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ANALYSIS OF REGIONAL INCOME CONVERGENCE IN TURKEY

Doktora Tezi

HAKKI KUTAY BOLKOL

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Danışman: PROF. DR. ALİ SUUT DOĞRUEL

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SOSYAL BİLİMLER ENSTİTÜSÜ MÜDÜRLÜĞÜ

TEZ ONAY BELGESİ

İKTİSAT (İNGİLİZCE) Anabilim Dalı İKTİSAT (İNGİLİZCE) Bilim Dalı DOKTORA öğrencisi HAKKI KUTAY BOLKOL'nın ANALYSIS OF REGIONAL INCOME CONVERGENCE IN TURKEY adlı tez çalışması, Enstitümüz Yönetim Kurulunun 18.04.2019 tarih ve 2019-10/24 sayılı kararıyla oluşturulan jüri tarafından oy birliği / ~~oy çokluğu~~ ile Doktora Tezi olarak kabul edilmiştir.

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Öğretim Üyesi Adı Soyadı			**İmzası**
1.	Tez Danışmanı	Prof. Dr. ALİ SUUT DOĞRUEL	
2.	Jüri Üyesi	Prof. Dr. FATMA DOĞRUEL	
3.	Jüri Üyesi	Doç. Dr. CAN KARAHASAN	
4.	Jüri Üyesi	Doç. Dr. YASEMİN ÖZERKEK	
5.	Jüri Üyesi	Dr. Öğr. Üyesi OYA KENT	

GENERAL KNOWLEDGE

Name Surname: Hakkı Kutay Bolkol

Field: Economics (English Medium)

Program: Economics (English Medium)

Supervisor: Prof. Dr. Ali Suut Doğruel

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ABSTRACT

ANALYSIS OF REGIONAL INCOME CONVERGENCE IN TURKEY

This thesis analyzes convergence among regions of Turkey with neoclassical exogenous growth perspective and endogenous growth perspective incorporating with descriptive statistics. According to results obtained from exogenous model part, there is a tendency of convergence among regions of Turkey. However, there is an important crisis (2008 crisis) in the investigation period in which the tendency of convergence increases. Besides, descriptive statistics show that during the crisis, the speed of convergence increases, however, apart from crisis period it is impossible to state that there is convergence or divergence among regions of Turkey. Therefore, the main conclusion is that crisis has a positive impact on closing income differences among regions. Furthermore, in endogenous model section, it is found that R&D personnel has negative impact on regions' economic growth with its current share in total employment. Moreover, catch-up strategy based on increasing the ratio of R&D personnel also has negative impact on regions' economic growth. Besides, increasing the share of R&D personnel in total employment decreases the growth differences between regions by affecting east region more negatively since in the

investigation period east region grows more than west region. On the other side, U-shaped relation between the share of R&D personnel in total employment and economic growth is found. However, when it comes to convergence issue, since rich west is closer to take a positive effect from R&D personnel and with relatively low share of R&D personnel the economic growth of east region is more negatively affected by R&D personnel, by applying a strategy based on increasing the share of R&D personnel, east region cannot close the income differences. Moreover, east region is far away from taking positive effect from R&D personnel so that convergence policy insists on increasing the share of R&D personnel in east region may cause divergence rather than convergence.

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ÖZET

TÜRKİYE'DEKİ BÖLGESEL GELİR YAKINSAMASININ ANALİZİ

Bu tez Türkiye bölgelerinin yakınsamasını neoklasik dışsal büyüme modeli ve içsel büyüme modeli çerçevesinde açıklayıcı istatistiklerden de faydalanarak analiz etmektedir. Dışsal model kısmının sonuçlarına göre Türkiye'de bölgeler arasında bir yakınsama olduğu söylenebilir. Ancak inceleme döneminde yakınsama eğilimin arttığı önemli bir kriz (2008 krizi) yer almaktadır. Ayrıca açıklayıcı istatistikler de kriz döneminde yakınsama hızının arttığını göstermiştir. Ancak kriz dönemi dışında Türkiye'de bölgeler arası bir yakınsamanın veya ıraksamanın olduğunu söylemek mümkün değildir. Bu nedenle, çıkarılan ana sonuç, kriz döneminin bölgesel gelir farklılıklarını kapatma açısından pozitif bir etki yaptığıdır. Buna ek olarak, içsel model kısmında AR-GE personelinin toplam istihdamdaki güncel payı ile bölgelerin büyümesine negatif bir etki yaptığı bulunmuştur. Ayrıca, AR-GE personelinin oranını arttırmaya dayanan bir yakalama stratejisinin de bölgelerin büyümesine olumsuz bir eti yaptığı sonucuna ulaşılmıştır. Bunun yanında, incelme döneminde doğu bölgesi batı bölgesinden daha fazla büyüdüğü ve AR-GE personelinin etkisi doğu bölgesi için daha negatif olduğu için toplam istihdamdaki AR-GE personel oranının artması bölgeler arası

büyüme farklılıklarını kapatmaktadır. Diğer taraftan, bölgenin AR-GE personelinin toplam istihdamdaki payı ile ekonomik büyümesi arasında U-şeklinde bir ilişki saptanmıştır. Ancak yakınsama konusunda, görece zengin batının AR-GE personelinden pozitif etki almaya daha yakın olması ve görece fakir doğunun düşük AR-GE personel payı ile AR-GE personelinden daha negatif etkilenmesi, doğu bölgesinin AR-GE personeli payını arttırmaya yönelik bir yakalama stratejisinin bölgesel gelir farklılıklarını kapatamayacağını göstermektedir. Ayrıca, doğu bölgesi AR-GE personelinden pozitif etki almaya çok uzaktır. Bu nedenle, eğer doğu bölgesinde AR-GE personel payını arttırmaya yönelik bir yakalama politikası üzerinde ısrar edilirse bu yakınsama yerine ıraksamaya sebebiyet verebilir.

To my family

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LIST OF ABBREVIATIONS

CI	Confidence Interval
CPI	Consumer Price Index
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
GPT	General Purpose Technology
ICI	Istanbul Chamber of Industry
IID	Independently and Identically Distributed
IPC	International Patent Classification
KOSGEB	Small and Medium Enterprises Development Organization
NACE	Nomenclature of Economic Activities
NUTS	Nomenclature of Units for Territorial Statistics
OECD	Organization for Economic Co-operation and Development
R&D	Research and Development
TFP	Total Factor Productivity
TUBITAK	The Scientific and Technological Research Council of Turkey
TURKSTAT	Turkish Statistical Institute
WC	Windmeijer-corrected

1. INTRODUCTION

On theoretical ground, the pioneer study for convergence belongs to Solow (1956). In his theory of neoclassical growth, there will be convergence among all economies towards balanced growth paths because of the assumption of decreasing return to scale to capital. More simply, according to neoclassical theory, relatively low income and capital stock regions obtain higher returns from additional unit of capital. When it comes to empirical ground for convergence literature, first Baumol (1986) then Barro and Sala-i Martin (1991) pave the way for other researchers by making a great contribution for the popularity of convergence among countries and regions in the field of empirical economics.

Neoclassical models starting with Solow (1956) can be called exogenous technology growth models since they treat technology as an exogenous factor. Technology finds itself in Total Factor Productivity (TFP), in other words, Solow residual in neoclassical models. TFP is the unexplained part of the economic growth which is not related with capital or labor. Technological advancement is accepted as an explanation for TFP. In other words, what is left after subtracting the share of capital and labor from output is TFP.

On the other side, new growth theory starting with Lucas (1988) endogenizes the economic growth by addressing human capital as an engine of economic growth because according to endogenous technology growth models, human capital accumulation increases the productivity of labor and physical capital. The main idea of Lucas (1988) is that people divide their time between work and training so that trade-off between work and training emerges because during training process people renounce their work income, but enhance their future productivity, and so their future wages. This situation is related with postponing income today for the sake of better income tomorrow. The decision depends on the dynamics of the economy and this makes the model endogenous. Seminal work of Lucas (1988) paves the way for other seminal studies like Romer (1990), Grossman and Helpman (1990, 1991,

1993, 1994), Coe and Helpman (1995), Coe et al. (1997), Howitt (1999), Aghion and Howitt (1998) that make great contributions to endogenous growth theory on several counts.

This study is about regional income convergence in Turkey. The main reason for investigating this issue is that if a country suffer from significant income differences among its regions, it is almost impossible to obtain permanent growth for this country (Doğruel and Doğruel, 2003).

The prime purpose of this study is to analyze convergence issue on a regional ground in Turkey by not only using exogenous growth perspective but also endogenous growth perspective incorporating with descriptive statistics. The results obtained from neoclassical exogenous growth perspective can directly provide conclusion about convergence for the regions of Turkey. On the other side, the results of endogenous growth perspective, may show that whether human capital may help with respect to closing the income differences among regions. However, human capital is quite different than physical capital with respect to the assumption of decreasing returns. Researchers who have worked on this issue find that instead of decreasing returns, increasing returns is the dominant case for human capital. Therefore, this situation may cause divergence rather than convergence. The aim of this part is to analyze this issue on empirical ground for the regions of Turkey.

The rest of the thesis is organized as follows; section 2 presents a review on literature, section 3 explains how the data is converted into real term, section 4 and 5 provide exogenous model results and endogenous model results respectively, and lastly section 6 concludes.

2. LITERATURE REVIEW

Literature review is divided into two main topic as neoclassical exogenous growth models and endogenous growth models.

2.1 NEOCLASSICAL EXOGENOUS GROWTH MODELS

This part is divided into two as Pioneer Studies and Empirical studies on Turkey because this study works on Turkey case and the models that empirical studies use are taken from these pioneer studies.

2.1.1 Pioneer Studies

Baumol (1986) investigate convergence issue by touching on productivity growth. Maddison's long-run data which includes data 16 countries[1] is used in this work. This study indicates the existence of noteworthy convergence among developed countries. On the other hand, by investigating Summer-Heston's data that includes more countries, it is stated that only underdeveloped countries are not in a trend of convergence. By constructing a regression, inverse relationship between growth rate of GDP per work hour and absolute level of GDP per work hour is found. Therefore, paper indicates that as country's productivity level increases, its growth rate decreases. Furthermore, study also mentions the public good characteristics of knowledge and its spillover effect. In this respect, by following the leaders' footsteps, laggards can take the benefit from the public good characteristic of knowledge with spillover effect. This situation may create convergence. On the other side, less developed countries cannot benefit much from public good characteristics of knowledge

[1] Australia, Austria, Belgium, Canada , Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Sweden, Switzerland, United Kingdom, United States.

owing to having insufficient human capital. This is the main reason of the poor performance of underdeveloped economies. Study indicates that the main problem of less developed countries is education. Moreover, study denies the single convergence club. In this respect, it is stated that there is one for developed countries one for middle-income countries and underdeveloped economies diverge over time.

De Long (1988) criticizes Baumol (1986) due to the problem of sample selection bias in his empirical work. According to this work, Baumol uses ex-post sample which means that sample is consist of only already rich and successfully developed countries. Moreover, Maddison also excluded some countries that have not converged from the sample. Therefore, Baumol's results do not sufficient to indicate convergence. According to De Long (1988), other countries that have a tendency to converge but haven't converged yet (ex-ante sample) need to be included into the sample. In this respect, this study adds seven[2] more countries. In empirical part, different than Baumol (1986), logarithmic income specification is used because it has two additional advantages. It eases the measurement of slope and adding new countries to the existing sample. Moreover, it is stated that simple regression is not sufficient for analyzing convergence. More sophisticated estimation techniques are applied for the modified sample and study finds weak convergence. On the other side, depending on the capability of adaptation of technology, paper does not deny the force of convergence.

Beta convergence terminology is widely used in growth studies. This terminology gain popularity mainly after Barro and Sala-i Martin (1990, 1991, 1992). It investigates the relationship between growth rate of per capita income and income level in the starting period. There is beta convergence if the partial correlation between growth of income and its initial level is negative (Barro and Sala-i Martin, 1995). It assumes that sooner or later low income regions catch up the high income regions by growing faster than high income regions. In this respect, it reflects the dynamics of neoclassical growth theory in which factors of production are subject to diminishing returns. By constructing a unique model that widely used by other

[2] Argentina, Chile, East Germany, Ireland, New Zealand, Portugal and Spain.

growth studies, Barro and Sala-i Martin (1990, 1991, 1992) make a beta convergence analysis by using panel data regression techniques. They mainly focus on the regions of United States. According to results of beta convergence analyses, Barro and Sala-i Martin (1990, 1991, 1992) find an evidence for convergence. Barro and Sala-i Martin (1990, 1991, 1992, 1995) pave the way for other studies on convergence issue with their uniquely constructed beta convergence model. A few examples (other than Turkey case), by using their model Bergström (1998) and Kangasharju (1998) find an evidence for convergence for the regions of Sweden and Finland respectively. On the other side, despite of using their model, there are also some studies that could not find an evidence for convergence like Siriopulos and Asteriou (1998) that investigates the convergence issue for the regions of Greece and Dobson and Ramlogan (2002) that examines the convergence issue for Latin America.

2.1.2 Empirical Studies on Turkey

Filiztekin (1999) analyzes convergence issue among Turkish provinces for 1975-1995 period. Study applies coefficient of variation method in order to investigate the degree of dispersion. According to result, the dispersion increased sharply in the investigation period. Furthermore, it is found that there is convergence only among rich provinces. In order to make a convergence analysis, paper uses beta convergence. According to results there is no unconditional convergence across Turkish provinces. Besides, paper also adds the share of agricultural sector to the equation in order to investigate the convergence issue for conditional case by control structural differences among provinces. Distinct from unconditional convergence result, it is found that there is an existence of conditional convergence across Turkish provinces.

Tansel and Güngör (1999) investigates the validity of convergence among Turkish provinces between 1975 and 1995. While examining convergence issue, dependency of convergence on human capital is also investigated in this study. Study does not use single methodology as for empirical technique. Firstly, it uses the model of Barro and Sala-i Martin (1992) in order to investigate beta convergence. Secondly, for the purpose of adding human

capital in to the analysis, paper uses the methodology of Mankiw et al. (1992). Lastly, paper uses the methodology of Islam (1995) and investigate convergence issue with a dynamic model. Consequently, it is found that there is absolute convergence and adding human capital to the analysis increases the speed of convergence.

Doğruel and Doğruel (2003) examine convergence issue for Turkey for the period between 1987 and 1999. In the empirical part, in order to test the convergence, study uses beta convergence methodology from Barro and Sala-i Martin (1995). Apart from that, study also uses sigma convergence and as an alternative to sigma convergence coefficient of variation method. Beta convergence indicates the validity of convergence while sigma convergence refers weak convergence which occurs only in high income provinces. Other than high income provinces, there it is found that there is no sigma convergence. In order to eliminate the potential biased results that can be obtained from sigma convergence analysis because of large fluctuations, coefficient of variation method is used and the results prove the validity of convergence which only occurs in high income regions. Consequently, according to results, while crises and natural disasters create a convergence among provinces of Turkey, during general periods the picture is closer to indicate divergence.

Karaca (2004) also examines the convergence issue for Turkey by touching on the problem of high income differences between rich west and poor east which brings about migration problems with respect to irregular urbanization, and public order. Therefore, policies are implemented by government in order to overcome the problem of income differences among regions. This study aims to examine the success of these policies on declining the differences with respect to income. Provincial level analysis is made. The investigation period is the years between 1975 and 2000. As for empirical technique, study uses beta convergence by applying the model of Barro and Sala-i Martin (1992). In order to make more comprehensive analysis, sigma convergence and coefficient of variation methods are also used. Beta convergence is investigated with both conditional and unconditional case. For conditional case east-west dummy and the share of agricultural sector is added to the model. According to results, no evidence for convergence is found. Conversely, it is found

that there is divergence among provinces of Turkey. Therefore, study concludes that there is a requirement of reconsideration on policies implemented for decreasing the income differences across regions.

Gezici and Hewings (2004) examines convergence in Turkey between 1980 and 1997. Study implements beta convergence model for both conditional and unconditional case. Besides, sigma convergence and the method of coefficient of variation are also applied in order to make a more comprehensive analysis. According to results, no convergence is found among Turkish provinces. Moreover, there is also no evidence for convergence across functional regions of Turkey.

2.2 ENDOGENOUS GROWTH MODELS

Literature of endogenous growth models is divided into two as emergence of endogenous growth models and pioneer studies and regional empirical studies because in empirical studies the ideology is taken from these pioneer studies and this study will investigate endogenous growth models at regional level.

2.2.1 Emergence of Endogenous Growth Models and Pioneer Studies

Lucas (1988) improves the Solow (1956) model by adding human capital and endogenizing the model. It is hard to mention on Lucas' (1988) model as a new invention rather it can be stated that he redefines Solow Model by dynamic optimization. He sees some reality which does not fit within the Solow model so Lucas (1988) explains this issue with human capital because it is less risky than handling this issue by touching on technology. Using human capital also creates externalities but it is less problematic compared to model includes technology. The main innovation of Lucas (1988) is that the time spent on education/training in which there is no production. Thus, this creates trade-off between production and education that depends on the dynamics of economy. This issue makes the model endogenous. The other things are almost the same as in Solow Model. Therefore, there

is no much change in the foundation of the Solow model; rather Lucas (1988) puts the human capital into the production function. In other words, without complicating the production function, according to trade-off between production and education, human capital is defined. Lucas (1988) endogenizes the theory and put it in a wider perspective by emphasizing on human capital which is, for him, the main source of economic growth. Human capital accumulation enhances the productivity of labor and physical capital. As it is mentioned, he states that people divide their time between work and training (or education depending on the measurement of human capital), so that there is a trade-off because during training process, while they waive their work income, their future productivity and wages increases. Actually, this trade-off is like a trade-off in physical capital accumulation since it is also related with postponing income today for the sake of better income tomorrow. Consequently, the decisions for accumulation of human capital depends on dynamics of the economy and this situation makes the model endogenous.

Moreover, there is a need of funding for education/training since for the sake of this, people give up their current income. There are two options for that; one is subsidy from government and the other is excess profit that appears in the case of monopoly. Because Lucas can be seen as neoclassical, he does not think the case of monopoly that's why he proposes subsidy at this point, however, it is also unacceptable according to neoclassical perspective. Consequently, it can be stated that the assumption of perfect competition restricts the elbow room of the model because there can't be any excess profit. Therefore, there is a need of subsidy which is directly against the spirit of neoclassical point of view. So what is the alternative? There is a need to mention on Romer (1990) at this point. Romer (1990) constructs a linkage between technical progress and production of knowledge. In this respect, he explains production of knowledge by using labors working in R&D (research and development) sector. According to his model, there is positive relationship between the growth of productivity and the stock of R&D personnel. Apart from that, because he forms the model under monopolistic competition there is a room for funding. Therefore, there is an opportunity to sell the goods for a price higher than its production cost. Thus, without subsidy there is a way for solving funding problem. Because of the nature of the monopolistic

competition there is free entry so that firms earn zero profit in the long run, however, by differentiating the product, they can create a source for education (or R&D in Romer's (1990) perspective). On the other side, Romer (1990) also touches on the policy issue since because of free entry, in the long run there is zero economic profit meaning funding problem for education/training/R&D. Consequently, in endogenous growth models, there is no escape from policy interventions.

The other issue related with Lucas (1988) is that he could not explain excludability and rivalry issue in his model, instead he states that production of non-rival and non-excludable good is an unintentional side effect of the production of conventional good which is both rivalrous and excludable. Again the solution comes with the Romer (1990) because within his model, he explains this issue by dividing the inputs into two as non-rival (design) and rival inputs (human capital) and within this context he also explains the excludability issue. Consequently, it can be stated that that Lucas (1988) tried to improve the Solow model by adding human capital and endogenizing the model but some inconsistencies occur. Moreover, it can be indicated that with a little modification (adding human capital), model proposes entirely different results than Solow model because Lucas (1988) model indicates divergence while Solow defends convergence. Lucas (1988) uses neoclassical model and its lots of assumptions with proposing some ideas that entirely contradicts with neoclassical sense. On the other side, he is the first who introduce human capital and many of other academicians influenced from him and improve the idea and adding process of human capital to the models (like; Romer (1990)).

Furthermore, since the aim of this thesis is to analyze the convergence on regional level, it is better to mention on "cities and growth" section of Lucas' (1988) work. In this section he touches on interaction and externality. The existence of these terms means that human capital do not move just because of higher wages as there is an externality feature of human capital (example: Silicon valley). What's more, other than the interaction, there is a level effect of some specific regions. Consequently, movement of human capital is more problematic than physical capital.

It can be beneficial to mention on Romerian perspective (Romer (1990)) by comparing it with Schumpeterian perspective (by benefiting from Aghion et al. (2013)) because although both of the models are endogenous type models, there are huge discrepancies between these models. Firstly, Schumpeterian Growth Model reflects micro-based approach when it is compared with Romer (1990). Moreover, in Romer (1990) every invention makes contribution to overall general knowledge and they manage to survive, however, in Schumpeterian case, theory come up with bringing the time dimensions to the ideas. In other words, only new ideas can survive. Thus, there is strict depreciation while in Romer (1990), there is no depreciation. In other words, there is no depreciation in Romer (1990) and every new knowledge makes some contribution to overall knowledge while also existing ones manage to survive. On the other side, there is creative destruction in Schumpeterian Growth which provides large fluctuations in the business cycle. At this juncture, it will be beneficial to mention on some works like Grossman and Helpman (1990, 1991, 1993) which includes international trade issue and find the middle way by proposing a depreciation according to time dimension (neither strict nor zero depreciation). Furthermore, in Schumpeterian perspective there is a need to mention on GPT (General Purpose Technology). It is random and stochastic process. Therefore, there is a room for possibilities and chance. Also in Aghion et al. (2013), it is stated that discovery arrives as a serendipitous by-product of learning by doing with the previous one. At this point it is better to count some advantages of this model like; it includes the process of adaptation of new, external technology, however, the negative side of the model is that it does not mention on how knowledge arrives. In other words, there is no production stage for knowledge which is presented in Romer (1990) because Romer (1990) aims to define the knowledge like a product.

Since Schumpeter has a capitalist view, he defines the crises as a success of capitalism. And according to his view, crises are not bad things because in crises the ones who are weaker disappear and the ones who are strong can survive. It is like a natural selection and with this process economy becomes stronger at the end of the crises since the share of strongers increases.

Turning the issue of GPT in Schumpeterian perspective, the emergence of new GPT (like steam engine, electricity etc.) is not a short run or medium run thing. Also it is not predictable. These kinds of new GPTs can change the path but it cannot be valid in short or medium run that's why the model need a lot of time to prove itself. On the other side, in order to find a solution and avoid complexity, Aghion et al. (2013) uses single sector - single product and look for whether emergence of new GPT is accomplished or not.

Furthermore, it can be stated that Schumpeterian growth theory uses the profit side of knowledge rather than using externality side. However, it is not stressed on the issue of "who uses this new technology or knowledge?". According to perspective of the Schumpeterian model, you can be a leader as long as you keep the knowledge to yourself. Moreover, in the model it is stated that incumbents do not have incentive to work on new technologies while new entrants have because while leader has already monopoly profit and there is high opportunity cost of putting effort on new technology, new entrants has probable future positive return. However, in the model there is no information about the funding process of these new entrants. It is completely about expected returns. On the other side, in Romer (1990), it is not a random process as he talks about monopoly surplus.

Some studies related with endogenous growth such as Grossman and Helpman (1990, 1994), Coe and Helpman (1995), and Coe et al. (1997)) touch on the diffusion of technology via international trade. These studies, adopt some properties of Schumpeterian perspective and some properties of Romer's perspective and blend them. The reason for this kind of deduction is that, for example, in Grossman and Helpman (1990), it is stated that Schumpeterian perspective has been adopted. Recall in Schumpeterian perspective, there is a very strict depreciation called "creative destruction". In this work, based on Schumpeterian perspective, it is stated that there is room for profit opportunities because the success in research sector can bring about some degree of market power. Moreover, according to this work, potential profits are based on the expenditures on R&D. Niche market can be established by innovator who introduce new product which substitutes for the brands of incumbents by charging a price more than its marginal cost in an oligopolistic competition.

However, in this study, it can be stated that the strictness of Schumpeterian perspective softens because it is stated that improving the product may also give the opportunity to set a price above marginal cost to leader. Especially in Aghion et al. (2013), which is also about Schumpeterian growth, the innovation issue had been put in a very restricted area tie in with the creation of General Purpose Technology (GPT). On the other side, here, it can be stated that Schumpeterian perspective is softened a little bit. Based on this perspective, study touches on international trade issue since it is stated that the time of profit opportunities may be running out because of the existence of foreign competitors that engage in reverse engineering or product development. By mentioning this, the model is also related with Romer's (1990) product variety model since with the international trade; it mentions knowledge spillover and product variety and old innovation can pave the way for new innovation with the interaction comes from international trade. Moreover, study talks about public good, non-rivalrous feature of knowledge which create spillover effect like Romer (1990). Besides, it talks about some difficulties about setting property rights such as non-excludability. More simply, innovators cannot easily prevent others who want to access and use existing knowledge created by them. After mentioning these, paper becomes obliged to adopt Romer's (1990) assumption that research projects make contribution of overall knowledge as well as generating patentable blueprints for its owners.

Moreover, in their later work (Grossman and Helpman, 1994), they state that knowledge is cumulative (like Romer (1990)) whereas machines deteriorate and must be replaced. By stating this, they put the emphasis on R&D. On the other side, it is possible to establish a strong connection between their studies and Schumpeterian growth perspective since in Grossman and Helpman (1991), they construct a model with intermediate inputs in the production. So the model is differentiated with Romer (1990) since in that study Romer constructs a model with final goods under the assumption of perfectly competitive R&D market.

Grossman and Helpman (1991) touch on quality ladder approach. According to this approach, leader firm is at least one step ahead of its closest rival so that firms in an industry

compete with each other in order to innovate next step in the quality ladder for a targeted product. Consequently, they mention "vertical innovation" which means that a newly innovated product becomes obsolete when more recent and better breakthrough occurs in this market. This is consistent with Schumpeterian case, however, adding the cumulative feature of knowledge, and also not putting strict depreciation on knowledge like mentioning GPT, they also seem to be taking something from Romer's (1990) perspective.

It is better to mention on "convergence and divergence" issue that can be deduced from the studies related with diffusion of technology. In Grossman and Helpman (1990), they suppose that North makes the innovation and then South imitate that, and it is beneficial for both because South benefits from spillover. At the same time, imitation process of South brings about an incentive to innovate for North due to the desire of protecting its monopoly. What's more, if a country has a comparative advantage in the field of R&D, subsidizing this field not only improves country's growth but also world growth. On the other side, if a country that has a comparative advantage in manufacturing rather than R&D, will subsidize R&D sector, this may decline world growth rate. Consequently, because of the comparative advantage principle, paper proposes that advanced countries should make the innovations and developing countries should imitate those innovations with knowledge spillover. Besides, protective trade policy may cause a shift from research to manufacturing. Therefore, this kind of policy can be beneficial for a country that has comparative advantage in manufacturing. On the other side, this kind of policy can be harmful for a country that has a comparative advantage in R&D. Consequently, as the paper sets its model according to comparative advantage principle and states that growth is a consequence of research activity, research activities and innovations are done only by developed countries while others imitate. Here, there is a need to mention that not every country can imitate the technology. There is also a cost of imitation (like; human capital etc.) and not every country can afford that. Consequently, the convergence become conditional on cost of imitation. It is conditional because a country that imitate may pass the threshold after some time and become an innovator and this is related with the endowments (physical and mainly human capital), institutions, policy implications etc. This possibility creates conditionality. On the other side,

if imitators could not pass the threshold, and the poor could not develop themselves based on human capital and other factors like institutional improvement, successful policies etc., the gap between poor and rich will be widen according to models.

On the other side, in Grossman and Helpman (1994), with the proposition of "comparative advantage", it is stated that companies in high-wage countries may open their plants in a low-wage foreign country. However, it is also stated that although it may appear that knowledge always flow costlessly and rapidly around the globe, the reality is quite different because of mainly interactions[3] . Knowledge possibly stuck in a specialized location because of interactions of human capital. On the other side, trade between North and South may create divergence, however, trade between North and North, which is most productive one, might create convergence. Of course it is not automatic, there is a need of some conditions that's why it is also conditional. On the other side, South and South trade may not give any gains. Consequently, it is better to stress on the threshold which should be jumped by imitators in order not to allow the gap to be widened. Besides, for jumping the threshold, the crucial thing is R&D and stock of knowledge[4] in these studies. There is world-wide technology frontier, and the more you close to it, harder to make progress. On the other hand, innovations can shift the frontier. If a country is far away from the frontier, it becomes hard to absorb the technology, and here, the factor of "human capital" steps in. For instance, Coe et al. (1997) mentions this frontier issue indirectly by touching on the benefits that developing countries can take from developed countries via trade. However, taking homogenous countries as a sample like; Coe and Helpman (1995), the results are closer to imply convergence. To sum up, in studies mention diffusion of technology via international trade, it is not stated directly that the poor remains poor and rich remains rich, however, they mention differentiation and the gap can be widened, but, there is a possibility of convergence

[3] Like Lucas (1988) mentions in the subtitle of "cities and growth".

[4] By integration with global economy.

by absorbing the technology through human capital and step up from imitating to innovating by jumping the threshold.

2.2.2 Regional Empirical Studies

Although empirical endogenous models which are constructed for making regional analysis are rare, there are some studies.

Wei et al. (2001) analyze regional growth (for 27 provinces; time period: 1986-1995) for China in order to support the endogenous innovation growth theory by using R&D expenditures as a one of the determinant of economic growth. According to empirical results, it is found that R&D expenditures have significant impact on economic growth which proves the validity of endogenous type growth theories for the case of China.

Bode (2002) investigates endogenous regional growth for the case of Germany during 1976-1994. As for empirical model, paper uses idea-based growth model developed by Romer (1990). Paper extends the model by considering the sources of regional differences in R&D productivity[5]. According to empirical results, R&D employment shows highly significant and positive impact on income growth.

Izushi (2008) examines the validity of endogenous growth models on regional basis (31 European NUTS1 regions) with productivity growth based on R&D worker during 1990s. This work empirically tests several models derived from Romer (1990) and Lucas (1988). When several models based on Lucasian and Romerian framework are tested against productivity growth rates, overall, empirical results support Lucasian framework rather than

[5] In the model it is assumed that the region-specific public knowledge to accumulate not on a one-to-one basis with the number of innovations, but on a $(1 + \varphi_r)$-to one basis. The sectoral concentration of R&D employment in Manufacturing industry is used as an element of φ_r. Second source may be the spillovers from universities, however, due to some technical reasons; it cannot be used in this study.

Romerian framework. According to empirical results, study concludes that Lucasian framework provides valuable comprehension for the technical progress in regional economy.

3. CONVERTING DATA INTO REAL TERM

Regional level data is available in TURKSTAT (Turkish Statistical Institute) with nominal values. Therefore, it is better to mention how the data is converted from nominal to real term. In that scope, the first way is to use the CPI (Consumer Price Index) data. However, on regional level, CPI data is only valid for NUTS2 level regions of Turkey. Second way is using GDP deflator. GDP deflator can be obtained by dividing nominal GDP to real GDP, however real GDP is only valid for NUTS0 level so it becomes the deflator of Turkey.

Furthermore, the price of all goods produced are taken into account in GDP deflator, while the CPI reflects only consumer side. To illustrate this point, when there is a change in the price of a good that is bought by government or firms will appear in GDP deflator, it will not be shown up in CPI. Therefore, using GDP deflator can be more beneficial. Of course, using Turkey's deflator for every regions can also cause some problems. In that respect, it is better to analyze CPI for the NUTS2 level (it is only available for NUTS2 level in TURKSTAT). If there is no much differences among regions, using GDP Deflator can be better option.

Table 3.1 shows the average CPI for the period between 2005 and 2017 (regional level data only valid for 2004-2017 and regional level CPI data starts with 2005). Also figure 1 shows the trend of average CPI. According to Table 3.1 and Figure 3.1, it can be stated that there is no much differences among regions so that using GDP deflator can be better way for converting the data into real term.

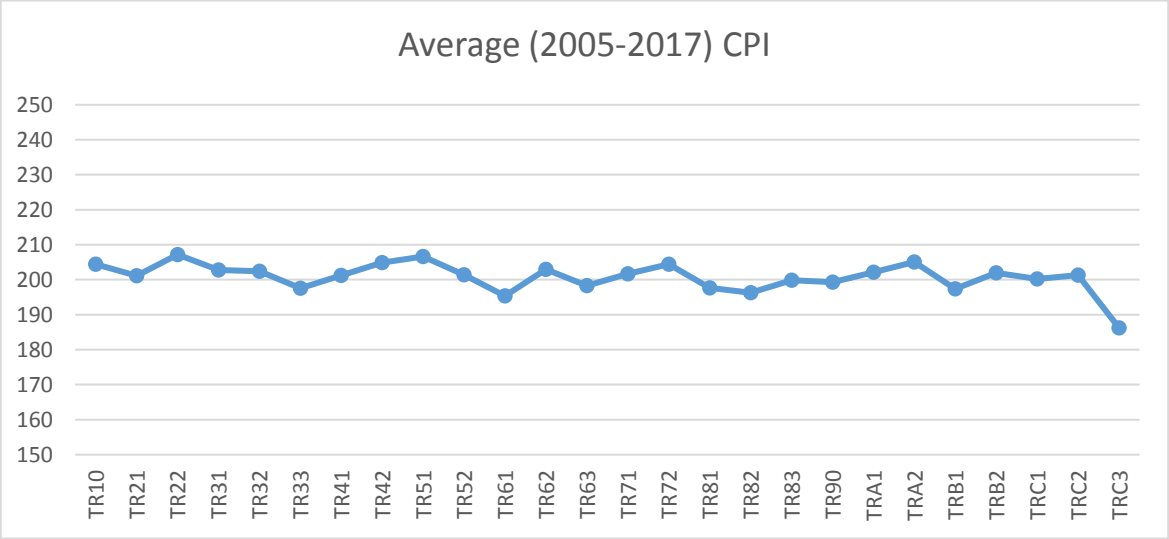
However, it is not sufficient to give a decision by only investigating average CPI. Therefore, standard deviation (2005-2017) and average growth rate (2006-2017) of CPI are also investigated (see table 3.2, 3.3 and figure 3.2, 3.3) and it is found that there is no much differences among regions. Consequently, it is decided to use GDP Deflator while converting the data into real term.

Table 3.1: Average CPI for NUTS2

Region	Average CPI (2005-2017)
TR10	204.4326
TR21	201.1159
TR22	207.1875
TR31	202.7845
TR32	202.4227
TR33	197.5509
TR41	201.1855
TR42	204.8458
TR51	206.6549
TR52	201.3672
TR61	195.3451
TR62	202.9178
TR63	198.3395
TR71	201.6857
TR72	204.4475
TR81	197.6215
TR82	196.2877
TR83	199.8087
TR90	199.2921
TRA1	202.1213
TRA2	205.0364
TRB1	197.3954
TRB2	201.9378
TRC1	200.2477
TRC2	201.3447
TRC3	186.2424

Note: See Appendix B, Table B.1 for the provinces included in regions specified by codes.
Source: Author's own calculations.

Figure 3.1: Average CPI for NUTS2



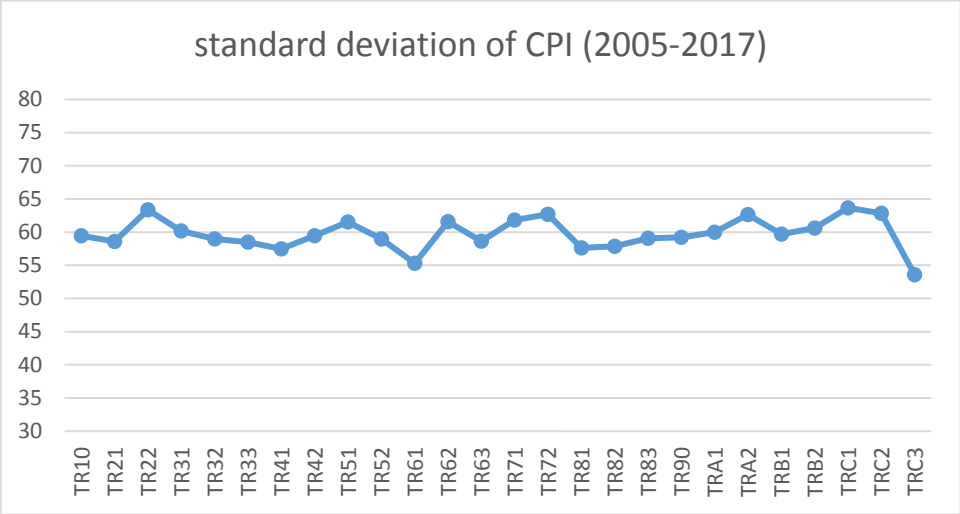
Source: Author's own calculations.

Table 3.2: Standard Deviation of CPI (NUTS2) (2005-2017)

region	standard deviation of CPI (2005-2017)
TR10	59.4510
TR21	58.5866
TR22	63.3396
TR31	60.1987
TR32	58.9570
TR33	58.4658
TR41	57.4876
TR42	59.4656
TR51	61.5232
TR52	58.9529
TR61	55.2832
TR62	61.5831
TR63	58.6223
TR71	61.8110
TR72	62.6714
TR81	57.6211
TR82	57.8593
TR83	59.0633
TR90	59.2122
TRA1	59.9702
TRA2	62.6233
TRB1	59.6803
TRB2	60.6224
TRC1	63.6731
TRC2	62.8307
TRC3	53.5813

Note: See Appendix B, Table B.1 for the provinces included in regions specified by codes.
Source: Author's own calculations.

Figure 3.2: Standard Deviation of CPI (NUTS2) (2005-2017)



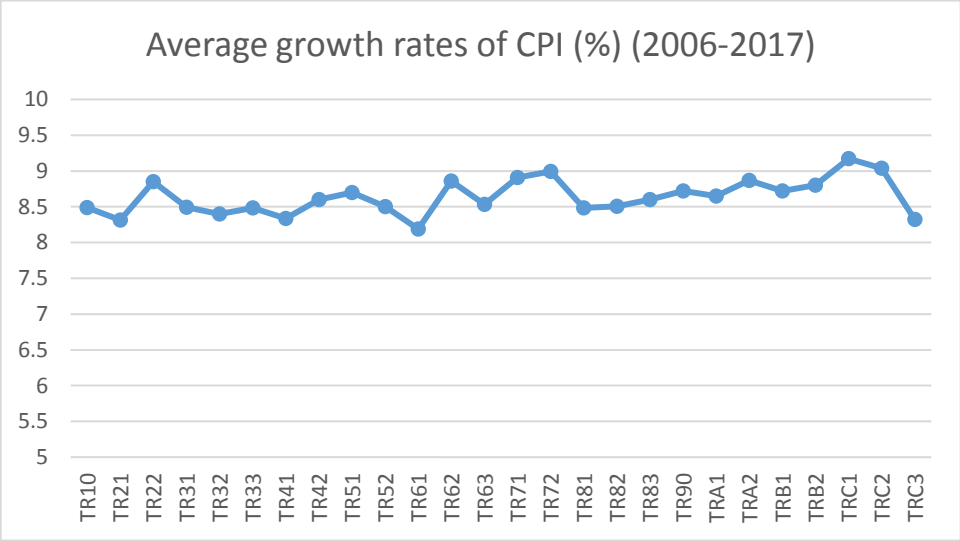
Source: Author's own calculations.

Table 3.3: Average Growth Rates of CPI (NUTS2) (%) (2006-2017)

region	Average growth rates of CPI (%) (2006-2017)
TR10	8.4877
TR21	8.3124
TR22	8.8501
TR31	8.4926
TR32	8.4007
TR33	8.4855
TR41	8.3366
TR42	8.6016
TR51	8.6978
TR52	8.5005
TR61	8.1886
TR62	8.8606
TR63	8.5346
TR71	8.9108
TR72	8.9947
TR81	8.4846
TR82	8.5049
TR83	8.6020
TR90	8.7193
TRA1	8.6477
TRA2	8.8697
TRB1	8.7230
TRB2	8.8031
TRC1	9.1711
TRC2	9.0400
TRC3	8.3211

Note: See Appendix B, Table B.1 for the provinces included in regions specified by codes.
Source: Author's own calculations.

Figure 3.3: Average Growth Rates of CPI (NUTS2) (%) (2006-2017)



Source: Author's own calculations.

Moreover, the comparison of exogenous model beta convergence (both for conditional and unconditional), sigma convergence and coefficient of variation with real values by using CPI and GDP deflator for NUTS2 level regions of Turkey is given in Appendix A since CPI on regional level is only valid for NUTS2. It can be observed that the results are almost the same so that using GDP Deflator is not a handicap under these conditions rather due to the reasons that are mentioned, it is relatively better than using CPI.

4. EXOGENOUS MODEL

The prime aim of this part is to analyze the convergence among regions of Turkey by using neoclassical exogenous technology model.

4.1 METHODS AND DATA

There is beta convergence if partial correlation between growth of income and its initial level is negative (Barro and Sala-i Martin, 1995). Beta convergence indicates that poor regions grow faster than rich regions and this catching up process creates a convergence. This reflects the characteristics of neoclassical growth theory formulated by Solow (1956) that the main assumption is that factors of production are subject to diminishing returns. In this work, beta (both conditional and unconditional) convergence analysis is made by using widely used neoclassical convergence model from Barro and Sala-i Martin (1992). The equation of the model is given below.

[4.1] $$\frac{1}{T}\log\left(\frac{y_{i,t}}{y_{i,t-T}}\right) = a - \left[\frac{1-e^{-\beta T}}{T}\right]\log\left(y_{i,t-T}\right) + u_{i,t}$$

In above equation, T represents the time interval, $y_{i,t-T}$ represents per capita income in the beginning year, $y_{i,t}$ represents per capita income for region i in year t (end year). Parameter β is the measure of beta convergence. In this model, positive β refers convergence while negative β implies divergence.

There are two different ways of obtaining the β. First way is to apply linear regression and finding β from $b = \left[\frac{1-e^{-\beta T}}{T}\right]$. The second way is to construct non-linear

regression that gives the value of β directly. However, in this model only beginning and end values are used. In other saying, there is a dependency of initial and end conditions. This may cause some problems if the economy faces different economic conditions like crisis in between period. Therefore, in order to use all available time periods, Lall and Yılmaz (2001) and Doğruel and Doğruel (2003) are followed and the model is converted into two successive years. The final equation for unconditional convergence is given in equation [4.2].

[4.2] $$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t$$

In this equation beta becomes $-\ln b$ by calling $\left[\frac{1-e^{-\beta T}}{T}\right]$ as "b" and taking the natural logarithm: $-\ln b = -\ln e^{-\beta T}$. This form can be rewritten as: $-\ln b = \beta$. The term "T" helps to control for the trend effect. Again positive β is required in order to indicate that there is convergence.

Moreover, in order to test the model for conditional convergence case, new variables that can represent the structural differences among regions/provinces need to be added to the equation. Within this scope, percentage share of agricultural and services sector in GDP are added to the model. Unlike per-capita income, these variables are added in current prices since they represent share, converting them into real values brings about conflict between relative and real values. Moreover, due to the nature of the model, one period lag of these variables are added to the model. Equation used to analyze conditional convergence given below.

[4.3] $$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t + eA_{i,t-1} + fS_{i,t-1}$$

In this equation $A_{i,t-1}$ and $S_{i,t-1}$ represent the percentage share of agricultural and services sector in GDP, respectively.

Furthermore, current income (GDP) data for regional level is only valid for the period between 2004 and 2017. Therefore, the investigation period for that part is the years between 2004 and 2017. The data is obtained from TURKSTAT.

Also, the analysis is made for NUTS1, NUTS2, and NUTS3 level regions of Turkey in order to make a comparison between different levels of regions.

According to Baltagi (2008) serial correlation and cross-sectional dependence are problems belong to macro panels that have long time series (over 20-30 years). Since the investigation period of this study is much shorter than this threshold, robustness check of the regressions is only made for heteroskedasticity and in the case of the validity of heteroskedasticity, robust standard errors are used. Furthermore, due to the short time period (small T), unit root tests are not applied.

Neoclassical model which investigates beta convergence from Barro and Sala-i Martin (1992) that is used in this work, usually indicates convergence because of the nature of this model. This model is about investigation between income and income with one lag when this model is converted into linear and two successive years form. As it is mentioned, beta equals to minus natural logarithm of the coefficient of one period lagged value of income. Therefore, there is very low possibility to find negative value of beta. Consequently, there is a need to investigate some other descriptive statistics like sigma convergence, coefficient of variation, richest poorest ratio, first second ratio and first third ratio and decrease in these ratios indicates convergence while increase implies divergence. Like in original model, in descriptive statistics, log form of income is used. Besides, descriptive statistics contains east-west comparisons in order to reach more accurate and comprehensive results. By following the general procedure east-west classification is made and it is illustrated in Appendix B. NUTS1, NUTS2 and NUTS3 level classifications are also given in Appendix B.

Apart from beta convergence, sigma convergence is also used in order to analyze the direction of change in regional differences because it investigates the standard deviation of the logarithm of per capita income. For convergence, standard deviation of income should have a decreasing trend. If it has an increasing trend, this represents divergence. Beta convergence is necessary but not sufficient condition for sigma convergence (Sala-i Martin, 1996). More simply, without sigma convergence, there may be beta convergence but if there is no beta convergence it is unnecessary to apply sigma convergence. As an alternative to sigma convergence, coefficient of variation method is also used. In this method standard deviation is divided by the mean so that potential biased results due to the potential effects of large fluctuations (because of rapid changes in growth rates) obtained from sigma convergence can be eliminated with the method of coefficient of variation. As in the sigma convergence if coefficient of variation will have a declining trend, this is a sign for convergence while increasing trend represents divergence.

4.2 EMPIRICAL RESULTS FOR NUTS1

4.2.1 NUTS1 Beta Convergence Results

Table 4.1: Hausman Test for NUTS1 (Unconditional)

Hausman Test
Ho: difference in coefficients not systematic
Prob>chi2 = 0.0000

Table 4.2: Heteroskedasticity Test for NUTS1 (Unconditional)

Heteroskedasticity Test
Modified Wald test for groupwise heteroskedasticity in fixed effects regression model **H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.9969

$$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t$$

Table 4.3: Beta Convergence (Unconditional) for NUTS1

Unconditional Convergence Results **Fixed-effects regression** **Number of observations:** 156 **Number of groups:** 12 **Dependent Variable:** $\log(y_{i,t})$	
Independent Variables	**Coefficient**
$\log(y_{i,t-1})$	0.6146*** (9.32) [0.0659]
T_t	0.0066*** (5.63) [0.0012]
Cons	1.5486*** (5.91) [0.2619]
Prob > F = 0.0000	**R-squared (within) =** 0.9449
Calculated β value: 0.4868	**Result:** Convergence

t statistics in ( ), standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

Table 4.4: Hausman Test for NUTS1 (Conditional)

Hausman Test
Ho: difference in coefficients not systematic Prob>chi2 = 0.0000

Table 4.5: Heteroskedasticity Test for NUTS1 (Conditional)

Heteroskedasticity Test
Modified Wald test for groupwise heteroskedasticity in fixed effects regression model **H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.9512

$$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t + eA_{i,t-1} + fS_{i,t-1}$$

Table 4.6: Beta Convergence (Conditional) for NUTS1

Conditional Convergence Results **Fixed-effects regression** **Number of observations:** 156 **Number of groups:** 12 **Dependent Variable:** $\log(y_{i,t})$	
Independent Variables	**Coefficient**
$\log(y_{i,t-1})$	0.5357*** (6.55) [0.0818]
T_t	0.0080*** (6.36) [0. 0013]
$A_{i,t-1}$	0. 0010 (0.55) [0.0016]
$S_{i,t-1}$	-0.0024** (-2.00) [0.0012]
Cons	1.9794*** (5.23) [0.3781]
Prob > F = 0.0000	**R-squared (within)=** 0.9488
Calculated β value: 0.6242	**Result:** Convergence

t statistics in ( ), standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

According to results, Hausman tests suggest to use fixed-effects regression as it should be because this work makes a regional analysis for Turkey in which all parts of the

country exists so that one need to care about within variation. Moreover, there is no heteroskedasticity problem in both regressions. Furthermore, tables above indicates convergence for both conditional and unconditional case. Besides, not surprisingly beta convergence for conditional case gives higher beta values because in that case structural differences among regions is controlled with the share of services and agricultural sector.

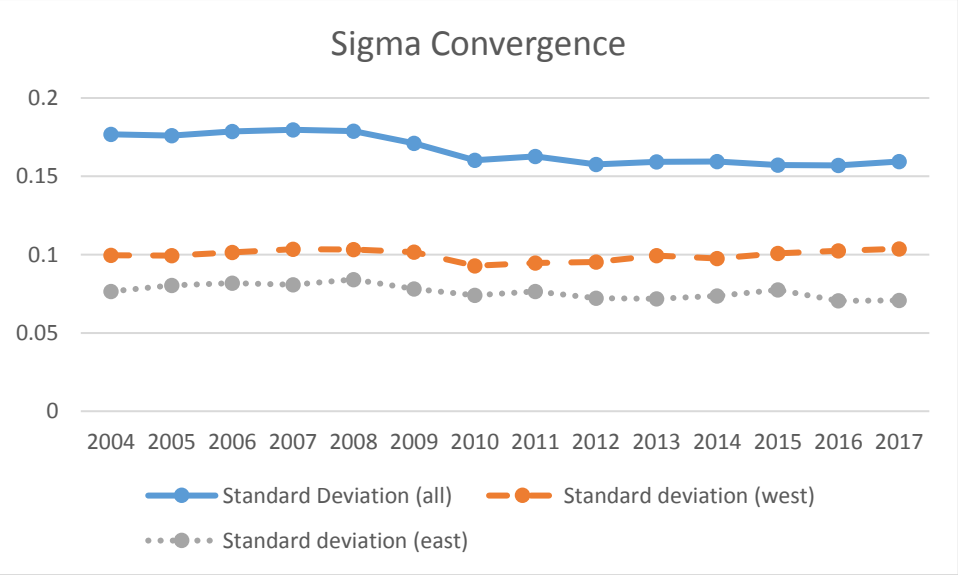
4.2.2 NUTS1 Descriptive Statistics

According to sigma convergence results given in Table 4.7 and Figure 4.1, it can be stated that the trend is fluctuating but looking for all (whole country), there is a decrease which indicates convergence. Besides, investigating the table and the figure carefully, one can easily notice that the main decrease happens in the crisis (2008 crisis). Subtracting the crisis years from the sample the trend may not indicate convergence. Besides, looking for east and west separately, by comparing the beginning and end periods, there is a decrease in east (indication of convergence) and increase in west (indication of divergence). Consequently, sigma convergence does not indicate convergence or divergence. However, investigating this issue by looking at whole country (all), there is a decrease which indicates convergence. In other words, decrease in east is more dominant than increase in west. Consequently, it is impossible to state something certain related with convergence issue since the picture is somewhat different in east and west (the result is close to convergence in east but close to divergence in west. The reason of using the term “close” is that the trend is fluctuating and there is no much increase/decrease when end period is compared with beginning period).

Table 4.7: Sigma Convergence for NUTS1

year	Standard Deviation of $\log(y)$ (all)	Standard deviation of $\log(y)$ (west)	Standard deviation of $\log(y)$ (east)
2004	0.1768	0.0996	0.0765
2005	0.1760	0.0993	0.0803
2006	0.1786	0.1015	0.0817
2007	0.1797	0.1034	0.0808
2008	0.1789	0.1033	0.0841
2009	0.1710	0.1017	0.0782
2010	0.1603	0.0929	0.0740
2011	0.1627	0.0947	0.0765
2012	0.1576	0.0954	0.0721
2013	0.1593	0.0993	0.0717
2014	0.1594	0.0974	0.0737
2015	0.1572	0.1008	0.0776
2016	0.1569	0.1025	0.0705
2017	0.1593	0.1037	0.0707

Figure 4.1: Sigma Convergence for NUTS1

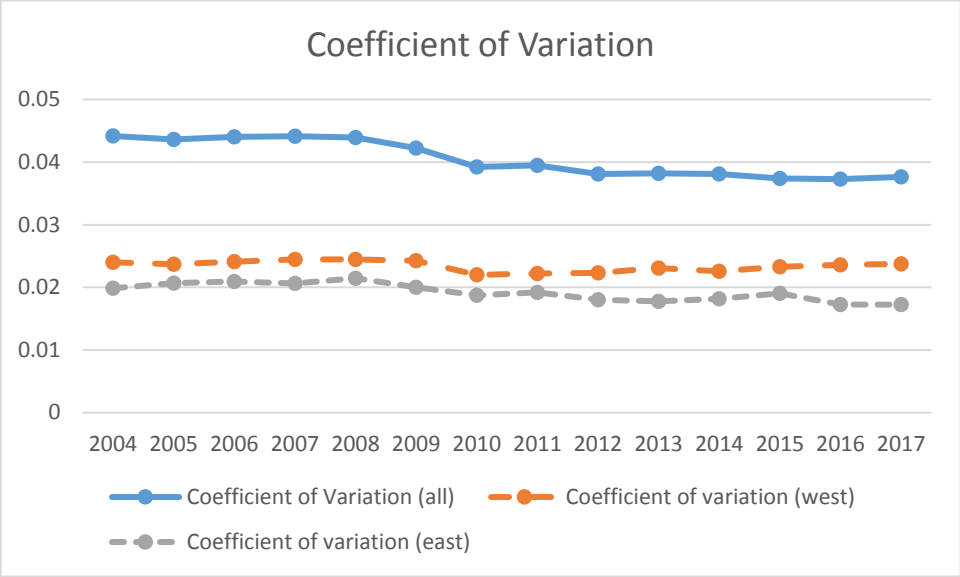


According to coefficient of variation results given in Table 4.8 and Figure 4.2, it cannot be stated that there is a general decrease because there is a decrease during crisis period but apart from that it is impossible to state that there is a general decreasing trend. Consequently, it can be stated that there is neither convergence nor divergence. However, comparing beginning and end periods, there is a decrease so that the result is close to convergence probably due to the effects of 2008 crisis.

Table 4.8: Coefficient of Variation for NUTS1

year	Coefficient of Variation of $\log(y)$ (all)	Coefficient of variation of $\log(y)$ (west)	Coefficient of variation of $\log(y)$ (east)
2004	0.0442	0.0240	0.0199
2005	0.0436	0.0237	0.0207
2006	0.0440	0.0241	0.0209
2007	0.0441	0.0245	0.0206
2008	0.0439	0.0245	0.0215
2009	0.0422	0.0242	0.0200
2010	0.0392	0.0220	0.0187
2011	0.0395	0.0222	0.0192
2012	0.0381	0.0223	0.0180
2013	0.0382	0.0231	0.0178
2014	0.0381	0.0226	0.0182
2015	0.0374	0.0233	0.0190
2016	0.0373	0.0236	0.0173
2017	0.0376	0.0238	0.0172

Figure 4.2: Coefficient of Variation for NUTS1

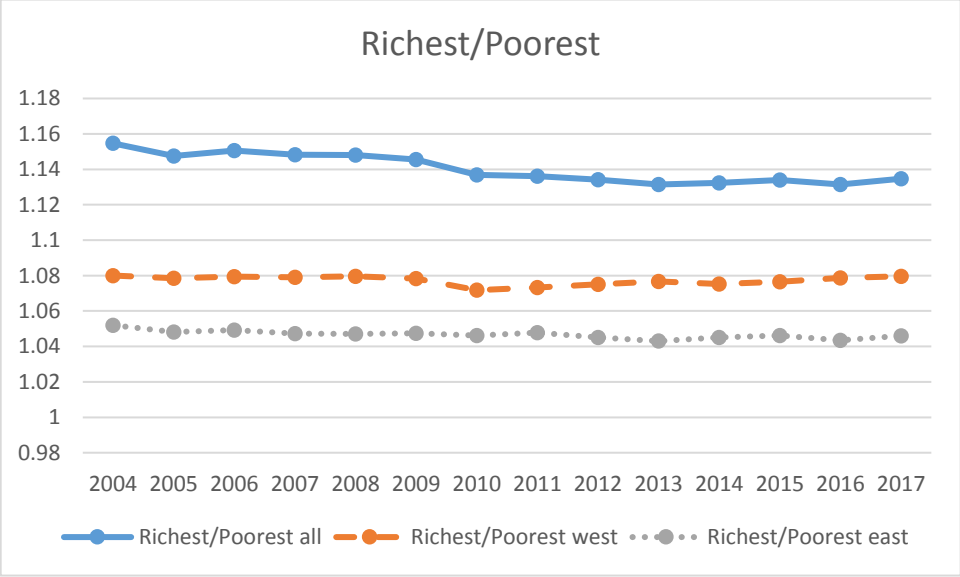


According to richest poorest ratio given in Table 4.9 and Figure 4.3, it can be stated that there is a decline in crisis period but apart from that, it cannot be stated that there is certain decrease or increase. Consequently, again it can be stated that there is neither convergence nor divergence. However, again comparing the beginning and the end periods it can be indicated that the results is close to convergence probably due the effects of 2008 crisis.

Table 4.9: Richest Poorest Ratio for NUTS1

year	Richest/Poorest ratio of $\log(y)$ (all)	Richest/Poorest ratio of $\log(y)$ (west)	Richest/Poorest ratio of $\log(y)$ (east)
2004	1.1547	1.0800	1.0520
2005	1.1476	1.0786	1.0482
2006	1.1507	1.0795	1.0492
2007	1.1483	1.0790	1.0472
2008	1.1481	1.0796	1.0471
2009	1.1456	1.0784	1.0475
2010	1.1368	1.0718	1.0461
2011	1.1361	1.0733	1.0478
2012	1.1342	1.0750	1.0451
2013	1.1315	1.0766	1.0430
2014	1.1324	1.0752	1.0451
2015	1.1339	1.0765	1.0462
2016	1.1315	1.0788	1.0435
2017	1.1347	1.0796	1.0461

Figure 4.3: Richest Poorest Ratio for NUTS1

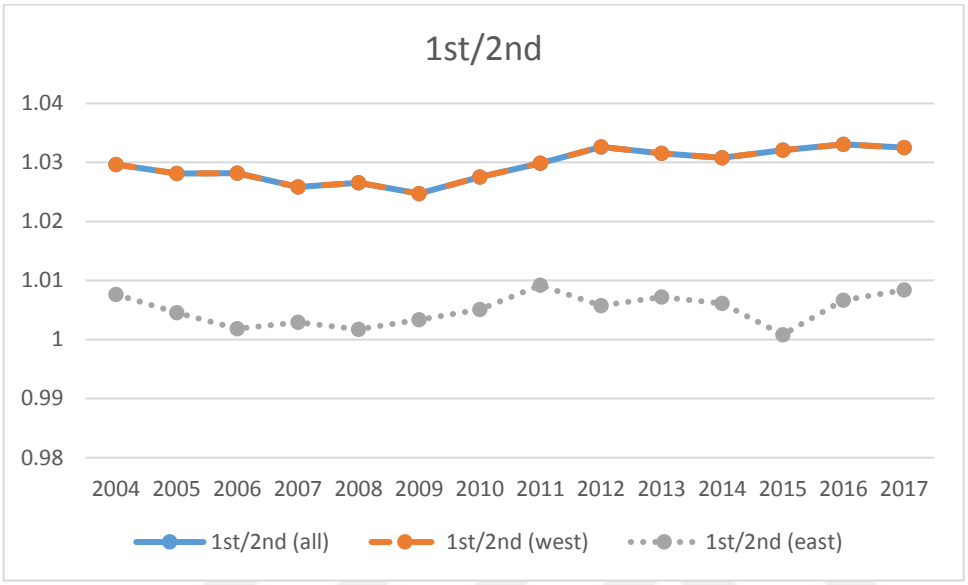


According to First Second Ratio given in Table 4.10 and Figure 4.4, it is impossible to state something certain since the trend is fluctuating. However, again comparing the beginning and end periods, it can be captured that there is a slight increase. Therefore, according to this statistics the result is close to divergence.

Table 4.10: First Second Ratio for NUTS1

year	1st/2nd ratio of $\log(y)$ (all)	1st/2nd ratio of $\log(y)$ (west)	1st/2nd ratio of $\log(y)$ (east)
2004	1.0297	1.0297	1.0076
2005	1.0281	1.0281	1.0045
2006	1.0282	1.0282	1.0018
2007	1.0259	1.0259	1.0029
2008	1.0266	1.0266	1.0018
2009	1.0247	1.0247	1.0034
2010	1.0275	1.0275	1.0051
2011	1.0299	1.0299	1.0092
2012	1.0326	1.0326	1.0057
2013	1.0315	1.0315	1.0072
2014	1.0308	1.0308	1.0061
2015	1.0321	1.0321	1.0008
2016	1.0331	1.0331	1.0066
2017	1.0325	1.0325	1.0084

Figure 4.4: First Second Ratio for NUTS1

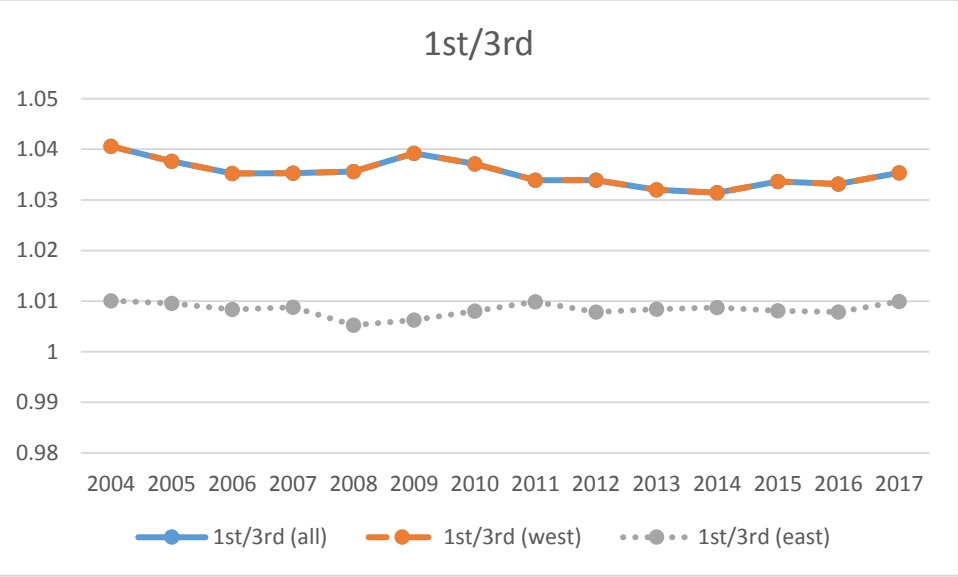


According to first third ratio given in Table 4.11 and Figure 4.5, it can be stated that the trend is fluctuating, but comparing beginning and end periods, the result is close to convergence.

Table 4.11: First Third Ratio for NUTS1

year	1st/3rd ratio of log(y) (all)	1st/3rd ratio of log(y) (west)	1st/3rd ratio of log(y) (east)
2004	1.0406	1.0406	1.0101
2005	1.0376	1.0376	1.0095
2006	1.0352	1.0352	1.0084
2007	1.0353	1.0353	1.0088
2008	1.0356	1.0356	1.0052
2009	1.0392	1.0392	1.0062
2010	1.0371	1.0371	1.0080
2011	1.0339	1.0339	1.0099
2012	1.0339	1.0339	1.0078
2013	1.0320	1.0320	1.0084
2014	1.0314	1.0314	1.0087
2015	1.0336	1.0336	1.0081
2016	1.0331	1.0331	1.0078
2017	1.0353	1.0353	1.0099

Figure 4.5: First Third Ratio for NUTS1



4.3 EMPIRICAL RESULTS FOR NUTS2

4.3.1 NUTS2 Beta Convergence Results

Table 4.12: Hausman Test for NUTS2 (Unconditional)

Hausman Test
Ho: difference in coefficients not systematic Prob>chi2 = 0.0000

Table 4.13: Heteroskedasticity Test for NUTS2 (Unconditional)

Heteroskedasticity Test
Modified Wald test for groupwise heteroskedasticity in fixed effects regression model **H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.0094

$$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t$$

Table 4.14: Beta Convergence (Unconditional) for NUTS2

Unconditional Convergence Results **Fixed-effects regression** **Number of observations:** 338 **Number of groups:** 26 **Dependent Variable:** $\log(y_{i,t})$	
Independent Variables	**Coefficient**
$\log(y_{i,t-1})$	0.6752*** (16.61) [0.0407]
T_t	0.0057*** (6.76) [0. 0008]
Cons	1.2977*** (8.14) [0. 1595]
Prob > F = 0.0000	**R-squared (within) =** 0.9398
Calculated β value: 0.3927	**Result:** Convergence

t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

Table 4.15: Hausman Test for NUTS2 (Conditional)

Hausman Test
Ho: difference in coefficients not systematic Prob>chi2 = 0.0000

Table 4.16: Heteroskedasticity Test for NUTS2 (Conditional)

Heteroskedasticity Test
Modified Wald test for groupwise heteroskedasticity in fixed effects regression model **H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.0018

$$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t + eA_{i,t-1} + fS_{i,t-1}$$

Table 4.17: Beta Convergence (Conditional) for NUTS2

Conditional Convergence Results **Fixed-effects regression** **Number of observations:** 338 **Number of groups:** 26 **Dependent Variable:** $\log(y_{i,t})$	
Independent Variables	**Coefficient**
$\log(y_{i,t-1})$	0.6227*** (9.33) [0. 0667]
T_t	0.0070*** (6.00) [0.0012]
$A_{i,t-1}$	0.0014 (1.39) [0.0010]
$S_{i,t-1}$	-0.0016 (-1.47) [0.0011]
Cons	1.5629*** (4.99) [0.3132]
Prob > F = 0.0000	**R-squared (within)=** 0.9437
Calculated β value: 0.4736	**Result:** Convergence

t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

Hausman tests suggest to use Fixed-effects Model like the case in NUTS1 level. However, this time, robust standard errors are used in order to cope with the heteroskedasticity problem. The results of beta convergence analysis indicate convergence for both unconditional and conditional case.

4.3.2 NUTS2 Descriptive Statistics

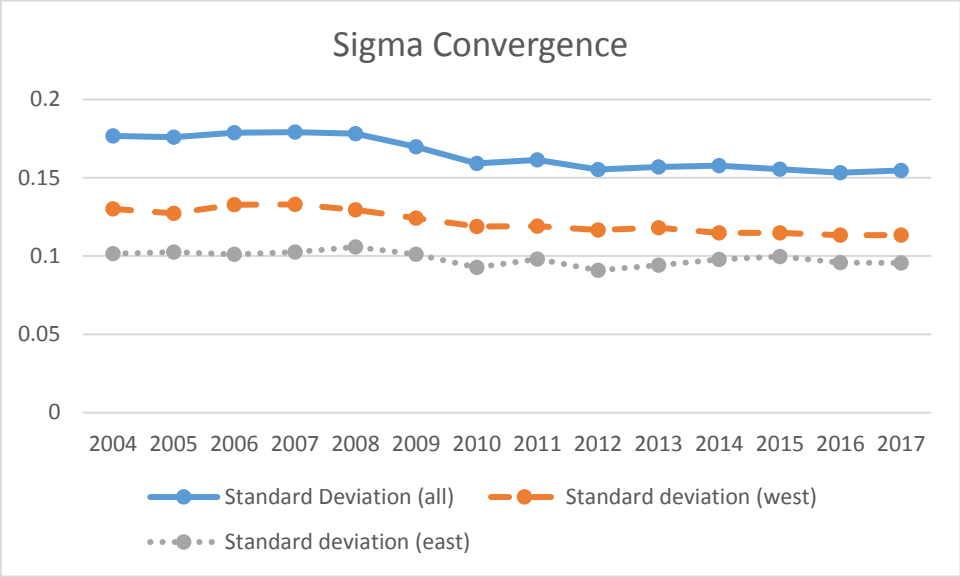
According to sigma convergence test results given in Table 4.18 and Figure 4.6, comparing the beginning and the end periods, one can capture that there is a decrease which indicates convergence. However, the picture is not clear again because the main decrease

happens in the crisis period. But after the crisis it cannot be captured any increase again and the post-crisis trend does not give any certain result. Consequently, comparing the beginning and end periods, there is a decrease so that it can be stated that the result is close to convergence.

Table 4.18: Sigma Convergence for NUTS2

year	Standard Deviation of $\log(y)$ (all)	Standard deviation of $\log(y)$ (west)	Standard deviation of $\log(y)$ (east)
2004	0.1766	0.1300	0.1016
2005	0.1760	0.1273	0.1026
2006	0.1787	0.1327	0.1011
2007	0.1791	0.1330	0.1026
2008	0.1781	0.1294	0.1058
2009	0.1698	0.1243	0.1011
2010	0.1592	0.1189	0.0928
2011	0.1614	0.1190	0.0981
2012	0.1553	0.1167	0.0909
2013	0.1569	0.1180	0.0941
2014	0.1578	0.1148	0.0979
2015	0.1554	0.1148	0.0996
2016	0.1532	0.1133	0.0958
2017	0.1547	0.1135	0.0957

Figure 4.6: Sigma Convergence for NUTS2

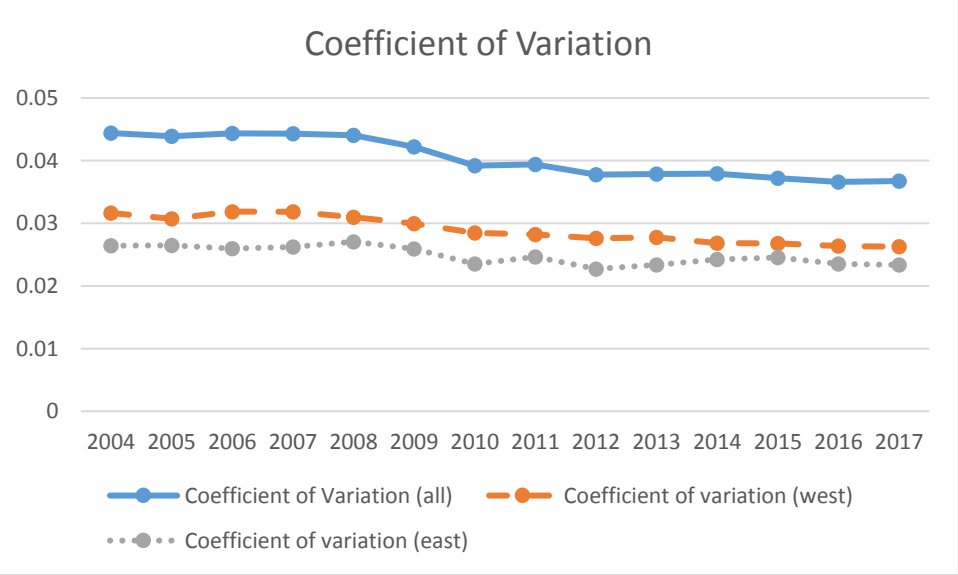


According to coefficient of variation results given in Table 4.19 and Figure 4.7, there is a decrease. But again this decrease mainly happens in the crisis period. However, after the crisis the trend does not increase again. Consequently, considering the crisis happens in the investigation period, it cannot be indicated something certain but the results are closer to state that there is convergence.

Table 4.19: Coefficient of Variation for NUTS2

year	Coefficient of Variation of $\log(y)$ (all)	Coefficient of variation of $\log(y)$ (west)	Coefficient of variation of $\log(y)$ (east)
2004	0.0444	0.0316	0.0264
2005	0.0439	0.0307	0.0265
2006	0.0443	0.0319	0.0260
2007	0.0443	0.0318	0.0262
2008	0.0440	0.0310	0.0270
2009	0.0422	0.0299	0.0259
2010	0.0392	0.0285	0.0235
2011	0.0394	0.0282	0.0247
2012	0.0377	0.0276	0.0227
2013	0.0379	0.0277	0.0234
2014	0.0379	0.0268	0.0242
2015	0.0372	0.0268	0.0245
2016	0.0366	0.0264	0.0235
2017	0.0368	0.0263	0.0234

Figure 4.7: Coefficient of Variation for NUTS2

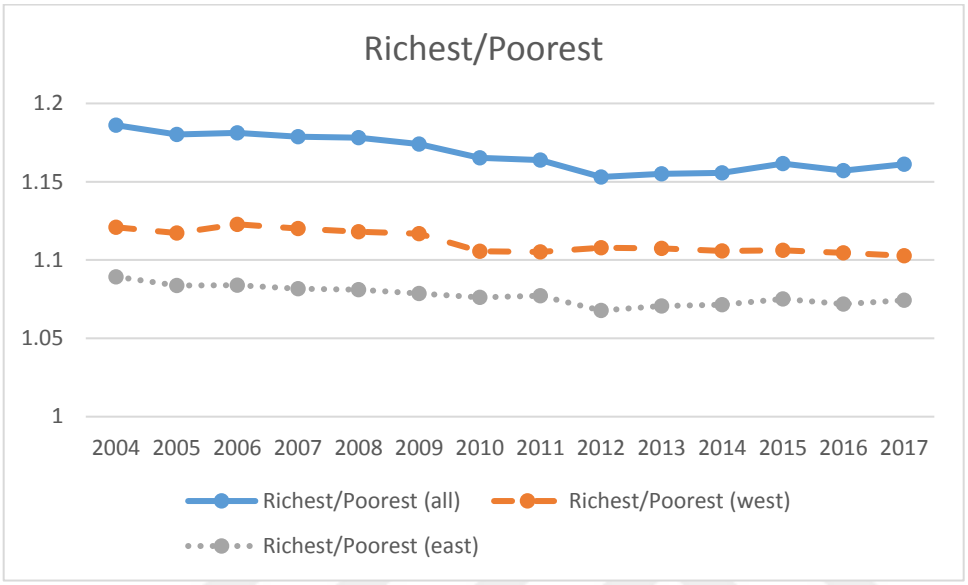


According to results of richest poorest ratio analysis, although the trend is not very clear and the crisis is the main actor for the main decrease, the picture is closer to state that there is convergence as the decreasing trend is more dominant.

Table 4.20: Richest Poorest Ratio for NUTS2

year	Richest/poorest ratio of $\log(y)$ (all)	Richest/Poorest ratio of $\log(y)$ (west)	Richest/Poorest ratio of $\log(y)$ (east)
2004	1.1861	1.1210	1.0894
2005	1.1801	1.1172	1.0837
2006	1.1811	1.1228	1.0840
2007	1.1787	1.1200	1.0817
2008	1.1782	1.1180	1.0811
2009	1.1741	1.1168	1.0787
2010	1.1653	1.1056	1.0761
2011	1.1639	1.1052	1.0773
2012	1.1531	1.1079	1.0678
2013	1.1550	1.1074	1.0706
2014	1.1557	1.1058	1.0714
2015	1.1616	1.1062	1.0751
2016	1.1571	1.1046	1.0718
2017	1.1613	1.1028	1.0743

Figure 4.8: Richest Poorest Ratio for NUTS2

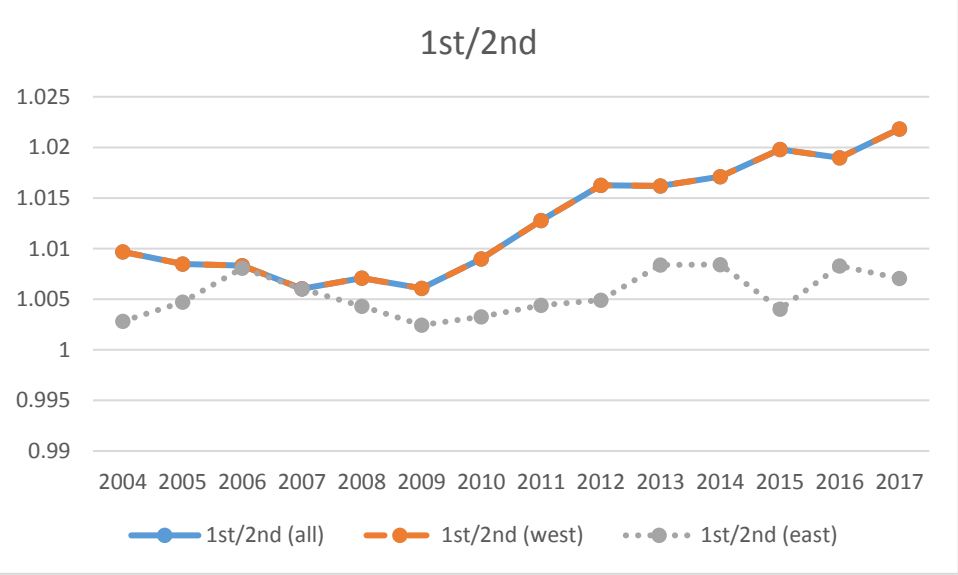


According to results of first second ratio analysis given in Table 4.21 and Figure 4.9, it can be stated that there is divergence. But the divergence is much clearer for west.

Table 4.21: First Second Ratio for NUTS2

year	1st/2nd ratio of log(y) (all)	1st/2nd ratio of log(y) (west)	1st/2nd ratio of log(y) (east)
2004	1.0097	1.0097	1.0028
2005	1.0085	1.0085	1.0047
2006	1.0083	1.0083	1.0081
2007	1.0060	1.0060	1.0060
2008	1.0071	1.0071	1.0043
2009	1.0061	1.0061	1.0024
2010	1.0090	1.0090	1.0033
2011	1.0128	1.0128	1.0044
2012	1.0163	1.0163	1.0049
2013	1.0162	1.0162	1.0084
2014	1.0171	1.0171	1.0084
2015	1.0198	1.0198	1.0040
2016	1.0190	1.0190	1.0083
2017	1.0218	1.0218	1.0071

Figure 4.9: First Second Ratio for NUTS2

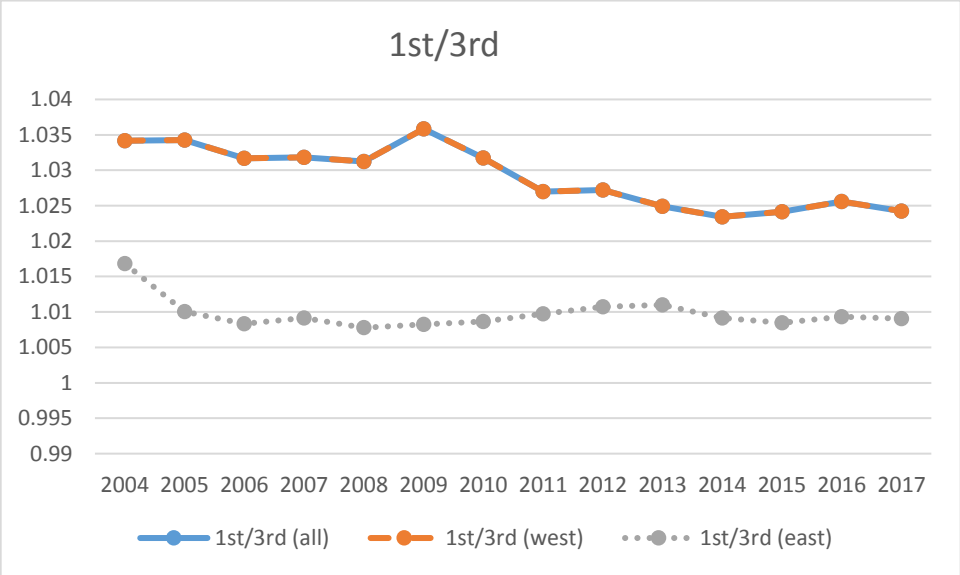


According to result of first third ratio analysis given in Table 4.22 and Figure 4.10, it can be stated that the picture is closer to state that there is convergence. Although the trend is not clear, decreasing trend can be captured by comparing the beginning and end values.

Table 4.22: First Third Ratio for NUTS2

year	1st/3rd ratio of $\log(y)$ (all)	1st/3rd ratio of $\log(y)$ (west)	1st/3rd ratio of $\log(y)$ (east)
2004	1.0342	1.0342	1.0168
2005	1.0342	1.0342	1.0101
2006	1.0317	1.0317	1.0084
2007	1.0318	1.0318	1.0092
2008	1.0312	1.0312	1.0078
2009	1.0358	1.0358	1.0082
2010	1.0317	1.0317	1.0087
2011	1.0270	1.0270	1.0097
2012	1.0272	1.0272	1.0107
2013	1.0249	1.0249	1.0110
2014	1.0234	1.0234	1.0092
2015	1.0242	1.0242	1.0085
2016	1.0256	1.0256	1.0093
2017	1.0243	1.0243	1.0091

Figure 4.10: First Third Ratio for NUTS2



4.4 EMPIRICAL RESULTS FOR NUTS3

4.4.1 NUTS3 Beta Convergence Results

Table 4.23: Hausman Test for NUTS3 (Unconditional)

Hausman Test
Ho: difference in coefficients not systematic Prob>chi2 = 0.0000

Table 4.24: Heteroskedasticity Test for NUTS3 (Unconditional)

Heteroskedasticity Test
Modified Wald test for groupwise heteroskedasticity in fixed effects regression model **H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.0000

$$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t$$

Table 4.25: Beta Convergence (Unconditional) for NUTS3

Unconditional Convergence Results **Fixed-effects regression** **Number of observations:** 1053 **Number of groups:** 81 **Dependent Variable:** $\log(y_{i,t})$	
Independent Variables	**Coefficient**
$\log(y_{i,t-1})$	0. 6399*** (22.13) [0.0277]
T_t	0. 0065*** (11.81) [0.0005]
Cons	1.4242*** (13.20) [0. 1079]
Prob > F = 0.0000	**R-squared (within) =** 0.9294
Calculated β value: 0.4465	**Result:** Convergence

t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

Table 4.26: Hausman Test for NUTS3 (Conditional)

Hausman Test
Ho: difference in coefficients not systematic Prob>chi2 = 0.0000

Table 4.27: Heteroskedasticity Test for NUTS3 (Conditional)

Heteroskedasticity Test
Modified Wald test for groupwise heteroskedasticity in fixed effects regression model **H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.0000

$$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t + eA_{i,t-1} + fS_{i,t-1}$$

Table 4.28: Beta Convergence (Conditional) for NUTS3

Conditional Convergence Results **Fixed-effects regression** **Number of observations:** 1053 **Number of groups:** 81 **Dependent Variable:** $\log(y_{i,t})$	
Independent Variables	**Coefficient**
$\log(y_{i,t-1})$	0. 5926*** (14.22) [0. 0417]
T_t	0. 0074*** (10.76) [0.0007]
$A_{i,t-1}$	0. 0002 (0.29) [0. 0006]
$S_{i,t-1}$	-0.0009 (-1.63) [0.0006]
Cons	1.6526*** (8.57) [0. 1928]
Prob > F = 0.0000	**R-squared (within)=** 0.9301
Calculated β value: 0.5233	**Result:** Convergence

t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

Hausman test again suggest to construct fixed-effects model as it should be. Robust standard errors are used in order to cope with the problem of heteroskedasticity as in NUTS2 level. According to beta convergence analysis, there is convergence for both unconditional and conditional case.

4.4.2 NUTS3 Descriptive Statistics

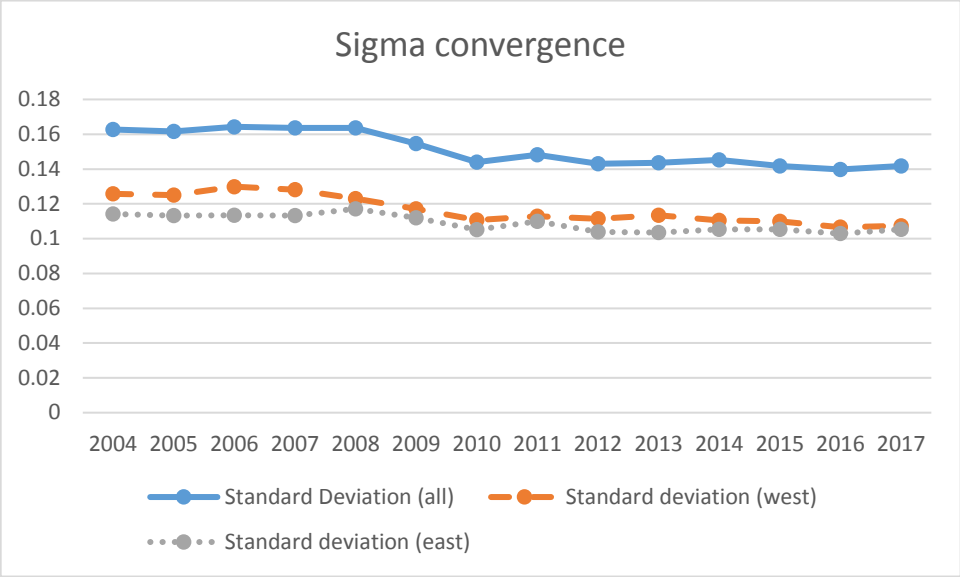
According to results of sigma convergence analysis given below in Table 4.29 and Figure 4.11, although the trend is not very clear and the main decrease happens due to 2008

financial crisis, the result is close to state that there is convergence when the decision is made by comparing the beginning and the end values.

Table 4.29: Sigma Convergence for NUTS3

year	Standard Deviation of $\log(y)$ (all)	Standard deviation of $\log(y)$ (west)	Standard deviation of $\log(y)$ (east)
2004	0.1627	0.1257	0.1142
2005	0.1617	0.1250	0.1132
2006	0.1643	0.1299	0.1135
2007	0.1636	0.1282	0.1133
2008	0.1636	0.1230	0.1171
2009	0.1546	0.1171	0.1120
2010	0.1440	0.1106	0.1051
2011	0.1483	0.1128	0.1099
2012	0.1430	0.1114	0.1039
2013	0.1436	0.1134	0.1034
2014	0.1453	0.1105	0.1053
2015	0.1417	0.1100	0.1054
2016	0.1398	0.1066	0.1029
2017	0.1418	0.1073	0.1054

Figure 4.11: Sigma Convergence for NUTS3

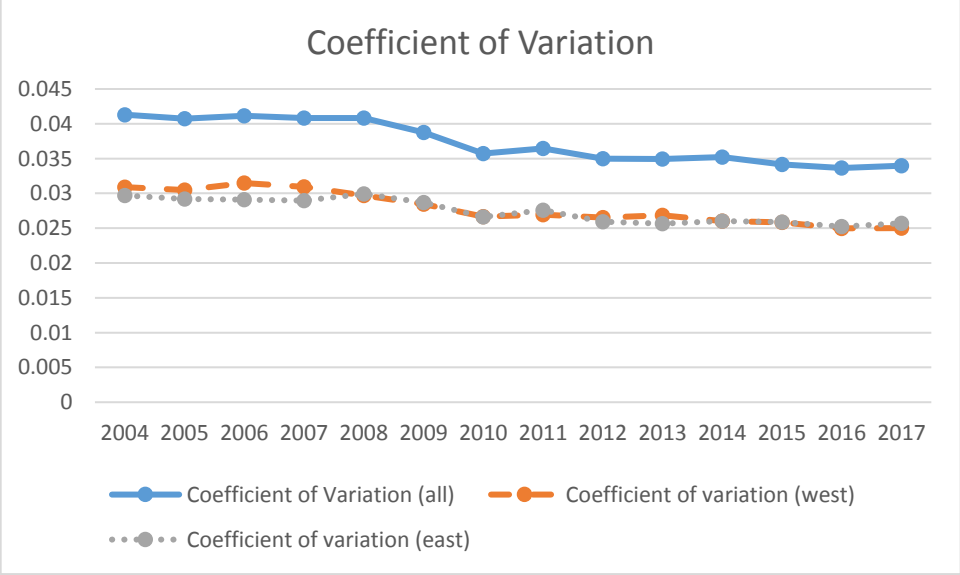


According to results of Coefficient of Variation analysis, the results are almost the same as sigma convergence analysis which indicates that it is close to state that there is convergence. However, the trend is not very clear again, and the main decrease happens in the crisis period.

Table 4.30: Coefficient of Variation for NUTS3

year	Coefficient of Variation of $\log(y)$ (all)	Coefficient of variation of $\log(y)$ (west)	Coefficient of variation of $\log(y)$ (east)
2004	0.0413	0.0309	0.0297
2005	0.0407	0.0305	0.0292
2006	0.0412	0.0315	0.0291
2007	0.0408	0.0310	0.0290
2008	0.0408	0.0297	0.0299
2009	0.0387	0.0284	0.0287
2010	0.0357	0.0267	0.0266
2011	0.0365	0.0270	0.0276
2012	0.0350	0.0265	0.0259
2013	0.0349	0.0268	0.0257
2014	0.0352	0.0260	0.0260
2015	0.0342	0.0258	0.0259
2016	0.0336	0.0250	0.0252
2017	0.0340	0.0250	0.0257

Figure 4.12: Coefficient of Variation for NUTS3

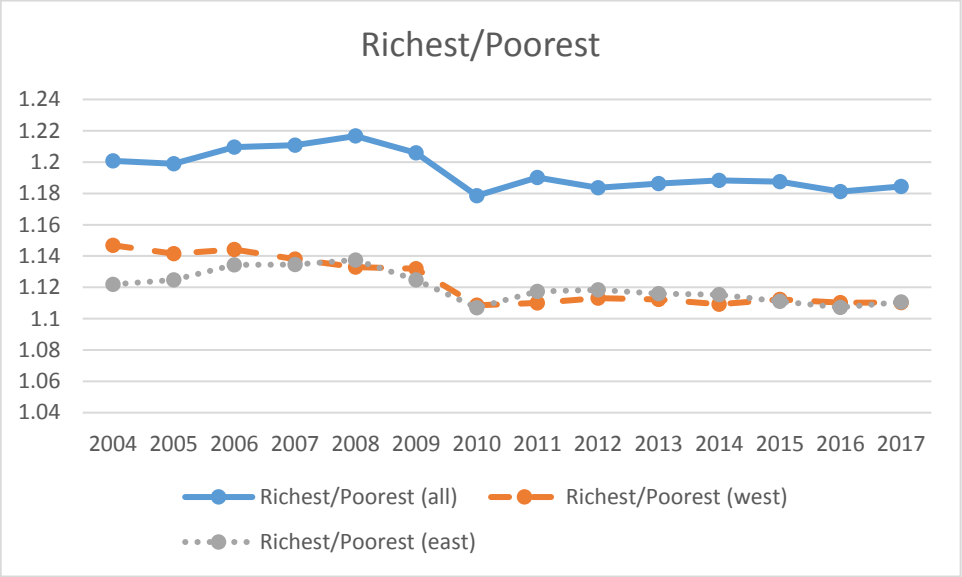


According to results of richest poorest analysis given below in Table 4.31 and Figure 4.13, comparing the beginning and end values, there is a decrease which indicates convergence. However, there is no such a certain decreasing trend apart from crisis period. Consequently, the result is uncertain but it is close to state that there is convergence.

Table 4.31: Richest Poorest Ratio for NUTS3

year	Richest/Poorest ratio of $\log(y)$ (all)	Richest/Poorest ratio of $\log(y)$ (west)	Richest/Poorest ratio of $\log(y)$ (east)
2004	1.2007	1.1468	1.1220
2005	1.1990	1.1415	1.1248
2006	1.2095	1.1442	1.1344
2007	1.2108	1.1381	1.1346
2008	1.2166	1.1329	1.1375
2009	1.2058	1.1319	1.1248
2010	1.1785	1.1086	1.1071
2011	1.1901	1.1100	1.1174
2012	1.1835	1.1132	1.1185
2013	1.1862	1.1123	1.1161
2014	1.1883	1.1093	1.1153
2015	1.1874	1.1123	1.1110
2016	1.1812	1.1102	1.1072
2017	1.1844	1.1103	1.1106

Figure 4.13: Richest Poorest Ratio for NUTS3

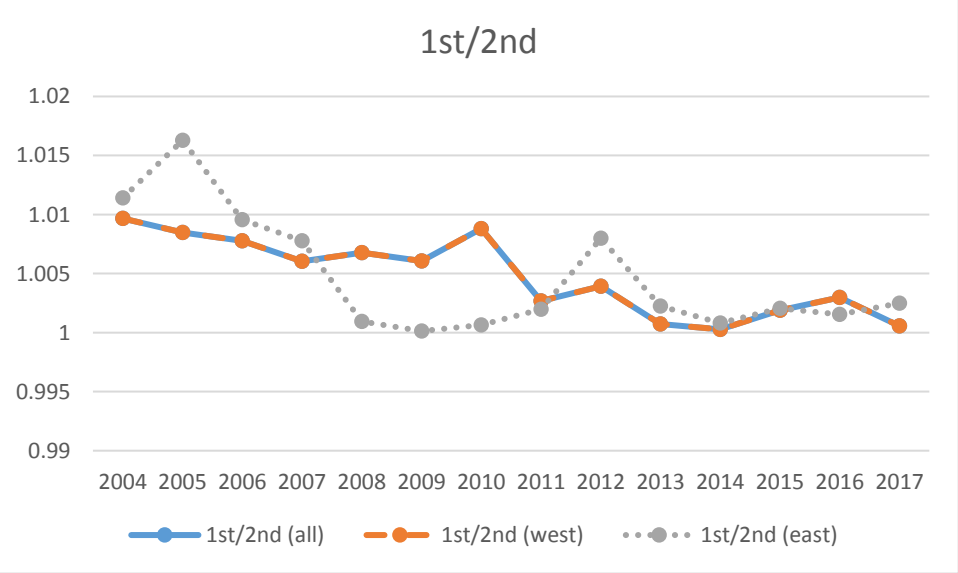


According to results of the first second ratio analysis, although the trend is fluctuating (there is a kind of uncertainty), mainly there is a dominance of decreasing trend which indicates convergence.

Table 4.32: First Second Ratio for NUTS3

year	1st/2nd ratio of log(y) (all)	1st/2nd ratio of log(y) (west)	1st/2nd ratio of log(y) (east)
2004	1.0097	1.0097	1.0114
2005	1.0085	1.0085	1.0163
2006	1.0078	1.0078	1.0096
2007	1.0060	1.0060	1.0078
2008	1.0068	1.0068	1.0009
2009	1.0061	1.0061	1.0001
2010	1.0088	1.0088	1.0006
2011	1.0027	1.0027	1.0020
2012	1.0039	1.0039	1.0080
2013	1.0007	1.0007	1.0022
2014	1.0003	1.0003	1.0008
2015	1.0019	1.0019	1.0021
2016	1.0030	1.0030	1.0015
2017	1.0006	1.0006	1.0025

Figure 4.14: First Second Ratio for NUTS3

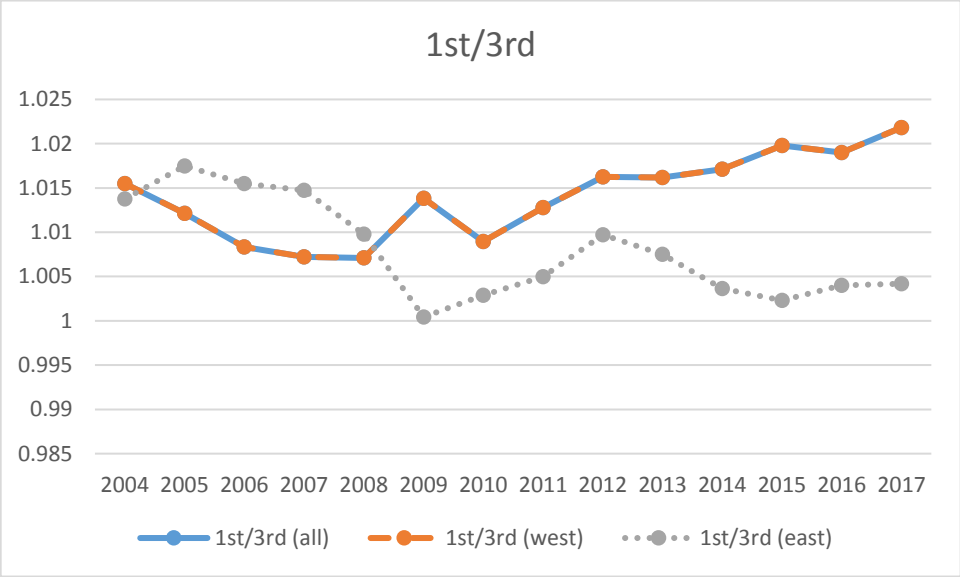


According to results obtained from the first third ratio analysis given in Table 4.33 and Figure 4.15, it can be stated that that there is again uncertainty because although there is a decreasing trend which indicates convergence in east, in west, there is an increasing trend which indicates divergence.

Table 4.33: First Third Ratio for NUTS3

year	1st/3rd ratio of $\log(y)$ (all)	1st/3rd ratio of $\log(y)$ (west)	1st/3rd ratio of $\log(y)$ (east)
2004	1.0155	1.0155	1.0138
2005	1.0121	1.0121	1.0175
2006	1.0083	1.0083	1.0155
2007	1.0072	1.0072	1.0148
2008	1.0071	1.0071	1.0098
2009	1.0138	1.0138	1.0004
2010	1.0090	1.0090	1.0029
2011	1.0128	1.0128	1.0050
2012	1.0163	1.0163	1.0097
2013	1.0162	1.0162	1.0075
2014	1.0171	1.0171	1.0036
2015	1.0198	1.0198	1.0023
2016	1.0190	1.0190	1.0040
2017	1.0218	1.0218	1.0042

Figure 4.15: First Third Ratio for NUTS3



4.5 SUMMARY AND COMPARISON AMONG NUTS1, NUTS2, AND NUTS3

In order to compare the results obtained from NUT1, NUTS2, and NUT3 level regions, summary tables are presented below.

Table 4.34: Beta Convergence (Unconditional)

Beta Convergence (Unconditional)					
NUTS1 (12 regions)		**NUTS2 (26 regions)**		**NUTS3 (81 provinces)**	
Heteroskedasticity Test		**Heteroskedasticity Test**		**Heteroskedasticity Test**	
H0: sigma(i)^2=sigma^2 Pr.: 0.9969		**H0: sigma(i)^2=sigma^2** Pr.: 0.0094		**H0: sigma(i)^2=sigma^2** Pr.: 0.0000	
$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t$		$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t$		$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t$	
Fixed-effects regression		**Fixed-effects regression**		**Fixed-effects regression**	
Independent Variables	**Coefficient**	**Independent Variables**	**Coefficient**	**Independent Variables**	**Coefficient**
$\log(y_{i,t-1})$	0.6146*** (9.32) [0.0659]	$\log(y_{i,t-1})$	0.6752*** (16.61) [0.0407]	$\log(y_{i,t-1})$	0. 6399*** (22.13) [0.0277]
T_t	0.0066*** (5.63) [0.0012]	T_t	0.0057*** (6.76) [0. 0008]	T_t	0. 0065*** (11.81) [0.0005]
Cons	1.5486*** (5.91) [0.2619]	Cons	1.2977*** (8.14) [0. 1595]	Cons	1.4242*** (13.20) [0. 1079]
$\boldsymbol{\beta}$ **value:** 0.4868 **Result:** Convergence		$\boldsymbol{\beta}$ **value:** 0.3927 **Result:** Convergence		$\boldsymbol{\beta}$ **value:** 0.4465 **Result:** Convergence	
t statistics in ( ), standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.		t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.		t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.	

Table 4.35: Beta Convergence (Conditional)

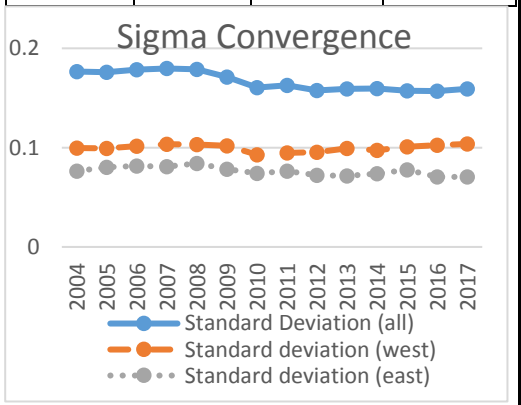
Beta Convergence (Conditional)					
NUTS1 (12 regions)		**NUTS2 (26 regions)**		**NUTS3 (81 provinces)**	
Heteroskedasticity Test		**Heteroskedasticity Test**		**Heteroskedasticity Test**	
H0: sigma(i)^2=sigma^2 Pr.: 0.9512		**H0: sigma(i)^2=sigma^2** Pr.: 0.0018		**H0: sigma(i)^2=sigma^2** Pr.: 0.0000	
$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t + eA_{i,t-1} + fS_{i,t-1}$		$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t + eA_{i,t-1} + fS_{i,t-1}$		$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t + eA_{i,t-1} + fS_{i,t-1}$	
ixed-effects regression		**Fixed-effects regression**		**Fixed-effects regression**	
Independent Variables	**Coefficient**	**Independent Variables**	**Coefficient**	**Independent Variables**	**Coefficient**
$\log(y_{i,t-1})$	0.5357*** (6.55) [0.0818]	$\log(y_{i,t-1})$	0.6227*** (9.33) [0. 0667]	$\log(y_{i,t-1})$	0. 5926*** (14.22) [0. 0417]
T_t	0.0080*** (6.36) [0. 0013]	T_t	0.0070*** (6.00) [0.0012]	T_t	0. 0074*** (10.76) [0.0007]
$A_{i,t-1}$	0. 0010 (0.55) [0.0016]	$A_{i,t-1}$	0.0014 (1.39) [0.0010]	$A_{i,t-1}$	0. 0002 (0.29) [0. 0006]
$S_{i,t-1}$	-0.0024** (-2.00) [0.0012]	$S_{i,t-1}$	-0.0016 (-1.47) [0.0011]	$S_{i,t-1}$	-0.0009 (-1.63) [0.0006]
Cons	1.9794*** (5.23) [0.3781]	Cons	1.5629*** (4.99) [0.3132]	Cons	1.6526*** (8.57) [0. 1928]
β **value:** 0.6242 **Result:** Convergence		β **value:** 0.4736 **Result:** Convergence		β **value:** 0.5233 **Result:** Convergence	
t statistics in ( ), standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.		t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.		t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.	

Table 4.36: Sigma Convergence

Sigma Convergence of log(y)

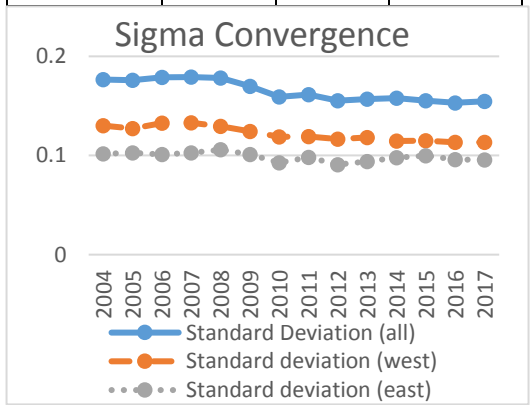
NUTS1 (12 regions)

year	All	West	East
2004	0.1768	0.0996	0.0765
2005	0.1760	0.0993	0.0803
2006	0.1786	0.1015	0.0817
2007	0.1797	0.1034	0.0808
2008	0.1789	0.1033	0.0841
2009	0.1710	0.1017	0.0782
2010	0.1603	0.0929	0.0740
2011	0.1627	0.0947	0.0765
2012	0.1576	0.0954	0.0721
2013	0.1593	0.0993	0.0717
2014	0.1594	0.0974	0.0737
2015	0.1572	0.1008	0.0776
2016	0.1569	0.1025	0.0705
2017	0.1593	0.1037	0.0707



NUTS2 (26 regions)

year	All	West	East
2004	0.1766	0.1300	0.1016
2005	0.1760	0.1273	0.1026
2006	0.1787	0.1327	0.1011
2007	0.1791	0.1330	0.1026
2008	0.1781	0.1294	0.1058
2009	0.1698	0.1243	0.1011
2010	0.1592	0.1189	0.0928
2011	0.1614	0.1190	0.0981
2012	0.1553	0.1167	0.0909
2013	0.1569	0.1180	0.0941
2014	0.1578	0.1148	0.0979
2015	0.1554	0.1148	0.0996
2016	0.1532	0.1133	0.0958
2017	0.1547	0.1135	0.0957



NUTS3 (81 provinces)

year	All	West	East
2004	0.1627	0.1257	0.1142
2005	0.1617	0.1250	0.1132
2006	0.1643	0.1299	0.1135
2007	0.1636	0.1282	0.1133
2008	0.1636	0.1230	0.1171
2009	0.1546	0.1171	0.1120
2010	0.1440	0.1106	0.1051
2011	0.1483	0.1128	0.1099
2012	0.1430	0.1114	0.1039
2013	0.1436	0.1134	0.1034
2014	0.1453	0.1105	0.1053
2015	0.1417	0.1100	0.1054
2016	0.1398	0.1066	0.1029
2017	0.1418	0.1073	0.1054

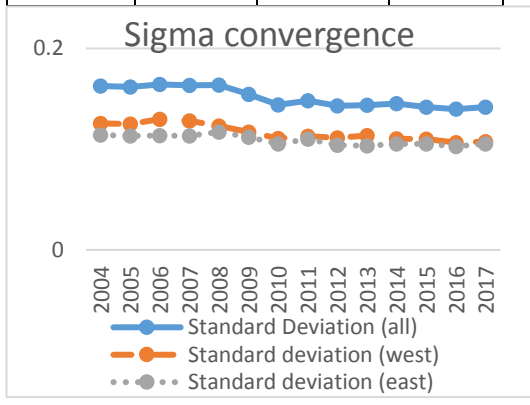
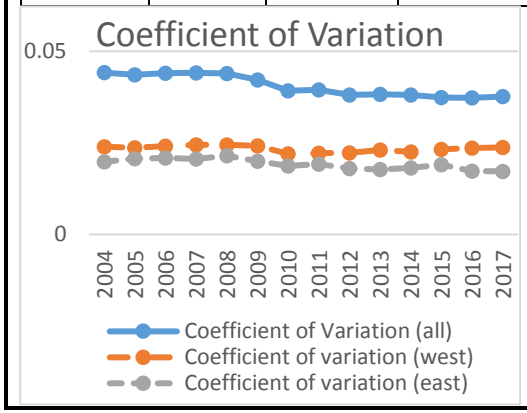


Table 4.37: Coefficient of Variation

Coefficient of Variation of log(y)

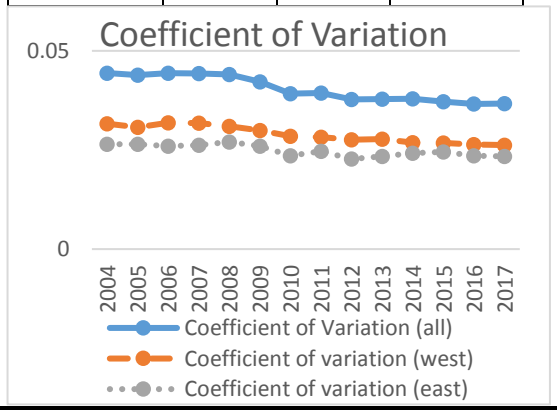
NUTS1 (12 regions)

year	All	West	East
2004	0.0442	0.0240	0.0199
2005	0.0436	0.0237	0.0207
2006	0.0440	0.0241	0.0209
2007	0.0441	0.0245	0.0206
2008	0.0439	0.0245	0.0215
2009	0.0422	0.0242	0.0200
2010	0.0392	0.0220	0.0187
2011	0.0395	0.0222	0.0192
2012	0.0381	0.0223	0.0180
2013	0.0382	0.0231	0.0178
2014	0.0381	0.0226	0.0182
2015	0.0374	0.0233	0.0190
2016	0.0373	0.0236	0.0173
2017	0.0376	0.0238	0.0172



NUTS2 (26 regions)

year	All	West	East
2004	0.0444	0.0316	0.0264
2005	0.0439	0.0307	0.0265
2006	0.0443	0.0319	0.0260
2007	0.0443	0.0318	0.0262
2008	0.0440	0.0310	0.0270
2009	0.0422	0.0299	0.0259
2010	0.0392	0.0285	0.0235
2011	0.0394	0.0282	0.0247
2012	0.0377	0.0276	0.0227
2013	0.0379	0.0277	0.0234
2014	0.0379	0.0268	0.0242
2015	0.0372	0.0268	0.0245
2016	0.0366	0.0264	0.0235
2017	0.0368	0.0263	0.0234



NUTS3 (81 provinces)

year	All	West	East
2004	0.0413	0.0309	0.0297
2005	0.0407	0.0305	0.0292
2006	0.0412	0.0315	0.0291
2007	0.0408	0.0310	0.0290
2008	0.0408	0.0297	0.0299
2009	0.0387	0.0284	0.0287
2010	0.0357	0.0267	0.0266
2011	0.0365	0.0270	0.0276
2012	0.0350	0.0265	0.0259
2013	0.0349	0.0268	0.0257
2014	0.0352	0.0260	0.0260
2015	0.0342	0.0258	0.0259
2016	0.0336	0.0250	0.0252
2017	0.0340	0.0250	0.0257

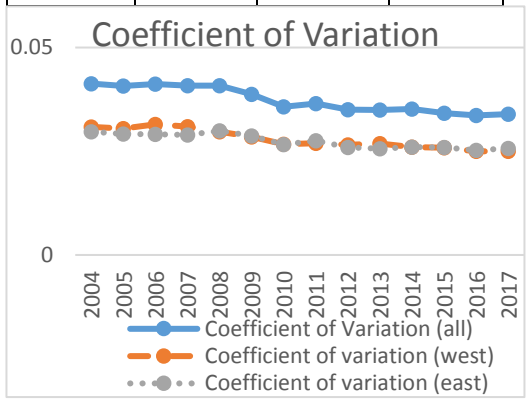
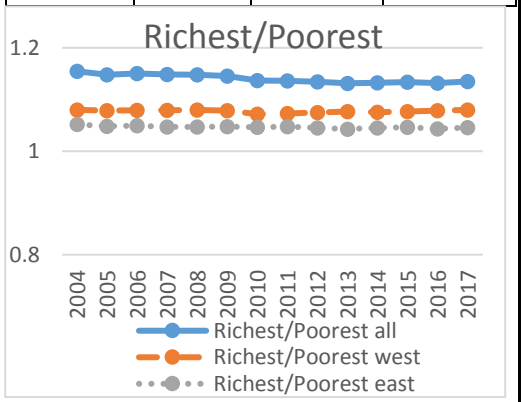


Table 4.38: Richest Poorest Ratio

Richest Poorest Ratio of log(y)

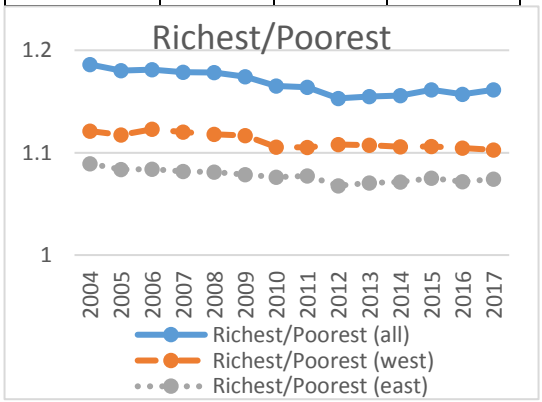
NUTS1 (12 regions)

year	All	West	East
2004	1.1547	1.0800	1.0520
2005	1.1476	1.0786	1.0482
2006	1.1507	1.0795	1.0492
2007	1.1483	1.0790	1.0472
2008	1.1481	1.0796	1.0471
2009	1.1456	1.0784	1.0475
2010	1.1368	1.0718	1.0461
2011	1.1361	1.0733	1.0478
2012	1.1342	1.0750	1.0451
2013	1.1315	1.0766	1.0430
2014	1.1324	1.0752	1.0451
2015	1.1339	1.0765	1.0462
2016	1.1315	1.0788	1.0435
2017	1.1347	1.0796	1.0461



NUTS2 (26 regions)

year	All	West	East
2004	1.1861	1.1210	1.0894
2005	1.1801	1.1172	1.0837
2006	1.1811	1.1228	1.0840
2007	1.1787	1.1200	1.0817
2008	1.1782	1.1180	1.0811
2009	1.1741	1.1168	1.0787
2010	1.1653	1.1056	1.0761
2011	1.1639	1.1052	1.0773
2012	1.1531	1.1079	1.0678
2013	1.1550	1.1074	1.0706
2014	1.1557	1.1058	1.0714
2015	1.1616	1.1062	1.0751
2016	1.1571	1.1046	1.0718
2017	1.1613	1.1028	1.0743



NUTS3 (81 provinces)

year	All	West	East
2004	1.2007	1.1468	1.1220
2005	1.1990	1.1415	1.1248
2006	1.2095	1.1442	1.1344
2007	1.2108	1.1381	1.1346
2008	1.2166	1.1329	1.1375
2009	1.2058	1.1319	1.1248
2010	1.1785	1.1086	1.1071
2011	1.1901	1.1100	1.1174
2012	1.1835	1.1132	1.1185
2013	1.1862	1.1123	1.1161
2014	1.1883	1.1093	1.1153
2015	1.1874	1.1123	1.1110
2016	1.1812	1.1102	1.1072
2017	1.1844	1.1103	1.1106

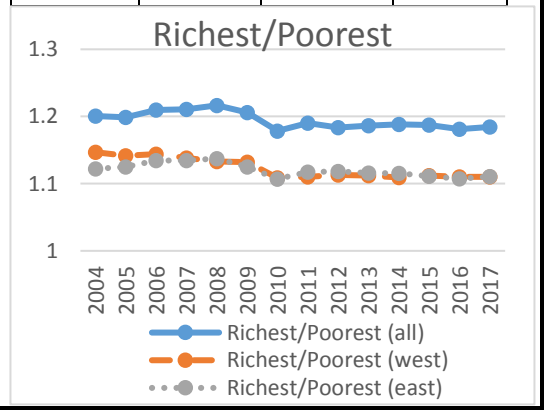
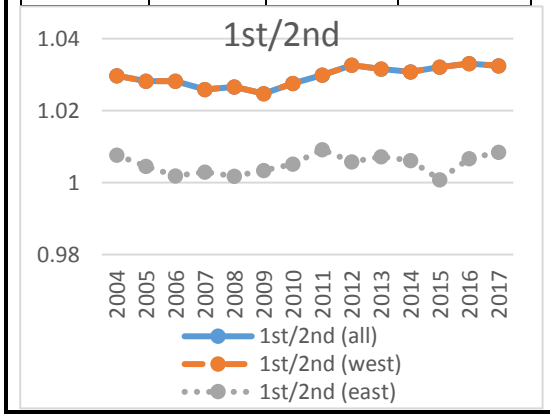


Table 4.39: First Second Ratio

1st/2nd ratio of log(y)

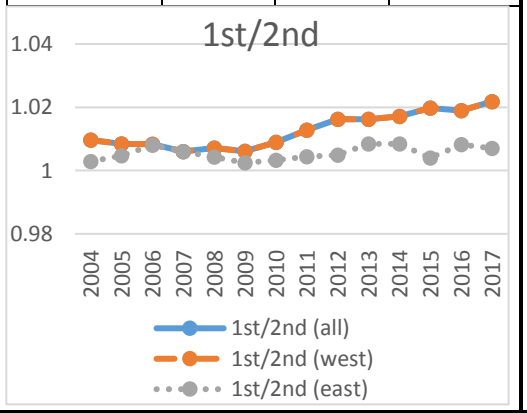
NUTS1 (12 regions)

year	All	West	East
2004	1.0297	1.0297	1.0076
2005	1.0281	1.0281	1.0045
2006	1.0282	1.0282	1.0018
2007	1.0259	1.0259	1.0029
2008	1.0266	1.0266	1.0018
2009	1.0247	1.0247	1.0034
2010	1.0275	1.0275	1.0051
2011	1.0299	1.0299	1.0092
2012	1.0326	1.0326	1.0057
2013	1.0315	1.0315	1.0072
2014	1.0308	1.0308	1.0061
2015	1.0321	1.0321	1.0008
2016	1.0331	1.0331	1.0066
2017	1.0325	1.0325	1.0084



NUTS2 (26 regions)

year	All	West	East
2004	1.0097	1.0097	1.0028
2005	1.0085	1.0085	1.0047
2006	1.0083	1.0083	1.0081
2007	1.0060	1.0060	1.0060
2008	1.0071	1.0071	1.0043
2009	1.0061	1.0061	1.0024
2010	1.0090	1.0090	1.0033
2011	1.0128	1.0128	1.0044
2012	1.0163	1.0163	1.0049
2013	1.0162	1.0162	1.0084
2014	1.0171	1.0171	1.0084
2015	1.0198	1.0198	1.0040
2016	1.0190	1.0190	1.0083
2017	1.0218	1.0218	1.0071



NUTS3 (81 provinces)

year	All	West	East
2004	1.0097	1.0097	1.0114
2005	1.0085	1.0085	1.0163
2006	1.0078	1.0078	1.0096
2007	1.0060	1.0060	1.0078
2008	1.0068	1.0068	1.0009
2009	1.0061	1.0061	1.0001
2010	1.0088	1.0088	1.0006
2011	1.0027	1.0027	1.0020
2012	1.0039	1.0039	1.0080
2013	1.0007	1.0007	1.0022
2014	1.0003	1.0003	1.0008
2015	1.0019	1.0019	1.0021
2016	1.0030	1.0030	1.0015
2017	1.0006	1.0006	1.0025

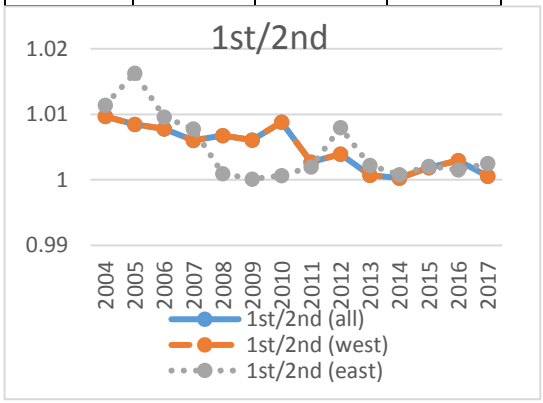
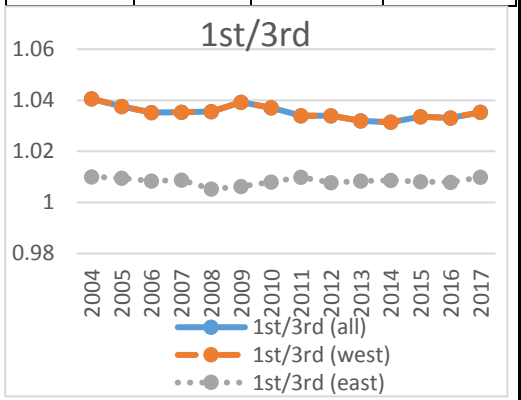


Table 4.40: First Third Ratio

1st/3rd ratio of log(y)

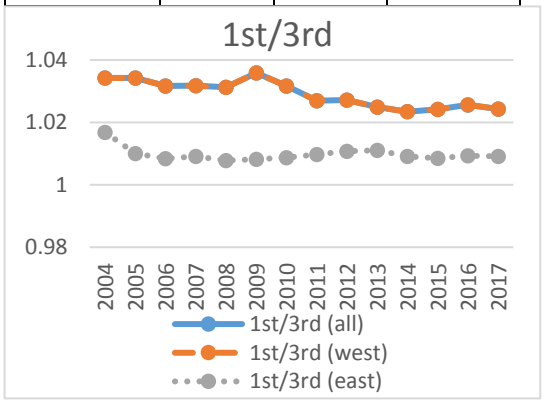
NUTS1 (12 regions)

year	All	West	East
2004	1.0406	1.0406	1.0101
2005	1.0376	1.0376	1.0095
2006	1.0352	1.0352	1.0084
2007	1.0353	1.0353	1.0088
2008	1.0356	1.0356	1.0052
2009	1.0392	1.0392	1.0062
2010	1.0371	1.0371	1.0080
2011	1.0339	1.0339	1.0099
2012	1.0339	1.0339	1.0078
2013	1.0320	1.0320	1.0084
2014	1.0314	1.0314	1.0087
2015	1.0336	1.0336	1.0081
2016	1.0331	1.0331	1.0078
2017	1.0353	1.0353	1.0099



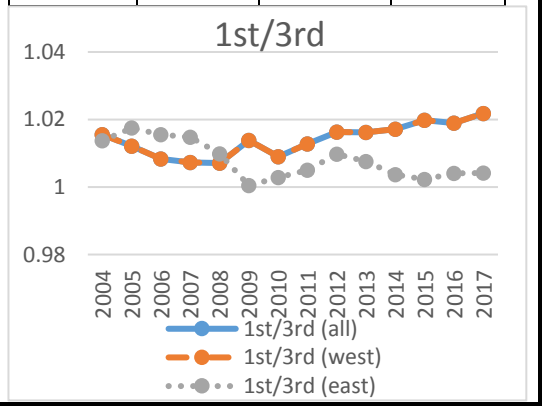
NUTS2 (26 regions)

year	All	West	East
2004	1.0342	1.0342	1.0168
2005	1.0342	1.0342	1.0101
2006	1.0317	1.0317	1.0084
2007	1.0318	1.0318	1.0092
2008	1.0312	1.0312	1.0078
2009	1.0358	1.0358	1.0082
2010	1.0317	1.0317	1.0087
2011	1.0270	1.0270	1.0097
2012	1.0272	1.0272	1.0107
2013	1.0249	1.0249	1.0110
2014	1.0234	1.0234	1.0092
2015	1.0242	1.0242	1.0085
2016	1.0256	1.0256	1.0093
2017	1.0243	1.0243	1.0091



NUTS3 (81 provinces)

year	All	West	East
2004	1.0155	1.0155	1.0138
2005	1.0121	1.0121	1.0175
2006	1.0083	1.0083	1.0155
2007	1.0072	1.0072	1.0148
2008	1.0071	1.0071	1.0098
2009	1.0138	1.0138	1.0004
2010	1.0090	1.0090	1.0029
2011	1.0128	1.0128	1.0050
2012	1.0163	1.0163	1.0097
2013	1.0162	1.0162	1.0075
2014	1.0171	1.0171	1.0036
2015	1.0198	1.0198	1.0023
2016	1.0190	1.0190	1.0040
2017	1.0218	1.0218	1.0042



According to results given in Table 4.34 and Table 4.35, it can be stated that there is beta convergence for both conditional and unconditional case. Fixed-effects regression method is used as Hausman test consistently suggests as the analysis is made for the regions of Turkey and all the parts are used so that what need to be focused on is the within variation. Besides, conditional convergence results indicate higher speed of convergence because in conditional convergence structural differences among regions are controlled by using share variables of services and agricultural sector.

Apart from beta convergence analysis (both for conditional and unconditional case), other analyses like: sigma convergence, coefficient of variation, richest/poorest, first/second, first/third (The ranking is given in Appendix C) are also made.

The results obtained from sigma convergence analysis do not indicate something certain about convergence issue because while there is a decrease in trend for NUTS2 and NUTS3 level regions, for NUTS1 there is decrease in trend of east region but increase in west region. Furthermore there is no certain trend but one thing is for certain that the main decrease belongs to crisis (2008 crisis) period. Therefore, crisis creates some degree of convergence.

According to coefficient of variation results, for both levels of regions the trend is decreasing which indicates convergence. However, it is impossible to conclude something certain because again the source of the main decrease is the crisis. This situation is also valid for richest poorest analysis. Consequently, in spite of stating something certain due to the effect of crisis, coefficient of variation and richest poorest results are close to indicate that there is convergence among regions of Turkey.

On the other side, according to results of first second and first third ratio analyses, it is impossible to state something certain. At NUTS1 region there is a fluctuating trend in first second ratio analysis but comparing the beginning and end values, an increase is captured which brings about the conclusion of convergence. On the other side, at NUTS2 level there is a dominance of increasing trend. However, at NUTS3 level there is a dominance

of decreasing trend. Consequently, the results of first second ratio analysis do not indicate something certain related with convergence issue among the regions of Turkey. Similarly, according to analysis of first third ratio, at NUTS1 and NUTS2 level although the trend is fluctuating, comparing beginning and end values, there is a decrease which implies convergence. On the other side, at NUTS3 level while there is a decreasing trend for east, for west there is a dominance of increasing trend.

Table 4.41 given below summarizes the general result obtained from different models and techniques.

Table 4.41: General Result

Method	General Result
Beta Convergence (Unconditional)	Convergence
Beta Convergence (Conditional)	Convergence
Sigma Convergence	Uncertain (close to convergence in Nust2 and Nuts3; close to convergence in east, close to divergence in west for Nuts1)
Coefficient of Variation	Close to convergence (due to the effect of crisis)
Richest/Poorest	Close to convergence (due to the effect of crisis)
1st/2nd	Uncertain (close to divergence in Nuts1; divergence in Nuts2; convergence in Nuts3)
1st/3rd	Uncertain (Close to convergence for Nuts1 and Nuts2; divergence in west, convergence in east for Nuts3)

Investigating the issue from general perspective, there is higher possibility to find convergence because there is global crisis (2008 crisis) in the short investigation period of this study. This is because crises (especially crises related with financial sector) hit riches more than the poor. Therefore, probability of finding convergence gets higher during this type of crises. What's more, neoclassical model from Barro and Sala-i Martin (1992) is a convergence-sided model. Because beta is equal to minus natural logarithm of the coefficient

of one period lagged value of income, there is very low possibility to find beta with negative value since when the coefficient of income with one period lag is between zero and one, calculated beta becomes positive. Not surprisingly, in this study it is also found that there is convergence in beta convergence analysis.

Consequently, according to the results obtained from neoclassical beta convergence analysis and other statistical analysis and descriptive statistics, it can be stated that the results are close to state that there is convergence among Turkish regions. The reason for using the word "close" is that the results obtained from descriptive statistics like sigma convergence, coefficient of variation, Richest-poorest ratio, first-second ratio, first-third ratio, do not give a clear picture and there is an important crisis (2008 crisis) in the investigation period in which the tendency of convergence increases. Maybe if there was no crisis in the investigation period of this study, the results would be different however due to the lack of regional data for Turkey it is impossible to extend to time dimension.

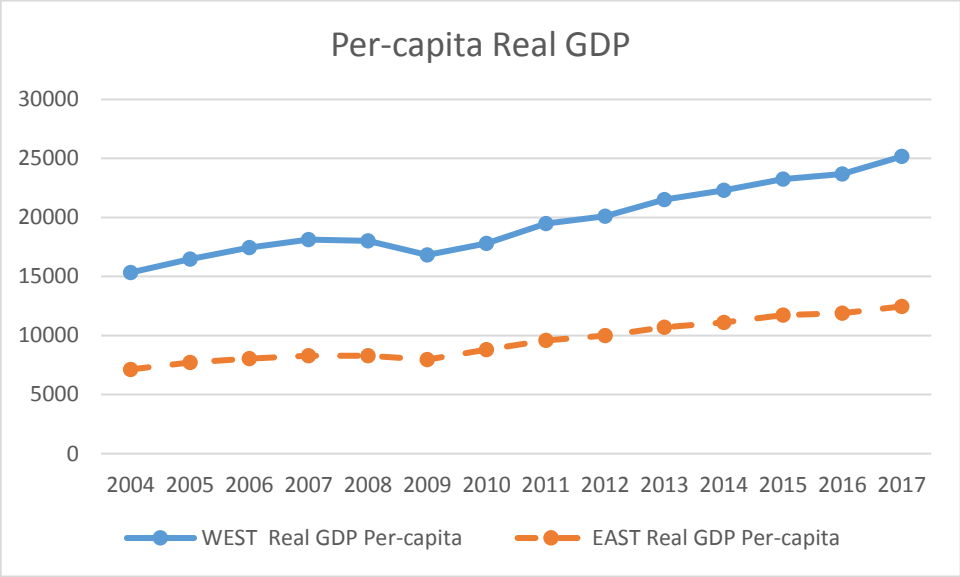
Moreover, in order to handle the convergence issue in a more general framework, it is better to investigate per-capita income and its growth for poor east and rich west separately during the investigation period. In order to make such an aggregate east-west classification in per-capita terms, there is a need to use mid-year region population estimation because per-capita GDP represents aggregate GDP divided by the mid-year region population estimation. Per-capita income and aggregate income is available in TURKSTAT so that mid-year population estimation can be found by dividing aggregate income to per-capita income. Thereafter, for east and west regions real GDP and mid-year population estimation for every unit are added, according to whether they belong to west or east, for every year and by dividing total real GDP to mid-year population estimation, real GDP per-capita and real GDP per-capita growth for east and west is found. (It is not reported but after that, for robustness check, by summing east and west total GDP and mid-year population estimation, per-capita GDP and per-capita GDP growth for Turkey is found and comparing with the original data the same results are found).

According to Table 4.42 and Figure 4.16, as it is known west region is much wealthier than east region and apart from the crisis period the gap does not seem to be closed. At the same time the gap does not seem to be widened which means that apart from the crisis period it is impossible to indicate that there is convergence or divergence between rich west and relatively poor east. It is not surprising because with the limited time period of this study indicating something certain about convergence issue would be extraordinary.

Table 4.42: West-East Real GDP Per-capita

year	**(WEST) Real GDP Per-capita**	**(EAST) Real GDP Per-capita**
2004	15343.3221	7137.4532
2005	16485.7305	7711.7600
2006	17465.1251	8059.9938
2007	18126.0308	8296.5681
2008	18011.5170	8302.5362
2009	16824.3078	7978.8483
2010	17796.1933	8819.3394
2011	19494.4316	9580.4002
2012	20107.0902	10012.3148
2013	21526.7532	10694.1502
2014	22302.0967	11099.6096
2015	23258.2885	11731.7364
2016	23683.9728	11883.8094
2017	25164.7197	12469.6595
Average	19684.9700	9555.5842

Figure 4.16: West-East Real GDP Per-capita

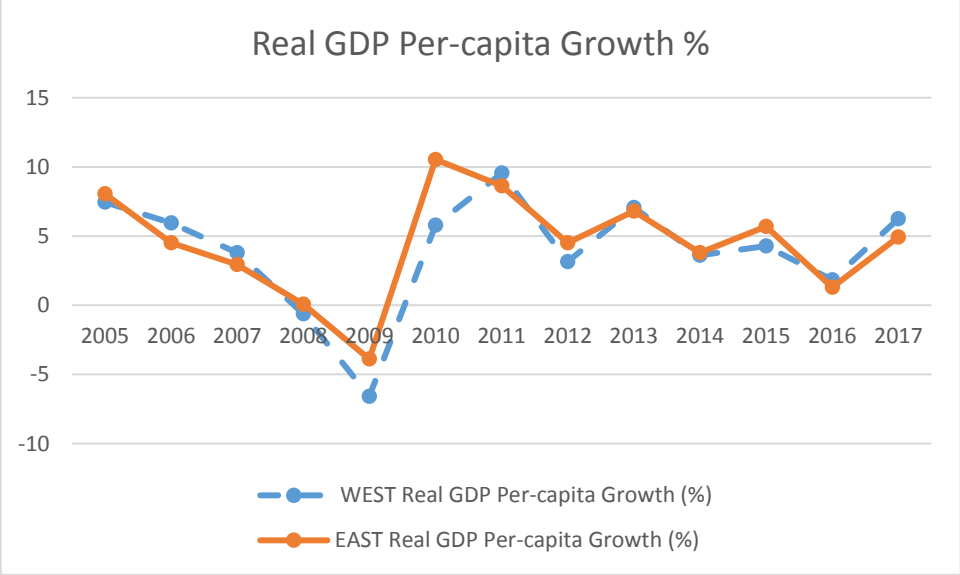


Per-capita growth rates are given in Table 4.43 and Figure 4. 17. According to table and figure, it can be stated that east region grows more than west region. However, as it can be seen, if crisis period subtracted from the sample the difference in growth rates becomes smaller because as it can be predicted, crisis hits rich regions more than poor regions. What's more, if after crisis excess capacity period (2010-2011) is also subtracted from the sample as well as crisis period (2008-2009), the growth of west becomes more than the growth of east (for 2005-2007 and 2012-2017 Growth of West: 4.8162; Growth of East (%): 4.7253). Therefore, it is impossible to state that there is convergence. At the same time it is also impossible to state that there is divergence. However, empirical results and descriptive statistics are closer to indicate that there is convergence probably due to the effect of crisis.

Table 4.43: West-East Real GDP Per-capita Growth (%)

year	(WEST) Real GDP Per-capita Growth (%)	(EAST) Real GDP Per-capita Growth (%)
2005	7.4456	8.0464
2006	5.9409	4.5156
2007	3.7841	2.9352
2008	-0.6318	0.0719
2009	-6.5914	-3.8987
2010	5.7767	10.5340
2011	9.5427	8.6295
2012	3.1427	4.5083
2013	7.0605	6.8100
2014	3.6018	3.7914
2015	4.2875	5.6950
2016	1.8302	1.2963
2017	6.2521	4.9298
Average	3.9571	4.4511

Figure 4.17: West-East Real GDP Per-capita Growth (%)



5. ENDOGENOUS MODEL

In this part, the main aim is to analyze the effect of human capital on economic growth performance of the regions of Turkey by using endogenous technology growth model. In this way, it can be captured whether investing on human capital can bring about convergence across regions. However, human capital is quite different than physical capital with respect to the assumption of decreasing returns. Researchers who have worked on this issue find that instead of decreasing returns, increasing returns is the dominant case for human capital. Therefore, this situation may cause divergence rather than convergence. The aim of this part is to analyze this issue on empirical ground for the regions of Turkey.

5.1 METHODS AND DATA

In endogenous model section the model is taken from Romer (1990) since within country analysis is made, other models that are related with diffusion of technology via international trade like Grossman and Helpman (1990, 1994), Coe and Helpman (1995), and Coe et al. (1997) are not applicable. Moreover, applying Schumpeterian perspective is also not applicable because the time period of this study is not too long to use such a perspective.

Furthermore, the main aim is to analyze the effect of human capital on economic growth performance of the regions of Turkey so that having a specified model that focuses on this issue is more applicable. Therefore, the model is taken from Romer (1990) because this model is the best model that serves the purpose of this study.

The original model from Romer (1990) is given below. In this equation L_A represents labors in research sector (human capital), δ represents productivity parameter, $\frac{\dot{A}}{A}$ represents the growth of knowledge. As it can be understood from the equation below growth

of knowledge, in other words, economic growth (according to endogenous growth perspective) is based on human capital which is defined by R&D personnel.

[5.1] $$\frac{\dot{A}}{A} = \delta L_A$$

Left-hand side of the equation can be called as Total Factor Productivity (TFP) growth. However, due to the data problem for TFP at regional level, instead of TFP growth, like Bode (2002) and many others, GDP growth is used because the main ideology in Romer (1990) is that technological change lies at the heart of economic growth. Therefore, since TFP can be used as a proxy for technological progress, per-capita real GDP growth can be used as a proxy of TFP growth. Furthermore, the aim of this work is to investigate the income convergence issue for Turkey at regional level that's why using per capita real GDP growth is more suitable. Therefore, in equations the term "Y" instead of "A" is used.

The main problem of Romer's (1990) model may be the scale effect. To illustrate this point, according to equation [5.1], when the economy grows with an increase in labor force or population, the number of labor in research sector also increases and this situation can affect the result. Jones (1995a, b) criticizes this issue because he finds that it is inconsistent according to the results of his works that work on some of the developed countries. For example, in the United States, the number labor in research sector increased fivefold from 1950 to 1987 due to the population growth and increase intensity of R&D, while productivity growth stays relatively constant (Izushi, 2008, p. 950).

In order to solve the problem of scale effect of Romer (1990), the idea of increasing product varieties is used. It is argued that (Aghion and Howitt, 1998; Howitt, 1999; Young, 1998) economic growth increases product varieties. Therefore, scale effect is neutralized by increasing product varieties as economy grows. Product differentiation is assumed to increase

in proportion to the labor force (L) (Izushi, 2008). Alternatively, equation [5.1] can be rewritten as follows;

[5.2] $$\frac{\dot{Y}}{Y} = \alpha + \delta\frac{L_A}{L}$$

In equation [5.2], as Izushi (2008) did, scale effect problem is eliminated by dividing labor in research sector to overall labor force (L).

Moreover, since this work is related with the investigation of income convergence, the model is also modified according to catch-up condition as follows.

[5.3] $$\frac{\dot{Y}}{Y} = \alpha + \gamma\frac{L_A}{L}\frac{Y_l - Y_r}{Y_r}$$

The aim is how a catch-up strategy based on an increase in R&D personnel will affect the growth of the region. Y_l represents the per-capita real GDP of leading region (for every period, it is Istanbul), while Y_r represents the regions' per-capita GDP. This equation indicates that the speed of catch-up is determined by the R&D personnel $\left(\frac{L_A}{L}\right)$. Again in order to eliminate the scale effect problem R&D personnel is divided to total employment.

When it comes to data part for Turkey, R&D personnel data is only valid for NUTS1 level and the available period is the years between 2010 and 2017. On the other side, new regional level GDP data is only valid for the periods between 2004 and 2017. Therefore, in this part there are 12 cross-sections and only 8 years (2010-2017) which means that analysis only has 96 observations. In order to cope with this problem, percentage share of R&D personnel data in general employment is transferred from NUTS1 to NUTS2 level. In this

respect, in NUTS2 classification, same value is given to the regions that are in the same group in NUTS1 level. This is not a big problem because of using share variable. Besides, using share of R&D personnel data, automatically eliminates the scale effect problem of original Romer's (1990) model. Finally, the equation below is tested for NUTS2 level regions of Turkey.

[5.4] $$\frac{\dot{Y}}{Y} = \alpha + \delta \mathrm{SHL_A}$$

$\mathrm{SHL_A}$ represents the percentage share of R&D personnel data in overall employment. Furthermore, NUTS2 (26 regions) analysis expands sample size to 208.

Moreover, in order to investigate whether an increase in share of R&D personnel decrease the per-capita income differences among regions, dependent variable is modified by subtracting the growth of Turkey from the growth of the region. The equation is given below.

[5.5] $$\left(\frac{\dot{Y}}{Y}\right)_r - \left(\frac{\dot{Y}}{Y}\right)_{TR} = \alpha + \delta \mathrm{SHL_A}$$

This issue is also investigated in NUTS2 level with the transformed share variable. The negative and significant coefficient of independent variable will represent that increase in the share of R&D personnel decrease the per-capita income differences among regions.

Furthermore, in order to analyze the quadratic relation between R&D personnel and economic growth of the regions, below equation is also constructed.

[5.6] $$\frac{\dot{Y}}{Y} = \alpha + \gamma(\text{SHLA})^2 + \delta\text{SHLA}$$

In order to control for the endogeneity that can be caused by omitted variable bias, one period lag of dependent variable is added to the equation by constructing a dynamic model.

[5.7] $$\left(\frac{\dot{Y}}{Y}\right)_{it} = \alpha + \gamma\left(\frac{\dot{Y}}{Y}\right)_{it-1} + \beta(SHLA)_{it}$$

The data is taken from TURKSTAT. R&D personnel data includes personnel work in business enterprise, government, and higher education. Detailed information about R&D personnel data is given in Appendix D.

After working on the R&D data, as an alternative, patent data is used instead of R&D data. The data is taken from Turkish Patent and Trademark Office. Owing to dealing with the regional analysis, distribution of patent grants with respect to cities is used (Detailed information about patent data is given in Appendix E). This provincial level data is valid for the period between 1995 and 2017. However, because regional income data is only available for the period between 2004 and 2017 and in order to cope with the scale effect problem there is a requirement of dividing the number of patent grants to population, the time period is restricted to the years between 2007 and 2017 since available provincial level population data starts from 2007 in TURKSTAT. The model is given below.

[5.8] $$\frac{\dot{Y}}{Y} = \alpha + \delta \frac{patent}{population(in\ thousands)}$$

Again in order to control for endogeneity problem that can be caused by omitted variable bias, patent data transformed to NUTS2 level by summing the patent grants for the provinces that are in the same group in NUTS2 classification, and share of R&D personnel in total employment is added to the model.

[5.9] $$\frac{\dot{Y}}{Y} = \alpha + \beta SHLA + \delta \frac{patent}{population\ (in\ thousands)}$$

What's more, in order to control for the endogeneity more precisely, by adding one period lagged dependent variable to the equation, dynamic model is constructed.

[5.10] $$\left(\frac{\dot{Y}}{Y}\right)_{it} = \alpha + \gamma \left(\frac{\dot{Y}}{Y}\right)_{it-1} + \beta (SHLA)_{it} + \delta \left(\frac{patent}{population\ (in\ thousands)}\right)_{it}$$

Furthermore, again in this part because time period is limited (small T), unit root tests are not applied and only the problem of heteroskedasticity is checked as a diagnostic test. The validity of heteroskedasticity is corrected by using robust standard errors.

5.2 MODELS, EMPIRICAL RESULTS AND DESCRIPTIVE STATISTICS

As it is explained in previous part, modified version (elimination of scale effect problem by dividing R&D personnel to overall employment) of the model from Romer (1990) is used in order to investigate the effect of human capital on the growth performance of the regions. Hausman test suggests to use fixed effects model as it should be and in order to handle the heteroskedasticity problem robust standard errors are used. According to results, R&D personnel has negative and significant effect on regions' economic growth performance.

Table 5.1: Hausman Test for Model [5.2]

Hausman Test
Ho: difference in coefficients not systematic
Prob>chi2 = 0.0000

Table 5.2: Heteroskedasticity Test for Model [5.2]

Heteroskedasticity Test
Modified Wald test for groupwise heteroskedasticity in fixed effects regression model
H0: sigma(i)^2 = sigma^2 for all i
Pr.: 0.0000

$$\frac{\dot{Y}}{Y} = \alpha + \delta\frac{L_A}{L}$$

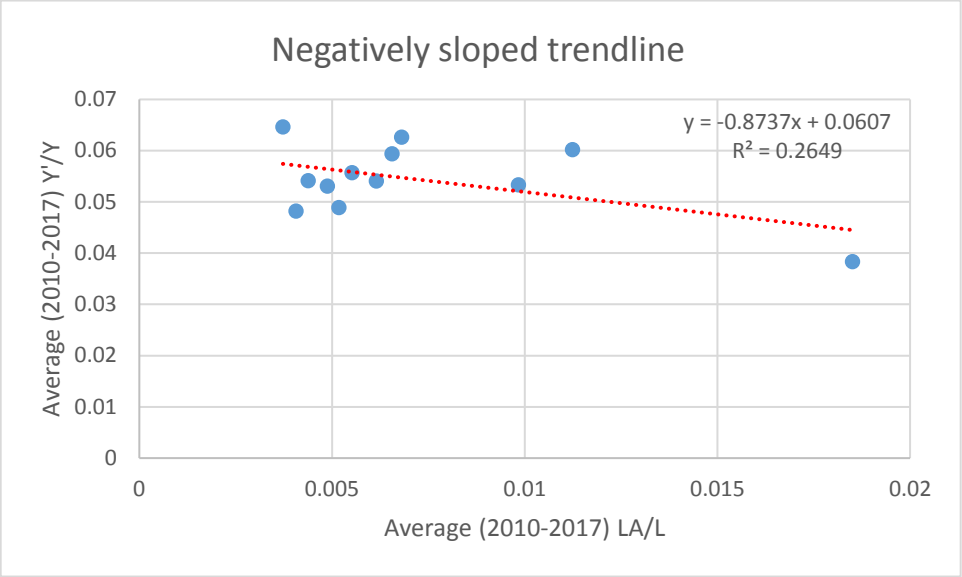
Table 5.3: Regression Results for Model [5.2]

Fixed-effects regression **Number of observations:** 96 **Number of groups:** 12 **Dependent Variable:** $\frac{\dot{Y}}{Y}$	
Independent Variables	**Coefficient**
$\frac{L_A}{L}$	-14.9361*** (-4.42) [3.3755]
Cons	0. 1624*** (6.65) [0.0244]
Prob > F = 0.0010 **R-squared (within)=** 0.2228 **Result:** Negative effect	

t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

In order to check the robustness of this result, it is better to use some other descriptive statistics. Figure 5.1 that is constructed by taking the average (2010-2017) of the variables for every individual unit proves the regression results by indicating negatively sloped trend line.

Figure 5.1: Scatter Plot (5.1)



Since this work deals with the income convergence issue, it is better to investigate the effect of human capital, as an engine for convergence, on regions' economic growth. Fixed effects model with robust standard errors is reported in Table 5.6. According to results, convergence strategy that is based on increase in R&D personnel has a negative impact on convergence since this strategy has negative impact on regions' economic growth.

Table 5.4: Hausman Test for Model [5.3]

Hausman Test
Ho: difference in coefficients not systematic Prob>chi2 = 0.0000

Table 5.5: Heteroskedasticity Test for Model [5.3]

Heteroskedasticity Test
Modified Wald test for groupwise heteroskedasticity in fixed effects regression model **H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.0000

$$\frac{\dot{Y}}{Y} = \alpha + \gamma \frac{L_A}{L} \frac{Y_l - Y_r}{Y_r}$$

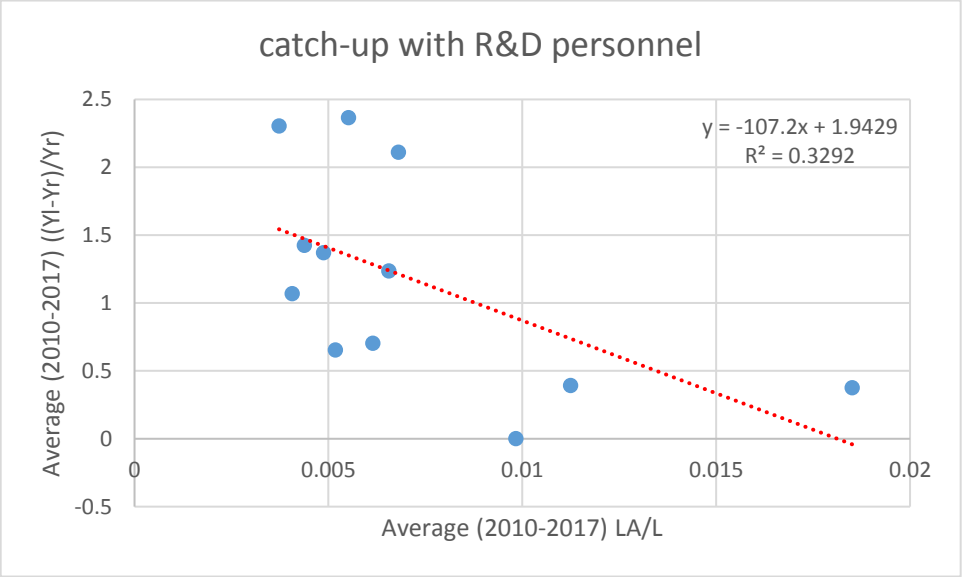
Table 5.6: Regression Results for Model [5.3]

Fixed-effects regression **Number of observations:** 96 **Number of groups:** 12 **Dependent Variable:** $\frac{\dot{Y}}{Y}$	
Independent Variables	**Coefficient**
$\frac{L_A}{L}\frac{Y_l - Y_r}{Y_r}$	-12.2309*** (-4.44) [2.7551]
Cons	0. 1365*** (7.38) [0.0185]
Prob > F = 0.0010 **R-squared (within)=** 0.2728 **Result:** Negative effect	

t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

In order to check the robustness of this results, average values (2010-2017) of the catch up part of the variable $\left(\frac{Y_l - Y_r}{Y_r}\right)$ and the ratio of R&D personnel in overall employment $\left(\frac{L_A}{L}\right)$ is investigated by using scatter plot diagram. In this diagram again every data point represents different individual unit. According to scatter plot analysis, there is negative relation between these variables which proves the results obtained from regression analysis.

Figure 5.2: Scatter Plot (5.2)



In order to increase the sample size, the share of R&D personnel data is transferred from NUTS1 to NUTS2 and this does not change the result. According to results the share of R&D personnel in overall employment has negative and significant impact on the regions' economic growth.

Table 5.7: Hausman Test for Model [5.4]

Hausman Test
Ho: difference in coefficients not systematic Prob>chi2 = 0.0000

Table 5.8: Heteroskedasticity Test for Model [5.4]

Heteroskedasticity Test
Modified Wald test for groupwise heteroskedasticity in fixed effects regression model **H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.0000

$$\frac{\dot{Y}}{Y} = \alpha + \delta \mathrm{SHL_A}$$

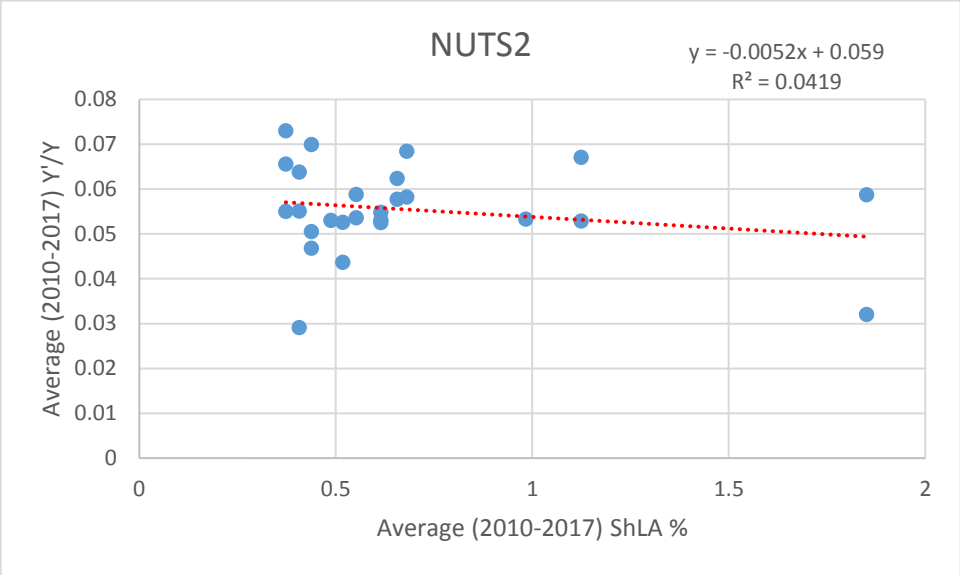
Table 5.9: Regression Results for Model [5.4]

Fixed-effects regression **Number of observations:** 208 **Number of groups:** 26 **Dependent Variable:** $\frac{\dot{Y}}{Y}$	
Independent Variables	**Coefficient**
SH L_A	-0.1765*** (-6.72) [0.0263]
Cons	0.1758*** (9.81) [0.0179]
Prob > F = 0.0000 **R-squared (within)=** 0.2080 **Result:** Negative effect	

t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

By taking the average (2010-2017) of the variables for every unit, Figure 5.3, indicating negative relation between share of R&D personnel and economic growth, proves the regression result.

Figure 5.3: Scatter Plot (5.3)



Turning back to the scope of this study, in order to capture the effect of R&D personnel on regional income growth differences, dependent variable is modified by subtracting the growth of Turkey from region's growth. In this case, negative coefficient of dependent variable will be a sign for closure of the growth differences among regions. This time, Hausman test suggest to use Random-effects model by a narrow margin. This is not surprising because modifying the data like taking difference, can cause such a change in Hausman test results. However, because this study deals with regional analysis, and every individual unit of whole sample is used in the analysis, one need to care about within variation. In other words, the units are not selected randomly. They are the regions of one country. Therefore, fixed effects regression results with robust standard errors are reported. According to results, an increase in the share of R&D personnel closes the gap in terms of regional growth differences.

Table 5.10: Hausman Test for Model [5.5]

Hausman Test
Ho: difference in coefficients not systematic Prob>chi2 = 0.1100

Table 5.11: Heteroskedasticity Test for Model [5.5]

Heteroskedasticity Test
Modified Wald test for groupwise heteroskedasticity in fixed effect regression model **H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.0000

$$\left(\frac{\dot{Y}}{Y}\right)_r - \left(\frac{\dot{Y}}{Y}\right)_{TR} = \alpha + \delta \mathrm{SHL_A}$$

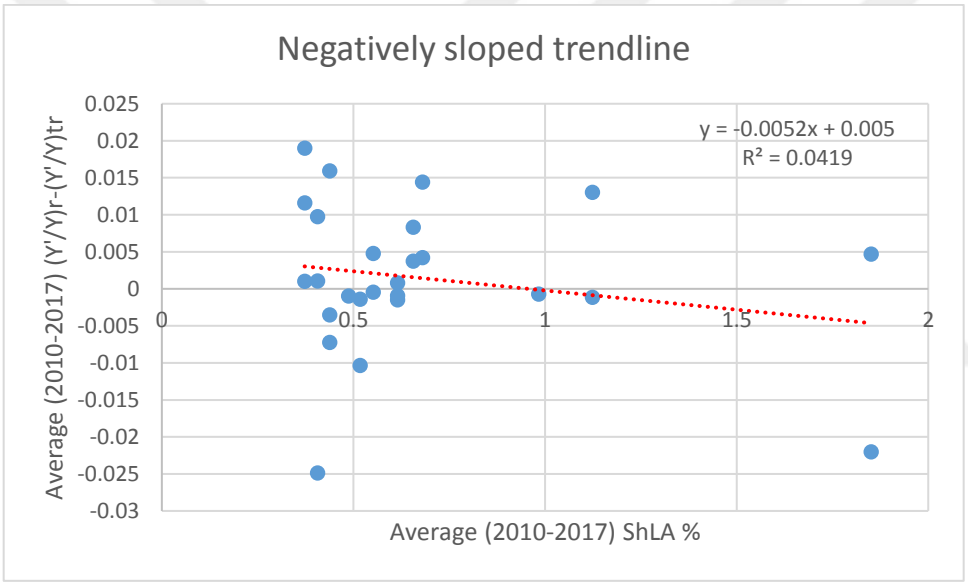
Table 5.12: Regression Results for Model [5.5]

Fixed-effects regression **Number of observations:** 208 **Number of groups:** 26 **Dependent Variable:** $\left(\frac{\dot{Y}}{Y}\right)_r - \left(\frac{\dot{Y}}{Y}\right)_{TR}$	
Independent Variables	**Coefficient**
SH L_A	-0.0403** (-2.16) [0.0186]
Cons	0.0289** (2.27) [0.0127]
Prob > F = 0.0406 **R-squared (within)=** 0.0193 **Result:** Negative effect	

t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

In order to make a robustness check of this regression result, as usual procedure of this work, average values (2010-2017) of the variables for every individual unit are taken and subject to scatter plot analysis. According to Figure 5.4, there is negative relation between variables which proves the regression results.

Figure 5.4: Scatter Plot (5.4)



However, it is better to mention which side of the country is the leader in terms of growth rates during the investigation period. As it is given in exogenous model part, the growth of east and west (in the investigation period) is given in Table 5.13. According to Table 5.13, the growth of relatively poor east is more than the growth of relatively rich west. Therefore, it can be stated that increase in the share of R&D personnel decreases the growth differences between regions via affecting east region more negatively. In order to prove that, handling this issue by using two different regressions (regression for west and regression for east) that examine the effect of the share of R&D personnel on regions' economic growth, and investigating the trend-lines can be beneficial. As it can be captured from Figure 5.5 and

Figure 5.6, the negative effect is more valid in east region. When it comes to west region, the effect of R&D personnel on regions' economic growth is also negative but it looks like it can turn out to be a positive if the share will increase a little bit more.

Table 5.13: Growth Rates % of Per-Capita GDP (West-East)

year	West	East
2010	5.7767	10.5340
2011	9.5427	8.6295
2012	3.1427	4.5083
2013	7.0605	6.8100
2014	3.6018	3.7914
2015	4.2875	5.6950
2016	1.8302	1.2963
2017	6.2521	4.9298
Average	**5.1868**	**5.7743**

Source: Author's own calculation

Figure 5.5: Scatter Plot (5.5)

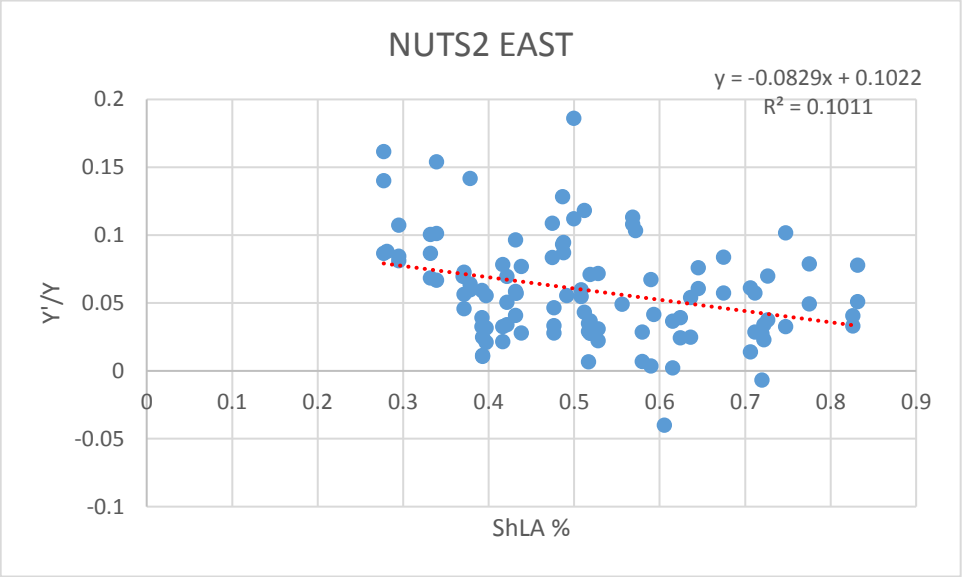
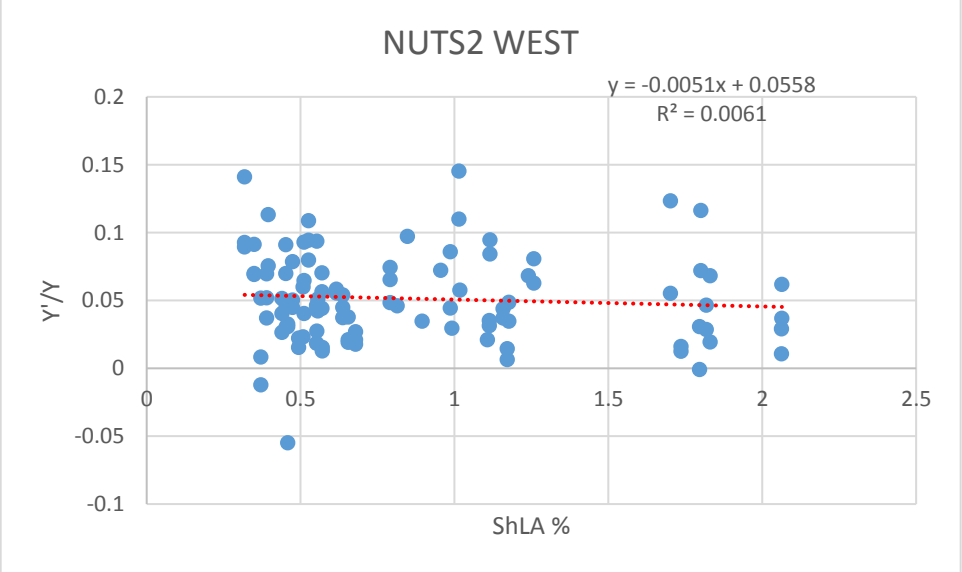


Figure 5.6: Scatter Plot (5.6)



Moreover, the reason that east region is more negatively affected from an increase in the share of R&D personnel is that the effect may not be turn to positive before reaching at some level. This situation can be understood by giving the shares of R&D personnel according to east and west. As it can be captured from Table 5.14, the share of R&D personnel in west is much more than the share of R&D personnel in east. Therefore, the negative impact is closer to turn to be a positive in west if the share will increase. In other words, it is estimated that there can be a U-shaped relation between share of R&D personnel and regions' economic growth. This situation is visualized in Figure 5.7. West region is on the less negatively sloped side, while east region is on the more negatively sloped side. The aim is to show the effect will not turn to be a positive before reaching a certain level regardless of the growth rates of the regions. West region is closer to reach a positive effect, as it is found in Figure 5.5 and Figure 5.6, as share will increase the negativity of the slope decrease.

Table 5.14: Share (%) of R&D Personnel (West-East)

year	**West**	**East**
2010	0.7779	0.3625
2011	0.7975	0.4106
2012	0.8501	0.4818
2013	0.8794	0.5009
2014	0.9346	0.5509
2015	0.9537	0.5697
2016	1.0153	0.5777
2017	1.0930	0.5766
Average	**0.9127**	**0.5038**

Source: Author's own calculation

Figure 5.7: Estimated U-Shaped Figure between Growth and Share of R&D personnel

Source: Author's own estimation

In order to prove the estimation of U-shaped relation between the share of R&D personnel and regions' economic growth, the square of the share is taken and included in the regression as an independent variable. Previously, it is found that share variable has negative and significant coefficient, however, coefficient of the square of the share variable need to be positive for U-shaped relation between the share of R&D personnel and regions' economic growth. Fixed-effects regression results with robust standard errors are given in Table 5.17. According to results, square of the share has positive and significant coefficient while the coefficient of the share variable remains negative and significant. This result supports the estimation of U-shaped relation.

Table 5.15: Hausman Test for Model [5.6]

Hausman Test
Ho: difference in coefficients not systematic Prob>chi2 = 0.0000

Table 5.16: Heteroskedasticity Test for Model [5.6]

Heteroskedasticity Test
Modified Wald test for groupwise heteroskedasticity in fixed effect regression model **H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.0000

$$\frac{\dot{Y}}{Y} = \alpha + \gamma(\text{SHLA})^2 + \delta\text{SHLA}$$

Table 5.17: Regression Results for Model [5.6]

Fixed-effects regression **Number of observations:** 208 **Number of groups:** 26 **Dependent Variable:** $\frac{\dot{Y}}{Y}$	
Independent Variables	**Coefficient**
$(\text{SHLA})^2$	0.0775*** (3.70) [0.0209]
SHLA	-0.3083*** (-7.38) [0.0418]
Cons	0.2169*** (11.56) [0.0188]
Prob > F = 0.0000 **R-squared (within)=** 0.2499 **Result:** Convex shape (U-shaped)	

t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

In order to capture the turning point, quadratic prediction plot which is constructed by using fitted values is given in Figure 5.8. This situation is also shown with 95% confidence interval (based on standard error of the mean) in Figure 5.9 and with scatter plot and 95% confidence interval (based on the standard error of the forecast) in Figure 5.10. Figure 5.9 indicates that real values are in the confidence interval. Figure 5.10 shows that majority of observations are in the confidence interval. These results demonstrates the robustness of the results.

Figure 5.8: Quadratic Prediction Plot

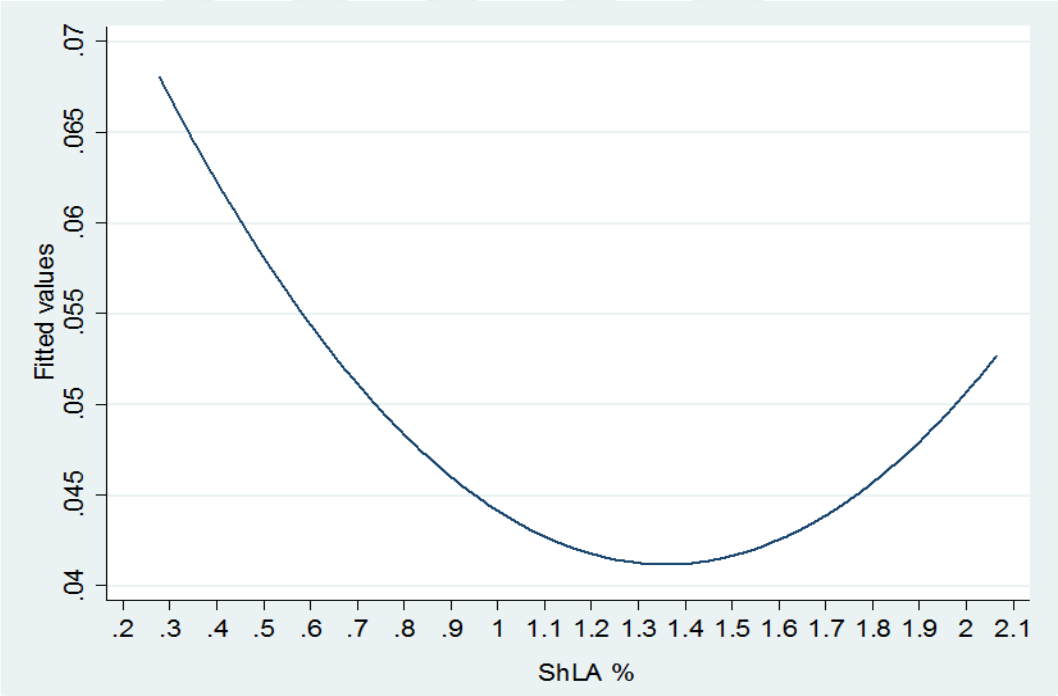


Figure 5.9: Quadratic Prediction Plot with 95% CI (based on standard error of the mean)

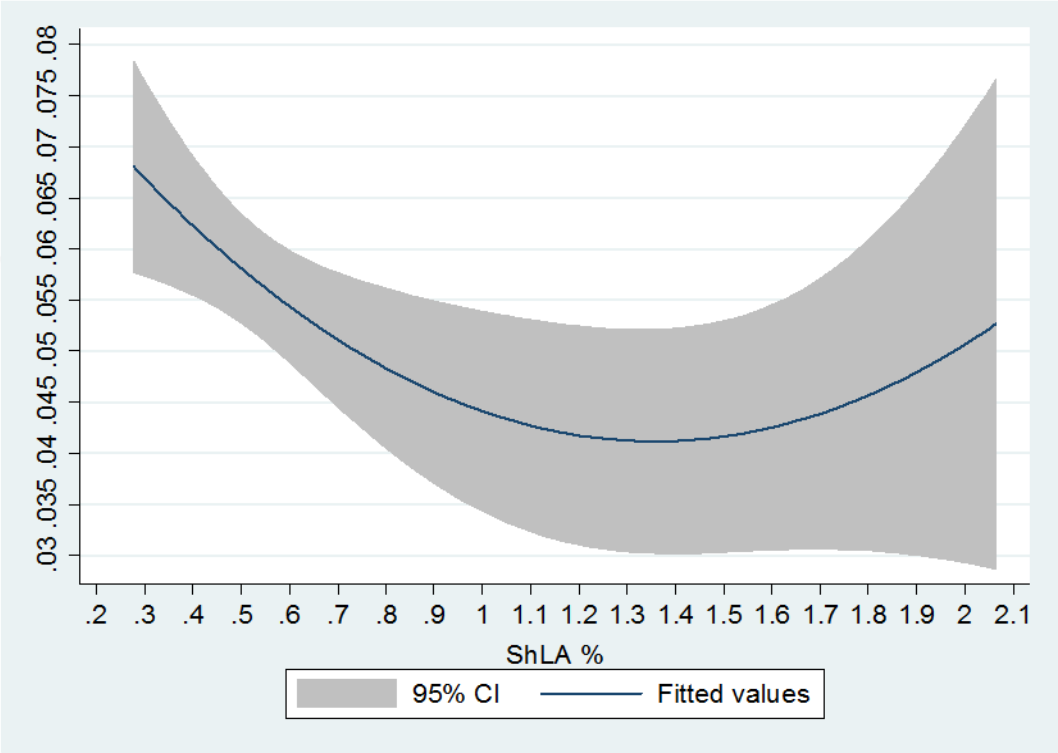
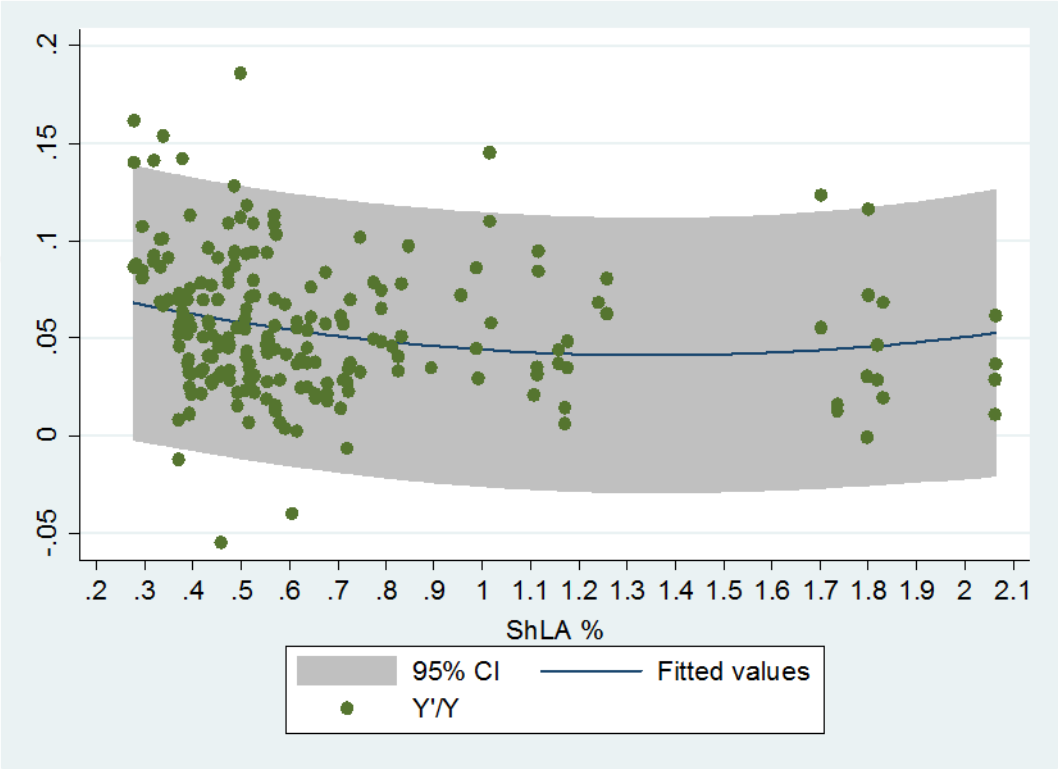


Figure 5.10: Quadratic Prediction Plot with Scatter Plot and 95% CI (based on the standard error of the forecast)



As it can be captured from the Figures, predicted turning point is 1.3576% for percentage share of R&D personnel and 4.1179% for economic growth. Average share of R&D personnel in observation period (2010-2017) is 0.7935%. This points coincides 4.8500% economic growth on quadratic fitted line. The actual average growth in observation period (2010-2017) is 5.4018% which is in the confidence interval for both based on the standard error of the forecast and standard error of the mean. Therefore, it can be indicated predicted turning point of 1.3576% share of R&D personnel is meaningful.

There are other factors that affect per-capita GDP growth (omitted variable bias: one of the sources of endogeneity) but because of degrees of freedom problem other factors cannot be directly added as an independent variable to the model. Therefore, instead of using

variety of variables, it is decided to use lagged dependent variable as one of the predictor of the model because it includes all other factors. By construction, the unobserved panel-level effects are correlated with the lagged dependent variables which makes the standard estimator inconsistent (in static models using lag dependent variable gives rise to autocorrelation). Therefore, there is a need to construct dynamic panel data model which includes p lags of dependent variable as covariates and contains unobserved panel-level effects (fixed or random).

Arellano-Bond dynamic panel-data estimation, Two Step Difference GMM (Generalized Method of Moments) is used in order to investigate this issue for NUTS2 level regions of Turkey (with transformed share variable; time period: 2010-2017). Arellano-Bond estimator is consistent with the case of this study (t=6 (year 2010 and year 2011 are eliminated because for instruments, Arellano-Bond estimator uses second lag of dependent variable and all feasible lags thereafter (detailed information is given in Appendix F)), N=26) since it was designed for panel with small T and large N (Arellano and Bond, 1991). Two-step estimator uses the first step estimates to estimate the parameters of interest in second step. Although two-step estimator is asymptotically more efficient than one-step estimator, its standard errors are downward-biased. However, it is possible to cope with this problem. In this respect, Windmeijer (2005) developed finite sample correction matrix that makes two-step robust GMM estimates more efficient than one step robust estimates (Roodman, 2009). Therefore, by using biased-corrected standard errors (WC-robust standard errors) developed by Windmeijer, two-step difference GMM results are reported. In addition, in order to check the robustness of the results and make a comparison, one-step difference GMM results (while all other conditions are the same) are also given in the Appendix F, and interpretation of the results did not change which proves the robustness of the results.

Moreover, classical difference GMM is preferred rather than system GMM in which lagged differences are used as a moment conditions also for level equation as well as differenced equation. By adding GMM-type instruments to level equation, system GMM has more instruments than difference GMM. Number of instruments (Technical details related

with the instruments (for current model: Arellano-Bond dynamic panel-data estimation, Difference GMM) are given in Appendix F) may be large relative to number of observations and the suggested rule of thumb is to keep number of instruments equal or smaller than number of groups. However, this work has limited number of groups (26 regions). In the case of using system GMM, number of instruments will be more than the number of groups for our estimation so that it is decided to use difference GMM.

The condition of the validity of the moment conditions must be satisfied in order to obtain consistent estimates by using GMM estimator. There is no direct way to test this bur the validity of overidentifying conditions can be tested. Sargan test and Hansen test serve this purpose. For two-step GMM, standard procedure is to use Hansen test (Roodman, 2009). The distribution of Sargan test is not known when the disturbances are heteroskedastic, so this test cannot be used with robust standard errors. In our case, biased-corrected standard errors (WC-robust standard errors) are used because of using two-step estimator. Therefore, instead of using Sargan test, Hansen test is used since it is robust to non-i.i.d. (independently and identically distributed) errors. According to Hansen test results, instruments are valid. However, the moment conditions are valid only if there is no serial correlation in the idiosyncratic errors. The Arellano-Bond Test tests for serial correlation in the first-differenced errors. Rejecting null hypothesis of no serial correlation at order one in first differenced errors does not mean that the model is misspecified because first difference of independently and identically distributed (i.i.d.) idiosyncratic errors are need to be autocorrelated. However, rejecting null at order two indicates that the moment conditions are not valid. In other words, for the robustness of the model there must be autocorrelation at order one (the first-differenced errors are first-order serially correlated, when the idiosyncratic errors are i.i.d.) but no autocorrelation at order two. According results of Arellano-Bond Test, this requirement has met. Consequently, Hansen and Arellano-Bond tests prove that the moment conditions are valid.

According to estimation results given in Table 5.18, the share of R&D personnel in total employment again affects regions' GDP per-capita growth negatively as it is found in

other models. Also all coefficients and model is statistically significant. With dynamic model, potential endogeneity problem is also controlled and the results prove that the share of R&D personnel has negative effect on regions' economic growth.

$$\left(\frac{\dot{Y}}{Y}\right)_{it} = \alpha + \gamma\left(\frac{\dot{Y}}{Y}\right)_{it-1} + \beta(SHLA)_{it}$$

Table 5.18: Regression Results for Model [5.7]

Arellano-Bond dynamic panel-data estimation, Two Step Difference GMM **Number of observations:** 156 **Number of Groups:** 26 **Number of instruments:** 23 **Dependent Variable:** $\left(\frac{\dot{Y}}{Y}\right)_t$	
Independent Variables	**Coefficient**
$\left(\frac{\dot{Y}}{Y}\right)_{t-1}$	-0.2219*** (-3.03) [0.0732]
SHLA	-0.2288*** (-5.51) [0.0415]
Cons	0.2210*** (6.17) [0.0358]
Prob > chi2 = 0.0000 **Wald chi2(2)** = 31.86 **Result:** Negative effect	
Hansen test of overidentifying restrictions **H0: overidentifying restrictions are valid** chi2(20) = 24.17; Prob > chi2 = 0.235	

Arellano-Bond test for zero autocorrelation in first-differenced errors

Order	**z**	**Prob > z**
1	-3.17	0.002
2	-0.29	0.771

H0: no autocorrelation

Note: Because the first difference of white noise is necessarily autocorrelated, one need to care about second order.

z statistics in ( ), WC-robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

After all these results, it is decided to use patent data as an alternative for R&D personnel data. In this respect, the data of distribution of patent grants with respect to cities is used. In order to cope with the scale effect problem, there is a requirement of dividing the number of patent grants to population (in thousands). If patent grants had not been divided to the population, Istanbul would have been an outlier. (Highest average (2007-2017) patent grants Istanbul: 541.8182; Average of Turkey (2007-2017): 1055.1818; Second highest average (2007-2017) Ankara: 108.0909; third highest average (2007-2017) Bursa: 85.2727; and 5 provinces[6] which have no patent grants during the investigation period). When per-capita terms is used, although Istanbul is still in the first place, it is no more to be an outlier (highest average (2007-2017) patent over population (in thousands) ratio Istanbul: 0.0381; second highest average (2007-2017) patent over population (in thousands) ratio Bursa: 0.0308, third highest average (2007-2017) patent over population (in thousands) ratio Kocaeli: 0.0261). Available time period fits the requirements of this model is restricted with the years between 2007 and 2017. Provincial level (NUTS3) fixed-effects regression results with robust standard errors are given below.

Table 5.19: Hausman Test for Model [5.8]

Hausman Test
Ho: difference in coefficients not systematic Prob>chi2 = 0.0003

[6] Artvin, Erzincan, Bayburt, Tunceli, Hakkari.

Table 5.20: Heteroskedasticity Test for Model [5.8]

Heteroskedasticity Test
Modified Wald test for groupwise heteroskedasticity in fixed effect regression model **H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.0000

$$\frac{\dot{Y}}{Y} = \alpha + \delta \frac{patent}{population(in\ thousands)}$$

Table 5.21: Regression Results for Model [5.8]

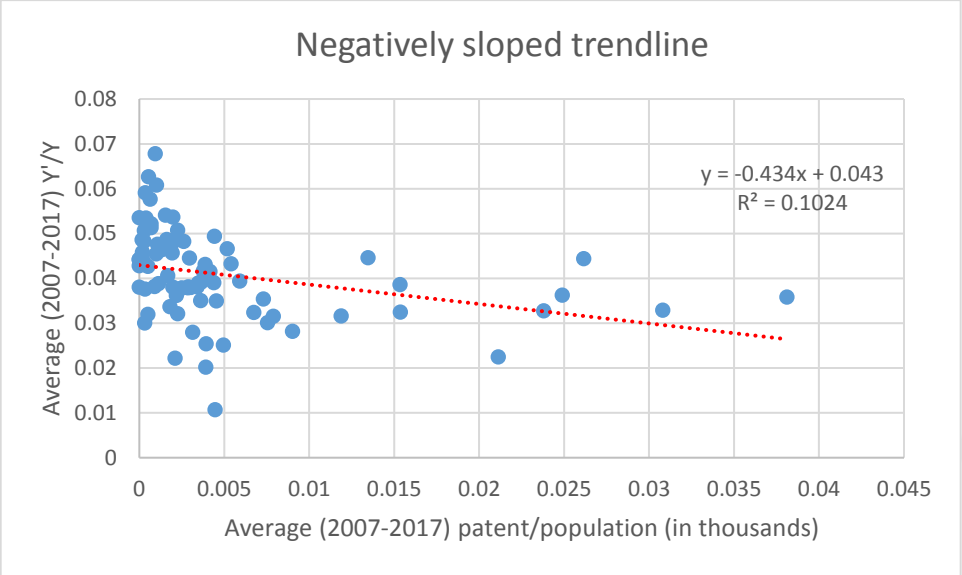
Fixed-effects regression **Number of observations:** 891 **Number of groups:** 81 **Dependent Variable:** $\frac{\dot{Y}}{Y}$	
Independent Variables	**Coefficient**
$\frac{patent}{population(in\ thousands)}$	1.0280*** (4.80) [0.2143]
Cons	0. 0358*** (34.11) [0.0010]
Prob > F = 0.0000 **R-squared (within)=** 0.0134 **Result:** Positive effect	

t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

According to results, contrast to R&D personnel data, patent grants has significant positive effect on economic growth. This result triggers making additional analysis since it is expected that R&D and patent data have in a similar trend (by transferring patent data to NUTS2 level, correlation between patent over population (in thousands) data and share of R&D personnel data is found to be 0.5922). Therefore, as standard procedure for this work, average values (2007-2017) of the variables for every individual unit is taken. Figure 5.11

indicates negative relation between patent variable and economic growth which contradicts to regression results so that there can be a misspecification in regression results.

Figure 5.11: Scatter Plot (5.7)



The regression results can be biased because of omitted variables problem which is one of the major sources of endogeneity. In order to cope with this problem, in first step, by transferring the patent data to NUTS2 level, regression includes both share of R&D personnel in total employment data and patent over population (in thousands) data as an independent variable is constructed. The time period for this analysis is the years between 2010 and 2017 since R&D personnel data available only for this period. Table 5.24 shows the fixed-effects regression results with robust standard errors. According to results, while all other conditions stay the same, the significance of patent variable decreases. This situation also paves the way for making dynamic analysis by adding lagged dependent variable to the model in order to cope with the endogeneity problem completely.

Table 5.22: Hausman Test for Model [5.9]

Hausman Test
Ho: difference in coefficients not systematic Prob>chi2 = 0.0000

Table 5.23: Heteroskedasticity Test for Model [5.9]

Heteroskedasticity Test
Modified Wald test for groupwise heteroskedasticity in fixed effect regression model **H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.0000

$$\frac{\dot{Y}}{Y} = \alpha + \beta SHLA + \delta \frac{patent}{population\ (in\ thousands)}$$

Table 5.24: Regression Results for Model [5.9]

Fixed-effects regression **Number of observations:** 208 **Number of groups:** 26 **Dependent Variable:** $\frac{\dot{Y}}{Y}$	
Independent Variables	**Coefficient**
SHLA	-0.2017*** (-8.03) [0.0251]
$\frac{patent}{population(in\ thousands)}$	0.8210* (1.74) [0.4710]
Cons	0. 1851*** (11.62) [0.0159]
Prob > F = 0.0000 **R-squared (within)=** 0.2207	

t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

Arellano-Bond dynamic panel-data estimation, Two Step Difference GMM results are given below. The moment conditions are also valid for this dynamic model (see Hansen test of overidentifying restrictions and Arellano-Bond test for zero autocorrelation in first-differenced errors). According to results, while all other results stay the same, the coefficient of the patent variable turns out to be insignificant. On the other side, the results related with share of R&D personnel data does not change which shows the robustness of the interpretation regarding the negative impact of R&D personnel on economic growth. Again for robustness test, one-step results are also given in Appendix F and according to one step results, the interpretation of the model does not change which shows the robustness of the results.

$$\left(\frac{\dot{Y}}{Y}\right)_{it} = \alpha + \gamma\left(\frac{\dot{Y}}{Y}\right)_{it-1} + \beta(SHLA)_{it} + \delta\left(\frac{patent}{population\ (in\ thousands)}\right)_{it}$$

Table 5.25: Regression Results for Model [5.10]

Arellano-Bond dynamic panel-data estimation, Two Step Difference GMM **Number of observations:** 156 **Number of Groups:** 26 **Number of instruments:** 24 **Dependent Variable:** $\left(\frac{\dot{Y}}{Y}\right)_t$	
Independent Variables	**Coefficient**
$\left(\frac{\dot{Y}}{Y}\right)_{t-1}$	-0.2176*** (-2.82) [0.0771]
SHLA	-0.2313*** (-4.85) [0.0477]
$\frac{patent}{population(in\ thousands)}$	0.0147 (0.02) [0.8267]
Cons	0.2221*** (6.28) [0.0354]
Prob > chi2 = 0.0000 **Wald chi2(2)** = 33.53	
Hansen test of overidentifying restrictions **H0: overidentifying restrictions are valid** chi2(20) = 24.13; Prob > chi2 = 0.237	

Arellano-Bond test for zero autocorrelation in first-differenced errors

Order	**z**	**Prob > z**
1	-3.19	0.001
2	-0.27	0.788

H0: no autocorrelation

Note: Because the first difference of white noise is necessarily autocorrelated, one need to care about second order.

z statistics in ( ), WC-robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

5.3 SUMMARY

Summary table below gives all the results obtained from different models in this section.

According to results in endogenous growth model section, it can be stated that R&D personnel has negative impact on regions' economic growth with its current share in total employment. Moreover, catch-up strategy based on increasing the ratio of R&D personnel also has a negative impact on regions' economic growth. Furthermore, increasing the share of R&D personnel in total employment decreases the growth differences between regions by affecting east region more negatively since, in the investigation period, east region grows more than the west region.

On the other side, there is an estimated U-shaped relation which is meant that if the share of R&D personnel in total employment will increase, the effect has a tendency of turning to be a positive. Especially, West region is closer to reach that.

Besides, patent data has no effect on regions' economic growth when the model is controlled for endogeneity.

Table 5.26: Summary Table

Models	Results
$\frac{\dot{Y}}{Y} = \alpha + \delta\frac{L_A}{L}$	R&D personnel has a negative impact on regions' economic growth.
$\frac{\dot{Y}}{Y} = \alpha + \gamma\frac{L_A}{L}\frac{Y_l - Y_r}{Y_r}$	Catch-up strategy based on increasing the ratio of R&D personnel in total employment has a negative impact on regions' economic growth.
$\frac{\dot{Y}}{Y} = \alpha + \delta \mathrm{SHL_A}$	Share of R&D personnel in total employment has a negative impact on regions' economic growth.
$\left(\frac{\dot{Y}}{Y}\right)_r - \left(\frac{\dot{Y}}{Y}\right)_{TR} = \alpha + \delta \mathrm{SHL_A}$	Increase in the share of R&D personnel closes the growth differences among regions.
$\frac{\dot{Y}}{Y} = \alpha + \gamma(\mathrm{SHLA})^2 + \delta \mathrm{SHLA}$	There is U-shaped (convex) relation between R&D personnel and regions' economic growth. In other words, it is estimated that after a certain level of share the effect will be positive.
$\left(\frac{\dot{Y}}{Y}\right)_{it} = \alpha + \gamma\left(\frac{\dot{Y}}{Y}\right)_{it-1} + \beta(SHLA)_{it}$	Controlling for endogeneity does not change the result that indicates share of R&D personnel in total employment has negative impact on regions' economic growth.
$\frac{\dot{Y}}{Y} = \alpha + \delta\frac{patent}{population(in\ thousands)}$	Patent grants has positive impact on regions' economic growth.
$\frac{\dot{Y}}{Y} = \alpha + \beta SHLA + \delta\frac{patent}{population\ (in\ thousands)}$	Patent grants and R&D personnel effect regions' economic growth positively and negatively respectively. However, adding R&D variable decreases the significance level of patent variable.
$\left(\frac{\dot{Y}}{Y}\right)_{it} = \alpha + \gamma\left(\frac{\dot{Y}}{Y}\right)_{it-1} + \beta(SHLA)_{it} + \delta\left(\frac{patent}{population\ (in\ thousands)}\right)_{it}$	Patent data has no significant effect on regions' economic growth when the model is controlled for endogeneity.

6. CONCLUSION

In this work, convergence issue for the regions of Turkey is investigated with neoclassical exogenous growth perspective and endogenous growth perspective incorporating with descriptive statistics. The results obtained from neoclassical exogenous growth perspective directly provide conclusion about convergence for the regions of Turkey. On the other side, the results of endogenous growth perspective, show that whether human capital may help with respect to close the income differences among regions.

According to results obtained from exogenous model part, it can be stated that there is a tendency of convergence for the regions of Turkey. However, one should keep in mind that there is an important crisis (2008 crisis) in the investigation period of this study in which the tendency of convergence increases. Besides, descriptive statistics show that during the crisis, the speed of convergence increases, however, generally it cannot be captured that there is convergence among regions of Turkey in periods other that crisis and post-crisis, excess capacity periods. On the other side, descriptive statistics show that periods without economic crisis do not indicate divergence also. Therefore, it cannot be stated that there is convergence or divergence among regions of Turkey for the investigation period of this study but the main conclusion is that crisis has a positive impact with respect to closing income differences among regions.

Furthermore, in endogenous model section, it is found that R&D personnel has negative impact on economic growth of the regions with its current share in total employment. Moreover, catch-up strategy based on increasing the ratio of R&D personnel also has a negative impact on regions' economic growth. Furthermore, increasing the share of R&D personnel in total employment decreases the growth differences between regions by affecting east region more negatively since, in the investigation period, east region grows more than the west region.

On the other side, it is found that there is an estimated U-shaped relation which is meant that if the share of R&D personnel in total employment will increase, after a certain level, the effect has a tendency of turning to be a positive. Especially, west region is closer to reach that.

Furthermore, patent data has no effect on economic growth when the model is controlled for endogeneity. Actually, it is not surprising because it represents very small part of the economy in Turkey and there is a noticeable difference between growth rates and patent grants among regions. Moreover, patent issue is little bit different as one can get patent in Istanbul (most patents obtained province) but can use it in another region. Consequently, because of these reasons, finding no effect of patent grants on regions' economic growth is meaningful.

When it comes to convergence issue, since rich west is closer to take a positive effect from R&D personnel and with relatively low share of R&D personnel the economic growth of east region is more negatively affected from R&D personnel, with the current share, by using strategy based on increasing the share of R&D personnel, east region cannot close the income differences in the short-run. Also in the medium and the long run, this strategy can be unsuccessful because as it is mentioned in "cities and growth" section of Lucas (1988), there is an interaction and externality effect which prevents east region leads west region regarding the share of R&D personnel in total employment. This means that although the effect of R&D personnel turns out to be a positive, the possibility of having higher share of R&D personnel than west region is very low for east region. Subsidy also cannot be a cure for this case because human capital does not move just because of higher wages as there is an externality feature of human capital.

Besides, according to results, east region is far away from taking positive effect from R&D personnel. If the convergence policy which is based on insisting on increasing the share of R&D personnel in east region will be applied, this may cause divergence rather than convergence.

Consequently, according to results of this work, income differences between rich west and poor east cannot be closed by applying a policy that is based on increasing human capital (R&D personnel for this study) in east regions. Conversely, this may cause divergence because it affects economic growth of the regions negatively with the current low share. It is not in the scope of this study but focusing on the policies for east region that east region has comparative advantage can be more beneficial in closing the income differences between west and east.

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APPENDIX A

Table A.1: Comparison between GDP Deflator and CPI (2005-2017) (1)

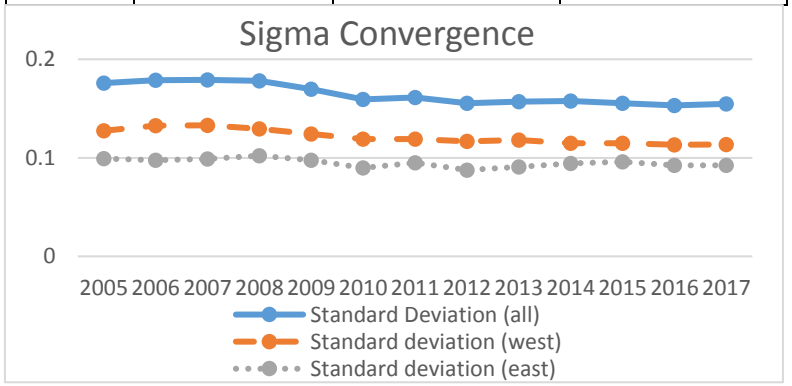
Beta Convergence (Unconditional) NUTS2	
GDP DEFLATOR	**CPI**
Heteroskedasticity Test	**Heteroskedasticity Test**
H0: sigma(i)^2 = sigma^2 for all i Pr.: 0.0001	**H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.0000
$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t$	$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t$
Unconditional Convergence Results Fixed-effects regression	**Unconditional Convergence Results Fixed-effects regression**
Independent Variables / **Coefficient**	**Independent Variables** / **Coefficient**
$\log(y_{i,t-1})$: 0.6720*** (1685.29) [0.0399]	$\log(y_{i,t-1})$: 0.6360*** (17.50) [0.0363]
T_t : 0.0064*** (7.32) [0. 0009]	T_t : 0.0068*** (8.59) [0. 0007]
Cons : 1.3103*** (8.36) [0. 1568]	Cons : 1.3767*** (10.15) [0. 1356]
Prob > F = 0.0000 **R-squared (within) =** 0.9367	**Prob > F =** 0.0000 **R-squared (within) =** 0.9133
Calculated β value: 0.3975 **Result:** Convergence	**Calculated β value:** 0.4525 **Result:** Convergence
t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.	t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

Table A.2: Comparison between GDP Deflator and CPI (2005-2017) (2)

Beta Convergence (Conditional) NUTS2	
GDP DEFLATOR	**CPI**
Heteroskedasticity Test	**Heteroskedasticity Test**
H0: sigma(i)^2 = sigma^2 for all i Pr.:0.0000	**H0: sigma(i)^2 = sigma^2 for all i** Pr.: 0.0000
$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t + eA_{i,t-1} + fS_{i,t-1}$	$\log(y_{i,t}) = \alpha + b\log(y_{i,t-1}) + cT_t + eA_{i,t-1} + fS_{i,t-1}$
Conditional Convergence Results **Fixed-effects regression**	**Conditional Convergence Results** **Fixed-effects regression**
Independent Variables / **Coefficient**	**Independent Variables** / **Coefficient**
$\log(y_{i,t-1})$ — 0.6436*** (11.05) [0. 0582]	$\log(y_{i,t-1})$ — 0.6051*** (9.57) [0.0632]
T_t — 0.0074*** (6.85) [0.0011]	T_t — 0.0072*** (7.65) [0.0009]
$A_{i,t-1}$ — 0.0024** (2.30) [0.0009]	$A_{i,t-1}$ — 0.0024** (2.36) [0.0010]
$S_{i,t-1}$ — -0.0009 (-1.01) [0.0009]	$S_{i,t-1}$ — -0.0010 (-1.00) [0.0010]
Cons — 1.4391*** (5.34) [0.2697]	Cons — 1.5090*** (5.25) [0.2875]
Prob > F = 0.0000 **R-squared (within)**= 0.9408 **Calculated β value:** 0.4407 **Result:** Convergence	**Prob > F** = 0.0000 **R-squared (within)**= 0.9205 **Calculated β value:** 0.5024 **Result:** Convergence
t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.	t statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

Table A.3: Comparison between GDP Deflator and CPI (2005-2017) (3)

Sigma Convergence of log(y) NUTS2			
GDP DEFLATOR			
year	Standard Deviation (all)	Standard Deviation (west)	Standard Deviation (east)
2005	0.1760	0.1273	0.0991
2006	0.1787	0.1327	0.0975
2007	0.1791	0.1330	0.0990
2008	0.1781	0.1294	0.1021
2009	0.1698	0.1243	0.0975
2010	0.1592	0.1189	0.0897
2011	0.1614	0.1190	0.0948
2012	0.1553	0.1167	0.0876
2013	0.1569	0.1180	0.0908
2014	0.1578	0.1148	0.0944
2015	0.1554	0.1148	0.0961
2016	0.1532	0.1133	0.0924
2017	0.1547	0.1135	0.0925



CPI			
year	Standard Deviation (all)	Standard Deviation (west)	Standard Deviation (east)
2005	0.1692	0.1243	0.0978
2006	0.1695	0.1266	0.0948
2007	0.1712	0.1281	0.0963
2008	0.1722	0.1242	0.1005
2009	0.1658	0.1196	0.0980
2010	0.1562	0.1160	0.0904
2011	0.1603	0.1177	0.0964
2012	0.1546	0.1158	0.0888
2013	0.1560	0.1163	0.0921
2014	0.1563	0.1119	0.0951
2015	0.1528	0.1117	0.0962
2016	0.1503	0.1103	0.0925
2017	0.1530	0.1119	0.0924

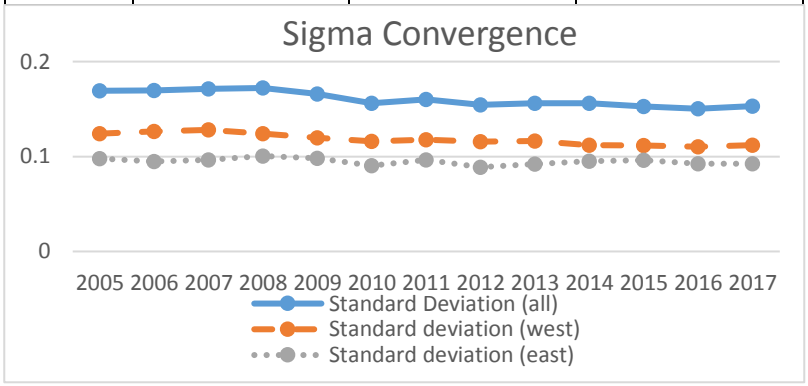
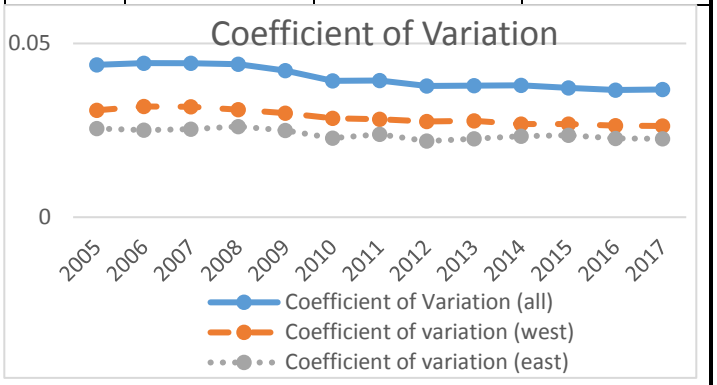
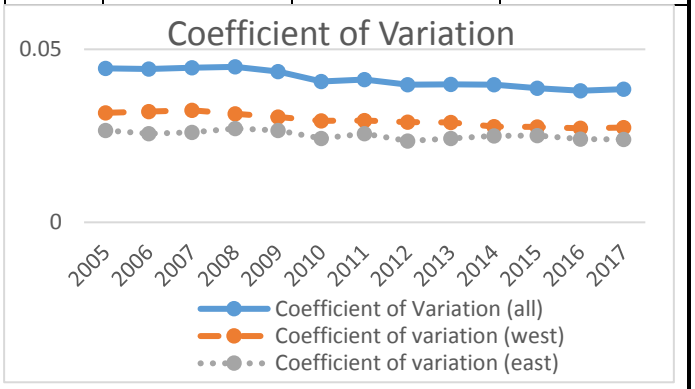


Table A.4: Comparison between GDP Deflator and CPI (2005-2017) (4)

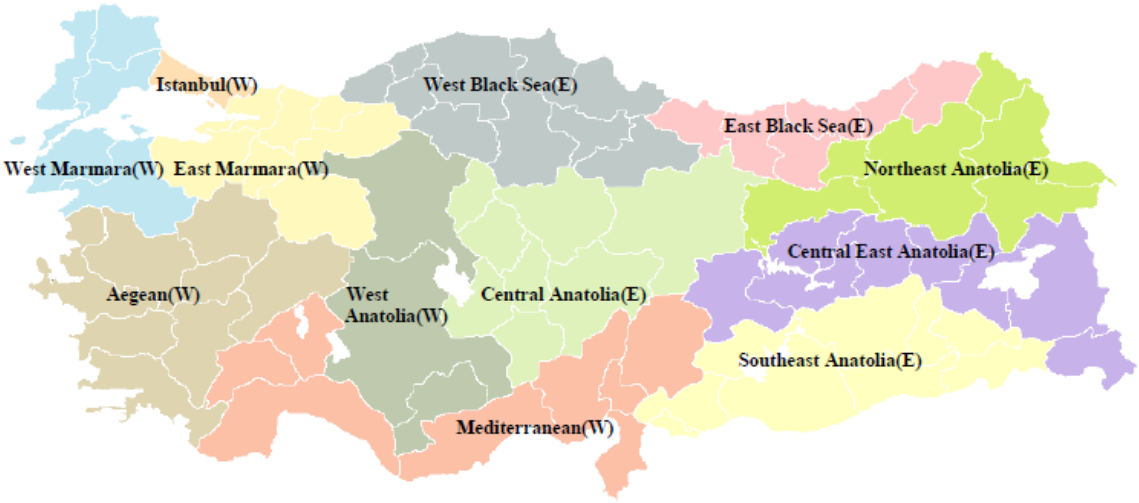
Coefficient of Variation of log(y) NUTS2							
GDP DEFLATOR				CPI			
year	Coefficient of Variation (all)	Coefficient of variation (west)	Coefficient of variation (east)	year	Coefficient of Variation (all)	Coefficient of variation (west)	Coefficient of variation (east)
2005	0.0439	0.0307	0.0256	2005	0.0445	0.0316	0.0266
2006	0.0443	0.0319	0.0250	2006	0.0443	0.0320	0.0256
2007	0.0443	0.0318	0.0253	2007	0.0447	0.0324	0.0260
2008	0.0440	0.0310	0.0261	2008	0.0449	0.0314	0.0271
2009	0.0422	0.0299	0.0250	2009	0.0435	0.0304	0.0266
2010	0.0392	0.0285	0.0227	2010	0.0407	0.0293	0.0243
2011	0.0394	0.0282	0.0238	2011	0.0413	0.0294	0.0256
2012	0.0377	0.0276	0.0219	2012	0.0397	0.0289	0.0235
2013	0.0379	0.0277	0.0225	2013	0.0399	0.0289	0.0242
2014	0.0379	0.0268	0.0234	2014	0.0398	0.0277	0.0250
2015	0.0372	0.0268	0.0236	2015	0.0387	0.0276	0.0251
2016	0.0366	0.0264	0.0227	2016	0.0380	0.0272	0.0240
2017	0.0368	0.0263	0.0226	2017	0.0385	0.0274	0.0239





APPENDIX B

Figure B.1: East-West Classification



W: WEST E: EAST

Source: Author's own work

Table B.1: NUTS1-NUTS2-NUTS3

NUTS1		NUTS2		NUTS3		NUTS1		NUTS2		NUTS3	
TR1	İstanbul	TR10	İstanbul	TR100	İstanbul	TR8	West Black Sea	TR81	Zonguldak, Karabük, Bartın	TR811	Zonguldak
TR2	West Marmara	TR21	Tekirdağ, Edirne, Kırklareli	TR211	Tekirdağ					TR812	Karabük
				TR212	Edirne					TR813	Bartın
				TR213	Kırklareli			TR82	Kastamonu, Çankırı, Sinop	TR821	Kastamonu
		TR22	Balıkesir, Çanakale	TR221	Balıkesir					TR822	Çankırı
				TR222	Çanakkale					TR823	Sinop
TR3	Aegean	TR31	İzmir	TR310	İzmir			TR83	Samsun, Tokat, Çorum, Amasya	TR831	Samsun
		TR32	Aydın, Denizli, Muğla	TR321	Aydın					TR832	Tokat
				TR322	Denizli					TR833	Çorum
				TR323	Muğla					TR834	Amasya
		TR33	Manisa, Afyonkarahisar, Kütahya, Uşak	TR331	Manisa	TR9	East Black Sea	TR90	Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane	TR901	Trabzon
				TR332	Afyonkarahisar					TR902	Ordu
				TR333	Kütahya					TR903	Giresun
				TR334	Uşak					TR904	Rize
TR4	East Marmara	TR41	Bursa, Eskişehir, Bilecik	TR411	Bursa					TR905	Artvin
				TR412	Eskişehir					TR906	Gümüşhane
				TR413	Bilecik	TRA	North East Anatolia	TRA1	Erzurum, Erzincan, Bayburt	TRA11	Erzurum
		TR42	Kocaeli, Sakarya, Düzce, Bolu, Yalova	TR421	Kocaeli					TRA12	Erzincan
				TR422	Sakarya					TRA13	Bayburt
				TR423	Düzce			TRA2	Ağrı, Kars, Iğdır, Ardahan	TRA21	Ağrı
				TR424	Bolu					TRA22	Kars
				TR425	Yalova					TRA23	Iğdır
TR5	West Anatolia	TR51	Ankara	TR510	Ankara					TRA24	Ardahan
		TR52	Konya, Karaman	TR521	Konya	TRB	Central East Anatolia	TRB1	Malatya, Elazığ, Bingöl, Tunceli	TRB11	Malatya
				TR522	Karaman					TRB12	Elazığ
TR6	Mediterranean	TR61	Antalya, Isparta, Burdur	TR611	Antalya					TRB13	Bingöl
				TR612	Isparta					TRB14	Tunceli
				TR613	Burdur			TRB2	Van, Muş, Bitlis, Hakkari	TRB21	Van
		TR62	Adana, Mersin	TR621	Adana					TRB22	Muş
				TR622	Mersin					TRB23	Bitlis
		TR63	Hatay, Kahramanmaraş, Osmaniye	TR631	Hatay					TRB24	Hakkari
				TR632	Kahramanmaraş	TRC	South East Anatolia	TRC1	Gaziantep, Adıyaman, Kilis	TRC11	Gaziantep
				TR633	Osmaniye					TRC12	Adıyaman
TR7	Central Anatolia	TR71	Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir,	TR711	Kırıkkale					TRC13	Kilis
				TR712	Aksaray			TRC2	Şanlıurfa, Diyarbakır	TRC21	Şanlıurfa
				TR713	Niğde					TRC22	Diyarbakır
				TR714	Nevşehir			TRC3	Mardin, Batman, Şırak, Siirt	TRC31	Mardin
				TR715	Kırşehir					TRC32	Batman
		TR72	Kayseri, Sivas, Yozgat	TR721	Kayseri					TRC33	Şırnak
				TR722	Sivas					TRC34	Siirt
				TR723	Yozgat	Total	12	26		81	

Source: TURKSTAT

APPENDIX C

Table C.1: Ranking (all)

RANKING (2004-2017) all								
NUTS1 (12 regions)				**NUTS2 (26 regions)**			**NUTS3 (81 regions)**	
2004, 2006-2008, 2010-2011, 2013,2016	2005	2009, 2012	2014-2015, 2017	2004-2005	2006-2017 (except 2013)	2013	2004-2005, 2007, 2009	2006, 2008, 2010-2017
1. TR1 **2.** TR5 **3.** TR4 **12.** TRB	**1.** TR1 **2.** TR5 **3.** TR4 **12.** TRA	**1.** TR1 **2.** TR5 **3.** TR4 **12.** TRC	**1.** TR1 **2.** TR4 **3.** TR5 **12.**TRB	**1.** TR10 **2.** TR51 **3.** TR31 **26.**TRB2	**1.** TR10 **2.** TR51 **3.** TR42 **26.** TRB2	**1.** TR10 **2.** TR51 **3.** TR42 **26.** TRA2	**1.** TR100 **2.** TR510 **3.** TR421 **81.** TRA21	**1.** TR100 **2.** TR421 **3.** TR510 **81.** TRA21

Note: See Appendix B, Table B.1 for the provinces included in regions specified by codes.

Table C.2: Ranking (west)

RANKING (2004-2017) west						
NUTS1 (12 regions)		**NUTS2 (26 regions)**		**NUTS3 (81 regions)**		
2004-2013, 2016	2014-2015, 2017	2004-2005	2006-2017	2004-2005, 2007, 2009	2006, 2008, 2010, 2012-2013, 2015	2011, 2014, 2016-2017
1. TR1 **2.** TR5 **3.** TR4 **6.** TR6	**1.** TR1 **2.** TR4 **3.** TR5 **6.** TR6	**1.** TR10 **2.** TR51 **3.** TR31 **13.** TR63	**1.** TR10 **2.** TR51 **3.** TR42 **13.** TR63	**1.** TR100 **2.** TR510 **3.** TR421 **33.** TR633	**1.** TR100 **2.** TR421 **3.** TR510 **33.** TR633	**1.** TR100 **2.** TR421 **3.** TR510 **33.** TR632

Note: See Appendix B, Table B.1 for the provinces included in regions specified by codes.

Table C.3: Ranking (east)

<table>
<tr><th colspan="12">RANKING (2004-2017) east</th></tr>
<tr><th colspan="2">NUTS1 (12 regions)</th><th colspan="5">NUTS2 (26 regions)</th><th colspan="4">NUTS3 (81 regions)</th></tr>
<tr><td>2004</td><td>2005</td><td>2004</td><td>2005-2010, 2012</td><td>2011</td><td>2013</td><td>2014, 2016</td><td>2004</td><td>2005-2007</td><td>2008</td><td>2009</td></tr>
<tr><td rowspan="2">1. TR7
2. TR5
3. TR4
6. TRB</td><td rowspan="2">1. TR7
2. TR4
3. TR5
6. TRA</td><td rowspan="2">1. TR82
2. TR72
3. TR71
13. TRB2</td><td rowspan="2">1. TR72
2. TR82
3. TR90
13. TRB2</td><td rowspan="2">1. TR72
2. TR82
3. TR71
13. TRB2</td><td rowspan="2">1. TR72
2. TR82
3. TR81
13. TRA2</td><td rowspan="6">1. TR72
2. TR82
3. TR81
13. TRB2</td><td>1. TR721
2. TR821
3. TRA12
48. TRA21</td><td>1. TR721
2. TR905
3. TR901
48. TRA21</td><td>1. TR721
2. TR905
3. TRA12
48. TRA21</td><td rowspan="2">1. TRA12
2. TR905
3. TR721
48. TRA21</td></tr>
<tr><td>2010</td><td>2011-12</td><td>2013</td></tr>
<tr><td rowspan="2">2006-2008, 2009-2011, 2013-2017</td><td rowspan="2">2009, 2012</td><td rowspan="2">1. TR905
2. TRB14
3. TRA12
48. TRA21</td><td rowspan="2">1.TRA12
2. TR721
3. TR905
48. TRA21</td><td rowspan="2">1. TRA12
2. TR721
3. TRB14
48. TRA21</td></tr>
<tr><td rowspan="2">1. TR7
2. TR4
3. TR5
6. TRB</td><td rowspan="2">1. TR7
2. TR4
3. TR5
6. TRC</td><td colspan="2">2015</td><td colspan="2">2017</td><td>2014</td><td>2015</td><td>2016</td><td>2017</td></tr>
<tr><td colspan="2">1. TR72
2. TR90
3. TR82
13. TRB2</td><td colspan="2">1. TR72
2. TR81
3. TR71
13. TRB2</td><td>1. TR721
2. TRA12
3. TR904
48. TRA21</td><td>1. TR721
2. TR904
3. TR901
48. TRA21</td><td>1. TRB14
2. TR721
3. TR904
48. TRA21</td><td>1. TRB14
2. TR721
3. TR905
48. TRA21</td></tr>
</table>

Note: See Appendix B, Table B.1 for the provinces included in regions specified by codes.

APPENDIX D

Table D.1: Shares % of R&D Personnel by sector

year	Total share %	Higher Education share %	Business Enterprise share %	Government share %
2010	100	59.6247	31.1511	9.2242
2011	100	57.9401	33.4920	8.5679
2012	100	58.8591	33.3031	7.8377
2013	100	57.7671	35.1557	7.0772
2014	100	58.9866	34.5072	6.5063
2015	100	59.0840	34.5771	6.3388
2016	100	59.8515	34.6277	5.5208
2017	100	57.1327	38.0534	4.8139

Source: Author's own calculation by using TURKSTAT's data.

Table D.2: Ranking of Shares of Business Enterprises R&D Personnel by Economic Activity (NACE Rev.2)

Ranking	Economic Activities	Average share (2010-2017) %
1	manufacturing	49.5563
2	information and communication	32.1609
3	professional, scientific and technical activities	10.1029
4	other activities	8.1800

Source: Author's own calculation by using TURKSTAT's data.

Table D.3: Shares % of R&D Personnel by Occupation

year	Total Share %	Researchers share %	Technicians/ equivalent staff share %	Other supporting staff share %
2010	100	84.6551	9.0369	6.3080
2011	100	83.6658	9.9783	6.3560
2012	100	84.1737	9.7455	6.0808
2013	100	84.6048	9.6072	5.7880
2014	100	84.9583	9.3226	5.7191
2015	100	85.0636	9.4759	5.4605
2016	100	79.1736	12.9080	7.9184
2017	100	79.0943	13.0615	7.8442

Source: Author's own calculation by using TURKSTAT's data.

Table D.4: Shares % of R&D Personnel by qualification

year	Total share %	Doctoral or equivalent level share %	Post-graduate master's or equivalent level share %	Bachelor's or equivalent level share %	Short-cycle tertiary education share %	Upper secondary education share %	Other share %
2010	100	33.6630	17.0781	36.1519	4.1976	6.2557	2.6537
2011	100	35.4721	14.2428	36.9682	4.5061	6.2513	2.5595
2012	100	34.6645	15.1166	37.5728	4.5578	5.8247	2.2637
2013	100	34.7742	15.2190	37.9567	4.4926	5.7274	1.8302
2014	100	35.1488	14.6664	38.8846	4.3667	5.2671	1.6665
2015	100	34.6217	13.5422	41.0694	4.1514	5.0525	1.5628
2016	100	31.5254	14.8180	42.7524	4.9338	4.7624	1.2080
2017	100	29.4501	14.8549	45.0874	5.1186	4.3238	1.1652

Source: Author's own calculation by using TURKSTAT's data.

According to TURKSTAT the definition of sub-groups of R&D personnel is made as follows.

“R&D personnel:

Researcher: Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned.

Technicians and equivalent staff: Technicians and equivalent staff are persons whose main tasks require technical knowledge and experience in one or more fields of engineering, physical and life sciences or social sciences and humanities. They participate in R&D by performing scientific and technical tasks involving the application of concepts and operational methods, normally under the supervision of researchers. Equivalent staff perform the corresponding R&D tasks under the supervision of researchers in the social sciences and humanities.

Other supporting staff: Other supporting staff includes skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D projects or directly associated with such projects.”

Extra Information about R&D personnel data

- R&D data are compiled on the basis of Frascati guidelines prepared by OECD.
- Data Sources:
  - Public Institutions: Research and Development Activities Survey (by post)
  - Industry and Service Organizations: Research and Development Activities Survey (face to face interview)
  - Foundations Universities: Research and Development Activities Survey (face to face interview)
  - State Universities: Administrative registration information is used for Research-Development Activities

- Scope:
  - Government: R&D Scan Survey Questionnaire includes all public institutions that are found to have R&D activities. Research hospitals are not included in the coverage.
  - Business enterprise: Industry and service initiatives with 20 or more employees in the private sector and producer public sector are included.

Within the scope of the research; Technology Development Foundation of Turkey, Technology and Innovation Support Programs Directorate under TÜBİTAK (The Scientific and Technological Research Council of Turkey), Initiatives with R&D support from Small and Medium Enterprises Development Organization (KOSGEB), The first 1000 initiatives declared by ICI (Istanbul Chamber of Industry), according to the results of the Structural Business Statistics Survey, the first 500 initiatives, Initiatives from previous practices are included.

- Higher education: All state and foundation universities and research institutes are covered. Vocational school of higher education (school-to-work transition) are not included. The researchers consist of staff with an academic title. Information is not compiled for Technicians and equivalent staff and other supporting staff (Note: This information is available for 2016 and later after an updated version of the Frascati manual, published in 2015).

Note: Non-profit organizations are included for 2016 and later with an updated version of the Frascati manual, published in 2015.

APPENDIX E

Table E.1: Distribution of % shares of domestic Granted Patents with respect to IPC (International Patent Classification) Classes

Ipc / year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
A	29.9	23.7	22.9	22.6	24.0	27.4	23.8	26.6	31.5	30.1	28.0
B	14.1	15.1	16.3	17.9	22.7	21.4	23.9	22.3	17.5	16.6	16.7
C	6.6	8.6	7.7	7.2	6.5	5.5	6.6	6.1	5.5	6.10	6.0
D	9.1	8.9	9.9	8.7	4.4	6.4	6.2	3.7	5.6	5.9	5.0
E	7.5	7.4	7.0	8.9	5.8	5.1	6.3	7.5	6.0	5.5	4.8
F	19.2	19.2	20.9	19.2	18.9	18.6	16.2	14.4	16.2	13.6	16.4
G	9.4	8.0	8.4	7.9	9.3	8.7	11.9	11.7	11.2	12.3	12.6
H	4.1	9.2	6.8	7.5	8.4	6.8	4.9	7.4	6.5	9.7	10.4
Total	100	100	100	100	100	100	100	100	100	100	100

Source: Author's own calculation by using Turkish Patent and Trademark Office's data.
Note: A: Human Necessities. B: Performing Operations, Transporting. C: Chemistry, Metallurgy. D: Textiles, Paper. E: Fixed Constructions. F: Mechanical Engineering, Lighting, Heating, Weapon, Blasting. G: Physics. H: Electricity

Table E.2: Ranking of Distribution of % shares of domestic Granted patents with respect to IPC (International Patent Classification) Classes

Ranking	IPC	Average (2007-2017) share %
1	**A: Human Necessities**	26.4184
2	**B: Performing Operations, Transporting**	18.6058
3	**F: Mechanical Engineering, Lighting, Heating, Weapons, Blasting**	17.5378
4	**G: Physics**	10.1569
5	**H: Electricity**	7.4340
6	**D: Textiles, Paper**	6.7188
7	**C: Chemistry, Metallurgy**	6.5784
8	**E: Fixed Constructions**	6.5498
	Total share %	100

Source: Author's own calculation by using Turkish Patent and Trademark Office's data.

APPENDIX F

Dynamic Model

Information about Instruments

Table E2 below gives the detailed information about instruments of the model (Arellano-Bond dynamic panel-data estimation, Difference GMM).

Table F.1: Detailed information about GMM-type instruments of differenced equation

Information:

- For instruments, Arellano and Bond estimator uses the second lags of dependent variable and all feasible lags thereafter (Instruments cannot be correlated with error term ε_{it}(t) so that it cannot start from time t. Hereby, for differenced equation it cannot start from time $t-1$. Therefore, the instruments start from $t-2$).

Note: Sample: 2010-2017

year	GMM-type Instruments
t=2017	$\left(\frac{\dot{Y}}{Y}\right)_{t-2}=\left(\frac{\dot{Y}}{Y}\right)_{2015},\left(\frac{\dot{Y}}{Y}\right)_{t-3}=\left(\frac{\dot{Y}}{Y}\right)_{2014},\left(\frac{\dot{Y}}{Y}\right)_{t-4}=\left(\frac{\dot{Y}}{Y}\right)_{2013},$ $\left(\frac{\dot{Y}}{Y}\right)_{t-5}=\left(\frac{\dot{Y}}{Y}\right)_{2012},\left(\frac{\dot{Y}}{Y}\right)_{t-6}=\left(\frac{\dot{Y}}{Y}\right)_{2011},\left(\frac{\dot{Y}}{Y}\right)_{t-7}=\left(\frac{\dot{Y}}{Y}\right)_{2010}$
t=2016	$\left(\frac{\dot{Y}}{Y}\right)_{t-2}=\left(\frac{\dot{Y}}{Y}\right)_{2014},\left(\frac{\dot{Y}}{Y}\right)_{t-3}=\left(\frac{\dot{Y}}{Y}\right)_{2013},\left(\frac{\dot{Y}}{Y}\right)_{t-4}=\left(\frac{\dot{Y}}{Y}\right)_{2012},$ $\left(\frac{\dot{Y}}{Y}\right)_{t-5}=\left(\frac{\dot{Y}}{Y}\right)_{2011},\left(\frac{\dot{Y}}{Y}\right)_{t-6}=\left(\frac{\dot{Y}}{Y}\right)_{2010}$
t=2015	$\left(\frac{\dot{Y}}{Y}\right)_{t-2}=\left(\frac{\dot{Y}}{Y}\right)_{2013},\left(\frac{\dot{Y}}{Y}\right)_{t-3}=\left(\frac{\dot{Y}}{Y}\right)_{2012},\left(\frac{\dot{Y}}{Y}\right)_{t-4}=\left(\frac{\dot{Y}}{Y}\right)_{2011},\left(\frac{\dot{Y}}{Y}\right)_{t-5}$ $=\left(\frac{\dot{Y}}{Y}\right)_{2010}$
t=2014	$\left(\frac{\dot{Y}}{Y}\right)_{t-2}=\left(\frac{\dot{Y}}{Y}\right)_{2012},\left(\frac{\dot{Y}}{Y}\right)_{t-3}=\left(\frac{\dot{Y}}{Y}\right)_{2011},\left(\frac{\dot{Y}}{Y}\right)_{t-4}=\left(\frac{\dot{Y}}{Y}\right)_{2010}$
t=2013	$\left(\frac{\dot{Y}}{Y}\right)_{t-2}=\left(\frac{\dot{Y}}{Y}\right)_{2011},\left(\frac{\dot{Y}}{Y}\right)_{t-3}=\left(\frac{\dot{Y}}{Y}\right)_{2010}$
t=2012	$\left(\frac{\dot{Y}}{Y}\right)_{t-2}=\left(\frac{\dot{Y}}{Y}\right)_{2010}$
Total	21 GMM-type instruments for differenced equation. **Note:** with "D.SHLA (first difference of the regressor SHLA)" (standard instrument for differenced equation) and "constant" (standard instrument for level equation) in total the model has **23 instruments.** For the dynamic model that patent data and R&D data used together as an independent variable, number of instrumental variables increase to 24 since first difference of the regressor "patent/population (in thousands)" is added as a standard instrument for differenced equation.

Robustness Check with One-step Estimation

$$\left(\frac{\dot{Y}}{Y}\right)_{it} = \alpha + \gamma\left(\frac{\dot{Y}}{Y}\right)_{it-1} + \beta(SHLA)_{it}$$

Table F.2: Alternative Regression Results for Model [5.7]

Arellano-Bond dynamic panel-data estimation, One Step Difference GMM **Number of observations:** 156 **Number of Groups:** 26 **Number of instruments:** 23 **Dependent Variable:** $\left(\frac{\dot{Y}}{Y}\right)_t$	
Independent Variables	**Coefficient**
$\left(\frac{\dot{Y}}{Y}\right)_{t-1}$	-0.2166*** (-2.93) [0.0740]
SHLA	-0.2206*** (-6.11) [0.0361]
Cons	0.2167*** (6.77) [0.0320]
Prob > chi2 = 0.0000 **Wald chi2(2)** = 38.53 **Result:** Negative effect	
Hansen test of overidentifying restrictions **H0: overidentifying restrictions are valid** chi2(20) = 24.17; Prob > chi2 = 0.235	

Arellano-Bond test for zero autocorrelation in first-differenced errors

Order	**z**	**Prob > z**
1	-4.00	0.000
2	-0.22	0.826

H0: no autocorrelation

Note: Because the first difference of white noise is necessarily autocorrelated, one need to care about second order.

z statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

According to results, significance and the signs of the coefficients did not change in one-step estimation.

$$\left(\frac{\dot{Y}}{Y}\right)_{it} = \alpha + \gamma\left(\frac{\dot{Y}}{Y}\right)_{it-1} + \beta(SHLA)_{it} + \delta\left(\frac{patent}{population\ (in\ thousands)}\right)_{it}$$

Table F.3: Alternative Regression Results for Model [5.10]

Arellano-Bond dynamic panel-data estimation, One Step Difference GMM **Number of observations:** 156 **Number of Groups:** 26 **Number of instruments:** 24 **Dependent Variable:** $\left(\frac{\dot{Y}}{Y}\right)_t$	
Independent Variables	**Coefficient**
$\left(\frac{\dot{Y}}{Y}\right)_{t-1}$	-0.2190*** (-2.95) [0.0741]
SHLA	-0.2188*** (-5.44) [0.0403]
$\frac{Ptnt}{population(in\ thousands)}$	-0.1036 (-0.15) [0.7024]
Cons	0.2167*** (6.80) [0.0319]
Prob > chi2 = 0.0000 **Wald chi2(2)** = 41.60	
Hansen test of overidentifying restrictions **H0: overidentifying restrictions are valid** chi2(20) = 24.13; Prob > chi2 = 0.237	

Arellano-Bond test for zero autocorrelation in first-differenced errors

Order	**z**	**Prob > z**
1	-4.02	0.000
2	-0.15	0.885

H0: no autocorrelation

Note: Because the first difference of white noise is necessarily autocorrelated, one need to care about second order.

z statistics in ( ), robust standard errors in [ ], ***/**/* indicate significance at 1%, 5% and 10% respectively.

According to results, as it is found in two-step results, patent variable has no effect (insignificant) on regions' per-capita GDP growth. Moreover, the sign and the significance of other coefficients did not change.