IBN HALDUN UNIVERSITY
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF ECONOMICS

MASTER THESIS

AN ANALYSIS OF CONDITIONAL INCOME CONVERGENCE IN SELECTED OECD COUNTRIES

AHMAD SAMIR RANJBAR

THESIS SUPERVISOR: PROF. RASİM ÖZCAN

ISTANBUL, 2020

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AN ANALYSIS OF CONDITIONAL INCOME CONVERGENCE IN SELECTED OECD COUNTRIES

by

AHMAD SAMIR RANJBAR

A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of Master of Arts in Economics

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APPROVAL PAGE

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Arts in Economics.

Thesis Jury Members

Title - Name Surname	Opinion	Signature
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This is to confirm that this thesis complies with all the standards set by the School of Graduate Studies of Ibn Haldun University.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ÖZ

SEÇİLMİŞ OECD ÜLKELERİNDE ŞARTLI GELİR YAKINLIĞININ ANALİZİ

Yazar Ranjbar, Ahmad Samir
İktisat Yüksek Lisans Programı
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Yakınsama kavramı temelde bir grup ülke ekonomisinde aynı istikrarlı duruma veya büyüme düzeyine benzerliktir. Bu tezin odak noktası, OECD ülkeleri arasında 2000-2017 yılları arasında koşullu gelir yakınsaması olup olmadığını doğrulamak için Beta ve Sigma yakınsama kanıtlarını bulmaktır. Beta yakınsama kavramı Absolut ve koşullu yakınsama arasında bölünmüştür. β yakınsama meydana gelir Eğer fakir ekonomiler zengin ekonomilerden daha hızlı büyüme eğilimindeyse; bununla birlikte, ekonomilerin kişi başına düşen gerçek GSYİH dağılımının zaman içinde kademeli olarak düşme eğilimi göstermesi halinde, σ-yakınsama varlığı gösterir. Bu çalışma, 33 OECD üyesi ekonomi arasında koşullu yakınsama varlığını belirlemek için Beta ve sigma yakınsama ekonometrik metodolojisini uygulamaktadır. Bu yönteme göre, seçilen ekonomiler arasında koşullu gerçek gelir yakınsamasını doğrulamak için Beta ve sigma parametrelerini tahmin etmek için kesit veri kümesi gereklidir. Beta yakınsama parametreleri En Küçük Kareler yöntemi (OLS) ile tahmin edilir. Ticaret açıklığı, Beta yakınsama regresyon denklemine ekleyerek kontrol değişkeni olarak dikkate alınır. Kullanılan modellerin ampirik sonuçları, tüm model için F-testi ve modelin münferit parametrelerinin sağlamlığını test etmek için t-testi gibi ekonometrik modellerin istatistiksel anlamlılık ölçümü yoluyla yorumlanmadan önce test edilir. Bulgular, 2000-2017 yılları arasında 33 OECD üyesi ekonomi arasında güçlü pozitif mutlak veya koşulsuz ve koşullu yakınsamayı göstermektedir. Modellerin sağlamlığı, hepsinin Autocorrelation veya seri korelasyon olmadığına vurgu yaptığı ekonometrik doğrulama teknikleri tarafından test edilmiştir. Model homossedastiktir ve artıklar normal olarak da dağıtılır. Ek olarak, Sigma yakınsama sonucu, kişi başına GSYİH'nin OECD ekonomileri arasında seçilen süre boyunca azaldığını öngörmektedir.

Anahtar Kelimeler: Koıullu Yakınsama, Mutlak Yakınsama, OECD, σ-Yakınsama, Ticarete Açıklıçk.

ABSTRACT

AN ANALYSIS OF CONDITIONAL INCOME CONVERGENCE IN SELECTED OECD COUNTRIES

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The concept of Convergence is fundamentally the similarity in economies of a bunch of countries towards the same steady-state or growth level. The focal point of this Thesis is finding the evidence of Beta and Sigma Convergence in order to verify whether there is conditional income convergence among a selected group of OECD economies within the time interval of 2000 to 2017or not? The concept of Beta convergence is divided between Absolut and conditional Convergence. When poor economies grow faster than rich economies, it illustrates β-convergence occurrence; nevertheless, σ-convergence exhibit a situation where real GDP per capita dispersion declines gradually over a certain time. This study applies Beta and sigma convergence econometric methodology to specify conditional convergence existence among 33 OECD member economies. According to this method, a cross-section dataset is required to estimate the parameters of Beta and sigma to confirm conditional real income convergence among selected economies. Parameters of beta convergence are estimated by the Least Square method (OLS). The trade openness is taken into account as a control variable, adding it to the Beta convergence regression equation. The empirical results of employed models are attested before interpretation through statistical significance measurement of the econometric models such as F-test for the whole model and t-test for testing robustness of individual parameters of the model. The findings appear to indicate strong positive absolute or unconditional and conditional Convergence among 33 OECD member economies for the period of 2000 to 2017. The model's robustness is tested by econometric verification technics where they all emphasize the absence of Autocorrelation or serial correlation. The model is homoscedastic, and residuals are normally distributed as well. Additionally, the result of Sigma convergence stipulates that GDP per capita dispersion has declined over the selected time period among OECD economies.

Keywords: Absolute Convergence, Conditional Convergence, σ-Convergence, OECD, Trade openness.

DEDICATION

I proudly devote this study is to my beloved parents; Mohamad Kabir Ranjbar and Hamida Ranjbar, as well as the dearest person in my life; my brother Ahmad Sahil Ranjbar. I feel indebted to my every academic and personal success, and without their care and unconditional love and support, this research would not have been possible to be conducted and accomplished.

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Ahmad Samir Ranjbar

ISTANBUL, 2020

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

σ	Symbol for Sigma
β	Symbol for Beta
γ	Symbol for Gama

CHAPTER I

INTRODUCTION

1.1. Introduction

Theoretical considerations are hardly found to address the issue of whether trade openness contribute or impede income convergence. Yet trade importance has intrigued many authors to estimate the relationship by employing different econometric technic and draw their conclusion based on their empirical analysis, whereas most of them focus on trade liberalization rather than trade openness. According to the traditional growth model of Solow Swan, Convergence comes to existence in a confined model of an economy in which adding certain restrictions can yield factor price equalization that does not necessarily imply income equalization (Dan Ben-David & Ayal Kimhi, 2004). Slaughter (2001), and Ben-David (1996), plus several other endogenous growth models, which allows for trade, primarily explains Convergence in the steady-state rate rather than the level of income. For more see, for instance, (Ben-David & Loewy, 1998; Ben-David & Kimhi, 2000).

Our understanding of the concept of Convergence has improved throughout the contribution and in-depth researches conducted by the aforementioned scholars and many more. However, the conclusion that is drawn is depending on the application of different econometric and statistical tools, the definition of Convergence itself, level of economies, whether it is high-income economies or low-income, variables, data, and time period that studies were conducted. To be precise, given the empirical literature, it is significantly important to make a distinction between the linkage of trade liberalization and Convergence and studies that sheds light on the relatedness level of trade openness and Convergence. In addition, a strong association between trade liberalization and income convergence has been discovered and approved by (Slaughter, 2001).

Ben-David & Kimhi (2004), suggests that rapid competition for domestic firms both

inside and outside of the country defines the presence of a possible association between trade and income convergence. Furthermore, Convergence happens through firms' absorption of foreign knowledge and idea. Thus the openness causes knowledge spillover among countries to the extent that knowledge converges to a common level and intuitively endorsed it will create the opportunity for economic development among economies. Grossman & Helpman (1991) uses trade volume as a proxy for the knowledge spillover among countries.

Even though international trade seems to be a huger player in defining Convergence among economies across countries, a few number of studies exist to address this issue. Trade openness expedites Convergence in the neoclassical growth model is a claim which is significantly supported by prominent scholars Barro & Sala-i-Martin (1990), among many other authors. Since they attribute to diminishing returns to capital because capital flows from high-income countries to low-income and labor flows in revers; nevertheless, the authors have not supported their claim by empirical estimates. In a study examining trade liberalization and GDP per capita income convergence consortium on a sample of six members of the European Economic Community (EEC), Ben-David (1991), attests the presence of a positive linkage among them. On the other hand, Giles & Stroomer (2006) verifies a positive association between trade openness (export plus import as a percentage of GDP) and pace of income per capita convergence based on empirical affirmation in a sample of 88 countries with various development level.

The economic convergence concept basically presents the equal level of income or economic growth among a set of countries, see (Barro & Sala-i-Martin, 1992). Old theory of trade Viner (1950), concluded that economic integration would be a potential cause of Convergence; however, economic integration is a possible instrument to create income disparity, according to the new theories of Paul Krugman (1991). On the other hand, new empirical studies imply that income level convergence is likely to happen in the homogeneous countries rather than heterogeneous states.

Convergence, as a dominant economic phenomenon, originates from exogenous growth theory that many recent convergence studies are engaged in the application of the Convergence. Exogenous theory is established on the basis of the Solow growth model, where it presents two separate notions of Convergence. If individual economies

have similar technology preferences inclined on diminishing marginal return of capital holding on steady-states peculiar to their economies, countries with a low level of income are more prone to grow rapidly than countries with a high level of income. Meanwhile, when the per capita income disparity declines, this process is so-called conditional income convergence. Nevertheless, if both high income and low-income countries hold the same income level of steady-state, then the process is called absolute or unconditional Convergence see (Maria *et* al., 2017).

Exogenous theory is based on cross-section or, in some cases, panel data. The convergence studies concentrated on confirming Absolut or conditional convergence existence on OECD economies reach to inconsistent and contradicting results by taking into account three discrete approaches such as time-series, panel, and cross-section; however, none of them are superior to each other, and there are advantages and disadvantages associated with them all, for more details see (Maria *et al.*, 2017).

1.2. Objectives of the study

Despite the availability of an enormous number of convergence research papers conducted upon OECD countries, what makes this study distinctive is that I have evaluated conditional income convergence by employing beta and sigma convergence estimators in selected OECD members overtime period of 2000 to 2017 by using trade openness as a conditional variable which could be considered as our modest contribution to the literature. On the other hand, our analysis provides some evidence indirectly on how economic cooperation organizations lead to income convergence of countries, and we will examine this phenomenon through adopting beta and sigma convergence econometric tools and will interpret their results on the chosen sample of economies in this paper.

The main scope of this paper is examining conditional income convergence in selected OECD countries. Our sample contains all the OECD countries except Belgium and Luxembourg due to the problem of missing data. The data is collected from the World Bank Indicators dataset for the period of 2000 to 2017. We analyze the conditional income convergence which is the reduction of disparity in income between economies with a high level of income and countries with low level of income through comparison of their growth rate in GDP per capita with their primary level across a

number of economies, conditioning it on trade openness as a macroeconomic variable. We estimate Beta-convergence by taking into account the econometric instrument of linear regression calculated based on collected cross-sectional data and analyze absolute and conditional real Convergence in the current piece. In absolute Convergence the dependent variable would be the annual average growth rate of GDP per capita and independent variable would be initial level of GDP per capita; however, in the conditional beta convergence, the dependent and independent variables will remain the same while trade openness will be added as an explanatory variable which means that the Convergence will be conditioned upon trade openness among OECD Economies. Furthermore, Sigma-convergence will be examined, which is calculated by the standard deviation of log GDP for each year, and the decline in the diffusion of income per capita within a specific time interval would confirm its presence.

The structure of this Thesis is formed as follows. It is comprised of four chapters which in the first chapter I shed some lights on general structure and argument of the Thesis in the form of introduction, chapter two discusses a tremendous number of previous researches and dispenses a comprehensive literature review regarding trade openness relation with economic growth, Trade openness and Convergence across countries, and discusses Convergence concept broadly with its components and critical view of the methodology. Section three provides some literature to clarify the beta and sigma convergence theoretical framework and their usage in a wide range of studies. Section four draws up the empirical results of this study, along with their explanation.

CHAPTER II

LITERATURE REVIEW

2.1. Trade openness and Convergence

This section provides some literature review regarding whether trade causes income convergence or divergence. Many of the studies regarding Convergence have drawn a mixed conclusion neither traditional models nor other well-known growth models, which conclusion strongly depends on research design, the development level of countries, choice of econometric technique, time period, sort of data, and the framework which Convergence is fitted in. However, income per capita convergence proof is accessible by some studies, and we can address it by asking the very question of; trade openness is associated with Convergence? International trade theory has made it clear that Convergence of factor prices could happen due to the exchange of physical materials in the form of goods as well as circulation of services among countries; this is to be of true nature under the presumption of factor price equalization theorem. See (Samuelson, 1948, 1949).

Economic growth literature has said very little about international trade and convergence process. Convergence seems to happen in closed economies supported by the premises of the conventional growth model of Solow Swan in which Convergence appears to be more concentrated over steady-state rather than on the level of per capita income among economies based on endogenous growth models. For more details, studies of Slaughter (2001), and Ben-David (1996), Shed more light on this subject plus research works conducted in pairs by (Ben-David & Loewy, 1998; Ben-David & Kimhi, 2000).

Another conclusion that could be drawn from findings of previous studies regarding Convergence can be the distinction between consideration of trade liberalization with convergence and trade openness with Convergence, which both variables lead to distinct results. There are a few theoretical models to address trade liberalization,

which is least of our concern in this study because we mostly focus on the association between per capita convergence and trade openness; Ben-David & Loewy (1998), model shows how trade causes knowledge spillover and subsequently affect positive income convergence. The predictions from the endogenous growth model developed by Ben-David & Loewy (2000), in an open economy stipulate an increase of steady-state outputs of countries due to trade liberalization corresponding to their income level.

Slaughter (1997), doubts the association between trade with Convergence in several ways, so he criticizes it accordingly. He argues that Convergence is proceeding toward steady-states while factor price equalization theorem stemmed from trade liberalization is not steady-state oriented rather free-trade equilibria causes steady-state as its byproduct. Moreover, he points out that even though trade eases up the technology spillover among economies and alters the factor prices and subsequently income per capita, one must not forget that factor endowments can diverge as well and could counterbalance the impact of technology spillover among countries. He also mentioned that the trade of goods causes income per capita convergence only if the factor prices are not diverging rapidly.

As of our aforementioned points regarding existence of mixed literature, we can observe the presence of a positive interrelation between trade liberalization and income per capita convergence studied by Giles & Stroomer (2006), as well as studies conducted by a number of authors; for instance, Ben-David and Bohara in the year (1997), as well as Ben-David and Kimhi in the year 2000 plus work of Slaughter in the year 2001 whose papers concentrate on countries engaged in trade liberalization, too. Whereas; Slaughter's (2001), study comes up with income divergence rather than Convergence in multiple countries after 1945, which are indulged in trade liberalization. Nevertheless, Dollar (1992), Edwards (1993), Harrison (1995), Sachs & Warner (1995), Henrekson *et al.*, (1997), Ben-David (1996), Giles (2005), Bernard & Jones (1996), find Positive, profound relatedness between trade openness and income per capita convergence.

Moreover, findings from the research of Stroomer & Giles (2006), supports the hypothesis of trade openness and convergence co-existence by adapting time-series analysis. Furthermore, Bernard & Durlauf (1995), and Nahar & Inder (2002)

conclusion of their results indicates that countries take advantage of bivariate conditional Convergence. Other authors emphasized upon role of migration on international Convergence displaying it more significant than the trade in the nineteenth century which has been done by O'Rourke (1996), Bernard & Jones (1996), leading to income divergence by freer trade; nevertheless, in summary, they acknowledge their studies ratification of a positive interconnection between trade openness and income per capita convergence based on empirical evaluations.

In the late 20th century, a bunch of prominent authors, including Ben-David, has put adequate effort into figuring out the mystery of international trade and income per capita convergence nexus. They have examined the causality issue to find out whether the soaring flow of trade among countries leading up to the Convergence or the other way around which is to be precise, the similarity of income leads to enhancement of trade. Ben-David (1993), evaluated the level of discrepancy in three phases of before, in the course of, and after fulfillment of trade liberalization over a limited sample of countries that decided to reduce trade barriers based on agreement among them. There was no evidence of income convergence prior and before trade reforms rather when the income gap started to pull down after the reduction of trade barriers and remained to be low on following up years until the end of the process. This result supports the speculation of, income convergence stems from trade with less or no blockade.

Furthermore, a pragmatic illustration of trade liberalization ramification on Convergence of income is observable in major trade reforms measures in the US and Canada, which happened between 1965-1973 and was followed by broader reforms from 1968 to 1973. See (Preeg, 1970).

The ratio of the U.S Canada trade is depicted in Figure 1, in which it displays trade ratio to both economies overall GDP for the period of 1948-1988. In Figure 1 there are three different timings presented where the pre-reform (1948 to 1965) and post-reform (1974 to 1988) periods show the average ratio of trade to aggregate GDP even though the latter average is twice the average prior to reform measurements while the reform period (1965 to 1973) presents an exponential increase in the trade ratio of both economies. More details are available in the work of (Dan Ben-David & Ayal Kimhi, 2004).

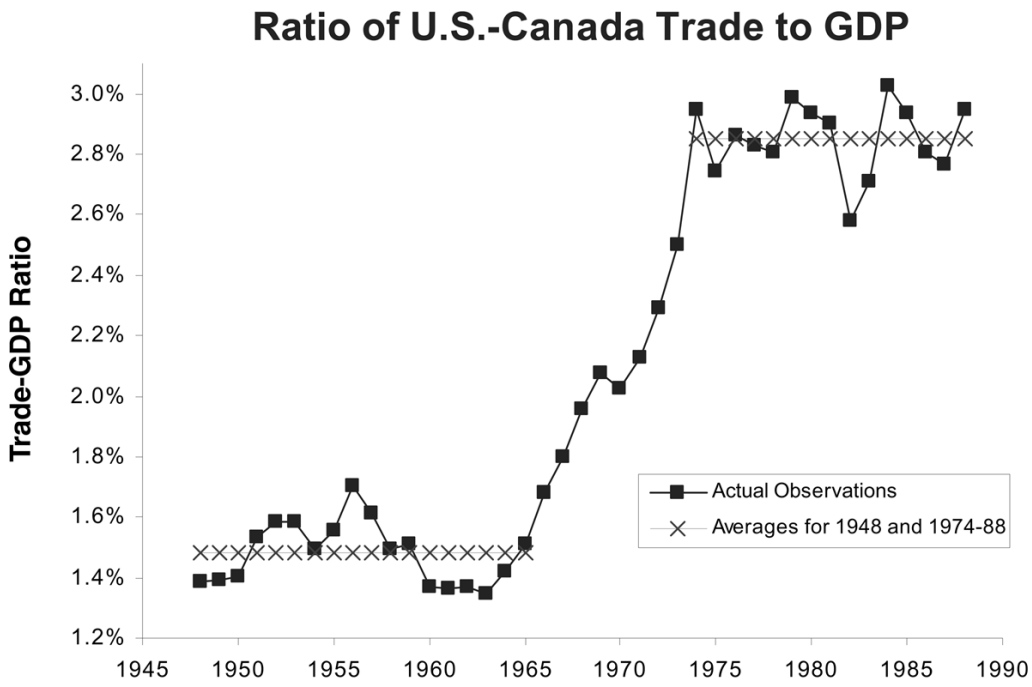

Figure 1.1. Ration of Trade in GDP Between the US and Canada Over 1945-1990 (Dan Ben-David & Ayal Kimhi, 2004)

Another example of trade reforms that shows the impact of trade liberalization on trade volume could be the European Economic Community emergence around 1950 and its enlargement later around 1970. the EEC countries started to remove the trade barriers among them and a series of further reductions in tariffs and quota. Later they experienced a substantial rose in their trade output ratio by the early 1970s. For more details, see (Dan Ben-David & Ayal Kimhi, 2004).

Ben-David (1996), has evaluated the trade liberalization and convergence nexus in two different clusters of countries. The first sample was comprised of approximately identical groups of countries. The result happened to show a high level of income convergence within the trade-based grouping of countries, while no prevalent convergence was found in random basis grouping of countries. Dan Ben-David & Ayal Kimhi (2004), later work concentrates on this very issue of Convergence's speed happing faster in some groups but not others. The result is that the extent of trade (heavy trade) appears to have effects on the level of income disparity among countries. The increase of trade further strengthens the income convergence when trade flows happen to be from poorer countries to wealthier.

Farhad Rassekh (1992), in his study of Convergence among OECD countries, while figuring out international trade influence and its impact on Convergence of GDP per capita over the period of 1950-1985, uses coefficients of variation (CV) for economies under consideration. His findings indicate that income convergence is strongly correlated with countries' engagement in international trade. From the results of his work, He accentuates the rate of alteration in trade openness rather than trade level and concludes that Convergence occurs through a rapid rise in exposure to international trade over a particular period.

Furthermore, the study's result points out on enhancement of trade exposure from poor countries more than the rich countries, which subsequently the rate of exposure helped low-income countries to grow exponentially, and it created a source of Convergence attributed to the catch-up process. Catch up process implies that economies with a lower level of income will grow faster than economies with a higher level of income depending on the flow of technology from developed countries to the poor (Baumol, 1986) and (Gruen *et a*l., 1986). However, in this Thesis we are putting some effort to find the real income conditional convergence among OECD countries from the year 2000 to 2017 which discerns it from Rassekh and all other similar studies focused on convergence analysis in OECD countries.

2.2. Convergence Concept

The notion of Convergence is widely studied in neoclassical growth theory, which is endorsed by many authors. This theory goes further and is available in details in Solow growth model in which economies with the low level of income grow faster than economies with the high level of income if they possess identical preferences and technological advances given their diminishing marginal return in capital and further equal level of income per capita or GDP. However, it is impossible to reach the equality of income per capita unless the theory of neoclassic meets the imposing of certain assumptions regarding accumulated factors. When a certain number of countries reach a similar level of steady-state, it shows absolute Convergence, which is also known as unconditional Convergence or in an econometric term, it is so-called unconditional β–Convergence (Maria *et al*., 2017).

Another concept of Convergence which is prevailing to be used in literature in order to close the income gap among economies is conditional Convergence, which is associated with neoclassic and Solow growth model in which it estimates the Convergence after conditioning it through certain variable which defines steady-state equilibrium in a group of countries. It is called conditional β–Convergence according to the econometric expressions. The saving rate and population growth rate are perceived as conditional variables as well; nevertheless, the conclusive model takes human capital in addition to the previous variables. Based on Barro's suggestion among determining factors, authors have used other macroeconomic variables as well; for instance, inflation rate, fiscal deficit, political instability impact growth see (Dollar, 1992).

According to the conditional convergence, economies are prone to get identical GDP per capita despite the presumption of holding their own steady-state, which basically means that countries with different steady-state still are converging to the corresponding GDP per capita or income level conditioned over certain macroeconomic variables. Another econometric tool for measuring up convergence levels among certain groups of countries is σ-convergence. This measurement also stems from the Neoclassic growth model, and it determines the Convergence when the standard deviation in GDP per capita over countries tends to diminish see for example (Maria *et al*., 2017).

A considerable set of researches and empirical studies are available concerning examining of convergence concept since the pioneered paper by Baumol (1986), where the majority of them have concentrated on developed economies such as OECD nations, European Union, and states of USA see for example the early studies which have been done by Baumol (1986), Barro (1991), Mankiw et al., (1992) and Sala-i-Martin (1996), in which conditional Convergence, as well as unconditional Convergence among OECD countries, are strongly confirmed. Latter studies take into account the cross-section correlation between primary level of GDP per capita and its subsequent level in the last year, depending on the period of time study takes place. In this analysis, a negative correlation is perceived to be presenting Convergence. This suggests that on average faster growth appears to occur from economies with a preliminary low level of GDP per capita than economies with a high level of GDP per

capita or income. Latter studies are in line with the methodology undertaken in this paper.

Researchers are adopting different datasets and methodologies in order to analyze Convergence over a set of countries within a particular time. Since the pioneering study of convergence authors have taken into account time series, panel, and cross-section, datasets and econometric methodologies depending on the drawbacks and advantages one has over another associated with each type of data and econometric tool. Islam (1995), finds strong conditional and unconditional Convergence among OECD countries from 1960-1985 by utilizing panel data. Nevertheless, estimation from the panel dataset neither can discern the short-run and long-run Convergence nor describe the profile of Convergence. Furthermore, it cannot unfold that which countries converge and which one does not, see (Fuente, 1997).

Recent studies employ a time-series dataset. In order to run convergence analysis, some papers have employed co-integration technique or GDP per capita univariate analysis methodologies of time series. For instance, over the period of 1950-1987, Bernard & Durlauf (1995, 1996), fail to accept the convergence hypothesis by applying time-series analysis of the co-integration technique over a sample of 15 OECD economies. Greasley & Oxley (1998), also utilized time-series methodology to study Convergence and discovered lenient random convergence evidence among Australia, Canada, and the USA, putting them all in pairs.

Moreover, Rassekh et al., (2001), due to non-stationarity of series, reject the convergence hypothesis for the entire period by applying the popular test of ARMA as a time-series econometric tool to analysis sigma and beta convergence. They used GDP diffusion among OECD countries over the period of 1950-1990.

A significant number of studies that have taken into account the time series dataset point out that this methodology is unsuccessful in proving GDP per capita or income convergence for OECD economies. Nevertheless, Nahar & Inder (2002), verifies Convergence among 19 OECD countries that converge toward the USA. Later Bentzen (2005), by replicating the latter study of Nahar and Inder confirms catching up with most of the countries toward the USA over the period of 1950-2000 for OECD

countries. While after applying the GLR test, he observes a reduction in speed of Convergence for significant breaks of the catch-up process.

The conclusion made by utilizing cross-section, time-series, and panel data approaches are different depending on the nature of methodology, dataset, the period of time, economies under consideration, and defining the convergence concept. They usually indicate contradictory conclusions for similar datasets. To make it clear, even though time-series approaches to overcome some disadvantages of cross-section and panel but neglects to provide us with indicating different steady states in which group of countries converge at a particular time. We only can observe the Convergence of a set of countries with leading country. Even though the flaw was tackled by kernel density methodology in Epstein et al., (2003), yet it could not resolve steady-state issues. While on the other hand, applying cross-section methodology on the evaluation of Convergence gives a much clearer outcome.

According to an earlier statement of this section, Convergence is a macroeconomic concept and is associated enormously with Neoclassic economic growth theory. This theory finds out the economic growth variables, and it describes their differences over a range of countries, particularly real income per capita. The literature introduces two kinds of Convergence; absolute Convergence, which refers to the faster growth of countries with lower capital per worker over countries with higher capital per worker. At the same time, conditional Convergence occurs among a set of homogenous economies. The concept of Convergence is distinguished as nominal and real Convergence based on comparative theory. Even though they tend to be similar but they differ; for instance, Nominal Convergence refers mostly for economic similarity from price aspect, which makes two economies to reach the same rate of inflation, interest, and other variables which are nominal in nature. However, we use real macroeconomic aggregates to measure up the real Convergence which is GDP per capita or GDP per worker in many empirical studies see (Zbigniew Matkowski & Mariusz Próchniak, 2007)

Accordingly, a tremendous number of papers have benefited from β-convergence and σ-convergence estimators in order to calculate Absolute and conditional Convergence which are accessible in studies of (Michelacci & Zaffaroni, 2000; Furceri & Karras, 2008; Pfaffermayr, 2009; Matkowski & Próchniak, 2007; Dvorokov, 2014; Batog &

Batog, 2015). These concepts have been introduced and studied primarily by neoclassical growth theory. The fundamental implication of this theory is that poor countries have more potential for growth; thus, they grow faster than rich ones. In investigating β-convergence, GDP per capita is associated negatively with its primary level. Besides, a negative decline of linear function indicates β-convergence.

Furthermore, another major estimator of Convergence premiered by the neoclassical theory of growth is σ-convergence, which indicates the Convergence of economies to the same level of growth and is available in studies of (Dalgaard & Vastrup, 2001; Miller & Upadhyay, 2002; Lucke, 2008). The σ- Convergence is calculated by the standard deviation of GDP per capita for each country, and its decline confirms the presence of sigma convergence. The result of empirical studies enormously are associate with the idea of homogeneity of countries. Fuente (2003), Dowrick, & Quiggin's (1997), findings focused on OECD members provide evidence for the presence of Convergence.

A significant conclusion offered by Mankiw (1992), and Solow (1956), ratifies the β-convergence of income convergence. According to the findings of their model, they proclaim that poor economies have more potential for growth; therefore, they grow faster than their rich partners.

CHAPTER III

METHODOLOGY

3.1. Econometrical Model

Convergence as an economic term is covered enormously in many authors' studies. The authors frequently has utilized the econometric approach of Beta and Sigma Convergence to investigate this concept. Baumol (1986), Barro & Sala-i-Martin (1992), and Mankiw (1992), pioneered this methodology and has examined it within the context of the neoclassic growth model. However, Solow-Swan (1956), have established the idea of Income convergence theory in the growth literature.

In this study as well as similar papers, typically cross-section correlation is considered, in which we suppose that economies do not converge regarded as null; however, in contrast to the null, alternative hypothesis indicates the presence of Convergence (Bernard & Durlauf, 1995, 1996). We investigate the notion of Convergence on a sample taken from OECD economies for the year of 2000 to 2017. The data collected for this sample is also based on the cross-section order. The methodology that we will use in this paper is β-convergence and σ-convergence. According to β-convergence, countries with a low level of income or, in other terms, emerging countries will experience a faster speed of growth than countries with a high level of income. Nevertheless, σ-convergence concentrates on the dispersion of real GDP per capita; thus, countries GDP per capita gradual decline over time indicates on the presence of sigma convergence.

3.2. Convergence

Baumol (1986), studied β-convergence for the first time where his study of Convergence was based on graphical data; Nevertheless, Mankiw (1992), Barro & Sala-i-Martin (1992), started to carry on with it more deeply and put it within the econometric framework. They developed the concept and refined it into a regression dependence theoretical framework of economic growth by approaching it differently

and building it up on certain popular growth models. For instance, Barro and Martin's convergence study relied mainly on the model established by three prominent authors Ramseyho, Casse, and Koopmans, which modified their equation for estimation of β-convergence; however, Mankiw, Romer and Weil theories and studies stems from Solow and Swan model. The concept of β-convergence is widely available in studies of (Michelacci & Zaffaroni, 2000; Matkowski & Próchniak, 2007; Furceri & Karras, 2008; Dvorokova, 2014; Batog & Batog, 2015).

The relevant literature on Convergence that relies on beta convergence is distinguishing between two concepts of Beta or so-called Absolut beta convergence (unconditional) and conditional beta convergence.

3.2.1. Absolut β-convergence

This is also called unconditional beta convergence. It is computed through a collection of cross-section dataset. In order to run the cross-section regression, the presumed dependent variable of Y will be mean of GDP per capita regressed on its initial level. It is assumed that all the economies end up shifting toward a similar level of steady-state. Barro & Martin (1992), suggested that predicting parameter β indicates Convergence. Similar studies that deal with Convergence are accessible in the analysis of (Slavik, 2005; Dvorokova, 2014; Dey & Neogi, 2015). The absolute β–Convergence is estimated by the following model:

$$\frac{1}{T}.ln\left(\frac{Y_{iT}}{Y_{i0}}\right) = \alpha_0 - \left(1 - e^{-\beta.T}\right).lnY_{i0} + \varepsilon_{iT} \quad (3.1)$$

where:

in the model above, the dependent variable is the annual mean of real GDP per capita growth rate for I country at T time.

Y_{i0} –primary volume of real GDP for i country.

Divergence seems to occur with a positive sign of β, which is completely opposite to the claim that poor countries will grow compared to the rich countries with a higher rate. However, the negative value of Beta or $\beta < 0$ manifests an absolute β-convergence. The rate of converge and its speed is identified by the estimated value of

β, in which the negative value of its coefficient confirms the existence of Convergence or, in simple terms, a rapid growth rate of poor countries than rich ones. The latter process is the so-called Convergence among a set of countries (Dey & Neogi, 2015).

Another major issue here is that $\varepsilon_{i,T}$, or disturbance term should be uncorrelated to $\ln(Y_{i,0})$, which is to put $\varepsilon_{j,T}$ ($j \neq i$). This notion explicitly exerts that poor economies catch up rapidly compared to the rich ones in terms of growth rate (Bruno, 2012).

It is feasible to figure out the speed rate of β-convergence through calculation of β-coefficient as formula below:

$$\boldsymbol{\beta = -\frac{1}{T}\, ln(1 + \alpha_1 T)} \tag{3.2}$$

From the formula above, we can drive half-life convergence, which is denoted by $T_{1/2,}$ and it shows the convergence process position, which is in the middle between an initial and steady-state level. The modification process is displayed below which through we can find half-life convergence:

$$\boldsymbol{e^{-\beta . T} = \frac{1}{2},} \tag{3.3}$$

hence:

$$\boldsymbol{T_{1/2} = \frac{ln2}{\beta}} \tag{3.4}$$

3.2.2. Conditional β–Convergence:

In the previous section, we introduced absolute Convergence, which follows the notion of the same steady-state for a set of economies. Nevertheless, countries are heterogeneous because of the difference in population rate, technology advancement, saving rates, and so on. The heterogeneity among these countries violets the assumption of the same steady-state and disproves it. Therefore, researchers come up with the sort of β–convergence idea where it allows for various economies to have their own steady-state and yet Convergence takes place which is so-called conditional Convergence; implying that per capita output or income level convergence is conditioned upon technological or institutional dissimilarities over variety set of

economies which might be used as a substitution for steady-state income levels (Sala-i-Martin, 1996).

This kind of Convergence occurs if there are discreet steady-states for each country under examination. The model below is employed to reckon the value of conditional β–Convergence as follow:

$$\frac{1}{N} log\left(\frac{y_{i,t+T}}{y_{i,t}}\right) = \alpha + \beta log(y_{i,t}) + \gamma X_{i,t} + \varepsilon_{i,t} \quad (3.5)$$

In the model above, the $X_{i,t}$– represents a bunch of explanatory variables covering up the growth rate difference in steady-state over economies. In the above model, a negative value of β indicates β–Convergence.

In these type of model where the average annual per capita is regressed on its initial level plus control variables as imposing conditions for income level convergence while each country preserves its steady-state level, the regresses might be correlated with disturbance term because of unobserved heterogeneity among countries; therefore, it may cause misleading inferences or inconsistent estimation of parameter β, researchers regard it as severe criticism of this methodology see (Durlauf et al., 2009).

3.3. σ-convergence

Another relevant concept is the σ-convergence, which is available in studies of (Dalgaard & Vastrup, 2001; Lucke, 2008; Miller & Upadhyay, 2002; Matkowski & Próchniak, 2007; Dvorokova, 2014). In fact, the concept originates from the neoclassical growth theory as well. The σ-convergence appears to take place whenever a gradual reduction in the variance of log per capita output or GDP per capita logarithm among countries over a particular time range is observable. Therefore, σ-convergence is plausible between time t and t + T if:

$$\sigma_{t+T} - \sigma_t < 0 \quad (3.6)$$

"In the above formula, $\sigma_t = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(Log(yi,t) - \overline{yt})^2}$ is the standard deviation of Log($y_{i,t}$) across i at the time t and $\overline{yt} = \frac{1}{N}\sum_{i=1}^{N} log(yi,t)$ is the sample mean at the

time t." β and σ-convergence are extremely correlated. In fact, it is apparently visible that estimating the variation of Log($y_{i,t}$) in (T=1) of countries based on cross-section methodology gives the result of:

$$\boldsymbol{\sigma_{t+1}^2 = (\beta + 1)^2 \sigma_t^2 + \sigma_\varepsilon^2} \quad (3.7)$$

The above formula implies that σ_t^2 can reach steady-state only if beta positions between the interval of -2 < β < 0. Thus depending on estimated value of σ_t^2 poor countries' economy grows faster, and income diffusion will diminish or expand if per capita output of two or more than two countries gets closer over time. Therefore, β–Convergence does not necessarily mean or lead to σ-convergence. There could be β–Convergence without having σ-convergence if the primary dispersion of log(y_t) is presumed to be more compact compared to its steady-state.

The notion of Sigma convergence is defined as a measure to show how much the economies catch up to each other. We use the least-squares method (OLS) for cross-section datasets collected for a certain set of OECD member countries in order to estimate the parameters of the linear regression model. The model will be calculated by using Eviews program.

The empirical results of employed models are confirmed before interpretation through statistical significance measurement of the econometric models such as F-test for the whole model and t-test for testing robustness of individual parameters of the model. The findings have undergone particular econometric verification, including Autocorrelation, Heteroscedasticity, normality test.

3.4. Variables and Resource

The dataset employed in this study comprises Annual gross domestic per capita or in another term GDP per capita. The GDP is taken as in the form of purchasing power parity (PPP), which is calculated based on the contemporary international value of dollars for our chosen countries, which is extremely important for the study of beta convergence. Furthermore, for the estimation of conditional beta convergence regression, I used to trade as a percentage of GDP as a proxy for trade openness. In this thesis, trade openness is computed by the summation of export and import of mercantile in the form of goods and services as a proportion to aggregate GDP. I have

collected both data for each country in my sample from World Bank Indicators (World Bank, 2020).

According to the reckoning of the GDP per capita in purchasing power parity (PPP); the GDP is to be transformed into international dollars by taking advantage of purchasing power parity rates in which buying power of an international dollar upon GDP is identical to the purchasing power of US dollar over GDP in the United States of America. For studies that have utilized similar variables evaluating Convergence see (Giles & Stroomer, 2006). “The collected data are in current international dollars based on the 2011 ICP round (World Bank, 2020).”

There are a tremendous number of indicators for trade openness; however, trade as a proportion to aggregate GDP is deemed to be one of the authentic standard measures for trade. “Trade openness assumed to be nominal trade (exports plus imports) ratio to the entire nominal GDP.” Another study that has used the same variable is Giles and Stroomer (2006); however, they have applied a time-series approach to compute Convergence over a range of countries. It measures up the aggregate flow of goods and services among countries; hence, taken as a proxy to present openness of trade among economies as high volume of trade as a proportion to aggregate GDP reveals a substantial amount of openness in exchange of mercantile in the forms of goods as well as services among various sets of economies. The collected dataset is collected from 2000 to 2017-time period, and the data resource is World Bank Indicators, WDI database year 2020.

3.5. Sample Countries

The total number of countries that have been under observation in this paper is 33 out of 35 official members of the “Organization for Economic Co-operation and Development, OECD." In the meantime, a few countries have been deleted from the OECD list in this study due to missing data such as Belgium and Luxembourg. The list of OECD countries taken in this study is illustrated in Table 3.1 below:

Table 3.1. Listed set of OECD member countries (OECD, 2020)

No	*Countries*	*Abbreviations*
1	Australia	AUS
2	Austria	AUT
3	Canada	CAN
4	Chile	CHL
5	Denmark	DNK
6	Finland	FIN
7	France	FRA
8	Germany	DEU
9	Greece	GRC
10	Hungary	HUN
11	Iceland	ISL
12	Ireland	IRL
13	Israel	ISR
14	Italy	ITA
15	Japan	JPN
16	Korea, Rep.	KOR
17	Latvia	LVA
18	Lithuania	LTU
19	Mexico	MEX
20	Netherlands	LUX
21	New Zealand	NZL
22	Norway	NOR
23	Poland	POL
24	Portugal	PRT
25	Slovenia	SVN
26	Spain	ESP
27	Sweden	SWE
28	Switzerland	CHE
29	Turkey	TUR
30	United Kingdom	GBR
31	United States	USA
32	Czech Republic	CZE
33	Estonia	EST

CHAPTER IV

EMPIRICAL RESULTS AND CONCLUSION

4.1. Empirical Results

This study consists of 33 OECD countries; however, a few countries have been removed because of missing values such as Belgium and Luxembourg. We have taken into account the real GDP per capita grounded on the purchasing power parity and trade as a proportion to the whole GDP as a proxy for trade openness, which in turn is computed by the summation of goods and services exchanged among countries in the form of export and import contracts. Our data source is the World Development Indicator database (WDI). I have estimated two models of absolute and conditional Convergence, and in the latter model, I have used the trade openness as a conditional variable.

This analysis established on cross-section data and the linear regression parameters are estimated by the least square method (OLS). The model's estimated values are statistically significant at all levels, and the significance of models is subjected to statistical verifications such as F-test for the whole model and t-test for individual parameters. The models are estimated by Eviews software.

To test the validity or robustness of our models, I have taken advantage of various statistical verification tools that meet the requirement of the Least Square Method (OLS). Those precise econometric validation measurements are including Autocorrelation, Heteroscedasticity, and normality test. The estimated values of them are present in each section with adequate explanations. For testing autocorrelation, we used the Breusch-Godfrey Serial Correlation LM test. Subsequently, for checking Heteroscedasticity, we used the White Heteroscedasticity test and Jarque-Bera test for ratification of Residuals Normality.

In the conditional beta convergence, we have taken trade as a proportion to aggregate

GDP that represents trade openness, which is the explanatory variable in our convergence model and contributes to the finding of conditional Convergence among 33 OECD countries. Trade, as a proportion to the whole GDP, exhibited in Figure 4.1.

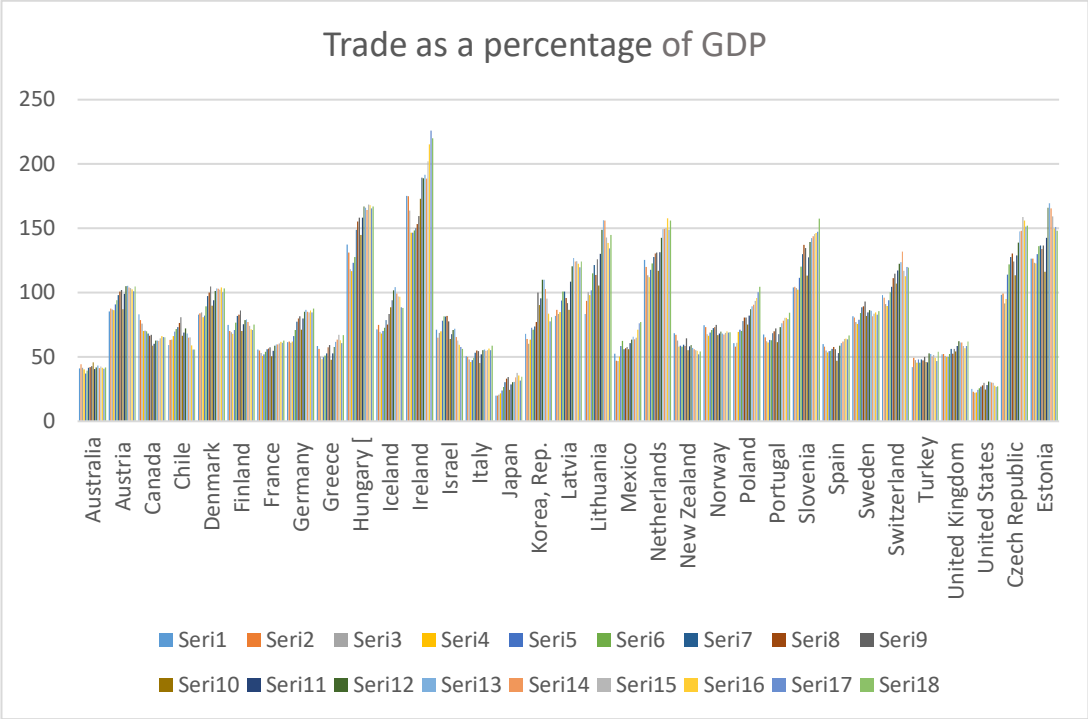

Figure 4.1. Trade as a Percentage of GDP (2000-2017) for 33 OECD Countries (WDI, 2020)

The Data description and sources of the variables in this Thesis's empirical model is available in the tables below. Table 4.1 contains detailed information peculiar to the employed variables. Whereas, Table 4.2 encompasses all the descriptive statistics of variables in this study.

Table 4.1. Data description and sources

Abbreviations Sources	Variable	Description	Frequency
GDP (WDI)	Gross Domestic Product GDP	GDP per capita in (PPP)	Annual
Trade (%GDP) (WDI)	Trade as proportion to aggregate GDP	Sum of export and imports of goods and services	Annual

Table 4.2. Descriptive statistics (calculated by the author of the thesis)

	Ln(GDPt+1/GDPt)	LnGDPt	Trade
Mean	0.038887	9.925311	92.59775
Median	0.034387	10.16947	80.77922
Maximum	0.076163	10.51709	219.9983
Minimum	0.021184	8.989156	27.14232
Std. Dev.	0.014437	0.471954	44.63563
Skewness	1.164480	-0.7355065	0.925058
Kurtosis	3.385202	2.157235	3.312782
Jarque-Bera	7.662101	3.948361	4.841050
Probability	0.021687	0.138875	0.088875

4.1.1. β-Convergence Result

The Absolut (unconditional) convergence, along with conditional convergence empirical results are stipulated in tables below alongside with their explanation. The estimation result of the absolute convergence model is depicted in Table 4.3, in which outcomes are significant at all levels.

Table 4.3. Absolut convergence (calculated by the author of the thesis)

Regression Outcome for β-Convergence							
Variables	**Coeff.**	**Std. E**	**t-Stat**	**β-Conv**	**Prob.**	**β-Coeff.**	**$T_{1/2}$**
Constant	0.277852	0.03367	8.2517	Yes	0.0000		
LnGDPt	-0.02407	0.0033	-7.1046	Yes	0.0000	3.11%	22.28
Note: t-statistics are shown in brackets Note: F-statistic is significant at all levels (1%, 5%, 10%)							

According to the estimated trend line from the regression of absolute Convergence, there is a negative slope with a value of -0.024, which suggests the β-coefficient to be

3.11 percent. It means that income converges with the speed or rate of 3.11 percent per year. While the half-life convergence seems to be 22.28 years in this scenario, which means that Convergence is half-way between initial and steady-state levels, see (Batog & Batog, 2015).

Moreover, At Table 4.4 we can observe the explanation of variation independent variable by the independent variable in the absolute convergence model by looking at the R-Square value which indicates that annual average GDP per capita in PPP is described 61.95 percent by explanatory variables on the right-hand side of linear function model and Adjusted R-Square is 60.72% which is R-Square after modification. R-Square and Adjusted R-Square is a desirable property of goodness of fit in a statistical model. They both remain high throughout the period.

The regression statistics determine the credibility of our estimation and finding. Thus the estimated values of absolute convergence model are quite convenient and econometrically plausible, observing the verification proves provided in Table 4.4. The outcome of this analysis is indistinguishable to findings from the study of Convergence of real income between the new EU members (CCE-8) and main EU-15 economies from 1993-2004 by (Matkowski & Prochniak, 2007). As well as Batog & Batog (2015), findings' of conditional convergence analysis among 21 European countries from 1999-2006.

Table 4.4. Absolut beta convergence model summary (calculated by the author of the thesis)

R-Square	Adjust. R-Square	Sig. F	D.Watson
0.6195	0.6072	0.000000	2.1035

The negative association between mean of GDP per capita annual growth rate and its primary volume determines the speed of Convergence. Figure 4.2 stipulates this negative slope as below:

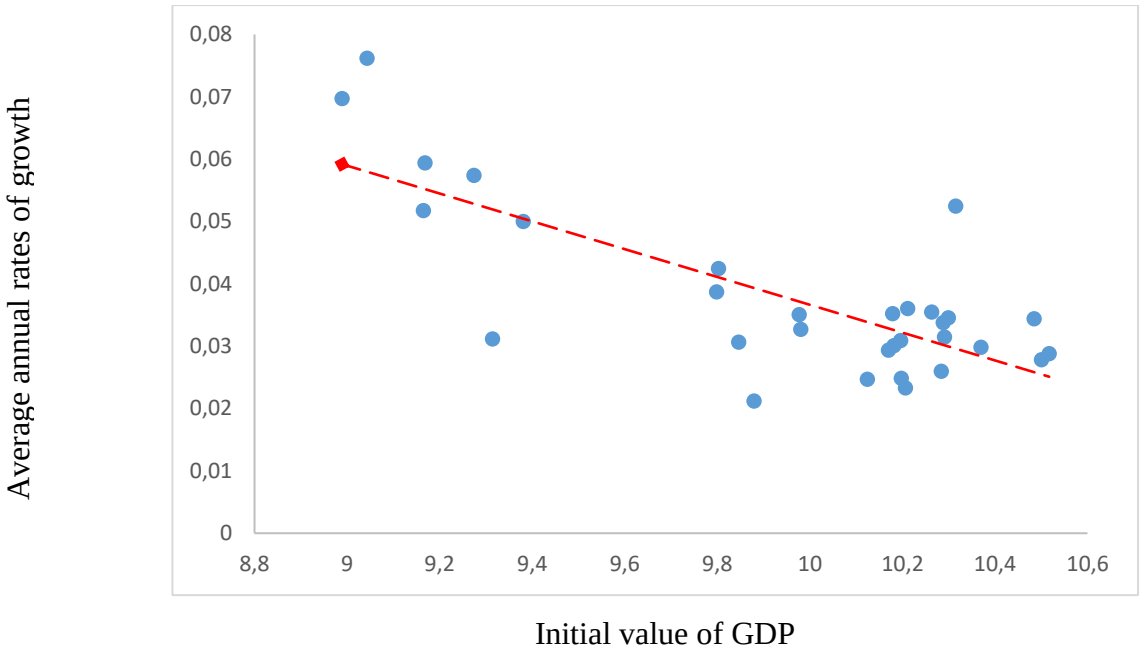

Figure 4.2. Mean of GDP Per Capita Annual Growth Rate And Its Primary Volume for 33 OECD Member Countries (β-Convergence Among 33 OECD Countries in 2000-2017 (Calculated by the author of the Thesis based on WDI, 2020)

Figure 4.2 shows a negative link between the primary level of GDP per capita to the mean of GDP per capita annual growth rate within the time range of 2000 to 2017 for the selected OECD countries or in another term inverse association between them is observable. The negative downward slope of the regression line explicitly ratifies beta convergence among the selected set of OECD members.

To clarify the very existence of beta convergence with more precise evidence relevant to the convergence concept's theoretical background, the prepared scatter plot of our regression with reference to real economies in Figure 4.3 is provided as of the countries position in Figure 4.2 verifies presence of absolute Convergence in the model where initially economies with a low level of income grow rapidly compared to the ones with a high level of income. For instance, the left side located countries in the Figure 4.3 such as Lithuania, Latvia, Turkey, Poland, Chile, Hungary, and Mexico show potentially expeditious growth rates in the particular time set. Meanwhile, countries with a higher level of income or economic growth are likely to be growing slower or

even have negative rates of growth such as the U.S.A, Canada, UK, France, Germany, Sweden, Luxembourg, and so on.

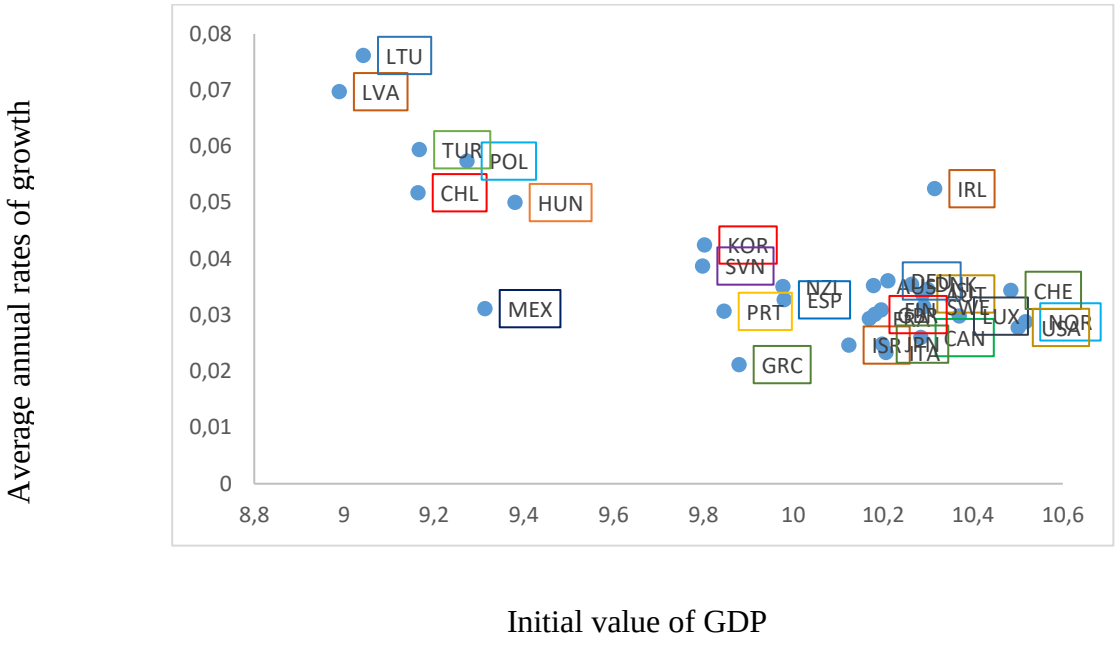

Figure 4.3. Beta-Convergence Among 33 OECD Countries in 2000-2017 (Calculated by the author of the Thesis based on World Bank Indicators database, 2020)

The model's robustness confirmation is tested by econometric verification technics, including Autocorrelation, Heteroscedasticity, and normality test, where their estimated values are presented in Table 4.5.

Table 4.5. Robustness attestation of the absolute β-convergence model (calculated by the author of the thesis)

Residuals Normality	
Jarque-Bera 1.6408	Probability 0.4402
Autocorrelation	
F. Statistic 0.8842	Prob.F 0.4239
Heteroscedasticity	
F. Statistic 0.7064	Prob.F 0.5016

In Table 4.5, estimated values of robustness verification econometric tools are presented. The test for Autocorrelation says that the model is not suffering from Autocorrelation according to all significance levels. Moreover, based on the White test for Heteroscedasticity, the model appears to be homoscedastic on a chosen level of significance, which in this model are all significance levels. Using the Jarque-Bera test for testing the normality of residuals, probability values show that residuals are normally distributed.

Furthermore, to confirm the Convergence among OECD countries, I have mapped the GDP per capita of each country for the initial year and last year available in Figure 4.4 and Figure 4.5, respectively.

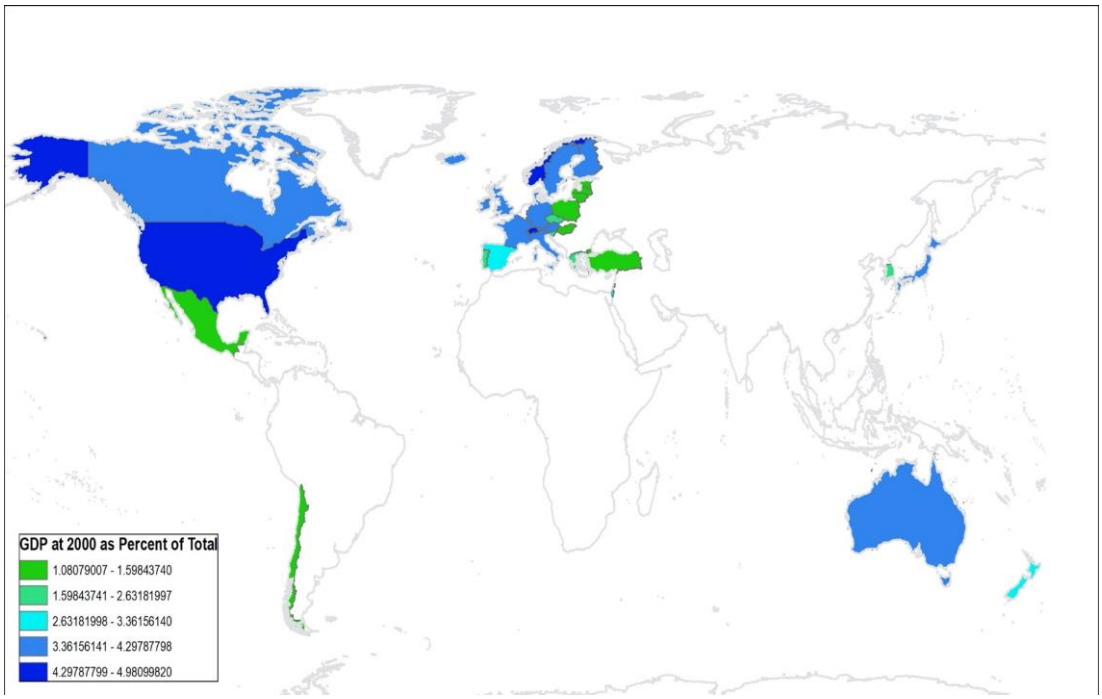

Figure 4.4. Map of OECD Countries in The Initial Year (2000)

Source: Author's calculation

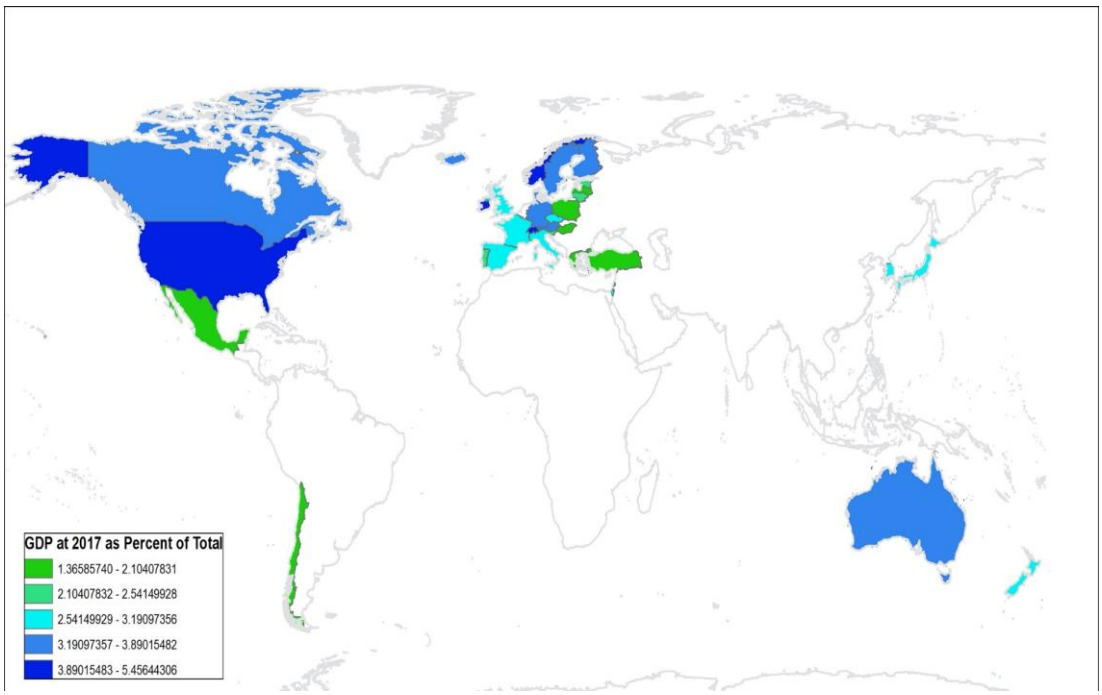

Figure 4.5. Map of OECD Countries in The Initial Year (2017)

Source: Author's calculation

According to this comparison, different countries possess certain colors based on their GDP per capita level. While comparing both maps, we can clearly observe that GDP per capita of countries such as France, Spain, Italy, the UK, New Zealand, Japan, and South Korea exhibit similar colors in 2017, which indicates them to have converged. However, only Spain, New Zealand, and South Korea seem to have the same color in 2000. Meanwhile, the remaining countries maintain their prior GDP level, which has the same color in both the initial and last year (Özcan, 2019).

Table 4.6 provides the result of Conditional convergence model; after adding trade openness as a control variable; we find coefficients which are all highly significant at 1%, 5%, and 10% significance levels and implies OECD countries are converging in real income considering different steady-states for each country and conditioned upon trade openness with each other from 2000 to 2017. This result is in line with the study of Batog & Batog (2015); however, in their study, conditional income convergence among 21 European countries is investigated from 1999-2006, they took ICT (Information and Technology Communications) as an explanatory condition to find Convergence which discerns it from the current analysis. Apparently, 2.7 percent of the reduction in the speed of Convergence per year turns out to be found; however, half-life convergence has increased to 25.67 years, for more details, associated with half-life convergence process see (Batog & Batog, 2015).

Table 4.6. Conditional convergence (calculated by the author of the thesis)

Regression Results for β-Convergence							
Variables	**Coeff.**	**Std. E**	**t-Stat**	**β-Conv**	**Prob.**	**β-Coeff.**	**$T_{1/2}$**
Constant	0.2411	0.0292	8.23505	Yes	0.0000		
LnGDPt	-0.0214	0.0028	-7.4897	Yes	0.0000	2.7%	25.67
TRDt	0.0001	3.03E-05	3.9477	Yes	0.0004		
Note: t-statistics are shown in brackets Note: F-statistic is significant at all levels (1%, 5%, 10%)							

Table 4.7 manifests the summary of conditional convergence model significance, where R-Square is 74%, and Adjusted R-Square is 73%, which implies that independent variables explain 73 percent of variation or variant in the dependent variable. And the model overall is significant at 1%, 5%, and 10% levels.

Table 4.7. Conditional β-convergence model summary (calculated by the author of the thesis)

R-Square	Adjust. R-Square	Sig. F	D.Watson
0.7496	0.7329	0.000000	1.7151

Source: Author's calculation

The robustness attestation of the model is stipulated in Table 4.8, which contains the estimated values of econometric verification tools such as Autocorrelation, Heteroscedasticity, and normality test.

Table 4.8. Robustness of The Conditional Beta Convergence Model (calculated by the author of the thesis)

Residuals Normality	
Jarque-Bera 3.1645	Probability 0.2055
Autocorrelation	
F. Statistic 1.3794	Prob.F 0.2683
Heteroscedasticity	
F. Statistic 0.9947	Prob.F 0.4395

The test for Autocorrelation provides the model without any serial correlation or Autocorrelation. Furthermore, the White test for Heteroscedasticity displays a result of homoscedastic based on selected significance level, which in this model are all significance levels. Jarcq-Bera normality test says the residual are distributed normally, and the model does not carry abnormality of residuals observing 1%, 5%, and 10% significance levels.

4.1.2. σ-Convergence result

This concept refers to the idea when income disparity among countries declines gradually over a precise time period. Furthermore, variance or standard deviation of real GDP per capita is an instrument to investigate income dissimilarity, see, for example, (Matkowski & Próchniak, 2007; Dvorokova, 2014). Econometricians suggest that computing Coefficient of Variation or in shorter terms CV of GDP per capita is the statistical approach that Sigma convergence can be estimated. According to the econometrical technique of how to find the value of CV, the standard deviation is divided by the mean value, and the latter attained outcome is multiplied by 100, see, for example (Dey & Neogi, 2015). Table 4.9 displays the values of CV of GDP per capita for each year from 2000 to 2017 as below:

Table 4.9. Coefficient of variation of GDP per capita over 2000-2017 (Author's calculation from the data collected from WDI indicator 2020)

Year	Coefficient of Variation	Year	Coefficient of Variation
2000	0,391	2009	0,332
2001	0,383	2010	0,323
2002	0,372	2011	0,318
2003	0,359	2012	0,3203
2004	0,355	2013	0,314
2005	0,353	2014	0,305
2006	0,347	2015	0,313
2007	0,337	2016	0,3048
2008	0,337	2017	0,3044

As we can observe from the table above, the CV is quite high at initial years, but it declined gradually among countries over the period of 2000-2017 with the lowest value in 2017.

We have further illustrated the CVs of GDP per capita in the Figure 4.6, where it also displays the result of our Sigma convergence assessed by the Coefficient of Variation for the time range 2000 to 2017 as follow:

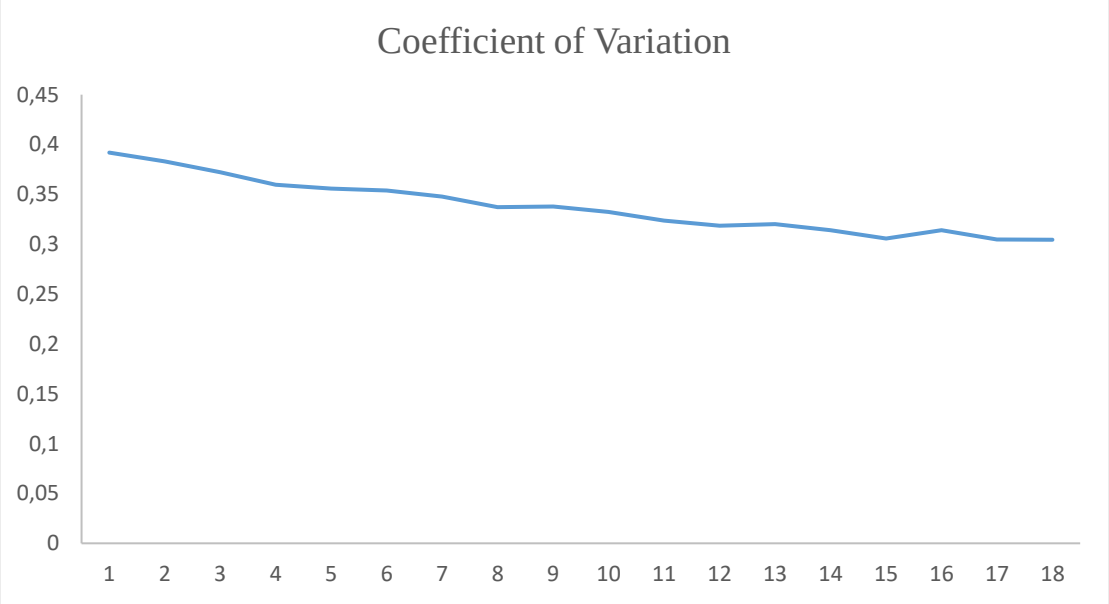

Figure 4.6. Calculation of Sigma Convergence For 33 OECD Countries in 2000-2017 (Author's calculation)

Taking Figure 4.6 under consideration, the linear function of the Coefficient of Variation displays a downward slope that indicates the presence of sigma convergence among the sample of the countries undertaken in this study. This means that income per capita diffusion among OECD member countries has diminished over time, which, according to this paper, it is from 2000 to 2017. Matkowski & Próchniak (2007), have found a similar result in studying real income convergence between the new European Union members from the central and eastern regions of the so-called continent CCE-8 and the main western members of European Union or EU-15 from 1993-2004. The result is in line with the finding of Dey & Neogi (2015), who, in their part, confirm σ-convergence for SAARC countries over the period of 1970-2011.

CHAPTER V

CONCLUSION

Even Though little theoretical consideration and literature are available regarding international trade and the convergence process, the importance of trade in an economy has intrigued researchers and economists to discover whether trade impedes income per capita Convergence or contribute to the process. These authors focus on trade liberalization more than trade openness, which are two separate economic variables. Some of the studies confirm that trade liberalization has a positive association with income convergence. Meanwhile, other studies refute co-existence of any sort of connection or whatsoever between trade and economic Convergence. They attribute the Convergence with immigration and knowledge spillover. Convergence studies present a mixed conclusion both the traditional models and other well-known growth models, which strongly depends on research design.

The concept of Convergence originates from the exogenous theory of the Solow growth model in which it presents two notions of Convergence that is so-called absolute income convergence, which is the movement of economies toward a similar steady-state. In addition, conditional income convergence considers shifting of economies toward the same level of income while each economy preserves discreet steady-states over a certain time period. The exogenous theory of Convergence relies on cross-section or panel dataset methodologies; however, the study of Convergence is not constrained to these two approaches, and researchers adopt time-series economic tools as well. In fact, the results from these methodologies sometimes are contradictory despite the similarity of the dataset under consideration. Therefore, none of them are superior to one another, and authors prefer any of them depending on the advantages and disadvantages associated with them. It is worth mentioning that plenty of studies utilizing time-series analysis are proven to be unsuccessful approaches in order to find out any sign for the presence of GDP per capita convergence among economies of OECD members.

The econometric tools of Beta and sigma convergence are widely employed in may

authors' papers in order to investigate income per capita convergence. Given the nature of these instruments, only applying a cross-section dataset is plausible. Fundamentally, the idea of Convergence is affiliated to the neoclassical growth model which in turn some prominent scholars have built on it and conducted certain researches to find out the Convergence among a group of similar or dissimilar economies; for instance, (Barro Sala-i-Martin, 1992; Baumol, 1986; Mankiw et al., 1992). Indeed, the notion of Convergence is widely implored and available in full-length in the empirical growth literature proposed and established by two outstanding growth theorists of the time (Solow-Swan, 1956). Given the nature of this methodology, it is presumed that all economies do not converge or based on econometrical terms Null hypothesis; however, in this regard, alternative hypothesis emphasizes the fact that Convergence exists comprehensively. The idea of Convergence is divided into two subdivisions; β-convergence that implies the rapid growth of low-income nations compared to the high-income nations. Meanwhile, if diffusion of real GDP per capita declined gradually within a certain time range, it indicates the presence of σ-convergence.

This paper examined the conditional economic Convergence in selected 33 OECD countries. The sample contained all the OECD countries except Belgium and Luxembourg due to the problem of missing data. In this Thesis I have used two variables; first, real GDP per capita in PPP and, second, trade as a proportion to the whole GDP. The latter variable is the summation of exchanged goods and services based on international trade contracts of export and import. I have assembled the data in this Thesis from the World Bank database for the year 2000 to 2017. After the application of the methodology, two models are estimated absolute convergence and conditional Convergence. The latter model of trade openness is used as a conditional variable.

This study analyzed the conditional income convergence, which is a reduction of the gap in the income gap between two sets of nations categorized as poor and rich. I have compared the primary level of GDP per capita with its later growth over time and conditioning it on trade openness as a macroeconomic variable. In order to examine absolute and conditional Convergence, I have taken into account the linear regression technique where it is applied on cross-section dataset. I estimated the parameters of models through the application of the least square method so-called (OLS).

The finding of the estimated models is strongly supporting absolute and conditional Convergence among 33 OECD members over the period of 2000-2017. According to the statistical verifications such as F-test for the whole model and t-test for individual parameters model's estimated values are statistically significant at all levels. The robustness of our models is subjected to various statistical verification tools that fulfill the requirement of the Least Square Method (OLS). Those precise econometric validation measurements are comprising Autocorrelation, Heteroscedasticity, and normality test. The estimated values of the Breusch-Godfrey Serial Correlation LM test presents that models do not suffer from Autocorrelation. Subsequently, the White Heteroscedasticity test's result indicates homoscedasticity. In addition, in order to check whether residuals are normally distributed in my models, I have applied the Jarque-Bera test; hence, estimated models are econometrically plausible.

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