THE RELATIONSHIP BETWEEN ECONOMIC GROWTH AND ROAD INFRASTRUCTURE: EVIDENCE FROM TURKEY

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ABSTRACT

THE RELATIONSHIP BETWEEN ECONOMIC GROWTH AND ROAD INFRASTRUCTURE: EVIDENCE FROM TURKEY

By common consent, governments want to increase their economic efficiencies, productivities, citizens' level of incomes and welfare and quality of their lives. Infrastructure investmens are prominent factors to boost the growth of the economies. In the aspect of infrastructure, transportation investments are also important for economic growths. Because people can reach education, health services and gain social benefits by using transportation networks. Measuring the impact of transportation investments on economic growth is important, gathering substantial results are important tools for policy makers, decision makers and development planners. There are studies to measure how much these benefits are gained by transport infrastructure expansions in many countries. The goal of this study is to achieve concrete evidences whether if road infrastructure expansion is effective or not in economic basis in Turkey for the country and provincial levels. To achieve this aim, two different econometric analyses are examined. Data is gathered from TURKSTAT, Directorate of Highways, Ministry of Development, TEPAV databases. Road infrastructure capital stocks and road density changes per capita values are used as main explanatory variables in terms of road infrastructure concept. Initial econometric analysis is performed at country based level with a Cobb-Douglas production function. In the last analysis, panel data approach is used on the Solow type growth framework. Results show that the road capital stock or road density per capita changes are not significant in determining the increase of the GDP levels for Turkey. If there is an existing sufficient capacity, an additional road creates less marginal benefit for the welfare. Also, alternative transportation instruments should also be considered for related future studies.

ÖZET

EKONOMİK BÜYÜME VE KARAYOLU ALTYAPISI ARASINDAKİ İLİŞKİ: TÜRKİYE'DEN BULGU

Bilindiği üzere, devlet yönetimleri ülkelerinde ekonomik etkinliğin, üretkenliğin, vatandaşlarının gelir düzeyi, refah ve yaşam kalitelerinin artmasını ister. Altyapı yatırımları ekonomik büyümeyi destekleyen önde gelen faktörlerdir. Altyapı açısından, ulaştırma yatırımları da ekonoik büyüme için önemlidir. Çünkü insanlar ulaştırma ağlarını kullanarak eğitim, sağlık hizmetlerine ulaşır ve sosyal faydalar elde ederler. Ulaştırma yatırımlarının ekonomik büyümeye etkisini ölçmek önemlidir, çünkü somut sonuçlar politika belirleyiciler, kara alıcılar ve kalkınma planlamacıları için önemli araçlardır. Çoğu ülkeler için ulaştırma altyapı genişletmelerinden elde edilen faydaların ölçümü ile ilgili birçok çalışma vardır. Bu çalışmanın amacı Türkiye'de yol altyapısının genişletilmesinin ekonomik açıdan etkili olup olmadığının ülke ve il seviyesinde güçlü bulgular elde etmektir. Bu amaçla, iki adet ekonometrik model uygulanmıştır. Veriler TÜIK, Karayolları Genel Müdürlüğü, Kalkınma Bakanlığı, TEPAV veritabanlarından alınmıştır. Yol altyapısı konsepti açısından yol altyapı stok ve kişi başı yol ağı değişim değerleri ana açıklayıcı değişkenler olarak kullanılmıştır. Ilk ekonometrik analiz ülke seviyesinde Cobb-Douglas üretim fonksiyonu kullanılarak gerçekleşmiştir. Son analizde Solow tipi büyüme modeli ile panel veri yaklaşımı kullanılmıştır. Sonuç olarak, Türkiye için, yol altyapı stok ve kişi başı yol ağı değişimlerinin GSYIH seviyesinde değişiklikte etkisi anlamlı bulunmamıştır. Eğer yeterli bir kapasite mevcutsa ilave bir yol refah açısından daha az marjinal fayda getirecektir. Ayrıca, alternatif ulaştırma enstrümanları da gelecekteki bu alan ile ilgili çalışmalarda dikkate alınmalıdır.

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LIST OF SYMBOLS

A	Technological progress
a, b	Elasticities
a, b	Regression coefficients
C	Private cost
d	Regression coefficients
I	Investment
i	Location index
K	Capital
L	Labor
ln	Natural logarithm
log	Logarithm
p	Input prices
Q	Output
q	Private inputs
S	Savings
t	Time index
u, e, b, m	Regression errors
v, u	Leontief production function constants

LIST OF ACRONYMS/ABBREVIATIONS

C-D	Cobb Douglas
CES	Constant Elasticity Substitution
CO	Car Ownership
FDL	Finite Distributed Lag
GDP	Gross Domestic Product
GNP	Gross National Product
KGM	The Directorate of Highways
OECD	The Organization for Economic Cooperation and Development
OLS	Ordinary Least Squares
R&D	Research and Development
TEPAV	Turkish Economy Policies Research Foundation
TURKSTAT	Turkish Statistical Institute
USA	The United States of America
VAR	Vector Auto Regression
WLS	Weighted Least Squares

1. INTRODUCTION AND BACKGROUND

Investments in modern infrastructure are regarded as the foundations for economic development and growth. Infrastructure investment is essential for every country to boost their economic growth. Modern and efficient infrastructure sectors such as energy, transport, water, digital communications, waste disposal networks, and social sectors like education and health are important contributors to the success of a competitive modern economy [1].

Drinking water, waste water disposal system, sewage system, dams, irrigation and drainage systems, electricity generation and transmission systems, cabling, railway, highway investments are called public infrastructure investments. Sufficient infrastructure systems can create productivity in industries and sectors. Besides that they are cost effective and supporter for economic growth. Furthermore, these invetsments lead to increase in the quality of life and the wealth of people [2]. Studies have shown that long term economic benefits can be achieved through well-designed infrastructure investments. These investments can increase potential economic growth and productivity [1].

Sufficient level of existing infrastructure systems to meet the demand of the economic decision units can increase the productivity and economic growth and social life standards. One of the typical characteristics of the infrastructure is the high level of costs. For the sustainable development of infrastructure system, there must be high amount of resources. Secondly, these are realized by the public sectors [2].

Infrastructure is a mean to reach a success in manufacturing and agricultural activities. Furthermore, new information and technologies can lead to growth, improvement in the health and education services and increase in the quality of life [3]. The electricity consumption change can be an indicator for the development of the World. In Figure 1.1, the electricity consumption in thousand of kWh per capita from 1990 to 2012 in the World is shown.

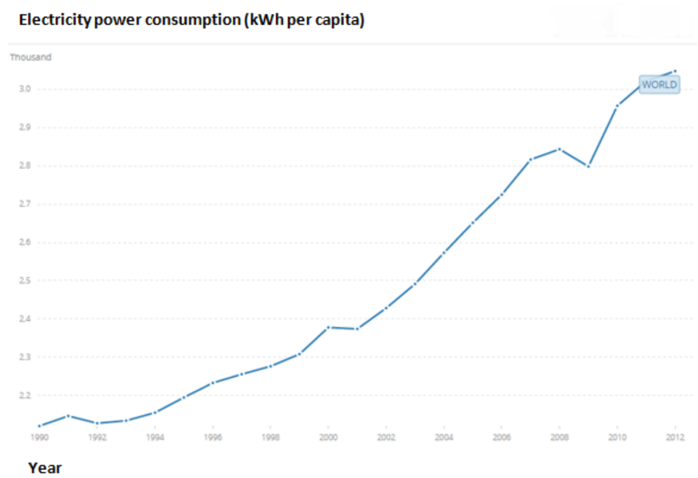

Figure 1.1. Electricity power consumption of the World vs. Year (1990-2012) [3].

Transportation expansion and improvement of the existing capacities are the key determinants for the performance of the infrastructure systems [4, 85, 86]. Efficient transportation system can lead to gaining more economic and social benefits to emerging and advanced economies by means of improving market accessibility, increasing the eficiency of productivity, providing balanced growth of regional economies, providing labour force by employment and labour mobility [4, 85, 86]. Furthermore, connecting communities by transportation and network systems is an essential factor to improve the economic efficiencies [4, 85, 86]. Road expansion and maintenance spendings are important aspects for countries in terms of their road network systems. In Figure 1.2, road infrastructure investment distribution in 2014 for 20 OECD countries is illustrated.

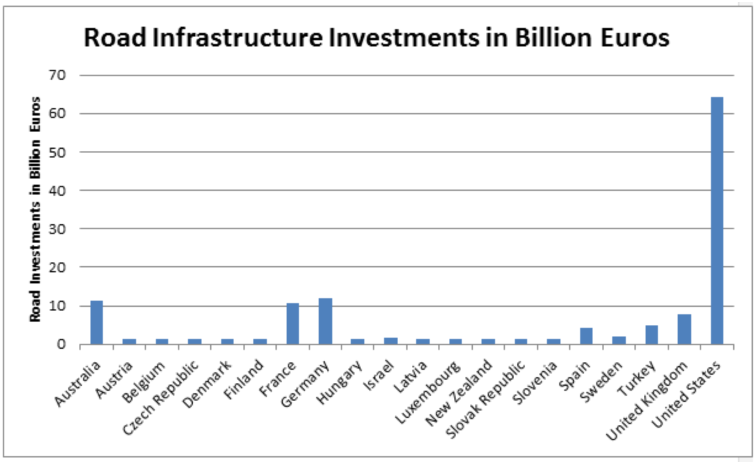

Figure 1.2. Road Investments of Countries in Billion Euros [4].

Referring to the Figure 1.2, Turkey has nearly 5 Billion Euros road investment and maintenance spending for 2014. There is a huge difference between the U.S. spendings and the all of the other countries. USA has a spending higher than 60 Billion Euros as it is about tenfold of the Turkey's spending in 2014 [4].

Capital formation includes the production, distribution and transportation of that part of a nation's output of productions and services that is not diminished immediately, but it is sustained and included into the nation's stock of wealth [99]. From 1980 to 2013, investments in transportation have averaged 32.2% of total public fixed capital investments in Turkey [1]. Within various forms of transportation investments, highways are considered as the most suitable instrument in the generality of the literature about economic growth [5].

Infrastructure investments have direct and indirect effects on total wealth. As investment amounts increase cumulative demand in the economy, realized infrastructure investments directly contribute to Gross Domestic Product (GDP) formation. Furthermore, these investments create an environment in which productive inputs would be utilized more efficiently, and may stimulate private sector economic activities [1].

The measurement of the impacts of infrastructure investments and stocks on economic growth is carried out using the econometric models. In these equations, on the left hand side, output is decided as income level or mostly GDP. On the right hand side, public or, in our scope, transportation investment or capital stock variables are used. Several results are found for different countries, states and other regional distinctions or in industrial levels.

In this dissertation, Turkey is in the scope of our study for country and provincial levels seperately in the terms of road infrastructure and GDP growths. In the next section, the reason for choosing the study and the definition of the dissertation topic is explained. Afterwards, Goals and Objectives are described. In the next chapter, Literature Review is done. In the Theory chapter, explicit technical information is given that is used in the analyses. Thereafter, analyses of the studies is shown clearly with their methods in the next chapter. After the analyses and their results shown, an informative chapter is existing for pre-informatively to explain the results reasonably. As the last chapter, limitations, contributions and possible implementations of the conclusions are present in the Results and Discussions chapter. At the end of the dissertation, references can be found as a list.

1.1. Problem Definition

Hereinbefore, the infrastructure investments are essential for economic productivity efficiencies and economic growth. Therefore, transportation is an important factor to create networks and increase the productivity efficencies and cost reductions. There are existing studies to measure the impacts of transportation and highways on economic growth for different countries and regions (e.g. Aschauer (1990)) [6]. In this dissertation, two econometric analyses are performed to measure if there is a reasonable relationship between them.

There are three types of econometric analyses in the dissertation. In the first one, a Cobb-Douglas production function is used in a time-series model in country level of Turkey. To study this model, road capital stock of Turkey is calculated by using the spendings of General Directorate of Highways (KGM) for the highway investments. In the second model, in provincial level, a panel data model with Solow growth model is used to analyze the effect of road density per capita on economic growth.

By using the results of the analyses this dissertation is attempted to be a guidance for policy decision makers, in order to know whether if the road expansion is really effective on economic growth reasonably or rather using resources on the highway constructions investment on the mobility management or any other alternatives such as parking facilities etc., or allocating funds mostly on the other types of sectors (telecommunications, energy etc.) is mostly effective on the economic growth and efficiency.

1.2. Goals and Objectives

The goal of this dissertation is to examine the effects of the road stocks and investments to the economic growth and to propose a dynamic panel model which fits the data obtained. These are achieved by;

- Using Cobb-Douglas production function and Solow type growth models for deciding the impact of road infrastructure on economic growth for Turkey
- Determining the appropriate road infrastructure variables which fit the models
- Calculating road infrastructure stocks for Turkey
- Gathering and adjusting data for 81 provinces in Turkey between 1998 and 2013 for panel data approach
- Applying a dynamic model for the panel data and compare the results with static approach.

2. LITERATURE REVIEW

In the literature various studies on the impact of capital stocks or infrastructure investments on economic development can be found. Romp and de Haan (2007) underline that this literature can be grouped into four methodological aspects: production function method, cost function method, growth models, VAR (Vector Auto-Regressive) models. A further categorization into three main groups is also possible: national and cross-country, regional, industry studies [7]. In the following sections, studies in the literature described in detail.

2.1. Production Function Approach

Production function approach is generally used to measure the impacts of the capital stocks on the economic growths. In the Figure 2.1, types of production functions can be classified.

The definition of the production function is as follows;

$$(x) \equiv max \{ y : y \in Y(x)\} \tag{2.1}$$

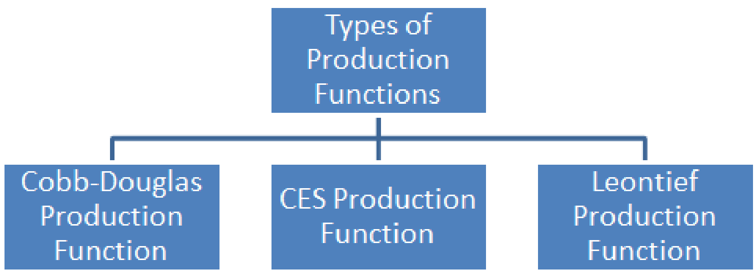

Figure 2.1. Types of production functions [8].

Three different main production function types exist, namely the Cobb-Douglas production function, the CES (Constant Elasticities of Substitution) production function and the Leontief production function. In this dissertation, the Cobb-Douglas production function will be used. It can be assumed that production function form is;

$$Q = \; A \; f \; (K, \; L) \tag{2.2}$$

Q can be defined as the output that can be assumed as real GDP per capita. The technological progress is denoted by A, while K is the capital and L is the labor. In the Cobb Douglas function,

$$Q = AK^a L^b \tag{2.3}$$

a and b are the elasticities. If a+b equals to one it is the constant returns to scale economies. When a+b is greater than one, the increasing returns to scale, if lower than one decreasing returns to scale.
The main characteristics of Cobb Douglas function are:

It is possible to make a log linear transformation,

$$\log Q \;\; = \;\; \log A \; + \; a \log K \; + \; b \log L \tag{2.4}$$

It is a homogenous production function that degree can be computed by adding values of a and b. If the a+b is 1, it means that the degree of homogeneity is 1 and also the constant returns to scale. The parameters a and b, can be used as elasticity coefficients to output for inputs, capital and labor.

The main principle of Leontief production function that there is a certain and fixed proportion of inputs that they have no substitution between them. The ratio of v/u is constant below.

$$Y = \min\left[\frac{K}{v}, \frac{L}{u}\right] \tag{2.5}$$

The main principle of CES (Constant Elasticity Substitution) production function is that output change amount is constant due to change labor and capital, which are inputs.

$$Y = \left[aK^{-c} + (1-a)\,L^{-c}\right]^{-c(1/c)} \tag{2.6}$$

$$0 \; < \; a \; < \; 1 \; and \; c \; > \; - \; 1 \tag{2.7}$$

CES has degree of 1 homogeneity means that output can be increased when the inputs increase [8].

In the production function approach, the implicit assumption is to consider the capital and labour as exogenous variables that their marginal productivity is paid attention. However, there is a potential for reverse causation that is announced as a major problem for production functions. As we think about the formula below, capital change namely capital investments depend on the income with savings:

$$I_t = \; \Delta\, K_t \; depends \;\; on \; S_t = \;\; s\; Y_t \tag{2.8}$$

Therefore it can be written as:

$$\Delta K_t = sY_t - dK_t, \tag{2.9}$$

where Y_t is total income and d is the depreciation rate. It gives the relationship as [8]:

$$K_t = sY_t/d \tag{2.10}$$

Therefore, the feedback from the output to the capital stock change makes the relationship more complex. It leads to a new problem to solve apparently the demand for infrastructure from income information. It is an important issue that is called causality in infrastructure stock or investment and growth relationships [7].

Dealing with the problem of causality is an important issue to conclude a significant outcome. To know if there is a causality or not is to derive an appropriate test to clarify how the causality runs. Besides, using appropriate estimations such as simultaneous equation models, instrumental variable methods, estimating panel models are the other solutions in the aspect of causality [7].

In the simultaneous equations approach, there are some relevant and important studies in the literature [9, 10, 11, 12, 13, 14]. If it is thought about the assesment of linking between vehicle intensity and economic productivity relationship, the positive relation can be found directly. However, this result can reflect a causation between the productivity and the infrastructure. Then, the direction of the causation is essential problem. In Fernald's (1999) study the vehicle intensive industries found more beneficial from the productivity of roads from 1953 to 1989 data in USA. However, road investment values are not found productive. Furthermore, interstate highway sytsem is productive, but the second highway does not create a marginal benefit to the productivity. Also, it is seen that after 1973 with higher vehicle shares, the productivity of industries tends to decrease. Then a relationship found that when road expansion increases, growth tends to rise in average vehicle intensive industries and fall in non-vehicle industries. It gives idea to create policy implications [11].

Developing a simultaneous-equations model, two equations are included, seems to be the best recipe to overcome the causality. From the two equations, one relates public capital to output and the other relates output to public capital. For the equation relating public capital to output the question about the functional form arises [7]. In the rate of return perspective, Demetriades and Mamuneas (2000) stuided in aggregate manufacturing sectors of 12 OECD countries from 1972 to 1991. From the profit maximisation framework they constructed a dynamic model. The results explain that public capital has an important effect on the output supply. It also have positive inducement on the demand for private inputs in the short and long-run terms. The public capital's output effects are 1 percent in USA, 0.76 percent in Germany and 0.36 percent in United Kingdom. The simultaneity problem is avoided by considering optimization of the behaviour of firms [9].

In a cross country study approach, Esfahani and Ramirez (2003) is a good example for trying to estimate a simultenaeous equation. They settled a model for infrastructure and output growth to consider institutional and economic factors with the sample of 75 countries between 1965 and 1995. After considering the simultaneity between GDP and infrastructure, the effect of infrastructure became more essential. It is concluded that institutional capabilities play important roles in the perspective of lending credibility and government policy effectiveness to gather economic growth. Therefore, countries can obtain economic growth by investing in infrastructure sectors [10].

The political economy model for distribution of public investments are are formulated by Kemmerling and Stephan (2000). They proposed a simultaneous equation for measuring the the effect of infrastructure accumulation on private consumption. They used as a sample of large 87 German cities for the years of 1980, 1986 and 1988. The results showed that there is a strong relationship between infrastructure investments, grants and policy and lobbying factors. It is explained that the investment grants are effected by the political affiliations. Governments current affiliations are successful to ditribute the the public investments. Also, mosstly "marginal voters" included cities are not received more public grants or investments. Furthermore, public investments can contribute on the private production. The simultaneity between output and public capital is found as weakly. Therefore, the feedback effect from output to infrastructure is found as negligible [11].

In the perspective of political decision making processes, Cadot, Melo and Olarreaga (1999)'s study is focused on endogenising public capital formation. In this study, political decision process that includes lobby works from different regions are modeled in an explicit policy equation. The sample is taken from 21 regions of France between 1985 and 1991. The elasticity of output with respect to public capital is estimated 0.101, the private capital is 0.181. The OLS elasticity estimate is about 0.099. Therefore, simultaneity bias is negligible. A major evidence from the study is that constructing new roads and railways or investing for an infrastructure is not stem from the reducing the traffic jams or increasing the efficiencies. Main motivation is to be re-elected. Pork barrel also effects the spatial allocation of the investments. According to experiments in the study, at least a part of the cross-regional variability originated by pork barrel [14].

In the simultaneity concept, Roller and Waverman (2001) studied on the relationship between telecommunications infrastructure and economic growth. Data of 21 OECD countries from 1970 to 1990 period are examined. To endogenize the telecommunications investments they used a production function framework. A micromodel for telecommunications is estimated for a macro prodcution function estimation. After considering for simultaneity and fixed effects, a causal relationship is found between aggreagte output and telecommunications infrastructure [13].

In the panel data approach, there are some studies in the literature [15, 16, 17, 18, 19, 20]. One of them is Ciaretta and Zarraga's (2010) study that economic growth and consumption of electricity relationship is investigated. Data of 12 European countries using annually periods between 1970 and 2007. They use Pedroni's (1999) [17] panel data approach that to test for cointegration in a heterogenous panel data. The proposed methodology for panel data cointegration by Pedroni (1999) can be considered as an extension of the traditional two-step residual-based method which was developed by Engle and Granger (1987) [18]. The results show that there is a strong casuality directed from consumption of electrcity to GDP and furthermore, this study shows that a negative short-run and a long-run equilibrium relationship between the three series are existed. In accordance with expectations, bidirectional causality among GDP and energy prices is existed. The results show that in the long-run there is a strong relationship, but a negative short-run and strong causality is found from consumption of electiricity to GDP [16].

In the scope of telecommunications and economic growth relationship Datta and Agarwal (2004) studied with panel data approach for causality. The data consist of 22 OECD countries from 1980 to 1992. A dynamic fixed effects method is utilized and panel data is chosen for eliminating omitted variable bias. They concluded that telecommunications and GDP relationship is positive and significant. The results show that telecommunication strategies can gain more efficiency for the economy by using government policies. To confirm the results that they are not due to reverse causality the relationship also tested by current and lagged values of telecommunication variables. The results show positive and significant values at both models. Therefore, the positive relationship is not only due to reverse causality [15].

In between 1950-1952 data for various countries Canning and Pedroni (1999) studied about the long run results of infrastructure provision on income per person. A growth maximizing level is defined. Below that level, income increase in the long run by increasing the infrastructure. Above this level, increase in infrastructure causes decrease in long run income. For different countries they find that on average, in the case of balanced panels, paved roads and telephones are supplied close to the growth-maximizing level, but that some countries have too many, others too few [19].

Another support for the panel data approach of the causality is the study of Canning and Bennathan (2000). They estimated the social rates of return to electricity generation capacity and roads. They found that electricity generation capacity and paved roads high social rates of return [20].

Instrumental variable method is also used to solve the causality problem by Calderón and Servén (2002). It is chosen due to the simplicity rather than simultaneous equations. Data of 100 countries between 1960 to 2000 are used in panel data approach with production function estimation. Two major conclusions are, infrastructure stocks have a positive impact on growth and income inequality can be decreased by higher infrastructure capacities. These two results can overcome the poverty [21].

According to empirical evidence in Kirdar and Saracoglu's (2008) study provincial growth rates are negatively impacted by a high level of internal migration in a developing country which is characterized by unskilled labour leaving rural areas to live urban areas. The study uses data between 1975 and 2000 and an instrumental variables estimation. The instrumental variables used are state of emergency, which is peculiar to Turkey, and provincial population densities. In conclusion, as a result of migration the convergence hypothesis holds for Turkey [23].

2.2. Cost Function Approach

Production function approach includes the analytical and statistical limitations. To handle these problems, many studies adopted a cost function based approach. As with the production function model the aim is to gather the information about the effect of public capital formation on productivity and economic growth on regional and national levels. The two functions differ as the production function model gives marginal product measures as an output while the cost function model's output are shadow value parameters indicating cost savings from an additional public capital investment. This implies that the cost function model must, in order to explain growth, show how the expansion of public infrastructure enables private firms to reduce their average costs by increasing the productivity of private inputs or by reducing their use. The associated reductions in cost can be seen as returns to public investment (Morrison and Schwartz 1996) [23, 24].

In these studies a cost function for the private sector is specified under the assumption, that companies target to produce a given level of output at minimum private cost (C). The instruments of the companies are the quantities of the private inputs (q_i) as the input prices (p_i) are exogenously determined. Alternatively, companies are supposed to target maximisation of their profits (π) given the input prices and output prices (p^Q). Formulations are [7]:

$$C(p_t^i, q_t^i, A_t, G_t) = \min \sum p_t^i q_t^i \ \textit{Subject to}\ Q_t = f(q_t^i, A_t, G_t) \tag{2.11}$$

$$\Pi(p_t^Q p_t^i, q_t^i, A_t, G_t) = \max p_t^Q Q_t - \sum p_t^i q_t^i \ \textit{Subject to}\ Q_t = f(q_t^i, A_t, G_t) \tag{2.12}$$

Firms consider the environment in which they are operating, when they are in the optimization process. The state of technical knowledge (A) is one of these environmental variables, while another one is the available public infrastructure capital stock (G). The public capital stock is put into the cost or profit equation as an unpaid fixed variable. Although the cost-function approach considers the stock of infrastructure as externally given, each individual company still needs to decide the amount it wants to use that causes a company optimisation problem of using the infrastructure [7].

An important issue is the proper definition and measurement of the price of public capital. For this the evaluation of its impact on the shape of the long-run private cost function is made possible through the inclusion of public capital making private capital's cost elasticity, i.e. -dlnC/dlnKg, or the computation of its shadow price the key element in the analysis [24].

Several studies have attempted to provide a proper measure for the price of public capital. While it is possible to argue that for private firms the price of public infrastructure such as transportation is zero, it is certainly not so from a social viewpoint. A further question is how to compute price of public infrastructure in the presence of spillover effects across metropolitan areas or even state borders. If such effects are, in fact, extensive they represent real alternative costs for firms that do not locate where they can most benefit from them [24].

The computation of a measure for the price of public capital involves (at least) three main factors: (a) the rate at which a government raises funds (e.g. through borrowing); (b) the rate of depreciation of public capital; (c) the deadweight loss (excess burden) of taxation. For example, Morrison and Schwartz (1996) [23], use government's bond yields as the cost of government's fund raising. They further use private sector rate of depreciation of capital as an upper bound of the rate of depreciation of public capital (assuming that the latter has, on the average, a longer life span than private capital has). Their measure of the price of the public capital is$(1/\lambda)(r_g + \Delta_g)$, where λ is investment price deflator and r_g and Δ_g are bonds' yields and rate of depreciation respectively. They further augment this measure by adding an index of the deadweight loss of taxation. For the USA, they take this loss to be between \$1.00 and \$1.50 for each dollar raised through taxes [24].

Two principal types of cost function models were used in the literature. There are translogarithmic (e.g. Nadiri and Mamuneas 1994) [26] and generalized Leontief (e.g. Seitz 1993) [27]. Both functions are part of the "flexible form" type function family. That is, these functions are permitting substitution and complementary relationships between inputs by placing very few priori restrictions on the attributes of the underlying production technology such as the degree of factor substituon or its homogeneity [24].

For the cost function approach there are some studies in the literature [23, 25, 26, 27, 28, 29, 30] One of them is Nadiri and Mamuneas's (1994) study about twelve two-digit US manufacturing industries analyses by using a translogarithmic cost function model approach, in respect to the effects of R&D capitals and publicly financed infrastructure on their productivity performance and cost structure. From these two types of capital significant productive effects were observed. Besides the fact that there is a downward shift of the cost function in each industry, their factor demand is also affected by these two mentioned public capitals, which leads bias effects. Besides that, in each industry, they determined the marginal benefits of them and estimated for the industries in their sample the "social" rates of return to those capitals. These rates of return change over time, reflecting the underlying rate of public sector investment in R&D and infrastructure. There are two major insights that can be learned from this study: One, even though the extent of the effects are much less than shown in literature, it was seen that the public infrastructure capital does affect the productivity and cost of the private sector industries. Second, productivity and cost of different industries are significantly affected by alternative types of publicly financed capital, such as public investment in R&D, which also have high social rates of return. [26]

A generalized cost function method is also used in a study by Seitz (1993). This study uses the method of generalized cost function containing both monetary and physical measures of the public road infrastructure capital. A data of 31 manufacturing industries in the Federal Republic of Germany is used in panel data concept as the basis for estimation. The outcome of the study suggest that public road infrastructure significantly contributes to the private industry's economic performance. It is shown that both public and private inputs of capital and labour are complementary and substitutive, respectively [27].

Sturm *et al.* (1998) point out that the cost function method's lesser restrictivity in comparison to the production-function approach is a significant advantage. Using a flexible functional framework leads to limitations on the production structure. For instance, a basic restriction for substitutability of production function does not apply in the production function approach. Besides its direct effects, public capital might also have indirect effects in the production function approach. Companies may regulate their demand for private entries if public capital is a complemet or substitute to these other production factors. For example, an increase in stock of infrastructure increases usage of amount of the private capital used thereby increasing production indirectly [29, 7].

The determination of the impact of public capital among private entries is possible through the using a flexible functional framework. Besides of many estimated parameters, a flexible function also includes some amount of second-order terms that are cross-products of the inputs, which is a basis for multicollinearity problems. Therefore a data set of relatively large and containing enough variability is necessary in order to be able to deal with the multi-collinearity. Therefore the cost-function approach's most attractive feature also causes the biggest problem, i.e., the considerable amount of information that needed to be included due to the flexibility of the functional form.

Hence panel data is used by the majority of cost function studies that are combinations of a time dimension with either a sectoral or a regional dimension [7].

Using the data of twelve Spanish manufacturing sectors in different regions between 1980 and 1991 Moreno *et al.* (2003) concluded that the public capital cost elasticity is on average only -0.022. They used a duality theory framework to assess the effectiveness of public and private investments on manufacturing sector performance. They concluded that the existing level of stock of public and private capital does not effect directly the cost of manufacturing sectors. For example, the two types of capital investment s can be in a kind of competition in some level of stocks. According to the results, it is found that private investments are effective in decreasing the manufacturing costs and therefore increasing the efficiency of manufacturing. [28]

Cohen and Morrison Paul (2004) used maximum likelihood techniques to estimated a cost-function model. They used data about amounts and prices of aggregate manufacturing output and the independent variables as labour, capital and materials and public highway infrastructure for 48 US states for the period between 1982 and 1996. The authors' assumption is that based on a certain level of input prices, capacity and demand and for given environmental and technological conditions manufacturing firms choose a combination of suitable inputs to minimise short-run costs. The model accounts for interaction between public infrastructure intra- and interstate effects and also distinguishes between these two effects. Specifically this indicates that the model includes also the infrastructure of the neighbouring states. In the study of Cohen and Morrison Paul (2004), they find that public infrastructure investments significantly contribute to lowering manufacturing costs and that this effect is strengthened with spillover effects. When spillover effects are considered the average elasticity reaches -0.23, while for the case in which the stock of infrastructure of a neighbour is not added into the elasticity is around -0.15. The latter is the case for the majority of literature and the elasticity of -0.15 is comparable to those found in other studies. This means that the estimated effects of intrastate infrastructure investment are increased as spatial linkages are recognised. The authors also observe an increase of the inter- and intrastate impacts of public capital along the time interval [30,7].

As a result, the cost-function studies reviewed in this section are broadly in the same direction with the the production-function approach used studies. General findings are public capital reduces costs, however heterogeneity across regions and/or industries should be considered [7].

2.3. Growth Models

There is a significant amount of growth model studies available in the literature. The models subject to the studies can be generally categorized into exogenous and endogenous growth models. The distinguishing factor is that in an endogenous growth model, the steady-state growth is determined endogenously, also known as endogrowth, while the steady-state in the exogenous growth model is determined exogenously. Technical change would be an example for the latter.

It is possible to classify endogenous growth models into five major grups: AK Type Model, Romer Model, Barro Model, Lucas Model and R&D Model [8].

2.3.1. AK Type Model

The "AK" model developed by Rebelo (1990) can be considered as the simplest possible endogenous growth. It assumes the production function to be linear in capital, causing the production function to be constant returns to scale and capital [31].

$$Y = F(K, L) = AK \tag{2.13}$$

where A is a constant, K is aggregate capital, which means that besides physical capital include stock of knowledge, human capital or any other capital types such as financial capital, etc.) [31].

In the "AK model" growth does not depend on technological changes. Growth is defined by the savings, population growth and depreciation, apart from the other growth models, the population growth rates and difference of the saving rates lead to economic growth. Besides, growth of income per person is independent from the level of income per capita, therefore the convergence does not occur [8].

2.3.2. Romer Model

The endogenous growth literature was started by Romer who considered a model in which firm level returns to scale stayed constant but economy-wide level is increased. Then, this model underpins a non-optimal competitive equilibrium. A higher growth rate could be reached if the investment could be endogenized [32].

In the model, new knowledge has a diminishing return to scale (the available knowledge has an increasing return to scale) assumption is made [8]. Romer follows Arrow's study about learning by doing. Arrow noticed that there was strong findings that experience is relevant with the increase of productivity. According to Arrow investment is a good measure of increase in experiment, because "each new machine produced and put into use is capable of changing the environment in which production takes place, so that learning takes place with continuous new stimuli" [32].

2.3.3. Barro Model

Through the endogenous growth models, Barro (1990) is the first that introduced the public spendings into the models. Barro investigated the public spendings' exogeneity rather than the Romer's (1986) model exogeneity [8].

According to the model, in a closed economy, infrastructure investments increase the private capital productivity and create exogenous productivity factor for firms. In the model, physical and human capital is considered together, therefore capital is considered constant returns to scale. However, each input seperately can be considered diminishing returns to scale [8].

In Barro's model, products or services that are provided by public sector is assumed to be inputs. In this model, these products are assumed to be private products that are produced by public. In another approach, these products can be assumed as common infrastructure investments or economic-political stability [8].

2.3.4. Lucas Model

In his paper on the “Mechanics of Economic Development”, Lucas develops a model in which through argumenting that all inputs can be accumulated, accumulated inputs in the constant returns to scale is gathered. Lucas assumes a production function which is constant returns to scale in human capital. Therefore, the incentive to spend time on studying which is called human capital, has a constant marginal product [33].

2.3.5. Research & Development Model

There are various growth models emphasizing R&D as an essential stimulus for economic growth. R&D contributes to growth in various ways out of which two stand out. The one way is the creation of capital goods that are new types whose productivity will or will not be higher than the productivity of existing ones. Romer (1987) and Barro and Sala-i-Martin (1990) [31] define output as a function of all qualities or varieties of capital goods of existing ones. If it shows “constant returns to the number of varieties or qualities” endogenous growth will be obtained.

The other way in which R&D contributes to economic growth is through potential spillovers on the aggregate stock of knowledge: the stock of knowledge is increased as scientists invest time to reflect on the development of new techniques or products. In turn R&D costs are reduced by this larger stock of knowledge. Hence, a “Constant Returns to Investing to R&D” is generated under some conditions through spillovers from R&D activities. This constant return motivates companies to increase the stock of knowledge at a constant rate by investing constant amounts of resources in R&D. Since general knowledge decreases manufacturing costs, manufacturing will be growing at a constant rate along a time period [31].

2.4. Var Model

Vector autoregressive (VAR) models are linear models used for a long time as tools for multiple time series analysis [34, 35, 36, 37]. Due to their linearity they are easy to apply in theory and practice and were the preferred model of choice until the spread of powerful computers, since they were able to handle some complexity despite straightforward computations.

Vector autoregression (VAR) models are used by variety of recent studies. They differ from the cost-function and production-function approaches in the way that they do not consider the enforcement causal links between the investigated variables. All variables in a VAR model are determined with there is no consideration about the causality. Therefore, VAR models let to check the existence of causal relationship or feedback effects of output to public capital. Besides, the VAR models permits to test whether an indirect effect is present between variables or not. An unrestricted VAR model can be settled by using the estimation of OLS. Even in the case of variables are integrated and likely cointegrated, OLS gives consistent estimations [34, 7].

However, even in a simple VAR model, choices may effect the models and alter the estimated results. However, Vector Error Correction Models (VECMs) give consistent estimates and forecast error decompositions if the number of cointegrating relationships are consistent [7].

Soytas and Sari's (2003) analyzed in their study the energy consumption and GDP and the causality relationship between the two series in 16 countries in a time series framework: the G-7 countries and the top 10 emerging market (excluding China due to lack of data). The maximum likelihood procedure is used by Johansen (1988) [38] and Johansen and Juselius (1990) [39] to test for co-integration whose existence rules out the Granger non-causality. Co-integration vectors were proven for seven out of the 16 countries, namely Korea, West Germany Argentina, Japan, France, Turkey and Italy, which implies that there is Granger causality. Vector error correction modeling (VECM) is used in order to decide the causality direction. The results made a long run uni-directional causality running from LEC (lagged energy consumption) to LGDP (lagged GDP) for France, Japan, Turkey and West Germany evident. There is a reversion of the long run causality for Korea and Italy while for Argentina bi-directional long run causality is existing as well as evidence of a short run bi-directional causality. For Turkey, the short run the bi-directional relationshipis applied as well. In all the other countries short run causality lack is implied as the LEC and LGDP do not included significantly in each other's equation [37].

In a study of six industrialized countries such as Canada, France, Great Britain, Japan, The Netherlands and Germany Mittnik and Neumann (2001) analyzed a dynamic framework of public investment and output relationship. They investigated the dynamic imoulse responses derived from vector autoregressive model. They also questioned if there is a reverse causation. They concluded that there is no support for reverse causation from GDP to public investment. Their results are evidence for endogeneity of public investments also. Impulse response analyses show there is a positive relationship with elasticities that do not exist 0.1 [35].

There can be some conclusions about VAR analyses. First, the majority of studies include a VAR model that contains four-variables: employment, output, public capital and private capital. Another conclusion is, a broad variety of model specifications is existing. Some studies test for cointegration obviously. However, in some VAR models in first differences, there is no test for cointegration. According to some studies in the literature, VAR coefficient estimations are even consistent if the regressors are nonstationary and likely cointegrated. Another result is, even though in the most of the studies,it is found that response of output to public capital shock is positive in long-run. Kamps (2004) underlines that most studies lack the provision of any uncertainty measure surrounding the impulse response estimates which makes the judgment of the statistical significance of the results impossible. To provide confidence intervals Kamps (2004) uses bootstrapping techniques [36, 7].

2.5. Highway Stock/Investment-Economic Development Literature

There are important studies that focus on the impact of infrastructural investments, especially in the area of transportation, on economic growth. A grouping of these studies can be done with regards to their point of focus.

The common feature of these studies is their positive result. Under the leadership of the transport infrastructure investment on economic growth have significant positive impacts in many studies [6, 40, 41, 42, 43, 44, 45, 46]. The output elasticity results differs from high to low values such as, 0.39-0.56 [47], 0.33 [48], 0.25 [40], 0.135-0.206 [21], 0.04 [41], 0.08 [49]. The difference in the models that underlie these studies as well as differences in the definition of capital stock, estimation methods and level of analysis can are assumed to be the main caused for the large variation of output elasticity estimations. Holtz-Eakin (1994) used state level data in a production function by including labor, state and local government capitals and private capital. The result shows that private capital output elasticity is significantly greater by compared to the public capital (0.23) [50]. On the other hand, Chandra and Thompson (2000), Evans and Karras (1994) find slight evidence for transport led economic growth contention [50, 51].

However, recent research has indicated that the level of infrastructure accumulation significantly affects the impact of a new transportation infrastructure addition into the capacity to economic growth. This economic observation can be explained through the network notion of the transportation [52]. Banister (2012) states that a rational level of density and quality of the transport network will effect local economic growth positively, but that once this level is exceeded, additional investments will have a lower effect on the growth due to less accessibility improvement advantages [53]. Fernald (1999) points out that the marginal benefit of building additional transport networks will be limited, even though the first network increased productivity significantly [54]. Age´nor (2010) claims, that because of the presence of network impacts, there is a threshold for the efficiency level of infrastructure [55].

There is another debate about that the optimal level for the transportation accumulation. Question is, what are the conditions that affect the economic growth due to the additional capacity of transportation infrastructure. Unlike the existing studies that focused on the output elasticities, optimal level of the transportation infrastructure is an important point. In (Zhang et al. 2013)'s study, result shows that when the existing accumulation of the transportation infrastructure is lower than a threshold, new investments affect the growth positively, but above a certain level, the output elasticity tends to get smaller [52].

A variety of studies were done on the topic of spillover effects. According to Munnell (1992) highway capital comprises positive spillover effects [56]. In his study in which he analyzed the impact of highway investments on redistribution of economic activity. In the study of Boarnet (1996) the effects of transportation infrastructure on economy is divided into a direct and an indirect effect concepts. The results show that the both effects were equivalent to each other by plus and minus, contrary signs [57].

Some important studies were conducted about the neighbor effects in spillover concept. It was pointed out that this can be even seen when people at another state from the state at the investment had been done. Highway investment had an indirect effect on the neighbor states in a study of Holtz-Eakin and Schwartz (1995) [58]. But, positive effect of spillover is not accepted by all of the researchers. According to the analysis of a study of Chandra and Thompson (2000), which collected the data in US from 1969 to 1993, result shows that national acting industries benefitted from these investments while only a redistribution of economic activity observed in local directed industries [50]. A cost function was used by Cohen and Paul (2004) to manufacturing data ranging from 1982 to 1996. Regressors in their study were production, capital, labor and materials of existing state's and the neighbours'. Results show that if a neighboring state's infrastructure stock is not included, the elasticity is about 0.15. But, considering spillover increase the elasticity value to 0.23 [59]. Pereira and Sagalés (2003) investigated the regional effects in Spain and the potential presence of spillover effects. They used employment, private and public capitals between the data between 1970 and 1995. Their suggestion is output is affected by public capital with an elasticity of 0.523 [60]. The authors' main result is that the spillover effect is more important than the public capital effects in one region itself.

Some researchers also interested in the lagged variables. In some studies the effect on output is investigated by the concept of lagged variables, though scant. Kocherlakota and Yi (1996) demonstrates the severity of impacts as endogenous versus exogenous growths by time series analysis on the data of US is gathered from 1917 to 1988. Results exhibit that structural capital has an undeniable impact on output in the long-run [61]. A research of Lynde and Richmond (1993) investigated the effect of public capital stock on productivity growth in the United States. A translog function used. Data is collected between 1958 and 1989. The researchers used lagged variables and found forty percent productivity decrease clarified by a decrease in public capital labor ratio [62]. Calderon and Servén (2002) also used lagged variables. They used the Cobb-Douglas production function. A longitudinal data analysis is conducted through 101 countries from 1960 to 1997 for 1960-1997. To get rid of the causality, lagged variable is used and the result was the average elasticity of 0.16 [63].

The correlation between economic growth and the transportation infrastructure is described by Banister and Berechman (2000) [64]. The framework shows that investments in the existing transportation infrastructure enhance accessibility, which on the other hand is leading to economic growth through changes in travel and land use patterns [65].

Dynamic analysis in the effect of investments on growth is an important issue in the literature. For example, In Ireland, the stock of public infrastructure is added as an explanatory variable in a production function to examine the connection among private sector output and public capital based on data from 1958-1990 was used by Kavanagh (1997). A capacity utilization term is adopted to adjust utilization rates for labor and capital was also part of her studies, which is used for projection of short-term versus long-term slack capacity information. An elasticity of 0.14 was found by the study for public capital but it was insignificant. In order to explain this insignificance the author mentioned, besides others, the poor utilized public capital as a possible reason.

In addition she contributed a dynamic approach to relate the difference in output in current time corresponding to the previous time transition values, to make the necessary arrangement towards long-run steady state position. This dynamic model also gives the potential capacity information at the long-run. Significance, 0.36, was determined for the coefficient on the dynamic term, demonstrating that the output corrects the previous disequilibrium [66]. Evaluating data from Greece between 1959 and 1995, Mamatzakis (1999) has conducted a study to determine the presence of a long-run interaction among public capital stock and private sector productivity. Cobb-Douglas model used private labor and public and private capital stocks as basic variables. As an outcome the study mentioned the public capital stock elasticity as 0.25. Hence this study underlines the importance of infrastructure for the industrial sector productivity. [67]. Farhadi (2015) studied public infrastructure impact on the growth in a longitudinal data analysis by the data of 18 OECD countries from 1870 to 2009. To measure the public infrastructure impact on the productivity, an endogenous growth model is proposed. The inputs are the educational level, distance to technological frontier, stock of knowledge, innovative activities and as a control variable transportation infrastructure capital. By using the system GMM method, social rate of return found high but not as much as the investment in the machinery and structure [68].

2.6. Infrastructure-Economic Development Literature for Turkey Studies

Studies exist describing the relationship of the economic development and the infrastructure stock and investments for Turkey. Public expenditures and economic growth has a positive relationship. In developing countries, by this infrastructure investments, government prepares the required socio-economic infrastructure, therefore lead to private capital investments. In Demir and Sever (2008)'s study, agricultural, manufacture, services, tourism and transportation investments are investigated with respect to GDP. According to this study, tourism, manufacture and transportation investments has a positive effect on GDP growth. However, agriculture and service investments has a negative impact on the output. In the agriculture investments, the political impacts are indicative rather than social and economic factors, therefore these investments affect the output negatively. In the services, the expenditures do not meet the total demand, impact of the service investments has a negative effect on the GDP [69]. Karadag, Deliktaş and Onder's (2004) study investigates the impact of public capital formation on private manufacturing performance on seperately aggregate and in seven regions of Turkey. The study aims to reach accumulated elasticities of private sector regressors in the long-run regarded to public capital using a VAR model for data between 1980 and 2000. Based on the results, it is concluded that public capital has a positive impact on private output in all regions apart from the Mediterranean and Black Sea regions and on aggregate. For Marmara region positive impact can be observed on input as well as on output. Additionally the study showed that in some regions public capital crowds in private sector inputs [70]. In Serdaroglu's (2016) study, public infrastructure investment's importance for Turkey is investigated. Cobb-Douglas production function is used for the data between 1980-2013. Public physical and public social capital stocks are calculated by the author. When the combined effect of public physical and social infrastructure capital on growth is taken into account, the output elasticity of output is found as 0.24, which is somewhat greater than the respective size found for OECD countries. However, this finding is not surprising as Turkey is an emerging market economy and needs further public infrastructure capital to spur its growth. In this sense, the private sector is expected to benefit more from positive externalities from public infrastructure investments. Therefore, it is important for Turkey to invest more in public infrastructure, because it can also have a stronger growth effect compared to its OECD counterparts [1]. Ismihan, Metin-Ozcan and Tansel's study in which they use cointegration, time-series and impulse-response analysis, describes the relationships between growth, macroeconomic instability and private and public capital accumulation in Turkey between the years 1963 and 1999. The results indicated that growth and capital formation were seriously affected by the increasing macroeconomic instability of Turkish economy. Additionally, this study shows that chronic macroeconomic instability can be a serious obstacle to the infrastructural component of public investment, as well as to public investment as a whole, and in the long run affects the complementarity between public and private investment reversely [71].

Eruygur, Kaynak and Mert's study (2012), in which VECM model and Cobb-Douglas production functions are assumed and they analyze the long-run and short-run relationships between output and transportation & telecommunication capital for Turkey. The study's outcome underlines the transportation & communication capital's lagged impact on economic growth. 0.59 was the value for elasticity of transportation & communication capital to outpu in the long-termt. In addition, the calculated long-term accumulated marginal product implies that an increase of 1.45 unit in per labour output results from a 1 unit rise in per labour transportation & communication capital in the long-run. These ?ndings strengthen the assumption that policy-makers own a powerful tool [72].

The relationship among private and public investments in Turkey between 1976-2012 is the focus of Kalem's (2015) planning expertise thesis prepared for the Turkish Ministry of Development. In the thesis Kalem aims to find public investment's crowding in, which is asserted by Keynesian Economics and its supporter theories, or crowding out, which is asserted by Neoclassical Economics and its supporter theories, effect on private investment through conducting an empirical test for Turkey. In this analysis the application of the ordinary least squares method and the use of regression analysis will explain the relationship between aggregate private investment and aggregate public investment. Furthermore, the use of vector autoregression method will explain cointegration, casuality and impulse response relationships among variables. Hence, the results indicate that private investment is crowded ou by public sector state economic enterprise investments, borrowing requirement and infrastructure investments [73]. In Pekbaş's study (2008), public infrastructure investment's impact on economic growth is investigated by the data between 1980-2004 by referring to VAR model. In this study, public infrastructure investments are decomposed into four subsectors, namely energy, transportation, telecommunications and water facilities and sewers. According to results, both VAR and production function methods reveal significantly positive effect of public infrastructure investments on growth. Especially, transportation and telecommunication infrastructure investments and energy infrastructure investments are found to be prominent. Finally, in this study. 0.124 was found as the the output elasticity of total public infrastructure [74, 7].

Table 2.1. Transportation vs. Economic Growth Relationship Literature Table.

Studies	Sample	Specification	Results
Taotao Deng, Shuai Shao, Lili Yang, Xueliang Zhang (2013) [52]	Chinas province-level panel data from 1987 to 2010	Barro-type growth model	In the aspect of highway density, if it is lower than 0.17 km/km2 results are insignificant. If it is between 0.17 and 0.38 km/km2 the coefficient is 0.23. If it is greater than 0.38 km/km2 the result is 0.09.
Khanam, Bilkis R (1996) [100]	pooled cross-section data for 10 Canadian provinces over the period 1961-1994.	both Cobb-Douglas and translog functional forms	Highway capital has a positive impact on provincial goods-producing output.
David A. Aschauer (1990) [6]	Data of 48 states of U.S. data in 1960-1985	OLS&WLS Methods	The quality and quantity of highways has a direct Effect on economic growth. Good roads are good businesses.
Alicia H. Munnel, Leah M. Cook (1990) [48]	Panel data of 48 States in the U.S. in 1970-1986.	C-D production function and Translog aggregate production function	For Cobb-Douglas function and translog production function, the output elasticities of highway are 6 and 4%.
Joyce Y. Man (2007) [101]	Cross section data in provinces of China in 1992	Aggregate production function	Results show that more invested provinces tend to gain more output.
Wei Zou, Fen Zhang, Ziyin Zhuang, and Hairong Song (2008) [102]	panel data of 1994-2002, as well as time series data of 1978-2002 in China	Aggregate production function	Results show that investing on road construction in poor areas is prominent to growth and poverty alleviation.
Easterly, W. and S. Rebelo (1993) [103]	Cross-section data of 1970-1988; Time-series data of 28 countries in 1970-1988	Aggregate production function	Transport and communications investment contributes positively to growth, and the correlation coefficient is between 0.59-0.66.
Paul Evans and Georgios Karras (1994) [51]	Panel data of 48 States in the U.S. in 1970-1986.	Translog aggregate production function	The effect of highway on growth is negative.
Nadiri, M.I., and T.P. Mamuneas (1991) [26]	Panel data of 12 manufacture sectors in the U.S. in 1955-1986.	Cost function	In general, infrastructure investment has insignificant positive effect on cost reduction in manufacture.
Teresa Garcia-Mila, Therese J. McGuire, and Robert H. Porter (1996) [104]	Panel data of the U.S. in 1970-1983	C-D function	The contribution of highway to production is around 12%.
Alfredo M. Pereira (2000) [42]	Time series data of the U.S. in 1956-1997	VAR model	Between infrastructure sectors, the investment return of electricity is 16.1% and transport is 9.7%. Both of them are higher than that of education and medicare.
Demetriades P.O. and T.P. Mamuneas (2000) [9]	Cross-section data of four-digit codes of manufacture sectors in the U.S. in 1987 and 1997.	Aggregate production function	Transport contributes to specialization and long-run growth.
Sylvie D´emurger (2001) [43]	Panel data of 24 provinces in China in 1985-1998	Aggregate production function	Transport and communication contribute the most to growth.
Amitabh Chandra, Eric Thompson (2000) [50]	Non-metropolitan counties in the continental US	Exogenous growth model	Highway investments lead to regional disparities and do not impact ongrowth significantly.
Seitz (1993) [27]	German highway data	Cost function	Change in average private cost elasticity is 0.05
Deno (1988) [105] Junjie Hong, Zhaofang Chu, Qiang Wang (2011) [46]	USA Data 31 Chinese provinces between 1998-2007	Profit function Barro type growth model	Highway capital elasticity is 0.08 Both land and water transport infrastructure have strong and significant impacts, but the airway is weak.
Xiaodong WANG, Danxuan DENG, Xiaoli WU (2014) [106]	China provincial data between 1990-2010	Feder Model, Basic Model, Time Lag Model, Spatial Model	Results show that transport infrastructure has a positive Spillover Effect on economic growth.

Table 2.1. Transportation vs. Economic Growth Relationship Literature Table (Cont.).

Studies	Sample	Specification	Results
Kaan Ozbay; Dilruba Ozmen-Ertekin; and Joseph Berechman (2003) [65]	Counties in New York/ New Jersey region between 1990-2000	Neoclassical growth model	Results show significant relationships among accessibility changes and economic development.
Kaan Ozbay, Dilruba Ozmen-Ertekin, Joseph Berechman (2007) [107]	Counties in New York/ New Jersey region between 1990-2000	Cobb Douglas	Results show that the spillover effects diminish with the distance, that there is a time lag effect that the investment time and the reaction of output positively. Furthermore, the ouput depends on significantly the previous values of itself.
Minoo Farhadi (2015) [68]	18 OECD countries between 1870-2009	Endogenous growth model	Results show that 10% increase in share of transport stock expenditures increases the labour productivity by 0.14%.
Holleyman, Chris (1996) [108]	US manufacturing industries between 1969-1986	translog cost function	In general case, materials and related input costs have positive relationship with highway stocks. The impact of highway and transportation on materials input prices may explain this relationship that are called as omitted variables.
Samia Islam (2010) [109]	410 US counties between 1977-1992	Production function framework	Results show that poor counties gain from highways. However, in competitive counties drawing productive activity away from those counties into neighboring counties causes problems.
Piyapong Jiwattanakulpaisarn, Robert B. Noland and Daniel J. Graham (2009) [110]	48 US states between 1984-1997	Cobb-Douglas production function	The short-run effects of highways are tended to be overestimated in static production functions; however they are underestimated in the long-run. More reasonable results are found when considering dynamic adjustments of state output.
Daniel Montolio, Albert Solé-Ollé (2007) [111]	NUTS 3 Spanish provinces between 1984-1994	Cobb-Douglas production function	Public investments in road infrastructures have impact on provincial productivity performance in Spain.
John G. Fernald (1999) [11]	29 sectors in US between 1953-1989	Cobb-Douglas production function	The interstate system was highly productive, but a second one would not be.

Table 2.1. Transportation vs. Economic Growth Relationship Literature Table (Cont.).

Studies	Sample	Specification	Results
Pedro Cantos, Mercedes Gumbau Albert & Joaquin Maudos (2007) [112]	Spanish regions between 1965-1995	Cobb-Douglas production function	The results show that there are spillover effects with transport infrastructures.
Kaan Ozbay, Dilruba Ozmen-Ertekin, Joseph Berechman (2006) [45]	48 states of US data between 1990-2000	Production function, lag model, spillover model	Transport investments create strong spillover effects according to distance and time. If these are not concerned, the results show biases.

3. THEORY

In this chapter, econometrical methodologies and theoretical informations are briefly explained. Firstly, data analysis methods are defined explicitly. Thereafter, econometrical growth analysis methods are described.

3.1. Data Analysis Methods

Economic data sets arrive in an assortment of kinds. While some econometric strategies can be connected with practically zero change to a wide range of sorts of data sets, the exceptional components of a few information sets must be represented or ought to be abused. We next depict the most critical information structures experienced in literature [75]. In the econometrics literature, there are three main approaches to conduct the data analysis. These are cross-section data, time-series data and panel data analysis.

A cross-sectional data group includes a set of of people, families, firms, urban communities, states, nations, or an assortment of different items at a specific time. Occasionally, all inputs data do not correspond to one-to-one the same time span. For example, if an arrangement of students was surveyed for a same time period, it can be assumed that it is a cross-sectional data set [75].

A time series data group includes data on a variable or different variables during a period. Variables can be consumer price index, spendings, public investments, annual homicide rates, and sales. Because previous facts can affect lags and future events, time is a significant factor in a time series analysis. Distinctly from cross section analysis, the successive ordering of observations in a time series transmits potential vital data [75].

In some cases, data displays the properties of time series and cross sectional data. For instance, assume that two cross-sectional student surveys are taken in a province, one in 1990 and one in 1995. A random sample of students is surveyed for regressors such as age, education level, course grades for 1990. A new random sample of students is taken and surveyed in the same way. To reach much more sample size, these two year can be combined and get a pooled cross section data set [75].

A panel (or longitudinal) data set comprises of each cross-sectional input of time series in the data group. For instance, assume we have income, average school year, and unemployment past data for a group of members in a five-year period [75]. In this dissertation, time-series data and panel data methods are used. In the following parts, these two methods are explained.

3.1.1. Time-Series Data Method

The most important and apparent difference between time series and cross-sectional data is temporal ordering [75]. Time series is used when the cross section analysis is insufficient to address the result. One of these questions is the causal effect of the change of the X on the Y during a time period. Another point is to find the best forecast values in the future. Time series analysis can find answers to these questions; however, there are some specific issues for itself and these must be solved using some techniques [75].

There is one more difference between time series data and cross section that the former one is more obscure. In cross section analysis the data have fair random outcomes; for example, choosing a different sample gives different dependent and independent variables, such as GDP, education level, income. In the time series randomness, it provides the conditions for intuitive requirements; for example, the next day's BIST value will achieve the today's level or the next year's GDP growth. Therefore, it can be assumed as random variables [75].

In general it is called time series process or stochastic (random) process when a range of random variables with time index. When we take time series data, we have only one realization or outcome of stochastic process, because we can not go back to the previous in time. This is similar in a way with cross section analysis that only one random sample can be drawn). However, if there are different certain conditions in the past, possibly there are different outcomes. Therefore, this is why the time series is thought as outcome of random variables [75].

In this part, there will be most used two types of time series models that can be easily estimated by OLS [75].

3.1.1.1. Static Models. It can be supposed that there are two variables y and z. Static model is formed as;

$$y_t = \beta_0 + \beta_1 z_t + u_t, t = 1, 2, ..., n \tag{3.1}$$

It is the static model for relationship between y and z. It can be constituted that the change in z in time t has an effect on y as:

$$\Delta y_t = \beta_1 \Delta z_t,\ when\ \Delta u_t = 0 \tag{3.2}$$

3.1.1.2. Finite Distributed Lag Models (FDL). An FDL model contains one or more independent variables with their lags that effect dependent variable. The model is defined as:

$$y_t = \alpha_0 + \delta_0 x_t + \delta_1 x_{t-1} + \delta_2 x_{t-2} + \cdots + \delta_n x_{t-n} + u_t \tag{3.3}$$

where n is the lag number [75].

3.1.1.3. Autocorrelation. In time series data, Y value in a time period is correlated with the next year's Y value. The correlation of the series with their own lag values called autocorrelation or serial correlation.

In a Y_t series, j^{th} autocovariance is the covariance between Y_t and its j^{th} lag Y_{t-j}:

$$\begin{aligned} j^{th} autocovariance &= cov\left(Y_t, Y_{t-j}\right) \\ j^{th} autocorrelation &= \rho_j = corr\left(Y_t, Y_{t-j}\right) \\ &= \tfrac{\text{cov}(Y_t, Y_{t-j})}{\sqrt{\text{var}(Y_t)\text{var}(Y_{t-j})}} \end{aligned} \tag{3.4}$$

<u>3.1.1.4. Autoregression.</u> Autoregressions can be defined as the models that the independent variables are the lagged values of the dependent value. For using a one lag in an autoregressive model can be shown as:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + u_t \tag{3.5}$$

It can be shown as AR(1) model.
AR(p) models, p shows the lag number, can be described as:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \cdots + \beta_p Y_{t-p} + u_p \tag{3.6}$$

$$E = (u_t / Y_{t-1}, Y_{t-2}, \cdots) = 0 \tag{3.7}$$

<u>3.1.1.5. Decision of Lag Number by Using Information Criteria.</u> In some studies, for example estimation of some explanatory variables 1 or 4 lags are used. But, deciding an autoregressive model lag number is an important issue for the time series analysis. There are some methods to decide the lag number [76].

<u>3.1.1.6. F Statistics.</u> One of the techniques is starting the model with excess number of lags and doing an F-statistics test for the last lag. For example, starting with an AR(7) model and the seventh lag is tested for 5% confidence level. If it is not significant, then it is omitted and continuing with AR(6) model. It proceeds until the significant value is found [76].

3.1.1.7. Bayes Information Criterion (BIC). In this method, the least value of BIC is tried to find. It can be also called Schwarz Information Criterion (SIC).

$$BIC(p) = \ln(\frac{SSR(p)}{T}) + (p+1)\frac{\ln T}{T} \tag{3.8}$$

SSR(p) is the sum of square of residuals for AR(p) model. The estimator of BIC is $\hat{p}$ that creates minimum BIC(p) through p=0,1,...,p_{max} values [76].

3.1.1.8. Akaike Information Criterion. Another information criterion is Akaike Information Criterion (AIC). It can be defined as:

$$AIC(p) = \ln(\frac{SSR(p)}{T}) + (p+1)\frac{2}{T} \tag{3.9}$$

The only difference between AIC and BIC is that in this formula lnT term is replaced by 2, as well 2 is less than the other one. For example, in an autoregressive model with 200 observations give lnT=5.298. It is greater more than double of 2. Theoretically, the second term of AIC is not great enough to guarantee to find the correct number of lags. Therefore, p the estimator of AIC is not consistent.

Despite the theoretical error the AIC is being preferred much more in practice. If it is thought that BIC will give very few lags, then AIC is a good choice [76].

3.1.1.9. Trends and Stationarity. Time series data are generally include time trend that causes a tendency to grow along a time interval. We should consider the time trend concept in the regression analysis. If we ignore, the two sequences that are trending in the same way in opposite direction can lead misleading results. One of the methods to capture the time trend is:

$$y_t = \alpha_0 + \alpha_1 t + e_t, t = 1, 2, ... \tag{3.10}$$

It is called linear time trend. To avoid trend values, variables can be detrended by linear or non-linear detrending methods and by taking the differences of the variables [75].

Stationarity is also playing an important role in the time series analyses. Stationarity of a variable means that probability distributions of the variable along a time period is stable. It means that taking a sample from a time interval and gives the same probability distribution with another sample from any time interval different from the before.

The stationarity can be achieved by taking the first differences of the variables. However, taking differences can eliminate the information in the long-run. If it is possible, taking the own values of the data is the most preferred option [75].

3.1.2. Panel Data Method

In this section two types of data sets are considered. Firstly, independently pooled cross section is gathered from in a large population at different time points by sampling randomly. These data sets can be gathered at one year and in another year from a different sandom sample. These dataset have an important property as: independently sampled observations [75].

A panel data or longtitudinal data set is familiar to independently cross section data. However, the same individuals, families, countries etc. are selected along a time period. Panel data analysis is a more advanced method, and it is more reliable than the independent cross-section analysis [75].

General aim to use panel data is to search the unobserved factors which impacts the output. There are two types of those factors that are constant or varying over time. Let i represent the location and t the time, a single regressor observed model is:

$$y_{it} = \beta_0 + \delta d2_t + \beta_1 x_{it} + \alpha_i + u_{it} t = 1, 2... \tag{3.11}$$

The variable $d2_t$ is a dummy variable that equals zero when t = 1 and one when t = 2. Dummy variable does not change between locations. Therefore, the intercept for t = 1 is β_0, and the intercept for t = 2 is $\beta_0 + \delta_0$. In independently pooled cross sections, allowing the intercept is allowed to change over time [75].

The α_i variable includes all time-constant and unobserved factors over yit. α_i is called unobserved effect and does not change over time. The error u_{it} is generally named as time-varying error or idiosyncratic error. It displays the unobserved effects that change over time [75].

If the model (1) considered, two years period can be thought in two ways: just pooling two years and using OLS, and assuming that α_i is uncorrelated with x_{it}:

$$y_{it} = \beta_0 + \delta d2_t + \beta_1 x_{it} + v_{it} \tag{3.12}$$

$$v_{it} = \alpha_i + u_{it}. \textit{ It is called composite error} \tag{3.13}$$

But, if α_i and x_{it} are correlated, OLS is biased and results are biased. It is called heterogeneity bias, resulting from omitting a time-constant variable [75].

Second approach is writing the two years as:

$$y_{i2} = (\beta_0 + \delta_0) + \beta_1 x_{i2} + \alpha_i + u_{i2}\,(t = 2) \tag{3.14}$$

$$y_{i1} = \beta_0 + \beta_1 x_{i1} + \alpha_i + u_{i1}\,(t = 1) \tag{3.15}$$

If the second equation is subtracted from the first one;

$$(y_{i2} - y_{i1}) = \delta_0 + \beta_1\,(x_{i2} - x_{i1}) + (u_{i2} - u_{i1}) \tag{3.16}$$

or

$$\Delta y_i = \delta_0 + \beta_1 \Delta x_i + \Delta u_i \tag{3.17}$$

α_i is differenced in that operation. It is called first-differenced estimation [75].

3.1.2.1. Fixed Effect. An alternative way to eliminate ai is to called fixed effect estimation. For a basic, with one explanatory variable:

$$y_{it} = \beta_1 x_{it} + \alpha_i + u_{it} t = 1, 2, ...T \tag{3.18}$$

For each i, taking averages over time gives:

$$y_i = \beta_i \bar{x}_i + \bar{\alpha}_i + \bar{u}_i(2) \tag{3.19}$$

If the Equation 3.19 is subtracted from Equation 3.18;

$$y_{it} - \bar{y}_i = \beta_1(x_{it} - \bar{x}_i) + u_{it} - \bar{u}_i, t = 1, 2, ...T \tag{3.20}$$

or

$$\dot{y}_{it} = \beta_1 \dot{x}_{it} + \dot{u}_{it}, t = 1, 2, ...T \tag{3.21}$$

where $\dot{y}_{it} = y_{it} - \bar{y}_i$ is the demeaned data on y. This method is called within transformation or fixed effect approach. A pooled OLS estimator that is based on time-demeaned variables is called fixed effect estimator or within estimator [75].

3.1.2.2. GMM Approach. A one-way error component model is proposed such as,

$$q_{it} = \delta q_{i,t-1} + x'_{it}\beta + e_{it} \tag{3.22}$$

It is supposed that eit is following one-way error model such as;

$$e_{it} = m_i + b_{it} \tag{3.23}$$

Which corresponds the distributions of $m_i \sim IID(0, \sigma_{m2})$ and $b_{it} \sim IID(0, \sigma_{b2})$
The fundamental problems are:

- Due to q_{it} is a function of mi, so is $q_{i,t-1}$, Ordinary Least Square is biased and inconsistent even if the bit are not serially correlated.
- Since the within transformation clears the m_i, but we get problems because the correlation with $q_{i,t-1}$ and $b_{avg,i}$ (this mean contains bi,t-1). Therefore, Fixed Effect is biased but still consistent for $T \to \infty$.

Anderson and Hsiao (1981) proposed a model which makes first difference to clear the content of the mi, and afterward utilizing an Instrumental Variable technique. However, this model causes to not enough effective assessments, due to the items below;

- it does not satisfy the whole moment conditions in the model,
- it does not consider the residual errors ∆bit in the differenced structure.

Then, Arellano and Bond (1991) suggested a procedure for estimating more efficiently.

Arellano and Bond claim that insertion of new instruments can be accumulated on the off chance that one uses the orthogonality features that present between disturbance bit and lagged values of q_{it}.

Initially, first differenced model provides for wiping out the individual effects. By the way, enables to use whole the previous information of q_{it}.

To show it the simple model of Equation 3.24 can be used.

$$q_{it} = \delta q_{i,t-1} + e_{it} \tag{3.24}$$

It is supposed that u_{it} is following one-way error model such as;

$$e_{it} = m_i + b_{it} \tag{3.25}$$

Which corresponds the distributions of $m_i \sim IID(0, \sigma_{m2})$ and $b_{it} \sim IID(0, \sigma_{b2})$
Initially, a difference is made to clear the unobserved individual effects,

$$q_{it} - q_{i,t-1} = \delta(q_{i,t-1} - q_{i,t-2}) + (b_{it} - b_{i,t-1}) \tag{3.26}$$

If t = 4 is put firstly, equation becomes;

$$q_{i4} - q_{i3} = \delta(q_{i3} - q_{i2}) + (b_{i4} - q_{i3}) \tag{3.27}$$

In this equation, q_{i1} is a valid instrument because, it is not correlated with the error. Also, it is correlated with (q_{i3} - q_{i2}) and not with (b_{i4} - b_{i3}).

For t=5 which is one period further, equation becomes;

$$q_{i5} - q_{i4} = \delta(q_{i4} - q_{i3}) + (q_{i5} - q_{i4}) \tag{3.28}$$

It is obvious that qi2 and qi3 are valid instruments. Hence, in period T, (q_{i1}, ..., ($q_{i,T-2}$)) can be defined as the group of valid instruments.
The matrix that contains all instruments of individual i is:

$$H_i = \begin{bmatrix} [q_{i1}] & 0 & \dots & 0 \\ 0 & [q_{i1}, q_{i2}] & \dots & \vdots \\ \vdots & \vdots & \ddots & 0 \\ 0 & \dots & 0 & [q_{i1}, \dots, (q_{i,T-2})] \end{bmatrix} \tag{3.29}$$

But differenced error term of $(b_{it} - b_{i,t-1})$ in (3.26) should be considered.
The variance-covariance matrix of it is;

$$E[\Delta b_i \Delta b_i'] = \sigma_{b2}(IN \bigotimes Y) \tag{3.30}$$

The Y matrix is;

$$Y = \begin{bmatrix} 2 & -1 & 0 & \dots & & 0 \\ -1 & 2 & -1 & 0 & \dots & 0 \\ \vdots & -1 & \ddots & & \vdots & 0 \\ 0 & \vdots & 0 & -1 & 2 & -1 \\ 0 & \vdots & 0 & 0 & -1 & 2 \end{bmatrix} \tag{3.31}$$

Due to the orthogonality of instrumental variables to the disturbance, the Equation 3.32 can be obtained.

$$E = [H_i' \Delta b_i] = 0 \tag{3.32}$$

Transforming the Equation 3.26 gives the Equation 3.33.

$$H' \Delta q = H'(\Delta q_1)\delta + H' \Delta b \tag{3.33}$$

Using GLS estimation method in this equation, it can be obtained as the one-step consistent estimator that is proposed by Arellano and Bond (1991) is in Equation 3.34 [77]:

$$\begin{aligned} &\delta = [(\Delta q_{-1})' H (H'(IN \otimes Y) H)^{-1} H' (\Delta q_{-1})]^{-1} \\ &x[(\Delta q_{-1})' H (H'(IN \otimes Y) H)^{-1} H' (\Delta q)] \end{aligned} \tag{3.34}$$

3.2. Specifications

Robert Solow presented a seminal paper about economic growth named as "A contribution to the Theory of Economic Growth" in 1956. After the publishment of this work, Solow was awarded the Nobel Prize in economics in 1987 [78]. In this part, the Solow model will be explained. In the dissertation, Solow growth model and production function approaches are used.

3.2.1. Growth Accounting

First of all, the Solow model is an aggregate production function. The model is :

$$Y(t) = F(K(t), L(t), A(t)) \tag{3.35}$$

In the dissertation, the simplest version of this framework is used. If it is considered as a continous-time economy and assume that the Equation 3.35 is satisfied, the derivatives of F can be written as:

$$\frac{\dot{Y}}{Y} = \frac{F_A A}{Y}\frac{\dot{A}}{A} + \frac{F_K K}{Y}\frac{\dot{K}}{K} + \frac{F_L L}{Y}\frac{\dot{L}}{L} \tag{3.36}$$

Now the growth rates of output, labor and capital stock are:
$g \equiv \dot{Y}/Y$ $gK \equiv \dot{K}/K$ $gL \equiv \dot{L}/L$ and the equation of technology becomes:

$$x \equiv \frac{F_A}{Y}\frac{\dot{A}}{A} \tag{3.37}$$

Defining $\in_K \equiv F_K K/Y$ and $\in_L \equiv F_L L/Y$ as the elasticities of the output with respect to capital stock and labor. It is also defined as:

$$x = g - \varepsilon_K g_K - \varepsilon_L g_L \tag{3.38}$$

The estimate of total factor productivitiy (TFP) at time t is:

$$\hat{x}(t) = g(t) - \varepsilon_K(t)g_K(t) - \varepsilon_L(t)g_L(t) \tag{3.39}$$

In the Equation 3.39, there is a potential problem when discrete time intervals are used. The question is, should the beginning-of-period or end-of-period values of εK and εL be used? The most used way to overcome this problem is taking the average of these values. The equation can be redefined as:

$$x_{t+1,t} = g_{t+1,t} - \varepsilon_{K,t+1,t} - \varepsilon_{L,t+1,t} \tag{3.40}$$

$g_{t+1,t}$ is the growth rate of output, other growth rates can be defined as [79]:

$$\underset{K,t+1,t}{\bar{\varepsilon}} \equiv \frac{\varepsilon_{K(t)} + \varepsilon_K(t+1)}{2} and \underset{L,t+1,t}{\bar{\varepsilon}} \equiv \frac{\varepsilon_{L(t)} + \varepsilon_L(t+1)}{2} \tag{3.41}$$

3.2.2. The Solow Type Growth Model

According to the fundamental Solow model with technology change and constant population growth in continuous time, the equilibrium is defined as:

$$y(t) = A(t)f(k(t)) \tag{3.42}$$

and

$$\frac{\dot{k(t)}}{k(t)} = \frac{sf(k(t))}{k(t)} - (\delta + g + n) \tag{3.43}$$

A(t) is the labor-augmenting technology term, $k(t) \equiv K(t)/(A(t)L(t))$ is the effective capital-labor ratio, f is the per capita production function. Differentiating and dividing both sides of equation (3.42) by y(t) gives the equation as:

$$\frac{\dot{y(t)}}{y(t)} = g + \varepsilon_k(k(t))\frac{\dot{k(t)}}{k(t)} \tag{3.44}$$

where

$$\varepsilon_k(k(t)) \equiv \frac{f'(k(t))k(t)}{f(k(t))} \in (0,1) \tag{3.45}$$

Now, according to the Taylor Equation 3.43) with respect to log k(t) around the steady-state value k*, the expansion gives,

$$\begin{array}{l} \frac{\dot{k}(t)}{k(t)} \approx (\frac{sf(k^*)}{k^*} - \delta - g - n) \\ (\frac{f'(k^*)k^*}{f(k^*)} - 1)s\frac{f(k^*)}{k^*}(logk(t) - logk^*) \end{array} \tag{3.46}$$

$$\approx (\varepsilon_k(k^*) - 1)(\delta + g + n)(\log k(t) - \log k^*) \tag{3.47}$$

$\approx$ symbol implies that the second order terms are ignored in this approximation.

$$sf(k^*)/k^* = \delta + g + n \tag{3.48}$$

therefore the equation becomes;

$$\frac{\dot{y(t)}}{y(t)} \approx g - \varepsilon_k(k^*)(1 - \varepsilon_k(k^*))(\delta + g + n)(\log k(t) - \log k^*) \tag{3.49}$$

Let us define $y^*(t) = A(t)f(k^*)$ as the steady-state level of output per capita, a first order Taylor expansion of log $y(t)$ with respect to log $k(t)$ around log $k^*(t)$ gives,

$$\log y(t) - \log y * (t) \approx \varepsilon_k(k^*)(\log k(t) - \log k^*) \tag{3.50}$$

Combination of these two equations gives that convergence equation;

$$\frac{y(\dot{t})}{y(t)} \approx g - (1 - \varepsilon_k(k^*))(\delta + g + n)(logy(t) - logy * (t)) \quad (3.51)$$

Using a discrete time approximation, the Equation 3.51 can be obtained.

$$g_{i,t,t-1} = b^o + b^1 \log y_{i,t-1} + \varepsilon_{i,t} \quad (3.52)$$

where $g_{i,t,t-1}$ is the growth rate of location i bewteen $t-1$ and t, log $y_{i,t-1}$ is the initial $(t-1)$ log of output of the location i.

When b_i^o is allowed to vary across countries, the representation of convergence is emphasized by Solow model by negative estimates of b_1. According to studies of Barro and Sala-i Martin (1992, 2004) and Barro (1991), b_i^o is accepted as a function of investment rate, openness, schooling rate, etc. The defined equation is:

$$g_{i,t,t-1} = X_{i,t}^T\beta + b^1 \log y_{i,t-1} + \varepsilon_{i,t} \quad (3.53)$$

where $X_{i,t}$ is a vector includes the variables which are mentioned in the studies above.

This regression have some problems for several reasons. These are:

(i) Most of the variables of $X_{i,t}$ and log $y_{i,t-1}$ are called endogenous in an econometric sense according to t-1 and t times. For example, reducing log $y_{i,t-1}$ affect the growth rate after time t. Causal effects can create bias to estimate the β coefficient due to the endogeneity of $X_{i,t}$ variables.

(ii) The interpretation of Equation 3.52 is not straight-forward. In the literature it can be observed that investment rate can be used as a part of vector Xi,t. But, in the Solow model, differences in investment rates are the basic variables that effect the economic growth. Therefore, once the investment rates or schooling rates are established, the other parts of $X_{i,t}$ will not measure their full impact on economic growth. As a result, regressors of investment-like variables are hard to link to the theory.

(iii) In the Solow model, each country is assumed as an island that there is no interaction between them. However, in reality, countries trade goods, borrow and lend in international financal markets. This can create misleading results in cross-country studies.

The complementary or more basic way to define the regression frame is:

$$\log y_{i,t} = \alpha \log y_{i,t-1} + x_{i,t}^T \beta + \delta_i + \mu_t + \varepsilon_{i,t} \tag{3.54}$$

where δ_i denotes country fixed effects and μ_t as time specific fixed effects [79].

3.2.3. Production Function Based Models

There are many of studies about the production function based models. The Cobb-Douglas structure is:

$$Y_t = (MFP)_t . L_t^{\alpha} . K_{P,t}^{\beta} . K_{G,t}^{\gamma} \tag{3.55}$$

where Y is the aggregate output (for example GDP), MFP is a measure of multi-factor productivity (for example technology), and L, K_P and K_G are, respectively, labour, private and pubic capital stocks.

According to these variables, public capital stock elasticity can be calculated as:

$$\varepsilon_G = \left(\frac{dY}{dK_G} \right) / \left(\frac{Y}{K_G} \right) \tag{3.56}$$

Typically, if the production form of (3.54) is linearized, the natural logarithm of both sides can be taken as:

$$\ln Y_t = \ln (MFP)_t + \alpha \ln L_t + \beta \ln K_{P,t} + \gamma \ln K_{G,t} \tag{3.57}$$

The coefficients can be regarded as elasticities in Equation 3.57.

$$\frac{\partial \ln Y}{\partial \ln K_G} = \gamma \tag{3.58}$$

4. ANALYSES AND METHODOLOGY

There are mainly two types of analyses in this dissertation: Time-Series Data and Panel Data approaches. In time series analyses, Cobb-Douglas production function is used. Detailed information and results are described in the following sections.

4.1. Time Series Approach

In country-based level model Cobb-Douglas production function is used. In this part, the data and how the road infrastructure capital stock is calculated are described. Thereafter, the analyses are conducted and results are discussed.

4.1.1. Data Description

In time series analyses, Cobb-Douglas approach is used. According to that method, the independent variable is GDP of Turkey between 1995 and 2014 as the output. From TURKSTAT, the level of GDP values are taken and converted to 1998 TL prices.

At the right hand side of the equations; labour, private capital stock, public capital stock (excluding highway stock values) and highway capital stock are included as the explanatory variables with two year dummies, d2001 and d1999. Labour values are taken from TURKSTAT between 2005 and 2014. From 1995 to 2004 employment values are taken from Serdaroglu (2016)'s study [1].

The public and private capital stock values are calculated by Saygili, Cihan and Yurtoglu in their work published in DPT (Ministry of Development) between 1972 and 2000. However, the capital stock values for 1995 and 2014 is needed. Therefore, the investment values are obtained from the Ministry of Development's database [81] and capital stock values are calculated with the method of Coe and Helpman (1995)'s study [80].

The highway capital stock is not found in the literature for Turkey. The capital stock values of roads are calculated by using the expenses of KGM (General Directorate of Highways) information that is on the website [83]. Again, the Coe and Helpman's method is used to calculate the highway stock values for Turkey. The limitation for the year of 1995 is due to the KGM's proper expense information on its website.

Initially, hereinbefore, the capital stock values are up to the year of 2000. It should be recalculated to 2014. Moreover, the depreciation assumption is different than our assumption in this dissertation.

In Saygili, Cihan and Yurtoglu's (2002) study, the capital stock values are calculated for each sector and total of them. In their work, the investment values start from 1948 to 2000 [83]. In that study, capital stock values are calculated by perpetual inventory method:

$$K_t = I_{t-1} + (1 - \delta)K_{t-1} \tag{4.1}$$

where δ is the depreciation rate, K is the capital stock and I is the investment value [1].

The depreciation rate decision is made by using the OECD's service lives for each sector and linear retirement assumption:

In Saygili, Cihan and Yurtoglu's (2002) study, the retirement function is assumed as in the Figure

By using these assumptions and methods, in Saygili, Cihan and Yurtoglu's (2002) study, the capital stock values are calculated. However, in this dissertation, the retirement assumption is different than the Figure 4.1. According to OECD 1999 report;

Table 4.1. Service lives and sectoral average shares of capital stock figures (in constant prices) [83, 1].

Sectors	Service lives (years) OECD country averages
Energy	31
Transportation	25
Education	29
Health	29
Agriculture	23
Mining	23
Manufacturing	26
Tourism	29
Residence	62
Other Services	26

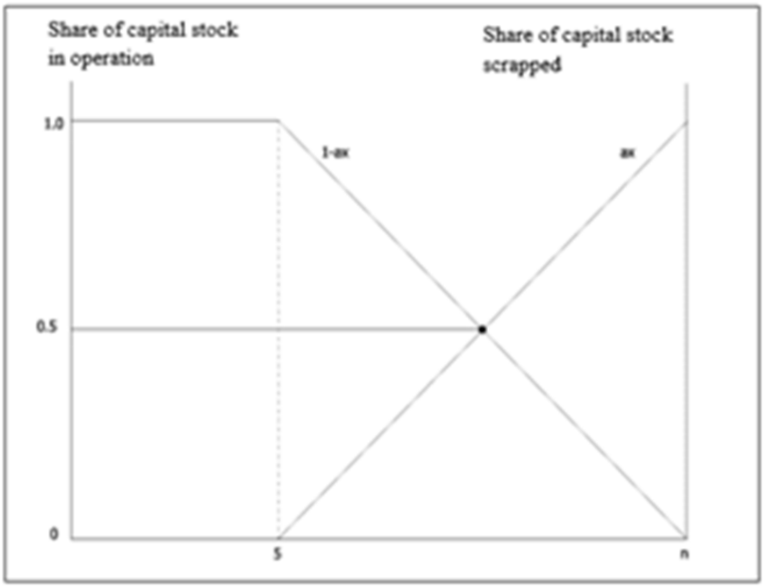

Figure 4.1. Delayed Retirement Pattern Graph of Capital Investments [83].

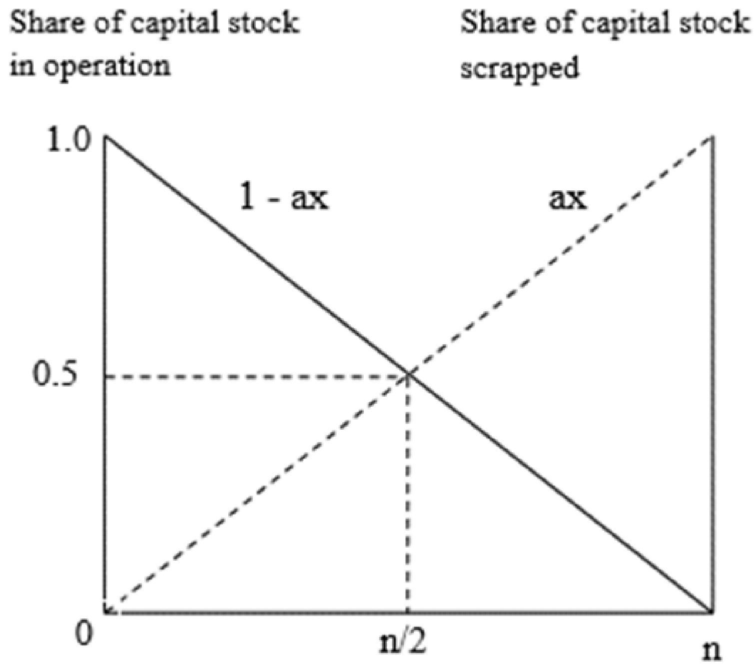

Figure 4.2. Linear Retirement Pattern Graph of Capital Investments [1].

In that dataset, the public and private investments can be calculated by these assumptions. However, the highway expenses by published KGM is not big enough to find the initial capital stock for highways. Therefore, Coe and Helpman (1995)'s method is used to find the first year's capital stocks. The service life of total capital stock is assumed 35 years same with Serdaroglu (2016)'s study. The capital stock values of Saygili, Cihan and Yurtoglu and our capital stock values are compared below [80, 83, 1]:

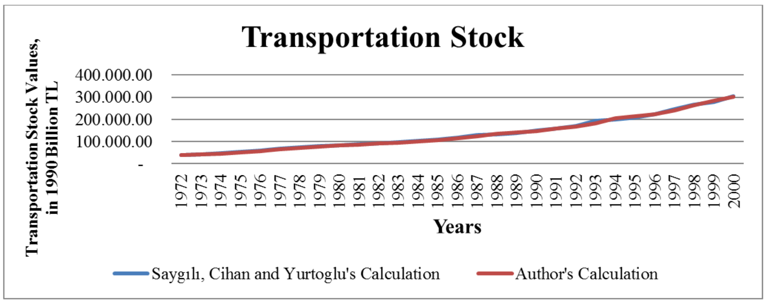

Figure 4.3. Transportation Capital Stock Comparison between Saygili, Cihan and Yurtoglu's (2002) work and the author's calculation [83].

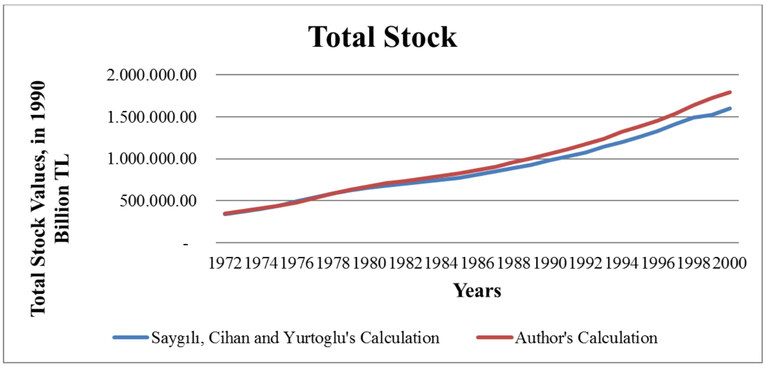

Figure 4.4. Total Capital Stock Comparison between Saygili, Cihan and Yurtoglu's (2002) work and the author's calculation [83].

In the transportation & communication sector, our calculations and the previous calculations are compatible. In the total stock values, they are familiar, but there are some differences according to differences in assumptions and data years. Anyway, the capital stock assumptions can be accepted and can be used to calculate the highway stock values.

The investment values are obtained from the expenses of KGM that is presented on the website [82]. A snapshot of the data is shown in Figure 4.2. In the table, transportation investment values are chosen and used in the analyses. In the next part, data are described and investigated more detailed. Definitions of variables are listed in the Table 4.3.

4.1.2. Stationarity and Trends of Data

In the time series analysis, one of the most problem is stationarity and trend concept. As it is mentioned in the last chapter, trend and non-stationarity can cause spurious relationship between the regressors. Therefore, the results and coefficients could be overestimated. To avoid this problem, differences of the variables are taken. First of all, to decide the existence of the non-stationarity, the Dickey-Fuller test is applied all of the variables.

Table 4.2. A snapshot of budget and expenditure table of Directorate of Highways [82].

YILLAR	ÖDENEKLER	YATIRIM								
		ULASTIRMA				TURIZM	ENERJI + TARIM	YATIRIM TOPLAMI (Kamulastirma Hariç)	KAMULASTIRMA	YATIRIM TOPLAMI (kamulastirma Dahil)
		BÜTÇE ÖDENEKLERI (Kamulastirma Hariç)	** A.T.V.	** OTOYOL	TOPLAM					
1980	SENEBASI	17.110			17.110	285		17.395	1.300	18.695
	SENESONU	29.988		1.024	31.012	385		31.397	1.272	32.669
	HARCAMA	29.643		996	30.639	376		31.015	1.266	32.281
1990	SENEBASI	1.021.756	185.177	7.000	1.213.933	43.824	36.432	1.294.189	57.645	1.351.834
	SENESONU	1.067.126	146.039	7.400	1.220.565	43.824	42.482	1.306.871	50.728	1.357.599
	HARCAMA	1.063.693	143.947	3.725	1.211.365	43.824	42.824	1.297.465	50.712	1.348.177
1995	SENEBASI	10.991.095	395.000	35.000	11.421.095	309.420	248.300	11.978.815	732.007	12.710.822
	SENESONU	12.602.870	394.290	69.000	13.066.160	309.420	248.300	13.623.880	740.007	14.363.887
	HARCAMA	11.969.613	393.940	68.859	12.432.412	308.483	248.203	12.989.098	590.928	13.580.026
1996	SENEBASI	30.046.600	760.000	125.000	30.931.600	427.500	626.050	31.985.150	793.250	32.778.400
	SENESONU	37.120.059	1.119.918	60.796	38.300.773	667.500	756.050	39.724.323	2.943.250	42.667.573
	HARCAMA	36.701.098	1.084.352	56.783	37.842.233	655.883	736.861	39.234.977	2.939.175	42.174.152
1997	SENEBASI	63.183.265	2.160.000	75.000	65.418.265	1.021.250	1.377.500	67.817.015	2.584.000	70.401.015
	SENESONU	102.862.062	2.036.747	75.218	104.974.027	10.437.250	1.428.450	107.839.727	6.652.450	114.492.177
	HARCAMA	97.984.585	1.732.468	61.884	99.778.937	1.504.609	1.196.639	102.480.185	6.636.022	109.116.207
1998	SENEBASI	97.630.000	5.865.000	100.000	103.595.000	1.700.000	3.750.000	109.045.000	3.501.000	112.546.000
	SENESONU	152.829.289	4.214.958	263.863	157.308.110	1.950.000	3.750.000	163.008.110	5.337.000.00	168.345.110
	HARCAMA	151.363.830	3.887.666	262.125	155.513.621	1.943.894	3.748.822	161.206.337	4.189.107	165.395.444
1999	SENEBASI	139.621.500		85.000	139.706.500	2.356.000	3.990.000	146.052.500	3.712.500	149.765.000
	SENESONU	244.166.705		82.977	244.249.682	2.556.000	3.090.000	249.895.682	3.712.500	253.608.182
	HARCAMA	240.207.304		73.211	240.280.515	2.526.740	2.883.993	245.691.248	3.606.446	249.297.694
2000	SENEBASI	261.440.665			261.440.665	4.657.700	4.063.100	270.161.465	11.247.850	281.409.315
	SENESONU	393.894.080			393.894.080	4.957.700	4.063.100	402.414.880	11.302.288	413.717.168
	HARCAMA	382.207.909			382.207.909	4.835.188	3.787.512	390.830.609	10.954.353	401.784.962
2001	SENEBASI	573.270.000			573.270.000	6.008.500	5.259.900	584.538.400	25.413.000	609.951.400
	SENESONU	1.189.715.862			1.189.715.862	7.008.500	6.059.900	1.202.784.262	25.413.000	1.228.197.262
	HARCAMA	1.162.436.473			1.162.436.473	6.605.649	5.710.424	1.174.752.546	19.692.458	1.194.445.004
2002	SENEBASI	920.000.000			920.000.000	10.000.000	10.100.000	940.100.000	103.794.000	1.043.894.000
	SENESONU	1.722.331.604		144.084.856	1.866.416.460	10.000.000	10.100.000	1.886.516.460	128.273.027	2.014.789.487
	HARCAMA	1.694.081.139		134.626.931	1.828.708.070	9.850.782	4.269.858	1.842.828.710	113.373.977	1.956.202.687

Table 4.3. Definition of the variables.

Variable	Definition
gdp	Natural logarithm of gross domestic product
road	Natural logarithm of road stock
labour	Natural logarithm of employer number
pr	Natural logarithm of private stock
pb	Natural logarithm of public stock except road
d1999	Year dummy of 1999
d2001	Year dummy of 2001

Table 4.4. Dickey-Fuller results for 1st differenced variables.

1st Difference			
Variables	trend	trend&constant	no trend&no constant
gdp	-4.058**	-4.177**	-2.787***
pr	-2.085	-2.057	-0.626
pb	-1.538	-1.218	-0.88
road	-3.261*	-2.189	-1.308
labour	-3.571*	-2.256*	-1.553

Table 4.5. Dickey-Fuller results for 2nd differenced variables.

2nd Difference			
Variables	trend	trend&constant	no trend&no constant
gdp	-6.625***	-6.832***	-7.040***
pr	-3.491**	-3.598**	-3.709***
pb	-4.891***	-4.614***	-4.516***
road	-4.551***	-4.692***	-4.593***
labour	-5.114***	-5.239***	-5.362***

where *, ** and *** are representatives for respectively 10%, 5% and 1% significance levels.

From the test results, first differenced values can be used in the regressions. The natural logarithm values of the variables are used in the analyses. Before the differencing operation, the variables vs. time graphes are in below:

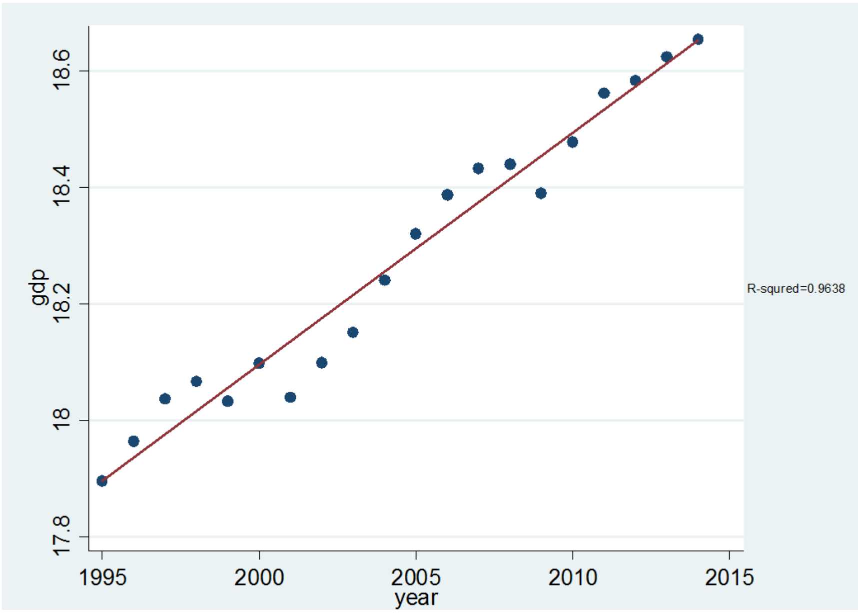

Figure 4.5. GDP vs. Time Graph.

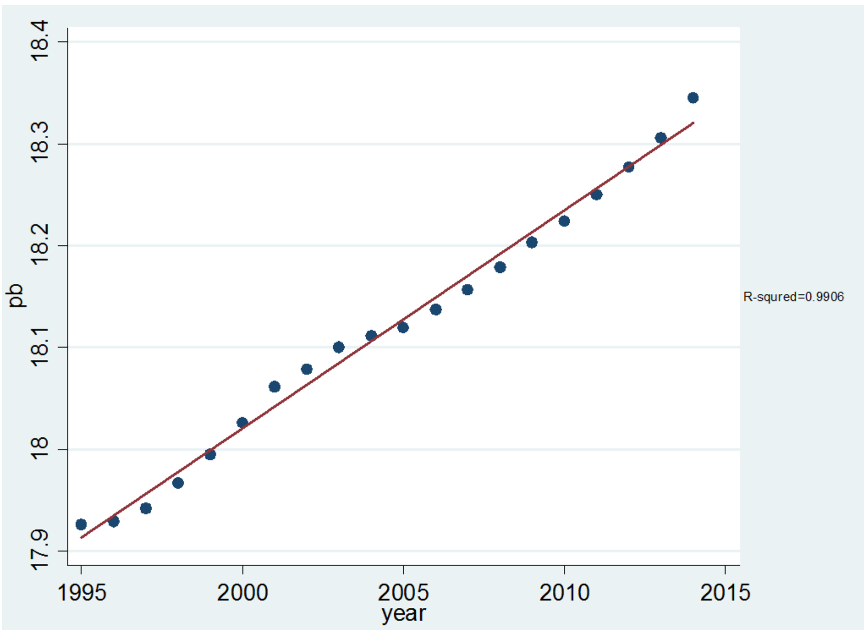

Figure 4.6. Public Capital Stock vs. Time Graph.

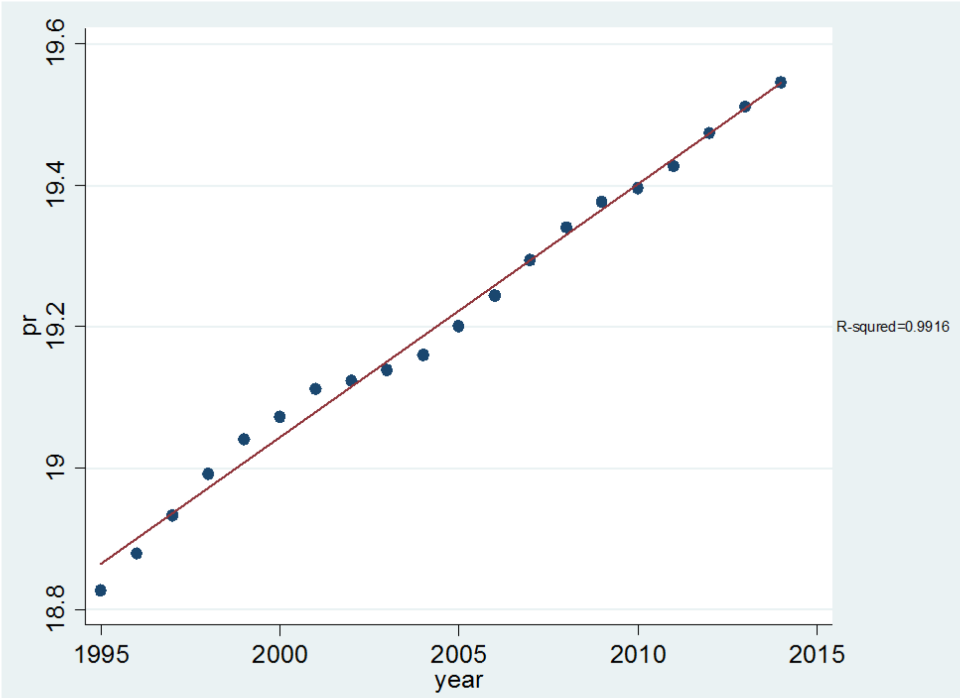

Figure 4.7. Private Capital Stock vs. Time Graph.

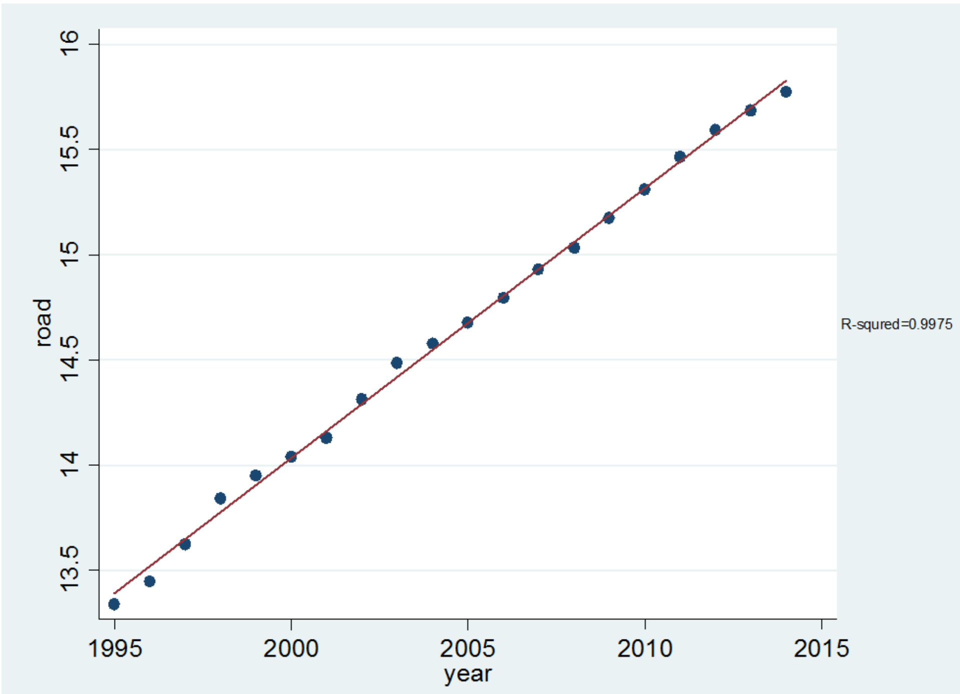

Figure 4.8. Road Capital Stock vs. Time Graph.

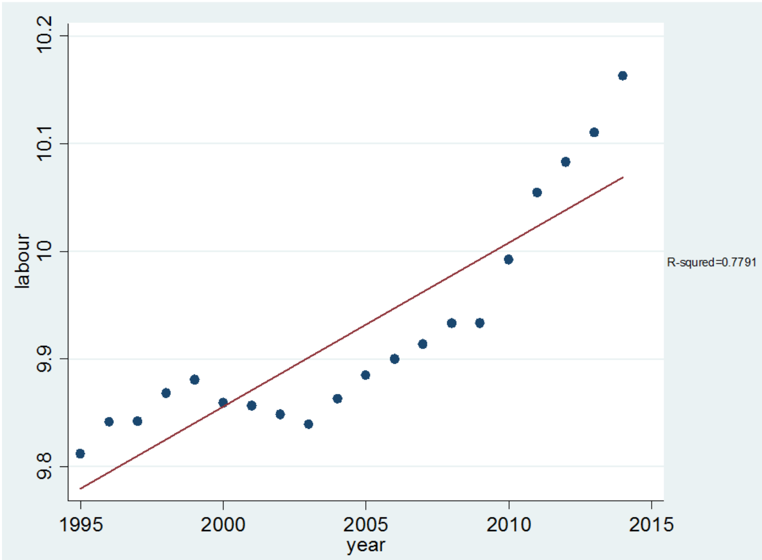

Figure 4.9. Labour vs. Time Graph.

In the graphes above, there are obvious trends from 1995 to 2014. Therefore, these variables should be detrended. To overcome this problem, first differencing operation is applied. The first differenced variables vs. time graphes are;

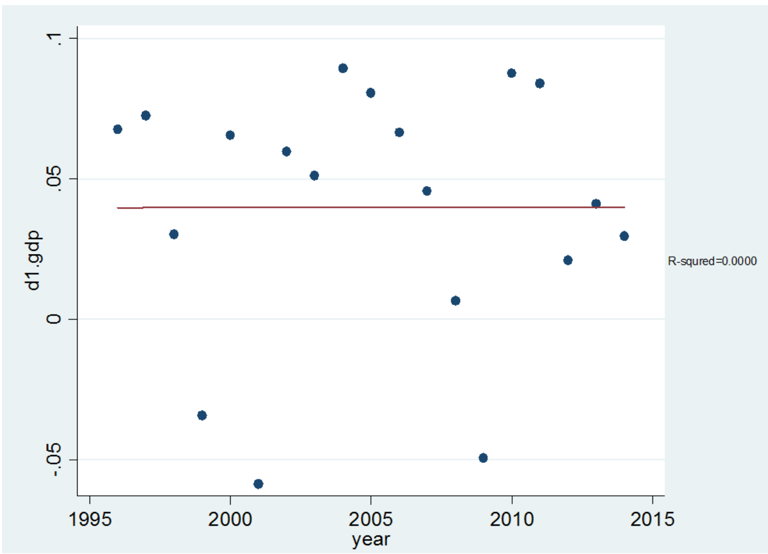

Figure 4.10. 1st Differenced GDP vs. Time Graph.

Figure 4.11. 1st Differenced Public Capital Stock vs. Time Graph.

Figure 4.12. 1st Differenced Private Capital Stock vs. Time Graph.

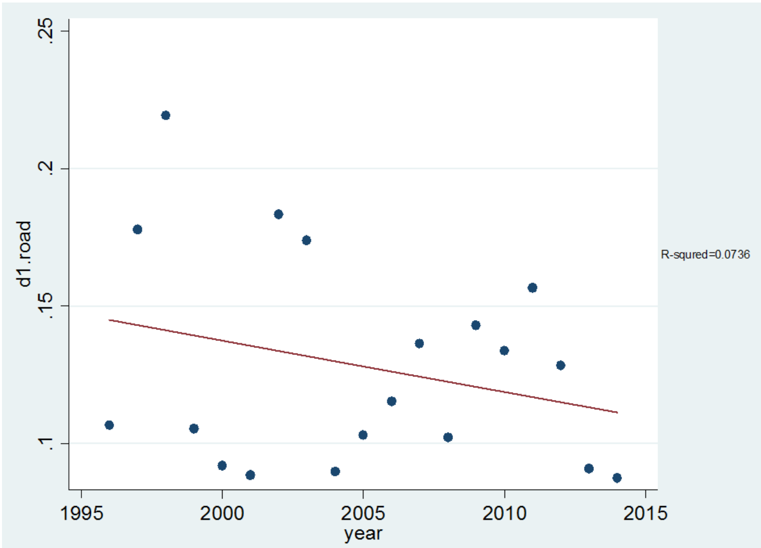

Figure 4.13. 1st Differenced Road Capital Stock vs. Time Graph.

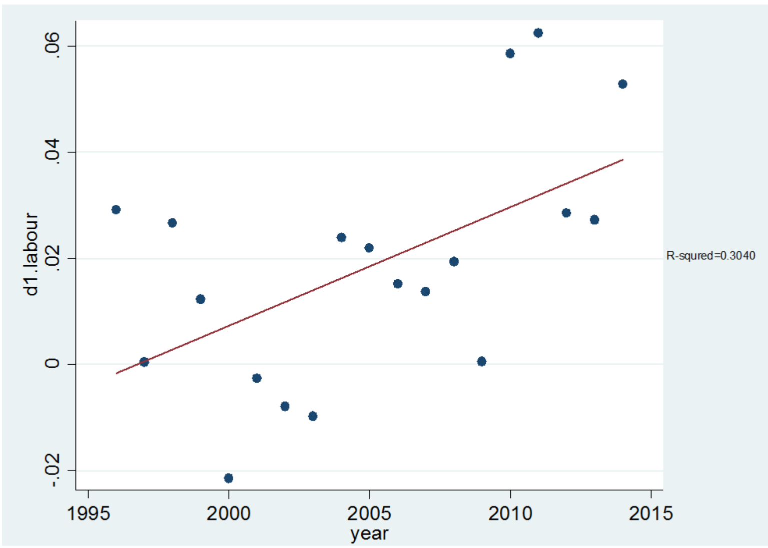

Figure 4.14. 1st Differenced Labour vs. Time Graph.

On the first graph, differenced GDP shows a constant tendency along the time interval. There is not a obvious change between 1995 and 2014. Differenced public capital stock increases with time. However, differenced private and road capital stocks show decreasing tendency between 1995 and 2014. On the last graph, differenced labour increases with time obviously. Besides the graphes of GDP and other variables are;

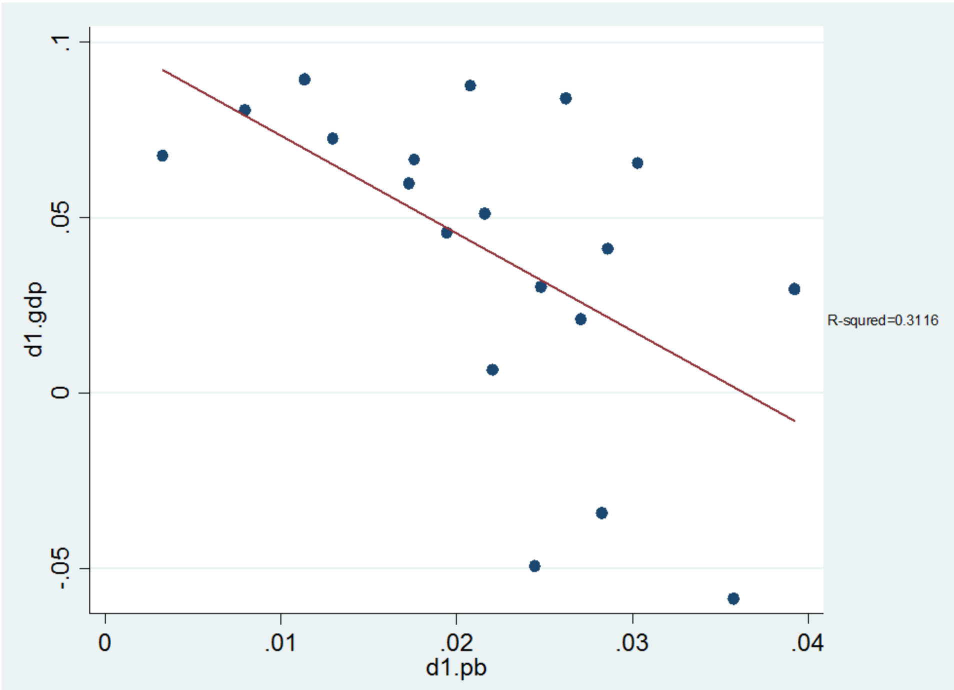

Figure 4.15. 1st Differenced GDP vs. 1st Differenced Public Capital Stock.

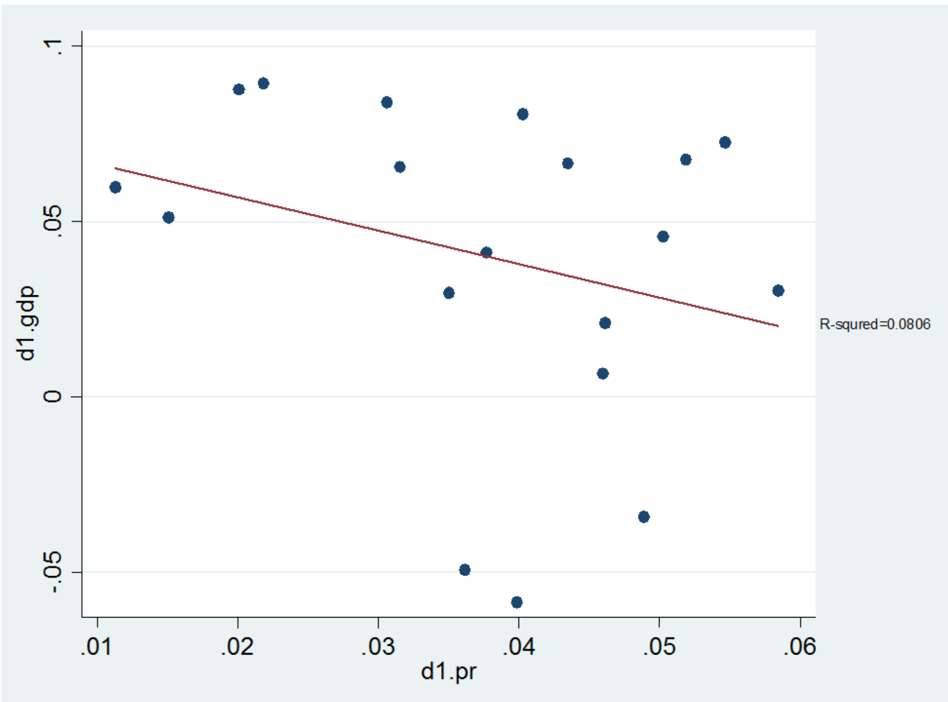

Figure 4.16. 1st Differenced GDP vs. 1st Differenced Private Capital Stock.

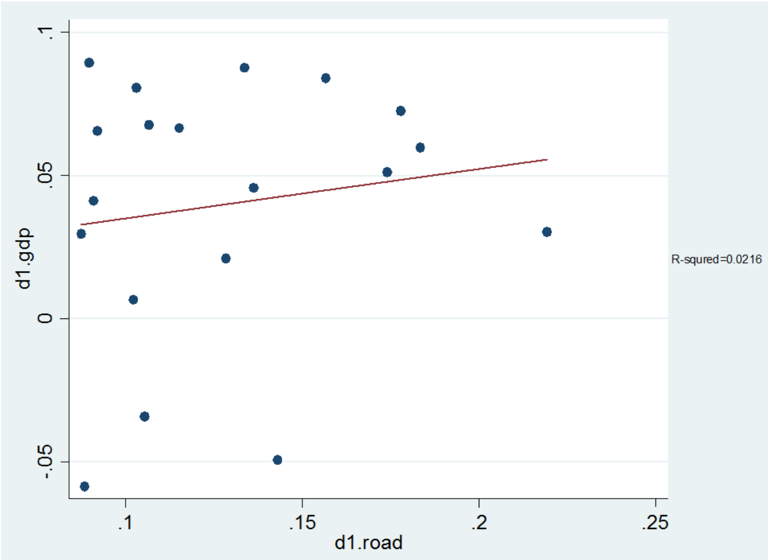

Figure 4.17. 1st Differenced GDP vs. 1st Differenced Road Capital Stock.

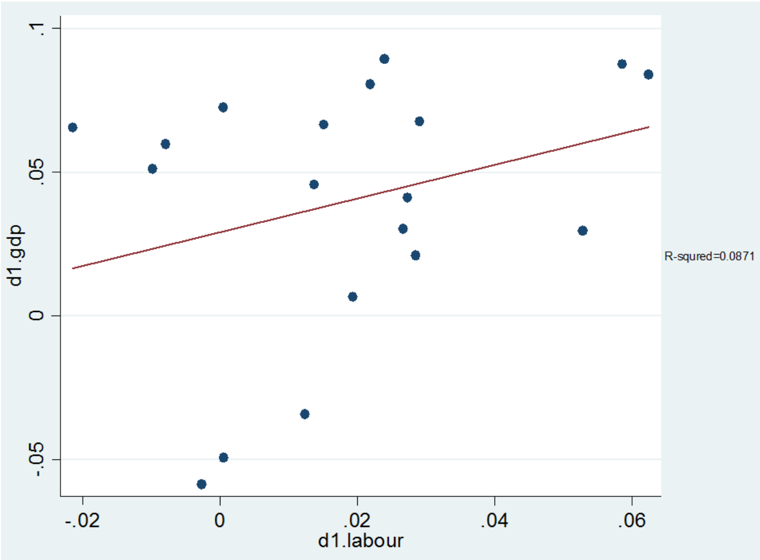

Figure 4.18. 1st Differenced GDP vs. 1st Differenced Labour.

On the initial two graphes, differenced gdp vs. differenced public and private capital stocks show negative relationship between each other. On the third graph, differenced gdp and differenced road capital stocks shows a positive relationship. Also, on the last graph, differenced labour variable has a positive relationship with differenced gdp, dependent variable. The statistical summary of the variables are shown in Table 4.6.

Table 4.6. Summary of the variables

Variable	Obs	Mean	Std. Dev.	Min	Max
year	20	2004.5	5.91608	1995	2014
gdp	20	18.27483	0.240315	17.8962	18.6538
road	20	14.61011	0.759936	13.34	15.7739
labour	20	9.924124	0.10201	9.8123	10.1633
pr	20	19.20451	0.212847	18.82684	19.54623
pb	20	18.11671	0.127449	17.92594	18.34507
d2001	20	0.05	0.223607	0	1
d1999	20	0.05	0.223607	0	1

4.1.3. Analyses and Results

In Cobb-Douglas approach, six different models are assumed. Initial three models assumed variable constant to scale which the sum of the elasticities varies from one. The last three models are same with the initial models regarded to their frameworks respectively, but these are assumed as constant to scale that the sum of the elasticities equal to one. Models are listed in Table 4.7:

Table 4.7. Cobb-Douglas Production Function Model.

MODELS			
Unrestricted Models	Model 1	Basic Model	$\Delta gdp = a_0 + a_1\Delta pr_t + a_2\Delta pb_t + a_3\Delta road_t$ $+a_4\Delta labour_t + a_5\Delta d2001 + a_6\Delta d1999 + \Delta\varepsilon_t$
	Model 2	1st lags of public capital and road capital stock	$\Delta gdp = a_0 + a_1\Delta pr_t + a_2\Delta pb_{t-1} + a_3\Delta road_{t-1}$ $+a_4\Delta labour_t + a_5\Delta d2001 + a_6\Delta d1999 + \Delta\varepsilon_t$
	Model 3	2nd lags of public capital nd road capital stocks	$\Delta gdp = a_0 + a_1\Delta pr_t + a_2\Delta pb_{t-2} + a_3\Delta road_{t-2}$ $+a_4\Delta labour_t + a_5\Delta d2001 + a_6\Delta d1999 + \Delta\varepsilon_t$
Restricted Models	Model 4	Basic Model	$\Delta gdp = a_0 + a_1\Delta pr_t + a_2\Delta pb_t + a_3\Delta road_t$ $+a_4\Delta labour_t + a_5\Delta d2001 + a_6\Delta d1999 + \Delta\varepsilon_t$
	Model 5	1st lags of public capital and road capital stocks	$\Delta gdp = a_0 + a_1\Delta pr_t + a_2\Delta pb_{t-1} + a_3\Delta road_{t-1}$ $+a_4\Delta labour_t + a_5\Delta d2001 + a_6\Delta d1999 + \Delta\varepsilon_t$
	Model 6	2nd lags of public capital and road capital stocks	$\Delta gdp = a_0 + a_1\Delta pr_t + a_2\Delta pb_{t-2} + a_3\Delta road_{t-2}$ $+a_4\Delta labour_t + a_5\Delta d2001 + a_6\Delta d1999 + \Delta\varepsilon_t$

The key variable is “road” which is the road capital stock variable. The key coefficient is α_3. Road capital stock, public capital stock excluding road stocks, private capital stock, labour variables are adopted with their natural logarithm (ln) values.

Additionally, 2001 and 1999 year dummies are included. Then, in the second model, public capital and road capital stocks are lagged for one year period. In the third model, public and road capital stocks are lagged two years period. The initial three models are unrestricted models which stand for variable returns to scale (increasing or decreasing). The last models are the same models with the initial models respectively, but these are restricted models which are constant returns to scale. The results are listed in Table 4.8.

According to the results, the road infrastructure stock does not give significant results in any models. The lagged models also used, but the reults are not effective to reach a conclusion about the road stock and economic growth relationship. In the first basic model, all of the variables are insignificant statistically. Road stock variable gives a coefficient of 0.13. It can be accepted by the literature but the p value is greater than the acceptable intervals, 0.31. In the second model, first lag of road stock and public capital stock are replaced by their initial variable. The coefficient is changed to 0.14, but the significance is not sufficient also. In the third model, second lagged variables of public and road capital stock are replaced by their currents. However, the results are statistically insignificant again. The last three models are the same models with the initial models regarded to their frameworks respectively. However, their assumption is constant to scale namely restricted models. Their results are positive but not statistically significant.

According to the models above, we can not reach a result from these models. Therefore, a relationship between GDP and road capital stock is not present significantly. As it will be discussed in the next chapter, it can be thought that the road infrastructure expansion is not developping the economic efficiency in that level. Utilising the existing infrastructural capacity, focusing on mobility management and cost effective solutions can increase the effectiveness of the economy. Constructing a new road may not have a greater impact on economic growth, if there is enough infrastructure. In the reducing congestion perspective, it can be thought if there are existing road capacities, but again, the mobility management, cost-effective any other solutions should be compared inbetween.

Table 4.8. Comparison of the results of the models.

		Δpr	Δpb	$\Delta road$	$\Delta labour$	$\Delta d2001$	$\Delta d1999$	$\Delta pb(-1)$	$\Delta road(-1)$	$\Delta pb(-2)$	$\Delta road(-2)$	Number of obs
MODEL 1	Coefficients	1.93496904	0.121995185	0.127193814	0.51089995	-0.057988987	-0.051456482					19
	standard errors	0.604642029	0.432104646	0.119803777	0.467510623	0.003278967	0.011371036					
	t-value	3.200189445	0.282327871	1.061684503	1.092809285	-1.768513962	-4.525223854					
	p-value	0.007629856	0.78250255	0.309279333	0.295930893	5.83E-05	0.00069546					
MODEL 2	Coefficients	1.990063515			0.51280596	-0.04987544	-0.053129052	0.119962367	0.1413366			18
	standard errors	0.859627221			0.491564343	0.017164164	0.012148221	0.655022533	0.2284298			
	t-value	2.315030825			1.043212283	-2.905789103	-4.373401789	0.183142352	0.618731			
	p-value	0.040934506			0.31923485	0.014296304	0.001111235	0.858018309	0.5486921			
MODEL 3	Coefficients	2.111947982			0.824527506	-0.057578456	-0.063247131			0.511560475	0.175368903	17
	standard errors	0.761435046			0.485233905	0.010327032	0.015130357			0.598009857	0.243823029	
	t-value	2.773641683			1.699237207	-5.575508551	-4.180148039			0.855438199	0.719246676	
	p-value	0.019664033			0.120116359	0.000235575	0.001887266			0.41233546	0.488456113	
MODEL 4	Coefficients	0.976534734	-0.351106046	0.112792678	0.261778635	-0.059581457	-0.051449913					19
	standard errors	0.529151271	0.34163429	0.183969668	0.407106646	0.023640299	0.025045507					
	t-value	1.845473661	-1.027724842	0.613104752	0.643022258	-2.520334281	-2.054257182					
	p-value	0.087862079	0.322822756	0.550383448	0.53138846	0.025587855	0.06062932					
MODEL 5	Coefficients	1.114537804			0.210113038	-0.040554598	-0.050437872	-0.525984307	0.2013335			18
	standard errors	0.514923852			0.401414895	0.028143565	0.024833884	0.363286232	0.2354688			
	t-value	2.164471116			0.523431095	-1.440990054	-2.031010244	-1.447850926	0.8550324			
	p-value	0.051299649			0.610204496	0.175168359	0.065012662	0.173277014	0.40928			
MODEL 6	Coefficients	0.790243922			0.388020288	-0.061090731	-0.066275955			-0.495154298	0.316890088	17
	standard errors	0.520999274			0.411375157	0.022344582	0.025774657			0.312776862	0.216315644	
	t-value	1.516785073			0.943227324	-2.734028777	-2.571361252			-1.583091201	1.464942997	
	p-value	0.157520484			0.365820296	0.019437844	0.025987287			0.141707171	0.170925439	

4.2. Panel Data Approach

In this part, the data are described. Thereafter, the analyses are conducted and results are discussed.

4.2.1. Data Description

In this analysis, panel data is covered by 1998 to 2013. Düzce has been the 81st province of Turkey since December of 1999. Therefore, it is included in the 14th province, Bolu. Therefore, 80 provinces are used in the models.

According to that method, the independent variable is GDP of Turkey between 1998 to 2013 as the output. However, the GDP values are not computed in province-based level in TURKSTAT. Therefore, GDP values are used from the TEPAV (Turkish Economy Policies Research Foundation) that the night light data is used to calculate for each provinces [84].

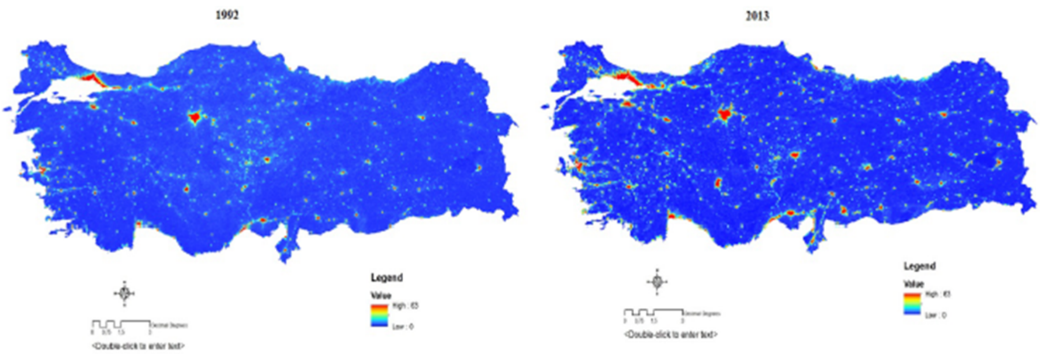

Figure 4.19. Emitted Light from Turkey, 1992 and 2013 [84].

The independent variables are public capital investment (excluding transportation & communication investment values), road density (road/province area), total credit given by private banks, net migration values are included as the explanatory variables by using their per capita values. Road density values are also used by totally and province/state roads with interprovince highways seperately. Public capital investment values are taken from the website of the Ministry of Development from 1999 to 2013.

Figure 4.20. Night Lights from Turkey, 2013 [84].

Road length, net migration, area and population values are taken from TURKSTAT. Credit values are taken from the website of the Association of Private Banks of Turkey [113, 114, 115].

Road density value can be assumed as a capital, but other values are investments and credits, assumed as a flow. Therefore, road density values are subtracted from the last periods to convert them into as a flow. Furthermore, to capture the variation within the periods, time periods are not taken annually, but each three year is averaged and assumed as one period. Then, each averaged regressor is divided by the corresponding year's population values. Except net migration values, natural logarithm of other variables are used. Division of time periods of the variables are listed in Table 4.9.

Table 4.9. Years-Period No-Divided Population Year Table.

Years	Period no	Divided population year
1998-1999-2000	1	2001
2001-2002-2003	2	2004
2004-2005-2006	3	2007
2007-2008-2009	4	2010
2010-2011-2012	5	2013

The data abbreviations and descriptions can be listed in Table 4.10.

Table 4.10. Variable Abbreviation and Description Table.

Variable	Description
il	province no
t	time period
gdp	ln of gdp per capita
pgdp	ln of previous gdp per capita
dyt	ln of public investment, excl. transportation&communication per capita
krd	ln of credits per capita
netmig	net migration per capita *1000
yola	total road/area change average per capita

The statistical summary of the variables are listed in Table 4.11.

Table 4.11. Summary of the variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
il	400	40.5	23.12113	1	80
t	400	3	1.415985	1	5
gdp	400	6.897179	0.579767	5.33078	8.205477
pgdp	400	6.789034	0.576798	5.33078	8.073187
dyt	400	9.546378	0.787453	7.644606	12.76217
krd	400	4.575827	1.159372	1.571041	7.350047
netmig	400	-3.5905	9.350682	-34.1619	39.90833
yola	400	0.001084	0.005839	-0.02166	0.077146

4.2.2. Analyses and Results

There are two different analyses in this section, first one is static the second one is dynamic modelling part. In the static modelling there are two different models in Table 4.12.

Table 4.12. Table of the static panel data models.

Model 1	$gdp_{it} = \alpha_0 pgdp_{it} + \alpha_1 dyt_{it} + \alpha_2 krd_{it}$ $+\alpha_3 netmig_{it} + \alpha_4 yola_{it} + \mu_i + \nu_t + \varepsilon_{it}$
Model 2	$gdp_{it} = \alpha_0 pgdp_{it} + \alpha_1 dyt_{i,t-1} + \alpha_2 krd_{i,t-1}$ $+\alpha_3 netmig_{i,t-1} + \alpha_4 yola_{i,t-1} + \mu_i + \nu_t + \varepsilon_{it}$

The key variable is "yola" which is the road density per capita variable. The key coefficient is $\alpha 4$. In the first model, previous gdp, public investments excluding transportation & communications sector, total credits, net migration and road density (all of the variables are per capita) variables are used in their current time periods. In the second model, except the previous gdp, other explanatory variables are lagged for one period. The results of the static models are listed in Table 4.13.

In static approach, we looked at two different models. First one is the basic model that all the variables are used in their current times. The road density per capita gives significant result with the coefficient of 1.87. The other explanatory variables are insignificant. Net migration shows negative effect. And previous gdp level is 0.84 with 5% significance level. In the second model, the key coefficient is -1.34 with 1% significance level. However, in the initial model, it is positive. In the first model, one percent increase in road density per capita increases the gdp level by 1,88%. However, in the second model, one percent increase in road density per capita decreases the gdp value by 1.33%. It is statistically acceptable, but not economically. It is obvious that the independent variables are endogenous. Therefore, it can cause a simultenaeity bias.

Table 4.13. Table of the static panel data models.

		pgdp	dyt	krd	netmig	yola	-cons	pgdp(-1)	dyt(-1)	krd(-1)	netmig(-1)	yola(-1)	Number of obs
MODEL 1	Coefficients	0.8431811	0.0166475	0.01630317	-0.001454	1.87172475	0.93201939						400
	standard errors	0.038088	0.0147251	0.01116217	0.001143	0.88967308	0.2719545						
	t-value	22.137728	1.1305512	1.46057428	-1.272156	2.1038343	3.42711515						
	p-value	1.29E-35	0.2616647	0.1480981	0.2070497	0.03857408	0.00097121						
MODEL 2	Coefficients	0.6949359					2.25868538		0.0019337	-0.00959479	0.0005463	-1.341567	320
	standard errors	0.0180968					0.12873506		0.0072627	0.00446523	0.0008111	0.3601641	
	t-value	38.401013					17.5452234		0.2662508	-2.14877872	0.6736002	-3.724878	
	p-value	7.26E-53					5.61E-29		0.7907397	0.03471414	0.5025316	0.0003651	

Additionally, provinces are aggregated into the seven region levels distinctly. Each seven panel data group are examined according to the same models. However, significant results are not obtained again. Therefore, the region level work is not included in this dissertation and in the dynamic modelling process province based level work is continued.

In dynamic modelling, Arellano Bond method is applied. In this method, lags of the variables are being used as instrumental variables in the equations. In the Table 4.14, Arellano-Bond dynamic models are listed.

Table 4.14. Arellano-Bond Dynamic Panel Data Models.

	Dependent Variable	No of Lags	Max Lag of Dependent Variable	Endogenous Variables	No of Lags	Instrumented Lags
Dynamic 1	gdp	2	2	dyt, krd, netmig, yola	1	2
Dynamic 2	gdp	2	3	dyt, krd, netmig, yola	1	3
Dynamic 3	gdp	2	3	dyt, krd, netmig, yola	2	3
Dynamic 4	gdp	2	2	dyt, krd, yola	1	2
Dynamic 5	gdp	2	3	dyt, krd, yola	1	3
Dynamic 6	gdp	2	3	dyt, krd, yola	2	3

In Arellano Bond dynamic models, after the analyses, there are two different specification tests to validate the results. These are autocorrelation and Sargan tests. Autocorrelation test to ensure that the differenced error term is not correlated with the previous residuals. Sargan test is done to validate the overidentifying restrictions of the model. Therefore, in the above models, dependent variable, GDP per capita's two lags are used as intruments in the dynamic models to validate the results. In initial three models, net migration is used; in the last three models net migration is omitted. Different lag combinations are used which are compatible with the specification test results. The results of the dynamic models are listed in Table 4.15.

Table 4.15. Dynamic panel data model results comparison.

		gdp(-1)	gdp(-2)	dyt	dyt(-1)	krd	krd(-1)	krd(-2)	Number of obs
MODEL 1	Coefficients	0.830597656	-0.09524381	-0.0309625	0.068593217	0.615157149	-0.381937346		240
	standard errors	0.145453419	0.116017936	0.0495359	0.042434719	0.073415296	0.039252156		
	t-value	5.71040311	-0.820940391	-0.6250528	1.616440939	8.3791414	-9.730353215		
	p-value	1.13E-08	0.411680222	0.5319364	0.105999013	5.33E-17	2.24E-22		
MODEL 2	Coefficients	0.869706956	-0.132570448	-0.0153682	0.063070121	0.620927957	-0.38507697		240
	standard errors	0.139594621	0.112067838	0.0487919	0.042022133	0.073232872	0.040987161		
	t-value	6.230232579	-1.182948209	-0.3149732	1.500878625	8.478814813	-9.395063176		
	p-value	4.66E-10	0.236829674	0.752782	0.133386958	2.27E-17	5.72E-21		
MODEL 3	Coefficients	1.223938783	-0.15687375	0.0460762	-0.03212049	0.441481024		-0.0279077	240
	standard errors	0.254690446	0.211014392	0.1128174	0.126507139	0.283890216		0.0674716	
	t-value	4.805593621	-0.74342678	0.4084143	-0.253902586	1.555111799		-0.4136209	
	p-value	1.54E-06	0.457223336	0.6829695	0.799570817	0.119919445		0.6791518	
MODEL 4	Coefficients	0.792033686	-0.041971384	-0.0447214	0.085449236	0.582780132	-0.369279272		240
	standard errors	0.179718059	0.151179543	0.0644269	0.049261603	0.095933017	0.061001101		
	t-value	4.407090152	-0.277626079	-0.6941422	1.734601202	6.074865058	-6.053649274		
	p-value	1.05E+05	0.781299411	0.487593	0.082811466	1.24E-09	1.42E-09		
MODEL 5	Coefficients	0.816253697	-0.063139151	-0.0311423	0.078091931	0.580536793	-0.367347753		240
	standard errors	0.191310107	0.146663751	0.0654895	0.047897341	0.097770538	0.064119345		
	t-value	4.266652248	-0.430502767	-0.4755307	1.630402239	5.937747748	-5.729.125.212		
	p-value	1.98E+05	0.666829954	0.6344088	0.103016512	2.89E-09	1.01E-08		
MODEL 6	Coefficients	1.041754158	-0.242844069	0.0252757	-0.024098993	0.319774721		0.0220324	240
	standard errors	0.63582153	0.291617445	0.1481204	0.126798794	0.213835711		0.075466	
	t-value	1.638438003	-0.832748771	0.1706426	-0.190056956	1.495422446		0.2919511	
	p-value	0.101330357	0.404986433	0.8645048	0.849264499	0.134804226		0.770324	

In the time series analysis, the stock of road infrastructure change is investigated in country based level. However, the variations within and between 80 provinces one examined in parallel data approach. Düzce, the 81th province is included into the Bolu (14th province) due to the time limitations.

The panel data approach, it is different than the last two ones. In the time series analysis, the investment and stock of road infrastructure change is investigated in country-based level. However, the variations within and between 80 provinces are examined in that approach. Düzce, the 81th province is included into the Bolu (14th province) due to the time limitations.

To avoid the simultaneity problem, a dynamic model approach is used after the static models. In the dynamic model problem, Arellano Bond approach is used. As we can see the Table 4.15, there are six different dynamic models that different lag combinations are used. However, significant and compatible results are not found.

As it wil be explained in the next chapter, the road infrastructure expansion may not be effective significantly in economic efficiency. The enough capacity may be existing, but enhancing the present highways can create more marginal benefit than expanding them. The results show that a relationship between economic growth and road density per capita is not significantly existing for Turkey between 1998 to 2013.

5. IS HIGHWAY CONSTRUCTION REALLY A SUFFICIENT METHOD FOR ECONOMIC GROWTH?

Transportation has an important role in economic development. Transportation has wide ramifications in that role. The basic purpose of transportation is moving people and goods from one location to another. But it is obvious that transportation is essential for market economy, because an efficient system can increase the productivity in the economy [85].

Furthermore, transportation has a wider role in shaping the environment and development. People lives and bussinesses locate mostly near the transportation facilities that effects the land use patterns, congestion, using the scarce natural resources, air, water and noise pollution, overall quality of life. Transportation has effects not only economic but also socially [85].

Most important problem for the decision makers is capital expansion or capital enhancement decision. Constructing additional highways, adiitional capacity for terminals by using traditional technology are included in the expansion. Enhancement includes increasing the efficiency of the existing transportation system, for example using congestion pricing, GPS systems, inteligent transportation system. Another important question is should money be spent on transportation or any other sectors, such as education, health, infrastructure systems. In transportation perspective, the money should be spent on additional highways or enhancing the existing systems [85]. The effect of transportation systems on economic development can be summarized at the Table 5.1.

5.1. Roadway Improvements

In the literature there are many studies that found transportation infrastructure investments can increase the economic output [21, 40, 41, 47, 48, 49] with a range of

0.04 between 0.56.

Table 5.1. Transportation factor vs. Economic Evaluation Methods [86].

Factor	Description	Evaluation Methods
Project spendings	Jobs and business activity resulted by project spendings.	Regional economic models, input-output tables.
Comsumer spendings	Effects of future consumer transport spendings.	Consumer spending surveys and regional economic models.
Project cost efficency	Measurement of transport investment repaying costs and optimizing values.	Extensive benefit/cost models.
System efficiency	Benefits to costs ratio. Whether the policies of transportation meet the economic targets.	Measure of whether the transport policies reflect efficient market principles.
Basic access	Effects on basic mobility (access to schools, jobs, shops).	Analysis of affordable housing and jobs, services.
Retail and Tourism	Effects on retail and torusim sectors.	Surveys, input-output tables.
Effects on specific sectors	Effects on some specific sectors (vehicle and fuel producers, taxis etc.)	Analysis of employment and productivity of those specific businesses.
Property valuation and development	Measurement of property values increase caused by transport policies and projects.	Property valuation studies and real estate surveys.
Land use	Efficient land use objectives lead to more accessiblity.	Land use development impact analysis.
Affordability	Effects on on transportation and house affordability.	Transportation and housing affordability analysis.
Wealth accumulation	Created wealth caused by housing investments.	Spendings on housing versus transportation.
Outputs	Developed health, education, quality of life.	Sustainable development indicators.

However, in the reality, expansion of infrastructure has a wide range of effects. For instance, building the first roadway can create a huge increase in the productivity of economy in that location. But, constructing the second highway may decrease the marginal benefit of the productivity. Due to the congestion, building a new highway lane may decrease the costs caused by congestion, however, different congestion management strategies can lead to more cost effective results [86].

Some studies can show that suburban or rural areas that have well accessiblity faced with more employment growth, industrial diversification and poverty alleviation [Weiss (1999), Horst and Moore (2003) [87, 88]. But these are caused by largely economic transfers rather than overall gain in economic activities [86, 89, 90].

Jiwattanakulpaisarn, *et al.*, (2009) have found results that employment growth is affected by annual highway growths, but existence and direction of influences due to time lag and highway type considered. In the study of Noland and Graham (2009), similar results are found that more highway investment gains smaller economic outputs. In the short run the economic gain is higher than the long run. Hymel (2009) studied on traffic congestion and employment growth relationship in US metropolitan areas. The results show that the congestion causes reduction in employment growth. Particularly, in high congested places, it occurs in the long-run period. As a result of this study, it is suggested that in highly congested cities a 10% increase in congestion leads to reduction in employment growth by 4%, such as Los Angeles [86, 91, 92].

The economic sprawl caused by the roadway improvements can create harmness in economy locally. For example, in Nelson and Moody (2000)'s study economic retail and services per person is reduced by increasing the number of beltway increase. The result shows that beltways cause deconcentration of people and economic activities that reduces the agglomeration efficiency of industries [86, 93].

There are some conclusions due to SACTRA 1999 and O'Fallon (2003)'s studies as [94-96]:

(i) Transport investments can lead to wide impacts, however, these can be positive or negative. For instance, increase of travel of residents for shopping and services can reduce the bussinesse in that community.

(ii) Improving the efficieny of using existing capacity can be more productive than expanding the infrastructure. The demand management can be better alternative than expanding the infrastructure.

(iii) Reliability of an infrastructure is an important factor for international trade. Poor quality and inefficient infrastructure can lead to reluctance of the firms to invest capital in those locations.

(iv) Existence of surplus of infrastructure can cause a negative impact because of the usage of scarce resources unnecessarily.

(v) Making decisions according to political influences (ie. lobbying, coalition aggreements) can lead to distortions in infrastructure improvements.

Different strategies are compared according to Litman's (2006) study [86]. The comparison table is listed in Table 5.2:

Table 5.2. Comparison of transportation strategies [86].

Planning Objective	Roadway Expansion	Fuel Efficient Vehicles	Mobility Management
Motor Vehicle Travel Impacts		Increased	Reduced
Congestion reduction Road and parking cost savings	x		x x
Consumer cost savings			x
Reduced traffic accidents			x
Improved mobility options			x
Energy conservation		x	x
Pollution reduction		x	x
Physical fitness & health			x
Land use objectives			x

Additional roadway or constructing a new lane can be accepted to lead to decrease of congestion, but increasing the capacity can generate its own traffic demand, which is called induced traffic. Mostly this traffic is generated by personal trips that create the minimum economic output and increases the congestion, parking costs, fuel imports etc. From Litman's report the Table 5.3 can answer the impact questions [86]:

Table 5.3. Productivity Impacts-Roadway Expansion [86].

Increases Productivity	Reduces Productivity
* Reduces traffic congestion	* Costs per additional peak-period * peak-period vehicle trip are often high
* Provides short- term employment	* Wider roads and increased vehicle traffic often * degrade walking and cycling conditions
	* Often increases automobile depenency and sprawl, which reduces travel options and
	increases parking, accident, consumer, fuel import, and pollution costs

Rather than choosing expansion, demand management is a good alternative. Again in Litman's report, demand management and roadway expansion are compared in Table 5.4.

Table 5.4. Roadway Expansion vs Mobility Management Economic Impacts [86].

Economic Impact	Roadway Expansion	Mobility Management
Project expenditure impacts	Generates construction jobs.	Generates construction and ongoing management jobs.
Future consumer expenditures	Stimulates driving which increases vehicle and fuel expenditures.	Reduces vehicle travel and therefore vehicle and fuel expenditures.
Investment cost efficiency economic returns on investments	Tends to be less cost effective than demand management.	It often most cost effective and efficient overall.
Transport system efficiency	Is inefficient	Increases efficiency by favouring higher value trips and more efficient modes.
Basic mobility and affordability	Tends to reduce basic mobility and affordability by stimulating automobile dependency.	Many demand management strategies improve basic mobility and affordability.
Property values and development	Can increase urban fringe property values.	Mixed. Can increase property values near transit stations.
Land use development patterns	Stimulates sprawl	Tends to support smart growth.
Wealth accumulation (increased home equity value)	Encourages consumer expenditures on vehicles rather than housing.	Allows households to reduce vehicle costs and invest more in housing.

According to Litman's report, highway expansion supporters assume that traffic congestion causes reduction in productivity, but expanding roadway decreases these costs and alternative strategies to reduce the congestion are not sufficient. But, it can not generally be true. As we can see from the table, in the Litman's study in 2007, congestion is a moderate cost totally, but consumer cost, parking costs etc. Highway expansion tends to decrease the congestion in the long period, but the benefits are captured generally by the consumer costs. Therefore, net productivity does not improve significantly. But, in mobility management, it generates overall improvement in the productivity due to increase of overall efficiency [86].

Table 5.5. Optimal Pricing Summary - Middle-Range Values [86].

Cost Category	Per Vehicle-Mile
Vehicle congestion - delays a vehicle imposes on other vehicles	0.010 USD
Nonmotorized delays - delays a vehicle imposes on walkers and cyclists	0.005 USD
Roadway facilities - costs of building and maintaining roads	0.030 USD
Registration & licensing - existing fees made distance-based	0.020 USD
Roadway land value - rent paid for road rights-of-way land	0.040 USD
Traffic services - costs of services such as policing and emergency response	0.010 USD
Land use impact costs - external costs of sprawl	0.010 USD
Accidents - cost of traffic accident damages	0.100 USD
Air pollution - costs of vehicle air pollution	0.040 USD
Noise pollution - costs of vehicle air pollution Water pollution - costs of vehicle air pollution	0.005 USD 0.005 USD
Parking facilities - costs of parking facilities used by a vehicle	0.120 USD
Fuel externalities - economic costs of importing and using vehicle fuel	0.014 USD
General Taxes - average sales taxes, if applied to vehicle fuel	0.006 USD
Total	0.415 USD

We should ask these questions below before deciding the strategies [86]:

Table 5.6. Critical Analysis - Roadway Expansion [86].

Questions	Conclusions and Comments
Does the proposal really increase overall productivity?	Reducing congestion, particularly for freight and delivery vehicles, can improve productivity.
Is this proposal really the best way to support local development?	Building the first highway to an area tends to support economic development, but road expansion provides much less marginal benefit.
Is the proposal really the best way to improve access?	Improved vehicle traffic flow may be partly offset over the long term by generated traffic and sprawl.
Does it provide true economic gains rather than just economic transfers?	In the short-term congestion is reduced, increasing productivity, but long-term benefits are often small or negative due to generated traffic.
Do the benefits justify subsidies?	Such projects are most efficiently financed by user fees.
Do economic benefits offset indirect costs?	To the degree that the roadway expansion induces additional travel it increases external costs that offset some of the direct benefits.

In Sahin (2015)'s study, automobile and person numbers passed over the initial two Bosphorus Bridges in Istanbul are compared before and after they are constructed. It is seen that the expected drop of demand of the first bridge did not occur. In 1988, the annual traffic demand of Bosphorus Bridge was 50,985,942. It was reached to 51,198,604 in 1990. Besides that the demand of the FSM Bridge was 16,621,662 in 1990. According to Sahin (2015)'s study, it is obvious that FSM Bridge created its own demand [97].

Furthermore, the transportation market distortions can be explained with encouraging economically inefficient vehicle travel and underpricing of automobile travel. These cause to decrease the marginal benefits with respect to marginal costs. In Figure 5.1, annual per capita congestion delay and GDP relationship is shown.

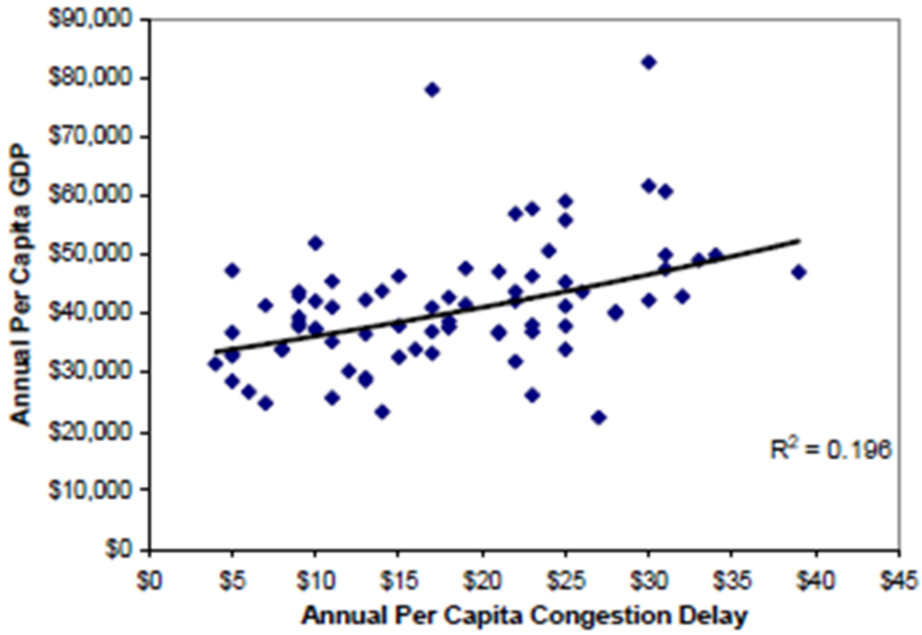

Figure 5.1. Per Capita Congestion Delay vs. GDP [86].

Planning and pricing policies are important for economic growth. There are two explanations about the tnedency of GDP decrease at high levels of VMT:

(i) The decrease of the share of productive-purposed travels, such as freight, business travels and service delivery.

(ii) The increase of VMT leads to new economic costs, such as vehicle expenses, traffic service costs, road and parking facility costs, accident and pollution damages [86].

In another aspect, car ownership vs. GDP relationship is another factor to impact on the traffic congestion. By the increase of gdp level, automobile ownership also increases.

Car ownerhsip increase according to economic growth is an important issue. Rise of cars can cause additional congestion in metropolitan areas. According to the Ögüt's (2004) study, the car ownership vs GNP relationship can be obtained and forecasted over 2020 for Turkey. S-Curve models are defined by using Gompertz Curve Model which is:

$$CO = Sexp\left[-aexp\left(-bGNPPC\right)\right] \tag{5.1}$$

Which CO is car ownership, a and b are calculated as coefficients and GNPPC is Gross National Product per capita. In the figures below about car ownership between 1950 to 2002 and the S-Curve estimations of CO and GNPPC are:

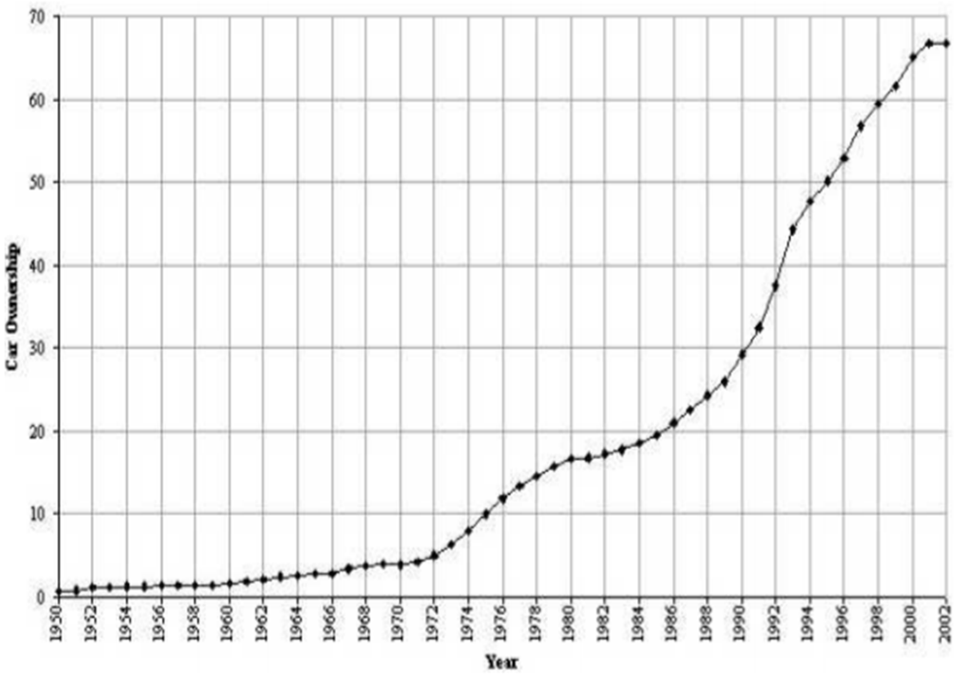

Figure 5.2. Car Ownership in Turkey between 1950-2002 [98].

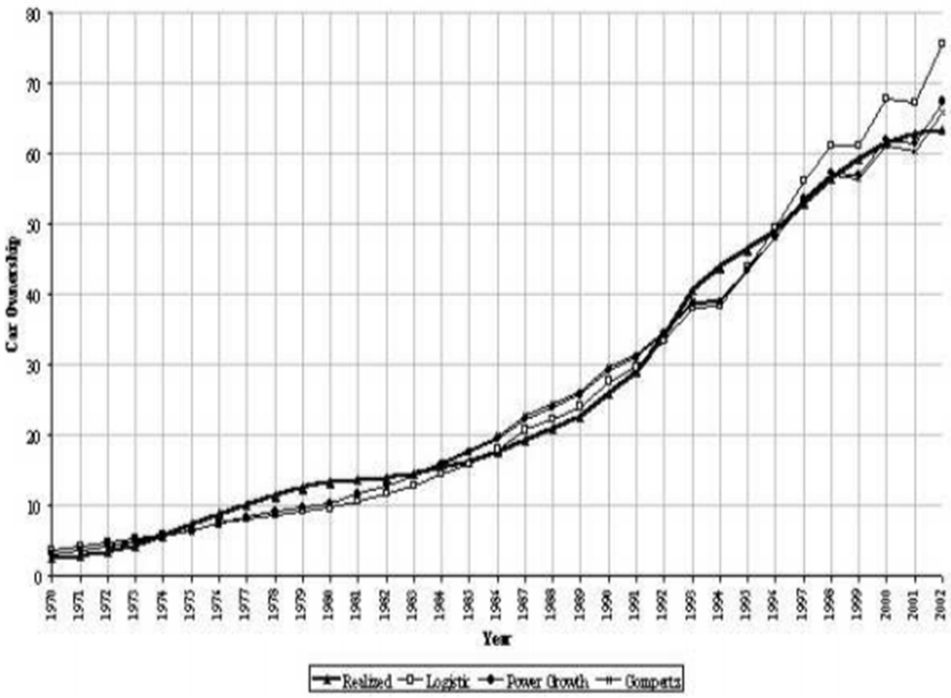

Figure 5.3. The Estimations of the S-Curve Models for the Car Ownership in Turkey [98].

In his study, a forecast for 2020 is done for car ownership vs GNP for different GNP growth assumptions for the future. According to this study, the GNP increase and car ownership reltaionship can be formulized. Car ownership increase can cause additional traffic congestion [98].

6. RESULTS AND RECOMMENDATIONS

In this chapter, the limitations of the model, contributions in the dissertation and the implementations of the study area are presented.

6.1. Limitations of the study

In this dissertation, the general limitation is finding the sufficient long data set and appropriate variables. Gathering the information of the variables and in an efficent time period is the basic problem.

Firstly, in the Cobb-Douglas approach, there was no information for the road capital stock for Turkey. To obtain this information, the spending table of KGM about highway investments is used by using the perpetual inventory method. However, there is not proper data before the year of 1995 the capital stock data of road infrastructure variable is between 1995 and 2014. The other variables such as labor, GDP and total capital stock are existed for a longer period than road stock, but the period of road stock variable restricted the time set of this analysis.

In the last model in panel data approach, initially the GDP variable data are not existed in TURKSTAT database after 2001. Therefore, GDP dataset is chosen from the study of TEPAV which is prepared by using the night light measurements between 1992 and 2013. Besides that some provinces are declared as a province after these time period. Due to this limitation, Duzce (the last province) is agrregated with Bolu which is a district in it before December of 1999. Furthermore, in this time period, there are limited control variables. Public investment data for province-level are present for between 1999 and 2015. This condition is also limited the time period of the study. Lastly, there is no information about the private investment between this time period, total credit values that given by private banks are used as proxy variable instead of private investment.

6.2. Contributions

Contributions of the dissertation are listed below:

- Road infrastructure stock is calculated for Turkey in country-based level between 1995 and 2014.
- The effect of road density per capita on economic growth is implemented for Turkey in province-based level in a static panel data approach.
- A dynamic panel approach namely Arellano Bond method is implemented into panel data approach for province-based level.
- Road infrastructure expansion impact on economic growth is investigated for Turkey in country and province-based levels. It is concluded that the road capital stock or road density per capita changes are not significant in determining the increase of the GDP or income levels for Turkey.

6.3. Implementation of the Dissertation

Initially this dissertation can be a guidance to implement policies and decision making phase of the allocation the investment amounts in highway infrastructure or another alternatives of the transportation sector. Furthermore, it can be a reference to decide the resources on the sectoral level of public investments. In the preparing the development plans in Ministry of Development, these results can be concrete evidences for the allocation of the investment funds more accurately. Therefore, the scarce resources can be used more efficiently.

GDP increase and car ownership is an important issue for traffic congestion. Car ownership increase can cause additional traffic congestion. Expansion of roadways is an apparent solution for reducing the congestion. However, new roadways again cause induced traffic problems that new roads create their own demands. Besides that constructing new roads can generate inefficient land use problems. In order to prevent this loop, alternative ways should be considered, such as intermodal trips, efficiency of connectivity with other modes, utilising the capacity of existing roads, traffic management. They must be considered at the creation phase of master plans of the provinces. Afterwards, the accessibility concept should be taken into account. These are the main instruments of the transportation system of a province.

As it is mentioned in the previous chapters, efficient transportation systems are instruments for boosting the economic growth. In this dissertation, the road capital stock or road density per capita changes are not significant in determining the increase of the GDP or income levels for Turkey. Therefore, other transportation alternatives or mobility management strategies should be considered as well while allocating the scarce resources and making policy decisions.

6.4. Recommendations

For the future studies, in terms of transportation infrastructure and economic growth relation, rail transport, maritime transport, airline transport systems can be used as key variables in different types of econometric models for Turkey in country or province based levels. These types of transportation modes, including road transport, district based studies can be done if appropriate data can be obtained. Besides that industry level studies can be done for these transportation modes by using cost and profit function methods explained in the literature chapter. Furthermore, accessibility index variables can be used as key variables to observe the change in the income levels or employment in location specific studies for Turkey.

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