

THE CONSTRUCTION OF HOUSE PRICE INDEX:  
MODELLING BY INCORPORATING ABSOLUTE LOCATION

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Especially for my beloved mother, Norimah binti Omar and father, Rosmera bin Ismail. Not forgotten to all my dearie sisters and brother, Saidatul Nazura, Nurul Islam, Ainul Mardhiah and Fakhrul Islam.



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## ABSTRACT

Price of residential property plays a very important role in the economy of developed countries. Price is an element for individual or household to decide on selling and buying properties, and to invest in the direct property market. In response to such a demand, most developed countries have produced a house price index to monitor price changes. In other countries, studies related to the construction of house price index are widely conducted. However, in Malaysian context, there is less attention regarding the construction of house price index. To fill in the gap, this research aims to construct a house price index by considering absolute location in modelling the house price index. Three models of house price index (HPI) are constructed. Method used in the construction of HPI is the hedonic method. The constructed HPI models are composed of different spatial elements as explanatory variables. Spatial elements included in this research are subdistricts dummy, distance of house to city centre, and coordinate of houses. The results show that the inclusion of property coordinate helps improve the model fitting and explains variation in house price. However, in terms of price index, the inclusion of coordinate of houses may not be important as it produces a similar movement pattern with price index that is composed of common locational variable. This research reveals that the common hedonic model that is composed of subdistricts dummy and distance to city centre as locational variable is sufficient to construct an HPI.

## ABSTRAK

Harga harta tanah perumahan memainkan peranan yang amat penting dalam ekonomi negara-negara maju. Harga harta tanah merupakan faktor bagi seseorang individu atau isi rumah untuk membuat keputusan di dalam pembelian atau penjualan harta tanah dan bagi membuat pelaburan dalam pasaran harta tanah langsung. Di atas permintaan tersebut, kebanyakan negara-negara maju telah menghasilkan indeks harga rumah bagi memantau perubahan harga harta tanah. Di negara-negara lain, kajian berkaitan pembinaan indeks harga rumah telah dijalankan secara meluas. Walau bagaimanapun, dalam konteks Malaysia, tumpuan berkenaan pembinaan indeks harga rumah adalah kurang. Bagi mengisi kekurangan tersebut, kajian ini memfokuskan kepada pembinaan indeks harga rumah dengan mengambil kira faktor lokasi mutlak dalam memodelkan indeks harga rumah tersebut. Tiga model indeks harga rumah telah dihasilkan. Kaedah yang digunakan bagi pembinaan indeks harga rumah tersebut adalah kaedah hedonik. Model-model indeks harga rumah tersebut terdiri daripada faktor lokasi yang berbeza sebagai pemboleh ubah bersandar. Faktor lokasi yang diambil kira di dalam kajian adalah sub kawasan, jarak rumah ke pusat bandar dan koordinat rumah. Hasil kajian menunjukkan bahawa koordinat harta tanah membantu di dalam menghasilkan model yang lebih baik dan dapat menjelaskan variasi harga rumah. Walau bagaimanapun, di dalam menghasilkan indeks harga rumah, koordinat rumah tidak begitu penting kerana ia menghasilkan corak perubahan harga yang sama seperti indeks harga yang terdiri daripada pemboleh ubah lokasi umum yang digunakan. Kajian ini telah menunjukkan bahawa model hedonik umum yang terdiri daripada sub kawasan dan jarak rumah ke pusat bandar sebagai pemboleh ubah bersandar adalah mencukupi untuk menghasilkan indeks harga rumah.

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**LIST OF ABBREVIATIONS**

<i>CBD</i>	-	Central Business District
<i>GIS</i>	-	Geographic Information System
<i>GWR</i>	-	Geographically Weighted Regression
<i>HPI</i>	-	House Price Index
<i>LAT</i>	-	Latitude coordinate
<i>LON</i>	-	Longitude coordinate
<i>MHPI</i>	-	Malaysian House Price Index
<i>MRA</i>	-	Multiple Regression Analysis
<i>NAPIC</i>	-	National Property Information Centre
<i>OLS</i>	-	Ordinary Least Square
<i>SPAR</i>	-	Sales Price Appraisal Ratio
<i>UTM</i>	-	Universal Transverse Mercator
<i>VPSD</i>	-	Valuation and Property Services Department



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## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction and research background

The advancement of technology provides opportunities to understand the dynamic of real estate market. Continuous effort can be advanced with the objective to produce an accurate real estate price indicator. Housing price index, which is an example of real estate price indicator, is an important tool to those involved in real estate market, including investors, financial institution, researchers, and developers. These people need such an index for a specific purpose (Gourieroux & Laferrere, 2009). In addition to that, policy maker also relies on housing price index prior to formulation of economics as the housing market contributes significantly to nation's GDP.

According to Longford (2009), price index has been used to benchmark and monitor equity investment such as investment returns by property owners. Similarly, price index is also used by investors to make comparison with other alternatives. Netzell (2010) notes that the real estate price index is used to monitor the real estate cycle and the relationship between real estate markets. Thus, price indices particularly for residential market are very important to those who have interest in real estate market including financial services as well as the government.

The purpose of house price index is to provide an overview on the changes of house prices over time. For example, Longford (2009) posits that the house price index play a significant role in individual's decision whether to buy or to sell a property. Other than that, house price index is also one of the important factors for policy makers who rely on property price signals to make a decision. As noted by

Lum (2004), real estate contributes to the nation's wealth, and has become one of the investment media.

Due to the importance of housing market to the economy, many countries have produced their own residential price indices to monitor changes in housing prices. Such countries include the UK and the US. In these countries, the house price index has been established for the past 40 years. In Malaysia, an effort to produce the house price index started in 1993 by the National Property Information Centre (NAPIC), while the production of the house price index began in 1997 (Kamaruddin et al., 2008). Known as Malaysian House Price Index (MHPI), the house price index was introduced by the Valuation and Property Services Department (VPSD).

Tan (2011) explains that the construction of MHPI comprises price indices for 13 states and 2 federal territories. The index is established to monitor the changes of real estate price from one period to another, and to assist the formulation of economic policy (Kamaruddin et al., 2008). The approach used to construct the MHPI is the hedonic method. This method of price index construction has been used widely in the US and the UK (Kamaruddin et al., 2008; Bourassa, Hoesli & Sun, 2006).

As real estate price indices are important, they should possess some quality in order to provide an accurate measurement of house price movements (Bourassa et al., 2006). Recently, there are growing interests in improving methodological aspect of real estate price index. Studies such as by Quigley (1995) and Vries et al. (2009) have used various techniques to develop reliable real estate price indices.

A few methods can be used to construct the price indices, and one that is widely used is the median price index. However, this method exhibits bias in its result due to the heterogeneous nature of residential property. Therefore, methods that could control different qualities of housing characteristics are needed to ensure the reliability of real estate price indices. Examples of methods that can handle the heterogeneity of real estate market are hedonic method, repeat sales method, and hybrid method (Case & Szymanoski, 1995). Among these three methods, the hedonic method has attracted particular attention and wide research.

The hedonic method is based on the hedonic hypothesis that products or goods are valued according to their respective characteristics (Rosen, 1974). In real estate market, house is an example of a product, and its characteristics can be

categorised into three parts namely structure, accessibility, and neighbourhood (Malpezzi, 2002).

Longford (2009) notes that repeat sales method can only be applied if the property has been transacted more than once. Practically, this approach is difficult to employ due to the thinness of the property market in short and medium terms.

Finally, hybrid method is the method that combines two equations of a single transacted property and also property that is transacted twice and more (Quigley, 1995). To apply this method in the construction of real estate price index, the sample data of single and multiple sales are combined. By using the repeat sales sample data, the parameters are then determined.

## **1.2 Research issue**

As noted earlier, the house price index is an important element in policy formulation and decision making. The price index especially the house price index helps monitor the price changes of real estate market. Most developed countries such as the UK and the US have more than one house price index. In the UK, house price indices such as Land Registry House Price Index, Halifax House Price Index, Nationwide House Price Index, Investment Property Databank (IPD) Property Index, and The Office for National Statistics (ONS) House Price Index have long existed. The most prominent house price index is the one produced by the IPD, which has published UK's first reliable index of investment property performance. The price index produced by the institution is also available monthly, quarterly, and annually.

Nevertheless, such transparency in real estate market remains opaque in Malaysia. There is only one house price index that is publicly available, namely the MHPI. This index is constructed based on the hedonic method. Kamaruddin et al. (2008) state that the samples of residential transaction used in the construction of MHPI were categorised according to district, type of house, location and condition.

In addition, there is lack of studies on the construction of house price index in Malaysia. Studies that relate to the property market modelling in Malaysia include the hedonic pricing model for Penang condominium market (Chau & Chin, 2002), integration of hedonic pricing models with GIS (Ismail, 2006), and property mass valuation model (Jahanshiri, Buyong & Shariff, 2011).



It is crucial to construct a reliable price index that can provide an accurate indicator of real estate price trends. A number of difficulties in constructing real estate price index have been examined. The difficulties are mainly due to the characteristics of the real estate market itself, which is heterogeneous and has infrequent transaction. According to Netzell (2010), the heterogeneity of real estate market is due to the characteristics of the individual property itself such as size, age, and distance to a specific location. Next, the infrequent transaction is due to few observable properties in a given period. The few observable properties are usually referred to the commercial property. On the contrary, residential property normally has higher number of transactions and they are relatively comparable (Netzell, 2010).

Past studies have adopted various methods in constructing house price index. As noted by Nagaraja, Brown and Wachter (2010), one of the methods is by taking the summaries of property prices that comprise means or medians of particular period. Similar method has also been employed by the Australian Bureau of Statistics to construct house price index (Nagaraja et al., 2010). Other established methods for real estate price index construction are hedonic method and repeat sales method. In this research, hedonic method was employed due to its ability to overcome the limitation of the median price and repeat sales method (Dorsey et al., 2010).

The hedonic method models property prices by its respective characteristics. It was pioneered by Griliches in 1961. Since then, the method has been used to construct price indices for automobiles, computers, and other products. The early application of hedonic method in house price can be seen in studies done by Rosen (1974) and Goodman (1978). In modelling housing price, hedonic method regresses the house price on a vector of its characteristics.

According to Bourassa et al. (2006), there are two approaches to constructing real estate price index based on the hedonic method. First is by performing a separate regression for each period, and the estimated implicit prices should be applied to a standardised bundle of attributes. Second is by including time dummy variables as part of the model.

Moreover, variables to be included in hedonic method should be properly identified. The regression with respect to both functional form and independent variables should also be defined correctly to ensure that the model will meet all the requirements under the Ordinary Least Square (OLS) assumption, hence unbiased estimates of the house price indices could be obtained.

However, as noted by Long, Paez & Farber (2007), the application of hedonic method in modelling real estate price index results in spatial effects. These effects exist in the property data when one property influences others in terms of the market price, resulting in autocorrelation in a model outcome. In order to determine the accurate market price and to produce an unbiased estimator, spatial effects must be considered in modelling the price index.

Spatial autocorrelation, which can be seen in cross-sectional data (Anselin, 1999), is a result of spatial effect. As explained by Anselin (1999), spatial autocorrelation can be defined as the coincidence of value similarity with locational similarity. For example, houses located in same neighbourhood tend to have similar house prices. This price similarity could be positive or negative depending on the value and locational similarity. In real estate studies, positive spatial autocorrelation exists when properties that have similar values tend to cluster together. On the other hand, negative spatial autocorrelation is when the property values in a defined geographic area show dissimilar pattern.

Intuitively, properties that are located close to each other tend to have similar values because they exhibit similar characteristics. For instance, terrace houses with three bedrooms are usually clustered together in an area, while terrace houses with six bedrooms are usually clustered together in other area. This situation can be observed from the development concept in Malaysia where a particular type of houses is mainly clustered together in one housing scheme, and this further reinforces the spatial autocorrelation problems. As the distance between properties increases, spatial autocorrelation between properties is expected to decrease.

Therefore, to construct real estate price index by adopting hedonic method, spatial data must be considered. According to Anselin (1999), spatial econometrics is a subset of the econometrics method concerned with spatial aspects present in the cross-sectional data. Distance, location, and arrangement (topology) are the variables included in the spatial econometrics (Gerkman, 2010). In real estate market, location plays a very important role in contributing to the property prices. Even so, it is difficult to quantify the locational factor of property in quantitative form. The complexity to identify locational factors could bring problems to the validity of the Multiple Regression Analysis (MRA) model (Gallimore, Fletcher & Carter, 1996).

It is important to determine a precise geographical location for a property. The characteristics of a house that affect its price are spatially related in the form of

locational hierarchy (Kiel & Zabel, 2008). Recent studies show that location of a property is measured according to its distance with the nearest Central Business District (CBD), distance of the properties to the submarkets, and distance of the properties to the nearest public facilities (Gallimore et al., 1996).

However, Wilhelmsson (2002) notes that the inclusion of those locational characteristics still could not reject the hypothesis of no spatial effects. To encounter the spatial effect problem, this research used geocoded data that describe the precise location of a property. The availability of the exact location perhaps can contribute to determining the exact property prices. Studies done by Fik, Ling and Mulligan (2003), Gelfand et al. (2004), and Xu (2008) have incorporated geocoded data, i.e., coordinate  $(x, y)$ . These studies show that the variable is significant in house price modelling. Therefore, this research incorporated spatial elements in the construction of the house price index.

### **1.3 Research aim**

The aim of this research is to model and subsequently construct the house price index by incorporating absolute location.

### **1.4 Research questions**

The research questions are:

- i. What are the methods applicable to be used in constructing house price index?
- ii. How do spatial elements contribute in modelling a house price index?
- iii. What is the model appropriate to construct a house price index?

### **1.5 Research objectives**

- i. To evaluate the applicability of existing methods for constructing a house price index.
- ii. To investigate the significance of spatial element in modelling a house price index.

- iii. To suggest an appropriate model for the construction of a house price index.

## **1.6 Research contribution**

By achieving the research objectives, this research will contribute in the following ways:

### **i. Theoretical contribution**

- a. This research helps identify essential elements of locational factor expectedly to improve the modelling of residential price index.
- b. This research extends the potential benefit of incorporating spatial elements in the modelling of residential price index.

### **ii. Practical contribution**

- a. This research assists in improving decision making process by policy makers as a result of improving the accuracy level in price indices.
- b. This research helps related institutions especially banking institution in monitoring asset markets and in promoting financial stability.
- c. This research highlights to data provider, i.e., VPSD of the importance of spatial data in real estate market so that their data collection methods can be improved.

## **1.7 Research scope**

This research is focused on the spatial effects that arise in the application of hedonic method to construct a real estate price index. An appropriate model of house price index is constructed by incorporating spatial elements in the model. GIS technique is employed in order to obtain the geocoded data of the observation points. Kuala Lumpur area is used as a case study for this research with the focus on the residential property.

## **1.8 Research design and methodology**

### **1.8.1 Research approach**

This research is based on quantitative techniques by employing secondary data. The secondary data include the transaction data of residential properties located in Kuala Lumpur from 2005 to 2012.

### **1.8.2 Data collection**

Data used in this research are mainly from the secondary sources. The secondary data, which are the transaction data, are obtained from NAPIC. The data comprise transaction data from 2005 to 2012. A total of 3,200 transaction data covering Kuala Lumpur area are available to be used in the construction of house price index for this research.

### **1.8.3 Data processing**

The transaction data obtained from NAPIC are analysed and processed using Stata II and SPSS software. Besides, Google earth software is used in order to obtain the geocoded data of houses involved in this research.

### **1.8.4 Techniques of analysis**

To construct the real estate price index, hedonic method is employed in this research. This method, a special case of MRA, incorporates spatial elements in the price index model. It is based on the OLS technique that estimates the coefficient of time series attributes.

### **1.8.5 Stages of study**

There are three main stages in this research. These stages are the theoretical, empirical, and evaluation. The first stage namely theoretical stage comprises literature review and theoretical overview. In this stage, literature and evidence

related to this research are examined and critically evaluated. The important areas reviewed are on the methods applied in the construction of real estate price index model. The review also focuses on the spatial element in order to solve for the spatial effects issue that exist in the hedonic price indices.

Second stage is the empirical stage. The use of spatial econometrics and Geographic Information Systems (GIS) is highlighted in order to address the issues of spatial autocorrelation in the present hedonic method. The empirical data are prepared prior to the identification of spatial element. The OLS model is used to estimate the unknown parameter in the multiple regression method.

Evaluation stage is the final stage. In this stage, the constructed house price index, which incorporates spatial elements, is evaluated. The constructed models are compared in order to identify the appropriate model for the construction of house price index.

## 1.9 Thesis structure

There are six chapters in this thesis. Each chapter discusses specific aspects of this research. The chapters are as follows:

*Chapter 1* is the introductory chapter of the thesis. The chapter discusses preliminary, research background, research issue, research aims, research questions, research objectives, research contribution, research scope, research methodology, and thesis structure. This chapter is significant as it provides the framework for the whole study.

*Chapter 2* discusses the literature review specifically on the construction of real estate price index. Basically, this chapter reviews the price index and the application of price index in real estate market. The method of constructing the real estate price index model is discussed in this chapter. It also examines the problems that arise in implementing hedonic price modelling to construct the real estate price index.

*Chapter 3* is another part of literature review that discusses the spatial element of property. Spatial element used to describe the location of property and types of spatial effects present in the property data are discussed in this chapter. This discussion is very important in order to achieve the aim of this research, which is to incorporate spatial elements in the constructed house price index. This review helps

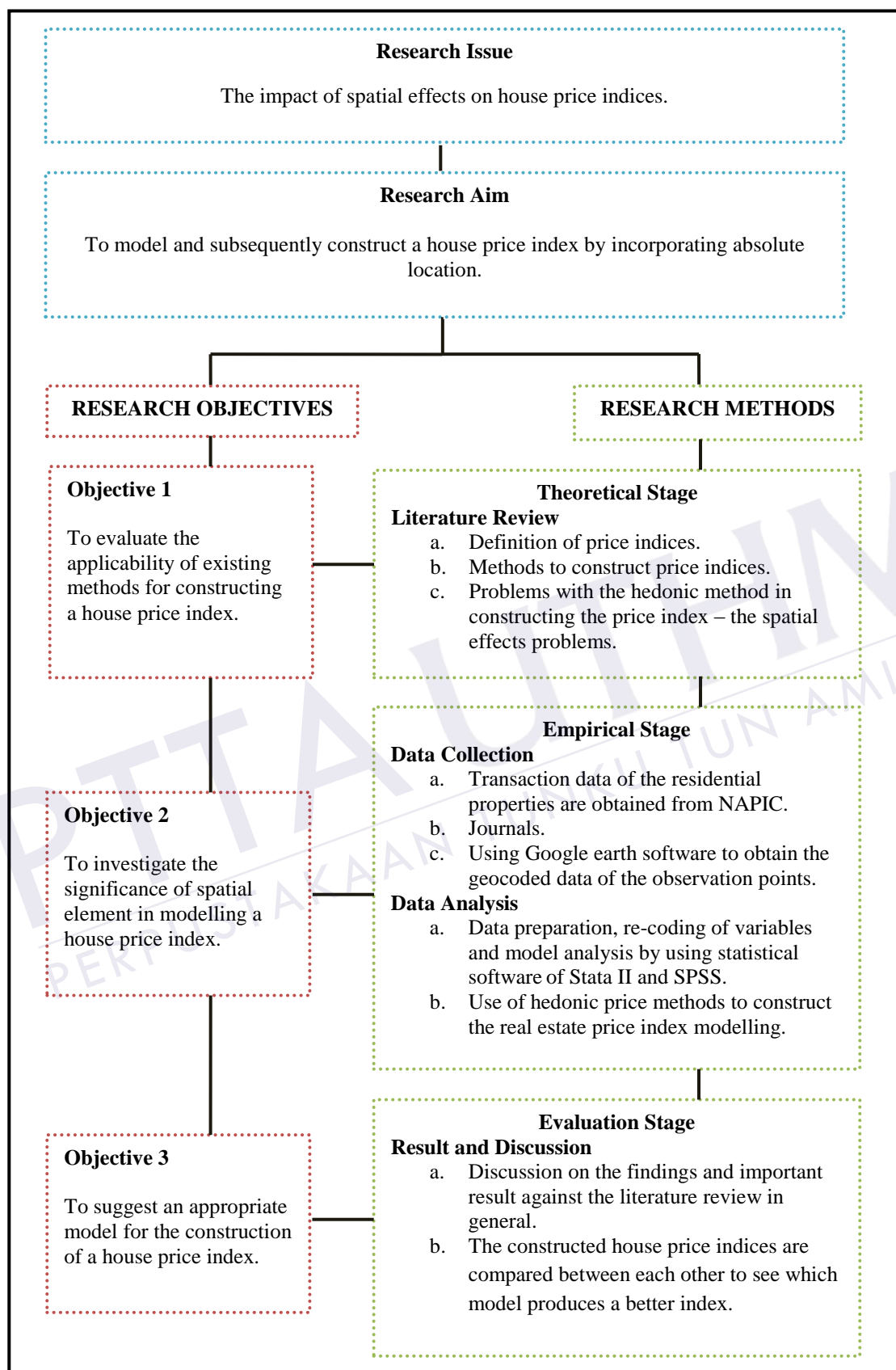
review and analyse the exact locational aspects that are suitable to describe the exact geographical location of property.

*Chapter 4* discusses the method used to achieve the second and third objectives of this research. This chapter offers discussion on research process, characteristics of the research method, application of research method, and construction of real estate price index. To implement this research, secondary data are used. For the data processing, it involves the use of Stata II and SPSS statistical software to analyse and clean the collected data. The method used to construct the real estate price index modelling is the hedonic method.

*Chapter 5* is the data analysis part. Prior to the data analysis, all of the collected data are cleaned and analysed using the statistical software. For the geocoded data, they are obtained from Google Earth software. All of the spatial data are stored in the software. The hedonic method, which is based on multiple regressions and OLS, is used to construct the real estate price indices. The constructed real estate price indices are compared between each other in order to find the model that is able to produce a better price index.

Finally, *Chapter 6* summarises the whole study according to the three stages in this research. This chapter presents the findings of the study. The limitation of the study and potential areas for future research are also discussed in this chapter. Finally, this chapter is concluded by highlighting the contribution the research has made to knowledge. Figure 1.1 summarises the main elements of the thesis.





**Figure 1.1: Summary for the thesis elements (Researcher, 2014)**



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