional degree is possible. Should the market observations be atypical in their quantity or quality, or the market situation is considered volatile, predictability cannot be considered conventional.
- The audit is based on examining and testing the functioning of the valuation models, reviewing the model forming process and studying applied work methods. A deeper analysis of the models was done sampling based and on models where potential issues were detected by the auditor. The conclusions are based on the data and information obtained from Orava and other sources, in part verified against each other.
- There are certain issues in the used models. These are covered in the previous sections of the audit. In the current form of the automated valuation model, with comparable data, the valuation of the Orava portfolio is sufficient in accuracy, balance and fairness in valuing market value at complete portfolio level.
- While Realia's responsibility is to offer a statement based on the audit, the final responsibility of the automation valuation model lies with Orava Residential REIT.
- The audit covers data acquisition, data pre-processing, modelling, model post-processing and reporting of result.
- We have found the extent and quality of data to be sufficient for the formation of the models as at 20 January 2017. Should the quality of data, as a whole, remain at the same level, and employing equal practices, we have reason to believe that future models will continue to provide a fair and balanced estimate of market value.
- We have found the processes, methods and work practices in forming the automated valuation model to be of sufficient standard to attain an objective measure of market value within standard valuation accuracy.

The auditors have independently ascertained the quality, balance and the true and fair treatment of the data and the results in respect to all parties involved.

The auditors have found the processes and models to follow good practices, to be of reasonable accuracy for the purposes of market value estimation, and the result reporting to be objective and fair in nature.

Helsinki, 20 January 2017

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Auditointilausuman tiivistelmä

- Realia Management Oy on auditoinut tammikuussa 2017 Orava Rahastot Oyj:n kehittämän ja käyttämän automatisoidun arvonmääritysmallin sekä siihen liittyvät prosessit, lähtöaineistot, työmetodit ja raportoinnin.
- Mallin soveltuvuuden edellytys kiinteistökannan arvioimiseen on kiinteistömarkkinoiden normaali tila ja toiminta. Markkinoiden normaalin tilan ja toiminnan määritelmä voidaan kiteyttää tavanomaiseen ennustettavuuteen. Mikäli markkinahavainnot eivät ole tyypillisiä joko määrältään tai laadultaan, tai markkinat katsotaan muuten hyvin epävakaaksi, ei ennustamisen katsota olevan mahdollista tavanomaisella tarkkuudella.
- Auditointi perustuu arvonmääritysmallin testaukseen ja verifioimiseen, arviointimallin muodostamisprosessin tarkasteluun ja toimintamenetelmien seuraamiseen. Arvonmääritysmallit ja -menetelmät, joissa on havaittu mahdollisia poikkeavuuksia, on otettu tarkempaan tarkasteluun. Malleja on lisäksi valittu tarkempaan analysointiin satunnaisotoksin. Johtopäätökset perustuvat edellä mainitun lisäksi Oravan toimittamiin ja muista lähteistä saatuihin lähtötietoihin ja näiden tietojen keskinäiseen vertailuun.
- Auditoinnissa on tunnistettu mahdollisia ongelmanlähteitä. Tunnistettuja ongelmalähteitä sekä näiden mahdollisia vaikutuksia ei ole käsitelty tässä auditointilausuman tiivistelmässä.
- Realian vastuu rajoittuu annettuun lausuntoon suoritetusta auditoinnista. Lopullinen vastuu arvonmääritysmallin toimivuudesta on Orava Rahastot Oyj:llä.
- Tämä lausuma on yhteenveto tammikuussa 2017 suoritetusta audioinnista. Auditoinnin tarkka merkitys ja sisältö löytyvät täysimittaisesta auditointiraportista.
- Auditointi käsittää lähtötietojen keräämisen, tietojen esikäsittelyn, mallintamisen, mallin jälkikäsittelyn ja tulosten raportoinnin.
- Olemme todenneet käytetyn lähtötiedon olevan riittävä laadultaan ja kattavuudeltaan mallien muodostukseen (päiväyksellä 20.1.2017). Mikäli toimintamallit ja lähtötietojen laatu pysyvät yhtäläisinä, uskomme että arvonmääritysmallit tulevat antamaan myös jatkossa objektiivisen ja tasapuolisen estimaatin markkina-arvosta.
- Olemme todenneet automaattisen arvonmääritysmallin muodostamisessa käytetyt prosessit, menetelmät ja menettelytavat olevan riittävällä tasolla objektiivisen markkina-arvon määrittämiseksi tavanomaisen arviointitarkkuuden puitteissa.

Auditoinnin suorittajat ovat riippumattomina toimijoina vahvistaneet käytetyn materiaalin, materiaalin käsittelyn ja tulosten raportoinnin laadun, objektiivisuuden ja tasapuolisuuden.

Auditoinnin suorittajat ovat todenneet, että arvonmääritysprosessi ja mallit noudattavat hyvää toimintatapaa, ovat objektiivisia ja tasapuolisia sekä tarkkuudeltaan riittäviä rahaston omaisuuden markkina-arvon määrityksessä.

Helsingissä 20.01.2017

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