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KINNISVARA HINDAMINE HULGIKRITEERIUMITE ANALÜÜSI MEETODIL RIDAELAMUTE NÄITEL

PROPERTY VALUATION OF TERRACED HOUSES USING MULTIPLE CRITERIA DECISION ANALYSIS

MAGISTRITÖÖ

Üliõpilane: Simon Rubinstein

Üliõpilaskood:: 153957

Juhendaja: Emlyn David Qivitoq Witt

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Juhendaja: **Emlyn David Qivitoq Witt** emlyn.witt@taltech.ee

Lõputöö konsultandid:

Tiitel või ametikoht, Ees- ja Perekonnanimi	Kontakt (e-post või telefon)	Allkiri ja kuupäev
Kaleem Ullah	kaleem9191@gmail.com	

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Juhendaja: **Emlyn David Qivitoq Witt** .....

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ABSTRACT

The substantial increase in property sale-purchase prices within the last 5 years in Estonia has created the necessity for constant property re-evaluation. This thesis aims to determine whether the property valuation process can be improved through the use of advanced property valuation methods. By using a combination of Complex Proportional Assessment (COPRAS) and Multiple Criteria Decision Analysis (MCDA), an estimated value for a selected property is determined. The methodology involves the collection of initial data by interviewing local real estate experts, who can provide valuable insights into the specifics of the Estonian terraced housing market. The results of the research include a comprehensive list of variables which is deemed to be relevant for describing terraced houses. Furthermore, the study determines the weights and individual values of variables and the estimated value of the selected property. The findings indicate that COPRAS and MCDA can be effectively used to estimate property values. Furthermore, these methods can be used for comparing specific variables and determining the extent to which each variable affects the overall property value.

RESÜMEE (SUMMARY IN ESTONIAN)

Eesti kinnisvara hindade märkimisväärne kasv viimase viie aasta lõikes on tekitanud pideva kinnisvara väärtuse ümberhindamise vajaduse. Käesoleva lõputöö eesmärgiks on uurida, kas kinnisvara hindamise protsessi on võimalik parendada läbi edasiarendatud kinnisvara hindamismeetodite kasutuse. Uuringu jaoks valitud kinnisvara väärtust hinnatakse läbi kompleksete proportsioonide hindamise ja hulgikriteerium otsuste analüüsi kombineeriud meetodi kasutuse. Metoodika rakendamise aluseks on esmase informatsiooni kogumine läbi kinnisvara turu olukorrast teadlike ekspertide küsitlemise. Uuringu tulemiks on detailne ridaelamuid kirjeldav omaduste nimistu, nende omaduste tähtsused ja valitud kinnisvara näidete kindlaks määratud väärtused. Tulemused tõestavad, et kasutatud metoodika on sobilik kinnisvara hindamiseks, lisaks on metoodika sobilik ka kinnisvara iseloomustavate omaduste individuaalsete väärtuse määramiseks.

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1. INTRODUCTION

In Estonia, the average property sale-purchase price has risen 34.5% in the last five years. Putting this into monetary value, on the example of apartments, terraced houses, and semi-detached houses in Harjumaa (including Tallinn), the average price per square meter has increased from 1746 €/m² to 2726 €/m² (Maa-amet, 2019; Maa-amet, 2023). This means that over the last five years property prices have risen, on average, by almost 200€/m² per year.

Terms Property value and Property price are often seen as synonyms however they are not. Property value indicates the estimated monetary worth of real estate. Property value is usually determined by a professional appraiser who considers key factors and variables that describe the property. As a result of their research, appraisers assign an estimated market value to the property. Property price describes the amount of money for which a certain property is sold or bought for. It is a monetary figure which the buyer is willing to pay, and the seller is willing to accept for a certain property (Gaca, 2018). Property value and property price do not have to be equal, but they are dependent on one another. A process which results in determining the value of a property is called Property valuation.

Standard practice in Estonia is that when a property is put up for sale, it is appraised by a property appraiser beforehand. One of the main methods, that property appraisers use when determining property value, is that they look for comparable properties in recent real estate market transactions. Comparing recently sold properties with properties currently being evaluated, appraisers can calculate property values. This means that when property prices change, property values change as well, and vice versa. As per market data presented above, property prices are in constant change. Considering property value is dependent on property price, property value must be in constant change as well.

Every day are new listings added to the market, most of which need to be appraised. When purchasing a property using 3rd party financing e.g., banks or financing platforms, property valuations are required. As established previously, property value is in constant change, therefore property valuations are given validity periods. Those periods are usually three to six months, but in some cases, they can be as short as a single month, depending on the type of property. This often results in appraisers needing to evaluate a single property many times before a sale is made.

Another reason for determining property value is to give potential sellers an insight into their desired selling price matches the current market conditions. For example, if a

homeowner has invested most of their life savings into a given property, then they may value it more than the property may be currently.

Determining property value is also important if a property is used as collateral for a loan. It serves as a security for the lender since they have the right to seize the property in case the loan is not repaid. The valuation is grounds for the lender to assess how much and on what conditions they can lend.

These instances are just a few cases where property valuation is required. In fact, property valuation is used for many more reasons such as property tax assessments, insurance purposes, or investment analysis. Such a wide range of use requires constant repetitive work from property appraisers.

This thesis focuses on finding property valuation methods that could be adapted to the Estonian real estate market in pursuance of optimizing the property valuation process. The desired outcome of the research was to come up with an automated property valuation tool that could rival or even better conventional valuation methods.

Estonian urban and suburban city planning does not follow a common pattern; therefore, it was necessary to apply some constraints to the research. After some market analysis and consideration of desired outcomes, the selection fell on terraced housing in Harjumaa. Terraced houses were selected since the majority of terraced houses in Estonia conform to a specific framework unlike apartments or single houses. Locational limitations were set to properties within Harjumaa due to it being the most populated county in Estonia both real estate as well as population-wise. Furthermore, pricing classes in Estonia are different county by county, therefore only a single county was selected.

Considering the aforementioned, this research will:

1. Provide an overview of common property valuation methods.
2. Determine their applicability in the Estonian terraced housing market.
3. Provide an overview of variables most relevant to terraced houses.
4. Estimate the value of a terraced house by comparing it to other similar properties using the Multiple Criteria Decision Analysis method.

The following chapters of the paper are organized as follows: a literature review of publications on property valuation methods and variables, that is followed by research methodology breakdown, next up is a case study properties overview, after that the results of interviews are presented, following that is the applied method results and discussion, and finally, the research is summarised, and conclusions are presented.

2. LITERATURE REVIEW

2.1 Main approaches

Property valuation methods can be sorted into categories based on how the data is collected. The three main approaches are as follows (French & Gabrielli, 2018):

1. Cost Approach.
2. Income Approach.
3. Sales Comparison Approach.

All these methods have their own strengths and weaknesses, therefore each of them is more suitable for different scenario. Predominantly a single approach is selected since these methods can be used independently. Selection on which method to use is determined based on multiple factors, such as what are the desired outcomes; what is the purpose of valuation or what type of property is being appraised.

Understanding how to determine as precise as possible value of real estate presents a crucial role in economy since investors' decisions are based on property values. Primarily, methods how to determine property values can be separated into two parts, them being Main approaches and Advanced Methods. Either of those techniques have their own pros and cons and determining the better of the two is impossible due to either technique having their own strengths and weaknesses (Abidoye & Chan, 2018).

2.1.1 Cost Approach

The Cost Approach is a technique for valuing real estate that is based on the idea of substitution. It can also be labelled as the Contractor's Valuation method. This approach is built on the premise that potential buyers should pay for the exact cost of constructing a comparable building.

The Cost Approach is suitable to appraise properties that have just undergone major renovations; properties that are optimized for specific use; or for evaluating fresh-build properties. In common practise, this approach is not publicly presented, since the method does not include markup and it could result in potential buyers knowing how much a certain type of building costs and they may not be willing to pay more than that amount. The Cost Approach is most frequently used for establishing the property value for insurance purposes since this method is based on calculating the costs of labour, materials, and other necessary expenses to replicate a property and it excludes effects of comparable properties and hidden incomes. Another use for forenamed method is to analyse and compare property value estimates which are done using other appraisal methods.

Due to the limitations of the approach, out of the three main property valuation methods, The Cost Approach is the least used, therefore a lot less research is done into and based on that method. For those reasons, Cost Approach method will not be considered further during the writing of this thesis.

2.1.2 Income Approach

The Income Approach is a technique for valuing real estate that is based on the idea of expectation. The approach estimates the market value of a property based on equalling present value to future income revenues. In comparison with Sales Comparison Approach and Cost Approach, it is notably more complicated method, however, it provides remarkably more detailed data to investors for decision making purposes.

To use The Income Approach, appraiser must calculate the potential income that the property could generate through rental fees whilst taking into consideration possible vacancies and other hindering factors. Last step before concluding the property valuation is to apply the desired capitalization rate.

Accurate appraisals are needed to determine property values for the stakeholders to know how well they maintain control over market and how to keep their profit margins up to date (Del Giudice et al., 2017).

Estimating property value is key factor that determines how real estate investors and shareholders such as single individuals, corporate organizations and the government make strategic decisions (Abidoye & Chan, 2018).

Income focused property valuation method is mainly used by investors for properties which are aimed for rent generating purposes such as commercial and office building or apartment complexes. Purchasing real estate is a well-known method of investment for different types of investors such as individuals, corporations, and various funds.

The Income Approach does not account for some key property value affecting variables such as locational attributes, structural attributes, and environmental attributes. This creates a situation where properties with similar attributes are evaluated differently.

This results in contrasting values in similar types of real estate mainly by investors disregarding some key aspects. Therefore, it is important for investors to consider for valuers' judgement on some attributes of property valuation (Abidoye & P.C. Chan, 2016).

The Income Approach could be beneficial during the following stages of this thesis, and therefore this method will be analysed further.

2.1.3 Sales Comparison Approach

The Sales Comparison Approach is a property valuation method which is built on analysing market transactions to determine subject property value. This approach is the most frequently used method thanks to its many benefits and wide range of adjustability. The method relies on existing sales data and therefore it accurately reflects current market conditions. Furthermore, this method allows for straightforward adjustments based on variables and their conditions. Comparison method is also the most studied and developed one due to it being the least complicated of the three main approaches.

Applying this method generally requires data on at least three recently sold and similarly constructed properties. That allows to determine currently evaluated property value through a process of comparative breakdowns and calculations. In itself, the method is quite simple - if the subject property has most of the same attributes that it is being compared to but lacks a few, price is decreased. Vice versa, if subject property has all the attributes as the comparable property but in more favourably situated geographically, price is increased accordingly. Ordinarily professional appraisers have a tier-list of different types of variables based on their importance and influence on price corrections.

Trends and preferences in property market change with the time and therefore, it is curial that properties, that subject property is being compared to, are recently sold. Finding comparable properties in Estonia could prove a problem, considering low mobility in real estate markets outside of Tallinn and Harjumaa. Additionally, urban planning in Estonia can be considered rather chaotic and that complicates finding comparable properties.

Considering Sales Comparison Approach popularity and adaptability, this method will be analysed further the following steps of this thesis.

2.2 Advanced approaches

The main methods of property valuation have limitations which have led to the adoption of more advanced techniques. This development is encouraged by advancements in computing techniques. (Chan & Abidoye, 2019). All these advanced approaches are further developments of the three main methods.

Due to the diversity of housing characteristics, it is difficult to build an all-inclusive model that can count for all available characteristics (Komagome-Towne, 2017). To counter that, different types of methods have appeared, each more suitable for certain market strand.

2.2.1 Hedonic Pricing Method

Developed in the 1960s, Hedonic Pricing Method (HPM), also referred to as the Hedonic Price Model or HPM, is regarded as an advanced property valuation approach and is among the earliest of its kind (Griliches, 1971; Komagome-Towne, 2017). The method is based on principals from Lancaster's consumer theory and Rosen's model. According to Lancaster's consumer theory, consumers choose products with features most important to them based on individual preferences. Rosen's model focused on explaining decisions from both buyers and seller's view in state of market equilibrium (Jayasekare et al., 2019).

HPM is a method of property valuation which relies on dividing property into variables and evaluating them individually. It takes into consideration both internal and external factors (Griliches, 1971). Main purpose of Hedonic Pricing Method is to find relationships between dependent and independent variables by linking variables with their importance (Gaetano Lisi, 2021). This process is also known as regression analysis, and it can be divided into simple and multiple regression (Abidoye & Chan, 2018). The purpose of simple regression analysis is to determine changes in an independent variable influence the dependent variable. Multiple regression analyses relationships between a dependent variable and multiple independent ones such as location, specification, or environmental characteristics. Regression analyses enables to determine the value of property by identifying the influence and significance of defined variables (Gaetano Lisi, 2021). In property valuation, multiple regression analysis tends to be more popular considering that real estate property value is determined by more than one characteristic (Abidoye & Chan, 2018).

Considering Hedonic Pricing Method allows to determine the value of single variables, HPM is best suited for appraising properties that have unique attributes which could be valued differently by buyers and sellers (Hill, 2011). Furthermore, Hedonic Pricing Method can be applied to review property value assessments done using other methods (Linh, 2020).

Main advantages of Hedonic Pricing Method stem from its adaptability and reliability. In terms of adaptability, HPM allows for individual approach to each property based on its unique characteristics. Furthermore, considering that Hedonic Pricing Method focuses on consumption patterns and uses regression to estimate property value, it can reliably combat the limitations of traditional "non-advanced" methods (Linh, 2020). Thanks to using regression, Hedonic Pricing Method had the potential to overcome the deficiencies of the main property valuation methods (Linh, 2020). Finally, Hedonic Pricing Model

gives buyers better framework to find their likes and dislikes when comparing properties.

The main disadvantage of HPM is the fact that this method does not count for information that affects property value but is not visibly accountable (Gaetano Lisi, 2021). An example of this would be when a property is in area which is subject to occasional noise pollution and that is not stated by the seller in attempt to hide shortcomings of the property. Another disadvantage of HPM is that it does not take into consideration taxes or interest rates, which may have a detrimental impact on final sale price (Gaetano Lisi, 2021). Furthermore, HPM needs assessment of variables both from sellers' and buyers for the sake of accuracy (Heyman & Sommervoll, 2019).

Overall, Hedonic Pricing Method is a useful approach for property valuation when a more detailed assessment is required in case a property features unique variables or they are few comparable properties. Hedonic Pricing Method will be considered further during this thesis thanks to its versatility and precision.

2.2.2 Artificial Neural Networks

First developed in the early 1990s, Artificial Neural Networks (ANNs) are an automated method of property valuation which rely on analysing patterns and relationships on provided data to estimate property values (Abidoye & Chan, 2017). ANN is designed as a three-layered (input layer; hidden or process layer; and output layer) model which replicate the process of a human brain. The three layers in case of property value would be: property data entry, data analysis, property price calculation (Limsombunchao, 2004; Abidoye & Chan, 2017).

ANNs must be trained with existing data to assure model reliability and credible results (Chiarazzo et al., 2014). In case of property valuation, that data would have to be about different variables which describe the property, such as location, age, size, state of repair etc. The network studies through trial and error how these variables affect one another whilst adjusting itself to minimize the deviations (Limsombunchao, 2004).

Considering the unique approach ANNs have, they can be useful in multiple different scenarios. Arguably most beneficial would be to use ANNs in scenarios where property has large number of different variables (Chiarazzo et al., 2014). Another occasion to consider using Artificial Neural Networks is in case mass appraisal in needed (Yacim & Boshoff, 2016).

Main benefits of ANN method arise from the fact that, unlike other property valuation methods, building the framework of Artificial Neural Networks do not require human input and therefore, the method is less subjective to personal opinions and preferences

(Abidoye & Chan, 2017). Furthermore, on the grounds that ANN requires no prior research between the connections of input variables and that the model can be adapted to work with non-linear connections, ANN is considered a versatile and user-friendly approach to property valuation (Mimis et al., 2013; Abidoye & Chan, 2017).

One of the significant drawbacks of ANN is the inability to fully examine the process of how the variables are linked to their weights and therefore, how the output is generated (Limsombunchao, 2004; Mimis et al., 2013). However, thanks to the constant progress in ANNs development, these shortcomings are being addressed and the efficiency and understanding of the approach is improving (Abidoye & Chan, 2017).

Thanks to their uniqueness, ANNs have they place in property valuation field. Even if the method does not receive wide acceptance in Estonian market, it can be used as a supervising method. Using ANNs will be considered further during the writing of this thesis.

2.2.3 Fuzzy Logic Approach

Originating from 1965, Fuzzy Logic was introduced by prof. L. A. Zadeh as a new approach to understanding uncertainty (Yacim & Boshoff, 2014). It is a mathematical theory of assigning linguistical values to imprecise information based on the order of thought process (Hakan Kuşan et al., 2010).

In property valuation, Fuzzy Logic is adapted to evaluate various features of the property and to identify their influence on value. The process consists of ranking each variable based on their appeal, then combining same ranked variables into singular group and finally assigning them a grade which represents the influence between the group and each variable (Yacim & Boshoff, 2014; Del Giudice et al., 2017).

Since Fuzzy Logic assigns linguistical values (such as "good", "average" and "poor") to variables, the approach can be applied to simplify the evaluation and categorisation of variables (Del Giudice et al., 2017).

One of the benefits of Fuzzy Logic is that it can be combined with other property valuation approaches which relay of assigning value to variables. This could be useful when a property has a vast number of variables and valuating them individually would be impractical (Yacim & Boshoff, 2014). Another benefit of Fuzzy Logic is that it could reduce the effects of uncertainty in property valuations (Del Giudice et al., 2017).

From other perspective, Fuzzy Logic could also increase the effects of uncertainty when the method is applied in a way which would result in excluding important variables due to not having a suitable categorisation (Del Giudice et al., 2017).

Fuzzy Logic is most suited to use as an addition to other property valuation methods for simplifying or clarifying purposes, but it can be efficiently used as a stand-alone method. Fuzzy Logic principals will be considered further during the writing of this thesis.

2.2.4 Decision Tree

First introduced in 1880s, Decision Tree was a mathematical approach to showcase connections between different batches of data, but it was not until the 1960s when it developed into a tool for decision making (Sridharan et al., 2022). This approach was not thoroughly adapted to property valuation until the late 1990s and early 2000s, when it was used together with regressing property transaction data. That resulted in a property valuation method which was able to predict housing value (Fan et al., 2006).

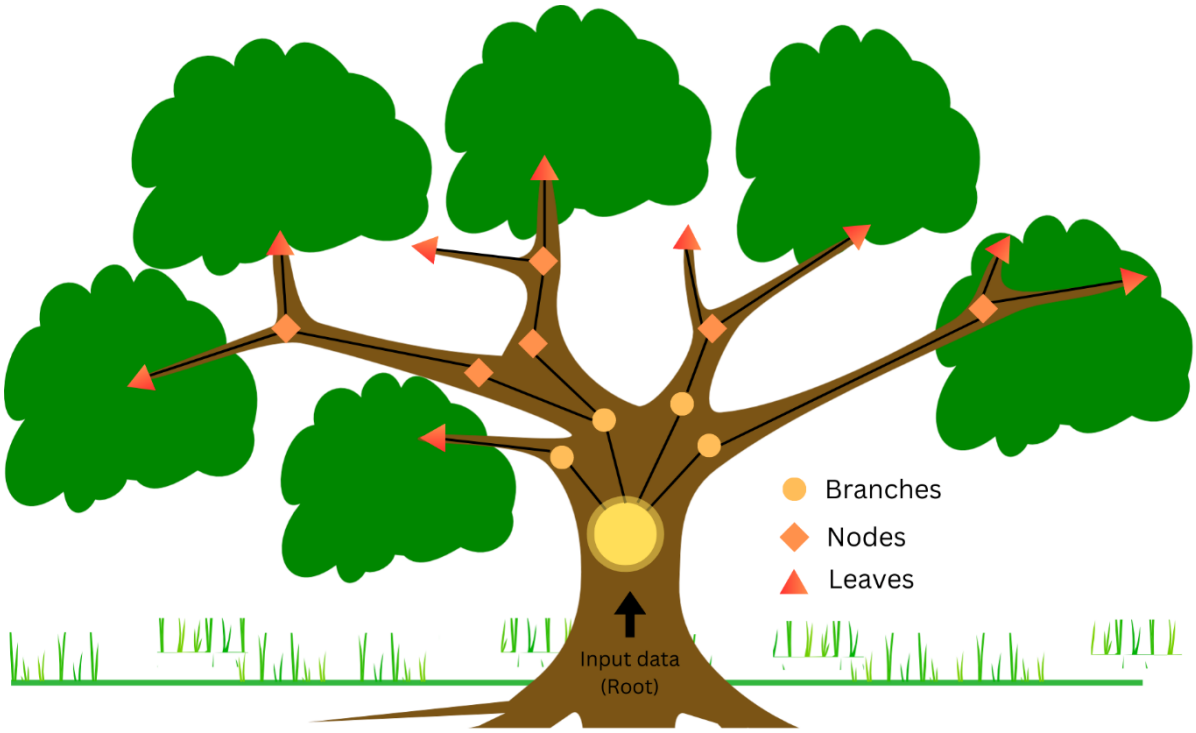

Figure 1 - Decision Tree model

Decision Tree method creates a tree-shaped model (Figure 1) by analysing the input data and dividing it into groups, which in turn are separated into sub-group and then sub-groups are furthermore broken into sub-sub-groups and so on (Fan et al., 2006). The model requires the process to begin from the Root of the Tree since that is the leading element of the model and therefore the most important part (Gacar & Kocakoç, 2020). The groups closest to the Root are called Branches which themselves contain the sub-groups named Nodes which in turn contain the sub-sub-groups that are also called Nodes (Fan et al., 2006). The whole structure is built by applying rules to input data which look for independent variables called Splitters. These Splitters are indications for the model to create a new Branch or Node. When a variable cannot be categorised any

further, it will be left as a standalone element named Leaf (Fan et al., 2006). Once the Decision Tree is built, comparable property sales data can be applied to it. Considering the Tree showcases importance of variables, the method can apply a value to each variable (Yücebaş et al., 2022).

Decision Trees can be used to effectively valuate individual properties as well as generate mass appraisals. From the viewpoint of individual properties, Decision Tree can be an effective method for determining the key variables which influence the price. From mass appraisal aspect, Decision Trees are beneficial since they can be used to identify and group similar properties by analysing the Branches. From there on, each subgroup can be appraised by applying most suitable methods (Fan et al., 2006; Gacar & Kocakoç, 2020; Sridharan et al., 2022).

One of the biggest advantages of Decision Tree method is that the whole model has a visual presentation, which allows to analyse and adapt the whole process as necessary (Fan et al., 2006). Another benefit of the method is that applying base data does not require making any assumptions and therefore the method is less subjective (Gacar & Kocakoç, 2020).

The method has some shortcoming, most of which are related to the way the model analyses data. Arguably the main drawback stems from the fact that the model categorises the data instantly and independently, which could result in some Branches being off-balance (Fan et al., 2006). One other drawback is that the Tree may become over-Branched and the whole model become too complex to analyse and develop further. This could be the case when input data is very diverse and rules of the model are set too strict (Yücebaş et al., 2022).

Decision Tree method is a unique approach to property valuation due to which it has developed into considerable tool for analysing real estate markets in certain situations. During this research, the approach will not be considered any further since Decision Tree is a standalone method, and it cannot produce all the set goals.

2.3 Factors influencing property value

2.3.1 Uncertainty

Uncertainty is a factor in property valuation which must be always considered if one wishes to minimize risks. It is always present and follows the trends of the real estate market. Uncertainty can be caused by many different variables and factors especially when there is a foul up in information (Meszek, 2013).

Uncertainty can cause discrepancies in property prices and that can in turn effect the valuations of other properties. For that reason, it is important to evaluate if and how uncertainty plays role on property values. Market analysis and practical experiences have led to the development a sequence which can be used to identify or even tackle uncertainty (Kucharska-Stasiak, 2013).

- First step in the model would be identifying the variables and factors which describe the property and can introduce uncertainty during property valuation.
- Next step should be determining the maximum and minimum effects of these variables and factors and their likelihood of occurrence.
- Following that, a model of variables and factors can be built which combines the gathered data into a range of property values.
- Final step would be to analyse the range on property value. Result of that analysis should be a conclusion of how much of that value fluctuation is standard deviation and how much is caused by uncertainty.

2.3.2 Government influence

Government influence on property valuation is a factor which should be accounted for since governments have the ability to offset and alter certain ongoing price trends and property developments. These influences can be split into two main directions.

First method for governments to influence property valuations is by altering tax rates which are usually regulated by local governments since transactions in real estate market are one of the biggest sources of tax gains for them. This is a dangerous trajectory since over-taxing properties may cause drops in market trends and that would result in financial difficulties for local governments (Jiang & Wang, 2020).

The second method for governments to influence property valuations is via permits and licensing. An example of this would be when the demand for properties outweighs the available supply and to counter that, governments reduce the demands for developers to quicken the resupply.

2.3.3 Supply-demand

Supply-Demand is a factor in property valuations which can be explained as the relationship between the need for properties and the available inventory to fulfil that need at the time. Supply and demand relationships can be predicted ahead of time to some extent by analysing ongoing and possibly incoming real estate developments; household wealth and unemployment; bank trends and credit availability; and population data. Property value is in large part dependent on supply and demand and

therefore, it is one of the biggest factors to consider when it comes to predicting property values in the future (Conefrey & Whelan, 2013; Stepanyan et al., 2010).

An example showcasing the importance of analysing Supply-Demand could be the development of new properties, since to analyse profit margins, real estate developers must predict property price trends ahead of time to estimate to estimate the realistic selling prices for the completed properties.

2.3.4 Road noise

A vast amount of research has been carried out to analyse how noise pollution affects property values (Egbenta et al., 2021). That research can be credited as one of the provoking elements which has led to constructing more soundproof properties.

In most research, noise pollution is viewed as a singular factor affecting property value but in some research that variable is deconstructed further by analysing different noise producing sources (Sklarz & Miller, 2018). Road noise is often found the be one of the most frequent noise pollution sources however little research is done analysing direct connection between road noise and property value (Blanco & Flindell, 2011).

Road noise as a factor should be researched more in depth for future property developments considering evolution in electric vehicle sectors and increasing tax burdens for internal combustion vehicles. Some buyers take advantage of current situation by purchasing properties which are discounted for high levels of road noise hoping that in the future noise levels coming from roads will decrease (Blanco & Flindell, 2011). This could also arise as a prime opportunity for Long Position investment on subletting.

Another angle to consider, related to road noise and potential necessity to evaluate its effects on property value in depth, is that in major urban areas where properties are indistinguishable in most aspects, road noise may be the key factor on which potential buyers make their decision (Blanco & Flindell, 2011). A solution to prepare for such occasion would be to calculate the value of road noise as a single variable and deduct that from the asking price.

2.3.5 Air quality

A great deal of research has been carried out globally to analyse if, how, and by how much air quality affects property value. Most of the findings display the same answers to the first two questions, which is that notable decrease in air quality leads to decrease in property value (Azmi et al., 2012; Ayan & Erkin, 2014). Some studies show that in areas with a generally low air pollution rates, slight change in air quality plays little to now effect on property value (Tang & Niemeier, 2021). Therefore, determining the

influence of air quality as a singular factor which affects property value requires location-based adaptation.

Most of the research, done on analysing relationship between air quality and property value, can be concluded as these three following findings (Wang, 2021):

- The level of air pollution has the biggest effect on property value in areas, where air quality changes are apparent to the potential buyers.
- Health-conscious people, such as families with new-borns or people with respiratory problems, are very selective when it comes to selecting home location. That could result property value changes as some demographics start avoiding certain areas.
- Constant high level of pollution may cause extra wear on different property elements and therefore, maintenance expenditures may increase. That could be a deciding factor between two otherwise equal properties.

2.3.6 View

View is often regarded as one of the most important aesthetical factors in property valuation for both sides of the possible transaction (Jim & Chen, 2009). From homeowners' perspective, a pleasant view is important part of the property since it is something, they must live with on daily basis. From developers' perspective, a nice view allows to ask for a price premium and therefore, it should be accounted during development is as large extent as possible (Jayasekare et al., 2019).

Buyers may have different preferences in their choice of view, therefore it is wise, to create as many variations as possible. One of the methods for developers to create more units with most favourable views is to carry out market research to evaluate the preferences that potential buyers have. From the other perspective, developers may also do market research to analyse what type of view is the least favourable to adjust urban planning as much as possible (Jim & Chen, 2009). That research may also be useful for developers to identify possible future development areas (Jayasekare et al., 2019).

View, as a singular factor in property valuation, can be analysed in great depths to make conclusions on local market preferences. That in turn can be used to plan future developments and urban planning considering that real estate market is one of the main tax income sources for local governments (Jiang & Wang, 2020).

2.3.7 Historical value

Historical Value is a wild card in property valuation since it can be considered a positive and negative factor. Historical value as a stand-alone variable can be seen as positive factor since in most markets, historically valuable properties are situated near city

centres, historical districts, or heritage sites (Hicks & Queen, 2007; Kaklauskas et al., 2010). From the other side, historical value can be linked with the state of repair and that many be seen as a negative factor when it comes to maintenance of upkeep costs.

A few other arguments for considering historical value and its pros and cons, can be as follows:

- When a property was owned by historically important or famous person. An example of this would be the childhood homes of celebrities which can be converted into museum for business purposes.
- When property was the location for a historically important event. An example of this would be properties where peace treaties were signed, or ground-breaking discoveries were made.

2.4 Summary of literature review

This literature review provides an overview of different property valuation methods and noteworthy variables used in real estate markets. First, three of the main property valuation methods were identified, these being The Cost Approach, The Income Approach and The Sales Comparison Approach

- The Cost Approach is built on the logic of replacement. The methods states that the value of a property should be equal to the total cost of building an equal one.
- The Income Approach is a method which estimates the value of a property by equalling it with the income a property generates over a certain period.
- The Sales Comparison Approach uses comparable recent real estate market data to appraise a certain property.

Moving forward to research methodology, Income Approach and Sales Comparison Approach will be considered further when choosing the final research method.

After the main methods, four Advanced Methods were introduced: Hedonic Pricing Method, Artificial Neural Networks, Fuzzy Logic Approach and Decision Tree.

- Hedonic Pricing Method estimates the value of a property by analysing and appraising each property variables individually. By analysing the impact each variable has on the property, a value can be assigned to them.
- Artificial Neural Networks is a machine learning algorithm that learns the relationships between property characteristics and its market value. ANNs can process large amount of data and nonlinear connections in minimal timeframe.

- Fuzzy Logic Approach uses linguistic terms as values for analysing variables and their effect on property valuation. Fuzzy Logic can process imprecise and hazy information.
- Decision Tree method uses a tree-shaped model to visualise the importance and value of different property variables. It is an automated method which can process and analyse large amount of data.

Out of these methods, Hedonic Pricing Method and Fuzzy Logic Method will be considered more in depth when choosing the final research method.

Last step of Literature Review was to identify individual variables and their effects on property valuation process. These variables were: uncertainty, government influence, supply-demand, road noise, air quality, view, and historical value. All these variables will be considered further during the later stages of this research.

3 RESEARCH METHODOLOGY

Figure 2 provides a flow chart of research methodology followed in this thesis.

- Segment 1 focused on assessing the suitability of various variables and property valuation methods for terraced housing evaluation by analysing scientific publications.
- Segment 2 focused on collecting data from local real estate experts and processing gathered information.
- Segment 3 focused on applying the chosen property valuation method.

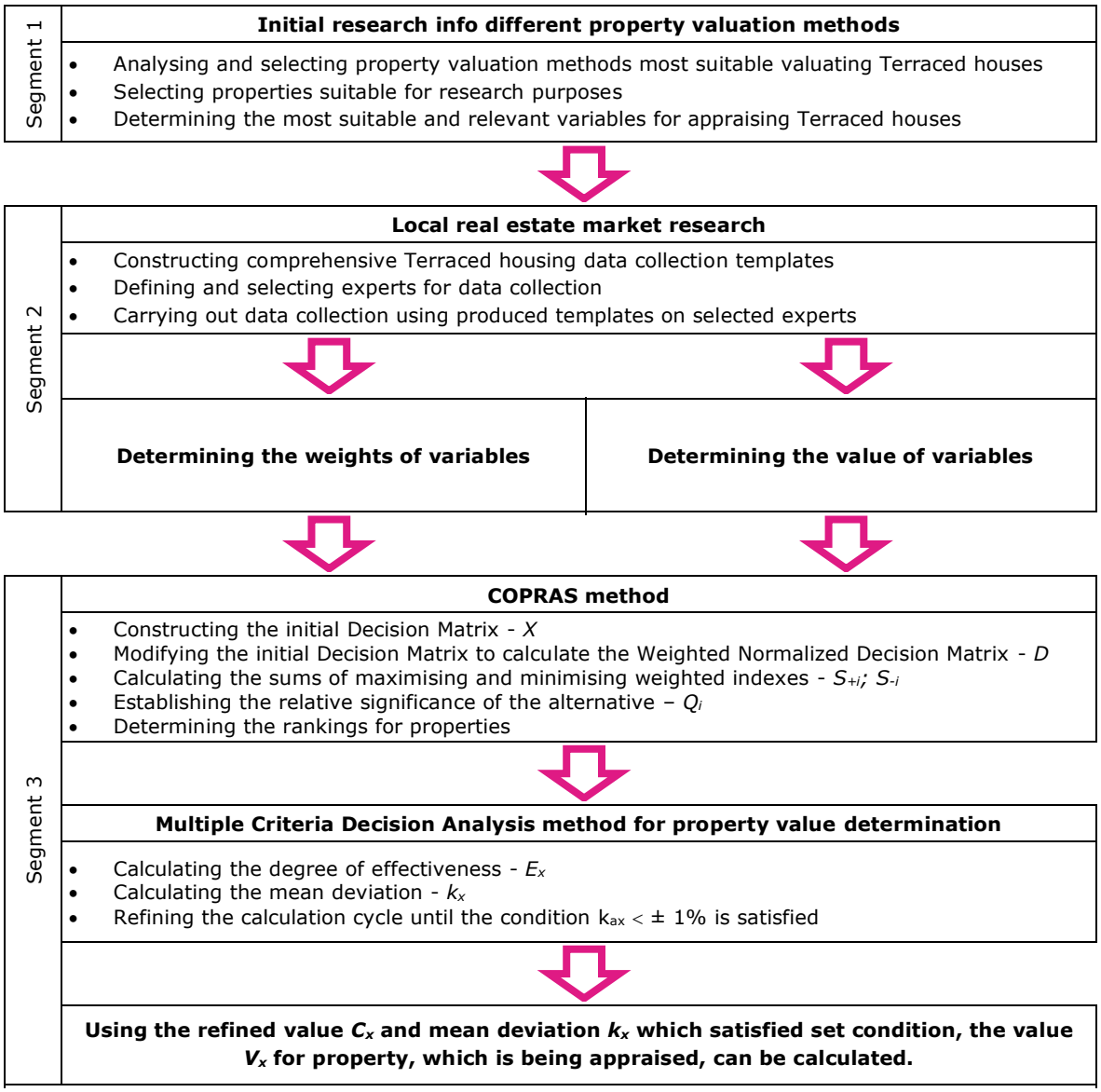

Figure 2 - Research process methodology flow chart

3.1 Literature analysis

The first segment of the research methodology focused on analysing various scientific publications on property evaluation methods. The objectives for this segment were:

- Selecting of the method or methods for research
- Determining of the initial relevant variables

That required finding scientific publications related to the goals of the research. All the articles, books, and other scientific works were compiled into a comprehensive table with the intent to deconstruct them for further analysis. The complete table is presented in Appendix A2.

3.1.1 Main approach categorisation

First task whilst making the table was to determine which main approach was used during each scientific publication. As discussed during literature review part of this thesis, main approaches were the following:

- The Income Approach
- The Sales Comparison Approach
- The Cost Approach

The aim of this categorisation was to provide an early insight to the direction of the publication. These results were entered to the column labelled *Main Approach.* If the publication did not feature any of the three abovementioned approaches, further description was provided.

3.1.2 Research method analysis

Next step was to identify which specific research methods were used within the publications. This sorting is labelled as *Research method.*

Aim of this determination was to further differentiate papers from each other based on the following:

- Whether the publication used one or many property valuation methods
- Whether the publication used a main or advanced approach

3.1.3 Key aspects

Moving forward, all *Key aspects* in the publications were listed. These aspects showcase what were the goals in corresponding papers, what framework was established before research was carried out and any other relevant information about respective publications.

In some cases, relevant and required information about each method was marked under *Key aspects* as a quick overview of necessary data required to replicate the method. This can be useful when determining which methods to use in latter stages on the research based on available data.

3.1.4 Variable determination and selection, additional data, and findings

Next step was to identify most relevant variables used within analysed publications. These finding were marked as *Variable 1*, *Variable 2,* and *Variable 3.*

Decision was made to note a maximum of three of the most influential variables per publication. If three variables could not be determined, cells were left unfilled. When deemed necessary, exceptions could be made by listing more variables which were required to replicate the method.

All extra information and key aspects which did not fall under previously mentioned captions, were listed under caption *Additional data and findings.* This was mainly information which was believed to be beneficial in the research.

3.1.5 Concluding the literature analysis

The final steps of literature analysis were selecting the method or methods which were used to carry out the research and coming up with initial set of variables relevant to selected approach and properties.

Research method/methods selection was done by comparing the available data on the properties and the goals of the research to the required information for applying each method. Once the approach to research was selected, variables were determined by analysing the input required for method application.

3.2 Local market data collection and processing

The second segment focused on data collection by interviewing real estate experts on three different occasions and processing gathered data in unison with variables determined during literature analysis. This goals for this segment were.

- To determine the most relevant variables from the experts' points of view.
- To compile a conclusive list of variables which to analyse during subsequent steps.
- To determine the weights of the variables in relation to each other.
- To determine the value of variables for each property.

3.2.1 Respondent selection

The first step on second segment was to determine the variety of experts to interview. This was done to increase the reliability of findings by including various professional viewpoints in the field. The selection of experts had to satisfy the following requirements.

- A range of different professions in the real estate field must be considered.
- The number of respondents must be broad enough to offset response bias.

3.2.2 Variable determination

First round of interviews was carried out between various experts from different professions within the real estate field. They were asked to name 10 to 15 variables and factors in no particular order, which are (in their professional opinion) important to consider whilst evaluating terraced houses.

3.2.3 Comprehensive list of variables

Next step was to compile the variables, determined from the literature and from interviewing the experts, into a comprehensive table that presented the number of times each variable was featured during the research. That table was then used to determine the relevancy of the variables and whether they will be included in the following stages of the research.

Chosen variables were assigned a category and presented with a unit of measure in constructing a new table that was used in the following steps of the research.

3.2.4 Variable weight determination

The second round of interviews were conducted to determine the individual weight of each variable. This was done by asking the experts to evaluate the variables on a predetermined scale in relation to each other in case of terraced houses.

3.2.5 Variable value determination

The third round of interviews were conducted to determine the values of variables on a predetermined scale. The experts were presented with equal amount of information for each property and were then asked to evaluate the features of the properties presented in the questionnaire based on provided information.

3.3 COPRAS Method

Complex Proportional Assessment or COPRAS in short, is a Multiple Criteria Approach which can be used for decision making between many variables. First introduced by Zavadskas and Kaklauskas in 1994, this method uses step-by-step ranking and evaluates set data in terms of significance (Ullah et al., 2022). The relevance and utility level of the accessible alternatives under the presence of mutually conflicting criteria are assumed to be directly and proportionally dependent in case of COPRAS method. It can calculate maximizing and minimizing criteria and takes into consideration both quantitative and qualitative criteria. Main upsides of COPRAS method are its ease of use and clear ranking system. COPRAS method is made up by six procedural steps:

- Step 1: Constructing the initial Decision Matrix
  As is custom to all multiple-criteria decision making cases, decision matrix needs to be formulated:

$$X = [X_{ij}]_{mxn} = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \quad (1)$$

  where:
  m - number of criteria;
  n - number of alternatives

- Step 2: Normalizing Decision Matrix
  Normalization procedure is used to transform performances of in consideration alternatives into comparable dimensionless values:

$$R = [r_{ij}]_{mxn} = \frac{X_{ij}}{\sum_{i=1}^{m} X_{ij}} \quad (2)$$

  where:
  X_{ij} - performance of the *i*-th alternative with respect to the *j*-th criterion;
  R - normalized value;
  m - the number or alternatives

- Step 3: Weighted Normalized Decision Matrix
  Next step is to construct Weighted Normalized Decision Matrix using the following formula:

$$D = [y_{ij}]_{mxn} = r_{ij} X W_j \quad (3)$$

  where:
  i=1, 2, ..., m;
  j=1, 2, ..., n

- Step 4: Sum of Weighted Normalized Decision Matrix
  The sums of maximising *(S_{+i})* and minimising *(S_{-i})* indexes can be calculated using the following formulas:

$$S_{+i} = \sum_{j=1}^{n} y_{+ij} \tag{4.1}$$

$$S_{-i} = \sum_{j=1}^{n} y_{-ij} \tag{5.2}$$

  where:
  i=1, 2, ..., m;
  j=1, 2, ..., n

- Step 5: Determining the relative significance of the alternatives
  Relative weight Q_i of the *i*-th alternative is calculated using the following formula:

$$\mathrm{Q_i} = \mathrm{S_{+i}} + \frac{\mathrm{S_{-min}} \sum_{\mathrm{i=1}}^{\mathrm{m}} \mathrm{S_{-i}}}{\mathrm{S_{-i}} \sum_{\mathrm{i=1}}^{\mathrm{m}} (\mathrm{S_{-min}}/\mathrm{S_{-i}}} \ (i = 1, 2, \ldots\ldots, m) \tag{6}$$

- Step 6: Calculate the quantitative utility.
  To determine ranking, quantitative utility U_i is calculated using following formula:

$$\mathrm{U_i} = \left[\frac{\mathrm{Q_i}}{\mathrm{Q_{max}}}\right] \times 100\% \tag{7}$$

  Alternative having the highest U_i % is the highest ranked.

Step 6 is final step of COPRAS method. From here forward, further steps have been developed as an addition to the COPRAS method for value calculation purposes. The whole progress is presented in Figure 3.

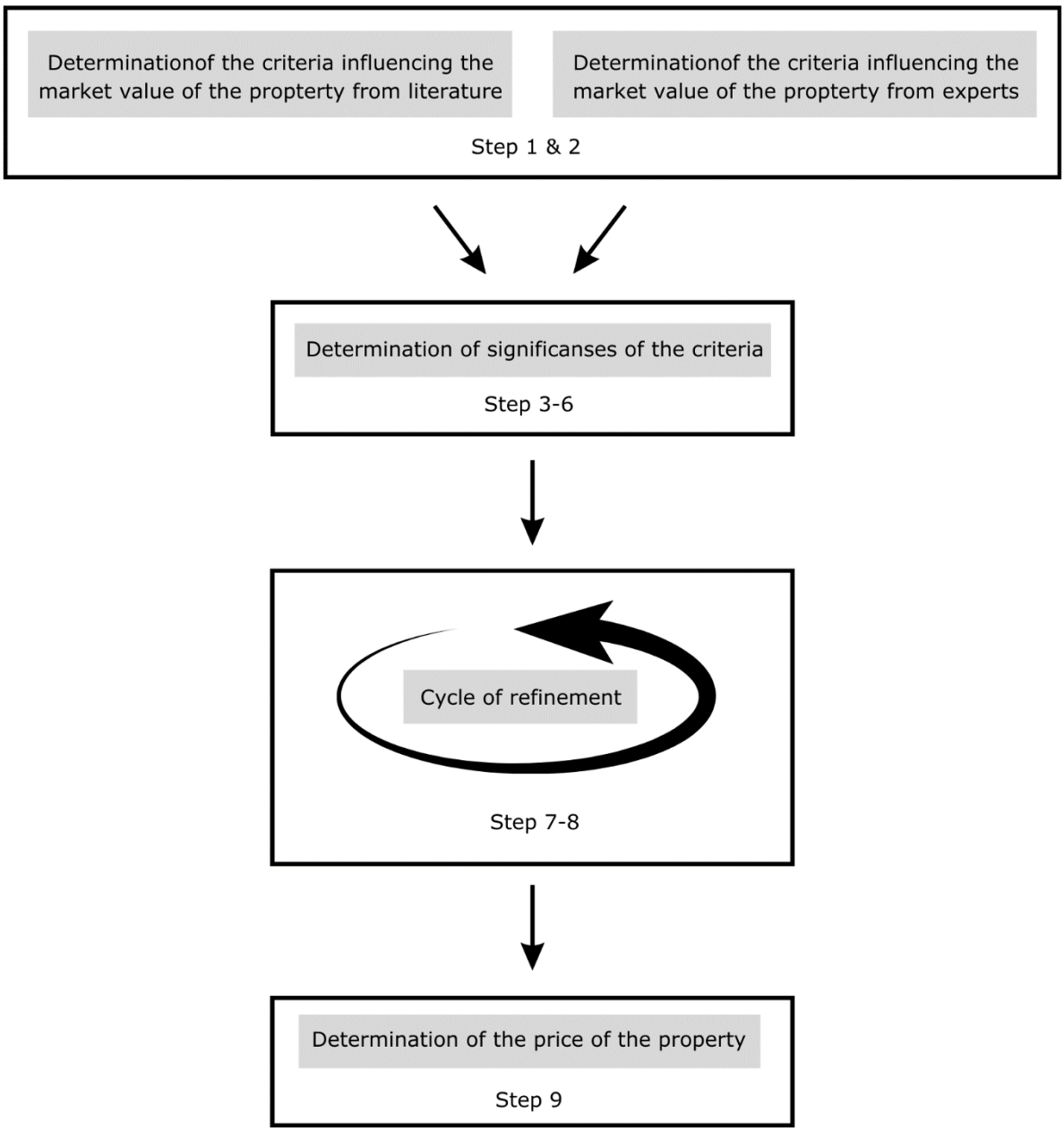

Figure 3 - MCDA process overview

Literature on the method did not provide a particular name for the following steps, rather it is called Multiple Criteria Decision Analysis or MCDA in short in general.

To construct Multiple Criteria Decision Analysis (MCDA) decision-making matrix on under evaluation properties, following stages need to be followed:

- Stage 1: Information about under evaluation property is collected.
- Stage 2: Criteria describing the aim of valuation needs to be set.
- Stage 3: Set values, weights and measuring units need to be set.
- Stage 4: All data from Stages 1-3 is collected into single decision-making matrix.

Multiple Criteria Decision Analysis method follows all the same formulas and steps as COPRAS method up until and including Step 6. From there MCDA method proceeds further in the following steps:

- Step 7: Degree of effectiveness E_x

  Degree of effectiveness is calculated to determine by what percentage in either better or worse way a property differs from another:

  $$E_{xj} = U_x - U_j \quad (8)$$

  where:

  $j = 1, n$

- Step 8: Mean deviation k_x

  Mean deviation is calculated using the following formula:

  $$k_x = \sum_{j=1}^{n} E_{xj}/(n-1) \quad (9)$$

  Mean deviation k_x must satisfy the condition

  $k_{ax} < \pm 1\%$,

  to proceed directly toward calculating final estimated property price.

  If the condition is not satisfied, a refinement process must be conducted.

- Step 9: Refinement of k_x (when required):

  $$V_{xp} = C_x(1 + k_x/100) \quad (10)$$

The identification of the values and their degrees of importance for the criteria characterising the alternatives is crucial phase in a multiple criteria decision analysis. Using expert and literature review techniques, levels of relevance of the criteria defining the quality and quantity of the criteria to be evaluated and values of the qualitative criteria for the alternatives are estimated.

4 CASE STUDY PROPERTIES

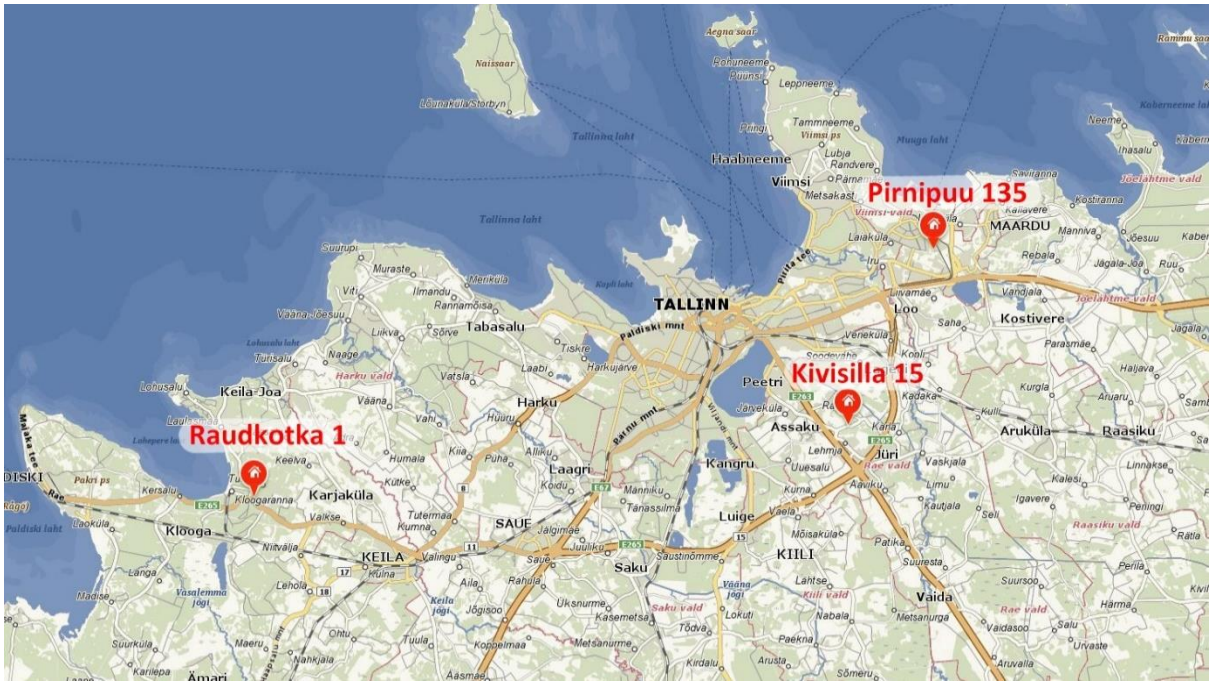

Figure 4 - Location overview

All three properties used within this research are terraced houses located in Harjumaa. Their positioning is featured in Figure 4.

The selection of which properties to use and analyse within this research was done on the following criteria.

- All properties must be terraced houses.
- All properties must be located in Harjumaa.
- All properties must be two-storey.
- All properties must be in similar state of repair.

4.1 Property X - Kivisilla 15, Rae, Harjumaa

Figure 5 - Kivisilla 15, source: ALG Liisingu AS

Located in Rae is a in progress development currently in project stage. Building under valuation is in plot with address Kivisilla 15. It will feature a four-unit two storey terraced house. Each unit has total area of 119 m² of which 85,5m² is living quarters, 33,5 m² in combined area of terrace and balcony. Plot size is 1677 m² of which each unit will have claim for one fourth given by order of use. Each unit will also have two private parking spaces on the withing the plot.

First floor consists of open kitchen and living room, a bathroom/toilet with sauna, hallway with storage room, a terrace, and a housekeeping room. Second floor features two bedrooms with separate balconies, a stairs hall, and a bathroom/toilet.

Building will be stone construction; heating system is planned as ground heating based on air-water heating system. Ventilation will be with heat recovery system and on request will also feature a cooling capability. Each unit will also have a chimney installed

as a readiness to install a fireplace if client so wishes. Building is planned to have energy class A with solar panels installed on the roof.

Landscape is planned as classical solution – grass in the backyard, paving stones in the front. Plot will be bordered with metal fencing with automatic gates/barrier allowing entrance to the units.

Räägusilla is located 10,5 kilometres from Tallinn city centre, driving time during average traffic conditions is 12 minutes. All the roads from Kivisilla 15 to Tallinn city centre are well maintained asphalt roads. Closest shop is Peetri Selver, which is 5 kilometres or a 7-minute drive. Closest bus stop is 1 kilometre and closest school Kindluse Kool is 3,4 kilometres away.

All units will be sold with use permits, as new and with 2-year warranty.

4.2 Property A - Raudkotka 1, Lääne-Harju, Harjumaa

Figure 6 - Raudkotka 1

Located in Tuulna village near Kloogaranna is Raudkotka 1 - a three-unit two storey terraced house built on 2016. Each unit is made up of 98,6 m² living space, 11,6 m² terrace and 3,5 m² utility/storage room. Plot size is 2618 m² and each unit has rights to one third of this based on order of usage. Parking is not set by order of usage; however, land is big enough that there is room to park at least 2 cars per unit.

First floor consists of kitchen (newly built, unused, and fully equipped), living room, hallway, anteroom, utility/storage room and bathroom/toilet with sauna. Second floor has three bedrooms, storage room, hallway, and toilet.

Building is of wood construction; heating system is split between air-air heating pump and electric radiators. Ventilation is natural operated by open-close fresh air valve except for bathroom, which has motor operated air extraction valve. Building has not been given an energy class.

Whole plot is covered with grass, including parking areas. Corner of the land also features a pond which operates as fire emergency water pumping location. Metal fencing surrounds the whole plot with metal gates at the entrance to the premises.

Raudkotka 1 is located 36,4 kilometres from Tallinn city centre, driving time during average traffic conditions is 36 minutes. First 200 meters of road from Raudkotka to Tallinn is of gravel, rest of the roads are well maintained asphalt roads. Closest shop is Treppoja, which is 550 meters away. Closest bus stop is 250 meters, and it has direct bus route to Laulasmaa School, which is 4,5 kilometres away.

All three units have use permits, are used, and were sold with warranty on hidden defects.

4.3 Property B - Pirnipuu 135, Maardu, Harjumaa

Figure 7 - Pirnipuu 135, source: ALG Liisingu AS

Located in Muuga Aedlinn, Pirnipuu 135 in a three-unit two storey terraced house built in 2020. Each unit is made up of 95,9 m² living area, 3,5 m² storage room and 1,7 m² utility room. Furthermore, on the 1st floor there is a terrace (12,9 m²) and on the second floor a balcony (5,9 m²) which give a total area of 119,9 m². Each unit has 2 personal parking spaces and rights to one third of the 1020 m² land based on order of usage.

First floor includes an open kitchen (without any furniture or equipment), hallway, utility room, bathroom/toilet with sauna and living room. On the second floor, there are 3 bedrooms, a bathroom/toilet, and a hallway.

Building is of stone construction; heating system is floor heating operated on air-water heat pump. Ventilation system is with heat recovery capabilities. Building has been given energy class B. Each unit also has a chimney for a fireplace possibility.

Landscaping features basic solutions – grass covers most of the land, except for front side of the units which has been done with pavements stone. Whole plot is surrounded my metal fencing.

Pirnipuu 135 is located 14,9 kilometres from Tallinn city centre, driving time during average traffic conditions is 20 minutes. All the roads from Pirnipuu 135 to Tallinn city centre are well maintained asphalt roads. Closest shop is Muuga Maxima, which is 2,8 kilometres or 5 minutes' drive away. Closest bus stop is 350 meters and from there, one can access the closest school Lasnamäe Põhikool, which is 8,4 kilometres away.

All three units have use permits, are unused and were sold with 2-year warranty.

5 RESULTS AND DISCUSSION

This chapter presents the results and discussions of the research in the following sections:

- Findings from the literature
- Local market data collection and processing

5.1 Findings from the literature

5.1.1 Main approach categorisation

First step in the first segment was categorising the publications based on their main approaches. A total of 30 different scientific publications were analysed and categorised based on their main approach in the first step of research. A breakdown of their frequency is presented in Figure 8.

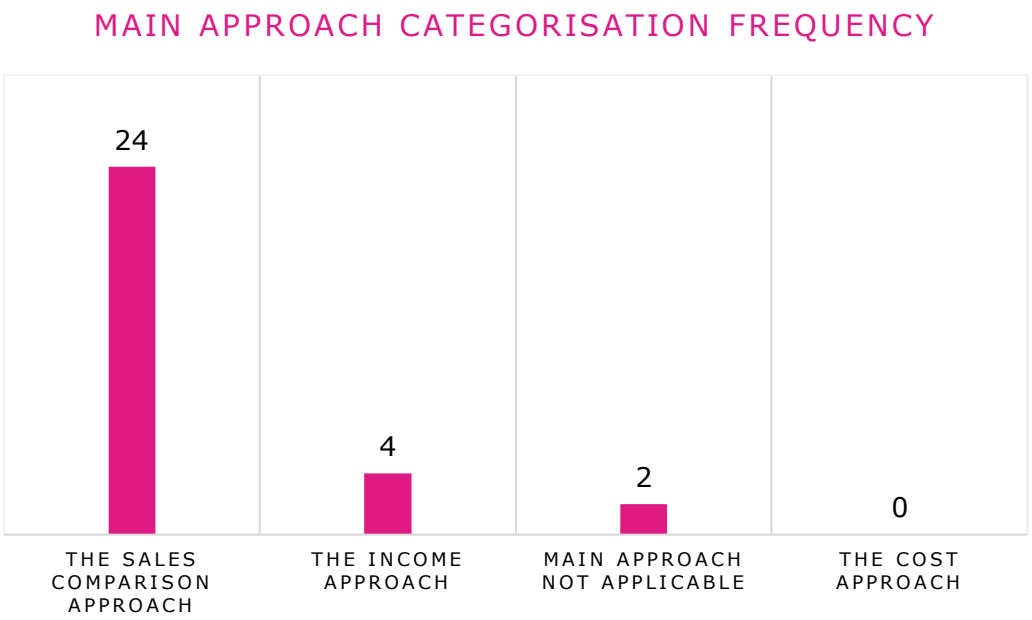

Figure 8 - Breakdown of frequency of Main Approach variants

Sales Comparison was the most popular method, with a total of 24 occurrences out of 30. This is not surprising considering, that this method is widely used in property valuation since it is seen as the most conclusive and accessible method.

The Income Approach was used on four instances. Considering that this research focused on terraced houses and the Income Approach is most beneficial in evaluating rental properties and office buildings, it is understandable that the Income Approach did not feature more often.

Lastly, on two instances, the main approach was not applicable on the account that these publications used different kinds of approaches. One on these publications focused on discussing different variables and how to they are affected by various factors. The second publication focused on analysing how a single mass appraisal method works and what input data is required to use the method.

The Cost Approach was not featured in any of the publications. Most logical reason to explain that would be the fact that the Cost Approach is predominantly used for insurance replacement purposes and rarely used to appraise faultless properties.

The full overview of researched publications and their determined main property valuation approaches are presented in Table 1.

Table 1 - Main approach and source overview

Property valuation approach	**References**
The Sales Comparison Approach	(Meszek, 2013), (Abidoye & Chan, 2018), (Jiang & Wang, 2020), (Alqaralleh & Canepa, 2020), (Linh, 2020), (Heyman & Sommervoll, 2019), (Gaetano Lisi, 2021), (Stepanyan et al., 2010), (Komagome-Towne, 2017), (Zietz et al., 2007), (Mimis et al., 2013), (Fan et al., 2006), (Jayasekare et al., 2019), (Rudokas et al., 2019), (Blanco & Flindell, 2011), (Ayan & Erkin, 2014), (Jim & Chen, 2009), (Kim et al., 2010), (Wen et al., 2004), (Selim, 2009), (Abidoye & Chan, 2017), (Ebru & Eban, 2011), (Maliene, 2011) (Kaklauskas et al., 2010)
The Income Approach	(Giudice et al., 2017), (Abidoye & Chan, 2018), (Crespo & Crespo, 2013), (Del Giudice et al., 2017)
Main approach not applicable	(Abidoye & P.C. Chan, 2016), (Bunyan Unel & Yalpir, 2019)
The Cost Approach	Not featured in any publications

5.1.2 Research method analysis

Second step was determining the exact research method(s) of each publication. These methods were divided into five categories based on what type of research was done. These categories were: advanced approach, single determinant study, multiple determinants study, advanced method comparison, and market analysis. A precise breakdown is presented in Figure 9.

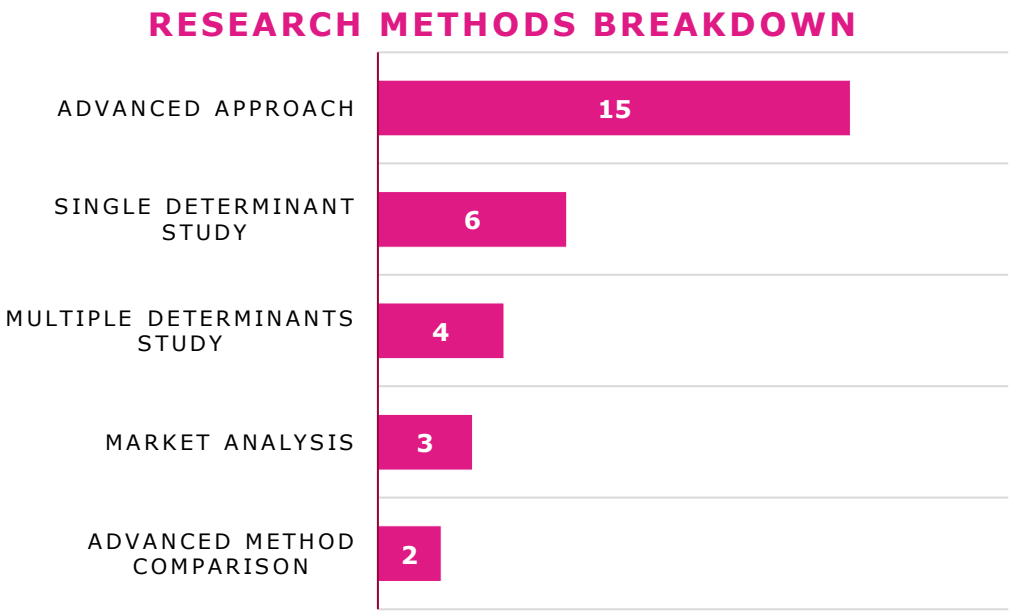

Figure 9 - Literature research methods breakdown

5.1.2.1 Advanced approaches

Half of the publications (15 out of 30) focused on evaluating properties using a single advanced approach. Research was done by either trying to apply the advanced method in certain location or by operating the method within desired framework.

Most frequently applied advanced property valuation approach was Hedonic Pricing Method (HPM). In 7 out of 30 publications the Authors were adapting and applying HPM to value properties in their chosen locations.

The second advanced property valuation method, Artificial Neural Network (ANN), was featured in 2 out of 30 publications. The Authors were researching how ANN method works and how to determine the most relevant factors for the application.

One publication out of 30 analysed and used the Decision Tree (DT) approach. The Author's research was focused on evaluating the usefulness of DT by determining the relationship between property prices and property characteristics.

On a single occasion, the Analytic Hierarchy Process (AHP) was featured. The research consisted of presenting the possibilities AHP has, and the requirements needed to use

the method. Furthermore, an overview of the whole application process was provided and executed.

Multiple Criteria Decision Analysis (MCDA) featured in two publications. Both researches focused on adapting the MCDA method to their respective locations and using gathered data to evaluate a property.

Fuzzy Logic (FL) based advanced research method was featured in one research. The Authors looked to pinpoint key aspects which are required to make FL method work instead of trying to use it within desired framework.

And finally, on research featured the advanced property valuation method named Genetic Algorithms (GA). The goal for the research was to explain relationship between rental prices and geographical location. The research was carried out to determine the maximum and minimum property values between which all observed units must fit. The Authors also presented the pros and cons of GA method together with scenarios when using GA as a method to value property could be and will not be useful.

5.1.2.2 Single determinant study

Coming in as the second most frequently featured category, Single Determinant Study was featured in 6 publications out of 30. In five of those researches, HPM was used as the base model to analyse the subject determinant and the one other research focused on identifying all the aspects that go into a single determinant.

The singular determinant research, which did not use HPM as a base for calculations, was Location. The Authors identified the different approaches and degrees of importance location as a determinant has to be considered.

View as a single determinant was researched and analysed on two separate publications, both based on the theory of HPM. One of these researches focused determining the degree of influence view has on property value and the other publication conducted research to determine the ranking for different types of views. Both researches were based on analysing how different groups of people value the same view and how influential that determinant if for then when selecting properties.

Following that, Heritage and Historic Environment was researched as a singular determinant in property valuation. The publication focused on determining whether and how heritage and historic environment could play role as a determinant in property valuation.

Next study on the influence of a singular determinant was a publication analysing the value of Air Quality in property valuation. The research examined multiple same-location

property sales and air quality data in attempt to determine the direct relationship between air quality data and property value changes.

And finally, the last single determinant that came up during the literature review was Road Noise. The study used HPM model to research how noise pollution can affect property prices.

5.1.2.3 Multiple determinants study

Out of 30, four publications can be categorised as Multiple Determinants Studies. In those researches, the Authors were analysing the relationships between selected number of variables and property values. Three of those researches were built to identify how a set range of determinants affect property value and what further assumptions could be made based on those findings. In the fourth publication, the Author aimed to deconstruct how each determinant could affect property value in different markets and circumstances.

5.1.2.4 Market analysis

Research categorised as Market Analysis was reviewed on three instances. Each of those researches focused on analysing and explaining different unmeasurable factors that affect property value.

The first research, which carried out market analysis for understanding government influences as factor in property valuation, dug deeper to determine the various methods how governments can influence property valuations and how it can be manipulated to achieve desired effects. The publication also provided an explanation for why government influence can be important in different types of market movements.

The second Market Analysis conducted comparative research on six metropolitans with the goal to explain asymmetric behaviours during market shifts. The research required identifying the factors which affect property values likewise in most or all examined metropoles.

The last research conducted analysis on uncertainty and information inefficiency in property valuation. The authors carry out in-depth market research with the goal to identify factors which most likely may cause discussed uncertainty and information inefficiency.

5.1.2.5 Advanced method comparison

The final category that was featured on two occasions, was Advanced Method Comparison. Both of the publications use Hedonic Pricing Method and Artificial Neural Network approaches to determine the values of selected properties and then carry out

comparisons to determine the strengths and weaknesses of both approaches. They also examine the how useful either method would be in certain predetermined scenarios.

5.1.3 Key aspects

Next step of the research was to identify the Key Aspects in each publication. These Key Aspects were essential for marking down important information about each publication as they could provide useful insights in later stages of this research. Up to three Key Aspects were determined per publication, but in most cases, one or two were plenty to present all the information. This chapter is used to provide explanations behind different types of Key Aspects.

To begin with, for publications that used Hedonic Pricing Method (HPM) to conduct the research, Key Aspects showcase either what limitations were set before carrying out research, or what were the major takeaways in each publication. These notes were taken as a possible example for what limitations might have to be set if I decide to use HPM to conduct my research.

In publications that carried out comparisons between advanced property valuation methods, Key Aspects showcased what data was used to conduct the research and what questions were raised to be answered.

In case of publications focusing on Multiple Determinants, Key Aspects state the goals of the research.

5.1.4 Additional data and findings

Additional Data and Findings columns were used to provide extra information which might be crucial in the next stages of this research.

In case of most publications belonging in the Advanced Methods Category, Additional Data and Findings provide information on what were the outcomes of the research and what are potential dangers that have to be accounted for if said method is chosen for case study research.

For one publication on Multiple Determinants, additional data features two more property valuation variables since the data collection was done through public research and all those variables were determined to be of same importance.

In case of Fuzzy Logic research, additional data column is used to mark down how Fuzzy Logic method works and how I could be used for my research.

5.1.5 Variable determination

In papers, which focused solely on Hedonic Pricing Model, variables were listed by the Authors. Since HPM gives variables weighted values, selection was done based on Authors' weighing data.

Papers that analysed a single HPM determinant, variables were provided from the introduction, however in some cases a single variable was portrayed in many perspectives or parts. I have noted down these if it was so presented.

Analytic Hierarchy Process was a one-off approach in the literature which I analysed, therefore I focused more on how beforementioned method is built. Variables point out main requirements and data which are necessary for the method to work.

In papers which focused on drawing comparisons between HPM and ANN, I wrote down variables which Author determined to be the most influential within both method analysis progress.

In one of the papers that was exclusively using ANN as their research method, I listed out variables which were most influential in given research. The other paper which discussed ANN method, no specific variables were relevant since the paper was focused on the theoretical aspects behind the ANN method. For that reason, I wrote down key elements which Author proposed to be basis for ANN method development.

In papers that focused on multiple determinants and how they influence property valuation, variables showcase the most influential factors on case-by-case examples.

Research, which featured comparisons between 6 different metropolitans, variables were not featured but rather the paper analysed property value as whole, therefore no variables are presented.

Fuzzy logic method does not feature a set list of variables; therefore, none are marked down.

As decision tree focuses on making decisions based on relevant variables, I wrote down three on the most commonly occurring variables during different scenarios.

Market analysis research papers focused on a single variable and therefore only a single variable can be written down.

Genetic algorithms method uses a small number of variables which are assigned relevancy percentages. I noted down three variables which had the highest relevancy set by the Authors.

5.1.6 Overview of variables found in literature

This chapter will break down the findings and provide a discussion on all the variables determined and presented during the Literature Review segment of this research starting from the variable with the most occurrences. All the variables and their frequencies are summarised in Figure 10.

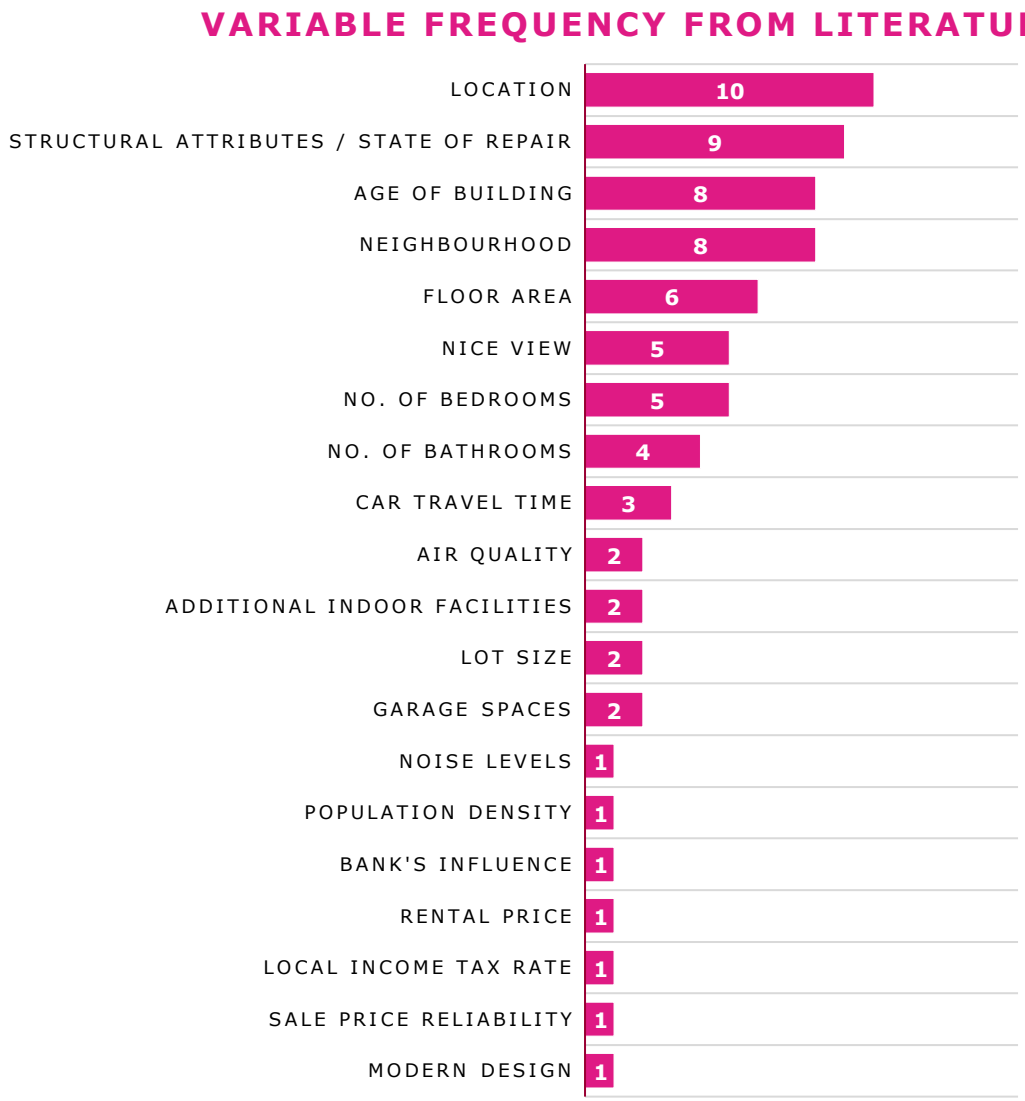

Figure 10 - Frequency of variables determined from literature review

The Literature Review culminated in a list of 20 unique variables that were determined to have the highest influence when evaluating various types of properties. These variables may affect terraced housing evaluation and should be considered in the next stages of the research.

The variable with the most occurrences was Location and that was to be expected considering that in all the publications examined during the first segment that featured Location as a variable, it was the found to be either one of the most or the most

important variable when determining property value. Location can also be linked with Car Travel (featured three times) considering they are dependent on one-another.

Next variable came up on 9 occasions and that was Structural Attributes/State of Repair. This variable is rather comprehensive considering nearly all aspects of a property, whether it is the foundation or the roof, the fence, or the ventilation unit, all these parts can be described to some extent with this variable. Considering this, Structural Attributes/Stage of Repair was bound to be one of the more frequent variables.

In some parts, the next variable Age of Building links with the previous one. Higher age is often linked with worse state of repair as a diminishing factor and that might explain most the eight times that Age of Building came up as variable to consider when conduction property valuation. It is still important to remember that, as it was established during literature review, higher age can be interpreted as a positive factor when it comes to historically relevant objects. However, in the context of terraced houses in Harjumaa, it is unlikely that some terraced houses have historical value.

Up next, also with eight occurrences, is the variable Neighbourhood, which might often be considered the same as Location but in reality, it is a stand-alone variable which plays a big part in property valuation since it is an indication of safety and life-comfort.

Moving on, next variable was Floor Area and that featured on six instances. This can be linked with No. of Bedrooms and No. of Bathrooms, which featured respectively on five and four instances, since they all refer to the size on the property. Also, Garage Space and Lot Size, both with two occurrences can be added here since they too are references to the size of the property.

Second to last, Nice View, Air Quality and Additional Indoor Facilities are variables that come up more than once, but they are very much linked with personal preferences and therefore difficult to get exact valuations for.

Final variables that came up just once were such variables like: Noise Level, Population Density, Bank's Influence, Rental Price, Local Tax Income Rate, Sale Price Reliability and Modern Design. All these variables are important and should be considered when the occasion demands that, but it is doubtful that they will play big role on the final outcome.

5.1.7 Discussion and conclusion of literature review results

Based on the results and discissions of the literature review provided during Section 5.1, it is apparent that several advanced property valuation methods are suitable to carry out the next segments of the research. It is also clear that each of those methods has

its benefits and drawbacks, therefore it is important to determine the best suited approach for evaluating properties presented in Chapter 4.

After researching and comparing various property valuation methods, a hybrid of Multiple Criteria Decision Analysis (MCDA) and Complex Proportional Assessment (COPRAS) was selected as the preferred method of research. COPRAS will be used in the first part to determine the importance of selected variables and their values in selected properties. COPRAS method will end with determining the ranking amongst the three properties and from there, a MCDA based approach will be used to appraise the focus property.

5.2 Local market data collection and processing

This chapter presents and discusses the results obtained from the second segment of research. Said research was conducted in step-by-step manner in form of variating questionnaires and data processing's.

- The first step of this segment was to come up with variables which should be considered when appraising terraced houses in Harjumaa.
- Next step was to compile variables from experts and literature review into a single table and determine which will be used further and which are eliminated.
- Once the list was set, the weights of chosen variables were determined.
- Final step was to determine the value of each variable in provided properties.

5.2.1 Discussion of variables

An initial set of 20 unique variables was acquired from Literature Review. Considering those 20 variables are deducted from 30 different sources of literature originating from all over the world, their relevance and conclusiveness describing terraced house market in Harjumaa cannot be determined. Majority of the articles were analysing either private houses or apartment buildings, none were considering terraced houses. Therefore, further research was required to generate a list the variables, which are most crucial and influential for appraising terraced house properties in Harjumaa. Decision was made that the most conclusive and thorough method to compile beforementioned list of variables, was to question experts familiar with Estonian terraced housing market.

A set of rules for experts' selection were established to compile as comprehensive array of experts as possible. There rules were:

- Expert must have at least 2 years of professional experience in real estate field.
- The selection must include experts who represent both sellers' and buyers' interests.
- No profession may occur more than twice.

- Experts may not have any personal interests regarding the selection of case study properties, nor may they know the final complete selection.

In total, four experts were selected and questioned. An overview of chosen experts is presented in Table 2. Questioning was conducted in form of one-on-one interview, in which experts were asked to list ten to fifteen variables, which best describe terraced houses within Harjumaa borders. The data of case study properties was not presented to them for the sake of gathering as comprehensive list as possible.

Table 2 - Overview of experts

Overview of Experts				
	Expert 1	Expert 2	Expert 3	Expert 4
Profession	Real estate sales director	Real estate appraiser	Real estate development project manager	Real estate broker
Experience in the field	23 years	3 years	6 years	4 years

5.2.2 Results of questionnaire 1 – Determining variables

Table 3 presents the overview of all the variables given by the experts sorted in alphabetical order.

Table 3 - List of variables from expert survey

Results of questionnaire 1 - Terraced housing variables from experts				
	Expert 1	Expert 2	Expert 3	Expert 4
1	Balcony/terracce	Heating system	Complexity of project	Architecture (apprearance)
2	Construction materials	Interion decoration state	Energy label	Backyard privacy
3	Cost of utilties	Interior decoration quality	Heating system	Distance to shops/schools
4	Distance to neighbours	Landscaping	Location	Energy class
5	Distance to schools and kindergartens	Location	Parking space availability	Floor plan
6	Distance to shops	Lot size	Road contitions	Heating system
7	Dog walking areas	No. of bedrooms	School/kindergarten proximity	Interior quality
8	Landscaping	Parking options	Shop proximity	Location
9	Parking spaces (inc. guest spaces)	Placement of unit (middle or corner unit)	Utility networks	Neigbourhood safety
10	Personal storage room	Construction materials	Construction price	Age on the building
11	Playing grounds	Preinstalled builtins	Ventilatsion system	Neigbouring wall placement
12	Position of the Sun	State of building		Position of the Sun
13	Public transport	Unit size		Quality of building
14	Quality of roads	Ventilation		Sauna, garage, storeageroom availability
15	Storey	Year of construction		State of building

5.2.3 Data analysis

Findings presented in Table 3 allowed to better understand and determine what are the key variables in Estonian market that potential terraced house buyers analyse. Four experts gave a total of 56 variables, 37 of which were unique as presented in Figure 11.

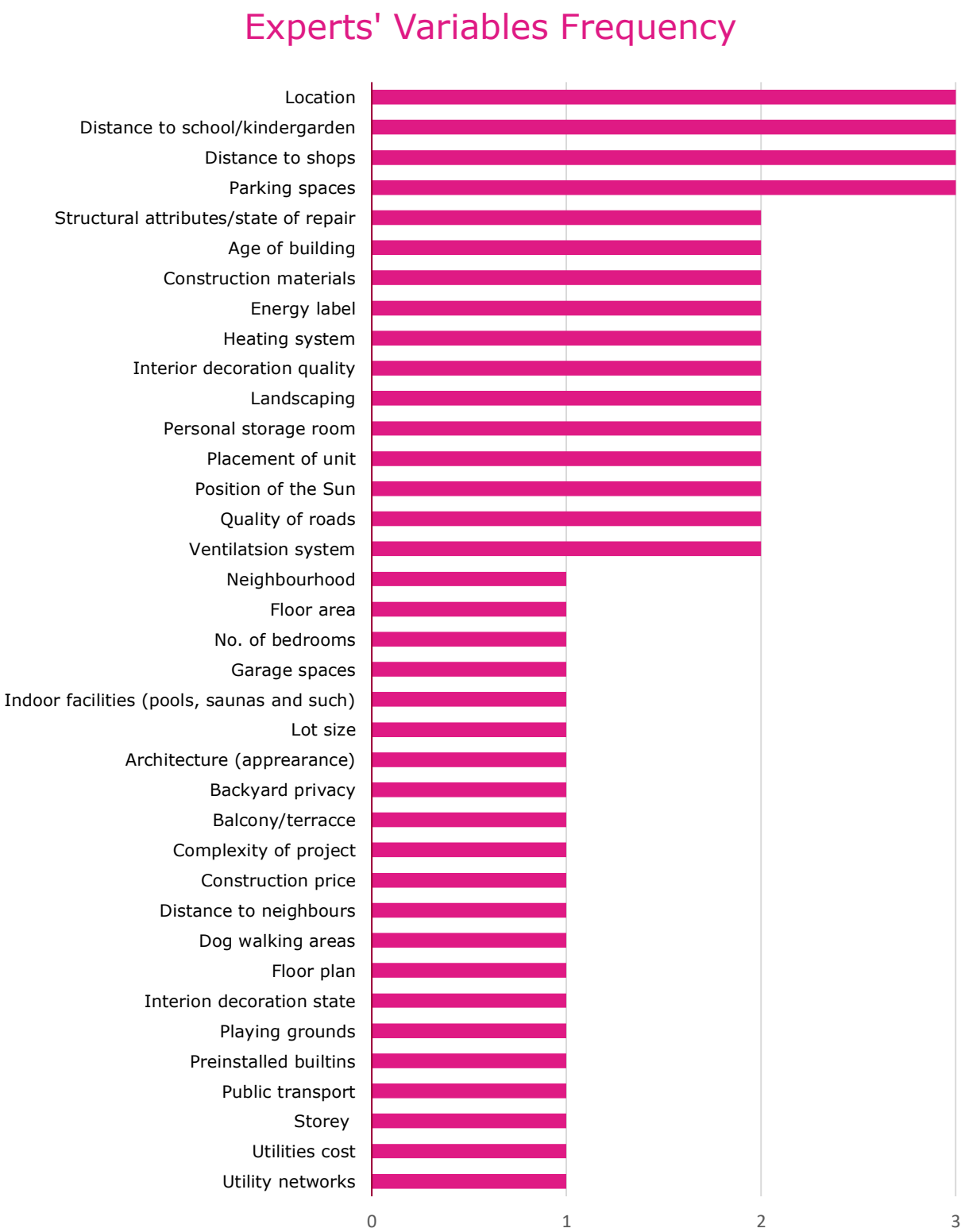

Figure 11 - Frequency of variables from surveying the experts

Most occurring variables were location; distance to school/kindergarten; distance to shops; and parking spaces, each mentioned on three occasions. All of these variables relate to accessibility and convenient positioning of the property considering day-to-day activities.

Twice mentioned variables are mostly related to the physical aspects of the property - these being: structural attributes or state of repair; age of the building; construction materials; heating and ventilation systems; energy label; interior decoration quality. These variables in unison describe the total condition of the building and predominantly are valued equally by buyers and sellers alike. Also mentioned on two occasions were the following variables – landscaping; placement of unit; quality of roads; position of the sun; and the size of personal storage area. These variables describe living comfort and the level of privacy therefore valuation is more diverse since it depends to personal preferences.

Mentioned on singular occasion were variables that either describe an extensive variable more if depth or outline other perspectives for valuating properties. Variables related to locational attributes that focus on more-in-depth description are neighbourhood; dog walking areas; playing grounds; and public transport. Property specific variables such as floor area; number of bedrooms; garage spaces; indoor facilities; lot size; architecture (appearance); backyard privacy; balcony/terrace; distance to neighbours; floor plan; interior decoration state; preinstalled built-ins; and storey are more dependent on personal preferences however they still contribute to the value of the property.

5.3. Combined variables

Combining variables gathered from surveying the experts and variables deducted from literature review, a total of 48 unique variables were established. Considering all these variables may not be suitable or relevant for describing the properties selected for this study, their relevancy was evaluated. Table 4 presents the frequencies of combined chosen variables from literature, from experts and their combined values.

Table 4 - Combined frequency of literature review and expert survey.

Variable	From literature	From experts	Combined
Condition of the building	9	2	11
Age of building	8	2	10
Neighbourhood	8	1	9
Internal floor area	6	1	7
No. of bedrooms	5	1	6
No. of bathrooms	4	0	4
Plot size	2	1	3
Parking spaces	0	3	3
Additional indoor facilities	2	1	3
Distance from city centre	3	0	3
Distance to school/kindergarden	0	3	3
Distance to shops	0	3	3
Structural materials	0	2	2
Heating system	0	2	2
Ventilation system	0	2	2
Area of storage rooms	0	2	2
Energy label	0	2	2
Landscaping	0	2	2
Quality of roads	0	2	2
Shared walls	0	2	2
Daily exposure to the Sun	0	2	2
Balcony/terracce	0	1	1
Interior decoration state	0	1	1
Public transport	0	1	1

5.4 Variable inclusion and exclusion

This chapter focuses on determining which variables to include and which to exclude for further consideration along with the reasoning behind every decision.

5.4.1 Included variables

Age of building was included since it was frequently occurring variable and the information is easily accessible.

Balcony/terrace was included since it is accessible information.

Car travel time was included since it occurred on multiple times and the data is quickly accessible.

Construction materials was included since the data is accessible.

Distance to school/kindergarten was included since it occurred on multiple times and the data is quickly accessible.

Distance to shops was included since it occurred on multiple times and the data is quickly accessible.

Energy label was included since it occurred on multiple times and the data is quickly accessible.

Floor area was included since it occurred on multiple times and the data is quickly accessible.

Garage spaces was included since it occurred on multiple times and the data is quickly accessible.

Heating system was included since it occurred on multiple times and the data is quickly accessible.

Indoor facilities (pools, saunas etc.) was included since it occurred on multiple times and the data is quickly accessible.

Interion decoration state was included as it is accessible information.

Landscaping was included as it is accessible information.

Location was included since it occurred on multiple times and the data is quickly accessible.

Lot size was included since it occurred on multiple times and the data is quickly accessible.

Neighbourhood was included since it occurred on multiple times and the data is quickly accessible.

No. of bathrooms was included since it occurred on multiple times and the data is quickly accessible.

No. of bedrooms was included since it occurred on multiple times and the data is quickly accessible.

Parking spaces was included since it occurred on multiple times and the data is quickly accessible.

Personal storage room was included since it occurred on multiple times and the data is quickly accessible.

Placement of unit was included since it occurred on multiple times and the data is quickly accessible.

Position of the Sun was included since it occurred on multiple times and the data is quickly accessible.

Public transport was included as it is accessible information.

Quality of roads was included since it occurred on multiple times and the data is quickly accessible.

Structural attributes/state of repair was included since it occurred on multiple times and the data is quickly accessible.

Ventilation system was included since it occurred on multiple times and the data is quickly accessible.

5.4.2 Excluded variables

Air quality was excluded considering that in Estonia air quality fluctuations are in most part physically indistinguishable and can only be measured by specific devices. Main exceptions would be larger city centres and properties near polluting industries. None of the case study properties are located near city centres nor industry pollution zones, therefore no data is available, and the variable can be considered nil-factor.

Architecture (appearance) was excluded on the grounds that this variable is unmeasurable and subject to personal preference. Therefore, this variable may offset other important factors and clutter results.

Backyard privacy was excluded considering that it is partially covered within other variables such as lot size and landscaping.

Bank's influence was excluded considering it would require extensive research into correlations between real estate sales data, bank's interests' rates, and other relevant factors.

Complexity of project was excluded since it subjective to personal/professional preferences and difficult to accurately measure.

Construction price was excluded considering that this information in mostly classified.

Distance to neighbours was excluded considering that in case of terraced houses this variable can be considered a constant.

Dog walking areas this variable was excluded since it was mentioned on a single occasion, and it is partially covered by neighbourhood and lot size.

Floor plan was excluded on the grounds that this variable is unmeasurable and subject to personal preference. Therefore, this variable may offset other important factors and clutter results.

Interior decoration quality was excluded since it is complex to measure and would require extensive research into each property.

Local income tax rate was excluded since it is not applicable in Estonian market.

Modern design was excluded on the grounds that this variable is unmeasurable and subject to personal preference. Therefore, this variable may offset other important factors and clutter results.

Nice view was excluded on the grounds that this variable is unmeasurable and subject to personal preference. Therefore, this variable may offset other important factors and clutter results.

Noise levels was excluded considering the lack of existing measurements on the subject and it is partially covered under other factors such as location and neighbourhood.

Playing grounds was excluded since it was mentions on a single occasion and partially covered under other variables such as location and neighbourhood.

Population density was excluded considering that all case study properties are located in similarly populated areas.

Preinstalled built-ins was excluded considering it is mentions on a single occasion and it is subject to personal preferences.

Rental price was excluded considering this research focuses on sale/purchase data.

Sale price reliability was excluded since it was mentioned on a single occasion, and it would require extensive research into causing factors and market sales data correlations.

Storey was excluded considering it was featured on a single occasion and all case study properties have the same storey, therefore it would be a nil-factor.

Utilities cost was excluded considering this variable in most part covered under other factors such as ventilation and heating systems. Also, it is dependent on personal preferences and would require researching private data.

Utility networks was excluded since it was mentioned on a single occasion and would require extensive research into the topic.

5.5 Chosen variables

5.5.1 Name simplification and clarification

Before moving on to analysing chosen variables any further, some cleanup and modifications were done.

Car travel time was renamed to **Distance from city centre** for more precise understanding and easily accessible data collection and processing.
Construction materials was renamed to **Structural materials** to convey the focus of this chosen property describing variable more accurately.
Garage spaces was renamed to **Parking spaces** considering only a fraction of Terraced houses in Harjumaa and none of the chosen case study properties have parking garages.
Storage room was renamed to **Area of storage rooms** since that allows to assign the variable a definitive measuring unit for very precise and easily accessible data gathering method.
Placement of unit was renamed to **Shared walls** as that eliminates the possible subjectiveness of this variable and warrants a more accurate data gathering method.
Position of the Sun was renamed to **Daily exposure to the Sun** because that eliminates the personal preference from Sunlight and allows to determine the values for each property based on floor plan and compass.
Structural attributes/state of repair was renamed as **Condition of the building** to clarify the concept of the variable.

5.5.2 Categorisation

The chosen variables were assigned into categories for further clarification. Variables and their assigned categories are presented in Table 5.

Table 5 - Chosen variables categorisation

Category	Variables
Evaluation of the building	• Age of building • Condition of the building • Structural materials • Heating system • Ventilation system
Quantitative criteria of the premises	• Internal floor area • Plot size • No. of bathrooms • No. of bedrooms • Parking spaces • Area of storage rooms • Balcony/terrace
Qualitative criteria of the premises	• Energy label • Interior decoration state • Landscaping • Additional indoor facilities (e.g., sauna)
Location and placement	• Distance from city centre • Distance to school/kindergarten • Distance to shops • Public transport • Quality of roads • Neighbourhood • Shared walls • Daily exposure to the Sun

5.5.3 Determining positive and negative values

Next step was to determine whether a variable characterises the property in a positive or a negative aspect. Variables that add value (benefits) to the property were given a "+" sign and variables that decrease the value (costs) were given a "-" sign. The assigned signs are presented in Table 6.

Table 6 - Value affects and units of measurement

Criteria	+/-	Units of measurement
Evaluation of the building		
Age of building	-	Years
Condition of the building	+	Points
Structural materials	+	Points
Heating system	+	Points
Ventilation system	+	Points
Quantitive assesment of the premises		
Internal floor area	+	Square meters
Plot size	+	Square meters
No. of bathrooms	+	Units
No. of bedrooms	+	Units
Parking spaces	+	Units
Area of storage rooms	+	Square meters
Balcony/terracce	+	Square meters
Qualitative assesment of the premises		
Energy label	+	Points
Interior decoration state	+	Points
Landscaping	+	Points
Additional indoor facilities (sauna etc)	+	Points
Location and placement		
Distance from city centre	-	km
Distance to school/kindergarden	-	km
Distance to shops	-	km
Public transport	-	km
Quality of roads	+	Points
Neighbourhood	+	Points
Shared walls	-	Units
Daily exposure to the Sun	+	Points

5.5.4 Units of measurement

Each variable was assigned a unit of measurement (presented in Table 6) which would allow to draw comparisons when valuating selected properties and rank said properties in relation to one another. That process was carried out concurrently with the determination of whether the variable describes the property in a positive or negative aspect.

Variables that could be compared conclusively by a mutual unit were described by that measurement. Such variables were as follows.

Age of building was given the unit years. Accuracy was set to full years; no decimal numbers may be presented. Predetermined guidelines were that the newer the building

is, the more value it holds. In regard to constructing the property valuation matrix, the age for new properties will be set as one (1) year. If the age for new properties was set to zero (0) years, the matrix would perceive the property as non-existent.

Internal floor area, plot size, area of storage rooms and **balcony/terrace** were given the unit square meters (m²). Accuracy was set to one decimal place. Considering all the chosen properties and their respective variables are within the same proportions, guideline was set as larger area holds more value.

No. of bathrooms, no. of bedrooms and **parking spaces** were assigned numeral units. Guideline was set that larger quantity holds more value.

Shared walls was also given the numeral unit measurement, however, the guideline for that variable was that larger quantity hold less value.

Distance from city centre, distance to school/kindergarten, distance to shops, and **public transport** were given the unit kilometres (km). Accuracy was set to one decimal place. Set guideline was that lesser distance holds more value.

For variables which could not be described by predetermined unit of measurement, creation of a ranking system based on a custom-made comprehensive unit was required. Variables that required such unit were **condition of the building; structural materials; heating system; ventilation system; energy label; interior decoration state; landscaping; additional indoor facilities; quality of roads; neighbourhood;** and **daily exposure to the Sun.**

5.6 Questionnaire 2 - Determining the weights of variables

This chapter focuses on determining the weights of variables through the use of expert surveying. In order to fulfil that goal, the following was carried out:

- Constructing a ranking scale together with a singular measuring unit based on linguistic terms
- Establishing expert selection criteria
- Creating a questionnaire template
- Expert interviewing
- Presenting and processing gathered data
- Calculating the weights of chosen variables based on collected data

5.6.1 Build-up

First step for building Questionnaire 2 was to, through the use us linguistic terms, create a weight establishing method for chosen variables. Proposed method had to feature a

ranking system that would allow to describe all chosen variables collectively and definitively in equal proportions using singular unit of measurement.

Table 7 - Linguistic terms and their numerical values

Linguistic term	Numerical value
Very low importance	1
Low importance	2
Moderate importance	3
High importance	4
Very high importance	5

A total of five linguistic terms were selected and each term was given a corresponding numerical point value as presented in Table 7. Accuracy was set to be determined for up to two decimal points.

5.6.2 Expert selection guidelines

The rules for expert selection and carrying out the survey section were as follows:

- Chosen experts had to be professionally linked to real estate markets
- Chosen experts had to have a minimum of one year of work experience in real estate
- Chosen experts may not have personal of professional involvements with case study properties
- A minimum of 10 experts had to be interviewed
- Each expert had to complete the questionnaire individually

5.6.3 Questionnaire template

Questionnaire 2 template is presented in the Appendix part of this thesis under the name **Appendix 1.1 Questionnaire 2 template.**

Questionnaire template was created using the chosen variables that were established in Chapter 5.5. All experts who participated in Questionnaire 2 were asked to assess the variables based on the following question:

"How important are each of the following criteria for Terraced housing evaluation in Harjumaa?"

For clarity purposes, variables in the template were sorted using their assigned categories.

5.6.4 Experts' and data gathering details

Variable weight determination survey was carried out from November 2022 to January 2023. During that time, a total of 17 experts were interviewed from 11 different real estate agencies across Tallinn.

The profiles of all the experts are presented in Table 8.

Table 8 - Expert profiles

#	Profession	Work experience in years
1	Real estate broker	26
2	Sales director	23
3	Sales director	20
4	Real estate broker	18
5	Agency manager	5
6	Real estate broker	5
7	Appraiser	3,5
8	Real estate broker	3
9	Sales director	3
10	Real estate broker	2,5
11	Sales partner	2,5
12	Real estate broker	2,5
13	Real estate broker	2
14	Appraiser	2
15	Real estate broker	1
16	Real estate broker	1
17	Appraiser	1

The average work experience of all the real estate experts was little over 7 years, with 26 years being the longest and 1 year being the shortest experience.

5.6.5 Results

Using data gathered from interviewing the experts, the weights of the chosen variables for describing Terraced houses in Harjumaa were calculated in following steps:

- Average variable importance values were calculated using formula (2) and presented in Table 9 under column named Average values
- Weights for each individual variable were determined using formula (3) and presented in Table 9 under column named Weights

Table 9 - Weights of variables

Variables		Importance ratings					Average values	Weights
		1	2	3	4	5		
Evaluation of the building								
1	Age of building	0	0	5	8	4	3,94	4,26
2	Condition of the building	0	0	1	7	9	4,47	4,83
3	Structural materials	0	1	4	6	6	4,00	4,32
4	Heating system	0	0	0	7	10	4,59	4,96
5	Ventilation system	0	1	9	4	3	3,53	3,81
Quantitive assesment of the premises								
6	Internal floor area	2	3	4	7	1	3,12	3,37
7	Plot size	0	3	9	4	1	3,18	3,43
8	No. of bathrooms	0	2	6	6	3	3,59	3,88
9	No. of bedrooms	0	0	2	6	9	4,41	4,77
10	Parking spaces	0	2	2	6	7	4,06	4,39
11	Area of storage rooms	0	2	3	5	7	4,00	4,32
12	Balcony/terracce	0	1	2	5	9	4,29	4,64
Qualitative assesment of the premises								
13	Energy label	0	0	7	7	3	3,76	4,07
14	Interior decoration state	0	2	6	9	0	3,41	3,69
15	Landscaping	1	5	6	5	0	2,88	3,12
16	Additional indoor facilities	0	2	7	5	3	3,53	3,81
Location and placement								
17	Distance from city centre	0	0	7	5	5	3,88	4,20
18	Distance to school/kindergarden	0	0	0	2	15	4,88	5,28
19	Distance to shops	0	2	1	11	3	3,88	4,20
20	Public transport	0	0	1	4	12	4,65	5,02
21	Quality of roads	0	3	6	4	4	3,53	3,81
22	Neighbourhood	0	1	6	9	1	3,59	3,88
23	Shared walls	0	2	9	3	3	3,41	3,69
24	Daily exposure to the Sun	0	2	1	10	4	3,94	4,26

5.7. Questionnaire 3 – Properties assessment

This chapter presents the individual variable values for all case study properties. The data collection and processing were carried out in the following steps:

- Generating valuation method for subjective variables
- Determining the values for non-subjective variables
- Establishing expert selection criteria
- Creating the questionnaire templates
- Expert interviewing
- Presenting and analysing collected data

5.7.1 Build-up

Once the weights of the selected variables were determined, next step of the research was to determine the specific variable values for each property. Considering that each variable is described by the same unit of measurement for all three properties, they could be collectively compared through that unit. Majority of values for selected criteria could be accurately determined as these variables are both tangibly measurable and factual, therefore impartial to opinion. Variables which did not fulfil both of the beforementioned criteria, required further research into determining their measuring units before their values could be established.

As to combat the immeasurability and subjectiveness of such variables, a uniting ranking system was required. A total of five different valuation units were created (Table 10), with each unit being given a linguistic and numeric value.

Table 10 - Variable valuation scale

Linguistic term	Numerical value
Very low value	1
Low value	2
Medium value	3
High value	4
Very high value	5

5.7.2 Measurable variable data collection process

Majority of the values for chosen variables were provided by the developer or collected from public sources and registers like *Ehitisregister* or *Maa-amet*. Some data was also provided by the Author based on predetermined guidelines. Presented in Table 11 are the sources where data was gathered for each chosen variable.

Table 11 - Measurable variable data collection process

Variable	Unit of measurement	Data source
Age of building	Years	Value was measured as number of years since the initial construction was concluded. If a property was newer than one year or construction was not finished, the value was set to 1.
Structural materials	Points	Value was assigned by the Author based on a customised ranking order of structural parts. The ranking order was created in collaboration with property valuators and civil engineers and is presented in Table 12.
Internal floor area	m²	Provided by the developer
Plot size	m²	Provided by the developer
No. Of bathrooms	Units	Provided by the developer
No. Of bedrooms	Units	Provided by the developer
Parking spaces	Units	Provided by the developer
Area of storage rooms	m²	Provided by the developer
Balcony/terracce	m²	Provided by the developer
Energy label	Points	Based on energy label index scale, a ranking scale was established, where label A equals 5; B equals 4; C equals 3, D equals 2 and E to H equals 1 (including of a lable is not provided)
Additional indoor facilities	Points	A valuation system was created where every additional indoor facility is worth one point. In case of examined properties, sauna is seen as a only additional facility
Distance from city centre	km	Measured from Tallinn city centre to the address of the property using the shortest public route
Distance to school/kindergarten	km	Measured from the property to the closest public school using shortest suggested route.
Distance to shops	km	Measured from the property to the closest grocery store using the shortest suggested route
Public transport	km	Measured from the property to the closest public transport stop which provided commute to Tallinn city centre
Quality of roads	Points	Value was assigned by the Author based on the proportion of unpaved roads.
Shared walls	Units	Value was determined by counting the number of shared walls and multiplying that with number of floors.

Table 12 – Structural materials ranking order

Structural element	Ranking order
Foundation	RC slab < RC strip < RC post
Floor construction	Concrete < RC/metal beams < Wood beams
Load bearing walls	RC/stone blocks < Metal posts < Prefab timber panels < Timber posts
Non-bearing walls	Stone < Drywall < Timber panels
Roof framework	RC panels < Metal beams < Timber beams

5.7.3 Expert selection guidelines

The guidelines for expert selection were as follows:

- Previously interviewed experts may not be selected
- Chosen experts had to be professionally linked to real estate markets
- Chosen experts may not have personal of professional involvements with case study properties
- A minimum of 15 experts had to be interviewed
- Each expert had to complete the questionnaire individually

5.7.4 Questionnaire template

Questionnaire 3 templates are presented in the Appendix part of this thesis under the following names:

- **Appendix 1.2 Questionnaire 3 template Property X**
- **Appendix 1.3 Questionnaire 3 template Property A**
- **Appendix 1.4 Questionnaire 3 template Property B**

Questionnaire templates were created using the variables that were determined to be subjective and therefore require assessments from experts. These variables were: condition of the building; heating system; ventilation system; interior decoration state; landscaping; neighbourhood; daily exposure to the Sun.

All experts who participated in Questionnaire 3 were asked to assess the values of presented variables based on the following question:

"Based on the information provided, how would you rate the value these criteria give to this building?"

5.7.5 Experts' and data gathering details

Property valuation survey was carried out from January 2023 to March 2023. During that time, a total of 19 experts were interviewed from 8 different real estate agencies across Tallinn.

Each questionnaire together with corresponding information about that property was presented individually to increase data accuracy. Respondents were also asked not to adjust their valuation based on previously valued property.

5.7.6 Results

Using beforementioned methods and guidelines, the values for all three properties were collected and summarised in Table 13.

Table 13 - Variable value data on selected properties

	Criteria	Unit of measurement	Property X under valuation	Comparable property A	Comparable property B
Evaluation of the building					
1	Age of building	Years	1	5	2
2	Condition of the building	Points	4,47	3,05	4,42
3	Structural materials	Points	5	2	4
4	Heating system	Points	4,37	2,37	4,37
5	Ventilation system	Points	4,11	2,42	3,95
Quantitive assesment of the premises					
6	Internal floor area	Square meters	85,5	98,6	101,1
7	Plot size	Square meters	1677	2618	1020
8	No. of bathrooms	Units	2	2	2
9	No. of bedrooms	Units	3	3	3
10	Parking spaces	Units	2	1	1
11	Area of storage rooms	Square meters	3,6	2,3	3,5
12	Balcony/terracce	Square meters	33,2	11,6	17,8
Qualitative assesment of the premises					
13	Energy label	Points	5	2	4
14	Interior decoration state	Points	3,26	3,16	2,89
15	Landscaping	Points	3,05	3,00	2,84
16	Additional indoor facilities	Points	1	1	1
Location and placement					
17	Distance from city centre	km	9,8	36,4	14,7
18	Distance to school/kindergarden	km	3,4	4,5	8,1
19	Distance to shops	km	5,3	0,6	3,0
20	Public transport	km	1,1	0,3	0,4
21	Quality of roads	Points	5	4	5
22	Neighbourhood	Points	3,37	3,11	3,32
23	Shared walls	Units	2	2	2
24	Daily exposure to the Sun	Points	3,47	3,32	3,42

6 MULTIPLE CRITERIA DECISION ANALYSIS

Table 14 - Grouped decision matrix of MCDA of terraced housing properties

	Criteria	+/-	Units of measurement	Weight, %	Comparable properties		
					X	A	B
1	Selling price	-	1000 €	100,00	280	195	290
Evaluation of the building							
2	Age of building	-	Years	4,26	1	5	2
3	Condition of the building	+	Points	4,83	4,47	3,05	4,42
4	Structural materials	+	Points	4,32	5	2	4
5	Heating system	+	Points	4,96	4,37	2,37	4,37
6	Ventilation system	+	Points	3,81	4,11	2,42	3,95
Quantitive assesment of the premises							
7	Internal floor area	+	m²	3,37	85,5	98,6	101,1
8	Plot size	+	m²	3,43	1677	2618	1020
9	No. of bathrooms	+	Units	3,88	2	2	2
10	No. of bedrooms	+	Units	4,77	3	3	3
11	Parking spaces	+	Units	4,39	2	1	1
12	Area of storage rooms	+	m²	4,32	3,6	2,30	3,50
13	Balcony/terracce	+	m²	4,64	33,2	11,6	17,8
Qualitative assesment of the premises							
14	Energy label	+	Points	4,07	5	2	4
15	Interior decoration state	+	Points	3,69	3,26	3,16	2,89
16	Landscaping	+	Points	3,12	3,05	3,00	2,84
17	Additional indoor facilities	+	Points	3,81	1	1	1
Location and placement							
18	Distance from city centre	-	km	4,20	9,8	36,4	14,7
19	Distance to school/kindergarden	-	km	5,28	3,4	4,5	8,1
20	Distance to shops	-	km	4,20	5,3	0,55	3
21	Public transport	-	km	5,02	1,1	0,3	0,4
22	Quality of roads	+	Points	3,81	5	4	5
23	Neighbourhood	+	Points	3,88	3,37	3,11	3,32
24	Shared walls	-	Units	3,69	2	2	2
25	Daily exposure to the Sun	+	Points	4,26	3,47	3,32	3,42

To implement multiple criteria decision analysis, the details on properties Kivisilla 15 (property X), Raudkotka 1 (property A) and Pirnipuu 135 (property B) were collected and grouped in a summarised decision-making matrix (Table 14). The list of criteria was determined as a combination of literature analysis and data provided by local real estate experts. The weights for each variable were calculated through the process of expert

valuation of criteria by assigning linguistical terms to ranking scale (Table 7). Values for factual criteria were determined by data provided by the developer and information collected from public registers. For criteria which were subjective to personal preferences, a custom ranking scale was created (Table 10) and experts were asked to rate properties on said scale based on information provided to them.

6.1 Calculation process

The initial decision-making matrix was weighted and normalized by using formulas (1), (2) and (3) and the results are presented in Table 15.

Table 15 - Results of terraced housing MCDA

Variables	**+/-**	**Weight, %**	**Comparable properties**		
			x	A	B
Selling price	-	100,00	36,601	25,490	37,908
Age of building	-	4,26	0,532	2,662	1,065
Condition of the building	+	4,83	1,809	1,234	1,788
Structural materials	+	4,32	1,965	0,786	1,572
Heating system	+	4,96	1,951	1,058	1,951
Ventilation system	+	3,81	1,495	0,882	1,438
Internal floor area	+	3,37	1,010	1,165	1,194
Plot size	+	3,43	1,083	1,691	0,659
No. of bathrooms	+	3,88	1,293	1,293	1,293
No. of bedrooms	+	4,77	1,589	1,589	1,589
Parking spaces	+	4,39	2,193	1,097	1,097
Area of storage rooms	+	4,32	1,647	1,061	1,615
Balcony/terracce	+	4,64	2,461	0,860	1,320
Energy label	+	4,07	1,849	0,740	1,480
Interior decoration state	+	3,69	1,292	1,250	1,146
Landscaping	+	3,12	1,069	1,051	0,995
Additional indoor facilities	+	3,81	1,271	1,271	1,271
Distance from city centre	-	4,20	0,675	2,508	1,013
Distance to school/kindergarden	-	5,28	1,121	1,484	2,671
Distance to shops	-	4,20	2,513	0,261	1,422
Public transport	-	5,02	3,069	0,837	1,116
Quality of roads	+	3,81	1,362	1,090	1,362
Neighbourhood	+	3,88	1,334	1,230	1,313
Shared walls	-	3,69	1,229	1,229	1,229
Daily exposure to the Sun	+	4,26	1,449	1,383	1,427
Sum of weighted normalised maximising S_{+i}			28,1238	20,7301	24,5091
Sum of weighted normalised minimising S_{-i}			45,7411	34,4710	46,4248
Significance of the alternatives Q_i			66,3571	71,4636	62,1794
Utility degree of alternatives N_i (%)			92,85	100,00	87,01
Ranking			2	1	3
Market value (€)			275 902		

Furthermore, featured in Table 15 are the sums of weighted normalised maximising and minimising values for all three properties, calculated using formulas (4.1) and (5.2). After that, the relative significance of alternatives and the qualitative utility of alternatives are calculated using formulas (6) and (7) respectively. Based on utility degree, the alternatives are ranked on the value of their criteria relative to each other. Property with rank 1 is the best of chosen alternatives.

The market value of chosen terraced house was estimated on two instances. In case of the first instance, the starting valuation was set to 280 000 €. After a singular refinement cycle, the mean deviation k_x satisfied the initially set condition $k_{ax} < \pm 1\%$. After some deliberation, decision was made to increase the accuracy condition to 0,1%. Continiung with the value estimation calculations, a total of 5 refinement cycles were conducted before the mean deviation k_x satisfied the condition $k_{ax} < \pm$ 0,1%. Table 16 illustrates the changes in mean deviation and the refined prices of the property throughout all 5 cycles of refinement. The market value of selected property was estimated to be 276 139 €.

Table 16 - Cycle of refinement, starting with higher initial value

Cycle of refinement	**Refined price V_{xp} of the property**	**The mean deviation k_x**	**Market value of the property under valuation V_x**
1	280 000 €	-0,650 > ± 0,1%	
2	278 180 €	-0,361 > ± 0,1%	
3	277 175 €	-0,201 > ± 0,1%	
4	276 619 €	-0,111 > ± 0,1%	
5	276 310 €	-0,062 < ± 0,1%	
			276 139 €

In the second instance (Table 17), the initial property value was set to 260 000€. A total of 7 cycles of refinement were carried out before the mean deviation k_x satisfied the condition $k_{ax} < \pm$ 0,1%. The market value for selected property was estimated to be 275 664 €.

Table 17 - Cycle of refinement, starting with lower initial value

Cycle of refinement	**Refined price V_{xp} of the property**	**The mean deviation k_x**	**Market value of the property under valuation V_x**
1	260 000 €	2,694 > ± 0,1%	
2	267 004 €	1,478 > ± 0,1%	
3	270 955 €	0,815 > ± 0,1%	
4	273 158 €	0,450 > ± 0,1%	
5	274 389 €	0,250 > ± 0,1%	
6	275 073 €	0,138 > ± 0,1%	
7	275 453 €	0,077 < ± 0,1%	
			275 664 €

Using determined values from both estimation instances, the mean value was calculated to be 275 902 € and presented in Table 15.

6.2 Discussion

Through the use of COPRAS and Multiple Criteria Decision Analysis based calculations, estimated market value for property under valuation was calculated. Having already determined the variables most suitable for characterising terraced houses (Table 5), next step towards estimating property value was to determine the weight for each individual variable. When comparing the weights of the variables to the literature and expert interviews combined occurrence data, only one correlation emerged – condition of the building. Based on combined sources occurrence frequency, condition of the building was the second most occurring variable. The weight for condition of the building was determined to be 4,83% which ranked it the fourth highest. The correlation highlights the importance of the variable in determining the value of terraced houses. When comparing variables provided by experts to their weights (Table 9), a lot more correlations appeared. Distance to school/kindergarten was mentioned by 3 out of 4 experts (Table 3) and with a weight of 5,28%, it was the most influential variable. Out of five of the most influential variables based on their weights, three variables were mentioned by at least half of the experts. The difference between correlations in comparing weights to expert provided variables and combined variables data suggest that variables accumulated from literature are less likely to be accurate for characterising terraced houses.

Comparing the weights of the variables (Table 9), a handful of observations and derivatives can be made about the influence individual variables play in determining the property value and desirability.

Two of the highest ranked variables are distance to schools/kindergartens and public transportation with weights of 5,28% and 5,02% respectively which suggests that terraced houses are primarily valued by families with children. Ranked 6th is the variable no. of bedrooms with a weight of 4,77% which further contributes to the previous suggestion.

Comparing the determined weights for no. of bedrooms (4,77%) and internal floor area (3,37%), a significant discrepancy between them can be seen. This suggests that potential buyers are more interested in privately accommodating all individuals which is reflective of larger families.

When comparing the weights of condition of the building (4,83%) and age of the building (4,26%), assessment can be made that when it comes to valuating terraced houses, discrepancies in age can be overshadowed by constant maintenance and proper upkeep.

With a weight of 4,96%, heating system is significantly more influential than energy label with a weight of 4,07%. That discrepancy suggests that the reliability of a heating system is prioritised above the overall thermal efficiency of the property. Another

possibility is that people are less aware about the meanings behind specific energy labels.

Variables distance to city centre and distance to shops both feature a weight of 4,20% which ranks them in the middle in terms of importance for determining value. This suggests that potential buyers are willing to accept longer travel times if that is compensated by other characteristics. Anther assumption that can be made based on the weights of the variables is that some of the potential inhabitants do not require access to city centre or shops and therefore the variables are less prioritised. The low weights of plot size and landscaping (3,43% and 3,12% respectively) illustrate that due to the nature of terraced housing, where outdoor space is often shared and co-managed, these variables are less prioritised by potential buyers and therefore they contribute less to the overall value of property.

The research results determine property A to be the best ranked alternative (Table 15) despite being assessed to have significantly worse ratings in some of the higher weighted criteria (e.g., heating system, structural materials, condition of the building) as presented in Table 13. Further negative impact on the ranking of property A provide its higher age, furthest distance from city centre and lower energy label to name a few. All these discrepancies are overweighed primarily by the strength of substantially lower selling price, however, other aspects like plot size, and proximity to shops and public transport access aid with the ranking. Ranked 2nd is property X. Some of the strengths from which the rating of property X benefits from its structural materials, modernity, size of the balcony and terrace area and proximity to city centre. Weaknesses of property X are lesser internal floor area and distance to shops and public transport access. Property B is ranked 3rd due to weaknesses like high selling price, limited plot size, lowest rated state of interior decoration and landscaping and distance to educational institution. The strength of property B is its greatest internal floor area.

The results suggest that property valuation through the use of multiple criteria decision analyses can be done. The accuracy of calculated property value in comparison with its expert determined value cannot be compared considering the property has not undergone construction nor professional property value estimation. The limitations of this study include the limited number of variables determined which may have resulted in overlooking relevant criteria. Another limiting factor is the number of alternatives considered. However, the featured alternatives were carefully chosen to maximise compatibility and therefore the author is confident that findings are accurate. The developed model for terraced housing evaluation can be used in the future for further property value estimations and further developed to increase the comprehensiveness.

7 CONCLUSIONS

The aim of this research was to determine the possibility of using automated property valuation methods in the Estonian real estate market. To carry out the research, suitable automated methods were chosen and the data for their application was collected through literature review and expert surveys.

The findings from the combined method of COPRAS and MCDA for property value estimation revealed that it can be used for more than just value estimation. The method can be applied to determine the influence a specific characteristic has on determining the entire property value or to carry out detailed comparisons between properties using unified variables and their values.

The multiple criteria decision analysis-based property valuation method is useful for mass evaluating similar properties as it requires a small data sample to carry out value determination.

In the context of the Estonian real estate market, this method could be useful for real estate developers for determining the most valued characteristics for certain property types. From a real estate broker perspective, this method could be applied for simplified property value change determination.

For future research, the Author's recommendations are to determine a larger initial set of variables for compatibility of the whole Estonian terraced housing market, which would further increase data accuracy. The developed model could be further expanded to include other residential property types.

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APPENDICES

A1 Templates

Appendix 1.1 Questionnaire 2 template

How important are each of the following criteria for Terracced housing evaluation in Harjumaa?

The aim of this survery is to determine maximizing and minimizing index values for property valuation matrix using the COPRAS method.

Very low importance	1
Low importance	2
Moderate importance	3
High importance	4
Very high importance	5

Profession

No. of years in profession

Criteria		Importance				
Evaluation of the building		**1 (V. Low)**	**2**	**3 (Med)**	**4**	**5 (V. High)**
1	Age of building					
2	Condition of the building					
3	Structural materials					
4	Heating system					
5	Ventilation system					
Quantitive assesment of the premises		**1 (V. Low)**	**2**	**3 (Med)**	**4**	**5 (V. High)**
6	Internal floor area					
7	Plot size					
8	No. of bathrooms					
9	No. of bedrooms					
10	Parking spaces					
11	Area of storage rooms					
12	Balcony/terracce					
Qualitative assesment of the premises		**1 (V. Low)**	**2**	**3 (Med)**	**4**	**5 (V. High)**
13	Energy label					
14	Interior decoration state					
15	Landscaping					
16	Additional indoor facilities (sauna etc)					
Location and placement		**1 (V. Low)**	**2**	**3 (Med)**	**4**	**5 (V. High)**
17	Distance from city centre					
18	Distance to school/kindergarden					
19	Distance to shops					
20	Public transport					
21	Quality of roads					
22	Neighbourhood					
23	Shared walls					
24	Daily exposure to the Sun					

Appendix 1.2 Questionnaire 3 template Property X

Räägusilla, Rae vald

Neljast boksist koosnev ridaelamu Räägusilla uuselamurajoonis, Rae vallas Assaku küljeall.

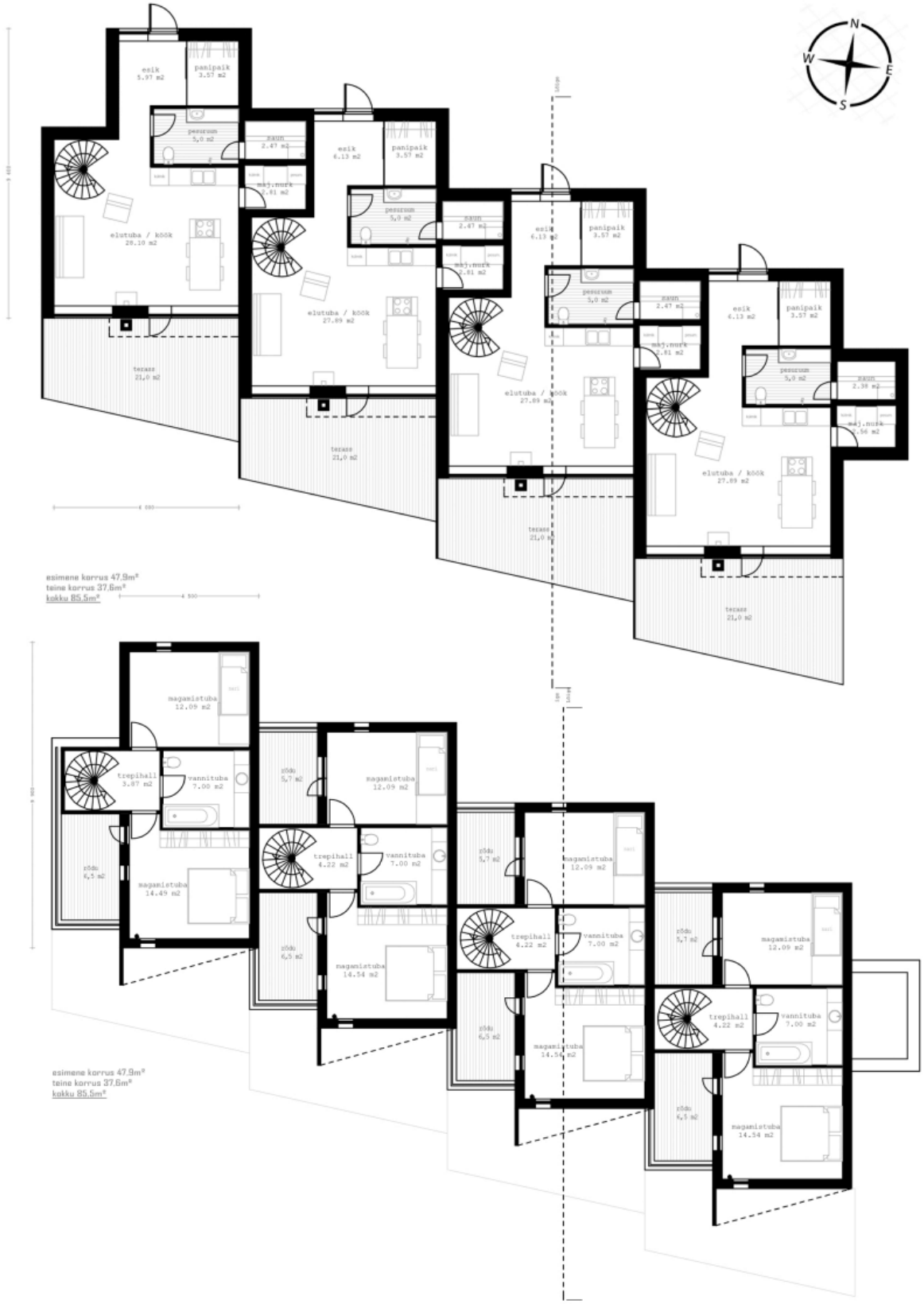
Üldpind on 119 m², millest elupind on 85,5m² ja rõdu/terrass 33,2m². Krundi suurus 1677m².

Hoone esimese korruse kooseisu kuulub ühendatud elutuba-köök, majapidamisruum, pesuruum saunaga, panipaik ja esik. Teisel korrusel on 2 magamistuba, vannituba, trepihall ja vastavalt boksi paiknemisele üks või kaks rõdu.

Tegu on kivikonstruktsioon majaga, kütteks kasutatakse õhk-vesipumba baasil põrandakütet. Energiaklass hetkel teadmata, projekteeritud A.

Based on the information provided, how would you rate the value these criteria give to this building?					
	Very low value	Low value	Medium value	High value	Very high value
Hoone seisukord Condition of the building					
Küttesüsteem Heating system					
Ventilatsioonisüstem Ventilation system					
Sisustuse tase Interior decoration state					
Haljastus Landscaping					
Naabruskond Neighbourhood					
Igapäevane päikesevalgus toas Daily exposure to the Sun					


Räägusilla
Tallinn
PÕHJA-TALLINN
PELGURANNA
KALAMAJA
Iru
Liivamäe
HAABERSTI
LASNAMÄE
Loo
Harkujärve
KRISTIINE
Soodevahe
MUSTAMÄE
Ülemiste järv
Lagedi
Peetri
Rae
Harku
Räägusilla
NÕMME
Karla
Järveküla
Lehmja
Pildiküla
Vaskjala
Jüri
390
340
420
115
290
110
302
303
330


esik
5.97 m2
panipaik
3.57 m2
pesuruum
5,0 m2
saun
2.47 m2
maj.nurk
2.61 m2
elutuba / köök
28.10 m2
terass
21,0 m2
esik
6.13 m2
panipaik
3.57 m2
pesuruum
5,0 m2
saun
2.47 m2
maj.nurk
2.61 m2
elutuba / köök
27.09 m2
terass
21,0 m2
esik
6.13 m2
panipaik
3.57 m2
pesuruum
5,0 m2
saun
2.47 m2
maj.nurk
2.61 m2
elutuba / köök
27.09 m2
terass
21,0 m2
esik
6.13 m2
panipaik
3.57 m2
pesuruum
5,0 m2
saun
2.38 m2
maj.nurk
2.56 m2
elutuba / köök
27.09 m2
terass
21,0 m2
esimene korrus 47.9m²
teine korrus 37.6m²
kokku 85.5m²
magamistuba
12.09 m2
trepihall
3.87 m2
vannituba
7.00 m2
rõdu
5,7 m2
magamistuba
12.09 m2
rõdu
6,5 m2
magamistuba
14.49 m2
trepihall
4.22 m2
vannituba
7.00 m2
rõdu
6,5 m2
magamistuba
14.54 m2
rõdu
5,7 m2
magamistuba
12.09 m2
trepihall
4.22 m2
vannituba
7.00 m2
rõdu
6,5 m2
magamistuba
14.54 m2
rõdu
5,7 m2
magamistuba
12.09 m2
trepihall
4.22 m2
vannituba
7.00 m2
rõdu
6,5 m2
magamistuba
14.54 m2
esimene korrus 47.9m²
teine korrus 37.6m²
kokku 85.5m²

Appendix 1.3 Questionnaire 3 template Property A

Raudkotka, Lääne-Harju vald

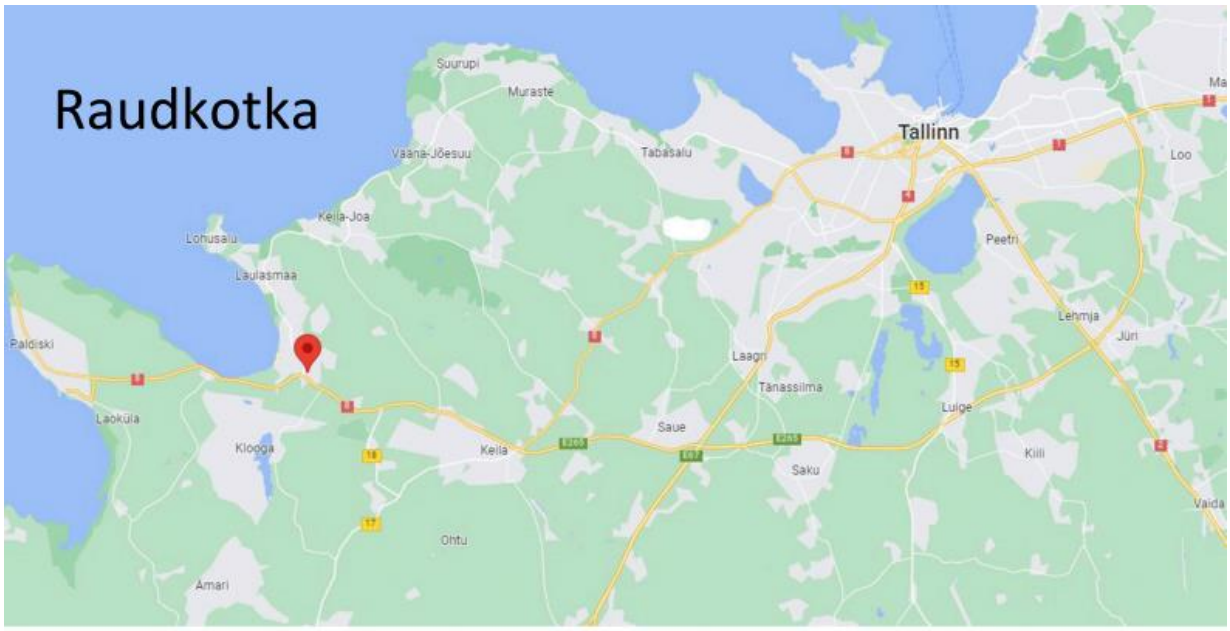
Kolmest boksist koosnev ridaelamu Kloogaranna lähedal Tuulna külas.

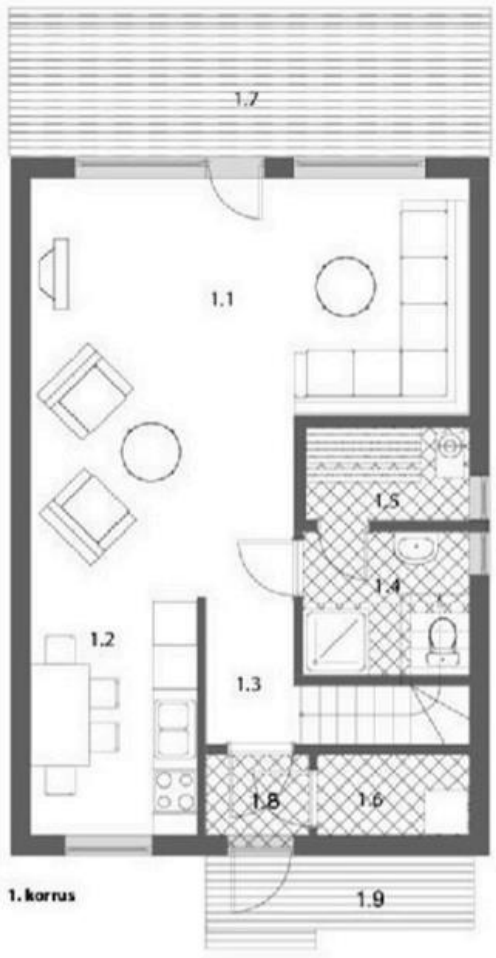
Üldpind 113,7 m², elamispind 98,6m², terrass 11,6m². Krundi suurus 2618m².

Esimese korruse koosseisu kuuluvad elutuba, köök, tuulekoda, saun, dušširuum wc-ga ja terrass. Teise korruse koosseisu kuulub 3 magamistuba, trepihall, panipaik ja wc.

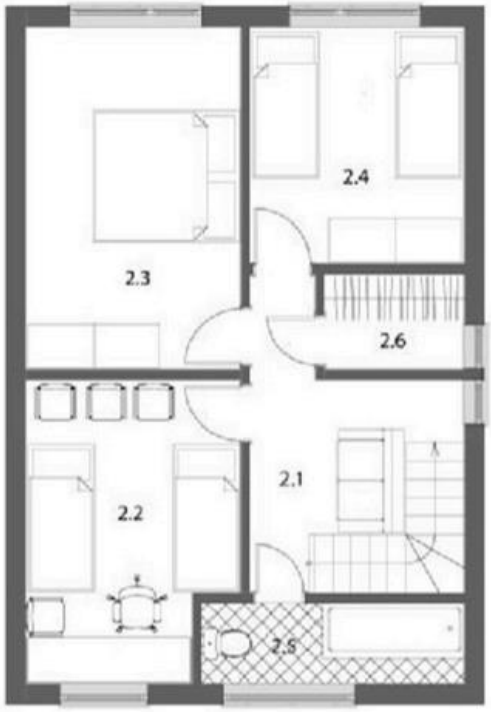
Puitkonstruktsioon maja, kütteks kasutatakse õhk-õhk pumpa ning elektriradikaid.

Based on the information provided, how would you rate the value these criteria give to this building?					
	Very low value	Low value	Medium value	High value	Very high value
Hoone seisukord Condition of the building					
Küttesüsteem Heating system					
Ventilatsioonisüstem Ventilation system					
Sisustuse tase Interior decoration state					
Haljastus Landscaping					
Naabruskond Neighbourhood					
Igapäevane päikesevalgus toas Daily exposure to the Sun					


Raudkotka
Suurupi
Muraste
Tallinn
Väänа-Jõesuu
Tabasalu
Loo
Keila-Joa
Lohusalu
Peetri
Laulasmaa
Lehmja
Jüri
Paldiski
Laagri
Tänassilma
Laoküla
Luige
Saue
Klooga
Keila
Saku
Kiili
Vaida
Ohtu
Ämari



1. korrus



2. korrus

Appendix 1.4 Questionnaire 3 template Property B

Pirnipuu puiestee, Maardu

Kolmest boksist koosnev ridaelamu Muuga aedlinnas uuslamu rajoonis.

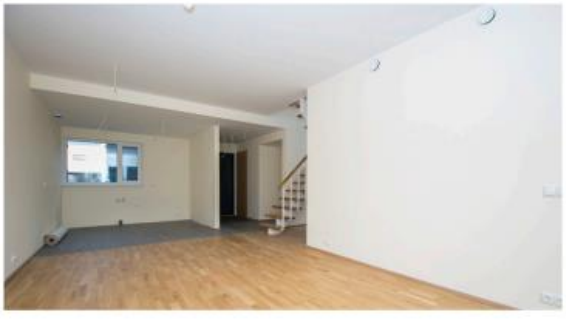
Bokside suletud netopindala on 101,1m², millest 95,9m² on elamispind, 3,5m² panipaik ning 1,7m² tehnoruum. Krundi suurus 1020m².

Esimese korruse koosseisu kuulub elutuba köögiga, hall, tehnoruum, pesuruum wc ja saunaga ning terrass. Teise korruse koosseisu kuulub hall, vannituba wc-ga ning 3 magamistuba. Iga boksi juurde kuulub 2 parkimiskohta hoovis.

Hoone on kivikonstruktsioonist, kütteks kasutatakse õhk-vesi põrandakütet. Ventilatsioon on soojustagastusega, energiaklass B.

Based on the information provided, how would you rate the value these criteria give to this building?					
	Very low value	Low value	Medium value	High value	Very high value
Hoone seisukord Condition of the building					
Küttesüsteem Heating system					
Ventilatsioonisüstem Ventilation system					
Sisustuse tase Interior decoration state					
Haljastus Landscaping					
Naabruskond Neighbourhood					
Igapäevane päikesevalgus toas Daily exposure to the Sun					


Pirnipuu
Tallinn
Viimsi
Muuga
Uusküla
Kallavere
Ülgase
Laiaküla
Maardu
Rebala
Liivamäe
Vandjala
Loo
Maardu village
Kostivere
Saha
Soodevahe
Lagedi
Tiskre
Harkujärve
KRISTIINE
MUSTAMÄE
LASNAMÄE
HAABERSTI
KOPLI
PÕHJA-TALLINN
PELGURANNA
KALAMAJA



Pirnipuu 1 .korruse põhiplaan

Pirnipuu
2 .korruse põhiplaan

A2 Gathered data processing

Appendix 2 Literature analysis table

	Title	Main Approach	Research method	Key aspect I	Key aspect II	Key aspect III	Variable 1	Variable 2	Variable 3	Additional data and findings I	Additional data and findings II
1	Critical determinants of residential property value: professionals' perspective	Not applicable. Public research	Multiple determinants study	Research lists most influential determinants from developers perspective	-	-	Location. Social and economic facilities and accessibility to them.	Neighborhood (Good roads)	Structural attributes/state of repair.	Age of building	Modern design and nice views
2	Property valuation under uncertainty. Simulation vs strategic model	Sales Comparison Approach	Market analysis (effects of uncertanty and information inefficiency)	Valuation is based on the assumption that market is efficient, however this isnt always the case.	-	-	Information inefficiency	Property attributes	Sale price reliability	-	-
3	Improving property valuation accuracy: a comparison of hedonic pricing model and artificial neural network	Sales Comparison Approach	Advanced methods comparison (HPM and ANN)	Same input data was used to have common basis to compare.	Will those methods compare similarly in develepoed and developing countries?		No. of bedrooms and bathrooms	Location and age	-	ANN turned out to be twice as accurate is HPM	-
4	Price dynamics of China's housing market and government intervention	Sales Comparison Approach	Market analysis (government influences)	Government claims they regulate sales and development to maintain stability in market	Supply and demand is parallel with governent influence	Results show that government attempt to achieve high economic deleopment	-	-	-	Easing/tightening housing development	Easing/tightening down-payment and loan interest rates

	Title	Main Approach	Research method	Key aspect I	Key aspect II	Key aspect III	Variable 1	Variable 2	Variable 3	Additional data and findings I	Additional data and findings II
5	Valuation of Real Estate Investments through Fuzzy Logic	Income Capitalization Approach	Advanced method, Fuzzy Logic (FL)	List of key parameters has to be created	Marginal growth and tax rates need to be known	Final sale price needs to be roughly estimated	-	-	-	Predicted market trends in order to count for best and worst case cenarios	Fuzzy logic allows for more room for uncertanity as rates and marginals are taken from one end of spectrum to the other
6	Valuations of building plots using the AHP method	Not applicable. New approach generated for mass apprisal	Advanced method, Analytic Hierarchy Process (AHP)	There has to be an even amount of experts to make pairs for this method to work	Every expert is given an scale on which mark importance of different determinants	Based on those judgements, matrixes are created which up on solving will give importance raitings and based on those, value can be calculated	-	-	-	AHP incorporated the judgements of 2 experts and through their ratings of importance of factors finds a middleground	It is a mass apprisal system that incorporates the data on given regions and carries out valuation calculations.
8	Hedonic Valuation of Real Estate Properties in Nigeria	Income Capitalization Approach	Advanced method, Hedonic Pricing Model (HPM)	A predetermined area was selected for the result to be as accurate and comparable as possible	Following 3 variables were taken and based on them reseach was carried out	-	Structural attributes/state of repair	Location (access to social and exomonic facilities)	Neighborhood (quality aspect)	-	-
9	Local Hedonic House-Price Modelling for Urban Planners: Advantages of Using Local Regression Techniques	Income Capitalization Approach	Advanced method, Hedonic Pricing Model (HPM)	Hedonic method is best used to generate location based information	Paper gives comparison to local and global approaches	-	Floor area	Local income tax level	Car travel time	-	-

	Title	Main Approach	Research method	Key aspect I	Key aspect II	Key aspect III	Variable 1	Variable 2	Variable 3	Additional data and findings I	Additional data and findings II
10	Using Genetic Algorithms for Real Estate Appraisals	Income Capitalization Approach	Advanced method, Genetic Algorithms (GA)	GA is able to count for best and worst case cenarions unlike some other valuation methods	Five domans where GA can be applied usefully: Control; Design; Simuation and identification; Planning; Classification, modelling and machine learning.	-	Rental price	Floor area	Structural attributes/state of repair	-	-
11	Housing market cycles in large urban areas	Sales Comparison Approach	Market analysis, comparison of 6 metropolitans to find and explain asymmetries	Determined period sales data	Determined market states on given metropolitans	Period of data considered	-	-	-	Three strands of research were found in recent literature which could explain cyclical behaviour of housing markets.	They were: 1. Housing market cycles theory on supply-demand where supply is always rigid, but demand is not. 2. Cyclicality can be described by combination of out of normal expectations and slow response of supply. 3. Nonlinear change in credit cycles and financial liberalization can bring up asymmetries and cyclical movements in real estate.

	Title	Main Approach	Research method	Key aspect I	Key aspect II	Key aspect III	Variable 1	Variable 2	Variable 3	Additional data and findings I	Additional data and findings II
12	The Hedonic Pricing Model Applied to the Housing Market	Sales Comparison Approach	Advanced method, Hedonic Pricing Model (HPM)	Article lists different determinants, reseach done about them and how they affect pricing	-	-	Proximity to city centres	House size and type	Structural attributes/state of repair	Article also draws conclusions about set goals and how well estimations did compares to results.	-
13	House prices and relative location	Sales Comparison Approach	Single determinant study (location)	Talks more about location and how they differ as absolute versus relative location	-	-	Walking distance to different facilities	Accessibility with cars	Accessibility to nature (parks/forest etc)	Relative location is seen as things that people us in their daily lives or things that are within walking distance,	-
14	Property valuation: the hedonic pricing model: the application of search-and-matching models	Sales Comparison Approach	Advanced method, Hedonic Pricing Model (HPM)	Main idea of the search-and-match development is to find matching market types and compare sales prices there.	Target markets, number on trades	Vacancies to sell and buy	-	-	-	Example of that would be labour market where a trade is decentralised, un coordinated and time-consuming economic activity.	Paper suggests further development ideas for HPM
15	House Price Determinants in Selected Countries of the Former Soviet Union	Sales Comparison Approach	Multiple determinants study	Study analyses house price determinants in FSU counties on cross-country bases.	-	-	Banks' infuence (willingness to give loans and interess rates)	Household income	Foreign inflows	Results show that foreign inflows play bigger role in pricing than in other parts of the world.	-

	Title	Main Approach	Research method	Key aspect I	Key aspect II	Key aspect III	Variable 1	Variable 2	Variable 3	Additional data and findings I	Additional data and findings II
16	Models and Visualizations for Housing Price Prediction	Sales Comparison Approach	Multiple determinants study	Time from listing to sale	Alot of formulas and tables, thesis focuses on mathematical aspect of research.	-	Housing density	Lot size	-	My assessment is that this thesis is too technical to be of use for my thesis.	-
17	Determinants of House Prices: A Quantile Regression Approach	Sales Comparison Approach	Multiple determinants study	Paper aims to prove that house pricing variables and determinants chance as pricing classes change.	-	-	Size of house and lot	No. of rooms and bathrooms	Garage spaces	Results show that buyers of higher-prices homes value variables such as area and no. of bathrooms differently to lower-price home buyers.	-
19	Property valuation with artificial neural network: the case of Athens	Sales Comparison Approach	Advanced method, Artificial Neural Network (ANN)	ANN approach seems to be able to deal with large amounts of data compared to some more traditinal methods.	-	-	Structural attributes/state of repair	Population density	Neighbourhood	Results show a non-linear relationship between property value and floor space and age.	-
20	Determinants of House Price: A Decision Tree Approach	Sales Comparison Approach	Advanced method, Decision Tree (DT)	Decision Tree provides a powerful tool for the description, classification, regression and prediction of data	-	-	Floor area	No. of bedrooms	Age of building	Results show that people who buy up to four-room flats are mostly interested in such variables as floor area, model type and flat age.	Five and more rooms buyers are more interesed in floor level and basic hosing characteristics

	Title	Main Approach	Research method	Key aspect I	Key aspect II	Key aspect III	Variable 1	Variable 2	Variable 3	Additional data and findings I	Additional data and findings II
21	The price of a view: estimating the impact of view on house prices	Sales Comparison Approach	Single determinant (view) study using HPM	-	-	-	Beach/sea view is considered most importaint	Inland water views	Conservation areas	Results show that even 1% increase of beach view can drive the price up by nearly 2-3%.	Other variables such as no. of bedrooms and bathrooms are incorporated into the formulas as control variables
22	Hedonic Analysis of Housing Prices and Development in Kaunas: Heritage Aspect	Sales Comparison Approach	Single determinant (heritage and historic environment) study using HPM	Paper analyses property age as positive and negative variable	-	-	District	Builing year	Surrounding state of repair	Results show that heritage status and year of construction have no siginificant positive effect on real estate pricing.	Study shows what potential those building have and suggests how they could be applied into pricing considertaions.
23	Property prices in urban areas affected by road traffic noise	Sales Comparison Approach	Single determinant (road noise) study using HPM	Study was carried out by giving people living in high noise pollution areas an opportunity to sell their house for under market value.	-	-	Noise level	House's structural attributes	Household charateristics	Results are mixed and therefore no direct conclusions can be made.	-
24	Hedonic Modeling for a Growing Housing Market: Valuation of Apartments in Complexes	Sales Comparison Approach	Advanced method, Hedonic Pricing Model (HPM)	Most importaint variables such as floor area and no. of bedrooms and bathrooms are normalized to make for more accurate results	-	-	Building characteristics (ease of use and access	Internal characteristics (swimming pools and gyms etc.)	Location (access to good schools)	Results show that structural characteristics of the apartment and amenities provided by the complex are important determinants of price.	-

	Title	Main Approach	Research method	Key aspect I	Key aspect II	Key aspect III	Variable 1	Variable 2	Variable 3	Additional data and findings I	Additional data and findings II
25	Value of scenic views: Hedonic assessment of private housing in Hong Kong	Sales Comparison Approach	Single determinant (view) study using HPM	Study assessed two major types of views: harbor and mountain	-	-	Herbour view prefered	Broad mountain view decresed apartment value	Street views decreased property value	Research shows that people seem to prefer inwards facing views opposed to mountain and landscape views.	-
26	Measuring the value of air quality: application of the spatial hedonic model	Sales Comparison Approach	Single determinant (air quality) study using HPM	Article is rather technical and focuses more on mathematical side of things rather than valuation	-	-	-	-	-	Results differ from state to state, so no conclusive results can be drawn.	-
27	Hedonic price analysis of urban housing: An empirical research on Hangzhou, China	Sales Comparison Approach	Advanced method, Hedonic Pricing Model (HPM)	Total of 18 determinants were chosen to draw comparisons and results.	-	-	Floor area	Location (access to social and economic facilities)	Environment	Research done was rather broad and for more accurate results, more specific study should be carried out.	-
29	Determinants of house prices in Turkey: Hedonic regression versus artificial neural network	Sales Comparison Approach	Advanced methods comparison (HPM and ANN)	Research compared two methods using similar variables.	-	-	Type of house	Age of building	Locational characteristics	Results show that ANN method is better suted for given market	-
30	Artificial neural network in property valuation: application framework and research trend	Sales Comparison Approach	Advanced method, Artificial Neural Network (ANN)	Lists strenghts and weaknesses	Need for little sample data	Given insights how method is built	-	-	-	Could be useful for my thesis if I choose to go with this method, otherways doesnt have much use for me	-

	Title	Main Approach	Research method	Key aspect I	Key aspect II	Key aspect III	Variable 1	Variable 2	Variable 3	Additional data and findings I	Additional data and findings II
31	Determinants of house prices in Istanbul: a quantile regression approach	Sales Comparison Approach	Advanced method, Hedonic Pricing Model (HPM)	-	-	-	Age has positive effects on pricing (newer houses are built on less prefered side of town)	Security (unemployment is rising)	Traffic (noise and air pollution)	Pretty general results expect for few oddidies in global scale	Could be useful for my thesis if I choose to use hedonic method.
32	Specialised property valuation: Multiple criteria decision analysis	Sales Comparison Approach	Advanced method, Multiple Criteria Decision Analysis (MCDA)	Information of atleast 2 comparable properties is required	Determination of criteria infliencing the market value of property	Determination of significances of the criteria	-	-	-	First, data from experts needs to gathered	Inspected property value has to be guessed
33	Defining the utility and market value of a real estate: A multiple criteria Approach	Sales Comparison Approach	Advanced method, Multiple Criteria Decision Analysis (MCDA)	Information of atleast 2 comparable properties is required	Determination of criteria infliencing the market value of property	Determination of significances of the criteria	-	-	-	First, data from experts needs to gathered	All the data gathered is used to calculate property value using cycles of refinement til required mean deviation is reached.