Modeling the Impacts of Izmir Subway on the Values of Residential Property Using Hedonic Price Model

By

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ABSTRACT

The thesis analyses the effects of subway investment on the value of residential properties in the case of Izmir subway. It has been known that there is a strong relationship between investments in transport infrastructure and real estate values. There have been many empirical studies associated with the objective of the thesis in urban planning practice, in the world. The empirical studies provide information about economic returns, benefits and costs of proposed investments for policy makers and practitioners. However, there has been little empirical research in Turkey. Therefore, the study attempts to investigate a relationship between property values and changes in accessibility caused by transportation infrastructure investment.

In order to achieve the objective of the thesis, an extensive research methodology has been developed. First, many empirical studies are reviewed. The literature survey provided information about the models, variables and functional forms. Hedonic price model is one of the most favored techniques for analyzing urban rent determination in general and the impacts of transport investment on property values in particular.

Within the context of the thesis, hedonic price model has been applied to analyze the effects of subway investment on property values in Izmir. In the modeling process, Eviews and SPSS econometric – statistical softwares were used. In addition, Geographical Information Systems (GIS) in hedonic modeling of property values was used for measuring spatial-related variables and for creating buffer zones. For this reason, MapInfo software was used. In the models, four different functional forms were used for the case study. The results of the models were analyzed under the assumptions of the regression models.

In conclusion, the models give a high level of explanatory power on price variations. The results indicate that proximity to the subway stations is a statistically significant determinant of the market price of house units. It means that direct savings from transportation improvements have been capitalized into property values due to improved accessibility. In addition, it is observed that the influence of transport investment on property values depends on transport costs, total vehicle time and distance to the nearest station. The effects associated with accessibility have been

measured using distance and travel times as proxies. The effects are high in the impact zone of the subway stations, but it is small for greater distance from the buffer zones of the subway stations. Log linear and linear log forms are statistically superior to other functional forms.

ÖZ

Bu tez Izmir Metrosu örneginde, metro yatiriminin konut yerlesim birimlerinin degeri üzerine etkilerini incelemektedir. Ulasim altyapisindaki yatirimlar ve gayrimenkul degerleri arasinda güçlü bir iliskinin varligi bilinmektedir. Dünya örneginde, kent planlama pratiginde, tezin konusu ile iliskili olarak pek çok deneysel çalisma mevcuttur. Bu çalismalar karar mekanizmasindakilere ve uygulayicilara teklif edilen projelerin geri dönüsleri, yarar ve zararlari hakkinda önemli bilgiler temin etmektedir. Ancak, Türkiye'de bu konu ile ilgili çok az arastirma vardir. Çalisma, emlak degerleri ve ulasim yatirimindaki yatirimdan kaynaklanan erisilebilirlik arasindaki iliskiyi arastirmaktadir.

Tezin amacina ulasmak için, kapsamli bir metodoloji gelistirilmistir. Öncelikle, empirik çalismalar gözden geçirilmistir. Bu literatür taramasi modeller, degiskenler ve fonksiyonel formlar hakkinda bilgi temin etmektedir. Hedonik fiyat modeli, genel olarak kentsel rantin tesbitinde ve özelde ise ulasim yatiriminin emlak degerleri üzerine etkilerinin incelenmesinde kullanilan bir metotdur.

Tezin içeriginde, hedonik fiyat modeli Izmir'de metro yatiriminin emlak degerleri üzerine etkisinin ölçülmesinde kullanilmaktadir. Modelleme sürecinde, Eviews ve SPSS ekonometrik – istaistiksel yazilimlarindan yararlanilmistir. Ayrica, mekansal iliskili degiskenleri ölçmek ve etki bölgeleri olusturmak için hedonic modellemede, Cografi Bilgi Sistemlerinden (GIS)' de yararlanilmistir. Bu amaçla Mapinfo programi kullanilmistir. Çalisma alani için dört fonksiyonel form kullanilmistir. Modelllerin sonuçlari, regresyon modellerin varsayimlari altinda analiz edilmistir.

Sonuçta, modeller fiyat varyasyonu üzerinde yüksek bir açiklama düzeyi vermektedir. Sonuçlar, metro istasyonlarina yakinligin konut birimlerinin önemli bir göstericisi olduguna isaret etmektedir. Ulasim altyapisindan kaynaklanan tasarruflar emlak degerlerine yansimis oldugu anlamina gelmektedir. Ayrica, ulasim yatirimlarinin deger üzerinde ki etkisinin ulasim maliyetleri, toplam seyahat zamani ve en yakin istasyona olan mesafeye baglidir. Metronun etki alani içinde etkiler yüksektir, fakat etki alaninin disinda azalmaktadir. Log lineer ve lineer log fonksiyonel formlar diger formlara göre daha üstün sonuçlar vermektedir.

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CHAPTER 1

INTRODUCTION

It is expected that investment in transportation infrastructure will bring economic benefits into urban areas. These benefits range from user benefits to employment-income growth, social and urbanization benefits. There is a growing interest in recent years to measure the economic impacts of alternative transit investments among policy-makers and urban planners in decision-making process. Comparing alternative projects, forecasting economic growth and estimating benefit-cost of transportation investments need reliable estimation methods. Measuring the economic impacts of transit projects is one of the main subjects of planning practice in the world. However, it is not paid enough attention to this subject in Turkey. Nonetheless, the subject is very important for public decision-making and as well as location decisions for firms and residents. For this reason, the objective of the study is to apply hedonic price model to identify the effects of the subway investment on the value of residential properties in the case of Izmir.

In the house purchase decision-making process, the location of a property and its value are interrelated. These two features are affected by transportation system. Accessibility is a key determinant in the location decisions and it is determined by the time and cost of traveling to other locations. A house buyer considers the distance from location to amenities such as CBD, employment centers, shopping centers or public establishments. A new investment in public transportation system will change the locational accessibility. Improved accessibility is expected to increase property values. These changes can start and affect land use development, real estate investment, and built environment.

In fact, the relationship between accessibility, property values and land use is the subject of residential location theories. In Alonso, Muth and Mills Model as access-space models, transportation costs are traded off against land rents. It is accepted that an improvement in transportation infrastructure reduces commute costs. Many theorists and empirical studies focus on this relationship. It is this hypothesis that the thesis wants to test. The hypothesis of the thesis is that proximity to subway stations causes higher property values due to reducing transportation costs and access advantages in the impact zone of the subway stations in Izmir.

Within this context, the subject of the thesis is related to the studies including economic impact analysis of transit investments, real estate valuation and econometric modeling of individuals' decisions concerning amenities. Economic impact analysis includes 12 traditional methods used for selecting the best proposed project among a set of alternatives. Hedonic price model is one of the traditional methods. It is used for assessing the relative impact of transport accessibility on house prices at different spatial scales. The behind hedonic price model is to find a relationship between variation in house prices and amenities or disamenities. This relationship provides information about marginal willingness to pay function of individuals for amenities. This subject plays important role on real estate investment.

Housing market is related to the economic health and wealth of a nation. A high demand for housing sector may cause to start growth in many economic sectors of a city. It is known that transportation is one of the factors affecting urban form, land development and land values. Investment in new transportation infrastructure will trigger real estate investment and development decisions. The purchase of a residential property is an investment and consumption decision. Therefore, hedonic price model is an important tool in the modeling of urban housing markets.

Chapter 2 represents literature review of the studies examining the relationship between investment in transportation infrastructure and real estate values. In the literature, there are extensive empirical studies. The studies focus on understanding the effects of influence of transport investment on property values or the relationship accessibility and house prices. The results and methodology of the studies show differentiation. Generally, the results of the studies confirm the hypothesis of the thesis, but some studies have found that a new transport investment has not effect on price.

Chapter 3 examines the structure of real estate valuation and hedonic pricing models. Firstly, different types of property valuation methods are reviewed. In the literature, there are many valuation methods. These are range from hedonic property value model to the repeat sales model, from income capitalization approach to sales comparison approach. Among property valuation models, a cross sectional hedonic price model has been chosen. Hedonic price is determined as the implicit price of each characteristic associated with that good, so price paid for a particular property is the sum of the implicit prices. Its theoretical background is based on the traditional urban economics framework. In addition, in this chapter, functional form, model specification and variables used in the hedonic price model are discussed based on theoretical background of the model. Chapter 3 also provides guidance for empirical application of the models used in the case of Izmir subway.

Chapter 4 describes the case study. In this chapter, briefly development of rail transit investments in Izmir City are presented and then existing subway system and the impact zones of each station on the route are discussed.

In the case of Izmir subway, the hedonic price model was chosen to investigate the effect of transit investment on the value of residential properties. Because of this, in chapter 5, modeling methodology is discussed. Variables, functional forms and model specification used within the context of the empirical application, are discussed. In addition, research methodology includes briefly as follow steps:

- Problem definition,
- Literature review,
- Data gathering, and choice of the model best fit to the data,
- Models run,
- Evaluating the results.

Chapter 6 presents the data used in the study. Cross-sectional data is used in the models. In this chapter, data processing and descriptive statistics for the impact zones of the case study are discussed.

Chapter 7 represents the results of the study. The models indicate proximity to the subway stations increase residential property values in the impact zones due to improved accessibility. Empirical results indicate that savings in transportation costs have been capitalized into property values. This chapter also includes the evaluation of the hedonic model results for the case study and elasticity analysis.

In chapter 8, the conclusion of the thesis is completely discussed according to the results of the study. In conclusion, the thesis is expected to contribute of existing literature and provide guidance for next studies.

CHAPTER 2

LITERATURE REVIEW: THE STUDIES ON THE RELATIONSHIP BETWEEN INVESTMENT IN TRANSPORTATION INFRASTRUCTURE AND REAL ESTATE VALUE

2.1. The Conceptual Framework of Theory and Practice in Transportation Investment Impact Studies:

It is expected that a new transportation investment into an urban area or a region will affect land use and property values, since there is a significant relationship between transportation and land use. A new transportation investment will increase property values due to improved accessibility. However, in some cases, there may be an inverse relationship or a small increase on the value due to negative externalities such as noise, pollution and congestion. Although many empirical studies questining this relationship have reached varying results, it can be said that a transportation investment will bring certain benefits. In this part of the thesis, the study will focus on rail transit investment and its potential effects on property values. The study includes a critical review of the previous studies and their methodologies.

Department of the Environment, Transportation and the Regions, (DETR, 1998) in England, reported that the rate of congestion and journey times in rush hours increased in towns and cities. This situation caused increasing cost in urban economy. For example, the cost is estimated about £15 billion every year in British economy. Thus, a new transportation and environment policy in the European Union is concerned to alleviate harmful effects of traffic. Transportation system management has been implemented on existing facilities. These controls provided many benefits to urban economy. Environmental policies have been devised to decrease air pollution, noise, congestion and accidents on roads. Also, the benefits of these controls can be estimated or measured in terms of accessibility, since the transportation and environmental policies will impact on the accessibility level of urban areas. According to The Integrated Transport White Paper: Royal Institution of Chartered Surveyors (The RICS, 1998) it suggests that transportation networks have a major impact on land uses and land values. Improved accessibility in urban areas will increase value and price; a new transportation infrastructure will be expected to increase the level of accessibility and decrease transportation costs (Wrigley and Wyatt, 2001). Hence, these expected benefits (or costs) are estimated in terms of property value and land use change. These estimations are related to the part of the economic impact of a transport investment.

Early urban location and rent studies such as Hurd, David Ricardo, Von Thunen and Alonso (cited in Alonso, 1964; Mills, 1987; Barra, 1989) and later, many empirical studies such as Cervero (1994), Bajic (1983), Al-Mosaind (1994) studied the relationship between transportation investment and its probable effects in urban area.

According to Hurd, land rent in an urban area can vary: "*since value depends on economic rent, and rent on location, and location convenience, and convenience on nearness, we may eliminate the intermediate steps and say that value depends on nearness*" (Alonso, 1964: p. 6). In monocentric urban model, travel costs increase with distance to Central Business District (CBD). Thus, location decision for firms and residents is strongly related to distance from CBD. Alonso suggests that rents decline outward CBD. According to Alonso (1964), the CBD is important for households as a place of employment and it is important for firms as an export node, a source of secondary services and a place where managers can easily engage in face to face communications. In addition, travel cost savings allow firms or households to bid up property values (Ryan, 1999). Accessibility becomes an important determinant of residential land values eventually in terms of location theories.

Accessibility is a key market factor being traded off against housing consumption while making location desicions about residence in Alonso, Muth and Mills models (Mills, 1987; Vessali; 1996; Alonso, 1964; Muth, 1969 and Mills, 1972). A transportaion investment eventually decreases transport costs so that the land within a rail transit corridor has a higher demand and eventual value. Thus, savings in transportation costs and also access to transportation services should be capitilized into housing or property values. Many empirical studies have confirmed this theory such as Bajic (1983) and Chen, Rufolo and Dueker (1997)*.

Beyond these theorists, many researchers focus empirically on the analysis of the relationship between investment in transportation and land values, its effects on land development, land use changes. In literature, there are many studies related to the impacts of rail transit proximity on commercial or residential land values such as Bajic (1983), Cervero and Duncan (2002), Bowes and Ihlanfeldt (2001). These studies have

* The studies are critized in literature review of this chapter.

tested that whether proximity to rail stations has been capitalized into higher property values or not. Accessibility for these studies plays an important indicator role.

Transportation investment and price-value-rent determination studies generally are a part of **economic impact analysis of public transportation investments**. In the first part, the study will define economic impact of transit investments and then discuss economic impact methods. In the second part, the study will give a summary and critique of the recent empirical studies that examine the impact of rail transit investments on property values. The section will conclude with a general evaluation.

2.2. Economic Impact Analsis of Transit Investments: Methods and Study Design:

Transit investments may have important economic benefits to a metropolitan area. Also, transit's potential benefits become important in decision-making process. Thus, policy makers, planners want to know probable economic-environmental benefits or costs before a transit project implemented. In literature, **12 traditional methods** are used to analyze the economic impact of transit investments (TCRP Report 35: Transit Cooperative Research Program 1998). In addition to this, many economic impact analyses according to type of economic impact analysis may be divided into two groups: ***predictive and evaluative*** analysis.

Predictive economic impact analysis is used to evaluate or forecast economic impact of one or more proposed transit projects. Evaluative economic impact analysis is used to determine economic conditions of proposed transit projects before and after a project has been implemented. Each 12 economic impact method can be used for predictive or evaluative studies.

Also, According to the Report 35, there are three main groups of transit related economic impacts: *generative impacts, redistributive impacts and transfer impacts.* These impacts are shown in table 1.

Table 1. Categories of Transit - Related to Economic Impacts

Generative Impacts	Redistributive Impacts	Financial Transfer Impacts
• User benefits(travel time savings, safety benefits, changes in operating costs)	• Land development(e.g., clustered development around transit stations)	• Employment and income growth related to system construction, operation, or maintenance
• Employment and income growth unrelated to system construction, operation, or maintenance	• Employment and income growth due to land development	• Joint development income to local agencies
• Agglomeration/ urbanization benefits(e.g.,higher productivity, lower infrastructure costs)	• Increased economic activity within corridor	• Property tax impacts
• External benefits(e.g., air Quality)		
• Accessibility benefits(e.g., access to employment)		
• Reduced development cost due to reduced parking		

Source. Transit Cooperative Research Program: Report 35, 1998: p. 3-1

Generative impacts consist of user benefits, regional employment, income growth, agglomeration and urbanization benefits, external benefits, reduced parking and job accessibility benefits. Therefore, genarative impacts are defined as *net economic growth in a region*. Increased quality of urban life and economic activity in a region derived from transit investment is the net economic growth for a region. Workers using transit line commute safely and quickly to their jobs in the region served by transit. In this way, more face to face meetings, higher savings in commuting costs, reduction in accidents and park costs, more leisure time will take place in a region. Also, a new transit investment may reduce accidents level. All benefits are related to user benefits.

Additionally, generative impacts include regional, agglomeration and urbanization benefits. Agglomeration of retail shops, offices and other urban uses around rail transit line or stations will create economic benefits in a region such as more attractive, more face to face meetings. Reduction in pollution and noise level and improved air quality are the other parts of the impacts. Also, land savings for new developments will be created due to reduced park space. Therefore, it is expected that more compact developments will take place around stations.

The most known example related to these impacts is **MARTA** (Metropolitan Atlanta Transit Authority) and **BART** (Bay Area Rapid Transit) Projects.* The all benefits mentioned above are direct economic growth in a region. Regional transportation–land use models, benefit–cost analysis, input–output models, economic forecasting and simulation models, multiple regression and econometric models, statistical and qualitative comparisons are the tools to measure the generative impacts.

Another economic impact is **redistributive impacts**. These impacts are related to the *locational shifts of economic activity within a region* (TCRP Report 35, 1998). The impacts include land development, employment and income growth. For example, land development around transit line will become more attractive for new development of office or housing. Firms may choose to locate around transit stations or more land development may become within a transit corridor. Thus, employment and income growth can be seen within a transit corridor.

The other impact of a transit investment is transfer impacts. Transfer impacts include financial impacts. A transit investment needs capital. The money will spend for construction, maintenance and operation for new projects. This situation will result in increase of regional employment and income growth such as full-time jobs. Also, these impacts include property tax incomes.

Financial transfer impacts affect private land owners and local governments. Redistributive and financial transfer impacts may be modeled by case comparisons, interviews/Focus Groups/Surveys, physical conditions analysis, real estate market analysis, fiscal impact analysis and development support analysis (TCRP Report 35, 1998). As mentioned above, the 12 methods for measuring economic impacts of transit investments are the part of these impacts. The methods are summarized in table 2 and described below briefly.

* Cervero and Landis examined Bart's influences and on urban development Bollinger and Ihlanfeld studied Marta's influences on economic development, the studies will be explained after this part.

Table 2. Methods for Measuring Economic Impacts

Methods	Impacts
Multiple Regression and Econometric Models	**Generative Impacts**
Regional Transportation and Land Use Models	
Benefit – Cost Analysis	
Input – Output models	
Economic Forecasting and Simulation Models	
Statistical and non-statistical comparisons	
Case Comparisons	**Redistributive & Financial Transfer Impacts**
Interviews/Focus Groups/Surveys	
Physical Condition Analysis	
Real Estate Market Analysis	
Fiscal Impact Analysis	
Development Support Analysis	

Source. TCRP Report35, 1998

1. Multiple Regression and Econometric Models are statistical tools. They are used for estimating the relationship between variables explaining the benefits of a transportation investment. Multiple regression analysis is the most known statistical tools to test a hypothesis. There is one variable (employment, sales or house price) to be predicted or explained using a set of explanatory variables. A general form of multiple regression is as follow;

$$\mathbf{Y} = b_0 + b_1 \mathbf{X_1} + b_2 \mathbf{X_2} + \ldots\ldots\ldots\ldots + b_k \mathbf{X_k} + e;$$

Where Y is the dependent variable of the model. $X_1 \ldots\ldots X_k$ are explanatory or independent variables of the model. $\beta_0 \ldots. \beta_k$ is regression coefficients and ε is error term. Therefore, multiple regression can be used for forecasting the effect of transit investment on property value (Makridakis, Wheelwright and Hyndman, 1998). In the literature, hedonic price models and logistic regression are used for determining economic impacts (TCRP Report 35, 1998). For example, **hedonic price model** is used widely to calculate the benefits of transit investments as capitalizing into land value.

According to the economic theory, access to transportation service should be capitalized into property values. In order to determine the effects of improved accessibility on property value, **hedonic price model** is widely used associated with measuring the impact of a transportation system on single or multi- family house values. For example, Chen, Rufolo and Dueker (1997) studied measuring the impact of light rail systems on single family home values in Portland, Oregon. The study used hedonic model and the model found that housing prices went down with distance from light rail transit stations about $32, 20 decreases in price for each additional meter from the station.

Also, regression models deal with generative impacts of transit investments and the models are used for measuring changes in price or value variations. Regression models allow analysts to examine the amount of economic changes caused by a transit investment. In order to do this, cross-sectional and time-series data set are used. Data source in these models can be obtained from many sources such as census sources, a proprietary data base such as Metroscan, or real estate brokers.

2. Regional Transportation and Land Use Models are used to understand the behavior of urban areas and to predict development impacts of an altenative project. Also, the models can be preferred to make comparisons among alternatives (TCRP Report 35, 1998). The models are used to estimate changes in land use and transportation system performance due to an alternative project. In some cases, the model can be used for measuring the change in transportation system performance associated with a transit project.

Several operational transportation/land use models have been developed. **ILUTM** (Integrated Land Use-Transportation Models) such as Von Thünen's model and Alonso's model, **MEPLAN**, **Lowry Model** and the **LILT** model (Leeds Integrated Land Use Transportation Models) are the most known models that explaine relationships between transportation and land use development in 1960s, 1970s and 1980s (Banister, 1994; Barra, 1989).

Transportation and Land Use models have four stages or include four stages for travel demand models as shown in figure 1. The stages consist of trip generation, trip distribution, mode split and trip assignment (Meyer and Miller, 2001; TCRP Report 35, 1998) in urban transportation level.

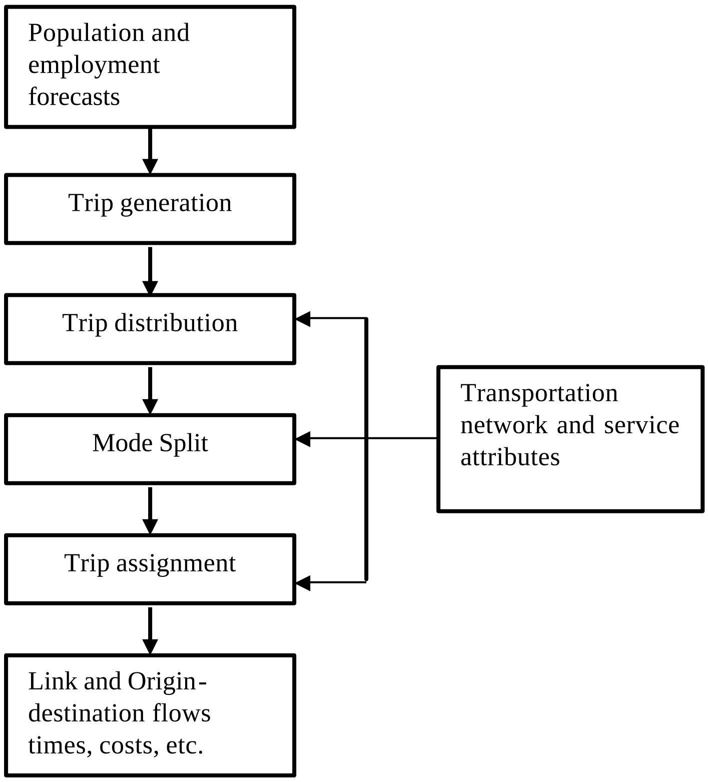


Figure 1. The Urban Transportation Modeling System

Source. Meyer and Miller; 2001

Trip generation models estimate trip rate, number of trip and number of trip ends of each zone. In other words, "*the trip generation phase of the analysis predicts total flows into and out of each zone in the study area*" (Meyer and Miller, 2001: 270). The model explains the relationship as mathematical relationships between trips and activity. The model uses linear regression models (Meyer and Miller, 2001). The second stage is trip distribution. The trip distribution model is linked between trip productions and trip attractions in each zone or trip origins and destinations. The gravity model is used in this stage (Barra, 1989; TCRP Report 35, 1998). Another stage is the modal split. The model split is used to predict travel mode choices, since the mode choices can vary from auto to transit or from bus to ferry or to bicycles. Generally, in this stage, logit model is used to determine mode choice. By surveys, socioeconomic factors, travel costs and other important indicators affecting mode choice of individuals can be obtained. The final stage is trip assignment models. Trip assignment models deal with various trip flows associated with origin–destination in each transportation network link and each time period.

3. Benefit – Cost Anaysis provides practitioners to evaluate the social and economic value of a transit investment project among proposed alternative transit projects. Also, the benefit-cost analysis is used to estimate a range of benefits and costs of an investment in transportation in monetary terms. Hence, the analysis must measure or assist in quantifying- monetizing benefits and costs of an alternative transportation investment. Impact of transportation investment can occur short or long term. In the analysis, benefits and costs of a project over a period of time is discounted to place in specific temporal terms. Benefit and costs for an alternative investment are estimated for each year over the economic life. Benefit-cost analysis generally consists of several steps as follow: (TCRP Report 35, 1998).

1. Defining the economic life of the project,
2. Choosing a discount rate,
3. Measuring benefits,
4. Calculating the benefit-cost ratio.

A transit investment is expected to cause travel time savings, reduction in accidents, reduction in pollution, improving air pollution etc. The analysis transforms these benefits or costs into monetary or dollar values to compare alternative projects. The main aim of the analysis is to find the best investment among alternatives. Therefore, planners can use these methods to find the best alternative and evaluate the economic impact of transit projects.

4. Input–Output Model is used to estimate the economic effects of a transit or transportation investment within a regional economy's industry sectors or to estimate the effects of relative costs of an investment in transportation network. The models can use a matrix system representing the economic system. Also, the model can be used for calculating regional economic effects of alternative financing package for expanding transit services in a metropolitan area.

The model can be worked for a single region or multiregion. Origin sectors and destination sector must be determined and take place in the matrix. Therefore, production and purchasing sectors can be determined and spatial interactions can be calculated (Barra, 1989).

5. Economic Forecasting and Simulation Models are used to predict changes in business output, employment–population level, production of an industry, sales, labor costs and taxes in the future for short or long term economic impacts of a transit system. Thus, the model tries to find the regional economic effects of a project. For example, the model is used for forecasting impacts on regional transportation costs, metropolitan and state economic growth and government finance. These types of models are extended version of multiple regression models in general.

The models are used to determine economic benefits of an alternative project after construction of a project for future. Many changes related to labor costs, time savings, employment may occur in long term. Therefore, these models also predict changes in regional economic impacts of a project and compare alternative projects. In order to do this, the models need extensive data set. Generally, in the 1970s, many urban simulation models were developed. In practice, these land use simulation models are used widely. The models have some sub-models which deal with residential location shifts, employment changes, demand and supply of construction of new housing. The Economic and forecasting models include statistical models and stochastic simulations such as **Monte Carlo simulation** (Meyer and Miller, 2001; TCRP Report 35, 1998).

6. Statistical and Non-Statistical Comparison models are used to determine impacts of a transit investment. The determination process may include before and after construction of a transit investment. Thus, the models need to extensive and reliable data set making comparisons. Comparisons are used to measure changes in employment, sales, income and property values. An example formulation related to determining transit impacts is as follow (TCRP Report 35; 1998):

$$\textbf{Effect of Transit} = (I_{TA} - I_{TB}) - (I_{CA} - I_{CB});$$

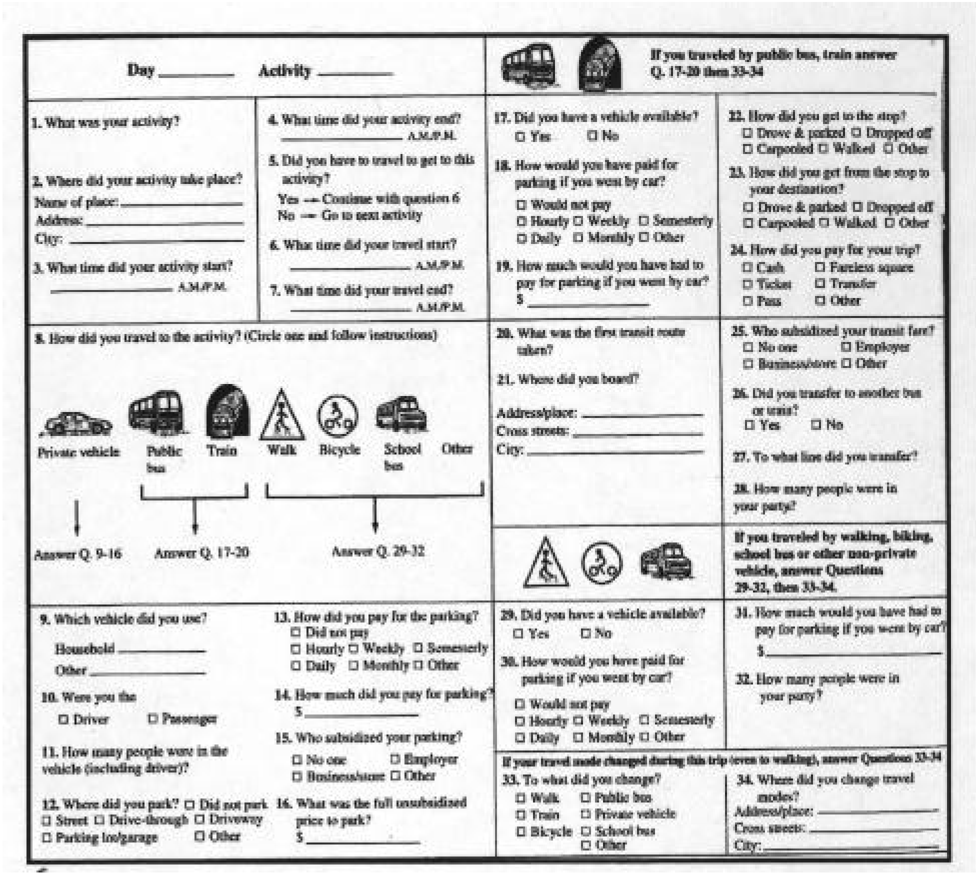
Where I is economic impact of transit, and T transit corridor being studied. C represents transit corridor used as a control. B represents the situation before transit investment, while A is after transit investment.

Therefore, many comparisons can be made to examine changes and compare alternatives. Comparisons provide information whether observed changes are important or not. A well known example of these models is used for examining BART's influences on urban development patterns 20 years after services started (Cervero and Landis, 1997). In this study, the authors made many statistical analyses to determine changes in vacant and developable land assocated with land use changes or residential/non residential land use changes around Bart stations. In the study, corridor analysis and matched-pair comparison of land use changes were made to understade change rates between Bart stations and non-Bart stations such as a comparing differences in rates of housing development around Bart stations and non-Bart stations. Thus, the technique may need reliable data including employment, wage, housing construction for before and after a transit system investment. Thus, the technique can be used for before and after comparisons resulting from a transit investment. Data can be obtained from assessor records.

7. Case comparisons method includes a literal reviews or interviews with planners, transit agencies, real estate brokers, developers who have particular knowledge about transit investment. The method analyzes the different experiences of a similar transit investment in other cities, since transit investment cause different results. Economic and social expectations can vary according to the characteristics of cities. Planners and decision-makers can learn much information before an investment about the results of a transit investment in other cities.

The method can be applied to determine changes in employment, property values, retail sales revenues, income within a corridor using comparison between transit investments. Thus, the technique provides the analysts to understand transit investments' potential results. Data can be obtained from journal articles, interviews with people who have particular knowledge about the study such as planners, real estate brokers.

8. Interview - Focus Groups - Survey Method is used for predictive and evaluative studies. The method can analyze the impacts of transit system investment such as economic, air quality benefits, etc. To do so, the method can need both quantitative and qualitative analysis of an investment. A researcher in this process can make many interviews with planning and economic development officials, brokers, local experts or residents in a metropolitan area. The goal of the gather information is to determine what a future investment is the role in the economy of an area and how an investment can impact on firms' and residents' location. The most known example in literature about survey studies is Portland Metro in Portland Oregon in 1995. A travel survey was prepared to collect data on the activities associated with individual travel (Meyer and Miller, 2001). Figure 2 shows the questions in survey. In this method, interviews and surveys may be based on individuals' opinions. Misinterpretations of individuals can yield unexpected results about a transit project. Hovewer, to collect data in comparison to the others is easy and unexpensive.


Day ________ Activity ________

If you traveled by public bus, train answer Q. 17-20 then 33-34

1. What was your activity?

2. Where did your activity take place?
Name of place: ________
Address: ________
City: ________

3. What time did your activity start?
________ A.M./P.M.

4. What time did your activity end?
________ A.M./P.M.

5. Did you have to travel to get to this activity?
Yes → Continue with question 6
No → Go to next activity

6. What time did your travel start?
________ A.M./P.M.

7. What time did your travel end?
________ A.M./P.M.

8. How did you travel to the activity? (Circle one and follow instructions)

Private vehicle | Public bus | Train | Walk | Bicycle | School bus | Other

Answer Q. 9-16 | Answer Q. 17-20 | Answer Q. 29-32

9. Which vehicle did you use?
Household ________
Other ________

10. Were you the
☐ Driver ☐ Passenger

11. How many people were in the vehicle (including driver)?

12. Where did you park? ☐ Did not park
☐ Street ☐ Drive-through ☐ Driveway
☐ Parking lot/garage ☐ Other

13. How did you pay for the parking?
☐ Did not pay
☐ Hourly ☐ Weekly ☐ Semesterly
☐ Daily ☐ Monthly ☐ Other

14. How much did you pay for parking?
$ ________

15. Who subsidized your parking?
☐ No one ☐ Employer
☐ Business/store ☐ Other

16. What was the full unsubsidized price to park?
$ ________

17. Did you have a vehicle available?
☐ Yes ☐ No

18. How would you have paid for parking if you went by car?
☐ Would not pay
☐ Hourly ☐ Weekly ☐ Semesterly
☐ Daily ☐ Monthly ☐ Other

19. How much would you have had to pay for parking if you went by car?
$ ________

20. What was the first transit route taken?

21. Where did you board?
Address/place: ________
Cross streets: ________
City: ________

22. How did you get to the stop?
☐ Drove & parked ☐ Dropped off
☐ Carpooled ☐ Walked ☐ Other

23. How did you get from the stop to your destination?
☐ Drove & parked ☐ Dropped off
☐ Carpooled ☐ Walked ☐ Other

24. How did you pay for your trip?
☐ Cash ☐ Fareless square
☐ Ticket ☐ Transfer
☐ Pass ☐ Other

25. Who subsidized your transit fare?
☐ No one ☐ Employer
☐ Business/store ☐ Other

26. Did you transfer to another bus or train?
☐ Yes ☐ No

27. To what line did you transfer?

28. How many people were in your party?

If you traveled by walking, biking, school bus or other non-private vehicle, answer Questions 29-32, then 33-34.

29. Did you have a vehicle available?
☐ Yes ☐ No

30. How would you have paid for parking if you went by car?
☐ Would not pay
☐ Hourly ☐ Weekly ☐ Semesterly
☐ Daily ☐ Monthly ☐ Other

31. How much would you have had to pay for parking if you went by car?
$ ________

32. How many people were in your party?

If your travel mode changed during this trip (even to walking), answer Questions 33-34

33. To what did you change?
☐ Walk ☐ Public bus
☐ Train ☐ Private vehicle
☐ Bicycle ☐ School bus
☐ Other

34. Where did you change travel modes?
Address/place: ________
Cross streets: ________
City: ________

Figure 2. Activity – based travel survey: Portland, Oregon

Source. Meyer and Miller, 2001; p. 192

The well known surveys are houhold travel behaviour surveys, workplace and special generator surveys, panel surveys. Interviews/Focus Groups/Surveys can also be used to examine potential impacts(redistributive and transfer) and also to analyze some benefits associated with a serious of interviews or survey groups such as planners, agencies or businesses in the metropolitan area. Thus, economic or social development interviews contribute tthe understanding the net economic benefits of a transit system.

The method can not need to collect comprehensive data set, instead of this; the method needs comprehensive interviews and surveys with transit agencies, business groups and land developers. The data can be obtained by telephone interviews or face to face interviews. The method can also be used for quantitative estimates using the results of interviews and surveys.

9. Physical Condition Analysis is used to determine a transit corridor's potential change for economic development and land use. "*This method is based on the well documented premise that a transit investment will influence development in a corridor only if land is available and the market conditions within the corridor are competitive with other areas of a region*" (TCRP Report 35, 1998: 4-56). The analysis is limited in specific along corridor and to predict redistributive and transfer impacts.

In literature, it is known that a transit investment will influence land use pattern and real estate market along a corridor in a city if there is vacant land, also capital development in a corridor will support the development. In the model, each corridor must be analyzed by researchers, since the characteristics of development for each corridor may be different from other corridors.

In this analysis, researchers can use parcel maps, aerial photographs and land use maps. The data provide information about built environment related to a proposed transit corridor. Generally, the analysis uses a matrix form. For example, a corridor analysis was prepared for the I-15 corridor south of Salt Lake City, a major artery of metropolitan area in Salt Lake City. Congestion levels are high in this corridor. In order to improve mobility, 12 alternative projects including a bus service and a light rail transit were proposed and then an evaluation matrix was prepared for the results of analysis of the alternatives. Evaluation table includes annual total cost, effectiveness (daily, work trips, level of service), impacts to natural and socioeconomic environments (noise, wetlands, air quality, land use and planning, net fiscal impact, local traffic impact), financial and institutional feasibility (revenues) and cost effectiveness of each alternative projects. Thus, the results of the analysis will allow the analysts, decision maker or planners to assess impacts of the alternative (Meyer and Miller, 2001).

10. Real Estate Market Analysis is another method for predictive and evaluative studies. It is expected that an investment will increase economic development through transit corridor. This situation can be seen on rent, land value premiums, vacancy rates, and rapid net absorption. Also, real estate investment analysis is needed to support in making real estate investment decisions. Market studies are used to select best properties in a competitive market. Property owners and assessment managers use this method to decide when and where to build investments. In this analysis, some real estate models such as Illini–Cooper Computer Simulation Models are used to calculate the internal rate of return, cash flow analysis, the present value and the effects of taxation for real estate investments (Cooper, 1974).

In the case of transit, the main aim of estimation is to determine corridor's potential impact on economic development. Thus, investors (public or private) can be encouraged to support a specific project (TCRP Report35, 1998). Data source may consist of housing data such as sales prices over time, real estate brokers, realtors, property records. In this analysis process, **Geographic Information Systems** are used widely to analyze data**.** In addition to this, interviews, physical condition analysis are made to collect comprehensive data to predict how much new development might be supported if a transit investment is built. Realtors or real estate brokers may have information about vacancy and fullness rates, rates of commercial, office and housing in a project area.

11. Fiscal Impact Analysis measures tax impacts including changes in revenue from property taxes, sales taxes, personal income tax. For example, if a government wants to detailed analysis of revenues and expanditures of metropolitan area, the method can be used. It is obvious that taxes are different for each municipality in the metropolitan area. Also, model measures transfer impacts for example; gains in employment can translate into increased income tax revenues.

The model plays an important role on investment decision process, since the investment decision is strongly related to government's revenues and expenditures since local governments deal with fiscal or economic impacts for evaluating land use and development and for financial planning purposes. Local governments want to learn the effect of land use or economic changes on local and state level. This is related to a governmental budget, the budget consists of revenues and expenditures. Data source are based on operating budgets, revenues and expenditures, real estate taxes and annual reports of transit agencies.

12. Development Support Analysis is strongly related to physical condition analysis interviews and real estate market analysis. The purpose of the model is to estimate the impacts of transit investments on real estate development at a station-area level including changes in employment and square footage development in a corridor. The analysis is related to predictive studies to measure redistributive and transfer impacts.

The data source of the analysis can be related to the real estate market analysis. For example, information about house price or property values in two analyses can be obtained from real estate agents or records when estimating the impacts of transit investment on urban real estate development. For this reason, the analysis is widely used for determining changes in a specific corridor or the amount of development as square footage (TCRP Report 35, 1998).

The goal of a public transportation investment as mentioned above is to improve urban mobility. It is also expected that a transit investment yields some economic benefits in urban area. Thus, in planning process, it is needed to conduct these methods. Table 3 presents reasons for conducting economic impact anlysis of transit investment.

Table 3. Reasons for Conducting Economic Impact Analysis of Transit Investments

Reasons for Conducting Analysis	**Typical Impacts of Interest**
Compare alternative transportation investment	User benefits; construction, operating, and maintenance costs; generative employment and income growth; land development and redevelopment potential; increased economic activity; intra-regional employment and income shifts; tax impacts; opportunities for joint development.
Meet federal environmental review Requirements	Employment and income growth related to construction, operation, and maintanence of the system; user benefits; generative employment and income growth; economic dislocation.
Stimulate corridor economic growth	Land development and redevelopment; intra-regional employment and income shifts; increased economic activity.
Secure long-term funding commitment	User benefits; net regional employment and income growth; external benefits; social benefits; tax impacts.
Encourage private participation	Reduced development costs; land development and redevelopment; increased economic activity; tax impacts; joint development opprtunuties.
Extend knowledge	User benefits; net regional employment and income benefits; agglomeration/urbanization benefits; external benefits; social benefis; land development and redewvelopment; interregional employment and income shifts; increased economic activity; tax impacts; joint development income.
Win public support	User benefits; net regional economic and income growth; agglomeration urbanization benefits; external benefits; social benefits; intra-regional employment and income shifts; construction/operations-related employment and income growth; tax impacts.

Source. TCRP Report 35, 1998

Finally, transportation investments are a part of the important public investments. Their effects on land use and land value become a strong indicator in the public welfare estimations and urban policy. The results of these models provide the policy makers or planners to understand the impacts of transit projects in decision-making processes. Many impacts of transit investment also can be measured with a combination of many different models depending on data source, the time period, the expectation from the study. Before a transit investment, to use the methods provide efficient and correct investment desicions and probable effects of an investment on land development, cost and benefits, land values etc. are determined in the future.

In the following section, the study will focus on the review of existing literature relating to the relationship between investment in transportation and urban real estate values. The review will try to make a critique of empirical property value and price determination studies with an emphasis of transport effects on property values and urban development including main findings, analytical techniques.

2.3. A Review of Empirical Studies on Determining Transportation Investments Impacts:

It has long been known that a new transportation investment have important effect on land use, urban development and property values due to improved accessibility and agglomeration benefits. These benefits theoretically have capitalized into property values in competitive markets related to proximity to transit service. The studies are reviewed according to the publication dates.

Dewees (1976) studied the relationship between residential property values and a subway investment in Toronto, Canada. The study is a before and after study in 1961 and 1971. Hedonic price regression model in the study was used to seperate the effect of structural and locational effects from transportation investment effects. The time series data consisted of 2000 residential property sales in 1961-1971 years. The data were obtained from Toronto Real Estate Board Multiple Listing Services. The functional form of the model is as follows:

$$P_i = a_i X_i + ß_i Y_i S + ?_i Z_i S + di\ T_i + ei_i$$

Where T includes transportation variables, S represents size variable and e is error term. Independent variables of the model classified as structural, neighborhood characteristics and transportation access. These variables are floor space, number of rooms and garage, parking space, age, house type, percantage non English speaking population, pollution and traffic level. Dependent variable is sale price. Travel time to the CBD gave more correct measurings than distance to the CBD After that, in the model, travel time savings as value per year were estimated. The savings reflected to price of a house. In the study, two models with different data set were estimated. Second model data set consisted of transportation variables. These are related to "door to door" access costs in major streets in Toronto before and after the construction. Cross-sectional data was used in the model.

The study found an increase in the slope of the rent surface with distance from the subway stations. The result indicated that $2370 premium per hour of travel time saved for sites within 20 minutes travel time (within 1/3 of a mile walk). Thus, the study suggested land values for areas near transit increased more than further away.

Bajic (1983) examined the effects of a subway line in Toronto on housing values using *a modal choice model and hedonic price regression model*. The claim of the study is that **direct savings in commuting costs have been capitalized into housing values**. Thus, the author expected that buyers were *willing to pay* a premium for houses close to rail station due to savings in commuting time and also high accessibility to CBD or employment centers. There are some differences associated with data used in two models. First, the data were obtained from the two areas: The Metropolitan Toronto (control) area and the Spadina (impact) area. The data used in the modal choice model included commuting trips and socio- economic characteristics about households who bought houses in 1978 and obtained from the new homeowners survey. The data used in the hedonic price regression model dated in 1971 and 1978. 1971 was the year before rail transit station opened and 1978 was the year when rail transit line opened. The data were obtained from the Sales Review and Multiple Listing Service (published by the Toronto Real Estate Board). The data included structural, locational and selling prices of the houses located within the two control area.

The modal choice model attemted to measure how direct benefits from the subway line in Toronto affected work trips. The model specification is as follow:

$$P = \exp(\beta_0 + \sum \beta_i Z_{ij} + \sum \delta_k S_{kj}) / [1 + \exp(\beta_0 + \sum \beta_i Z_{ij} + \sum \delta_k S_{kj})];$$

$$P = \exp(L(Z)) / [1 + \exp L(Z)];$$

The dependent variable used in the study is probability of choosing the auto mode (P). Independent variables are difference in money costs of auto travel and public transit trip (Z_{1j}), difference in two different travel times (Z_{2j}), difference in auto and public transit waiting plus walking times (Z_{3j}), socio-economic characteristics including age, education, income and emloyment status (S_k). The model focused on determining individual's behavior between the uses of auto as opposed to public transit. It was expected that money and time savings of public transit was higher than auto mode. Thus, variations of two different uses can be important for residential property values. The model showed for differences in costs, travel times and waiting times are significant, but employment status is not significant variable. The model confirmed that the benefits from the improvement in transportation such as commuting time savings reflected into housing values. The time savings in subway system are high. The estimation in 1978 is 4.11 minutes for the Spadina sample as the average value of the subway time savings. According to the authors, if 250 return work trips per year, savings per households yearly is about $120 (Bajic, 1983). This confirmed the thesis that the benefits resulting from transportation investment capitalized into housing values.

The hedonic price model was used to estimate the effect of a new rail line on housing prices. The specification of the model is as follows:

$$\text{Log } P_j = \alpha + \Sigma P_{zi} \log Z_{ij} + \Sigma P_{zi} Z_{ij} + \Sigma P_{dk} D_{kj} + \varepsilon_j;$$

The variables used in the model are house selling price (P, as dependent variable) usable outdoor space, floor area, number of rooms, total commuting time using public transport, auto in vehicle time in minutes, number of garage places, number of bathrooms (as independent variables) and also dummy variables such as house condition, presence of basement and recreation room* (Bajic, 1983).

The coeficients and signs of the many variables are significant. These are age, floor area, number of rooms, stone or brick house type, house condution, number of bathrooms, basement, recreation room, number of extras and total commuting time using public transport. The model found that the average premium provided by transport improvement for the average house unit in the spadina was $ 2,237. Thus, both methods confirmed the expectation that transportation investment provided benefits and these benefits are reflected into house prices, also the investment reduced commuting costs.

* In the model, relative transaction price information is shown as i, j, d, k. P_{zi} and P_{dk} parameters and Z_{ij} are variable records.

Gatzlaff and Smith (1993) examined the impact of the development of the Miami Metrail System on residential property values and urban form around to rail stations using two different methods: *repeat-sales and hedonic-regression methods*. In their literature review, the authors found little consensus in previous studies related to the effects of rail transit investments on real estate values. The result of each study was varying. For example, **The Rice Center** (Joint Center for Urban Mobility Research, 1987) discussed the effect of transit investments on property values. The Rice Center (1987) suggested that*"transit service may enhance the value of nearby properties, by providing greater accessibility and visibility, or it may depress value by causing noise, pollition temporary disruption due to construction, permanent isolation of some properties, or other incidental effects"*(Rice Center, 1987:1-2; Gatzlaff and Smith, 1993:58). Therefore, it can be seen that transit investments may have two different effects on property values: *positive or negative impacts*. In addition to this, Impacts on property values or urban development may occur before a new system opens as speculative effects or after many years. Furthermore, it is noted that the impacts can be realized in the short-term or long-term effects. Since the characteristics of each transit investment are different, measurement and seperating of the factors affecting property values and land development are difficult. In response to the Rice Center (1987), Knight and Trygg (1977) suggested that rail transit system has important effects on new land developments and population growth, only if there are complemantory factors such as land use policies. Gatzlaff and Smith (1993) did not find a literal consensus related to house price or property value impacts of transit investments. According to the authors, this result is highly related to study period and external factors such as land use policy.

After literal discussion, Gatzlaff and Smith (1993) studied whether the announcement of the development of the Miami Metrorail stations affect on the value or not. The study is a **before and after study** which examine the effects of the Miami Metrorail System. The data used in the study included house sale prices from 1971 (13 years before the system opened) to 1990 (6 years after the system opened) as comprehensive time-series data set including selling dates, selling prices, lot size, year–built and the records were coded as 100 land use codes (for example, single-family detached residential properties were coded as 01). Time-series data set allowed the authors to compare and test changes in the house prices and the data included single family house prices near 21-mile heavy rail system in Miami and were obtained from the Florida Department of Revenue's 1990 Dade County Property Tax Records. The two methods were used in the study: **comparing repeat-sales indices and hedonic regression method**.

Repeat-sales method compared house price index between 1970 and 1990 years for properties located within all Miami counties and nearby rail transit station. The method tested house price index of two different location and found differences as an index. This gave information about price variations in two different locations for Miami and station location. The variables used in the study are transaction prices, cumulative index of appreciation and sales in period. Method has not found strong effect of rail transit announcement on residential values, and there is not a significant increase on house price index for Miami and houses located within station location. House price index generally is higher for station location than the rest of Miami, but the difference is not significant. The house price indexes for properties around rail station are more volatile than the rest of Miami. The metrorail development announcement can impact on price index near stations.

The second method is hedonic model to estimate the price changes of rail transit investment before and after the transit operation in Miami. The method used propertys' locational and structural characteristics. Specification of the model used in the study is as follow:

$$S_{p1i} = \beta_0 + \beta_1(X_{1i}) + \beta_2 (X_{2i}) + ...+\beta_N (X_{Ni});$$

The dependent variable of the model is selling price and independent variables are locational and structural characteristics of property including total living area of the residence, lot size, age of the property, distance of property from the metrorail station. Additionally in order to determine the metrorail development announcement effects on property value, three control variables were added to model as dummy variables.

These variables try to measure interactive price effects of the Metrorail development after and before the rail development. These variables gave information about price movements. According to this, t statistics and the sign of these variables were used to test the hypothesis related to sales before and after the railroad development.The most significant variables are these control variables. The authors found that the value of properties located very close to rail stations was less due to congestion and nuisance.

Choosing the correct functional form fitting to the data set is important in hedonic price studies. There can be four functional forms: **linear, semi–log,**

exponential and double–log in the hedonic price method applications within the context of this study. In this study, four specifications were estimated for the samples using *Ordinary Least Squares (OLS)* procedure. The exponential functional form should the best fit to the data. As a result, the model showed that the announcement of metrorailroad development had a weak effect on residential property values. The property values increased with distance to railroad stations, but the effect was not strong. Also, the findings were varied according to neighborhood type and higher income households gained more net benefits from the announcement of metrorail development.

Al-Mosaind, Dueker and Strathman (1994) examined the effects of light rail transit stations on the value of single family house in Portland, Oregon using hedonic price model. According to the authors, proximity to light rail stations may have positive or negative effect on single family house values. Improved accessibility and savings in transportation costs will result in increase of house values, but proximity to railroad station may decrease single family house values due to noise and traffic effects.

In the study, two hedonic model specifications were used. The first model includes properties located within the 1000 meters band witdh along light-rail transit line, the other model includes properties located within 500 meters of a nearest station as walking distance. There is not important difference as specification of the models and used variables between the two models. Data is cross-sectional data.

The linear regression of the model was used in the study. The first model specification is as follows:

$$P_i = b_0 + b_1 \, DDST_i + \sum_j b_{ij} X_{ij} + \varepsilon_{i;}$$

The second model specification is as follows:

$$P_i = b_0 + b_1 \, DST_i + \sum_j b_{ij} X_{ij} + \varepsilon_{i;}$$

The dependent variable of the model is sale price and independent variables used in the study are structural characteristics (age, number of bedrooms, house and lot size, the presence of a basement). DDST is dummy variable equaling 1 for all homes that are within a 500-m walking distance from a station and 0 otherwise ($DDST_i$); distance of each home (i) from the station (DST_i). X_{ij} is characterisitc attribute; ε_i error term. Distance factor in the first specification is measured as dummy variables and in the second model; distance variable is measured in meter units. In other words, the impacts according to the two impact zones were wanted to control. The first model suggested that light rail transit (LRT) stations had a positive impact on the house values within 500 meters and proximity within 500 meters increased house prices about 10.6%, on average. The second model suggested that property values declined with distance from a LRT station at a rate of $21.75/m ($ 6.60/ft). The estimation is not significant. According to the authors, this situation can be effected by nuisance effects of LRT stations. Thus, the models showed that positive effects of accessibility are stronger than the negative nuisance effects for properties located within the 500 meters from the nearest station. In Portland, proximity to a LRT station provide positive benefits for properties within 500 meters as walking distance, but it is not great.

Cervero (1994) examined how transit investments and joint development affect office market conditions such as office rents and land use characteristics in impact area in Washington D.C. Metrorail System and Atlanta Marta System using five indicators related to office market conditions. These five indicators are average rents, vacancy rates, densities, absorption rates and the rate of construction of new office and total office near the rail stations. The data belonged to five rail stations over 1978 to 1989 periods and it was obtained within a one–quarter mile radius of rail transit station. The author accepted that the one–quarter mile radius was defined as land use impact zone. The author used multiple regresion analysis to measure the effects of rail transit on property values and the analysis allowed the analysts to seperate out the effects of rail transit from other factors.

In the study, five separate regression models were used to find the effects of the rail station on office rents, office vacancy/absorbtion rates; office density, regional office space and growth share in five stations. The variables used in the model are divided into four categories: station-area real estate market performance variables, transit service variables, regional economic and growth factors, station area transportation, infrastructure and development characteristics (Cervero, 1994).

For example, in order to estimate average effects on office rents, a multiple regression model was used. The dependent variable of the multiple regression model in order to find the effects on office rents is average annual office rent per square foot. Independent variables are daily system ridership, presence of a terminal station (dummy variables represents a terminal station at the end of a line equals 1 if a terminal station and 0 otherwise), the existence of a joint development program (dummy variable:

equals 1 if a joint development program exists and 0 otherwise) and regional unemployment rate (Cervero, 1994). The model found that average annual office rents for five stations increased. The most significant variable for this analysis is presence of a terminal station at the end of a line. "O*ffices near terminal stations rented for around $3.35 less per square foot than offices near non – terminal stations did"(Cervero, 1994: p. 87).* Also, the presence of joint development programs increase rents in impact zone.

Another multiple regression analysis was used for estimating the vacancy rate around five rail transit stations. In this model, explanatory variables are average office size, joint development and office growth share. One would expect that land values near rail transit stations would increase and building heights rates would raise. The study found that joint development projects were constructed near rail transit stations and joint development is an indicator of rent premium (Cervero, 1994).

Landis and Cervero (1997) examined the impacts of the Bay Area Rapid Transit System (**BART**) on urban development pattern, population-employment changes, land use changes and urban densities 20 years after since BART was opened. The measuring of population and employment changes is based on comparing between BART served and non BART superdistricts. The authors compared 1970, 1980 and 1990 population growth in BART and non–Bart areas: San Francisco, Alameda and Contra Costa. The data were obtained from the census tracts. It is observed that population has rapidly grown after BART had been opened. The authors prepared a table which shows absolute and % changes in land values over time. The analysis made a comparision between BART-served discricts and non-BART served districts.

According to the study, in 1970-1990 periods, population growth is higher for Bay Area superdistricts (San Francisco, Alameda and Contra Costa) than not served by BART. BART superdistricts attracted over 140.000 more residents than non-BART superdistricts (Cervero and Landis, 1997). In order to measure employment growth, the study used a shift-share analysis from areas BART and without BART stations. The data used in this analysis was obtained from US Department of Commerce's County Business Patterns. The result of the analysis shows that from 1981 to 1990, the BART districts gained 139.400 jobs, growing by 30, 3%. Employment growth is higher in BART stations than elsewhere in the region. The existence of BART is important for population and employment densities.

One of the important statistical analyses is to determine land use trends in BART stations. Data of this section is based on digitized property tax records including lot area, year of construction, and square footage. The authors used the sum of each year for square footage of residential and non-residential development within a quarter milering and half milering of stations. This analysis consists of 25 of the 34 BART stations and pre BART, early BART and recent BART. According to this study, non-residential uses such as commercial, office and industrial have more growth rates than residential uses. Also, growth rates for multifamily housing are higher than single family housing. However, growth rates for non-residential or residential uses did not show equivalent distribution. For example, while in San Francisco BART's effect on office development is low; in Oakland its effect is higher. *"...4.6 million ft^2 of office space only in Oakland was added between 1975 and 1992. A significant share of this was for public buildings"* (Cervero and Landis, 1995: 318). This development cause increasing office workers near the stations. In order to understand the rate of land use changes around the stations, matched-pair comparison was used along corridors. For example in Fremant bart Station, there have been important development trends: 150.000 ft^2 for retail shops, over 400.000 ft^2 of office space and over 800 condominium and apartment units with a half-mile ring(Landis and Cervero, 1995). According to the corridors and stations of BART, these amounts varied. Also, in order to find dominant land use near BART stations from 1965 to 1990, a binominal logit model was used. Data source of the model are aerial photographs and 1990 digital inventory of land uses for hectare grid cells (100*100m). According to this analysis, the dominant proportion of land use was residential uses increased from 47, 4 % in 1965 to 51, 3% in 1990. Vacant lands were converted to commercial, industrial and residential uses (Landis and Cervero, 1997).

The study suggested that a house sale price in Alameda County in 1990 incresed by about $2, 29. For every meter closer to the nearest BART station in Contra Costa County, the sales price incresed about $1, 96. According to the models, a house adjacent to BART is sold for 38% more than an identical house not near a BART station.

Craig, Palmquist and Weiss (1995) examined the transportation improvements and land values relationships in the Antebellum U.S. using hedonic price model. At the beginning of the 20. century, transportation projects such as railroad increased the value and the investments had important effects on local economy. The authors estimated the effects on the average value of farm land and the impact of access to transportation modes. To control different impacts, hedonic price model was used. In the study, many functional forms were tested and semilogarithmic form was used the best fitting to the data. The model specification is as follow:

$$Ln\ (value) = \alpha + \beta_1 water + \beta_2\ rail + \beta_3\ pctimpacre + \beta_4\ density + \beta_5\ Urban + \beta_6\ Nearurban + \beta_7\ Cotton + \beta_8\ Sugar + \Sigma\gamma_i\ Soil_i + \varepsilon;$$

Dependent variable of the model is natural logarithm of the ratio of farm value. Explanatory variables include four transportation variables: river/canal, Ocean, Lake and Rail. These variables entered into the model as dummy variables. River/Canal indicates whether the county was on a canal or not. Ocean shows that 1 if the county was on the Atlantic or 0 otherwise. Lake shows that 1 if county was on a Great Lake, 0 otherwise. Rail shows whether if a railroad ran through the county or not. The other variables were included to measure additional factors in determination of farm values. Urban shows that whether land is within a city of 20.000 residents or adjacent to urban county or not. The other variables are related to locate within cotton or sugar counties or not as dummy variables. Data were obtained from Historical Demographic, Economic and Social Data: the United States, 1790-1970, rail variable was obtained from Historical Atlas of the United States.

In 1850, having water access increased land values by about 28 percent or \$ 3.40 per acre; whereas rail access increased land values by about 15 percent or \$1.80 per acre. Water access in 1860 increased land values by \$ 4.10 per acre and rail access by 1.35. Having water or rail access yielded substantial increase in farm values also water access brought more benefit to land and had affect on average more than rail access. Thus, the study found that transportation access yielded susbstantial economic gains.

Kockelman (1995) tested and evaluated transportation's impact on land value in Alameda County using hedonic price model. The author referenced to the location theory and suggested that a household's location decision depends on opportinities in the sites. *"The value of travel savings as reflected in housing prices and households maximize their utility by locating in as desirable a home as possible–as near to necessary and desired activities(such as work, shopping and recreation) as possible"* (Alonso, 1964; Kockelman, 1995: p. 2) under budget, time constraints. Thus, it is suggested that accessibility plays an important role on land prices due to savings in travel expenses. In other words, reducing in travel expenses increased bidding for houses. The study focused on modelling travel time valuation as determinant of housing prices. The hypothesis of the study is that housing prices fall with travel costs. The hypothesis is based on trade-off between housing cost and travel costs developed by Alonso.

Cross-sectional data set consist of census data, housing sales and Bay Area Travel Survey data. The survey data was used to estimate average travel times, automobile ownership, vehicle miles per person in each census tract (VMT). Dependent variable of the model is house price for 1990 year and independent variables are number of bedrooms, bathrooms and half-bathrooms, square feet of floorspace, distance to highway interchange, distance to BART station, lot size, estimated travel time, estimated car ownership and VMT, accessibility to all jobs. Ordinary Least Square (OLS) and feasible generalized least square (FGLS) estimator were used. FGLS was used to correct error estimates of the OLS. Because of this, some different results occured associated with the coefficient and signs of the variables. Thus, the study found that travel costs played an important role in house price and also accessibility and distance to a Bart station played an important role on land value.

Olmo (1995) tested the hypothesis that housing price can be determined by locational and structural characteristics. In order to prove the hypothesis, hedonic regression model was used in Granada City, Spain using cross–sectional data. The formulation of hedonic housing price model is as follow:

$$Z = \alpha + \Sigma\beta_k S_k + \Sigma \delta_j L_j + \varepsilon;$$

Where L_j is locational characteristics, S_k is structural characteristics as independent variables, Z is housing price as dependent variable

The empirical application of the model has been tested in Granada, Spain, on 260 apartments. The number of sample is about 8.5 per cent of the total number in Granada. Explanatory variables related to structural characteristics are age of apartment, number of bathrooms etc. The generalised–least squares (EGLS) estimator was used in the model. Isoline maps which show locational rents of districts in Granada were prepared. The values range from positive to negative depending on locational differences. Districts which have highest value are close to hospital, recreational establishments and univercity campus. Other districts close to working–class area and have lower land values.

Forrest, Glen and Ward (1996) studied the impacts of commuter light rail system on house prices in Greater Manchester, in the North of England. A new commuter light rail line in Greater Manchester was constructed in 1992, in order to increase direct access to central facilities for commuters. Therefore, the new system provided user benefits and time savings for commuters. This benefit means a large monetary value. Because of this, the study focused on estimating price variations for properties with good access to the stations using hedonic price method.

The data were obtained from Nation Wide Building Society for the 1990 including 892 property sales. The data included property, neighborhood and location characteristics. The dependent variable of the study is natural log property prices and explanatory variables consisted of age, house type, floor area, number of bedrooms, number of garage, central heating, distance to central business district and distance to a nearest station.

In order to calculate distance factor, linear distance to a nearest station were used and then a classification was made to measure a property's distance to a nearest station. According to this, properties located within 1km, 1-2 km and more than 2 km from the nearest station were divided into the groups using dummy variables. Semilog model specification was used in the study and all the variables representing property characteristics except number of bathrooms had significant effect on price. The focus variables of the study are distance from CBD and distance to a nearest station. The model suggested that proximity to rail stations decrease property price.The model found a negative effect on price. One possible explanation for this result is related to the effects of noise and traffic congestion in Greater Manchester. There is no significant price difference according to different distance intervals.

Gallimore, Fletcher and Carter (1996) studied the influence of location on the property values using multiple regression analysis was used as the process of valuation in Stafford. In the study, a set of physical and locational variables were determined as independent variables. These variables are property type, age in years, property size in square meters, number of story, number of bedrooms, number of living rooms, number of bathrooms, number of garages, type of central heating (as good/bad or present/absent). All variables excepting age and size entered into the model as dummy variables. The others are quantitative variables. The dependent variable of the model is selling price.

The data were obtained from mortgage valuation reports prepared by a valuation firm in Stafford from 1992 to 1993. The model was estimated using OLS estimator. In the study, linear functional form was used. The model predicted the price of each property associated with property characteristics. The most important variables affecting the price were the size and age of the building variables. The study found that locational and physical characteristics played an important role on the value using multiple regression analysis. The study suggests that multiple regression analysis can be used to assist in the valuation of residential properties extensively.

Bollinger and Ihlanfedt (1997) analyzed the economic impacts of Atlanta's MARTA (Metropolitan Atlanta Rapid Transit Authority) rail transit system using a simultaneous models of cencus tract population and employment. The main purpose of the study was to find that the possible benefits of rail transit system on population and employment densification associated with accessibility served by MARTA. It was obvious that MARTA had some advantages such as the savings in travel time and travel cost to households and firms, MARTA brought decrease in labor costs and increase labor supply due to increased accessibility. The specification of the model for employment and population was estimated as follow:

$$POP^*_i = f\,(M_i, P_i, EMP^*_i),$$
$$EMP^*_i = g\,(M_i, E_i, POP^*_i);$$

The variables used in the model are equilibrum population (POP^*_i), equilibrium employment (EMP^*_i), MARTA proximity (M_i) at i. Population and employment data included from 1980 to 1990 about 299 census tracts. Population data were obtained from census of population and housing. Employment data was obtained from Atlanta Regional Commision. The study tested for 29 stations. In this study, *a- quarter-mile* ring was chosen as the impact area, since walking distance in literature is accepted as a quarter mile of a station. The study found that MARTA has had no significant effect on total employment and population in station areas, but MARTA has increased accessibility in Atlanta. In other words, MARTA has had neither positive nor negative impacts on employment and population in station areas.

So, Tse and Ganeson (1997) examined the effect of transportation on house prices in Hong Kong. In their study, So, Tse and Ganoson stressed that transportation on residential markets have four effects. These are availability of transport, transportation costs, travel time and convenience of transport. It is expected that these factors will effect the decision of home buyers. Thus, individuals can pay more for housing unit's accessibility level to their work.

Hedonic price analysis was used to explain house prices in terms of its own characteristics such as size of the flat, age, floor, neighborhood characteristics, and job accessibility. The data were obtained from the Hong Kong Property Journal's issues including a 12 month period. The specification of the model is as follow:

$$\text{Log } P = \beta_0 + \beta_1 \log(SIZE) + \beta_2 \log(AGE) + \beta_3 (HF) + \beta_4 (MF) + \beta_5 (GV) + \beta_6 (FV) + \beta_7 (MTR) + \beta_8 (BUS) + \beta_9 (MB) + \beta_{10}(CP) + \beta_{11} (SC) + \beta_{12} (SP) + \beta_{13} (ST) + \beta_{14} (GEQ) + u;$$

House price is the dependent variable of the model. The explanatory variables are size, age, high floor, middle floor, good view, fair view, accessibility to mass transit railway, accessibility to bus, accessibility to minibuses, accessibility of car park-shopping center-swimming pool-sport facilities and good environmental quality. Size and age variables are quantitative and the others are qualitative variables as dummy variables. The effect of transport accessibility on house prices varies across income groups. Transport accessibility was measured as distance to nearest rail stops on the mass transit railway (MTR), buses and minibuses. Also, in the model, the dummy variables were used for dwellings with greater or less than 10 minutes walk from a transport node. The functional form used in the study is log-linear. Accessibility to minibuses is the most influential effect on house prices, since minibuses pick commuters close to their homes and are widely used for connecting to other transport modes. According to the model, fair view, accessibility to bus, accessibility to car park and accessibility to swimming pool are insignificant variables. Presence of a car park is significant. In addition, since frequency of minibuses is higher than other services, accessibility to minibuses is a more determinant of house prices than other transport services.

Chen, Rufolo and Dueker (1997) studied the impact of the rail system in Portland, Oregon on single family house values using hedonic price model. The study expects that proximity to a light rail station may have positive effects on the residential property values. The distance to rail stations as a proxy for accessibility and the distance to the railroad line as a proxy for nuisance effect were used in the models. According to the existing literature, the study suggests that there are four categories affecting house prices. These are as follow:

"(1) Physical attributes of the house itself, including housing quality and quantity: frequently included variables are lot size, house size, number of bedrooms, number of bathrooms,presence of basement or not, age of building.

(2) Neighborhood attributes, such as median household income, occupation structure, white /minority ratio, school quality, crime rate.

(3) Locational attributes: distance to CBD and other major business or employment centers are included as proxies for locational attributes to measure accessibility.

(4) Fiscal and economic externalities: property tax, public facilities, zoning, air quality, proximity to a power plant, shoreline, traffic externalities" (Chen, Rufolo and Dueker, 1997: p. 3).

The data used in this study includes sale prices dated 1992-1994 obtained from the Regional Land Information System and Metroscan from Transamerica Intellitech: regional data base. Additionally, 1990 census was used to obtain neighborhood information. The authors used GIS to obtain and estimate "*spatial-related variables*": distance to the nearest light rail transit stations, shortest distance the rail line, distance to the nearest park and distance to the CBD. The functional form of model used in this study is a semi-log form.

The variables used in the study are the sales price as dependent variable (P), a vector of control variables (X) including age of house in years, square of house age, lot size in square feet, house size, and number of bedrooms, bathrooms and fireplace. Some variables were used as dummy variables. For example, the presence of basement for census was coded 1 for yes or 0 for absent. The most significant variables are age, size of house, distance to the nearest park, presence of basement, presence of garage, number of bedrooms and bathrooms. The distance to the CBD is not a significant variable. House prices in Portland go up with proximity to the park. The study focused on two variables: distance to a light rail transit (LRT) station and distance to the lrt line. The authors found that each additional meter from the LRT station result in a $32.20

decrease in price and the minumum price occured at 427 meter away from stations. Another important variable is distance to the LRT line. House prices increases when its distance to LRT line increase. The results of the model confirmed the hypothesis that light rail transit has positive (accessibility factor) and negative (nuisance factor) effect on single-family house values.

Chau and Ng (1997) studied the effects of public transportation investment in particular railway system, on the price gradient of residential properties in Hong Kong. This railway investment in Hong Kong is the electrification of Kowloon Canton Railway (KCR) after 1982. After the electrification, the average growth rate of journey has increased about 30 percent during 1982-1985. An improvement in transportation infrastructure will result in reduce of the price gradient along the transit line. Thus, the hypothesis of the study is that transportation investment reduces transportation costs and price differences. The study in order to seperate out the factors influencing on price used hedonic price model. Data were obtained from land offices and included time period between 1977 and 1992. The functional form is linear. The equation was estimated using OLS estimator. The form is as follow:

$$RP = a_0 + a_1F + a_2L + a_3KL + e;$$

Where RP is the transaction price of the property, F is the floor level, L represent location of a property in Sha Tin or not. K shows before and after public transportation investment as dummy variables, e is error term. In the study, since there is no common interpretation associated with choosing functional form, the authors used Box-Cox transformation for testing more flexible functional form against the linear form and the model was estimated by maximum likelihood estimator. The Box-Cox model for this study is explained as follow:

$$RP^{(\lambda L)} = a_0 + a_1F^{(\lambda R)} + a_2L + a_3 K.L + e;$$

Public investment in Hong Kong reduced commuting time and provided transportation savings for individuals. In both model, floor level, K and L variable are significant. For example, the results indicate that age and location are significant indicators of price. It means that investment in rail system reduced price differentiation along rail line.

Dueker and Bianco (1998) examined the effects of light rail transit on property values in Portland. Single family house price changes were analyzed statistically. Two time periods were used: in 1986, the year light rail opened, and 1995 the year the study was made. Number of vacant parcels rates were compared statistically, the built out rate around rail stations for parcels were estimated including rail stations, bus stops and arterials between 1986 and 1995.

The analysis revealed that multi-family development occured near rail stations more rapidly. Price effects of LRT on single-family housing in the study are correlated with distance to LRT. A house located within 200 feet from rail station valued $80,500, $78,554 a distance of 400 feet away, at a distance of 800 away $75,721, $74,835 a distance of 1000 feet away. There was a reduction associated with the distance from rail station.

Cofman and Gregson (1998) conducted an empirical study about the effect of railroad construction on land values away from the railroad using a regression equation in Knox County, Illinois. During the interstate railroad boom of the 1850s in the United States, land values grew rapidly. Lands within close proximity to new railroads became more valuable due to decreased transportation costs. Real land values increased more than 60 % in the regions including Indiana.

To estimate the effects of railroads on land value in Knox County, the data were obtained from the 1855 year tax records in Knox County in the United States. OLS estimator was used to find the value of land using sectional map. In order to determine the effect of newly built rail lines on the value of farm land, all lands in Knox County was divided into sections. The distance was calculated the distance from the center of each section to the nearest rail line using the sectional map. The model specification is as follow:

$$V = \beta_0 + \beta_1 (1 / DGB) + \beta_2 (1 / DRR) + \beta_i X + \varepsilon;$$

Where V is the average value per acre in each section (V). Independent variables are distance in miles from station (DGB), distance in miles from the nearest railroad (DRR), a vector of characteristics of each section (X) and the error term(ε). The result showed that rural land in Knox County was worth an average of $7, 77 per acre in 1855, the minumum value per acre was $1, 20. After the railroad construction, land values were affected by the proximity, and the value of properties increased in the market.

Minumum gains from the construction were 9% of total real estate wealth in the county and the coefficient on the distance from the railroad is positive and significant. This confirmed that there was a relationship between land value and distance from a railline.

Hennebery (1998) examined the effects of the development of the South Yorkshire Supertram, a light rail system on house prices. In other words, Hennebery's study as the study concept resemble other studies explained in this chapter measuring the effect of transport investment on residential property values, but data, model formulation and the results of the study certainly show differentiation than others. Hedonic analysis was run to estimate the effect of the Supertram on the value and the model seperates out the effect of different characteristics in value for three dates.

The three dates are before and after the decision of construction of the Supertram System (April 1988 and April 1996) and April 1993 shows the year when there was housing public knowledge about the system. Therefore, seperate hedonic price equations were estimated for each year. Cross-sectional data were obtained from real estate agents. Log linear form gave best results for three dates. The dependent variable of the models is natural log of house prices and explanatory variables are property variables including number of bedrooms, presence of extension, building type (semi, flat, deteched, bungalow, terraced), presence of garage and central heating, neighborhood variables including knowledge of sub-markets and distance variables measuring the distance from property to train line or to train stop in meters using GIS. In addition to distance variables, the two variables were used to measure generalised impact of area served by the system as dummy variables.

The results of the model for before the construction of the system suggested that the effects of the system were observed slighltly for properties near the system. According to the model, size, number of bedrooms, building type, presence of a garage and central heating are significant variables. The results of the 1988 and 1993 hedonic equations, significant variables are similar. Building type, number of bedrooms, central heating, and presence of garage, neighborhood variables are significant. In 1988, while there is an inverse relationship between distance and price, in 1993 and 1996 there is a direct relationship. However, there is no statistically significant relationship between distance and price. According to the authors, negative impact over time has been occured in impact area.

Dunse and Jones (1998) tested significant factors influencing office price in Glasgow. An office unit like housing is a heterogenous good. Because of this, office unit can be determined by a vector of physical, location characteristics. Hedonic price model in this study was used to measure how different characteristics effect on office rents. Linear form was chosen. Data were obtained from Scottish Property Network. Dependent variable of the model is rent per m^2. Explanatory variables are age, presence of basement, tea preparation area, air conditioning, security system, carpeting, ground floor, car parking, tea preparation area etc. as dummy variables. Also, distance from a street in the CBD entered into the model. While reception area, security system, and floor level, private entrance, presence of basement, presence of upper floor and ground floor are insignificant, other variables are significant. Also, stepwise procedure was used to find the best model.

Thus, the study suggested that age of location of a property is significant determinant of office rents. Also, offices within the city centre have a high value. Furthermore, it is an important factor influencing office rents. This study also suggested different attributes are valued differently when combined with other attributes (Dunse and Jones, 1998). However, before this study, hedonic price studies may be used as the same accross markets and property types. For example, a variable can have different importation level according to in the city centre or peripheral.

Adair et al. (2000) examined the relationship between house price and accessibility in Belfast Urban Area including sub-markets using hedonic price model. The main assumption of the study is that transportation accessibility is an important factor influencing the purchase decision. Cross-sectional data was used in the models and hedonic models were estimated for each sub-markets of Belfast Urban Area. The two functional forms were tested: linear and log-linear form in the study.

The variables used in the models mainly can be divided into three groups: accessibility, property characteristics and census variables. Explanatory variables include age of houses, building types, floor area, number of bedrooms and reception rooms, presence of bathroom, garage and central heating, the condition of repearing of house, census data including catholic households, economic condition of residents, owner occupies, single-person households and population managerial/professional. In this study, according to other studies, the measuring of accessibility variable shows differentiation. Accessibility indexes for the Belfast Urban Area developed by University of Ulster based on a transportation gravity model were estimated. Dependent variable of the model is transaction price. And log of price. The results of the model suggested that accessibility had an effect on price but not high. The most important variables are floor area of house and population. Accessibility is not significant factor explaining the variance in house prices.

Smersh and Smith (2000) examined the role of accessibility as an important determinant of residential land values and tried to model the impact of a new bridge (the Dames Point Bridge) as a goverment of transportation investments in Jacksonville. The construction of the new bridge was expected to reflect differently on house price in the south and the north of the bridge. In the north of the bridge, a new bridge increased benefits, while the south was suffered from increased congestion, crime etc. The authors employed a repeat–sales methodology as follow:

$$Ln\ (P_{it} / P_{iT}) = \sum_{\cdot t}^{T} c_t D_{it} + \sum_{\cdot t}^{T} c'_{\cdot t} D'_{\cdot it} + E_{it};$$

This model is used to evaluate the difference between the prices in the market and in a submarket. The variables used in the study are the ratio of sales price for property i in time periods T and t (P_{it} / P_{iT}). D'_{it} is a dummy variables showing initial sale (-1) and second sale (+1), 0 otherwise. C_t is the logarithms of any cumulative appreciation rate for year t. In the study, the repeat-sales spline-regression was used to test many distances of any miles in the submarkets for the north and south. *"A spline regression technique is applied where multiple iterations of the model are run to estimate the distance effects of any abnormal appreciation. The spline regression is a methodology which tests many distances of x (containing varying numbers of houses in the particular submarket) to determine the threshold distance at which the diffence between the market and submarket is most evident"* (Smersh and Smith, 2000; p:191-192). The data used in the study was obtained from the Florida Department of Revenue's property tax records between 1980 and 1990 years including square footage, age, lot size, last sale price, last sale price date, previous sale price and date (Smersh and Smith, 2000). GIS was used to estimate the distance from a house to the bridge. In the study, the properties were geocoded as latitude and longtude coordinate for each house G.I.S. calculated the distance from a house to the bridge.

The results revealed that house sales located 9.8 miles away at the north of the bridge were appreciated nearly 8.7% more than the market appreciation of 52% for the 10 year period. House sales located 2.1 miles away at the south of the bridge were appreciated over 5% less than the market appreciation of 52% for the 10 years period.

Consequently, the houses at the north of the bridge gain more benefits from increased accessibility.

Cervero and Duncan (2001) studied that the effects of commuter light rail transit on commercial land values in Santa Clara County, California. Some of the earlier studies suggested that rail transit did not provide benefits to commercial properties in the Bay Area. However, the authors claimed that there were measurable benefits. In the literature, accessibility benefits get capitalized into land.

A hedonic price model was used to estimate for predicting office and commercial land values from 1998 to 1999. Also, the model was used to separate out the effects of proximity to transit on land values. The data were obtained from Metroscan, a data base including information related to real estates sales transactions and it was cross-sectional. "*Weighted least squares (WLS) estimation was used to correct problems of heteroscedasticity that were encountered when attempting ordinary least squares (OLS)* (Cervero and Duncan, 2001: p. 13)". Also, WLS represents good fit to the data. The variables used in the study were land value as dependent variable and four main explanatory variables: rail/highway proximity, accessibility & location, density & land uses and neighborhood quality proxies.

The authors claimed that a statistical model could estimate and seperate out the influences of rail transit on land values. Proximities were determined with the distance from stations and it was measured within one quarter of a mile as straight line distance. The coefficients of railroad proximity variables are significant. It showed that being close to rail transit increased commercial land value, but these benefits were limited with the parcels within one quarter of a mile from a station. These parcels were worth more than $25 per square foot than other properties farther away a quarter mile from a station. While being near rail transit system provide some benefits, roadway system results in negative effects. Being near a freeway reduce land values about $ 2 per square foot.

Strand and Vagnes (2001) examined the relationship between property values and railroad proximity using *hedonic price model and real estate brokers' appraisals*. In Oslo, a new rail-road was intended to construct. There were alternative projects and the effects of these projects were needed to estimate. The hedonic price model was used to determine *willingness to pay to locate farther from the lines* as one of the calculation methods (Strand and Vagnes, 2001).

Data set used in the hedonic model was obtained from Central Government Data Registry Database. The data included the housing units sold in the period 1988-1995. Housing units used in the model lie within 100 meters, 200 meters and 500 meters from the rail line in Oslo. The specification used is used to determine relationship between housing price and railroad proximity and its formula is as follows:

$$\text{Log (pkv)} = a + b \log (\text{dist}) + c \log (\text{area}) + d \log (\text{age}) + \varepsilon;$$

The variables used in the model are the sale price per square meter (pkv as dependent variable), type of residential unit (multi or single), size (area), number of years since construction at the time of sale (age) and distance from a nearest station (dist). The functional form used in the study was log –linear model. *OLS* estimator was used in the model. In this stage, the authors discussed some problems related to the model-specification errors. One of the variables which affect the sale price of housing unit is quality. However, in the study, there was no information about quality. Because of this, it can not be measured in the study. The most important variable is distance to the railroad and it was used to explain the relationship between house price and railroad proximity. The coefficient of distance variable was higher for the houses between 100 and 200 meters, the prices of houses located between 100 and 200 meters increased more. The study also controlled the house price difference related to railroad proximity in central area and peripheral area. The model showed that the effect of railroad proximity in central area is more strong compared to those of peripheral area.

The real estate agent appraisal study is based on real estate agent's particular knowledge in Oslo's relative housing market. In other words, it can be called as an expert panel study. The authors conducted 15 real estate agents and the study is only made for apartment housing units. The goal of this method is to find how the values of apartment housing units were changed with different characteristics of apartments in this expert study. The technique estimated the implicit monetary value attached to changes in the different characteristics (Strand and Vagnes, 2001).

Thus, two methods suggested that the effects of proximity to railroad line within 100 meters are stronger or more significant, but if the distance from the railroad line is higher than 100 meters, the relationship is less. The proximity within 100 meters increased the property price about 10%. Also, the real estate brokers in Oslo said that properties located within a 100 meter range had higher price. It is obvious that there is a proportional relationship between house values and railroad proximity (Strand and Vagnes, 2001).

Bowes and Ihlanfeldt (2001) examined the impact of MARTA rail stations on residential property values within Atlanta Region. It is expected that, the station will raise the value of properties nearby the stations by reducing commuting costs or by attracting retail activity to the neighborhood.

The authors examined four factors including negative or positive effect on property values. The two of them are related to positive effect of railstation proximity on property values. For example, improved accessibility provided by rail transit will affect commuting costs and this factor will have important effect on the choice of households. Another positive factor is related to increasing retail services nearby rail transit station. Additionally, two factors will have negative effects on property values. These are noise, pollution and increasing of crime level. Their methodology consists of three separate equations. They are the hedonic house price equation, the crime model and the retail employment model. Three equations in the study were used to estimate the direct and indirect effects of rail stations on residential property values. There are a standart hedonic price model and two auxiliary regression equations. First; a linear property value equation is as follow:

$$P = a_0 + a_z Z + ß_L L + ßc C + ß_R R + ?s S + e;$$

The equation is called as the total impact of a rail station on nearby property values and the components of this formulation is where P is the price of house as dependent variable, Z is the set of physical characteristics, L is the set of location characteristics, C is a measure of neighborhood crime, R is neighborhood retail employment, S is the distance from the house to rail station, and e is error term. After this formulation, the authors used a second formulation including the sum of direct and indirect effects of MARTA. This equation is expressed as follow:

$$\P_P / \P_S = g_S + b_C * \P_C / \P_S + b_R * \P_R / \P_S$$

Total Effect ← $\P_P / \P_S$

Direct Effect ← g_S

Indirect Effect (crime and retail) ← $b_C * \P_C / \P_S + b_R * \P_R / \P_S$

Where left hand side shows total effect and right hand site include direct and indirect effect. Also, in order to estimate ∂_P / ∂_S and ∂_R / ∂_S, two axuliary equations related to crime and retail factors were used as follow:

$$C = \Psi_0 + \theta_N N + \psi_S S + v;$$
$$R = \varphi_0 + \pi_o Q + \varphi_S S + \delta;$$

Where N is the set of location characteristics for crime Q is **a** set of kocation characteristics for retail activity and S is neighborhood proximity to a rail station.

The data used in the hedonic model was single-family house price from between 1991 - 1994 and it was obtained from country tax assesment records. The data included parcel characteristics (number of bedrooms, number of bathrooms, lot area, number of fire place, basement, age of house) and location characteristics (median income, number of road miles to CBD, proximity to employment, density of total crimes in tract, density of retail employment). The authors used a semi-log form in the hedonic price model as the best fitting form.

To estimate distance to a rail station, linear distance from the centroid of a property to a nearest MARTA rail stop was used. The proximities used in the models are within one-quarter mile, half a mile, one mile, two miles, three miles of MARTA rail stop. The results of the hedonic price model showed that density of crime and retail employment had significant impacts on property values. The value of properties within a quarter of a mile from the stations is less than properties beyond three miles from a station. In opposition to this, properties located within one and three miles have a higher value. Thus, households were willing to pay more to locate within one or three miles from a station. However, households did not want being close to rail station due to the negative externalities such as nuisance and crime factor. Properties located within half a mile of a station have higher crime rate than other properties further away from the stations. Retail employment model suggested that after rail station opened, retail development rate for properties within one-quarter and one-half mile of a station increased. In summary, the hedonic model and other explanatory models (crime and retail employment model) suggested that rail transit had an important affect on property values. Also, properties located within a quarter mile from rail station sold 19% less than properties located within beyond three miles from a station. However, properties located within between one and three miles from a station had higher values compared to those farther away. Transit investments may have positive and negative effects at the same time.

Cervero and Duncan (2002) examined the land value impacts of rail transit services in Los Angles County using hedonic price models. The model estimated the land value premiums associated with four types of land uses: residential, multi family housing, single family housing and commercial. The data included the years between 1999 and 2001 and obtained from Metroscan, (*a proprieatry data base maintained by and available from first American Real Estate Solutions*) which gives information monthly on all real estate transactions.

The variables used in the study are transportation proximity variables, property and location attributes. Property - location attributes include structure size, lot size, age of properties, population density, employment density, household income. Proximity variables entered into the model as dummy variables that represent whether properties located within $^1/_2$ mile of rail station or not. Capitalization effects are expected within one-quarter and one-half mile buffers. Multi–family parcels near the Red Line station *largest value– added benefits*. These properties located within a half mile of a station sold more than $20,000. This is due to positive effects of the railroad station. However, the parcels close to highways and freeways located within a quarter mile sold less due to nuisance effects.

In Turkey practice, the two studies related to the objective of the study were chosen. **Sur (1998)** studied the effects of economic growth at macro level and transportation investments at micro level on real estate investment in the case of Ankaray and Metro projects in the CBD of Ankara using single constrained gravity model. The study indicates that transport investment increase accessibility level of CBD and improved accessibility resulted in increase the demand. Therefore, the demand caused a higher real estate prices in the CBD of Ankara. **Ayvaz (2002)** investigated the factors affecting house prices in Izmir housing market using hedonic price model. The data were obtained from real estate agents. In total, 2718 observations were used in the data set. Log-linear functional form was used in the models. The models were run for Izmir city and for each administrative district within the city. The results indicate that the value of house prices show differentiation according to the districts. House size, number of bathrooms, floor, and number of elevators affect positively house prices, while number of bedrooms can negatively affects price. In general, age is negatively correlated with price. The models provide information about factors affecting house price in Izmir housing market for house buyers.

In conclusion, in recent years, many studies have been examined the effects of transit investment on urban real estate values. It is obvious in these studies that transportation investments have brought some benefits to an urban area. However, some studies have showed that transit investment can bring disbenefits. The table 4 presents the results of the relative studies. Thus, the effects can range from positive to negative. Proximity to rail line station may increase the accessibility of people to a central business district, commercial, recreational areas or any important urban areas and also proximity may affect transportation costs. Thus, savings in transportation cost will affect the choice of a resident who want to move anywhere.

The purpose of the studies mentioned above is to find direct benefits or dis benefits from the improvement in transportation. The finding of the studies is related to the premium paid for housing units in impact area and also some studies can include the effect of a transit investment on land use and urban development since a transit investment cause transit-oriented development such as Cervero and Landis' (1995) study.

The effects of transit investment can vary from local to region and transit investment will result in changing of employment level, environmental quality, land development and land values. Because of this, estimating transportation's potential effects play important role for decision-making process and urban policies.

The main approach used in the literature is to compare directly land use type, density, and land values between the areas with transit access and without transit access. The analysts search that whether there is a shift around rail transit stations in land use type or land values or not. In the studies, generally two main data sets have been used: **cross-sectional and time-series (longitudinal) data**.

The time-series data set allows the analysts to do before and after comparisons in urban real estate values or land use type. Before-after comparisons using time-series data include three main time interval: before the years rail transit stations were opened, the years rail transit stations were opened and after the years rail transit stations were opened. However, these comparisons are based on reliable and comprehensive data set. In hedonic price model, locational and property attributes have been used increasingly. Tha data set are obtained from Real Estate Agents, Property Journal, County Property Tax Records, Surveys, Multiple Listing Services published Real Estate Board such as

Toronto Real Estate Board, Transit Commission Services and proprietory data base such as Metroscan including real estate sales transactions that are recorded in county assessor offices.

The most used model is **hedonic housing price** model for cross-sectional and time-series data set since the market price of a housing unit is related to the buyers' preferences of the housing unit's bundle of inherent attributes such as locational, structural or neighborhood attributes. Cross-sectional data must include these attributes to forecast house prices. Also, the model allows the analysts to seperate out the effects of proximity on property values from the other effects.

The hedonic price model has different specifications: linear, semilog, exponential and double log. The construction of wrong specification can result in unexpexted signs and coefficients of the variables. This situation can result wrong interpretations. Because of this, the best specification to the data must be chosen by analysts. In order to do this, in this stage, the authors use generally Box-Cox procedure to choose among alternative functional forms for hedonic price equation so as to obtain a better specification. In addition, many functional forms can be estimated and then the best functional form is chosen.

The measuring of accessibility is a key factor in determining land values and location decisions. For this reason, accessibility and proximity variables are focus variables. The signs and coefficients of these variables are correctly related to the hypothesis of the study as expected. Proximity in the studies is defined in terms of linear distance to a nearest station in impact zone.

GIS is widely used to calculate distance measures such as distance to a nearest lrt stations, and distance to C.B.D. Also, in the studies, a quarter-mile ring was drawn around each station. This distance is accepted as walking distance, but it is obvious that the effects of rail line vary with distance factor. For this reason, different distance levels can be used: one-quarter to one half mile, one-half to one-mile to two-miles etc. from 100 meters to 500 meters on the other hand or every a 100 meter interval. Positive effects are shown within 100 meter and 200 meter boundries. However, negative effects such as noise, traffic congestion may reduce property values. These effects of rail line may vary from positive to negative. In some cases, its effect may be small. Property value premiums due to improved accessibility can range between 3% and 40%. Negative impacts are strongly related to noise, congestion, and visual intrusion, while positive impacts are related to improved accessibility.

Table 4. A Review of Property Value Studies

Authors	Methodology	Measuring Proximity	Impact Level	Conclusion
V. Bajic(1983) Before: 1971, After: 1978, Opening: 1978 –Toronto Spadina subway line.	Cross-sectional data, Hedonic Price Model	-Total commuting time using public transit from house location to five chosen destinations on the subway system. -Auto in vehicle time minutes	-$2.237 premium for average house based on reduction in commute time resulting from opening subway.	-Savings in commuting costs increase house values; on the other hand commute time savings contributes most to house value premiums.
Gatzlaff&Smith(1993) [1971- 1990], Miami Heavy rail line.	Time series data, Repeat sales indices & Hedonic price models	-Within 1 square mile of a station, straight line distance, distance to nearest rail station.	-At most a 5% higher rate of appreciation in real estate sales value compared to the rest of the City of Miami.	-Residential values were impacted weakly from the announcement of the new rail system. -Higher-priced residential neighborhoods have experienced greater increases in property values near the Metrorail station while declining neighborhoods have not.
Strand&Vagnes(2001) [1988-1995], Oslo new Railroad line, Norway.	Cross-sectional data, Hedonic price model& Real estate agent appraisal study	-Within 100 and 200 meters of a nearest station as linear distance.	+%10 premium for property price within a 100 meter bound. The house value should increase by23% when moving from a 20 meter to a 100 meter distance.	-Proximity to railroad has positive effect on property values. There is a linear relationship between house values and railroad proximity.
Bowes&Ihlanfeldt(2001) [1991-1994], Atlanta heavy rail line.	Time-series data, Hedonic price study, Crime& retail models (as auxiliary models)	-Linear distance of the centroid of the property to the station.	-Properties located within one and three miles from a station have a higher value farther away. Properties within a quarter mile from a rail station are found to sell for 19% less than properties beyond three miles from a station -Within a quarter of a mile of a station crime density is high.	-Houses that are very close to stations were affected by negative externalities. -Premium paid for being close to a station for high income is high -Density of crime and retail employment are significant impacts of property values.
Bollinger&Ihlanfeldt(1997) [1980-1990], Atlanta's Marta heavy rail.	Time series data, Simultaneous models of population and employment.	-A quarter mile ring was used as impact area and walking distance.		-Martha has had no significant impact on total population or employment in station areas.
Al – Mosaind, et al.(1994) [1988],Portland-Oregon Max Light rail.	Cross-sectional data, Hedonic price model	-Within 500 meters of a nearest station, as walking distance, straight line distance.	+10.6 ($4.324) premiums for houses within 500 meters walking distance.	-Positive effects of accessibility are stronger than the negative nuisance effect. -However, the benefits of accessibility to a station may not be as great as some expect.
Smersh&Smith(2000) [1980-1990], the Dames point bridge, Florida	Time series data, Repeat sales and Spline-regression techniques.	-Within 9.8 miles north of the bridge and 2.1 miles south of the bridge, linear distance from a house to bridge calculated by ***G.I.S***.	-For the goegraphic submarket Dames point south (within 2.1 miles), the houses appreciated over 5% less than the market appreciation of 52% for the 10 year period. -For the geographic submarket Dames point north, (within 9.8 miles), the houses appreciated nearly 8.7% more than the market appreciation of 52% for the 10 year period.	-Positive effects of the bridge is stronger for the north of the bridge. -Increased accessibility reflected to the houses in the north, but disamenity effect of congestion decreased property value in the south.

Authors	Methodology	Measuring Proximity	Impact Level	Conclusion
Cervero&Landis(1995), [1970 – 1990], Bart heavy rail and commute rail	Time series data Matched pair Comparison, logit and Linear regression and shift – share analysis.	-Distance to the nearest Bart station and the nearest freeway to the station.	- Over the 1970 – 1990 period, population grew 35.2% in the 25 Bay Area superdistricts not served by Bart compared to 17.1% in the 9 Bart – served superdistricts. - During the 1970 – 1990 period, employment grew 84.5% in the non – Bart superdistricts compared to 38.9% in the Bart -served ones. -For half mile rings around the nine stations, vacant land fell sharply as the dominant land use from 27.6% of total area in 1965 to just 4.2% of area in 1990. Of the 1557 hectares of vacant land that had been developed by 1990: 41% to residential, 21% to commercial, 16% to public, 15% to industrial and 7% to roads or parking lots.	- Population and employment grew faster in non – Bart areas, more land use change around Bart stations than freeway interchange. - Bart has played a fairly modest role in shaping metropolitan growth in the San Francisco Bay Area.
So, Tse and Ganesan(1996), [1994,the 12 –month period], Mass transit railway, buses and minibuses. Hong Kong	Cross – sectional data, Hedonic price model	-Transport accessibility was measured by the distances to the nearest stations of the mass transit railway as shourtest route.	-	- Accessibility to minubuses emerges as the most influential in determining house prices. - Accessibility to transportation facilities increase house prices.
Cervero & Duncan(2002), [1999, 2000, 2001], light rail, commuter rail, bus rapid transit, Los Angles County.	Cross-sectional data, Hedonic price model, Descriptive statistics.	-Within one-quarter to one – half mile range as acceptable walking distance to rail stop.using G.I.S.	-Multi family parcels near red line subway stations were sold for over $20.000 more if they were within a half mile a station with respect to highways and freeways, parcels were sold less within a quarter – mile due to nuisance effects.	-Positive and negative effects were recorded. - Acess to jobs with highway and transit networks positively influenced values.
Cervero(1994), [1978-1989], Heavy rail Washington's metrorail and Atlanta's MARTA.	Time series data, Multiple regression Analysis	-Within a three mile radius of a station.	- Offices near terminal stations rented for around $3.35 less per square foot than offices near non-terminal station did. - Joint development projects provided about a 15 percent office rent premium.	- There is an important affect of rail transit and joint development on office rents.
Chen,Rufolo& Dueker(1997) [1992 – 1994], lightrail transit, in Portland, Oregon.	Cross-sectional data Hedonic price model	- Shortest to distance to the lrt line, distance to C.B.D. distance to nearest park, - Within 700 meters of an lrt station as straight line using G.I.S.	- at 100 meters away from stations, each additional meter further away from the lrt station will result in a $32.20 decrease in price for an average price at $85.724. - The minumum price was reached at 427,33 meters away from station.	-Housing prices go up with distance away from the lrt line. -accessibility effect dominates the nuisance effect and the nuisance effect declines much faster than the accessibility effect. Light rail has both a positive effect (accessiblity) and a negative effect (nuisance) on single-family house values.

Authors	Methodology	Measuring Proximity	Impact Level	Conclusion
Cervero and Duncan(2001), [1998 – 1999], light and commuter railline Santa Clara County, California	Cross – sectional data, Hedonic price model	- Within ¼ mile of lrt station and commuter rail and within ½ mile of freeway interchange as dummy variables and as proximity variables.	-Parcels within a quarter mile of a Cal Train station and in a business disctrict were worth more than $25 per square foot than otherwise comparable properties away from stations. - The nuisance effects of being near a freeway were a lowering of land values by nearly $2 per square floot.	-There are important effects of proximity to light and commercial rail stations as well as freeway interchanges on commercial – retail and office properties in fast growing Santa Clara County. - The capitalization benefits of being near lrt were smaller around $4 per square foot than those assocviated with commuter rail in business discrict.
Dueker and Bianco(1998), [1986 – 1995], Light railline in Portland.	Time – series data, Before and After Analysis using Comparing data as statistical	- Levels of transportation access were determined by use of a quarter – mile buffer around light rail stops, bus stops and major arterials using Arcview in order to buffer transit stops and arterials.	- The analysis showed that about 17 percent of all multifamily development projects built in 1986—the year light rail opened—through 1995, and 12 percent of the total amount of develo ped multifamily area in that 10 – year period has occured around rail stations. - The model estimated and showed that price effect of lrt on single – family housing was varied with distance, for example a house was valued at $80500 a distance of 200 feet away and $74835(reduction) a distance of 1000 feet away from a rail station.	- The study showed that distance to rail stations and the distance to the rail line incorporatedpositive and negative effects, in the study the accessibility effect(positive) dominated the nuisance (negative) effect.
Hennebery (1998) [1988 – 1993 - 1996] The South Yorkshire Supertram	Cross sectional data over three years Hedonic price model Before and After study	Linear distance from properties to supertram stops using GIS.	- In 1988, there was a modest inverse relationship between distance from the future route of supertram and its price. - In 1993, there was a modest direct relationship. The relationship was statistically significant in 1996. Supertram route had no statistically significant influence on its price.	- Property variables are significant factors affecting house price - The effect of distance factor to Supertram decrease overtime.
Forrest, Glen and Ward (1996) Greater and Manchester, England Metrolink, the light rapid transit	Cross sectional data Hedonic price model	- Properties were divided into five categories: within 1 km and 1-2 km of the nearest station on Metrolink route and non-metrolink route, properties more than 2 km from the nearest station as dummy variables.	- The results indicate no significant price difference according to whether the property is within a 1 km radius of a station or within the outer 1-2 km zone	- Proximity to station tends to lower property price. - The model found a negative effect on house prices associated with noise and traffic congestion.

Source. The Tables were prepared using the review of selected studies.

CHAPTER 3

REAL ESTATE VALUATION AND URBAN HOUSING MARKETS

3.1. A Review of Property Valuation Methods

Real estate sector is strongly related to the wealth and economic health of a nation. Also, real estate is an important determinant of other economic sectors. The purchase of a residential property is an investment decision and a consumption decision. Therefore, valuation is an important process of decision making and real estate investment. Real estate valuation can effect decision of an investor how much to bid for an investment. In addition to this, before an investment decision, the determinant of probable risks, incomes from investments, expected future cash flows and rate of return are needed to use property valuation techniques. In property valuation studies, *"real estate is determined that real estate is a complex economic good that actually consists of various component parts that contribute to the value of a particular property"* (Fisher and Martin, 1994: p. 3). These components can be subdivided into physical and legal rights. Table 5 shows these value components of real estate.

Table 5. Value Components of Real Estate

Physical real estate	**Bundle of rights(estates)**
Land	Fee simple
Improvements	Leased fee
Property rights	Leasehold
Real property interests	**Financial**
Non realty interests	Mortgage
Personal property	Equity
Intangible property	
Business value	
Financing premiums	

Source: Fisher and Martin, 1994

In the literature, real estate valuation are subdivided into residential (single-family or multifamily) and non residential (commercial: office, shopping centers, hotel, industrial etc.) valuation. Also, real estate studies can include environmental impact studies, cost-benefit studies, investment analysis and feasibility studies. The studies can be made to forecast expected future cash flows, direct and indirect effects of a project. In the study concept, the study will focus on residential property valuation models associated with the goal of the thesis.

Valuation as different from price means a prediction of price of a property in the market or an estimation of the most likely selling price (Isaac and Steley, 2000). Important factors in real estate valuation are population, environment, strong ness against natural disaster, safety, distance to social areas and shopping centers, level of public amenities, marketing easily, building quality and land availability (Alp and Yilmaz, 2000). In addition to these factors, social and economic characteristics, neighborhood characteristics, income level, ethnic and religious characteristics associated with location of a property can play an important role in real estate valuation. Thus, in real estate valuation process, these factors must be considered by an expert or appraiser.

Three traditional methods in the literature are used to estimate the value of real estate. These approaches are **income capitalization approach, cost approach and sales comparison approach**. In sales comparison approach, value is estimated by comparison between similar properties. For example, the comparison can be made according to square foot, age of building, price etc. In this approach, making comparisons correctly between properties are based on quality of data including price or property characteristics. In other words, if comparison is made for price of housing, rent sales associated with properties must be used. One of the traditional appraisals is income capitalization approach. Value is estimated to consider present value of future probable benefits. In other words, *"future cash flows are estimated and discounted to a present value using a capitalization rate"* (Fisher and Martin, 2000: p.449). Other traditional method is cost approach. In this method, value is estimated to add each depreciation amount into the value of real estate. For example, age of building over time cause depreciation in house units. This means cost for buildings and reduction in value (Fisher and Martin, 2000).

In addition to the traditional methods as mentioned above, one of the oldest approaches in property valuation is **multiple regression analysis**. Multiple regression analysis allows valuers to estimate the value of individual property attributes. However, there are some problems in the application of multiple regression analysis. These problems especially are related to market segmentation. In this situation, *"... regression models will be subject to aggregation bias"* (Watkins, 1998: p. 157). In order to correct this problem, Watkins analyzed different segments in urban housing markets and he developed some models best fitting to each market segment. In fact, regression models are one of the oldest methods used in property valuation in the U.S. and U.K.

Freeman (1993) suggested three property value models. These are the **cross-section hedonic property value model, the repeat sales model and discrete choice model**. Discrete choice models provide a method of valuation for housing attributes. The model includes binary, multi nominal, nested logit and probit models. An assumption is that a bundle of housing attributes chosen by the individual provide highest utility level.

The repeat sales model can provide good estimations associated with price movements. The model is based on the analysis of a time series of selling price. In a specific time period, house price indexes are compared in urban area. For example, Gatzlaff and Smith (1993) studied the impact of the Miami Metro rail on the value of residential property near station locations. One of the methods used in the study was repeat sales method. Since access was improved due to the development of rail system. It was assumed that changes in housing prices occurred near stations after the development decision, from 1970 to 1990, annual changes of price in the station location and Miami were estimated. Comparing a house price index for properties located near the stations and Miami indicates a weak increase in house value proximate to the stations. One of the assumptions of repeat sales model is a constant rate of physical depreciation of housing units in some studies such as Gatzlaff and Smith. Selling prices over time will change, but housing attributes are assumed not to change over time.

One of the property valuation models is **hedonic price model**. Central to this model is the assumption that property is regarded as a bundle of individual attributes and price paid for a heterogeneous good is the sum of the implicit prices (Rosen, 1974). Empirical studies associated with monetary values include environmental amenities, quality factors and price of housing units. For example, housing or office units are heterogeneous good and their value is dependent upon a great many attributes associated with locational, structural and neighborhood characteristics. Hedonic analysis is a statistical technique for finding significant determinants of the value. In the USA and UK, this technique has been applied in property valuation about 30 years (Dunse and Jones, 1998). Hedonic price applications in the literature vary from car, computer markets to housing markets. Within the housing market applications, the model has contributed to the understanding of the relationship between the effects of improvement in public transportation or improvement in transport accessibility and house prices. In the house purchase process, assumption is that individuals have perfect information on alternatives and they are free to choose any housing unit. In addition, accessibility can be significant determinant influencing the purchase decision of residential property such as proximity to shopping centers or proximity to rail transit stations. Individuals' willingness to pay for amenities is determined using the model. Hedonic model allows the analysts or valuers to estimate the effects of these factors on value of properties. Because of this, the model has been used widely in property valuation.

In the following sections, hedonic price model as one of the property valuation models are presented with detailed descriptions.

3.2. Hedonic Price Models (HPM):

Hedonic Price Model is based on the relationship between the attributes of a good and its price. In literature, the model is used effectively in the real estate, computer and auto markets. An early contribution in development of the model belongs to Waugh (1929), Court (1939) and Griliches (1961-1971) (Sheppard and College, 1997). The common point of these researchers is to determine and analyze the impact of quality change on the price of a good with many attributes. Waugh (1929) firstly analyzed the relationship between quality factors influencing price using statistical techniques. Court and Griliches used the model to analyze the effect in the change of quality on auto prices. In addition to this, Rosen's Model (1974) and Lancaster's (1966) Consumer Theory provided important contributions to the model. Rosen and Lancaster suggested that a good have different attributes, such a heterogeneous good is formed as bundles of utility–affecting attributes. In other word, there is a strong relationship between the attributes of a good and utility or attributes of the goods and the decision on buying. Also, Rosen's model is the first theoretic contribution in the analysis of housing market. After these studies, many empirical studies were made, and they are based on these studies such as Rosen's study. Generally, the interest of these empirical studies is to determine how consumers valued the attributes embodied in the heterogeneous goods. In this study, we will focus on theoretical background of the model developed by Rosen, and then this framework will provide guidance for functional form, model specification and the variables used in the model.

3.2.1. Theoretical Background and its application to Housing Market

The Hedonic Price Model developed by Rosen (1974) provides an important technique to analyze housing market. Rosen's study relating the hedonic prices and implicit markets is the first theoretical interpretations and formulations of hedonic method for housing market. In this theoretical framework, Rosen assumed that "*goods are valued for their utility bearing attributes or characteristics. Hedonic prices are defined as the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them*" (Rosen, 1974: p. 34) so that housing is a differentiated good and have different attributes.

A housing unit also is represented by its attributes, thus price paid for a differentiated good is the sum of the implicit or hedonic prices of each attribute associated with that good. In other words, hedonic prices can be defined as the implicit prices of attributes. Hence, hedonic method is used to analyze the supply and demand structure of attributes for differentiated goods in a competitive market in a product class. In literature, this relationship is determined as hedonic price function and house price function which is a measurable function of attributes constituting a housing unit (Rosen, 1974; Freeman, 1993).

Rosen assumed that a housing unit as differentiated good is defined by its sum of n component attributes. This is formulated as a vector of attributes that differentiate the good. The formulation of a Z heterogeneous good is written as $Z = (Z_1, Z_2.......Z_n)$. In this formulation, Z_i is an amount or quantity of each attributes. A vector of housing attributes can vary with component attributes so that the price of a heterogeneous good can be explained to consider the amount of different attributes of housing.

The hedonic price function for this good Z represents the implicit or marginal prices of various attributes so that hedonic price function, P(Z) will give information about how the change in the attributes of housing effecting the price variation. The estimation of hedonic price function for a differentiated good needs observations about the various attributes that differentiate goods each other. In this stage, Rosen suggested some market conditions to define hedonic price function. *"Amounts of commodities offered by sellers at every point on the plane must equal amounts demanded by consumers choosing to locate there. Both consumers and producers base their locational and equilibrium prices are determined so that buyers and sellers are perfectly matched"* (Rosen, 1974: p. 35) in this way, the price of heterogeneous good P(Z) such as housing unit will be determined by consumers and producers utility functions and implicit prices of n attributes (Z_i) contained in the bundle. Thus, hedonic price function of good (Z) is expressed as a function associated with prices of attributes. In other words, a property or a housing unit consists of n attributes, Z_1...........Z_n. The price function for good Z in Rosen's formulation is written as follow (Rosen, 1974; Freeman, 1993):

$$P(Z) = P(Z_1, Z_2 \ldots\ldots Z_n)$$

Hedonic price function P (Z) gives the price of a housing unit with n component attributes and it is determined by the price of each component attributes so that the function represents how the price varies associated with different characteristics of housing units. As mentioned above, Rosen's model accepted that a housing unit is determined as a bundle of attributes.

In this concept, since consumers and producers maximize utility levels, hedonic price function is valid for all heterogeneous goods like housing. Rosen started to analyze the consumption decision of individuals in a competitive market and under budget constraints and then he analyzed the production decision of producers (Rosen, 1974; Freeman, 1993). According to this, an individual who consume a good Z has a utility level and individuals have different utility levels from consumption of a heterogeneous good related to changing of n component attributes. Because of this, utility function of this individual who consumes the good Z can be written as (Sheppard and College, 1997; Rosen, 1974; Freeman, 1993):

$$u = u(X, Z, a) \text{ or } u = u(X, Z_1, Z_2 \ldots Z_n, a)$$

In this formulation, where X is all other goods consumed, a represents a vector of attributes determining individuals' preferences and u is utility function of individuals. In order to obtain utility function, the individual under budget constraint want to maximize their utility levels. The budget constraint of an individual or household is formulated:

$$y = P_x X + P_z Z;$$

In this formulation, y is income of household. P_x and P_z are relative prices of the goods. Rosen's model for consumption decision of consumers represents an optimization problem. There is a household who maximize utility level subject to a budget constraint. The household must choose relative bundle of attributes given income and utility level. The solution of the problem is done by setting up the Lagrangian and its first order condition (FOC).

The FOC give the implicit price or hedonic price of characteristic i, so that the function P (Z) is called as hedonic price function (Rosen, 1974; Freeman, 1993; Sheppard and College, 1997). In other words, partial derivative P (Z) with respect to its characteristics such as Z_i is implicit or marginal price in P (Z) and this is equal to equilibrium marginal attribute price (Dunse and Jones, 1998; Rosen, 1974). After utility function for a household, Rosen defined "**bid rent function**" term for consumers. The bid rent function represents that willingness to pay function of household given the income and achieved utility level (Rosen, 1974; Sheppard and College, 1997). The bid rent function is defined as:

$$\theta = (z, u, y; \alpha)$$

Where Z represents the attributes of a house, u is the utility level; y is the income for a household and a is a vector of parameter showing preferences for individuals. Given the income and achieved utility level, in Rosen's theory, the function gives willingness to pay function for a house. It is accepted that bid rent function is concave in Z. Different bid rent functions can be determined for each households given the income and achieved utility level. Bid rent function for each individual is different due to preferences, income factors. Figure 3 shows the bid curves for two individuals.

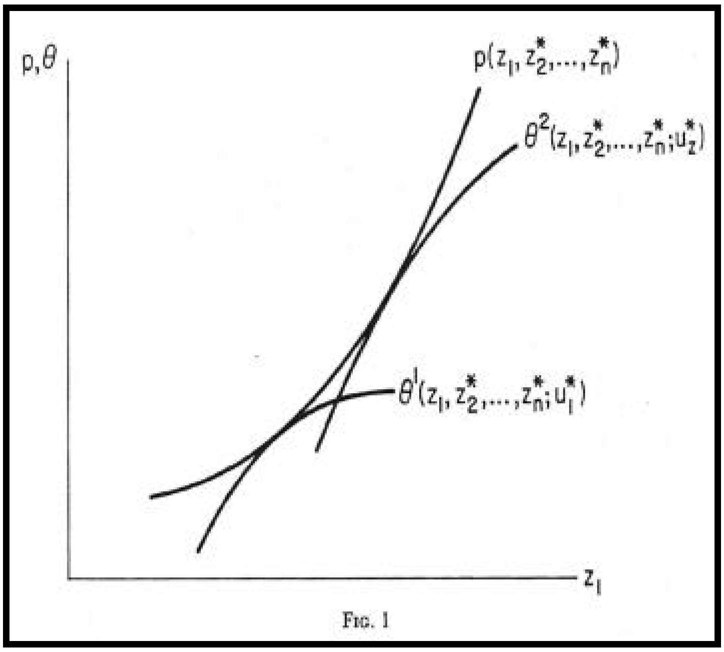


Figure 3. Bid functions of Consumers

Source. Rosen, 1974

In this stage, Rosen determined an equilibrium point. According to this, "*the amount the consumer is willing to pay for Z at a fixed utility index and income is Q (z; u, y), while p(z) is the minimum price he must pay in the market*" (Rosen, 1974: p. 39) and if each bid rent function of households in the market is tangent to hedonic price function P(Z). The equilibrium is provided for consumers. It is expected that the change in income level will result in changing of bid function. At the equilibrium point, marginal willingness to pay for the characteristics is equated with their marginal implicit prices.

Rosen's model tries to obtain a **market equilibrium** for consumers and producers and also in Rosen's base assumption, "*a theory of hedonic prices is formulated as a problem in the economics of spatial equilibrium in which the entire set of implicit prices* *guides both consumer and producer locational decisions in characteristics space"*(Rosen, 1974: p. 34). Because of this, in second stage of the model, Rosen named a function called the offer function or the production decision. To complete of the model, the study provides an explanation associated with producer condition in the market.

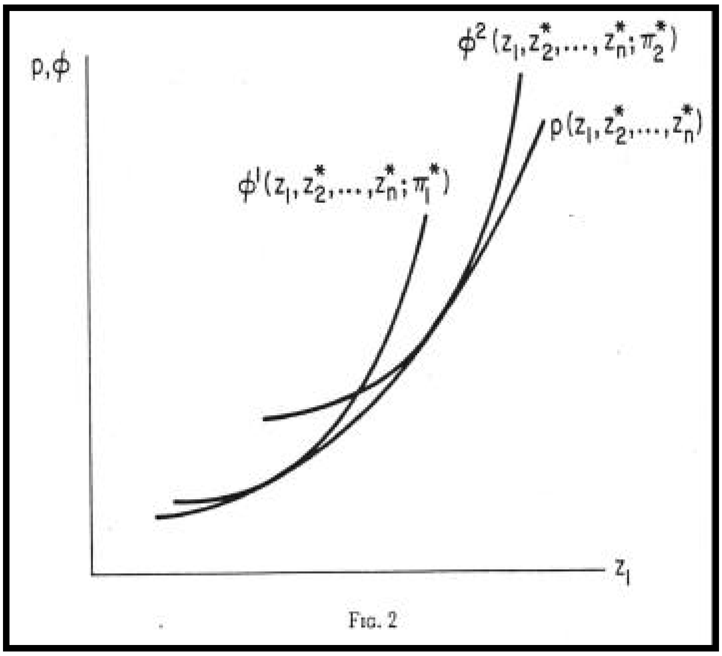


Figure 4. Offer functions of producers
Source. Rosen, 1974

The offer function is provided by producers of heterogeneous goods such as house units. Offer function shown in Figure 4 represents cost function of a producer. Producers who supply the goods have different cost functions like consumers. The cost function is given as follow:

$$C = (M, Z; ß);$$

Where M is the amount of housing units including characteristics of the house supplied good Z. ß represents characteristics of each producer. Each producer wants to maximize profit. Hence, the profit (π) of a producer formulation of producers is written as:

$$\pi = M\ P\ (Z) - C\ (M, Z_1 \ldots Z_n, ß)$$

Where π is the profit of a producer. C shows cost function of the producers. Thus, the profit for producers depend upon the difference between cost function and the number of houses sold the price P (z). The offer function (or offer curve) of producers is written as θ = (Z_1 ...Zn; π, ß) (Rosen, 1974). From the offer function, the profit of a producer is rewritten as optimization problem:

$$\text{Max } P\ (Z)\ M - C\ (M, Z, ß)$$

Figure 3 and figure 4 represent the bid rent functions of households and the offer functions of producers. As we shall see above, Rosen's model depend upon the market equilibrium consisting of supply and demand factors in the market. In Rosen's model, there are two maximization problems for producers and consumers. Consumers want to maximize utility. From this optimization problems, first order conditions gave hedonic price of characteristic i or implicit price relative characteristic of each characteristic (P_{zi} = ?P/? Zi).

Producers maximize profits. The formulation of the problem is written: Max ?= P(Z) M–C(M, Z, ß). The offer function is convex. From this point, equilibrium in Rosen's theory as mentioned above is determined that offer curves of sellers in the market ($\theta_{1,}$.......... θ_n) and bid rent curves of buyers in the market (θ_1, ...θ_n) will be tangent to each other (Sheppard and College; 1997; Rosen, 1974; Alkay; 2002). If this situation is obtained, equilibrium in the market arise and equilibrium can vary according to producer and consumer behavior in the market and *"equilibrium in this market for heterogeneous goods requires a hedonic price function P(Z) that equates supply and demand for every type of house Z"* (Sheppard and College; 1997). Thus, the equilibrium will occur at the point of tangencies between offer curves and bid rent curves as represented in Figure 5.

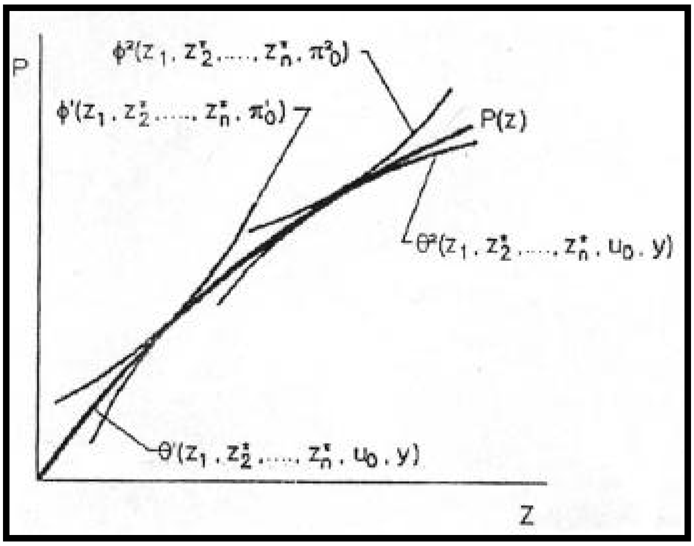


Figure 5. Hedonic Equilibrium
Source. Alkay, 2002

Although there are some articles critizing Rosen's theory, many empirical hedonic price applications is based on Rosen's theory especially in housing market researchers and these studies help decision making process to planners and also developers where to locate buildings or public investments and so on. Since housing is an important investment and consumption decision, economically the models measuring utility level of these actors are needed.

An investment in urban area will cause possible benefits or dis benefits for people who live there. The results of this investment decisions in terms of value must be known and estimated. The hedonic price method is an important technique to determine these relationships. In this stage, the analysts modeling house markets must know the following features related to housing markets (Sheppard and College, 1997).

- **Housing markets involves search,**
- **Housing markets are spatial,**
- **Housing markets include both new and existing homes**.

3.2.2. Functional Form, Model Specification and Variables

3.2.2.1. Functional Form and Model Specification

As mentioned in the theoretical background of the model, hedonic price model works under some assumptions. For example, housing market is in equilibrium, housing as a heterogeneous good consist of different attributes. Each attribute can be determined and its effect on price can be estimated. Under these assumptions, the functional form of the model generally is written as follow:

$$P_{hi} = P_h (S_i, N_i, Q_i)$$

Where S is a vector of structural attributes, N is a vector of neighborhood attributes and Q is a vector location-environmental attributes (Freeman, 1993). In this equation, structural attributes may include size, number of rooms, and age of a housing unit. Neighborhood attributes and location attributes denoted Q or L, in some studies represent accessibility attributes, for example accessibility to parks, transport services, shopping centers, work places and CBD.

Modeling of housing market needs choice of the functional form that gives the best fit to data set. In the literature, there are many proposed functional forms. There are mainly **linear, semi-log (log-linear), double-log (log-log), the inverse semi-log, the exponential, the quadratic and the Box-Cox transformation**. The most accurate functional form must be chosen according to reliability of regression estimation. In this stage, some functional form examples generally are as follow:

Equation 1: **Linear functional form:**

$P = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ...+ \beta_n X_n + \varepsilon;$

Equation 2: **Semi-log (or log-linear) functional form:**

$Ln\ P = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ...+ \beta_n X_n + \varepsilon;$

Equation 3: **Linear-log functional form:**

$P = \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + ...+ \beta_n \ln X_n + \varepsilon;$

Equation 4: **Double log (or log-log) functional form:**

$Ln\ P = \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + ...+ \beta_n \ln X_n + \varepsilon;$

Equation 5: **Inverse semi-log functional form:**

$LnY = \alpha - \beta_2 1/X_1$..$+\varepsilon$;

Equation 6: **Quadratic functional form:**

$Y = \alpha + \beta_1 + \beta_2 X_1 + \beta_3 X_1^2 +$ ....$+ \varepsilon$;

In hedonic price analysis, the choice of the best functional form is important for finding the correct results. However, in the literature, there is not a consensus for choosing the best functional form. Although hedonic theory can not give any information relating the chose of the best functional form, an analyst using hedonic regression model must use the best model specification. Hence, there is a lack of theoretical framework in this stage. In order to solve this problem, *"there have been two approaches: studies on the estimation of demand for housing characteristics have generally chosen a non-linear form which is estimated using the Box-Cox transformation procedure. The second approach has used either a linear or an intrinsically linear (semi-log, double log) functional form"* (Can, 1992: p. 459). Some studies tried many alternative functional forms related to hedonic price model. The functional forms were evaluated on the basis of best fit criteria since theory give no guide for detection of best functional form. For example, Gatzlaff and Smith (1993) evaluated four functional forms (linear, semi-log, exponential and double-log). The evaluation was based on according to the basis of R^2 statistics. Chen, Rufolo and Dueker (1997) estimated two functional forms: semi-log and double log for their study data set within 700 meters of a light rail station. The semi log functional form gave more correct estimations for whole data set. In addition to this, the analysts have some price information about regression coefficients and the sign of the variables used in the hedonic price model. An analyst has some expectations related to the signs and parameter coefficients of regression analysis. If the expectations do not become true, the functional form used in the study may be wrong. Because of this, in the studies, many functional forms are evaluated for all data set used in the studies (Adair, 1996; Bajic, 1983).

In addition, **Box-Cox transformation** can be applied to choose among alternative functional forms for the hedonic price model so more flexible specification and functional form are obtained by applying the Box-Cox transformation (Can, 1992; Freeman, 1993; Çelik, 2001).

$$X^{(\lambda)} = (X^{\lambda} - 1) / \lambda$$

Where X is the variable being transformed and λ is single parameter to obtain the variable X (Box and Cox, 1964; Greene, 1993). According to the estimated Box-Cox model, if λ equals 1, this becomes linear function and if λ equals 0, this is a log-linear or semi-log model. In the literature, linear, log-linear, quadratic Box-Cox model are used to obtain correct estimates of marginal implicit prices in hedonic price models (Freeman, 1993; Sheppard and College, 1997).

3.2.2.2 Variables

A residential property or a housing unit as a heterogeneous good can be determined by a vector of attributes relating to its physical, locational and neighborhood characteristics. Each attribute may have the effect on price and each attribute have different effects on price. As mentioned in theoretical background, the hedonic price model is estimated using regression analysis to find the implicit prices of the attributes and also the model tests and separate out the effect of the factors influencing house price or value. Because of this, the correct functional form must be used. The variables relating the house price must be chosen and observed by the analysts. The variables used in the model mainly are subdivided into physical, locational and neighborhood attributes. The independent variables of the model are derived from these attributes and the independent variables may be quantitative or qualitative. The dependent variable of the model is the variable representing the price, rent or the value of a residential property. An important point in this stage is the need for reliable observations to estimate hedonic equation.

3.2.2.2.1. Dependent Variable:

Hedonic price model is used to estimate the variation in the value of a residential property or house prices associated with its different attributes. In general, the price of a house is related to the characteristics of the house such as its structural, neighborhood and environmental characteristics so that in hedonic price method, one of the most important variables is dependent variable. The effects of different attributes on price or value can be estimated using hedonic price regression analysis. Because of this, according to Freeman (1993), there are two main questions that arise in hedonic price function.

Firstly, the dependent variable of the model is the sum of implicit prices of the attributes that differentiate goods. The dependent variable can represent land value or full price of the house and land together. Generally, in empirical studies, the information about price includes land and housing value. The second question is related to the source of data on real estate value or price. In empirical studies, there are differences associated with the two main questions. House prices do not represent speculative prices.

In empirical studies, the dependent variable of the model represents real estate sale price and the total of land house unit prices and also in commercial-retail, residential applications of the model. The information about sale price includes land and its structural investment (Freeman, 1993). However, in calculating the hedonic price function, according to alternative functional form, natural log can be taken of the dependent variable (Bowes and Ihlanfeld, 2001; Strand and Vagnes, 2001), so that the dependent variable is real estate sale price or its log transformation.

Secondly, the data can be obtained from real estate agents, professional appraisals, country tax assessment records, central government data registry. The source of data is important for reliable estimations. If an analyst can not find data, it is collected from the case area. In this situation, the data can be obtained from household real estate agents using with surveys or questionnaire. If the data can be obtained from professional appraisals or a proprietary data base, a time series dataset may be formed. If not, a cross sectional dataset can be obtained. In some studies, tax assessment records are used to obtain sale price information, but the sale transactions can include speculative price.

3.2.2.2.2. Independent Variables:

As mentioned above, a real estate as heterogeneous good are determined by a vector of attributes associated with its structural, locational-environmental and neighborhood characteristics. These attributes are the components of independent (or explanatory) variables of a hedonic price model so that hedonic prices represent the implicit prices of attributes affecting house price. In this stage, independent variables will be explained under three subcategories.

1. Locational variables of a residential unit are included to estimate the importance of accessibility factor for residential areas. Accessibility can be measured in different ways, but it is obvious that accessibility has influence on urban real estate values. In the studies, accessibility is measured in terms of regional job accessibility by auto, transit or walking times, proximity to transport services, proximity to rail transit line or distance to CBD, distance to a nearest park, op, a transit stop (Cervero and Duncan, 2002; Bowes and Ihlandfeldt, 2001). These variables are spatial-related variables and the measuring of these variables can be made by different methods. The most known and reliable method is to measure using GIS. One possible measuring is that linear distance from a housing unit to nearest a rail stop is estimated on a digitized map. Some classifications can be made, for example properties can be divided into groups: properties within 500 meter of a nearest station, within 1 km or within 1-2 km or more than 1-2 km of a nearest station can be determined. Properties within relative distance category represent distance variable. This variable can be coded as 1 or 0 dummy variables. In addition to this, in some cases, walking distance or frequency of transport services may be more important (So, Tse and Ganesan, 1996). The studies suggest that accessibility to transportation services may have different two effects on property values. Accessibility effect such as distance to a lrt station may cause higher property values or may cause lower property values due to nuisance effects (Bowes and Ihlandfeldt, 2001; Chen, Rufolo and Dueker, 1997; Al-Mosaind et al, 1994). Thus, distance variables can be miles, meter or km unit (Hennebery, 1997; Forrest et al, 1995; So, Tse and Ganesan, 1996) and in the empirical studies straight line distance is used to estimate accessibility factor.

2. Structural (Physical) Variables are used in the hedonic model as explanatory variables. These variables are strongly related to the price of a housing unit. The most important attributes affecting the behavior of households belong to these attributes. Some of these attributes can vary over time such as age. The physical characteristics are age of building, lot size, house size, and number of bedrooms, number of bathrooms, number of fireplace, presence of attached garage, building type as bungalow, semi detached, and water heating system etc.

According to the studies, households are willing to pay more for use space associated with size, number of bedrooms and bathrooms in residential units. Chau, Prectorius and Yu (2000) suggest that the relationship between shop size and price tends to be non-linear in Hong Kong for retail property unit prices. Lot size, number of rooms and bathrooms, presence of attached garage, presence of fire place is positively related to price, while age of building is negatively related to price. In empirical studies, house size is measured in squared feet or squared meter and age is measured in years. Contrary to these variables, corner location, presence of basement, presence of attached garage, building type, heating system are measured using dummy variables coded 1 if condition satisfied or 0 otherwise.

3. Neighborhood Variables are related to the quality of public schools, recreational facilities, and presence of hospital variables and so on. These variables are categorized as socio-economic and local government services. In addition to this, the studies suggest that externality factors such as noise and crime are related to neighborhood attributes. Also, population density, household income, proportion of black people and proportion of youth are a part of neighborhood attributes. The measuring of these variables can be made by GIS according to one mile radius of parcel or ½ mile of rail station called as buffer zone. As mentioned above, dummy variables can be used to measure the effect of the variables. Also, data can be obtained from census.

The explanatory variables entering the hedonic model may vary. The data set of explanatory variables of each empirical study is not identical. Because of this, case study must be correctly observed and the factors affecting house price must be determined and used in the hedonic model specification. However, one of the major problems of using hedonic price model is the presence of multicollinearity. There is collinearity between independent variables. Since housing is a heterogeneous good and has different attributes. The determination of house price needs reliable and correct measuring of variables dataset. Each attribute will have different implicit price so that these regression coefficient will indicate marginal willingness to pay for households.

3.2.3. Advantages and Issues regarding the Estimation of Hedonic Price Model:

Hedonic theory assumes that goods are heterogeneous and house price is determined by attributes and the model provides to estimate implicit price of individual attributes. One of the most assumptions is that individuals have information about all house prices and attributes of house units in the market so that individual will chose a housing unit in the market associated with budget constraint. However, hedonic theory works in the **market equilibrium** as mentioned above. If there is not market equilibrium, marginal willingness to pay function for individuals can not be estimated correctly, since each. In this point, Freeman focused on some possible estimation errors. Divergences from full equilibrium of the housing market in many circumstances will only introduce random errors into the estimates of marginal willingness to pay (Freeman, 1993). Equilibrium in the housing market may not occur due to some specific issues. For example, the valuation of professionals can not represent characteristics of housing market. It is expected that this situation can effect the measuring of dependent variable correctly.

Another potential problem is related to the changing spatial structure of supply and demand. If supply and demand can not be observed correctly, marginal implicit prices can not represent the marginal willingness to pay function. This results in estimation errors (Freeman, 1993). The model determined by Rosen is strongly related to optimization problem for individuals under budget constraint. He assumes that the individual choose a house and an individual gains maximum utility level associated with the chosen housing unit. In this point, first order conditions will give marginal implicit prices of attributes of a housing unit (Freeman, 1993), but this assumption will occur if there is equilibrium in housing market. According to Rosen's theory, partial derivatives are determinant of implicit prices and the implicit price function is differentiable and continuous so that if data is available, implicit prices can be estimated statistically, but in the literature, some important problems are determined in the estimating of hedonic price function statistically (Freeman, 1993).

Firstly, if number of housing units used in the model are large, but variation between attributes of housing units is small. The model can not give efficient information about implicit prices or marginal willingness to pay function for households. The significant levels between characteristics can not be determined. For this reason, hedonic price model in that housing market can fail. Variation between each housing units can be observed in the market, but these housing units can not be enough to run the model statistically. In other words, if a case study can not include different types of housing so that the measuring of hedonic price model for different urban area can not be possible. According to Freeman, this situation will affect marginal willingness to pay function for different type of households such as income. This situation can cause distortion of continuous assumptions of the model and equilibrium conditions so that marginal implicit price function can not represent equilibrium marginal implicit price for households. Because of this, the estimation does not represent real marginal implicit price at the equilibrium point (Freeman, 1993; Alkay, 2002; Rosen, 1974).

In the housing market studies using hedonic price model, the existence of market segmentation are determined in the literature. One of the most known studies related to market segmentation for an urban area belongs to Straizheim's (1974) study (Freeman, 1993). He studied using hedonic price model in San Francisco Bay Area and he estimated different hedonic price function for different areas of San Francisco Bay Area. In conclusion, he suggested that urban housing market had separate and different market segmentations. In order to correctly measure hedonic price model, different hedonic price functions must be determined by analysts. This situation is strongly related to demand and supply factors. Demand and supply can be change among segments in an urban area. Also, the behaviors of individuals can change among submarkets of urban housing market such as ethnic, income and cultural condition. In other words, each market segmentation has different structure of demand and supply, so that utility levels for household are expected to change among segments. This situation needs to analyze and determine the exist segments in urban housing market and then the different specifications of hedonic price function must be estimated (Freeman, 1993).

There are many empirical issues in the application of hedonic price model. One of the problems is choice of best functional form associated with the data. As mentioned previous chapter, these functional forms can be linear, log-linear, log-log, exponential and linear log. The correct estimation of hedonic price model is strongly related to correct choice of functional form. In opposition to this situation, the model can result unexpected results. Hedonic price function consists of dependent variable and explanatory variables. The major problem associated with the variables used in the model is *"misspecification"* or it is explained that relevant explanatory variables are not used in the model or irrelevant explanatory variables are used in the model. In this situation, it is expected that the wrong results and measurement errors will occur. The results cause biased. This situation is not wanted in the regression model applications due to decreasing of explanatory power of the model.

However, as mentioned in model specification, hedonic theory does not give any method associated with the selection of a set of independent variables. Another problem for cross-sectional data is heteroscedasticity problem. According to the assumption of regression model, there is a constant variance assumption and this situation is called as homoscedasticity ($E(u^2_i) = \sigma_i^2$) (Gujurati, 1995). The regression model assumes that the residuals have the same variance. If this assumption is not violated, heteroscedasticity problem can occur. Another econometric issue is that an incorrect selection of model strongly is related to model specification and functional form. The incorrect selection may cause unexpected prediction of parameters.

Hedonic price model as mentioned above is an effective tool of modeling of housing market in urban economics. After 1980s, both theoretical and empirical studies related to monetary values based on hedonic price model have increased. The hedonic price theory presents that the price of a heterogeneous good can be determined by its attributes. The price paid for a particular property is the sum of the implicit prices. Hence, it is possible that the relative impact of each attribute on the price can be determined. In housing market, although Rosen's interpretation is critized, it provides an important theoretical framework in understanding of the structure of heterogeneous goods.

In this context, the model has been used in the studies associated with economic impact analysis of transit investments. The determination of economic benefits of a transit investment will be possible. Therefore, it provides the guidance in the decision-making process about where to locate residential, commercial building or tax policies; hence it is very useful for urban planners, policy makers and economists. After 1980s, many empirical studies determining the effects of a rail transit investment or economic valuations of environmental amenities increasingly have been made. However, the reliability of the model is highly related to data source, the correct choice of the functional form. Data on real estate sales and characteristics are obtained from real estate agents or professional valuers, property journals and so on. In these studies, it is obvious that accessibility or distance variables play an important role in the application of the model since location theory suggests that accessibility is an important determinant of land values. In this stage, Geographical Information System (GIS) provide an efficient tool to measure the linear distance between locations of a property in the buffer zone of transportation investments.

An important question in the context of estimating hedonic price model for housing units depend on the market segmentation of housing market. Therefore, the structure of supply and demand in each segment and behaviors of individuals will be different in other segments, so separate hedonic price functions must be estimated for each segment.

CHAPTER 4

DESCRIPTION OF THE STUDY AREA

Subway investment in Izmir and its buffer zone have been chosen as a case study. Hedonic price model will be run for the properties located within the impact zone of the subway route. Therefore, this chapter will start with the explanation of rail transit investments in Izmir City and then study area is explained.

4.1. Rail Transit Investments and Development in Izmir County

Izmir being the third largest city in Turkey has a population of 3.2 million and has experienced very rapid growth. It is expected that the population growth and employment will continue in the coming years. The population in the year 2010 is forecasted to be 4 million and 47 percent of this population will commute to city centre as daily (Izmir Light Rail Transit Project: Prequalification Documents, 1992). This growth is considered to increase congestion levels in roads, so it is needed to improve existing transportation infrastructure and to prepare proposals for a new transit system for coming decades.

First preparations for subway investment in Izmir were made in the year 1989. Izmir Transportation Master Plan for Greater City of Izmir was prepared by Heusch-Boezefeldt in 1992. This study includes all statistical data for Izmir City and analysis of existing transportation systems, its problems, traffic volumes, and socio-economic data belonged to the city, transportation modes and demand, existing transportation network analysis in main arters for the year 2010. Existing transportation facilities in 1992 included ferry boats, taxi and shuttle taxi services, mini-buses (private), suburban railway system and municipality busses.

Izmir Transportation Master Plan prompted a new subway system expanding into all around the city: Bornova, Buca, Narlidere and Çigli as shown in figure 6. According to the Master Plan, subway system consists of 50 km line and Fahrettin Altay, Üçyol, Konak, Basmane route were approved in 1992. Construction was approved in 1993, and the part of Fahrettin Altay and Üçyol of the project was postponed until second stage in 1994.

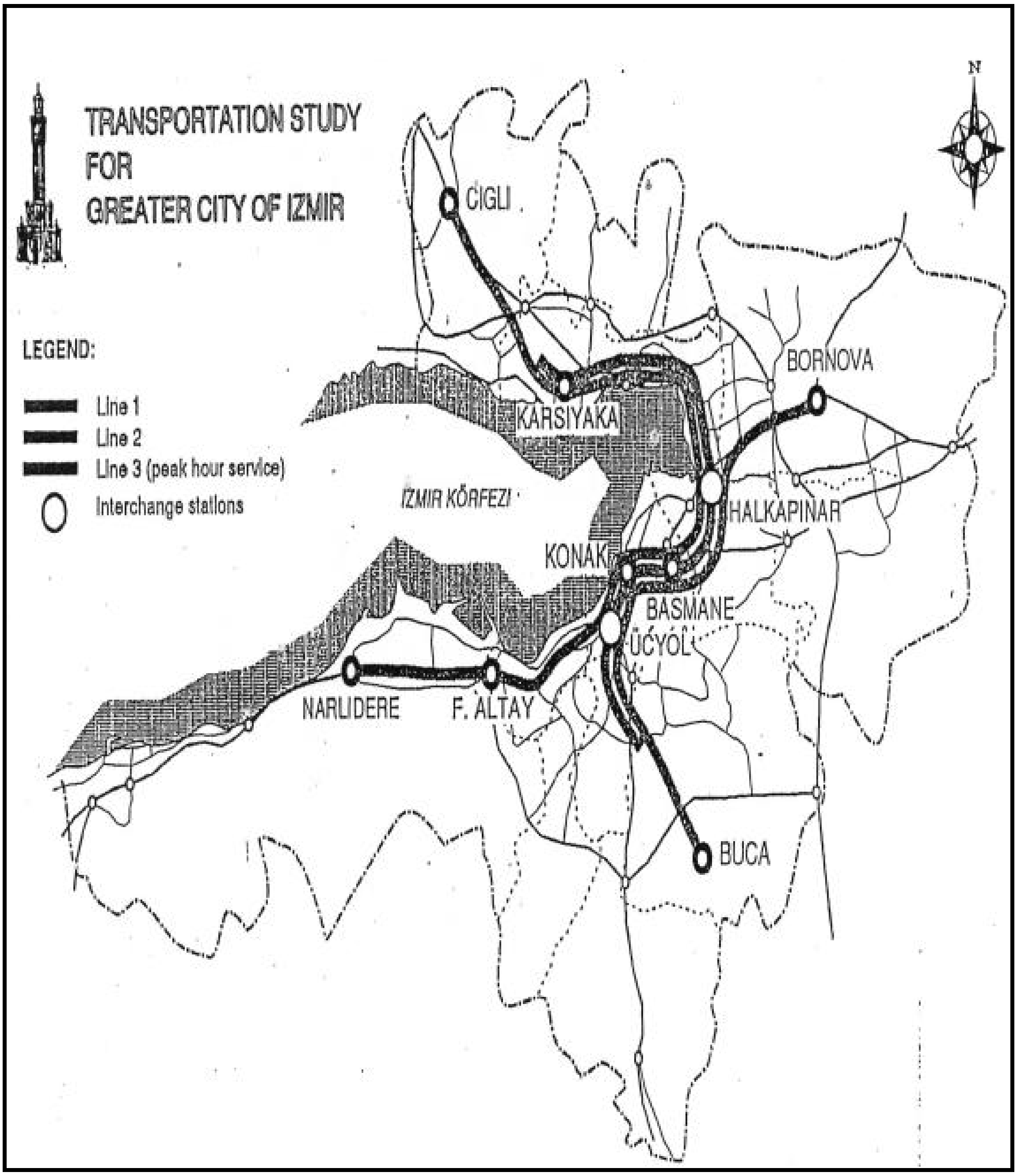


Figure 6. Proposed Subway Routes for Izmir

Source. Heusch-Boezefeldt Transportation Master Plan Study

In the first stage, Üçyol-Konak-Basmane-Halkapinar part of the system was accepted. In conclusion, the subway route started from Hatay-Üçyol point and reached to Bornova near Ege University and Ege University Hospital as shown in figure 7.

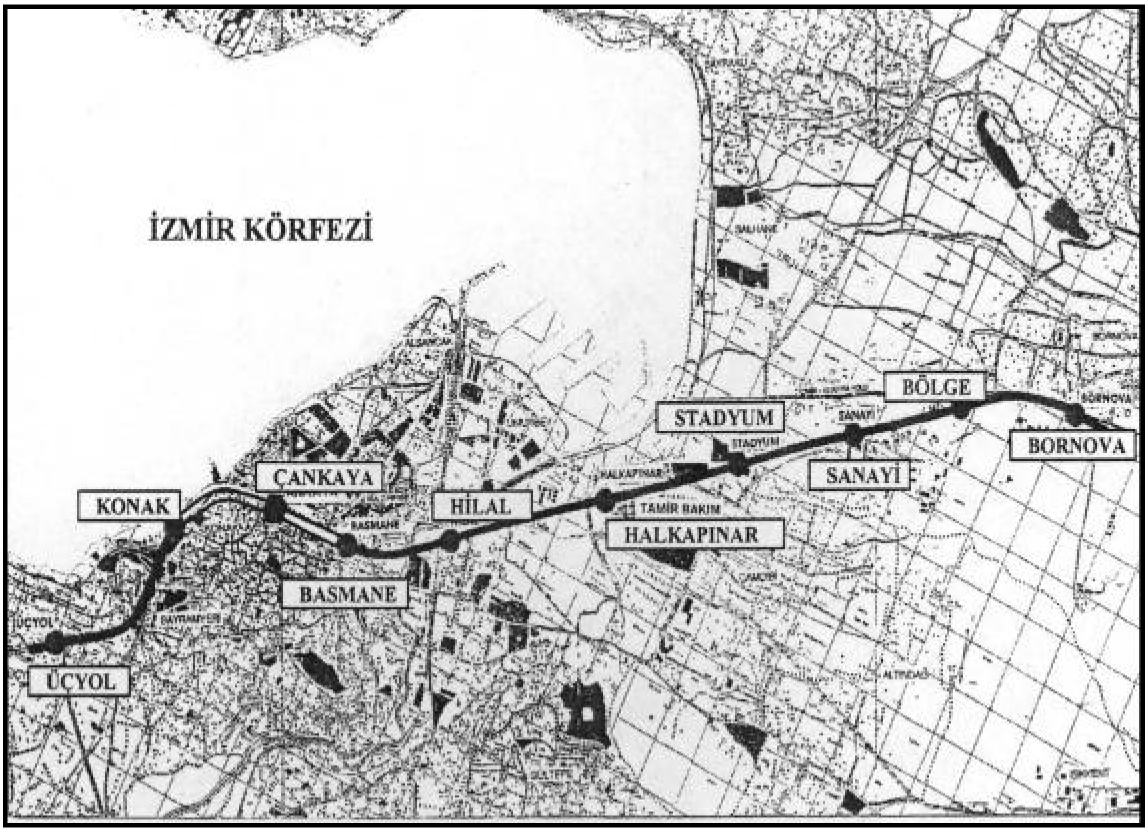


Figure 7. The Existing Subway System in Izmir
Source. Izmir Büyük Sehir Belediyesi(IBSB).

In addition to existing subway system, in the second stage, Üçyol-Fahrettin Altay route will be added to the existing system shown in figure 6. The system is 5.2 km in length. There will be five stations underground, so there will be 15 stations and 17 km in length totaly.

Another rail system project is modernization project of the existing Aliaga-Adnan Menderes rail route which is 80 km. This project will be completed by Turkish State Railways (TCDD) and Izmir Metropolitian Municipality (IBSB). After completion of the project, the system will be a total of 97 km, and then Buca, Çigli, Narlidere routes will added into the existing Üçyol-Halkapinar route in this way, the system will lie to all around the city as shown in figure 8.

These transportation investments are considered as a solution of urban transportation problems in Izmir. Also, it will cause to increase urban mobility. After completion of final subway project in Izmir, land development, change in property values and land use relating to infrastructure investment are expected to increase. In existing subway route, changes in property values have already been observed.

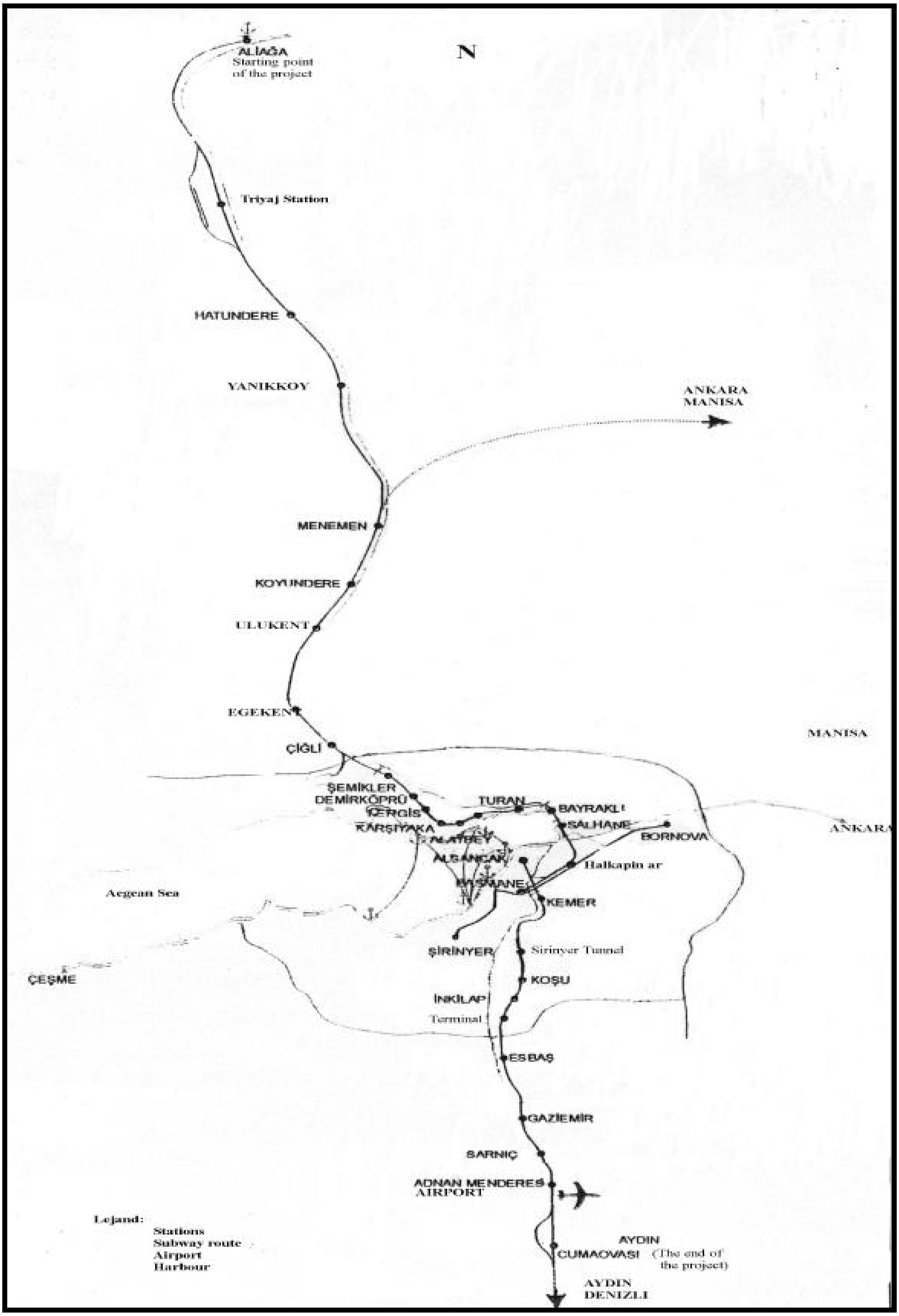


Figure 8. Modernization Projects of Aliaga-Menderes Route and Railroads in Izmir

Source. Izmir Büyüksehir Belediyesi-Department of Rail Systems

4.2. Determination of Characteristics of the Study Area

In existing subway route in Izmir, there are totaly 10 stations. These stations as shown in figure 7 are **Üçyol, Konak, Çankaya, Basmane, Hilal, Halkapinar, Stadyum, Sanayi, Bölge and Bornova** stations. Existing subway system lies from Üçyol to Bornova it is about 17 km in length. The 10 stations and nearby are the focus of the study.

These 10 stations serve city centre of Izmir, development areas of CBD, important industrial areas, public establishments, commercial areas, Ege Univercity and built-up areas as shown in Figure 11. In this route, residential areas focus on nearby Üçyol, Bölge and Bornova stations. In Sanayi, Halkapinar, Çankaya, Konak stations, there are a lot of industrial, public and commercial establishments. Also, retail and office properties locate near Konak and Çankaya stations. The CBD of Izmir includes the buffer zones of these stations. Since the thesis focus on the value of residential properties, these zones were omitted from the models.

Around Stadyum, Hilal and Basmane stations, there are many industrial, public, commercial and residential areas, but residential properties are not dominant land use with respect to other land uses. In addition, enough data were not obtained in these stations. In conclusion, Üçyol, Bölge and Bornova stations and their buffer zones have been chosen and hedonic price model has run for these areas.

A quarter mile ring (500 meters) as walking distance was created around all the subway stations using **Mapinfo** Georaphical Information System software. Also, one-half mile (1 km) was drawn around each station as second impact zone. The buffer zones were drawn using Mapinfo program. The data were obtained from these buffer zones. Firstly, Üçyol station, Bölge and then Bornova stations will be explained.

In the buffer zone of Üçyol station, residential properties are dominant factor of existing land use as shown in figure 9. This zone is also sub-centre of Izmir and Üçyol is one of the built-up areas near the CBD in Izmir. Inönü Street and Halide Edip Adivar Street are two main streets in Izmir and these main streets pass near the Üçyol station. Existing public transportation facilities, private transportation services and also subway investment have increased accessibility level in Üçyol.

The distance from Üçyol to the CBD takes about 1 minute by subway and it takes 5 minutes by bus. From Üçyol to Bornova, it takes about 17 minutes by subway and it takes about 47 minutes by bus. In the buffer zone of Üçyol station, there are 6 districts: Altintas, Kiliçreis, Akin Simav, Bahçelievler, Atilla, Piri Reis. Data set for Üçyol station consists of 173 house units. A quarter mile ring (500 meters) as the buffer zone was drawn around Üçyol station since the effect of subway investment is higher. For higher away from this zone, the effects of the subway decrease. Also, house prices are affected from other factors such as public establishments, presence of hospital.

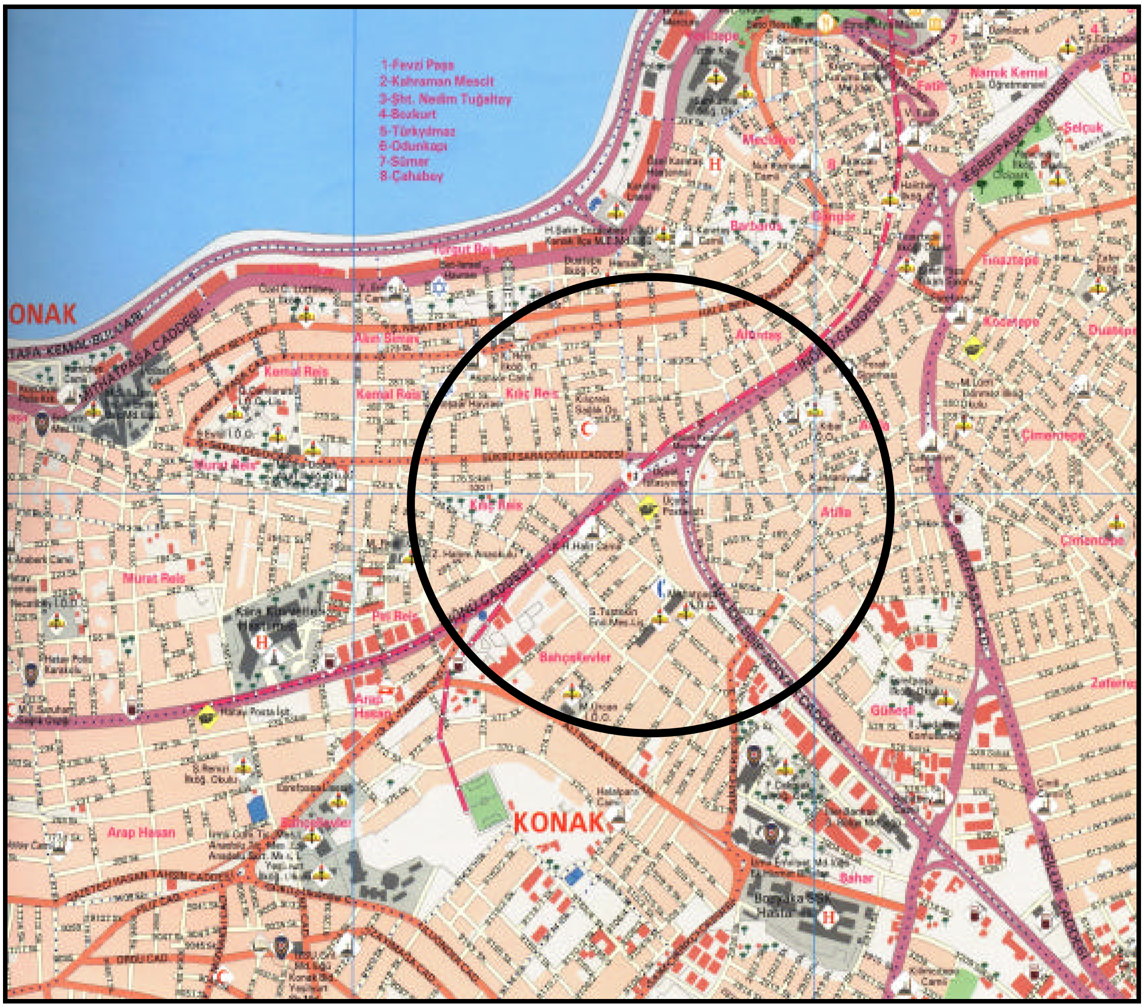


Figure 9. Üçyol station and its buffer zones

After Hatay and Üçyol area, Bölge and Bornova stations and their buffer zones were studied during February and March. The north of Bornova station consists of residential properties, while the south of the Bornova station includes Ege University and Ege University Hospital. Ankara street as one of the main arterial of Izmir City divides buffer zone into two different areas: Residential and University-Hospital, industrial, commercial, and public establishments in Bornova and Bölge stations and nearby shown in figure 10.

There are 2 districts: Erzene, Kazim Dirik in the buffer zone of Bornova station, and there are 3 districts: Kazim Dirik, Mansuroglu and Manavkuyu in the buffer zone of Bölge station. Mustafa Kemal Street is one of the important main streets in Bornova. Public transportation services such as bus, minibuses mainly use this street to achieve CBD and other locations. It takes 15 minutes from Bornova to city centre by subway and it takes about 41 minutes by bus. For Bornova and Bölge stations, the effects of the subway can extend to the north of the station about 1 km. Because of this, a quarter mile (500 meters) zone as walking distance and one-half mile zone (1 km) were drawn to measure the effects of subway stations correctly.

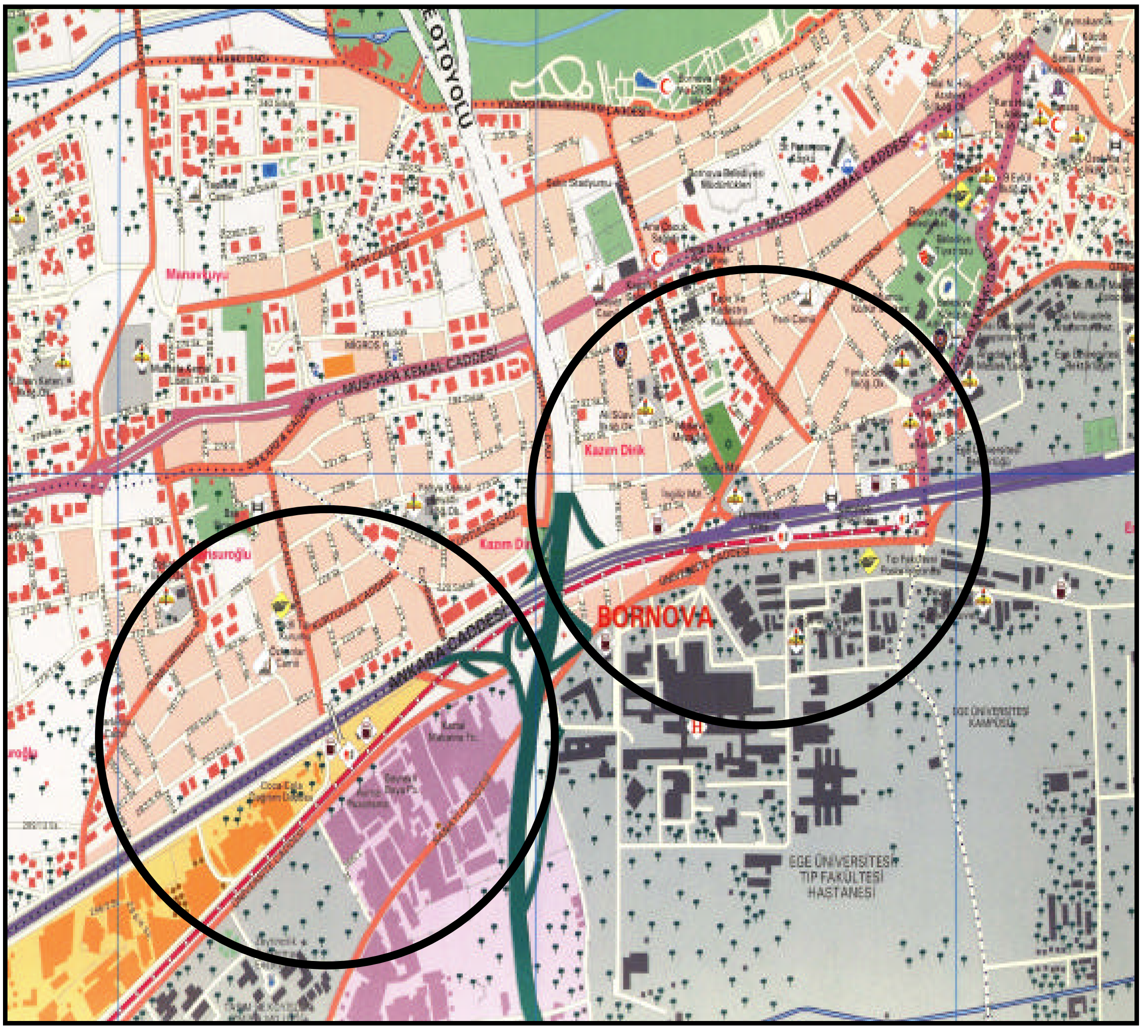


Figure 10. Bölge and Bornova Stations and Their Buffer Zones

The main factors affecting house prices in Bornova are existence of subway, the hospital, Ege Univercity and industrial areas. For this reason; students, academic personals, managers of industrial and commercial establishments located in Izmir and also Manisa, civil servants demand to locate in the buffer zone of these two stataions.

Residents who can not locate within these areas may demand the houses located within the buffer zone of Üçyol station.

There is a high demand in the two points of subway route in Izmir, but demand for houses near Bornova station is observed higher than Üçyol. This demand can lies on 1 km distance from the stations in Bornova and Bölge stations. In Bölge station and nearby, since Bölge subway route is at level and also existence of Ankara Street, they may cause to increase negative externalities such as nuisance for residents. This situation may not be desired for house buyers. Because of this, houses located in Ankara Street can not be demanded sometimes from house buyers. Modeling methodology will be explained in chapter 5.

CHAPTER 5

MODELING METHODOLOGY

In this chapter, the study will focus on the hypothesis expanded in the first chapter. Theoretical framework provides guidance for model specification, functional forms and variables used in the hedonic price model. The variables can be divided as dependent and explanatory variables. Explanatory variables will provide an understanding of significant determinants of the residential property values. Firstly, the method of the study will be explained and then empirical hedonic price model will be discussed.

5.1. Method of the Study

It is very difficult to measure the effects of improved accessibility in a transit investment on house prices. Since the purpose of this study is to examine the impacts of subway investment in Izmir, the study includes the empirical research of the hedonic price model in the case of Izmir subway. It is expected that existing subway system and also new investment in transit infrastructure will increase residential and firms' relative locations' accessibility, land values and also land development in the future. Existing subway system in Izmir has shown the effects on real estate market. The system has increased the demand for houses near light rail transit stations. Higher demand has caused value changes. Therefore, the objective of this study is to apply the hedonic price model for identifying the significant determinants of the values of residential property values in the buffer zones of the subway route. To achieve the aim of the thesis, the research method of the thesis includes the following steps:

1. Problem definition within the context of economic analysis of an investment in transportation infrastructure,
2. Literature review of the studies associated with the objective of the thesis in global level. This review includes the studies from Turkey and many countries,
3. Discussing the results, research methods, data, data sources, variables and models used in these studies,

4. Defining a study area: Izmir subway and its buffer zone were chosen as a case study.
5. Data gathering: preparing the questionnaire forms, obtaining the digital map of Izmir City for measuring spatial-related variables,
6. Preparing the data for the model as Excel table and SPSS data base and omitting the missing variables and speculative prices.
7. Choosing of the best model associated with the objective of the thesis, and also choosing of model specification and functional forms best fit to the data,
8. Running the models for the subway stations and their impact zones,
9. Evaluating the results of the models,
10. Deriving out the general conclusion for existing situation and next studies.

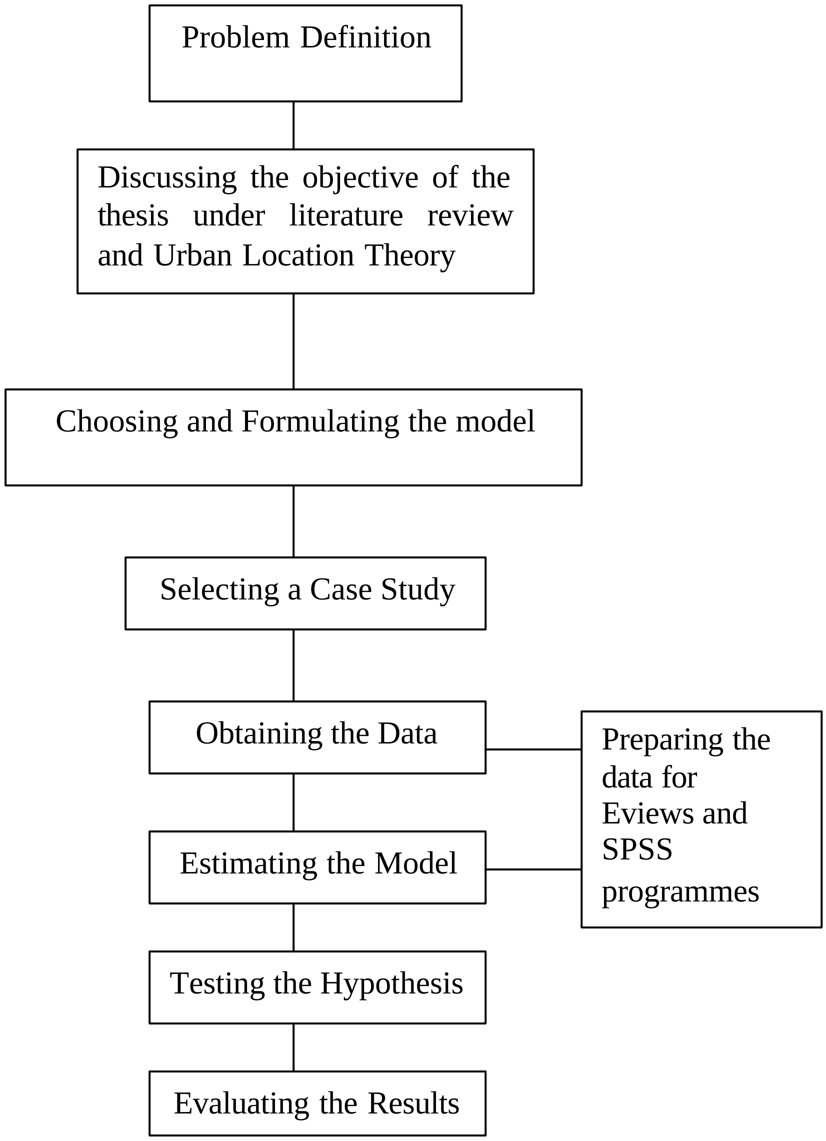


Figure 12. Flowchart for the Empirical Research Methodology

Research methodology is summarized in Figure 11. Since the study aims to determine the effects of subway investment on the values of residential properties, the case study includes the buffer zones about 500 meters and 1 km from the subway stations in Izmir. **The hedonic price model** has been chosen as the best model representing the relationship between investment in transport infrastructure and house price in the case of Izmir subway. Literature review of the studies as mentioned in chapter 2 indicates that hedonic approach is one of the most favorable techniques to assess the effects of transport accessibility on house prices. The model will run for Üçyol, Bölge and Bornova station since residential properties are dominant land use in the buffer zones of these stations. Also, data set could be obtained only from these buffer zones. Firstly, Üçyol station, Bölge and then Bornova stations were studied within a 500 meters and 1 km zone from the nearest station. Also, this zone was spreaded out over 1 km for Bornova and Bölge stations. Observations were chosen from these buffer zones.

In fact, the number of total observations is about 400 in total. However, missing variables were observed in the data set. Some property observations were omitted from the data set in order to ensure the robustness of the models due to the missing variables. After deleting these variables, 360 observations have remained.

At a first stage, a series of standard procedures were tested. Scatter plots, correlation matrices, descriptive statistics, detection of multicollinearity between quantitative variables, detection of heteroscedasticity, t and F tests, the explanatory power of the models namely R^2 and Adjusted R^2 were tested and examined. Also, the influences of many different functional forms used in the hedonic model applications were investigated. These functional forms are linear, log-linear, linear-log and double-log forms. They were tested to find the best functional form due to lack of theoretical background associated with choosing the functional form. OLS estimator was used in the models.

Empirical studies suggest that one of the major risks using the hedonic price model is the presence of multicollinearity problem. This problem occurs when explanatory variables are closely related to each other. Many studies eliminate this problem since it causes problems when attempting to explain house prices. If the presence of linear relationships among explanatory variables is observed, the estimates of the regression coefficients can be indeterminate or unreliable. Also, it leads to large standard errors. Regression coefficient can be wrong sign. Because of this, the study minimizes this problem. A correlation matrix and also scatter plots were used to detect the problem. There are many ways for dealing with multicollinearity. In this stage, one of the variables that are highly collinear was eliminated from the model.

After forecasting the models, the reliable of the models and the results of the models such as coefficients, the sign of parameters and significance levels for individual regression coefficients were tested. Test of R^2, t test and F test were used for testing the models statistically.

R^2 and Adjusted R^2 were used to measure the explanatory power of the models. In the hedonic models, the studies reviewed in chapter 2 use generally R^2 (the coefficient of determination), but in some cases, adjusted R^2 can be used for measuring the explanatory power of the models. In this study, R^2 and also Adj. R^2 are used. Also, two types of hypothesis testing were used. These are testing the statistical significance of individual coefficients (t test) and testing many coefficients jointly (F test) (Ramanathan, 1998). T test allows identifying the test of hypothesis on a single significant of individual coefficients. T test allows finding significant variables of the models. On the other hand, testing several coefficients jointly can be tested using F test. F test allows testing the significance of the overall regression model.

One of the assumptions of the regression models is that the residuals are identically distributed with mean zero and also the residuals have the same variance or constant variance. This assumption is called as **homoscedasticity.** If this assumption is not violated, **heteroscedasticity** problem can occur. Generally for cross-section data, heteroscedasticity is a common problem. It is shown as follow:

$$Var(\varepsilon i) = \sigma^2 i \quad i = 1, \ldots\ldots\ldots.n$$

If heteroscedasticity problem is ignored, it causes that **OLS** estimators do not have minimum variance and inefficient. Forecasts can be biased. Therefore, the test of the hypothesis is invalid. Because of this, heteroscedasticity must be detected and eliminated.

There are many tests for detection of heteroscedasticity problem. Detections include generally two different steps: informal and formal tests. Looking for patterns in the plot of the predicted dependent variable versus the residuals provides information about detection of heteroscedasticity. In addition, many formal tests can be conducted.

These are mainly **Goldfeldt-Quandt test, Breusch-Pagan test, Glejser test, Park** and **White test**.

In this study, **White test** was used for detection of heteroscedasticity. In White test, after OLS procedure, the model is forecasted and then residuals of the model are computed. In the second stage, a new auxiliary regression equation is constructed. In this regression equation, the squared residual (e_i) is dependent variable of the auxiliary model. For this equation, R^2 is estimated.

$$Y_i = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} + e_i;$$

The auxiliary regression is as follow according to White test:

$$e_i^2 = \alpha_1 + \alpha_2 X_{2i} + \alpha_3 X_{3i} + \alpha_4 X^2_{2i} + \alpha_5 X^2_{3i} + \alpha_6 X_{2i} X_{3i} + \nu_i;$$

Where e and ν are error terms of regression models. β_1, β_2 and β_3 and α_1 …..$\alpha 6$ are regression coefficients, i represents i th observations. In this equation, the test statistic is $\mathbf{nR^2}$ based on the auxiliary regression. White's test statistic is Chi-Square with degrees of freedom equal to the number of terms in the auxiliary regression, except for the constant term ($nR^2 \sim \chi^2_{df}$). If nR^2 value is greater than $\chi^2_{df,}$ an analyst can reject the null hypothesis of no heteroscedasticity (Ramanathan, 1998; Gujarati, 1995; Akkaya and Pazarlioglu, 2000). In other words, it is accepted that there is heteroscedasticity.

Eviews econometrics software allows estimating White heteroscedasticity for cross terms. Probability of the results of White test can be controlled at the α = 0, 01, α = 0, 05 or α = 0, 10 levels. In this study, probability of the results of White test are controlled at the α = 0, 05 level. Significance level of 5 per cent is commonly used for heteroscedasticity test.

In addition, 34 independent variables were initially tested in the models using stepwise, backward and enter regression procedure. For example, stepwise regression analysis allows finding the independent variables which contributes most to the explanatory power of the models. These variables enter into the model first, so that most significant variables were tested. Also, it reduces the risk of multicollinearity problem. These procedures provide guidance for testing the best equation. The estimation was made in SPSS and Eviews softwares. The results of the programs also were checked.

5.2. The Empirical Hedonic Price Model

A housing unit is a heterogeneous good and it is defined by a vector of individual attributes or characteristics. Price paid for residential property as mentioned in theoretical background of the model is the sum of the implicit prices. Hedonic price model can be expressed as a function of three vectors of variables. These are location, structural (physical) and neighborhood attributes. These variables are used to estimate marginal effect of each attribute on price. In the following sections, the variables used in the models are described and the choice of functional form and model specification will be discussed.

5.2.1. Variables

The dependent variable of the model is sales price of housing units. The attributes affecting house prices can be divided into two main groups as **quantitative and qualitative** variables. There are 34 variables in total. Quantitative variables are house area (**dairebuy**), number of apartments in building (**hanesayi**), number of apartments in a floor (**dairesay**), age of house units (**age**), number of bedrooms (**odasay**), number of bathrooms (**banyosay**), number of story in building (**katsayi**), floor (**kat**), distance from nearest subway station (**distance**), distance from nearest bus stop (**bus**), distance from nearest shopping centers (**shopping**), distance from nearest minibuses (**dolmus**), dues of apartment (**aidat**), total vehicle time by bus (**tvtbus**) and total vehicle time by subway (**tvtmetro**).

Qualitative variable is used as dummy variables. These variables are coded 1 and 0. 1 represents presence of relative attributes in that house unit, 0 represents absent. Qualitative variables are front (**cephe**), corner location (**kose**), presence of garage (**op**), presence of basement (**bodrum**), types of heating system (**isinma**), view (**manzara**), presence of garden (**bahce**), presence of doorkeeper (**kapici**), cable television (**kablolu**), location (**mevki**), type of kitchen (**mutfak**), type of ground (**zemin**), presence of elevator (**asansor**), presence of shutter (**panjur**), steel door (**kapi**) and type of window woodwork (**dograma**), properties located within 500 meters from a nearest station (**besyuz**), properties located within 500 meters-1 km from a nearest station (**besbin**) and over 1 km (**binust**). These variables are explained in table 6.

Table 6. Definitions of all the Variables used in the Empirical Hedonic Price Models

Variables	Meaning	Expected Sign
Price	**House Price** as dependent variable	
Independent Variables		
Dairebuy	Size of the house units,	+
Hanesayi	# of apartments in building,	+ / -
Dairesay	# of apartments in a floor,	+ / -
Age	Age of the house units,	-
Odasayi	# of bedrooms,	+ / -
Banyosay	# of bathrooms,	+
Katsayi	# of story in building,	+
Kat	floor located in building,	+
Kose	Corner location, (dummy variable)	+
Cephe	Front, (dummy variable)	+
Distance	Distance from nearest subway station,	-
Bus	Distance from nearest bus stop,	-
Shopping	Distance from nearest store,	-
Dolmus	Distance from nearest minibuses,	-
Tvtbus	Total Vehicle time by bus,	-
Tvtmetro	Total Vehicle time by subway,	-
Op	Presence of garage, (dummy variable)	+
Isinma	Heating system, (dummy variable)	+
Manzara	Presence of view, (dummy variable)	+
Bahce	Presence of garden, (dummy variable)	+
Kapici	Presence of doorkeeper, (dummy variable)	+
Aidat	Dues of apartment,	+
Kablolu	Presence of cable television, (dummy variable)	+
Mevki	Location, (dummy variable)	+
Mutfak	Kitchen, (dummy variable)	+
Zemin	Type of ground, (dummy variable)	+
Asansor	Presence of elevator, (dummy variable)	+
Panjur	Presence of shutter, (dummy variable)	+
Kapi	Steel door, (dummy variable)	+
Dograma	Type of woodworking, (dummy variable)	+
Bodrum	Presence of basement, (dummy variable)	+
Besyuz	Located within 20-500 meters, (dummy variable)	+/-
Besbin	Located within 500-1000 meters, (dummy variable)	+
Binust	Located within 1000 + meters, (dummy variable)	-

Structural Characteristics:

Size of a residential property **(size)** is obviously one of the most important variables. Previous studies generally suggest that larger the size, the higher the rent per unit area for housing units. This study assumes that the relationship between house size and price is positive. Size is measured in square meter.

Number of bedrooms **(odasayi)** and bathrooms **(banyosay)** are expected to increase with price, but there can be an inverse relationship between number of bedrooms and house prices. Increase in number of bedrooms can decrease use space for housing units. Ayvaz's (2002) study found that there is a negative relationship between number of bedrooms and price in the case of Izmir housing market. It is expected that buyers are willing to pay more for big space in housing units.

It is obviously known that buildings deteriorate overtime and age of the buildings (**age)** affects the price negatively. House prices may go down with age in the study area; generally age of the buildings is important factor affecting the behavior of individuals. Thus, the expected sign of the coefficient of age is negative.

Number of apartments in building **(hanesayi)** number of aparments in a floor **(dairesayi)**, number of story in building **(katsayi)** and floor **(kat)** play a role in determining the prices of apartments in the buffer zones of Izmir subway. In multi-family houses, floor may be more important determinant of the price. Buyers are willing to pay more for middle floors such as 3rd and 4th floor, but basement, first and up floors are not desired, the price of these apartments can be cheaper. These features are expected to be positively related to unit price of housing, but sometimes the sign of the coefficient of **hanesayi** and **dairesayi** variables may be negative.

Accessibility and Location Attributes:

Proximity to light rail transit (**LRT**) station may improve the accessibility of residents to the CBD, employment centers or other areas. Therefore, savings in commuting time as direct benefits may be reflected in the premium paid for housing units in a buffer zone. Proximity to LRT stations may reduce price gradient for nearby houses due to negative externalities of LRT stations and LRT lines.

Within the context of the study, it is expected that proximity to subway stations cause to increase price gradient for nearby properties. In the literature, generally 500 meters or a quarter-mile ring ($^1/_4$ mile, 1600 feet) was drawn around each station since people are willing to walk within this distance and walking distance is determined as being within 500 meters of a station in the studies related to the objective of the thesis. Also, in this application, the hedonic price model will be run for houses within 1000 meters and over from a station.

The best measure of distance to a nearest lrt station or accessibility is to use Geographic Information System (GIS) tools. There are four spatial-related variables measured by GIS. These are distance to the nearest subway station (**distance**), distance to nearest bus stop (**bus**), distance to shopping centers (**shopping**) and distance to minibuses stop (**dolmus**). In order to measure these variables, for subway stations, the linear distance from mid-point of a street where a house unit locate to a nearest lrt station are measured on digitized map of Izmir City.

In addition, it is observed that bus stops and subway stations may locate near to each other. To measure net effects of subway stations and other public transportation services such as bus, total vehicle times by bus **(tvtbus)** and total vehicle time by subway **(tvtsub)** are estimated. Total vehicle times include both out of vehicle time and in-vehicle time estimations. Out of vehicle time is constructed by estimating the walking time from any street where a housing unit locates to LRT station or bus stop as minutes. For this, I walked for different distance intervals from properties to nearest bus stops or LRT stations in Üçyol, Bölge and Bornova stations. I measured the walking times as minutes. Average walking time was estimated. According to this result, on the average, I walk the 200 meters in 2 minutes 30 seconds. In vehicle time includes travel time between bus stops or subway stations. Travel times for each vehicle are different. For bus, nearest and quick bus route was chosen from Üçyol to Bornova. Total vehicle times are constructed by summing in-vehicle time in minutes and out of vehicle time in minutes. The last quantitative variable is dues of apartment (**aidat**) variable. If house units have heating system, dues of apartment can be high.

In addition, 19 dummy variables are used totally. The expectation for the sign of these variables is positive, except for **binust** variable. Some of these variables can not be significant determinant of price and it can not play important role on behavior of individuals. For example, location nearby main streets may have a negative impact on the value of residential properties.

Generally, in the study area, if house units include doorkeeper **(kapici)** and central heating system **(isinma)**, dues of apartment (**aidat**) is higher. Residents with high income level demand these houses generally. Also, to measure the effect of the subway investment on different distance interval, qualitative variables such as **besyuz, binmeter and binust** were used as dummy variables.

5.2.2 Functional Forms and Model Specification

As mentioned in theoretical background, there is no theoretical basis for choosing the best functional form of a hedonic price model. In hedonic price regression applications, many functional forms have been used: **linear, semi-log, linear-log and double-log (log-log)** etc. The functional form best fit to data must be chosen by analyst.

Within the context of the thesis, **linear, log-linear (or semi-log), linear-log and Double-log** functional forms were tested and four different functional forms were estimated for the complete 360-observation (whole data set), 187-observation Bornova (Bölge and Bornova) and 173-observation Hatay-Üçyol sample using OLS procedures. According to the functional form, logarithmic transformations for the dependent and independent variables were taken. Excel and SPSS data base includes these transformations. Excel data was also used in database of Eviews program. For the functional forms listed above, R^2, F and t test and other assumptions of regression model were controlled as mentioned above.

Interpretation of functional forms and the concept of elasticity associated with chosen functional form show differentiations. The marginal effect and elasticity of different functional forms are shown in table 7.

Table 7. Functional Forms and Elasticity Analysis

Name	Functional Form	Marginal Effect (dY/dX)	Elasticity [(X/Y) (dY/dX)]
Linear	$Y = \beta_1 + \beta_2 X$	β_2	β_2 (X/Y)
Linear-Log	$Y = \beta_1 + \beta_2 \ln X$	β_2 (1/X)	β_2 (1/Y)
Log-Linear	$\ln Y = \beta_1 + \beta_2 X$	β_2 (Y)	β_2 (X)
Double-Log (Log-log)	$\ln Y = \beta_1 + \beta_2 \ln X$	β_2 (Y/X)	β_2

Source. Gujarati, 1995

The concept of elasticity refers that '*percentage change in Y with respect to a percentage change in X for a small change in X*' (Ramanathan, 1998: p. 256). It is defined as:

$$E = \text{\% change in Y / \% change in X} = (dY/dX)(X/Y)$$

Interpretations of elasticity according to functional form show differences. For example, in the log log model, the estimated attribute coefficients such as β_2 represents constant elasticity while in the log linear, elasticity is computed by multiplying the mean of X and the estimated attribute coefficient (β_2). In practice, elasticity is computed as the mean or average. In the context of the study, the interpretations of the models are based on the elasticity measure. Since the functional forms are determined, elasticity interpretations can be computed.

CHAPTER 6

DATA SOURCE AND PROCESSING

There are 10 stations in the existing subway route in Izmir. Residential areas are dominant land use in the buffer zone of Üçyol, Bölge and Bornova stations. Since the focus of the study is to determine the effect of Izmir subway on the value of residential properties, retail and industrial observations were not included into the data set. Therefore, the data used in the study belongs to Üçyol, Bölge and Bornova stations and nearby. Although the case study includes all the subway stations, enough data can not be obtained from other stations, except for the three stations.

Two main databases are used mainly in the study: Real estate agents and the digitized map of Izmir City. Before data processing, a standard questionnaire form associated with the variables affecting the house price was prepared. Data processing includes the time during December 2003 and March 2004. In total, there are 400 observations. After the elimination of missing data and speculative observations, there are a total of 360 observations for the three stations. Data set includes a sample of 83 residential properties in Bornova station, while data set in Bölge station consists of a sample of 104 observations. For Üçyol station, 173 observations are used in the models.

Data used in the study is **cross-sectional data**. Time series (longitudinal) data were not obtained from real estate agents or other establishments to do before & after comparison. Data were prepared in SPSS data editor and Excel program. To ensure the reliable and correct of the models, relationships between explanatory variables were tested and examined. Excel data base also was used for Eviews program. Also, mapinfo program was used for creating the buffer zone and for collecting spatial-related variables in data processing.

House prices as dependent variable and explanatory variables: house size, number of apartments in building, number of apartments in a floor, age, number of bedrooms, number of bathrooms, number of story in building, floor, distance from nearest subway station, distance from nearest bus stop, distance from nearest shopping centers, distance from nearest minibuses, dues to apartment, front, corner location, presence of garage, presence of basement, types of heating system, view, presence of garden, presence of doorkeeper, cable television, location (street or main street), type of kitchen, type of ground, presence of elevator, presence of shutter, steel door and type of window woodwork were obtained from the real estate agents located in the buffer zones of the subway stations. The detailed description of data source of the variables is presented in table 8.

Table 8. Data Sources

Variables	Source
House Price as dependent variable	Real estate agents
Independent Variables	
House size (dairebuy)	Real estate agents
# of apartments in building (hanesayi)	Real estate agents
# of apartments in a floor (dairesay)	Real estate agents
Age oh house units (age)	Real estate agents
# of bedrooms (odasayi)	Real estate agents
# of bathrooms (banyosay)	Real estate agents
# of story in building (katsayi)	Real estate agents
# of floor located in building (kat)	Real estate agents
Corner location (kose)	Real estate agents
Front (cephe)	Real estate agents
Distance from nearest subway station (distance)	digitized map
Distance from nearest bus stop (bus)	digitized map
Distance from nearest store (shopping)	digitized map
Distance from nearest minibuses (dolmus)	digitized map
Presence of garage, parking lot (op)	Real estate agents
Presence of basement (bodrum)	Real estate agents
Heating system (isinma)	Real estate agents
Presence of view (manzara)	Real estate agents
Presence of garden (bahce)	Real estate agents
Presence of doorkeeper (kapici)	Real estate agents
Dues of apartment (aidat)	Real estate agents
presence of cable television (kablolu)	Real estate agents
Location (mevki)	Real estate agents
Kitchen (mutfak)	Real estate agents
Type of ground (zemin)	Real estate agents
Presence of elevator (asansor)	Real estate agents
Presence of shutter (panjur)	Real estate agents
Steel door (kapi)	Real estate agents
Type of woodworking (dograma)	Real estate agents
Located within 20-500 m. (besyuz)	digitized map
Located within 500 – 1000 m. (besbin)	digitized map
Located within 1000m and more (binust)	digitized map

Accessibility variables: distance to nearest the subway station and distance to nearest bus stop, total vehicle time by subway and total vehicle time by bus were taken from two different sources. Spatial-related variables were measured using GIS. A digitized map of Izmir County was used for this purpose. Because of this, buffer zones were created using MapInfo Program. Distance was measured using MapInfo Program. In order to estimate total vehicle times for subway and bus, in-vehicle time and out of vehicle time were estimated. In vehicle time is estimated from house location to the chosen destinations on the subway route or bus route as minutes. Out of vehicle time was measured in two stages. Firstly, the linear distance from mid-point of street where a house unit locates to subway station or bus stop as meters. This estimation was transformed into walking times as minutes.

In order to understand characteristics of empirical data, descriptive statistics for the case study were estimated. Descriptive statistics include Üçyol station (West axis), Bornova-Bölge stations (East stations) and whole data set, so that the descriptive statistics provide some information about the variables used in the models.

Table 9 presents summary statistics of the variables used in the model for all subway stations. On average, properties are sold 51 billion TL or $ 37610. Maximum sale price of properties located in the buffer zones of the subway stations is 95 billion TL, while minimum sale price is 11 billion TL. This result suggests that the house prices in study area are very variable.

Distance as one of the focus variables ranges from minimum 20 meters to maximum 1610 meters. Properties located in maximum distance were generally obtained from the buffer zones of Bornova and Bölge stations. On average, properties locate within 535 meters from a nearest station. This distance is also accepted as actual walking distance to subway stations in the literature. On average, the distance from house location to a bus stop decreases 208 meters. Since the number of bus stops is more than the number of subway stations in the impact zones, distance to bus stop for the properties is less.

Travel time is a key determinant of transportation costs. Savings in transportation costs represent the benefits of transportation improvements. Travel time costs and savings in travel time are based on type of trip, the behavior of traveler and so on. In the hedonic price models, **tvtbus** and **tvtmetro** were measured as minutes. When comparing with total vehicle time by subway **(tvtmetro)** and total vehicle time by bus **(tvtbus)**, **tvtmetro** is less than **tvtbus**. For example, the distance from Üçyol to Bornova takes about 17 minutes by subway, but it takes about 47 minutes (for only in-vehicle times) by bus. There is an important time interval between bus and subway. According to descriptive statistics, travel by subway is more advantage than travel by bus as expected.

Table 9. Descriptive Statistics of the Variables used in the Hedonic Price Model for Whole Data Set

Variables	N	Minimum	Maximum	Mean	Std. Deviation
FIYAT	360	11,000,000,000	95,000,000,000	51,100,000,000	19,617,895,871,8847
KURFIYAT	360	8096,15	69921,32	37610,3101	14439,0440
DAIREBUY	360	65,00	186,00	112,3472	23,4599
HANESAYI	360	3,00	45,00	15,7167	8,5518
DAIRESAY	360	1,00	6,00	2,5194	,9900
AGE	360	2,00	35,00	16,9722	7,2462
ODASAYI	360	2,00	4,00	2,7417	,5034
KATSAYI	360	3,00	11,00	6,0833	1,5581
KAT	360	1,00	8,00	3,3083	2,0199
DISTANCE	360	20,00	1610,00	535,2083	323,9923
BUS	360	15,00	736,00	208,5250	119,8660
TVTMETRO	360	78,26	98,70	84,8822	4,1662
TVTBUS	360	326,19	335,46	328,6814	1,5414

The number of floor in building **(katsayi)** ranges from 3 to 11. Buildings with high floor such as 8, 9, 10 and 11 locate generally in main streets. On average, **katsayi** is 6. The number of bedroom (**odasayi**) in apartments is, on average, 3. The value of **hanesayi** variable ranges from 3 to 45, while the value of **dairesay** variable ranges from 1 to 6. Increase in **dairesay** and **katsayi** cause to increase the value of **hanesay**. On average, age of the buildings is about 17 years. Age ranges from 2 years to 35 years. This result indicates a heterogeneous space.

Table 10 presents summary statistics of the variables used in the models for Üçyol station. From the table, on average, properties are sold 43 billion TL or $ 31652. Maximum sale price of properties located in buffer zone of the subway station is 95 billion TL, while minimum sale price is 11 billion TL. As shown in the table 10, house prices in impact zone of Üçyol station area variable. It is observed that the value of properties located within Bahçelievler district is more than other districts. The price difference among the districts in Üçyol is high. The result indicates that space is heterogeneous in Üçyol.

Distance to subway stop (**distance**) variable ranges from minimum 20 meters to maximum 824 meters. On average, properties locate within 360 meters to subway station, while on average, the distance from bus stop (**bus**) decreases to 175 meters. Since Üçyol locates near the city centre and nearby main streets of Izmir, transportation facilities are high.

Table 10. Descriptive Statistics of the Variables used in the Hedonic Price Model for Hatay-Üçyol Data Set

Variables	N	Minimum	Maximum	Mean	Std. Deviation
FIYAT	173	11,000,000,000	95,000,000,000	43,005,780,346,82	19,233,040,584,2
KURFIYAT	173	8096,15	69921,32	31652,8519	14155,7851
DAIREBUY	173	65,00	186,00	105,0231	21,7162
HANESAYI	173	3,00	36,00	12,0694	6,1034
DAIRESAY	173	1,00	4,00	2,0809	,6141
AGE	173	2,00	35,00	20,4682	7,6461
ODASAYI	173	2,00	4,00	2,6532	,5238
KATSAYI	173	3,00	11,00	5,7341	1,6314
KAT	173	1,00	8,00	3,2486	2,0634
DISTANCE	173	20,00	824,00	360,5607	215,7952
BUS	173	15,00	586,00	175,8035	111,9346
TVTBUS	173	326,19	333,54	328,2607	1,4394
TVTMETRO	173	78,26	88,60	82,6364	2,7749

Total vehicle time for subway (**tvtmetro**) ranges from 78 minutes to 89 minutes, while total vehicle time for bus (**tvtbus**) ranges from 326 minutes to 334 minutes. Traveling by subway provides savings in transportation costs more than bus. The age of the buildings (**age**), on average is 20. This result suggests that the old houses locate nearby Üçyol station. On average, **hanesayi** is 12. Number of apartments in building (**hanesayi**) decreases in Üçyol in respect to other stations. Number of story in the buildings (**katsayi)** ranges from 3 to 11, while floor (**kat)** ranges from 1 to 8. On average, the number of apartment in a floor (**dairesay**) is about 2.

Table 11 presents summary statistics of the variables used in the models for Bornova and Bölge stations. On average, most expensive properties are sold about 59 billion TL or $ 43121. Maximum sale price of properties located in the buffer zones of the subway stations is 95 billion TL like Üçyol, while minimum sale price is 30 billion TL. As shown in the table 11, house prices in the impact zone of Bornova and Bölge stations area variable like Üçyol station. Distance to subway stop (**distance**) variable ranges from minimum 119 meters to maximum 1610 meters. On average, properties locate within 696 meters to subway station, while on average, the distance from bus stop (**bus**) decrease 238 meters.

From the table, total vehicle time for subway (**tvtmetro**) ranges from 74 minutes to 92 minutes, while total vehicle time for bus (**tvtbus**) ranges from 294 minutes to 302 minutes. Traveling by subway provides savings in transportation costs more than bus like Üçyol. The age of the buildings (**age**), on average is 14. This result suggests that the newer houses locate nearby Bornova and Bölge stations. On average, **hanesayi** is 19. Number of apartments in building (**hanesayi**) is higher than Üçyol. In other words, crowded buildings locate in the buffer zone of Bölge and Bornova stations. **Katsayi** ranges from 3 to 10, while **kat** ranges from 1 to 8. On average, the number of apartment in a floor (**dairesay**) is about 3. It is higher than Üçyol.

Table 11. Descriptive Statistics of the Variables used in the Hedonic Price Model for data set of Bornova and Bölge Stations

Variables	N	Minimum	Maximum	Mean	Std. Deviation
FIYAT	187	30,000,000,000	95,000,000,000	58,588,235,294	16,835,828,748,97
KURFIYAT	187	22080,42	69921,32	43121,7553	12391,4039
DAIREBUY	187	70,00	180,00	119,1230	23,0243
HANESAYI	187	4,00	45,00	19,0909	9,1044
DAIRESAY	187	1,00	6,00	2,9251	1,0948
AGE	187	2,00	34,00	13,7380	5,0397
ODASAYI	187	2,00	4,00	2,8235	,4705
KATSAYI	187	3,00	10,00	6,4064	1,4163
KAT	187	1,00	8,00	3,3636	1,9828
DISTANCE	187	119,00	1610,00	696,7807	323,9242
BUS	187	40,00	736,00	238,7968	119,2814
TVTBUS	187	293,51	302,46	296,0707	1,5338
TVTMETRO	187	73,53	92,70	80,9599	4,1653

In sum, average prices in Bornova are higher than Üçyol as expected. As mentioned above, the demand in impact zone of Bornova and Bölge stations for residential properties is higher. When comparing distance to bus stop (bus) and distance to the subway stations (distance), in the impact zones, distance to subway station in Üçyol is on average 360 meters, while it increases 696 meters in Bornova. Distance to bus stop is on average about 176 meters in Üçyol, while it is 238 meters in Bornova for both stations. It suggests that bus is more dominant in Bornova than Üçyol. Distance to subway station for residential properties in Üçyol is on average is lower than Bornova. Houses generally locate within 500 meters in the buffer zone of Üçyol station, but on average in Bornova it can lie to over 1000 meters. This result indicates that the distance effect of Bornova and Bölge stations can be higher than Üçyol. It is expected that the effect of subway investment for Üçyol station is highly correlated with price.

CHAPTER 7

RESULTS

It has been argued that there is a lack of theoretical basis associated with the choice of the functional form of the hedonic price function. Therefore, the study used many functional forms to analyze the relationship. The functional forms used in the study are **linear, log-linear, linear-log and double-log (log-log)**. The models allow a comparison of the results of functional forms and to find the best model best fit to the data.

Thirty four independent variables were initially tested in the models using stepwise and backward regression. A correlation matrix of the variables, stepwise and backward regression procedure provided guidance for eliminating multicollinearity problem and they were used for finding the best equation in the hedonic price models. Twenty independent variables in total entered into the models (A complete list of variables is summarized in chapter 5). The dependent variable of the models is sale price of house units. According to the functional forms, the logarithm of house prices was taken in log-linear and log-log models. Due to the large number of models, the results of the models including coefficients, t-values, R^2, Adj. R^2 and White heteroscedasticity test are presented in the tables as summarized form. White heteroscedasticity test was controlled at the α = 0, 05 level. There is not heteroscedasticity problem in the models and also the hedonic price models provide the assumptions of regression models. In the study, the models were run for Üçyol station (West axis), Bornova stations including Bornova and Bölge stations (East axis) and whole data set.

In order to analyze the effect of proximity to subway stations on house price and to determine significant factors of the value, the three models including the results of four functional forms were run and presented in table 12, 13 and 14. In these models, distance variable as mentioned in chapter 5 measures linear distance to the nearest subway station from house units. Distance for these models is the focus variable of the study.

After these models shown in table 12-14, the models including total vehicle time for bus and for subway variables were run. Total travel times instead of distance and bus variables were used in the models. It is expected that accessibility benefits of subway investment capitalized into property values. Also, savings from the subway and bus will be different. According to existing literature, some studies as mentioned in chapter 2 use travel times instead of distance factor such as Bajic (1983). The studies found that travel time presented the more accurate measurement of direct benefits resulted from a new subway investment. The result of the models is presented in summarized form (table 15 to 17) and then the models were run to test different distance intervals in the buffer zones of subway stations. Because of this, three dummy variables, representing properties located within 20-500 meters of a rail station (**besyuz**), 500-1000 meters of rail station (**besbin**) and over 1000 meters (**binust**) were used. The results of the models are presented in table 18, 19 and 20.

7.1. The Results of the Models determining the benefits of subway investment in Izmir

The effects of being near subway stations on the house prices are explained in this section. Firstly, the models for Üçyol station were run. The regression results are for four different models presented in table 12. The models are estimated with a sample of 173 observations. Fifteen independent variables were tested in the models. House size (**dairebuy**), floor (**kat**), distance from nearest subway station (**distance**), heating system (**isinma**), location (**mevki**) and type of ground (**zemin)** are significant at the 5 % level in the four models as expected. In addition, corner location (**kose**) is significant at the 5 % level in log-linear and log-log models while it is significant at the 10 % level in linear and linear-log models. The signs of other variables, except for **op** are almost as expected.

From the table, house size is an important characteristic of residential properties. It is expected that there is a positive relationship between size (**dairebuy**) and price. **Dairebuy** was found to be positively related to price and significant at the 5 % level as expected for all the models. Number of apartments in building (**hanesayi)** is negative and significant for linear and log-linear models. One possible explanation for **hanesayi** is that crowded buildings may not be desired for house buyers. Number of apartment in a floor (**dairesay**) is positive and only significant at the 10 % level in linear and log-linear models.

It is known that buildings deteriorate over time. Therefore, the age of house units is expected to have a negative influence on its price and **age** is negative as expected, but not significant. Number of bedrooms (**odasay**) is one of the important factors affecting the price. **Odasay** is positive and significant in log-linear and double-log models. Number of story in the building (**katsayi**) ranges from 3 to 11 near Üçyol station. **Katsayi** is positive, except for linear log model, which is negative. It is positively correlated with price.

Floor (**kat**) is positive and significant at the 5 % level. For Üçyol, it is expected that basement, 1st and up floors have negative effect on price, while other floors have positive effect. Corner location (**kose**) includes both location and physical characteristics of the house units. **Kose** was found to be positively related to price as expected and significant in the models. Presence of parking lot (**op)** is expected to be positively related to price, but in this case, **op** is negative in contrast to expectations. One possible explanation for this result is that nuisance and air pollution for residential units are not desired for residents. On the other hand, data obtained from real estate agents in Üçyol can not represent correctly presence of parking lot in the buildings. Sometimes, an empty parcel or a street is used for parking lot, so that this situation may result in wrong estimates.

Presence of heating system (**isinma**), location (**mevki**) and type of ground (**zemin)** are significant determinants of house price in Üçyol station. They are significant and positively related to price as expected for all the models. Generally, presence of heating system such as central heating in buildings needs presence of doorkeeper (**kapici**) in the buildings. Therefore, these buildings can be sometimes determined as lux buildings, according to the real estate agents. **Zemin** is positive and significant at the 5 % level. **Kapici** is positive and significant at the 5 % level in linear and linear log models. In this case, these variables increase price.

Table 12. The Results of the Models for Üçyol Station (West Axis)

Variables	Model 1 Linear	Model 2 Log Linear	Model 3 Linear Log	Model 4 Log Log
Constant (C)	-1138366612 (-0,13)	23,373 (113.89)*	-62660176642 (-2.48)*	22.05474 (35.42)*
Dairebuy	265909696 (5,25)*	0,00551 (4.58)*	31709821702 (5.92)*	0.696984 (5.25)*
Hanesayi	-920642140 (-1,97)**	-0.022842 (-2.05)*	-2769166714 (-0.47)	-0.124274 (-0.78)
Dairesay	5183281082 (1,74)**	0.128777 (1.82)**	2420366555 (0.40)	0.117568 (0.72)
Age	-89066922 (-0,84)	-0.002527 (-1.00)	-485715644 (-0.37)	-0.022273 (-0.67)
Odasay	2837205633 (1,35)	0.116176 (2.32)*	4196000523 (0.771)	0.218024 (1.66)**
Katsayi	1761857491 (1,52)	0.034534 (1.25)	-625371483 (-0.04)	0.006474 (0.035)
Kat	869982844 (2,15)*	0.021602 (2.24)*	3614417236 (3.38)*	0.088532 (3.330)*
Distance	-22,512,590 (-5,88)*	-0.000536 (-5.89)*	-7194492890 (-7.41)*	-0.141093 (-5.84)*
Bus	-15,176,833 (-2,15)*	-0.000510 (-3.04)*	-1737223353 (-1.61)	-0.064038 (-2.39)*
Kose	2496767483 (1,67)**	0.075842 (2.14)*	2464290914 (1.75)**	0.081014 (2.32)*
Op	-3216884169 (-1,18)	-0.059221 (-0.91)	-2138963252 (-0.83)	-0.047405 (-0.75)
Isinma	4010957636 (2,05)*	0.098985 (2.13)*	3652989273 (1.99)*	0.090926 (2.01)*
Kapici	6651710552 (2,19)*	0.096931 (1.34)	5331319670 (2.00)*	0.076029 (1.14)
Mevki	5114111690 (2,51)*	0.120127 (2.48)*	5331319670 (1.96)**	0.096434 (2.01)*
Zemin	8682101711 (5,07)*	0.202925 (4.99)*	7890212896 (4.92)*	0.190770 (4.80)*
R^2	0,80	0,79	0,83	0,80
Adj R^2	0,781	0,77	0,81	0,78
N	173	173	173	173
White Test	0,247	0,937	0,239	0,688

* Significant at 5 % level   ** Significant at 10 % level.

The focus variable of the study is **distance** variable measuring the distance to a nearest subway station as meters. **Distance** is negative as expected, also significant at the 5 % level for all the models. The literal interpretation indicates that the housing price decreases when ıs distance to a light rail station increases. In this case, housing price goes up with proximity to the stations. This result confirms the literature. Distance factor represents also accessibility effect. For Üçyol station, according to this result, nuisance effect is not observed. Since Üçyol station is underground, negative externalities are eliminated. The result indicates that direct benefits from proximity are reflected in the premium paid for houses in the buffer zone of Üçyol station. The results have confirmed the expectations. Also, in Üçyol station, **distance** is more significant determinant of house prices than **bus** variable measuring distance to a nearest bus stop. Bus variable, except for linear log model which is not significant, is significant at the 5 % level. In order to go to Bornova from Üçyol, the subway system provides time advantage and savings in transportation costs to buyers.

As can be seen in Table 12, the elasticity of the distance variable is always negative for each model. Distance elasticity coefficient in log linear model is -0, 000536, implying that a 1 per cent increase in **distance** leads to a 0, 19 percent decrease in price. Double log model for distance elasticity coefficient indicates that for a percent increase in the **distance**, house prices on the average decreases by about 0, 14 percent. According to the linear model, a 1 % increase in **distance** leads to a 0, 18 decrease in price. Linear log model suggests that a 1 % increase in **distance** leads to a 0, 16 decrease in price.

Most of the hedonic models run for this station provided expected levels of explanation. The highest explanatory power is in linear log model (R^2 = 0, 83 and Adj. R^2 = 0, 81). Proximity to the station is shown to have an important impact on price in the housing market for Hatay-Üçyol area. When comparing the overall results for Üçyol station, it is obvious that the models confirm the hypothesis and the models have high level of explanation power on price. The results suggest that the housing market in Üçyol area views proximity to subway station as a benefit.

Second model was run for the stations located in Bornova (Bölge and Bornova stations-East axis). Table 13 represents the results of the models for these zones. The models are estimated with a sample of 187 observations. The variables used in the models are the same as Üçyol. Four variables: **dairebuy**, **kat**, **isinma** and **zemin** are significant for each model.

House size (**dairebuy)** is positive as expected sign and significant at the 5 % level. In Bornova, house prices go up with house size like Üçyol. **Hanesayi** is positive in linear and log linear models, but it is negative in linear log and log-log models. **Hanesayi** is significant at the 10 % level for linear log model and also log-log model. **Dairesay** is negative for linear and log linear models, but it is positive for linear log and log-log models. It is not significant in the models. Crowded buildings may affect on the behavior of individuals.

Age is important factor of price. In this case, **age** is negative as expected, but not significant. Increase in **age** of the house units will result in a decrease in price for Bornova like Üçyol. In contrast to expectations, number of bedrooms (**odasay)** is negative. Ayvaz's (2002) study for Izmir housing market found that the sign of number of bedrooms is negative. It means that increase in number of bedrooms will decrease price in the case of Izmir housing market, since increase in number of bedrooms cause to decrease size of house units. Therefore, it can not be desired for house buyers. **Katsayi** is positive and significant at the 5 % level in both linear log and log-log models. **Kat** is important factor in the house purchase decision making process. Generally, middle-floors are desired for buyers according to the real estate agents in Bornova. The prices of these apartments are higher. **Kat** is negative and significant at the 5 % level. Increase in floor (**kat**) will result in a decrease in price.

Corner location (**kose**) is positively correlated with price as expected and it is significant level in linear, log linear and linear log models. Presence of parking lot (**op**) is positive as expected, except for log-log model, which is negative. In contrast to Üçyol, **op** represents correct information in Bornova. It is expected that presence of parking lot is positively correlated with price. **Op** is positive, but not significant. **Isinma** is positive as expected and significant at the 5 % level for each model. **Zemin** is positive and significant at the 5 % level for each model. Both attributes (**isinma** and **zemin**) will result in an increase in price for each model. In contrast to expectations, location (**mevki**) and doorkeeper (**kapici**) are negative. It is known that negative externalities of the stations in Bornova are higher than Üçyol. In Ankara Street; air pollution, congestion and nuisance effect are high levels. These factors have a negative effect on price. Therefore, **mevki** can not be significant factor of price in the buffer zone, but for some streets it can be significant level. **Kose** is positive as expected and significant level in linear, log linear and linear log models.

Table 13. The Results of the Models for Bornova and Bölge Stations (East Axis).

Variables	Model 1 Linear	Model 2 Log Linear	Model 3 Linear Log	Model 4 Log Log
C	2.34E+10 (2,25)*	24.05717 (139,07)*	-1.51E+11 (-4,88)*	20.83299 (40,87)*
Dairebuy	3.96E+08 (7,78)*	0.006911 (8,13)*	4.93E+10 (8,08)*	0.886374 (8,82)*
Hanesayi	1.93E+08 (0,40)	0.004165 (0,529)	-1.93E+10 (-1,75)**	-0.352154 (-1,93)**
Dairesay	-2.84E+09 (-0,89)	-0.047834 (-0,89)	1.33E+10 (1,20)	0.263137 (1,44)
Age	-1.33E+08 (-0,88)	-0.001012 (-0,40)	-2.01E+09 (-1,16)	-0.017655 (-0,61)
Odasay	-1.74E+09 (-0,84)	-0.011678 (-0,33)	-4.59E+09 (-0,82)	-0.044658 (-0,48)
Katsayi	5.00E+08 (0,40)	0.006850 (0,328)	2.61E+10 (2,27)*	0.468629 (2,48)*
Kat	-1.17E+09 (-3,23)*	-0.019630 (-3,25)*	-2.57E+09 (-2,32)*	-0.041277 (-2,26)*
Distance	-5,011,073 (-2,23)*	-0.000104 (-2,76)*	-1.25E+09 (-0,97)	-0.029166 (-1,38)
Bus	-17,950,810 (-2,74)*	-0.000247 (-2,25)*	-3.35E+09 (-2,26)*	-0.041492 (-1,70)**
Kose	3.80E+09 (2,28)*	0.051759 (1,86)**	3.25E+09 (1,93)**	0.039606 (1,43)
Op	1.00E+09 (0,622)	0.003728 (0,13)	2.74E+08 (0,16)	-0.010060 (-0,36)
Isinma	6.29E+09 (3,89)*	0.104068 (3,85)*	6.47E+09 (3,92)*	0.106698 (3,93)*
Kapici	-2.83E+09 (-1,51)	-0.036310 (-1,16)	-3.42E+09 (-1,81)**	-0.045752 (-1,46)
Mevki	-1.14E+09 (-0,74)	-0.023804 (-0,93)	-1.02E+09 (-0,65)	-0.021026 (-0,82)
Zemin	7.17E+09 (4,22)*	0.142555 (5,03)*	6.92E+09 (4,02)*	0.134154 (4,73)*
R^2	0,75	0,77	0,74	0,76
Adj R^2	0,72	0,74	0,71	0,74
N	187	187	187	187
White Test	0,155	0,161	0,232	0,320

* Significant at 5 % level   ** Significant at 10 % level.

Distance variable measuring distance to a nearest subway station as the focus variable of the study is negative as expected and significant at the 5 % level in linear, log linear. Distance to bus stop (**bus**) is negative as expected and significant at the 5 level in linear, log linear and linear log models. When comparing the results, distance to subway station (**distance**) is less significant factor than Üçyol. Descriptive statistics as explained in chapter 6 show that residential properties, on the average, are closer to the subway station in Üçyol than other residential properties in Bornova. One possible explanation for this result is that **distance** is more significant variable for Üçyol than Bornova, while **bus** is more significant variable for Bornova than Üçyol. In impact zone of Üçyol, proximity to subway station is a dominant factor of house prices due to time advantages and travel costs, but in the buffer zones of Bornova and Bölge stations, there are many factors affecting the price. As mentioned chapter 4, these are presence of the university and hospital. These factors increase the demand for these properties located within the buffer zone in Bornova.

The distance to subway station, **distance**, is always negative and significant for linear and log linear models. Distance in many studies represents transportation costs. Increasing in transportation costs affects the behavior of individuals and also location of firms. In this case, **distance** as a proxy of transportation facilities plays important role on price. Distance elasticity coefficient in log linear model is -0, 000104, implying that it will decrease about 0, 07 percent to the value or a unit change in the distance will result in a 0, 07 % decrease in price. Log log model suggests that a percent increase in distance to subway station in Bornova, the value of residential properties on the average decrease by about 0, 03 percent. According to linear model, a 1 % increase in distance leads to a 0, 06 per cent decrease in price. In linear log model, a percent change in distance is, on the average, results in a 0, 02 percent decrease in the price.

The model confirms the hypothesis that proximity to LRT stations is a key determinant of price. However, as mentioned above, the significance level of distance variable is higher for Üçyol than Bornova. Presence of Ege University and the hospital are important factors affecting price. **Log-linear model** has the highest explanation power and give more correct results than other models. The effects of being near subway stations on the value of residential properties in the buffer zones of Bornova and Bölge stations are significant.

The results of the models for whole data set are presented in Table 14. The model is estimated with a sample of 360 observations. In each model, **dairebuy**, **age**, **distance**, **kose**, **isinma**, **mevki** and **zemin** have a statistically significant influence on house prices. The signs of these variables are as expected. **Dairebuy** is positive and significant at the 5 % level. House prices in impact zone of the subway route go up with size of house units. **Hanesayi** is negative as expected, but not significant. Crowded buildings in general are not desired for house buyers. **Dairesay** is positive, but not significant.

Age is negative and significant at the 5 % level. It suggests that increase in age of house units will decrease price in the buffer zone. **Odasay** is negative in linear and linear log models, but positive in log linear and log log models. According to the real estate agents in the buffer zone, increase in number of bedrooms (**odasay**) has a positive effect generally on the value of residential properties. Some studies such as Ayvaz's (2002) study for Izmir housing market suggest that increase in number of bedrooms causes to decrease price. **Katsayi** is positive and significant in linear and log linear models. Buildings with high floors generally locate in the main streets and the price of these houses can be higher. **Kat** is negative in linear and log linear models, but positive in linear log and log log models.

Corner location (**kose**) is positively related to price as expected and it is significant at the 5 % level. Presence of parking lot (**op**) is positive except for log linear model. **Isinma**, **mevki** and **zemin** were found to be positively related to price as expected and significant at the 5 % level.

Presence of heating system (**isinma**) such as central heating increases the value of residential properties. Location (**kose**) is one of the most important factors of price. In this case, **kose** becomes important factor. **Kose** is significant at the 5 % level for each model. **Kapici** is positive as expected, but not significant. These variables provide information lux situation of the buildings.

Distance to subway station as focus variable is negative as expected for each model and significant at the 5 % level, suggesting that if properties are within the impact zone, they sold more than other properties located outside from the impact zone. This result represents premium paid for these properties within the buffer zones of the subway. In the case of Izmir housing market, the result also confirms the hypothesis that proximity to the subway station increases house prices due to savings in transportation costs, improved accessibility. Also, in contrast to the **distance** variable, **bus** is negative as expected, but not significant for each model. Distance to bus stop (**bus**) has not a strong influence on the value of residential properties more than distance to subway station.

Table 14. The Results of the Models for the Buffer zones of Izmir Subway (West and East Axises).

Variables	Model 1 Linear	Model 2 Log Linear	Model 3 Linear Log	Model 4 Log Log
C	-7.87E+09 (-1,05)	23.27336 (142,37)*	-1.51E+11 (-7,14)*	20.49075 (44,50)*
Dairebuy	3.74E+08 (9,47)*	0.006887 (7,95)*	4.47E+10 (9,87)*	0.872002 (8,87)*
Hanesayi	-4.03E+08 (-1,08)	-0.009202 (-1,12)	-1.40E+09 (-0,21)	-0.062184 (-0,44)
Dairesay	2.53E+09 (1,02)	0.072546 (1,33)	1.30E+09 (0,197)	0.093233 (0,65)
Age	-2.54E+08 (-2,80)*	-0.006215 (-3,11)*	-2.85E+09 (-2,42)*	-0.063073 (-2,46)*
Odasay	-1.21E+08 (-0,07)	0.049634 (1,38)	-3.62E+09 (-0,83)	0.045850 (0,490)
Katsayi	2.42E+09 (2,53)*	0.047748 (2,277)*	7.52E+09 (1,06)	0.162009 (1,05)
Kat	-3.79E+08 (-1,25)	-0.003493 (-0,52)	1.20E+08 (0,13)	0.015226 (0,80)
Distance	-6,462,674 (-3,15)*	-0.000124 (-2,76)*	-3.45E+09 (-4,41)*	-0.064249 (-3,78)*
Bus	-737,642.9 (-0,14)	-9.12E-06 (-0,07)	4.26E+08 (0,43)	0.006778 (0,31)
Kose	4.23E+09 (3,35)*	0.094660 (3,42)*	4.07E+09 (3,27)*	0.091601 (3,399)*
Op	1.62E+08 (0,10)	-0.008673 (-0,25)	7.34E+08 (0,48)	0.002706 (0,08)
Isinma	5.24E+09 (3,67)*	0.086074 (2,75)*	5.41E+09 (3,85)*	0.086056 (2,82)*
Kapici	1.59E+09 (0,88)	0.040275 (1,02)	1.43E+09 (0,83)	0.039260 (1,05)
Mevki	4.70E+09 (3,57)*	0.117306 (4,06)*	4.60E+09 (3,529)*	0.113425 (4,00)*
Zemin	9.25E+09 (6,80)*	0.196631 (6,59)*	8.98E+09 (6,69)*	0.188798 (6,47)*
R^2	0,73	0,71	0,74	0,73
Adj R^2	0,72	0,70	0,72	0,71
N	360	360	360	360
White Test	0,054	0,317	0,03	0,0177

* Significant at 5 % level ** Significant at 10 % level.

From the table, the elasticity of distance and bus variables are always negative. In linear model, a 1 % increase in distance leads to 0, 067 decrease in price. According to log linear model, a 1 per cent change in distance leads to a 0, 066 decrease in price. In addition to this, distance elasticity coefficient in double log model is -0, 064249, implying that for a percent increase in distance to subway station decreases by about 0, 06 percent in the price. In linear log model, a percent increase in distance is, on the average, results in a 0, 067 decrease in the price

Most of the hedonic price models explained in the case of Izmir subway provides high levels of explanation. The variance in house prices can be explained by accessibility factor or proximity to the subway station in Izmir housing market, in the buffer zone of Izmir subway. Also, **linear log** model provided highest explanation power of price for whole data set.

7.2. The Results of the Models for Total Vehicle Times:

It is known that travel time is a key determinant of transportation costs, and savings in transportation costs represent the benefits of transportation improvements. Travel time costs and savings in travel time are based on type of a trip, the behavior of traveler and so on. There are many studies measuring economic benefits, user benefits and costs of transportation investments. In these studies, total travel time entered into the models as an important factor of house prices. People are willing to pay more for centrally located land or for locating near transportation facilities in order to minimize transportation costs. In the case of Izmir subway, to measure net effects of subway investment on the value of residential properties, in the second stage, total vehicle times for bus and subway have been used.[*] Since it is observed that the distance from house to bus stop or to subway station can be same distance, measuring of accessibility effects may not give expectations. For example, in Bornova station, subway station and bus stop have located near Ege University. The distance between the two stops is almost the same. In order to separate out the effects of two different transportation facilities, total vehicle times were estimated and used in the models.

In the literature, Dewees (1976) and Bajic (1983) used travel times instead of distance. Dewees compared distance and travel time. He founded that travel time was the more accurate proxy for measuring the effect of subway on residential property values in Toronto. Bajic's (1983) study as one of the most known studies, in order to identify the effects of subway line in Toronto on house prices, estimated the difference in auto and public transit in-vehicle time and difference in auto and public transit

[*] Estimation of total vehile time for bus and subway were explained in chapter 5.

waiting plus and walking times. These estimates as minutes entered into the hedonic price model. The model represented time savings resulted from subway system. In this case, the study found that $ 2,237 premium for house, based on reduction in commute time resulting from subway investment.

In the case of Izmir subway, total vehicle time variables are constructed by summing in-vehicle time and out of vehicle time in minutes. Total vehicle time is represented by **tvtbus** (for bus) and **tvtmetro** (for subway). Four models including the results of four functional forms were run and presented in table 15-17. In these models, **tvtmetro** and **tvtbus** are the focus variables of the study for Üçyol, Bölge and Bornova stations.

Firstly, the models were run for Üçyol station. Table 15 presents the model results for Üçyol station. **Dairebuy**, **kat**, **tvtbus**, **tvtmetro**, **kose**, **mevki** and **zemin** variables are significant for each model. Except for **tvtbus** and **kose**, other variables are significant at the 5 % level for each model.

The significant and positive **dairebuy** indicates that there is a positive linear relationship with price. **Hanesayi** is negative as expected. As shown in the table, increase in **hanesayi** decrease price. **Hanesayi** is significant only at the 5 % level in linear and log linear models. It shows that **hanesayi** can be significant determinant of price. **Dairesay** is positive and significant at the 10 level in linear and log linear models. The coefficient sign of **age** is negative as expected, but not significant in the models. House prices go down with age in the impact zone of Izmir subway. Number of bedrooms (**odasay**) is positive as expected, but statistically not significant. Increase in number of bedrooms has positive effect on price. **Katsay** is positive as expected, but not significant. **Kat** is positive and significant at the 5 % level. This variable in the housing market sometimes can be one of the most important factors affecting price, but for basement and up floors, the effect of these variables can decrease.

Table 15. The Results of the Models measuring the effects of total vehicle times in Üçyol Station.

Variables	Model 1 Linear	Model 2 Log Linear	Model 3 Linear Log	Model 4 Log Log
C	520,180,795,752 (0,288)*	39.56596 (9,23)*	2.12E+12 (2,48)*	89.34339 (4,42)*
Dairebuy	265909696 (5,259)*	0.005511 (4,58)*	3.19E+10 (5,68)*	0.702475 (5,28)*
Hanesayi	-920642140 (-1,971)*	-0.022840 (-2,05)*	-5.12E+09 (-0,76)	-0.170125 (-1,07)
Dairesay	5183281082 (1,750)**	0.128742 (1,82)**	4.61E+09 (0,66)	0.158974 (0,97)
Age	-89066922 (-0,841)	-0.002524 (-1,00)	-2.32E+08 (-0,16)	-0.015898 (-0,48)
Odasay	2837205633 (1,350)	0.116115 (2,32)*	3.97E+09 (0,71)	0.212987 (1,61)
Katsayi	1761857491 (1,528)	0.034530 (1,25)	3.25E+09 (0,41)	0.075531 (0,41)
Kat	869982844 (2,151)*	0.021605 (2,24)*	4.07E+09 (3,57)*	0.101677 (3,77)*
Tvtbus	-118,234,794 (-2,152)*	-0.039702 (-3,04)*	-2.71E+11 (-1,83)**	-9.107266 (-2,60)
Tvtmetro	-174,968,670 (-5,886)*	-0.041685 (-5,89)*	-1.52E+11 (-6,23)*	-3.564035 (-6,16)*
Kose	2496767483 (1,677)**	0.075805 (2,14)*	2.91E+09 (1,96)**	0.088612 (2,53)*
Op	-3216884169 (-1,185)	-0.059287 (-0,91)	-3.43E+09 (-1,29)	-0.071540 (-1,14)
Isinma	4010957636 (2,054)*	0.099053 (2,13)*	3.10E+09 (1,62)	0.072710 (1,61)
Kapici	6651710552 (2,192)*	0.097012 (1,34)	6.54E+09 (2,34)*	0.095415 (1,44)
Mevki	5114111690 (2,518)*	0.120113 (2,48)*	4.89E+09 (2,42)*	0.117264 (2,46)*
Zemin	8682101711 (5,078)*	0.202951 (4,99)*	8.31E+09 (4,93)*	0.190410 (4,78)*
R^2	0,80	0,79	0,80	0,80
Adj R^2	0,78	0,77	0,79	0,78
N	173	173	173	173
White Test	0,21	0,94	0,18	0,74

* Significant at 5 % level ** Significant at 10 % level.

Corner location (**kose**) is positive as expected and statistically significant at the 5 % level in the models except for linear model, which is significant at the 10 % level. Parking lot (**op**) is expected to be positively related to price, but in this case, **op** is negative and not significant. One possible explanation as discussed earlier is that data obtained from real estate agents do not represent correctly presence of parking lot in the buildings. It is known that number of buildings with parking lot is very low in Üçyol.

Isinma is positive and significant at the 5 % level in linear and log linear model. Presence of heating system affects positively price. **Kapici** is positive and significant at the 5 % level in linear and linear log models. Location of a property (**mevki**) is important determinant of price. Generally, in the case of Üçyol station, the price of housing units located in the main streets is higher. In opposition to this situation, housing units located in the main streets such as Ankara Street can not be demanded by house buyers. **Mevki** is positive and significant at the 5 % level. **Zemin** is positively related to price and significant at the 5 % level in Üçyol. House buyers are willing to pay more for these attributes.

As can be seen in Table 15, the focus variables of the study are **tvtmetro** and **tvtbus**. The elasticity of the **tvtmetro** variable is always negative for the models as expected. **Tvtmetro** elasticity coefficient in log linear model is -0, 041685, implying that a 1 per cent in distance leads to a 3, 41 decrease in price. Double log model for **tvtmetro** elasticity indicates that for a percent increase in the **tvtmetro** variable, house prices on the average decreases by about 4 percent. According to linear model, a 1 per cent increase in **tvtmetro** leads to a 0, 33 decrease in price. Linear log model suggests that a 1 per cent increase in **tvtmetro** leads to 0, 0035 decrease in price.

The elasticities of the **tvtbus** variables like **tvtmetro** are always negative for each of the models. **Tvtbus** elasticity coefficient in log linear model is -0, 039702, implying that a 1 per cent increase in **tvtbus** leads to a 13, 02 % decrease in price. Double log model for **tvtbus** elasticity indicates that for a percent increase in the **tvtbus** variable, house prices on the average decreases by about 9 percent. According to linear model, a 1 percent increase in **tvtbus** leads to 0, 90 decrease in price. Linear log model suggests that a 1 per cent increase in **tvtbus** leads to a 0, 0062 % decrease in price.

For each of the models, the R^2 values are about 0, 80, suggesting that the models represent high levels of explanatory power. Most of the hedonic models generated in this study provide expected levels of explanation. Accessibility is shown to have an impact on the value of residential properties. The results confirm that people are willingness to pay premium for houses located near the station to reduce commute time. Linear, linear log and double log models exhibit to superior level of performance to other models.

The regression results for total vehicle time by bus and subway in Bornova station are presented in Table 16. The models are based on a sample of 83 observations obtained in February and March. **Dairebuy**, **tvtmetro** and **isinma** are significant variables for each model. **Dairebuy** is positive and significant at the 5 % level, indicating that house size increases house price in the impact zone of Bornova station. **Hanesayi** is negative, but not significant. **Dairesay** is positive and not significant in the models. Both variables are not significant factor of house prices in the impact zone of Bornova station. **Age** is negative as expected, but not significant for the models, implying deterioration effects on price. **Odasay** is negative and insignificant, suggesting that increase in number of bedrooms causes to decrease house size. Therefore, it is not desired for buyers. Number of floors (**katsayi**) is positive, but not significant, while **kat** is negative and it is significant only at the 5 % level in linear and log linear models. Corner location (**kose**) is expected to increase house prices. In this case, **kose** is positive as expected and significant at the 5 % level in linear model and also it is significant at the 10 % level in log linear and linear log models.

Presence of parking lot (**op**) is positive, but it is not significant. Generally, data obtained from the real estate agents represent correct information in the buffer zone of Bornova station. Presence of heating system (**isinma**) has significant effect on price. **Isinma** is positive and significant at the 5 % level in log linear and double log models and also it is significant at the 10 % level in linear log model and linear model. **Mevki** is positive in linear and linear log models, but negative in log linear and log log models. **Zemin** is positive and significant in log linear, log log models. **Zemin** is more significant factor of price than **mevki**. Price of house units located in Ankara Street can be low due to nuisance, congestion and air pollution. This factor can affect the sign of this variable. **Kapici** is negative and not significant. One possible explanation for this result is that data obtained from real estate agents do not represent presence of doorkeeper in the buildings correctly. It is observed that buildings with central heating system needs presence of doorkeeper, but for other buildings, doorkeeper only is responsible for cleaning, but real estate agents accept this situation as presence of doorkeeper in the buildings. It is known that the the value of house units with central heating system is higher than others. Also, dues of apartment are higher for these buildings.

Tvtbus and tvtmetro are the focus variables of the study. The sign of these variables are negative as expected. **Tvtmetro** is significant at the 5 % level for each model, while **tvtbus** is not significant level.

These variables provide guidance for understanding direct savings in commuting costs or travel times from the subway investment in Izmir. Increase in total vehicle time causes to decrease house prices. Also, increase in total vehicle time by subway has significant effect on price, while total vehicle time by bus is not determinant factor of price. One possible explanation for this result can be explained that Bornova station is very close to Ege University and the hospital. This result suggests that savings in travel time costs by subway capitalized into housing values.

Tvtmetro elasticity coefficient* in log linear model is -0, 019046, implying that a unit change in total vehicle time will result in a 1, 52 percent decrease in price, while log log model suggests that a percent increase in **tvtmetro**, the value of residential properties on the average decreases by about 1, 4 percent. According to linear model, a 1 % increase in **tvtmetro** leads to a 0, 14 decrease in price. In linear log model, a percent change in **tvtmetro** is, on the average, followed by a decrease in the value of residential properties of about 0, 013. **Tvtbus** elasticity coefficient in log linear model is -0, 022303, implying that a unit change in **tvtbus** leads to a 6, 60 % decrease in price, while log log model suggests that a 1 % increase in **tvtbus** leads to about a 4 per cent decrease in price. According to linear model, a 1 per cent increase in **tvtbus** leads to a 0, 76 % decrease in price. In linear log model, a 1 % increase in **tvtbus** leads to a 0, 0043 per cent decrease in price.

Most of the hedonic price models provided high levels of explanation. Log linear and log log models provided highest explanation power of price. The results confirm that people are willingness to pay premium for houses located near the station to reduce commute time. **Tvtmetro** is more significant determinant of price than **tvtbus**. Presence of Ege University and the hospital increase the rate of the use of subway station in Bornova station.

* The mean of tvtbus is 296 in bölge and bornova stations. The mean of tvtmetro is 82 in bölge station, while the mean of tvtmetro is 79,68 in bornova station. Estimations of elasticity for these variables were made according to this result. Elasticity estimations are summarized in table 7.

Table 16. The Results of the Models measuring the effects of total vehicle times in Bornova Station.

Variables	Model 1 Linear	Model 2 Log Linear	Model 3 Linear Log	Model 4 Log Log
C	555439833 (1,61)	32.16804 (5,67)*	1.68E+12 (1,15)	48.66311 (2,05)*
Dairebuy	331933545 (3,92)*	0.005703 (4,106)*	4.16E+10 (4,19)*	0.732805 (4,55)
Hanesayi	-239029517 (-0,31)	-0.003723 (-0,297)	-1.31E+10 (-0,96)	-0.233376 (-1,05)
Dairesay	101975172 (0,02)	0.006648 (0,07)	7.90E+09 (0,56)	0.171098 (0,75)
Age	-225164721 (-0,84)	-0.002415 (-0,54)	-2.44E+09 (-0,75)	-0.032470 (-0,61)
Odasay	-148303512 (-0,45)	-0.007151 (-0,13)	-4.02E+09 (-0,46)	-0.030791 (-0,21)
Katsayi	922766800 (0,49)	0.014780 (0,474)	1.68E+10 (1,125)	0.296317 (1,223)
Kat	-165046760 (-2,03)*	-0.027122 (-2,03)*	-3.00E+09 (-1,28)	-0.047352 (-1,24)
Tvtbus	-152,851,038 (-1,25)	-0.022303 (-1,10)	-2.59E+11 (-0,97)	-3.714709 (-0,85)
Tvtmetro	-101,209,123 (-2,10)*	-0.019046 (-2,40)*	-7.74E+10 (-2,06)*	-1.429573 (-2,35)*
Kose	7003344126 (2,22)*	0.089740 (1,733)**	6.11E+09 (1,95)**	0.075097 (1,47)
Op	154586830 (0,52)	0.007696 (0,157)	1.70E+09 (0,56)	0.006848 (0,13)
Isinma	641331308 (1,96)**	0.118267 (2,19)*	6.14E+09 (1,85)**	0.112358 (2,09)*
Kapici	-291575566 (-0,84)	-0.040289 (-0,70)	-3.74E+09 (-1,08)	-0.055295 (-0,98)
Mevki	470844515 (0,16)	-0.001590 (-0,03)	25909680 (0,008)	-0.006891 (-0,14)
Zemin	471111136 (1,45)	0.101144 (1,88)**	5.18E+09 (1,662)	0.103483 (2,04)*
R^2	0,74	0,76	0,74	0,77
Adj R^2	0,69	0,71	0,68	0,71
N	83	83	83	83
White Test	0,125	0,26	0,177	0,43

* Significant at 5 % level ** Significant at 10 % level.

Table 17 presents the results of the hedonic price models for Bölge station. The models include a sample of 104 observations. The models for Bölge station gave higher level of explanatory power than the models for Bornova station. From the table,

dairebuy, **tvtbus**, **isinma** and **zemin** variables are significant for each model. **Dairebuy** is positive as expected and significant at the 5 % level. This result suggests that house size is one of the most important factors affecting price in the buffer zone.

Table 17. The Results of the Models measuring the effects of total vehicle times in Bölge Station.

Variables	Model 1 Linear	Model 2 Log Linear	Model 3 Linear Log	Model 4 Log Log
C	5.05E+11 (3,11)*	30.58463 (11,01)*	1.96E+12 (2,23)*	53.06954 (3,64)*
Dairebuy	4.51E+08 (6,61)*	0.007924 (6,78)*	5.42E+10 (6,32)*	0.968629 (6,81)*
Hanesayi	1.05E+09 (1,60)	0.019665 (1,75)**	-1.83E+10 (-0,59)	-0.457438 (-0,89)
Dairesay	-8.15E+09 (-1,90)**	-0.144898 (-1,97)**	1.21E+10 (0,40)	0.355571 (0,71)
Age	-3.34E+08 (-1,58)	-0.003922 (-1,09)	-3.90E+09 (-1,83)**	-0.042228 (-1,19)
Odasay	-82022001 (-0,02)	0.024115 (0,49)	-2.89E+09 (-0,36)	0.009342 (0,07)
Katsayi	-2.36E+09 (-1,21)	-0.045677 (-1,37)	2.22E+10 (0,720)	0.512161 (1,00)
Kat	-7.45E+08 (-1,92)**	-0.012936 (-1,95)**	-1.81E+09 (-1,49)	-0.030869 (-1,52)
Tvtbus	-1.62E+09 (-2,98)*	-0.021450 (-2,31)*	-3.79E+11 (-2,45)*	-5.721849 (-2,23)*
Tvtmetro	-65,069,119 (-0,36)	-0.002740 (-0,90)	8187939. (0,00)	-0.090576 (-0,36)
Kose	1.79E+09 (0,85)	0.033240 (0,93)	1.58E+09 (0,75)	0.024154 (0,69)
Op	9.29E+08 (0,47)	0.008886 (0,26)	1.84E+08 (0,08)	-0.002928 (-0,08)
Isinma	3.40E+09 (1,80)**	0.055219 (1,71)**	4.19E+09 (2,09)*	0.069067 (2,07)*
Kapici	1.92E+09 (0,75)	0.034942 (0,80)	1.63E+09 (0,61)	0.031592 (0,72)
Mevki	-2.08E+09 (-1,19)	-0.031621 (-1,05)	-1.38E+09 (-0,77)	-0.025219 (-0,85)
Zemin	5.72E+09 (2,61)*	0.118846 (3,16)*	6.42E+09 (6,42)*	0.128283 (3,36)*
R^2	0,81	0,82	0,79	0,82
Adj R^2	0,77	0,79	0,76	0,79
N	104	104	104	104
White Test	0,65	0,57	0,84	0,79

* Significant at 5 % level ** Significant at 10 % level.

Hanesayi is positive in linear and log linear models and only significant at the 10 % level in log linear model, while **hanesayi** is negative in linear log and log log models, but not significant. In opposition to this, **dairesay** is negative in linear and log linear models, but positive in linear log and log log models. **Dairesay** is significant at the 10 % level in linear and log linear models. **Age** is negative as expected, but not significant, implying that increase in age of the house units decrease house price in the buffer zone of Bölge station. **Odasay** is negative for linear and linear log models, but it is positive for log linear and log log models. It is expected in this case that number of bedrooms is positively correlated with price. **Katsayi** is negative in linear and log linear models while it is positive in linear log and log log models. **Kat** is negative for each model and significant at the 10 % level in linear and log linear model. It indicates that increase in **floor** will result in a decrease in price. The result confirms the expectations that the price of houses located within middle floors is higher.

Corner location (**kose**) is positive, but not significant. Presence of parking lot (**op**) is expected to increase house prices. **Op** is positive except for log log model, which is negative. Presence of heating system (**isinma**) is positive and significant, implying that the price of buildings with heating system is higher than others. This attributes needs doorkeeper (**kapici**) in the buildings according to the real estate agents. **Kapici** is positive, but not significant. **Zemin** is positive and significant at the 5 % level. **Mevki** is negative as expected, but not significant. According to the real estate agents near Bölge station, the value of houses located in Ankara Street can be low due to nuisance and air pollution effects. The results confirm the expectations.

Tvtbus and **tvtmetro** as focus variables represents savings in travel time for house units located in the buffer zone of Bölge station. The sign of these variables are negative generally. In opposition to the result of Bornova station, in this case, **tvtbus** is significant for each model while **tvtmetro** is not significant. As mentioned above, presence of Ege University and the hospital cause to increase use of Bornova station. Commercial and industrial establishments have focused on the south of Bölge station. On the average, house units locate within 597 meters from the Bornova station, while this distance increases for Bölge station. However, distance to bus stop for Bölge station is lower than Bornova station.

Tvtmetro elasticity coefficient in log linear model is -0, 002740, implying that a 1 % change in total vehicle time leads to a 0, 22 per cent decrease in the price. According to log log model, for a per cent increase in **tvtmetro**, the price on the average decreases by about 0, 09 percent. Linear model suggests that a 1 % increase in **tvtmetro** leads to a 0, 092 % decrease in price, while linear log model suggests that a 1 percent increase in **tvtmetro** leadss to a 1, 41 % decresae in price. The results confirm that people are willingness to pay premium for houses located near the station to reduce commute time.

Tvtbus elasticity coefficient in log linear model is -0, 021450, implying that a 1 % increase in total vehicle time for bus leads to a 6, 34 per cent decrease in the price. According to log log model, for a per cent increase in **tvtbus**, the price on the average decreases by about 5, 72 percent. Linear model suggests that a 1 % increase in **tvtbus** leads to a 0, 82 % decrease in price, while linear log model suggests that a 1 percent increase in **tvtbus** leads to a 0, 0065 % decrease in price.

Most of the hedonic price models provided high levels of explanation. **Log linear and double log models** provided highest explanation power of price. Log linear model exhibits to superior level of performance to other models. In conclusion, total travel time provide information about the effect of a subway investment on the value of residential properties.

7.3. The Results of the Models measuring different distance effects:

In this stage, to isolate the effects of proximity to the subway stations on the value of residential properties according to different distance, properties were divided into three categories:

a) Properties within 500 meters (1600 ft or $^1/_4$ mile) of the nearest station as walking distance representing **besyuz** variable,
b) Properties within 500 m-1 km of the nearest station as walking distance representing **besbin** variable,
c) Properties more than 1 km from the nearest station, representing **binust** variable.

As stated before, one quarter mile and one half mile were created around all the subway station using Geographic Information System (GIS). It is expected that the effects of subway station should be capitalized into the value of residential properties in these buffer zones in the case of Izmir subway.

Regression results for the impact zone of Üçyol station were presented in Table 18. The models are based on a sample of 173 observations. For each model, **dairebuy, kat**, **distance**, **isinma**, **mevki** and **zemin** are significant variables and also the sign of these variables are as expected. House size (**dairebuy**) is one of the important factors of price in Üçyol. It is positive and significant at the 5 % level in the models. **Hanesayi** is negative as expected and significant only at the 10 % level in linear model and it is significant at the 5 % level in log linear model. **Dairesay** is positive and only significant at the 10 % level in linear and log linear models. It is expected that age of the buildings are negatively correlated with price due to deterioration effects. **Age** is negative, but not significant. Number of bedrooms (**odasay**) may positively or negatively affect the value of residential properties. For Üçyol, it is expected that the sign of **odasay** is positive. **Odasay** is positive, and only significant in log linear model. **Kat** is positive and significant for each model. Corner location (**kose**) is positive and significant. Presence of parking lot (**op**) is negative, but not significant. One possible explanation for this result is that data related to op can not represent the information about presence of parking lot in the buildings for Üçyol correctly. **Isinma** is significant at the 5 % level in log linear and log log models and also it is significant at the 10 % level in linear and linear log models. **Mevki** and **zemin** are positive as expected and significant for each model.

Distance is negative as expected and significant at the 5 % level while bus is negative. The result suggests that distance to subway station in the buffer zone of Üçyol has statistically significant influence on the value of residential properties more than distance to bus stop. Accessibility effects and savings in transportation costs and travel time for subway is more advantage than bus. In this case, in addition to distance variable, **besyuz** is one of the focus variables of the models. The sign of this variable is negative. According to the other models as mentioned above, proximity to the subway station in Üçyol as a benefit has capitalized into the property values in the impact zone of Üçyol.

Table 18. The Results of the Models measuring the effects of different distance for Üçyol.

Variables	Model 1 Linear	Model 2 Log Linear	Model 3 Linear Log	Model 4 Log Log
C	9.43E+09 (1,02)	23.54713 (105,93)*	-5.64E+10 (-2,21)*	22.00268 (34,64)*
Dairebuy	2.66E+08 (5,37)*	0.005514 (4,62)*	3.16E+10 (5,94)*	0.696884 (5,24)*
Hanesayi	-8.94E+08 (-1,95)**	-0.022396 (-2,03)*	-2.41E+09 (-0,37)	-0.129648 (-0,81)
Dairesay	5.02E+09 (1,73)**	0.126075 (1,80)**	2.01E+09 (0,30)	0.123074 (0,75)
Age	-93644052 (-0,90)	-0.002603 (-1,04)	-5.39E+08 (-0,40)	-0.021883 (-0,66)
Odasay	3.14E+09 (1,52)	0.121285 (2,44)*	4.24E+09 (0,80)	0.216555 (1,64)
Katsayi	1.60E+09 (1,41)	0.031782 (1,16)	-1.14E+09 (-0,15)	0.013962 (0,07)
Kat	7.67E+08 (1,93)**	0.019896 (2,07)*	3.51E+09 (3,27)*	0.089540 (3,34)*
Distance	-36,756,408 (-5,87)*	-0.000773 (-5,12)*	-811981619 (-6,65)*	-0.132883 (-4,36)*
Bus	-11,740,253 (-1,67)**	-0.000453 (-2,68)*	-144784886 (-1,31)	-0.066622 (-2,42)*
Kose	2.57E+09 (1,76)**	0.077125 (2,19)	2.56E+09 (1,82)**	0.080105 (2,28)*
Op	-3.21E+09 (-1,20)	-0.059045 (-0,92)	-2.11E+09 (-0,83)	-0.047276 (-0,75)
Isinma	3.65E+09 (1,90)**	0.092943 (2,01)*	3.57E+09 (1,96)**	0.091526 (2,01)*
Kapici	6.20E+09 (2,08)*	0.089411 (1,24)	5.34E+09 (2,00)*	0.076099 (1,14)
Mevki	4.78E+09 (2,40)*	0.114623 (2,39)*	3.59E+09 (1,86)**	0.097982 (2,04)*
Zemin	8.67E+09 (5,18)*	0.202662 (5,03)*	7.92E+09 (4,95)*	0.190410 (4,77)*
Besyuz	-735,570,813 (-2,83)*	-0.122144 (-1,95)**	-2.31E+09 (-1,23)	0.020611 (0,44)
R^2	0, 81	0,80	0,83	0,80
Adj R^2	0, 79	0,78	0,81	0,78
N	173	173	173	173
White Test	0, 111	0,46	0,30	0,75

* Significant at 5 % level   ** Significant at 10 % level.

Real estate agents suggest that proximity to subway station is one of the important factors affecting house prices within the buffer zone of Üçyol station. Since the buffer zone of Üçyol station shows heterogeneous structure, house prices are very changeable. For example, high and low income neighborhoods locate within the 500 meters of the station. House prices are very high in Bahçelievler, while house price decreases in Altintas and Atilla districts as shown in Table 10. Minimum sale price can decrease to 11 billion T.L. This situation affects the sign of **besyuz** variable. It is known that in Üçyol station, distance to the subway station affects house prices. The sign of distance variable indicates that house prices go up with proximity to the stations in Üçyol.

From the table, the elasticity coefficient of **besyuz** variable is – 735,570,813 in linear model, implying that the value of properties within 500 meters of the station were smaller, around 735,570,813 T.L., than properties located within 1 km of the station. According to log log model[*], a 1 % increase leads to a 2, 06 per cent decrease in price. Log linear model suggests that locating within 500 meters of the station decrease house prices about 11, 48 per cent.

Most of the hedonic models run for this station provide expected levels of explanation. The highest explanatory power is in linear log model (R^2 = 0, 83 and Adj. R^2 = 0, 81). The results suggest that proximity to the station has an important determinant of price in the housing market for Hatay-Üçyol area. When comparing the overall results for Üçyol station, it is obvious that the models confirm the hypothesis.

Regression results for the impact zone of Bornova and Bölge stations are represented in Table 19. The models are based on a sample of 187 observations. **Dairebuy**, **kat**, **bus**, **kose**, **isinma**, **zemin**, **besyuz** and **besbin** are significant variables. **Dairebuy** is positive and significant at the 5 % level, suggesting that house prices in the buffer zone of Bölge and Bornova tends to be positively correlated with house size. Negative externalities of Ankara Street such as nuisance and air pollution may cause to decrease house prices in the buffer zone of Bölge and Bornova stations. The value of house units located in the main streets can be lower. Because of this, **mevki** is negative and not significant.

[*] For log log and log linear models, antilog were estimated for besyuz and besbin dummy variables. The interpretations were made according to this result.

Table 19. The Results of the models measuring the effects of different distance for Bornova and Bölge stations:

Variables	Model 1 Linear	Model 2 Log Linear	Model 3 Linear Log	Model 4 Log Log
C	1.70E+10 (1,58)	23.93569 (133,51)*	-1.73E+11 (-5,06)*	20.40004 (36,44)*
Dairebuy	3.78E+08 (7,47)*	0.006620 (7,84)*	4.74E+10 (7,83)*	0.855044 (8,62)*
Hanesayi	2.43E+08 (0,51)	0.005300 (0,67)	-1.55E+10 (-1,43)	-0.283293 (-1,59)
Dairesay	-3.29E+09 (-1,03)	-0.057686 (-1,08)	9.76E+09 (0,90)	0.198688 (1,11)
Age	-90011658 (-0,60)	-0.000212 (-0,08)	-1.52E+09 (-0,89)	-0.008736 (-0,31)
Odasay	-2.08E+09 (-1,01)	-0.018818 (-0,54)	-6.36E+09 (-1,15)	-0.078860 (-0,87)
Katsayi	2.89E+08 (0,23)	0.002219 (0,10)	2.15E+10 (1,90)**	0.384670 (2,07)*
Kat	-1.26E+09 (-3,51)*	-0.021075 (-3,51)*	-2.71E+09 (-2,47)*	-0.043307 (-2,41)*
Distance	607,409.6 (0,13)	7.73E-06 (0,10)	2.54E+09 (1,01)	0.044058 (1,07)
Bus	-19,694,821 (-3,04)*	-0.000278 (-2,57)*	-3.36E+09 (-2,30)*	-0.042162 (-1,76)**
Kose	4.34E+09 (2,58)*	0.062457 (2,23)*	3.97E+09 (2,37)*	0.053383 (1,94)**
Op	1.72E+09 (1,07)	0.015980 (0,59)	1.34E+09 (0,81)	0.009142 (0,33)
Isinma	6.87E+09 (4,24)*	0.115033 (4,26)*	7.01E+09 (4,32)*	0.116649 (4,39)*
Kapici	-3.22E+09 (-1,73)**	-0.043756 (-1,41)	-3.80E+09 (-2,04)*	-0.052686 (-1,73)**
Mevki	-1.69E+09 (-1,11)	-0.032903 (-1,30)	-1.27E+09 (-0,83)	-0.025072 (-0,99)
Zemin	6.96E+09 (4,16)*	0.139289 (4,99)*	6.69E+09 (3,96)*	0.130203 (4,71)*
Besyuz	8.38E+09 (1,76)**	0.160399 (2,02)*	1.05E+10 (2,45)*	0.196916 (2,80)*
Besbin	7.87E+09 (2,57)*	0.141100 (2,77)*	7.85E+09 (3,10)*	0.141504 (3,42)*
R^2	0,76	0,78	0,75	0,78
Adj R^2	0,73	0,75	0,73	0,74
N	187	187	187	187
White Test	0,35	0,39	0,43	0,50

* Significant at 5 % level ** Significant at 10 % level.

Age is negative as expected, but not significant. Number of bedrooms (**odasay**), in contrast to Üçyol, is negative, indicating that increase in number of bedrooms (**odasay**) causes to decrease house prices in Bornova. **Kat** is negative and significant at the 5 % level for each model. Ground, first and up floors are not desired for buyers. Presence of parking lot is expected to increase house prices. In this case, the sign of **op** is positive, but insignificant. **Zemin** is positive as expected and significant at the 5 % level. Presence of heating system (**isinma**) is positive and significant at the 5 % level.

It is expected that house prices go down with distance to the subway station in the case of Izmir subway. Distance to subway station (**distance**) is positive and not significant for Bornova. It indicates that increase in distance to subway stations in the buffer zones of Bornova and Bölge stations causes to increase house prices.

As mentioned above, presence of Ege University and hospital cause to increase the demand for residential properties in the impact zone of the stations. Before the subway investment in Izmir, the demand to these properties was high. Although the subway investment has caused the demand, distance has not statistically significant effect on price. In data processing stage, it is observed that the demand can lie 1 km to the north of the stations. The value of properties located within 500 m-1 km of the nearest station can be higher than the value of properties located within 500. In order to determine the effect of different distance intervals on the value of residential properties, **besyuz**, **besbin** and **binust** dummy variables were used. **Besyuz** and **besbin** are positive and significant. The interpretation of the positive coefficient of the dummy variables suggests that subway stations have a positive impact on the values of residential properties in the two buffer zones of Bornova and Bölge stations.

From the table, the elasticity coefficient of **besyuz** variable is 837884914 in linear model, implying that if residential properties were within 500 meters of the station, they sold for over 837,884,914 TL. If residential properties were within 500 meters-1 km of the stations, they sold for over 787,337,477 TL. According to log linear model, properties located within 500 meters are estimated to sell 17,39 per cent more or it means 17,39 per cent premium, while residential properties were within 500 meters-1 km of the station are estimated to sell 15,15 per cent. According to log log model, properties located within 500 meters increase house price about 21.76 per cent. The value of properties located within 500 meters-1 km increase about 15, 20 per cent. Linear-log model suggests that properties located within 500 meters increase house price about 1,051,395 TL and properties located within 500 meters-1 km increase house price about 784,552,369 TL.

Most of the hedonic models run for this station provide expected levels of explanation. The highest explanatory power is in log linear model and double log models. The results sugget that proximity to the station is an important determinant of price in the buffer zones of Bornova and Bölge stations. When comparing the overall results, it is obvious that the models confirm that the value of properties located within the buffer zone of Bölge and Bornova stations are higher than others. Log linear and double log models exhibits to superior level of performance to other models.

In addition, for the buffer zone of Üçyol station, observations are obtained from distance including about 1 km of the Üçyol station while observations lies about 1,5 km to the north of Bornova and Bölge stations. In Üçyol, for higher away from the buffer zone, the effect of subway investment decreases. In Bornova, to measure the effects of subway investment on the value of residential properties within 1-1.5 km of the nearest station in Bornova, a second model was constructed.

The regression results are presented in Table 20. The models were estimated with a sample of 187 observations. Sixteen variables were tested in the models. **Dairebuy**, **kat**, **bus**, **kose**, **isinma**, **zemin** and **binust** are significant variables for each model. The sign of the variables resemble almost previous model. In this stage, the study will focus on interpretation of **binust** variable as a focus variable of the models.

From the table, the elasticity coefficient of **binust** variable is -917314554 in the linear model, implying that if residential properties were more than 1 km from the nearest station, they sold for less 917,314,554 TL. According to log linear model, properties located more than 1 km are estimated to sell 16,60 per cent less or it means 16,60 per cent decrease, while according to log log model, the value of properties located more than 1 km decrease 15,98 per cent.

Table 20. The results of the Models measuring the distance effects of Bölge and Bornova stations for over 1000 meters

Variables	Model 1 Linear	Model 2 Log Linear	Model 3 Linear Log	Model 4 Log Log
C	2.45E+10 (2,42)*	24.07534 (142,90)*	-1.50E+11 (-5,00)*	20.84955 (42,31)*
Dairebuy	3.73E+08 (7,45)*	0.006526 (7,80)*	4.64E+10 (7,76)*	0.836063 (8,52)*
Hanesayi	1.57E+08 (0,32)	0.003568 (0,46)	-1.71E+10 (-1,59)	-0.313494 (-1,78)**
Dairesay	-2.72E+09 (-0,87)	-0.045706 (-0,88)	1.16E+10 (1,08)	0.233621 (1,32)
Age	-85317192 (-0,57)	-0.000207 (-0,08)	-1.48E+09 (-0,87)	-0.008454 (-0,30)
Odasay	-1.99E+09 (-0,98)	-0.015807 (-0,47)	-5.43E+09 (-1,00)	-0.059330 (-0,67)
Katsayi	4.97E+08 (0,40)	0.006799 (0,33)	2.35E+10 (2,10)*	0.423163 (2,31)*
Kat	-1.32E+09 (-3,73)*	-0.022264 (-3,76)*	-2.99E+09 (-2,76)*	-0.048524 (-2,73)*
Distance	745495.7 (0,26)	-7.22E-06 (-0,15)	8.26E+08 (0,59)	0.006938 (0,30)
Bus	-20364666 (-3,17)*	-0.000287 (-2,67)*	-3.29E+09 (-2,29)*	-0.040554 (-1,72)**
Kose	4.38E+09 (2,68)*	0.061382 (2,25)*	3.81E+09 (2,32)*	0.049494 (1,83)**
Op	1.98E+09 (1,23)	0.020065 (0,75)	1.52E+09 (0,92)	0.011689 (0,43)**
Isinma	6.80E+09 (4,29)*	0.112540 (4,26)*	6.86E+09 (4,28)*	0.113521 (4,31)*
Kapici	-3.18E+09 (-1,74)**	-0.042260 (-1,39)	-3.72E+09 (-2,02)*	-0.050892 (-1,68)**
Mevki	-1.92E+09 (-1,27)	-0.036933 (-1,47)	-1.60E+09 (-1,05)	-0.031150 (-1,25)
Zemin	6.79E+09 (4,09)*	0.136078 (4,92)*	6.49E+09 (3,87)*	0.126676 (4,60)*
Binust	-9.17E+09 (-3,22)*	-0.153615 (-3,23)*	-8.52E+09 (-3,39)*	-0.148361 (-3,59)*
R^2	0,76	0,78	0,75	0,78
Adj R^2	0,74	0,76	0,73	0,76
N	187	187	187	187
White Test	0,26	0,29	0,41	0,48

* Significant at 5 % level ** Significant at 10 % level.

Binust variable is negative and significant at the 5 % level, suggesting that increase in distance to the subway stations causes to decrease the value of residential properties. The model founded a statistically negative effect on the value of properties located futher away 1 km. The benefits of the subway investment have loosed for the properties located more than 1 km of the nearest station.

From the table, the elasticity coefficient of **binust** variable is -917314554 in the linear model, implying that if residential properties were more than 1 km from the nearest station, they sold for less 917,314,554 TL. According to log linear model, properties located more than 1 km are estimated to sell 14,23 per cent less, while according to log log model, the value of properties located more than 1 km decrease about 13,78 per cent. In other words, binust is 14,23 per cent discount in log linear model and binust is 13,78 per cent discount in log log model.

The results suggest that distance from over 1 km to stations tends to lower house prices. The result holds that good access is defined by a radius of 500 meters and 1 km from the stations in the case of Izmir subway. Table 21 presents summary results of the models. In general, **dairebuy**, **distance**, **tvtmetro** variables are most significant variables. In chapter 8, general evaluation will be made according to the results.

Table 21. The Final Results from the Hedonic Price Models in the Case of Izmir Subway.

	Models	Focus Variables	Impact Zone	Significant Variables in the Models	Number of Variables	Sample Size	Explanatory Power (max)
Model 1	Distance effects	distance, bus	Üçyol station (West Axis)	dairebuy, kat, distance, kose, isinma, mevki, zemin	7	173	0, 83
Model 2	Distance effects	distance, bus	Bölge and Bornova (East Axis)	dairebuy, kat, isinma, zemin	4	187	0, 77
Model 3	Distance effects	distance, bus	All the subway stations	dairebuy, age, distance, kose isinma, mevki, zemin	7	360	0, 74
Model 4	Effects of total travel time	tvtbus tvtmetro	Üçyol station (West Axis)	dairebuy, kat, mevki, zemin tvtbus, tvtmetro	7	173	0, 80
Model 5	Effects of total travel time	tvtbus tvtmetro	Bornova station (East Axis)	dairebuy, tvtmetro, isinma	3	83	0, 76
Model 6	Effects of total travel time	tvtbus tvtmetro	Bölge station (East Axis)	dairebuy, tvtbus, isinma zemin	4	104	0, 82
Model 7	Different distance intervals	besyuz,	Üçyol station (West Axis)	dairebuy, kat, distance, isinma mevki, zemin	5	173	0, 83
Model 8	Different distance intervals	besyuz besbin	Bölge and Bornova (East Axis)	dairebuy, kat, bus, kose, zemin isinma, besyuz, besbin	8	187	0, 78
Model 9	Different distance intervals	binust	Bölge and Bornova (East Axis)	dairebuy, kat, bus, kose, zemin isinma, binust	7	187	0, 78

CHAPTER 8

CONCLUSIONS

The central aim of the study is to identify whether there is a relationship between investment in transportation infrastructure and property values. In this context, there is an underlying assumption in the empirical studies that proximity to light rail transit stations may positively or negatively affect the value of residential properties in the impact zone. The overall results of this thesis indicate that proximity to subway station cause higher property values due to accessibility advantage and reduced commuting time as a benefit. These benefits have been capitalized into house price in the case of Izmir Subway. Therefore, the empirical studies within the context of the thesis confirm the hypothesis that subway investment in Izmir has a positive effect as accessibility on property values.

The relationship between an investment in public transportation and its effect on the value are investigated using hedonic price model in a three-stage study. In the first stage, distance to transportation facilities (bus and subway) entered into the model as focus variables for Üçyol, Bölge-Bornova stations and whole data set. In the second stage, total vehicle time entered into the models as focus variables. At the final stage, different distance effects were measured for Üçyol and Bölge-Bornova stations. Since accessibility is measured using distance and travel time as proxies in the empirical studies. The study provide extensive information for estimating price differentials for properties with good access or not.

The empirical results show that distance to subway stations significantly affects house prices. Distance as proxy for transit accessibility is negative and highly significant for each model in the buffer zones of the subway station. The results confirm our expectations and literal interpretation that house prices goes up with proximity to the station. In the basic model, in addition distance to subway stations, distance to bus stops can be significant. In Bölge and Bornova stations, proximity to bus stop can be more determinant factor than subway. In general, proximity to subway station is more significant than bus proximity. Benefits of accessibility to subway investment is high level as expected. Also, this results indicate that positive effects of accessibility are stronger than negative effects such as nuisance and air pollution.

It is accepted that time and proximity from a subway station are key factors in estimating the effects of transportation accessibility. Therefore, in the second stage, models including total vehicle time instead of distance presents the amount of savings capitalized into housing prices from commuting time or travel time. Total vehicle time for subway and bus is negative. Total vehicle time for subway (**tvtmetro**) is significant in Üçyol and Bornova stations, while it is not significant in Bölge station. Total vehicle time for bus is more significant in Bölge station.

The results indicate that increase in total travel time negatively affects house prices, since residents minimize travel costs, they are willingness to pay premium for houses located near the station. Time advantage resulted from subway investment is higher than transportation facilities.

The results of the models measuring different effects indicates that there is a positive relationship between the house prices and proximity to subway stations in the buffer zones, but this relationship generally becomes weaker when considering house units at greater distances from the subway stations such as more than 1 km. the value of properties within more than 1 km from the nearest station in Bornova (East Axis) decreases significantly. This result indicates that the total positive contribution of proximity to stations in house prices is limited within a radius of 500 meters from the station or a buffer zone 1 km from the station. Proximity to the station tends to higher house prices and properties gains the largest value-added benefits in the buffer zone of Izmir Subway. The results indicates that the positive effects of accessibility are stronger than negative effects.

In the empirical applications of hedonic price model, the model provides to estimate house price in terms of its own characteristics. A house unit as a heterogeneous good includes a bundle of attributes. Therefore, price paid for a house unit is the sum of implicit prices associated with various attributes. Also, in this study, hedonic price model provide information about many variables affecting house price. The results of the models show that house size is one of the significant housing attributes in determining house prices in the buffer zone of subway route. House size is positive and highly significant for all the impact areas. Proximity and house size attributes are the most influential factors in determining the variation of house prices. Corner location (**kose**), floor (**kat**), heating system (**isinma**), type of ground (**zemin**) and location (**mevki**) are positive and significant effects in the buffer zone in general. Increase in may positively or negatively affect the value of residential properties. number of bedrooms (**odasay**) has a positive effect in Üçyol, while it has hegative effect in Bornova and Bölge stations and also whole data set. Higher level floors and presence of parking lot affect house prices positively.

Most of the hedonic models generated in this study explains about 80 per cent of variation in price. In many empirical studies, the log linear form was preferred, while the log linear and linear log form provided expected levels of explanation.

Overall, the hedonic price model provide extensive information to urban planners and policy makers for measuring the economic impacts of proposed transit investment. Measuring economic valuation of public space is important for determining tax politics in decision – making process and individuals' marginal willingness to pay for environmental amenities associated with public improvements can be estimated correctly. Also, urban rents resulted from investment in public transportation infrastructure are provided to return into public.

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World Wide Web Sites:

http://www.bart.gov
http://itsmarta.com

APPENDIX A

RAPID TRANSIT SYSTEMS

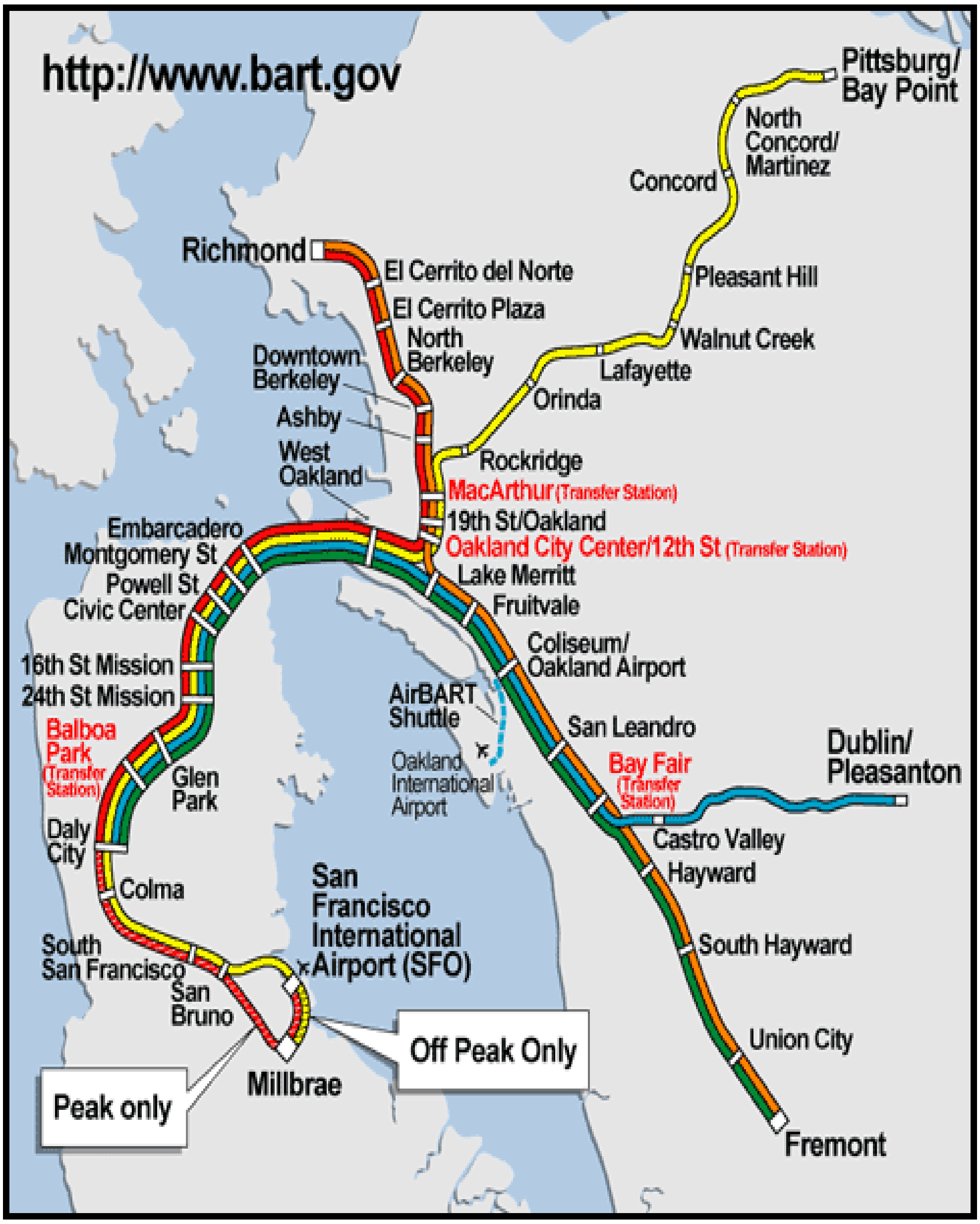

Figure A.1 Bay Area Rapid Transit System Map
Source. http: //www.bart.gov

Figure A.2 Metropolitan Atlanta Rapid Transit System Map
Source. http: //www.itsmarta.com

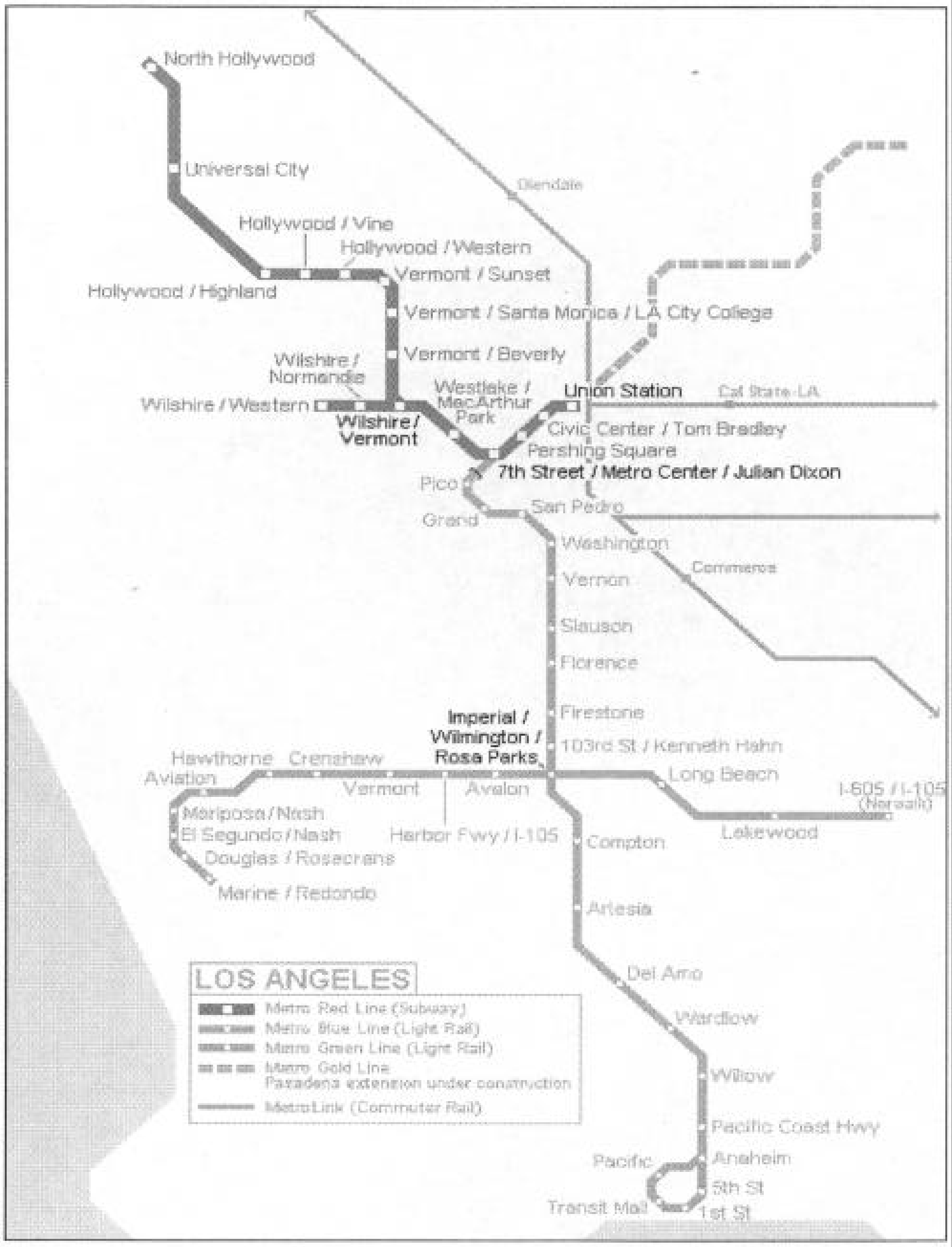

Figure A.3 Metro Rail Services in Los Angles County
Source. Cervero and Duncan, 2002

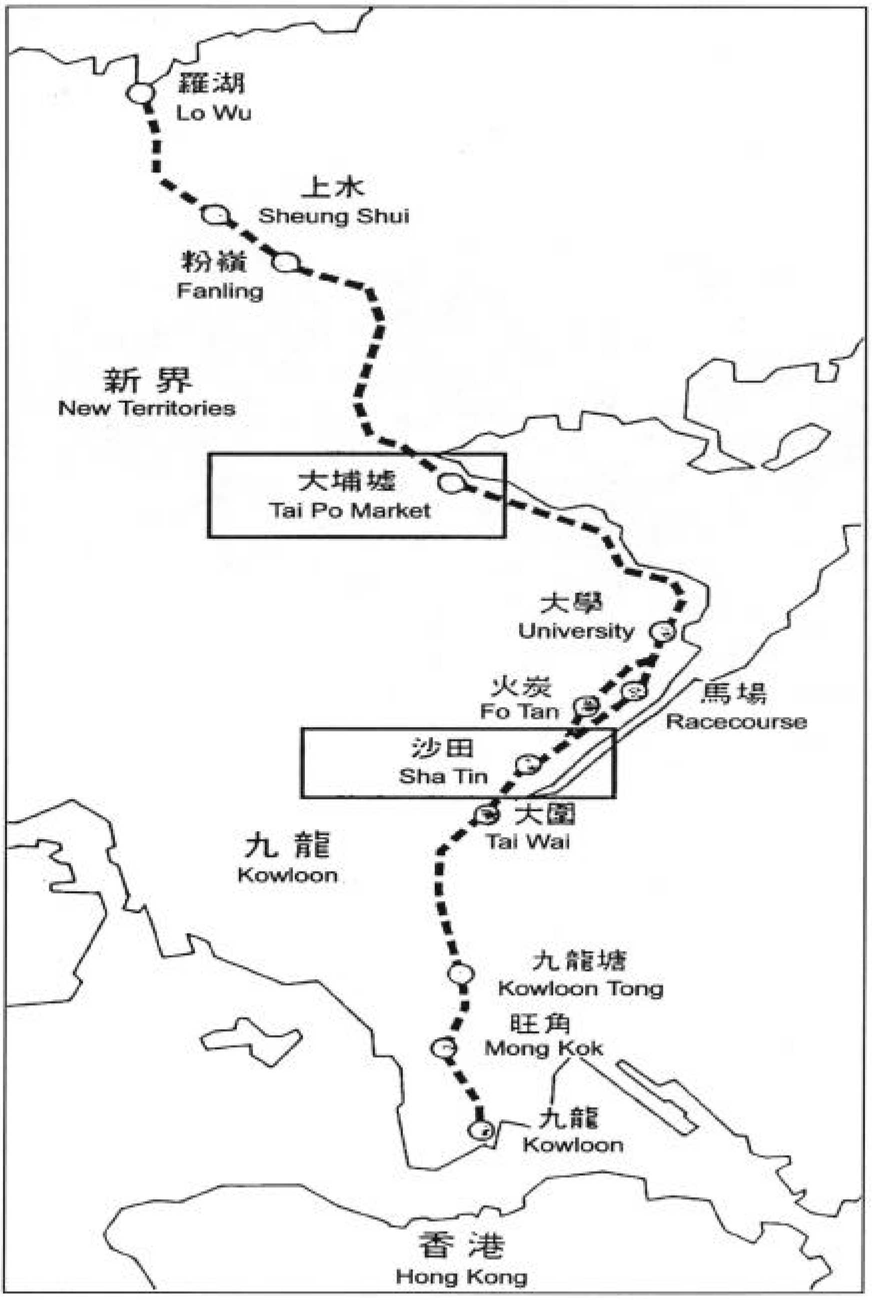

Figure A.4 The Kowloon Canton Railway Roue Map
Source. Chau and Ng, 1998