CONSUMPTION CONVERGENCE:
THEORY AND EVIDENCE

BAHAR TAŞ

Master's Thesis

Graduate School

Izmir University of Economics

Izmir

2021

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A Thesis Submitted to

The Graduate School of Izmir University of Economics

Master's Program in Financial Economics

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ABSTRACT

CONSUMPTION CONVERGENCE: THEORY AND EVIDENCE

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Master's Program in Financial Economics

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August, 2021

The objective of this thesis is to develop a solid theory of consumption convergence equation and to verify its validity by testing with actual data. To this end we use the Solovian growth model, in which the Keynesian saving-consumption allocation rule plays an essential role, and derive the consumption convergence equation. We show that the equation mimics the well-known income convergence equation. We next empirically estimate the per capita consumption convergence equation by employing the system GMM approach on a panel data set of 156 countries over the period between

1970 and 2019. Results suggest strong evidence towards the existence of conditional convergence for the global sample over the whole period. We also test the convergence performance of the high-income, the upper middle-income, the lower middle-income, the low-income countries to verify whether the global convergence behavior also applies for various income groups. We show that there exists a strong convergence in per capita consumption for the high-income and the upper middle-income countries. The policy implication is that equal redistribution of income should be supported. For this purpose, birth control policies and savings incentive policies should be on the agenda of policy makers.

Keywords: Consumption; Convergence; Dynamic Panel Data; Solow Model; System GMM

ÖZET

TÜKETİM YAKINSAMASI: TEORİ VE İSPATI

Taş, Bahar

Finans Ekonomisi Yüksek Lisans Programı

Tez Danışmanı: Prof. Dr. İ. Hakan YETKİNER

Ağustos, 2021

Bu tezin başlıca amacı, sağlam bir tüketim yakınsaması denklemi teorisi geliştirmek ve bu teoriyi güncel verilerle test ederek geçerliliğini doğrulamaktır. Bu amaçla, Keynesyen tasarruf-tüketim tahsis kuralının önemli bir rol oynadığı Solovyen büyüme modelinden yararlanarak tüketim yakınsama denklemi oluşturuldu. Denklemin bilinen gelir yakınsama denklemini taklit ettiğini gösteriyoruz. Daha sonra, 1970 ile 2019 arasındaki dönemde 156 ülkeden oluşan bir panel veri setinde sistem GMM yaklaşımı kullanılarak kişi başına tüketim yakınsama denklemi ampirik olarak tahmin edilmiştir.

Sonuçlar, tüm dönem boyunca küresel örneklem için yakınsamanın varlığına dair güçlü kanıtlar ortaya koymaktadır. Ayrıca yakınsama sürecinin çeşitli gelir grupları için geçerli olup olmadığını doğrulamak için yüksek gelirli, üst orta gelirli, düşük orta gelirli ve düşük gelirli ülkelerin yakınsama performansı da test edilmiştir. 1970-2019 döneminde kişi başı tüketimdeki yakınsama oranının yüksek gelirli ve üst orta gelirli ülke örneklemlerinde önemli ölçüde arttığını gözlemlenmiştir. Politika çıkarımı, gelirin eşit yeniden dağılımının desteklenmesi gerektiğidir. Bu amaçla, politika yapıcılarının gündeminde nüfus planlaması ve tasarrufu teşvik edici politikalar olmalıdır.

Anahtar Kelimeler: Tüketim; Yakınsama; Dinamik Panel Veri; Solow Modeli; Sistem GMM

Dedicated to my family

ACKNOWLEDGEMENTS

First of all, I would like to express my deepest thanks to my thesis supervisor Prof. İ. Hakan Yetkiner for his precious guidance, valuable insight, and unceasing support throughout the thesis. Despite his intensive responsibilities and limited time as a professor, he immediately responded to my emails and provided me with constructive feedbacks and priceless contributions. This thesis would never have been finished without his support and encouragement. I hope one day I would become a scientist as successful and helpful as he is.

I am thankful to the members of my thesis committee, Asst. Prof. Mehmet Aldonat Beyzatlar and Asst. Prof. Sıtkı Değer Eryar for agreeing to take part in the committee. I would like to express my sincere gratefulness to them for invaluable comments and suggestions.

I would like to offer my sincere thanks to Gamze Öztürk for her precious supports and contributions. I would like to give thanks to my professors at the Department of Economics at Izmir University of Economics for their contributions during my master's degree.

Finally, I thank my dear friends who are always kind and supportive of me. I thank my father and my mother for their limitless love, endless patience, and nonstop encouragement. Especially to my father, I am trying so hard to be the person that you want me to be. I hope you and my mom will always be proud of me.

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LIST OF ABBREVIATIONS

EU: European Union

GDP: Gross domestic product

GMM: Generalized method of moments

LSDV: Least-squares dummy variables

OECD: The Organisation for Economic Co-operation and Development

OLS: Ordinary least squares

PPP: Purchasing power parity

CHAPTER 1: INTRODUCTION

Economic theory presumes that welfare is the ultimate goal of economic activity, which is determined first and most by consumption. For this reason, the level of per capita consumption is considered as one of the most important pillars of an economy while it is also highly suitable for measurement. Consumption expenditure also has the highest share in GDP, irrespective of income group. Figure 1 demonstrates the average share of real consumption per capita in GDP per capita for the period between 1970 and 2019 for various income groups. To exemplify, the share of the per capita consumption over GDP per capita is 75.4 percentage for the high-income countries whereas this ratio rises to 81.53 percentage for the upper middle-income countries.[1] The highest ratio belongs to low-income countries, which is approximately 96% while the ratio of the lower middle-income countries follows by the percentage of 88.[2] The conclusion that can be drawn from Figure 1 is as follows: consumption expenditure has the highest share in income, while the consumers of the lower income economies allocate a higher portion of their income to consumption. The dual role of consumption, defining welfare and having the highest share in GDP, implies that one needs to understand it both at micro and macro levels. In this work, we will focus on one particular research question, namely consumption convergence at macro level. To this end, we will first examine the income convergence literature to build a background and next, we will relate this background to consumption convergence.

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[1] These shares are calculated by the data of 56 high-income countries and 38 upper middle-income countries for the period 1970-2019.

[2] These shares are calculated by the data of 38 lower middle-income countries and 24 low income countries for the period 1970-2019.

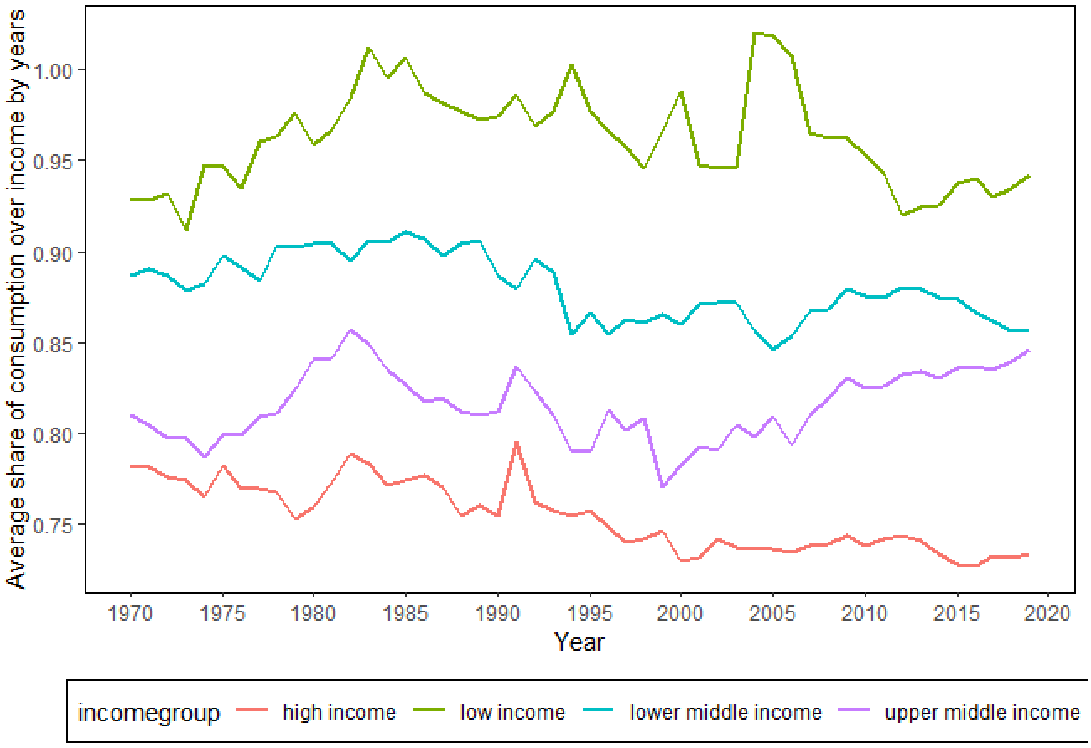

Figure 1. The average share of real consumption per capita (household and government final consumption expenditure divided by population) over real GDP per capita for the period between 1970 and 2019. Source: Penn World Table 10.0.

The neoclassical growth theory conjectures that per capita income will converge to its long-term value no matter which shocks it experiences as long as the parameters determining this long-term value do not change. The model suggests income convergence under the assumptions of having homogenous rate of time preference and identical production function. Convergence idea emanates from the law of diminishing returns to capital, which states that marginal product of capital will increase at diminishing rates, given other inputs. Hence, the further (closer) the economy is from (to) its long run equilibrium value, the higher (the slower) its growth rate. A natural extension of the law is for a group of countries similar in ‘fundamentals’: the per capita income of similar economies (countries) will converge to each other in the long run. This is because, within a group of countries similar in fundamentals, poorer countries farther from their steady state will have higher growth rates (as their marginal returns to capital are higher) and those closer to their steady states will have lower growth rates and they will meet at similar long run equilibrium values in time. Williamson (1996) extends the idea of income convergence across similar countries to living standards between the poor and rich countries and formulates income convergence as the fall in the difference in living standards between them.

We argue that consumption convergence is another natural extension of the idea of (income) convergence for two reasons: First, the law of diminishing marginal utility, which indicates that marginal utility of consumption diminishes by each additional unit, ceteris paribus, makes possible that consumption (per capita) converges to a long run equilibrium value. Assuming the identical utility functions of consumers across countries and homogenous rate of time preference also imply convergence of consumption (per capita). Second, there is a stable relationship between consumption and income, and the relationship has the highest share in GDP among expenditure. In the light of these assumptions, we may intuitively expect that per capita consumption of similar countries will converge to each other in the long run. Countries with low level of consumption will have a faster growing rate of consumption expenditure than countries with high level of consumption expenditure because (i) their marginal utility is higher comparatively, and (ii) if income converges, consumption also converges since the latter has the highest share in GDP. All in all, the aim of this thesis is to extend the theory and empirical evidence on income convergence to consumption convergence based on the natural expectation that the two convergence behaviors should show similar dynamics. We will start our literature review from the natural starting point, the income convergence literature.

Given the Solovian framework, the growth rate of output per worker in the transitional period, i.e., the income convergence equation, depends on initial level of output, the saving rate and the population growth rate augmented by the rate of technological progress and the depreciation rate. The income convergence equation predicts that the saving rate has a positive effect whereas the augmented population growth rate has a negative effect on the growth of output per worker in the transitional period. The convergence behavior, which is also called β-convergence and catch-up effect, has two fundamental versions: unconditional and conditional convergence. These two main convergence forms are proposed by Barro and Sala-i-Martin (1992). The unconditional convergence equation signifies that convergence (of income of an economy) to its steady state value or to a group of economies depends solely only on the initial value of income. In neoclassical growth models for closed economies, e.g., Ramsey (1928), Solow (1956), Cass (1965), and Koopmans (1965), the initial value of output (income per capita) has a tendency of being inversely associated with the growth rate of output (income per capita) (Barro and Sala-i-Martin, 1992). Hence, relatively poor economies will have a rapid growth rate than rich economies. On the other hand, conditional convergence symbolizes the idea that countries will converge to each other if they have similar parameters that determine their long-term income equilibrium; thereby, the convergence speeds of these countries are affected not only by the initial value of income but also some other fundamental determining variables, namely the saving rate, the augmented population growth rate. A further extension of conditional convergence includes relevant control variables such as education, investment, trade, and openness.

This work arises out of three motivations. First, there are extremely limited number of studies on consumption convergence. More than this, no theoretical background has been provided by any of these limited number of studies. The second reason is that consumption has a more stable data path than income, which might offer more robust results. Income is more prone to giving rapid reactions against short-term volatilities and shocks. Hence, income has a more fluctuating data path. The third reason is that consumption is a better indicator of household welfare than income. Therefore, the presence of convergence in consumption may prompt a better statistic of human welfare. Moreover, the convergence in consumption is expected to lead to an increase in quantity demanded. In conclusion, the phenomenon of consumption convergence is a subject worth to study and this work fills an important gap in the empirical growth literature.

One of the objectives of this thesis is to investigate whether convergence in consumption per capita across the globe is a fact or a myth. In the literature, convergence in consumption is divided into two parts in terms of drivers of consumption: preference-driven consumption convergence and income-driven consumption convergence. The hypothesis of preference-driven convergence has come up with a theoretical evidence of the stability assumption of preferences and tastes proposed by Stigler and Becker (1977). While the limitation of this hypothesis was highlighted at a later stage in the literature (see e.g., Selvanathan and Selvanathan, 1993; Carruth et al., 1999), with inclusion of the concept of globalization by Levitt (1999), the investigation of consumption convergence has become a pertinent focus among empirical economists. For example, Smith et al. (1999) base their study on the data from 15 member countries of the EU in order to examine convergence in consumption. They allege that advancing technology, standard forms of education, increase in health consciousness, and higher standards of living are powerful forces for global convergence of values and behavior, thus, consumption. Similarly, Dholakia and Talukdar (2004) investigate the effect of social influence on consumption trends in emerging markets by conducting empirical analysis on annual data from the 22 emerging markets and the U.S.. They analyzed the relative per capita consumption of EMs and the U.S.. Their results reveal that global integration and U.S exposure cause homogenization in consumption levels in the emerging markets. However, De Mooij and Hoffstede (2002) argue the opposite. Even though there is a convergence in technology and a decrease in income gaps, this will not lead to convergence in consumer behavior. Because, they assert that cultural differences will set a barrier to convergence in consumer behavior. They demonstrate this argument by conducting correlation and step-wise regression analyses using national wealth (GDP per capita) and Hofstede's cultural dimensions in order to examine the possible impact of culture on consumption. On the other side, income-driven consumption convergence concept presumes that income is an important determinant of consumption convergence. The results of this thesis also confirm this concept. With the inclusion of per capita income into the model, convergence in per capita consumption has observed in all income groups.

By following the Solovian setup, we try to confirm income-driven consumption convergence. Therefore, the main concern of this thesis is to address whether consumption per capita has been converging over the 50 years, and to detect the speed and mechanism of this convergence. First of all, in this thesis we will derive conditional and unconditional convergence models of consumption per capita theoretically. If it is the unconditional beta-convergence model, per capita consumption convergence is only function of the lag of consumption per capita. If it is the conditional convergence, the growth of per capita consumption in the transitional period hinges on the saving rate, and the augmented population growth rate next to the lag of the consumption per capita (we also used some control variables, such as investment, trade, openness, and government expenditure under the conditional runs). Next, we estimate these models by utilizing one-step system GMM method. The first reason to decide to use system GMM is that this methodology enables us to avoid the set of explanatory variables' endogeneity problem. Correlation between explanatory variables and the error term engenders the problem of endogeneity. The second reason is that the methodology eliminates omitted variable bias and correlated individual effects. Other remarkable characteristic of system GMM is being free of unobserved panel heterogeneity and removing potential measurement errors. As a result, system GMM provides more robust results than other methodologies.

We conducted our analysis on unbalanced panel data which involves per capita consumption in real terms across 156 countries and the period spanning 1970-2019. Herrmann and Röder (1995) have studied convergence in the demand for food nutrients. However, their study only covered the OECD countries and was limited to food product categories and the short period as ten years. On the other hand, we consider a longer period of time and a larger number of countries. Also, we have decomposed the countries into four income groups (high income, upper middle, lower middle, and low income) in order to obtain more consistent results. Moreover, we follow the methodology proposed by Islam (1995) in order to estimate both absolute (unconditional) and conditional convergence in consumption per capita. To estimate conditional convergence, we employed determinant variables including gross capital formation (saving rate) and population growth rate (augmented by 0.05) and control variable such as per capita income. Addressing unconditional (absolute) and conditional (relative) convergence separately enables us to make more sensible comparisons and inferences.

To sum up, this thesis contributes to the literature in two-fold. Firstly, we develop a novel theoretical framework for consumption convergence by extending the standard income convergence model. This provides an intriguing and conceptually testable empirical model for consumption convergence. Secondly, to the best knowledge of the authors, this is the first study that investigates the aggregate consumption convergence on a global scale along with a long period of time comprising 1970-2019.

The general structure of the thesis is structured as follows: chapter one offers a general introduction into the topic. Chapter two includes an overall review of literature related to income and consumption convergence. Chapter three provides a theoretical framework. In chapter four, the methodology performed in this thesis is described.

Further, chapter five reports the empirical results. Chapter six concludes and provides some suggestions for further research and recommendations related to the obtained empirical results in the conclusion part.

CHAPTER 2: LITERATURE REVIEW

This chapter reviews theoretical and empirical literatures on convergence in income and in consumption. The neoclassical model predicts that countries' per capita income levels will converge towards their respective steady state values in the long-run. Since the steady-state level of per capita income is determined by the saving rate and the augmented population growth rate, different countries achieve different steady-state levels. Also, the model presumes low-income countries far away from their long-run equilibrium income value will grow more rapidly than high-income countries closer to their long-run equilibrium values. The base of this assumption depends on the law of diminishing returns to capital, which implies that the marginal product of capital will increase at diminishing rates, given other inputs. The marginal product of capital derived from standard Cobb-Douglas production function, $Y = K^{\alpha}(AL)^{1-\alpha}$, which becomes $y = k^{\alpha}$ in intensive form is as follows:

$$[f'(k)] = \alpha k^{\alpha-1}$$

$$= \alpha y^{\frac{\alpha-1}{\alpha}}$$

Suppose that there are two countries, country A and country B. Presume that production elasticities of capital of these two countries are identical. Then, the marginal product of capital in country B would be as follows:

$$[f'(k)]_{country\,B} = \alpha\left(k_{country\,B}\right)^{\alpha-1} = \alpha(y_{country\,B})^{\frac{\alpha-1}{\alpha}}$$

Now assume that output per worker of country A is 5 times higher than that of country B.

$$\alpha(y_{country\,B})^{\frac{\alpha-1}{\alpha}} = \alpha\left(\frac{y_{country\,A}}{5}\right)^{\frac{\alpha-1}{\alpha}}$$

$$= \left(\frac{1}{5}\right)^{\frac{\alpha-1}{\alpha}} \alpha(y_{country\,A})^{\frac{\alpha-1}{\alpha}}$$

$$[f'(k)]_{country\,B} = 5^{\frac{1-\alpha}{\alpha}}[f'(k)]_{country\,A} \qquad (1)$$

For $\alpha = 0.25$, the return to capital in country B should be 125 times higher than the return to capital in country A. Thus, a large flow of capital from country A to country B can be expected until capital per worker is equalized between countries. At the end, equalization process in capital per worker will lead to convergence between country A and B.

In first place, Baumol (1986) has empirically tested the idea of income convergence. He points out that the higher a country's productivity level initially, 1870 in particular, the slower it grew over the next century. Countries that were late to industrialization and, in a way, to economic development, have tended to converge in per capita product levels in the long-run. Along the same line, Abramowitz's catch-up hypothesis (1986) asserts that countries that are backward in level of productivity will have more rapid growth rate of productivity than that of technologically more advanced countries since the growth rates of productivity in the long run incline to be inversely associated with the initial levels of productivity. Moreover, Abramowitz (1986) underlines that productivity gaps between countries offer a strong potentiality for convergence among later levels if backward countries have a “social capability” that requires to comprehend and implement more advanced technologies that leader countries invented. In a subsequent work, Mankiw, Romer and Weil (1992), henceforth MRW (1992), have contributed to the empirical literature of income convergence by including human capital into the Solovian setup:

$$
\begin{aligned}
Ln[y_{i,t_1}] - Ln[y_{i,t_0}] &= -(1-e^{-v\cdot t})\cdot Ln[y_0] + (1-e^{-v\cdot t})\cdot Ln(A_0) + x \cdot t \\
&+ (1-e^{-v\cdot t})\cdot \frac{\alpha}{1-\alpha-\beta}\cdot Ln(s_k) + (1-e^{-v\cdot t})\cdot \frac{\beta}{1-\alpha-\beta}\cdot Ln(s_h) \\
&- (1-e^{-v\cdot t})\cdot \frac{\alpha+\beta}{1-\alpha-\beta}\cdot Ln(n+\delta+x)
\end{aligned} \tag{2}
$$

where s_k represents the proportion of output invested in physical capital and s_h indicates the proportion of output invested in human capital. Also, v stands for the speed of convergence to the steady state. Their augmented model predicts that poor countries are prone to have higher rates of returns to physical and human capital. As a result, countries with similar rates of physical and human capital accumulation will eventually converge in per capita income, given constant population growth rate.

There have been also numerous studies dealing with consumption convergence across countries and regions. The main concern of these studies is that whether countries are becoming similar in terms of consumption pattern and consumption expenditure. Primarily, Stigler and Becker (1977) put forward a preference convergence hypothesis based on the theoretical evidence which claims that the stability of tastes and preferences across countries generate a particular pattern of consumption among them. However, at a later stage, the limitation of this hypothesis was highlighted by empirical results (see e.g., Selvanathan and Selvanathan, 1993; Carruth et al., 1999). After Levitt's argument regarding globalization leading to homogenization of preferences, the investigation of consumption convergence has gained importance among empirical studies. Mainly, homogenization of consumer behavior has been related several factors such as income, economic integration (international trade or openness), and communication technologies. For example, Friedman (1989) argues that communication technology has changed the life-styles of both developing and developed countries, so the preference convergence hypothesis is more likely to come true (Michail, 2020). Also, economic integrations pave the way for convergence in consumption. Kónya and Ohashi (2007) analyze convergence patterns of both total and eight sub-dimensions of consumption shares among OECD countries, and compare them with other country clubs, namely the EU and G-7. They use openness as a proxy of economic integration and show that the consumption pattern of a country with more trade becomes closer to the consumption pattern of the theoretical OECD average. Briefly, a 1% increase in openness leads to decrease the standard deviation of the relative consumption share by 1%. In a subsequent study, Michail (2020) discussed separately convergence in the subsets of product categories in the EU and compared the results with that of Kónya and Ohashi (2007). Along the same line, Dhalakia and Talukdar (2004) investigate how social influence, which represents ties to the U.S. and exposure to the American "way of life", affects consumption trends in emerging markets (henceforth, EMs) and construct an analysis by drawing upon psychological theories of social influence, and using national per capita consumption data from 22 major emerging markets and the US. They suggest that global integration and US exposure appear to homogenize consumption levels in the world's emerging markets. Their empirical results provide a strong support for consumption convergence in the aggregate level of EMs. Blandford (1984) confirms convergence in per capita food consumption among OECD countries by employing the coefficient of variation approach. Also, he states that high per capita food consumption is positively related to a higher per capita income. Similarly, Gil, Gracia, and Pérez y Pérez (1995) reach the same conclusion by applying different approach, time series method. They find a decreasing convergence speed in product level consumption structure among the 15 member countries of the European Union between the periods from 1970 to 1980, 1980 to 1990, and 1970 to 1990. They also observe that countries with higher income levels have higher consumption levels. Hermann and Röder (1995) state that these two papers use the indicators that are only based on descriptive statistics and time-series techniques. Therefore, they posit a new approach based on demand theory (they are including some explanatory variables such as income, price of food, etc.) and conclude convergence in demand for food nutrients within the OECD countries between 1978 and 1988. However, unlike Blandford (1984) and Gil, Gracia and Pérez y Pérez (1995), Hermann and Röder’s (1995) empirical results support that preferences are more important in determining inter-country differences in food demand within OECD countries than income and prices. Elsner and Hartmann (1998) use weighted relative deviation of consumption and pooled regression analysis in order to ascertain whether food consumption patterns have become similar between Eastern and Western Europe since the beginning of the transition period. Their results show that convergence has occurred although this does not hold for all Central and Eastern European Countries or all food commodities. They indicate that people’s diets in centrally planned countries depended primarily on what could be produced in the socialist block because of lack of hard currency spending the import of food products. So, consumer preferences can have little importance for the convergence of food products in these kinds of countries. Lastly, Waheeduzzaman (2011) considered whether emerging markets catch up with the development markets in terms of food consumption over a 30-year period with eight consumption variables, and concluded that the data indicate convergence with the slow rate in consumption.

However, there are also some studies that disagree the idea of consumption convergence. For example, De Mooij and Hofstede (2002) advocate that even there is convergence in technology and income, this will not lead to homogenization of consumer behavior because of cultural differences. They use correlation and step-wise regression analyses in order to investigate the possible influence of culture on consumption. They exploit the national wealth and Hofstede's cultural dimensions as independent variables and a variety of consumption and purchase behavior as dependent variables. They provide evidence that consumer behavior in Europe is diverging by indicating the consumption, ownership, and usage of many products and services. In a later study, De Mooij (2003) argues that consumer behavior diverges instead of converge once again. In this study, he works on the data from an economically heterogeneous group of 44 countries, from an economically more homogeneous group of 26 countries worldwide, and from an economically homogeneous group of 15 countries in Europe covering the period 1970 – 1998. By performing the coefficient of variation approach, he concludes a divergence pattern in consumer behavior rather than convergence. According to De Mooij (2003), at first stage of development, countries incline to converge in terms of behavior. However, they begin diverging after attaining a particular level of development. He argues that as people become affluent, their tastes diverge because of different value systems they own.

Some empirical studies have predominantly focus on convergence in specific product categories. For instance, Smith, Solgaard, and Beckmann (1999) focus on alcohol consumption. They use a univariate time series methodology over 15 member countries of the EU as from 1995. They argue that technological progress increasingly standardize forms of education and higher living standards will encourage more uniform social values, attitudes, and beliefs. Therefore, cultural differences will be getting disappear. In a subsequent study, Holmes and Anderson (2017) update earlier findings on convergence in total alcohol consumption and its mix of beverages. They find strong but indefinite signs of convergence in national alcohol consumption patterns around the world. Similarly, Aizenman and Brooks (2008) find a clear convergence in the consumption of wine relative to beer between 1963 and 2000. They suggest that convergence should be faster among certain groups of countries than others because the extent of integration varies across countries. As an example of specific product categories, Buongiorno (2009) shows that the coefficient of variation of per capita consumption across countries had tended to decrease over the period between 1961 and 2005 for all forest products except sawnwood, which is a strong evidence for convergence. He also indicates that countries with low consumption per capita for all forest products except sawnwood tend to grow faster.

Although the existing studies shed important light on cross-country consumption convergence patterns, they have several limitations. First, studies based on preference convergence hypothesis consider some prior convergence of tastes and preferences among countries. Indeed, the homogeneity of preferences among countries depends greatly on the specific conditions prevailing at country level, which may hamper the process of consumption convergence. Furthermore, the complexity of preference structures would be an additional constraint. Hence, the theoretical underpinning of the existing studies on consumption convergence appears rather limited. As such, it is necessary to explore other forces for consumption convergence among countries. Secondly, previous studies considered only a limited number of product categories and small number of countries, regions, or group of countries. To the best of our knowledge, only Ozturk et al (2020) investigate convergence in product categories on a global scale. The empirical results of these studies, however, do not show a complete and up-to-date picture of the global convergence trends in overall consumption. Therefore, a comprehensive analysis of aggregate consumption convergence on a global scale is lacking. The main attempt of this thesis, therefore, is to complement the existing literature on consumption convergence literature by providing a novel framework for consumption convergence which is based on the classical income convergence model proposed by Solow (1956), and empirically tests for convergence (beta) in the aggregate consumption levels in a dynamic panel data setup.

CHAPTER 3: THEORY

3.1. Income Convergence Theory

In order to derive consumption convergence model, we will exploit Solovian economic growth model. Therefore, initially, we assume that output Y_t is produced by the essential inputs physical capital K_t and labor L_t, the latter augmented by technology A_t, in the Cobb-Douglas form, $Y_t = K_t^{\alpha} \cdot (A_t \cdot L_t)^{1-\alpha}$, where α is input elasticity of physical capital. The form of the production function ensures that all factors of production are essential and that the homogeneity of degree one guarantees that the real profit is zero. Finally, we assume that the time behaviors of labor force and technological progress are respectively $L_t = L_0 \cdot e^{n \cdot t}$ and $A_t = A_0 \cdot e^{x \cdot t}$, where L_0 and A_0 are initial values and n and x are exogenous growth rates of them. Assuming a closed economy without government, macroeconomic equilibrium implies that output Y_t is equal to aggregate expenditure, $AE_t = C_t + I_t$, where C_t and I_t represent consumption expenditure and gross investment, respectively. As Y_t is allocated between consumption expenditure and private saving (since the model does not involve government, there is no government expenditure), S_t^p, the macroeconomic equilibrium implies $S_t^p = I_t$. The macroeconomic equilibrium, under the assumptions that private saving is a fixed proportion of income, s, and that gross investment is net investment plus depreciation, leads to $s \cdot Y_t = \dot{K}_t + \delta \cdot K_t$, where $\dot{K}_t$ is net investment, δ is the depreciation rate and s_K is the saving for physical capital accumulation. Accordingly, the fundamental equation of growth becomes $\dot{K}_t = s \cdot K_t^{\alpha} \cdot (A_t \cdot L_t)^{1-\alpha} - \delta \cdot K_t$. If we divide the fundamental equation of growth by per effective unit of labor $(A_t \cdot L_t)$:

$$\frac{\dot{K}_t}{A_t \cdot L_t} = \frac{s \cdot K_t^{\alpha} \cdot (A_t \cdot L_t)^{1-\alpha}}{A_t \cdot L_t} - \frac{\delta \cdot K_t}{A_t \cdot L_t}$$

$$\dot{\tilde{k}}_t = s \cdot \tilde{k}_t^{\alpha} - (n + \delta + x) \cdot \tilde{k}_t \qquad (3)$$

In equation (3), $\tilde{k}_t^{\alpha} = \tilde{y}_t$ and if we take the log-differential of the production function, we obtain $\hat{\tilde{y}}_t = \alpha \cdot \hat{\tilde{k}}_t$ (recall that $\hat{\tilde{y}}_t = \frac{\dot{\tilde{y}}_t}{\tilde{y}_t}$ and $\hat{\tilde{k}}_t = \frac{\dot{\tilde{k}}_t}{\tilde{k}_t}$). Thus, it is possible to rewrite the fundamental equation of growth in terms of $\tilde{y}_t$. First of all, we should divide the both sides of equation (1) by $\tilde{k}_t$ ($\tilde{k}_t = \tilde{y}_t^{\frac{1}{\alpha}}$).

$$\frac{\dot{\tilde{k}}_t}{\tilde{k}_t} = \frac{s \cdot \tilde{k}_t^{\alpha}}{\tilde{k}_t} - \frac{(n+\delta+x)\cdot \tilde{k}_t}{\tilde{k}_t} \Rightarrow$$

$$\frac{\dot{\tilde{k}}_t}{\tilde{k}_t} = s \cdot \tilde{k}_t^{\alpha-1} - (n+\delta+x) \Rightarrow$$

$$\frac{1}{\alpha} \cdot \frac{\dot{\tilde{y}}_t}{\tilde{y}_t} = s \cdot \tilde{y}_t^{\frac{\alpha-1}{\alpha}} - (n+\delta+x) \Rightarrow$$

$$\frac{\dot{\tilde{y}}_t}{\tilde{y}_t} = \alpha \cdot \left[s \cdot \tilde{y}_t^{\frac{\alpha-1}{\alpha}} - (n+\delta+x) \right] \Rightarrow$$

$$\frac{dLn[\tilde{y}_t]}{dt} = \alpha \cdot \left[s \cdot e^{\left(\frac{\alpha-1}{\alpha}\right) Ln[\tilde{y}_t]} - (n+\delta+x) \right] \equiv \phi(Ln[\tilde{y}_t]) \tag{4}$$

We will make equation (4) linear by drawing upon log-linearization and Taylor approximation in order to obtain an econometric equation. Taylor approximation is a technique which is established on an infinite summation of terms denoted in terms of a function's derivatives at a particular value. Approximating functions that can be difficult to compute becomes so much easier with Taylor approximation. Mathematical notation of the Taylor approximation is:

$$f(x) = f(a) + \frac{f'(a)}{1!}(x-a) + \frac{f''(a)}{2!}(x-a)^2 + \frac{f'''(a)}{3!}(x-a)^3 + \cdots \tag{5}$$

In equation (5), “a” represents a constant value where “$f'(a)$ and $f''(a)$” show the value of the first and second derivatives of the function f(x) with respect to x at constant value “a”. For example, the steady state value is accepted as the constant point in the convergence analysis. The equation becomes:

$$\frac{dLn[\tilde{y}_t]}{dt} \approx \phi(Ln[\tilde{y}_{ss}]) + \phi'(Ln[\tilde{y}_{ss}]) \{(Ln[\tilde{y}_{ss}]) - (Ln[\tilde{y}_{ss}])\} \tag{6}$$

In order to make the equation linear, we should find out the value of $\phi(Ln[\tilde{y}_t])$ and the evaluation of the derivative of $\phi(Ln[\tilde{y}_t])$ with respect to $(Ln[\tilde{y}_t])$ at a steady state. The value of $\phi(Ln[\tilde{y}_t])$ is $\phi(Ln[\tilde{y}_{ss}])$ and it is equal to:

$$\phi(Ln[\tilde{y}_{ss}]) = \alpha \cdot \left[s \cdot e^{\left(\frac{\alpha-1}{\alpha}\right) Ln[\tilde{y}_{ss}]} - (n+\delta+x) \right] \tag{7}$$

where $\tilde{y}_{ss} = \left[\frac{s}{n+\delta+x}\right]^{\frac{\alpha}{1-\alpha}}$ and $e^{\left(\frac{\alpha-1}{\alpha}\right)Ln[\tilde{y}_t]} = \tilde{y}_t^{\frac{\alpha-1}{\alpha}}$;

$$\phi(Ln[\tilde{y}_{ss}]) = \alpha \cdot \left[s \cdot e^{\left(\frac{\alpha-1}{\alpha}\right)\left(\frac{\alpha}{1-\alpha}\right) Ln\left[\frac{s}{n+\delta+x}\right]} - (n+\delta+x) \right] \Rightarrow$$

$$\phi(Ln[\tilde{y}_{ss}]) = \alpha \cdot \left[s \cdot e^{-Ln\left[\frac{s}{n+\delta+x}\right]} - (n+\delta+x) \right] \Rightarrow$$

$$\phi(Ln[\tilde{y}_{ss}]) = \alpha \cdot \left[s \cdot \frac{n+\delta+x}{s} - (n+\delta+x) \right] \Rightarrow$$

$$\phi(Ln[\tilde{y}_{ss}]) = \alpha \cdot [(n+\delta+x) - (n+\delta+x)] \Rightarrow$$

$$\phi(Ln[\tilde{y}_{ss}]) = 0 \tag{8}$$

Secondly, let us find the first derivative of $\phi(Ln[\tilde{y}_{ss}])$. To this purpose, one should take derivative of $\phi(Ln[\tilde{y}_t])$ with respect to $(Ln[\tilde{y}_t])$.

$$\phi'(Ln[\tilde{y}_t]) = \alpha \cdot \left[s \cdot \left(\frac{\alpha-1}{\alpha}\right) \cdot e^{\left(\frac{\alpha-1}{\alpha}\right)Ln[\tilde{y}_t]} \right] \Rightarrow$$

$$\phi'(Ln[\tilde{y}_t]) = \alpha \cdot \left[s \cdot \left(\frac{\alpha-1}{\alpha}\right) \cdot \tilde{y}_t^{\frac{\alpha-1}{\alpha}} \right] \tag{9}$$

Now, we can evaluate this derivative at steady state:

$$\phi'(Ln[\tilde{y}_{ss}]) = \alpha \cdot \left[s \cdot \left(\frac{\alpha-1}{\alpha}\right) \cdot \tilde{y}_{ss}^{\frac{\alpha-1}{\alpha}} \right] \Rightarrow$$

$$\phi'(Ln[\tilde{y}_{ss}]) = \alpha \cdot \left[s \cdot \left(\frac{\alpha - 1}{\alpha}\right) \cdot \left(\left[\frac{s}{n + \delta + x}\right]^{\frac{\alpha}{1-\alpha}} \right)^{\frac{\alpha-1}{\alpha}} \right] \Rightarrow$$

$$\phi'(Ln[\tilde{y}_{ss}]) = \alpha \cdot \left[s \cdot \left(\frac{\alpha - 1}{\alpha}\right) \cdot \left(\frac{n + \delta + x}{s}\right) \right] \Rightarrow$$

$$\phi'(Ln[\tilde{y}_{ss}]) = -(1 - \alpha) \cdot (n + \delta + x) \qquad (10)$$

If we substitute the values we found into equation (10), we get the following equation.

$$\frac{dLn[\tilde{y}_t]}{dt} \approx \phi(Ln[\tilde{y}_{ss}]) + \phi'(Ln[\tilde{y}_{ss}]) \, \{(Ln[\tilde{y}_{ss}]) - (Ln[\tilde{y}_{ss}])\}$$

$$\frac{dLn[\tilde{y}_t]}{dt} \approx -(1 - \alpha) \cdot (n + \delta + x)(Ln[\tilde{y}_t] - Ln[\tilde{y}_{ss}]) \qquad (11)$$

Now, we obtain the linear equation. Let's define $v = (1 - \alpha) \cdot (n + \delta + x)$. We assume that $Ln[\tilde{y}_t] < Ln[\tilde{y}_{ss}]$ so that the model economy will converge to steady state income from the left side. Under this assumption, the second term on the right side of equation (11) is negative, so $-v \cdot (Ln[\tilde{y}_t] - Ln[\tilde{y}_{ss}])$ will be positive. Furthermore, the higher the difference between $Ln[\tilde{y}_t]$ and $Ln[\tilde{y}_{ss}]$, the higher will be the value of $-v \cdot (Ln[\tilde{y}_t] - Ln[\tilde{y}_{ss}])$. Since the left side of equation (11) is the growth rate of income per efficient capita, countries whose income is closer (more distant) to steady state income level will have the lower (higher) growth rates. Therefore, convergence speed (convergence rate) indicates the pace to which an economy approaches its steady state income level. Using the above equation:

$$CR = \frac{d\hat{\tilde{y}}_t}{dLn[\tilde{y}_t]} = \frac{\frac{d\hat{\tilde{y}}_t}{dt}}{\frac{dLn[\tilde{y}_t]}{dt}} = \frac{\dot{g}}{g} \approx -v \qquad (12)$$

Hence, convergence speed represents the rate of change in the growth rate.

The growth rate of an economy depends on the extent to which this economy is far from its steady state; the further the initial point is from its steady state value, the higher the growth rate. Similarly, economies with income more distant from steady state value (or closer to steady state) will decrease at a higher (lower) rate in the case of $Ln[\tilde{y}_t] > \ Ln[\tilde{y}_{ss}]$, which implies they will have a negative growth rate.

Now, the equation $-v \cdot (Ln[\tilde{y}_t] - Ln[\tilde{y}_{ss}])$ is linear but it is still in differential equation form. In order to solve this differential equation, we define $z_t = Ln[\tilde{y}_t]$ and $b = v \cdot Ln[\tilde{y}_{ss}]$ and obtain $\dot{z}_t = -v \cdot z_t + b$. Then, one needs to use integrating factor method to solve the equation. The starting point is to multiply both sides by $e^{v \cdot t}$.

$$\dot{z}_t + v \cdot z_t = b \Rightarrow$$

$$(\dot{z}_t + v \cdot z_t) \cdot e^{v \cdot t} = b \cdot e^{v \cdot t} \Rightarrow$$

$$\dot{z}_t \cdot e^{v \cdot t} + v \cdot z_t \cdot e^{v \cdot t} = b \cdot e^{v \cdot t} \Rightarrow$$

$$\frac{d}{dt}(z_t \cdot e^{v \cdot t}) = \ b \cdot e^{v \cdot t} \Rightarrow$$

$$\int d[z_t \cdot e^{v \cdot t}] = \int b \cdot e^{v \cdot t} \cdot dt \Rightarrow$$

$$z_t \cdot e^{v \cdot t} = \frac{b}{v} \cdot e^{v \cdot t} + \ constant \Rightarrow$$

$$z_t = \frac{b}{v} + \ const \ \cdot e^{-v \cdot t} \Rightarrow$$

$$Ln[\tilde{y}_t] = \frac{v \cdot (Ln[\tilde{y}_{ss}])}{v} + \ const \ \cdot e^{-v \cdot t} \Rightarrow$$

$$Ln[\tilde{y}_t] = \ \left[Ln[\tilde{y}_{ss}]\right] + \ const \ \cdot e^{-v \cdot t} \tag{13}$$

For t=0, the above equation gives the value of *constant* from the $Ln[\tilde{y}_0] = Ln[\tilde{y}_{ss}] + const$. To put it another way, $Ln[\tilde{y}_0] - Ln[\tilde{y}_{ss}] = constant$.

$$Ln[\tilde{y}_t] = Ln[\tilde{y}_{ss}] + \ (Ln[\tilde{y}_0] - \ Ln[\tilde{y}_{ss}]) \ \cdot e^{-v \cdot t} \Rightarrow$$

$$Ln[\tilde{y}_t] = \ Ln[\tilde{y}_0] \cdot e^{-v \cdot t} + (1 - e^{-v \cdot t}) \ \cdot \ Ln[\tilde{y}_{ss}] \Rightarrow$$

$$Ln[\tilde{y}_t] - Ln[\tilde{y}_0] = \ -Ln[\tilde{y}_0] + Ln[\tilde{y}_0] \cdot e^{-v \cdot t} + (1 - e^{-v \cdot t}) \ \cdot \ Ln[\tilde{y}_{ss}]$$

$$Ln[\tilde{y}_t] - Ln[\tilde{y}_0] = \ -(1 - e^{-v \cdot t}) \cdot Ln[\tilde{y}_0] + (1 - e^{-v \cdot t}) \ \cdot \ Ln[\tilde{y}_{ss}] \tag{14}$$

Equation (14) is the solution of the linearized differential equation. However, the variable of 'income per effective capita', $\tilde{y}_t$, and its initial and steady state values are not meaningful practically. 'The income per capita' variable, y_t, is more suitable variable for economic analysis. Therefore, it is necessary to convert the equation into per capita income (output):

$$Ln\left[\frac{Y_t}{A_t \cdot L_t}\right] - Ln\left[\frac{Y_0}{A_0 \cdot L_0}\right] = -(1 - e^{-v \cdot t}) \cdot Ln\left[\frac{Y_0}{A_0 \cdot L_0}\right] + (1 - e^{-v \cdot t}) \cdot Ln\left[\left[\frac{s}{n + \delta + x}\right]^{\frac{\alpha}{1-\alpha}}\right]$$

$$\Rightarrow$$

$$Ln\left[\frac{Y_t}{L_t}\right] - Ln\left[\frac{Y_0}{L_0}\right] - Ln(A_t) + Ln(A_0) = -(1 - e^{-v \cdot t}) \cdot Ln\left[\frac{Y_0}{L_0}\right] + (1 - e^{-v \cdot t}) \cdot Ln(A_0) + (1 - e^{-v \cdot t}) \cdot Ln\left[\left[\frac{s}{n + \delta + x}\right]^{\frac{\alpha}{1-\alpha}}\right] \quad (15)$$

As we know $A_t = A_0 \cdot e^{x \cdot t}$:

$$Ln\left[\frac{Y_t}{L_t}\right] - Ln\left[\frac{Y_0}{L_0}\right] - x \cdot t = -(1 - e^{-v \cdot t}) \cdot Ln\left[\frac{Y_0}{L_0}\right] + (1 - e^{-v \cdot t}) \cdot Ln(A_0) + (1 - e^{-v \cdot t}) \cdot Ln\left[\left[\frac{s}{n + \delta + x}\right]^{\frac{\alpha}{1-\alpha}}\right]$$

$$Ln[y_t] - Ln[y_0] = x \cdot t + (1 - e^{-v \cdot t}) \cdot Ln(A_0) - (1 - e^{-v \cdot t}) \cdot Ln[y_0] + (1 - e^{-v \cdot t}) \cdot Ln\left[\left[\frac{s}{n + \delta + x}\right]^{\frac{\alpha}{1-\alpha}}\right] \quad (16)$$

If one defines $\beta_0 = x \cdot t + (1 - e^{-v \cdot t}) \cdot Ln(A_0)$, $\beta_1 = -(1 - e^{-v \cdot t})$ and $\beta_2 = \frac{\alpha}{1-\alpha} \cdot (1 - e^{-v \cdot t})$, the equation becomes:

$$Ln[y_t] - Ln[y_0] = \beta_0 + \beta_1 \cdot Ln[y_0] + \beta_2 \cdot Ln[s] + \beta_3 \cdot Ln[n + \delta + x] \qquad (17)$$

While estimating this conditional convergence equation, one uses average growth rate as the dependent variable. Hence, empirically the equation becomes

$$\frac{1}{T}\{Ln[y_{i,t_1}] - Ln[y_{i,t_0}]\} = \beta_0 + \beta_1 \cdot Ln[y_{i,t_0}] + \beta_2 \cdot Ln[s_{i,t_0-t_1}] + \beta_3 \cdot Ln[n_{i,t_0-t_1} + 5\%] + \varepsilon_{it} \qquad (18)$$

Equation (18) estimates conditional convergence. The dependent variable is the growth rate between time 0 (initial time) and time t (ending time). The interpretation of the second estimated coefficient $\hat{\beta}_1$ is that it detects the convergence speed (v). For example, let us suppose that $\hat{\beta}_1$ is equal to –0.35 and t=15 observations. So, $-0.35 = -(1 - e^{-v \cdot 15})$. By solving the equation, the convergence speed is found as $v = 0.0287$ or %2.87. As long as the estimated coefficient β_1 is negative, it is considered as proof of convergence. On the other hand, another estimated coefficient β_2 determines the contribution of the natural logarithm of the average investment ratio (=saving ratio) on the average growth rate between 0 (initial time) and t (ending time). Theoretically, this contribution is expected to be positive. The last estimated coefficient β_3 represents the effect of the natural logarithm of the population growth rate augmented by 5 percent on the average growth rate between 0 (initial time) and t (ending time). This effect is expected to be negative – just the opposite of the positive contribution of saving ratio – in the theoretical framework. In order to estimate unconditional convergence, we should run this equation in the form $\frac{1}{T}\{Ln[y_{it}] - Ln[y_{i0}]\} = \beta_0 + \beta_1 \cdot Ln[y_{i0}] + \varepsilon_{it}$. If we run this equation, the estimated convergence speed implicitly depends on only the initial value of income.

There is an alternative form of income convergence equation, more suitable for dynamic estimation. When deriving this alternative form, the income of the previous period is taken into account instead of the initial value of income. In other words, the income of the previous period is the initial value of the current period's income. In the above, we have obtained the equation $Ln[\tilde{y}_t] = \left[Ln[\tilde{y}_{ss}]\right] + \ const \ \cdot e^{-v\cdot t}$. Now suppose that the initial value is t_1. In this case, the equation will become $\left\{Ln[\tilde{y}_{t1}] - \left[Ln[\tilde{y}_{ss}]\right]\right\} \cdot e^{v\cdot t_1} \ = const$. Similarly, for $t_2 > t_1$ and $\tau = t_2 - t_1$, the equation turns into:

$$Ln[\tilde{y}_{t2}] = \ Ln[\tilde{y}_{ss}] + \ sbt \ \cdot e^{-v\cdot t_2} \Rightarrow$$

$$Ln[\tilde{y}_{t2}] = \ Ln[\tilde{y}_{ss}] + \ (Ln[\tilde{y}_{t1}] - Ln[\tilde{y}_{ss}]) \cdot e^{v\cdot t_1} \cdot e^{-v\cdot t_2} \Rightarrow$$

$$Ln[\tilde{y}_{t2}] = (1 - e^{-v\cdot\tau}) \cdot Ln[\tilde{y}_{ss}] + \ Ln[\tilde{y}_{t1}] \cdot e^{-v\cdot\tau} \qquad (19)$$

Finally, by substituting the values of $\tilde{y}_{ss}$, the following convergence equation is obtained.

$$\begin{aligned} Ln\left[y_{t_2}\right] - Ln\left[y_{t_1}\right] \\ &= -(1 - e^{-v\cdot\tau}) \cdot Ln\left[y_{t_1}\right] + \ (1 - e^{-v\cdot\tau}) \cdot \frac{\alpha}{1-\alpha} \cdot Ln[s] - (1 - e^{-v\cdot\tau}) \\ &\cdot \frac{\alpha}{1-\alpha} \cdot Ln[n + \delta + x] + (1 - e^{-v\cdot\tau}) \cdot Ln[A(0)] + x \cdot (t_2 \\ &- e^{-v\cdot\tau} t_1) \end{aligned}$$ [3]

If we consider as $\beta_0 = x \cdot (t_2 - e^{-v\cdot\tau} t_1) \ + (1 - e^{-v\cdot t}) \ \cdot \ Ln(A_0)$, $\beta_1 = -(1 - e^{-v\cdot t})$ and $\beta_2 = \frac{\alpha}{1-\alpha} \cdot (1 - e^{-v\cdot t})$, the equation becomes as:

$$Ln\left[y_{t_2}\right] \ - \ Ln\left[y_{t_1}\right] = \ \beta_0 + \beta_1 \cdot Ln\left[y_{t_1}\right] + \beta_2 \cdot Ln[s] + \beta_3 \cdot Ln[n + \delta + x]$$

$$\begin{aligned} Ln\left[y_{i,t_2}\right] - Ln\left[y_{i,t_1}\right] \\ &= \beta_0 + \beta_1 \cdot Ln\left[y_{i,t_1}\right] + \beta_2 \cdot Ln\left[s_{i,t_1-t_2}\right] + \beta_3 \cdot Ln\left[n_{i,t_1-t_2} + 5\%\right] \\ &+ \ \varepsilon_{it} \end{aligned} \qquad (20)$$

Consequently, we obtained income convergence estimation equation after implying standard process. Thus, equation (20) will become a basis for our consumption convergence equation.

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[3] Equation 11 in the article of Islam (1995).

3.2. *Consumption Convergence Theory*

The objective of this section is to derive consumption convergence equation. The paramount point is to construct a model to explain the rates of consumption growth. In the previous section, we derived equation (20) which represents income convergence model. Since we assert that consumption convergence and income convergence are lying in the same line, the model of consumption convergence will be derived from Solovian growth framework.

We begin with considering a closed economy without government predicated on the neoclassical growth model. All assumptions we made in the previous section are valid for this section as well. The production function is in the Cobb-Douglas form, $Y_t = K_t^{\alpha} \cdot (A_t \cdot L_t)^{1-\alpha}$. The time behaviors of labor force and technological progress are respectively, $L_t = L_0 \cdot e^{n \cdot t}$ and $A_t = A_0 \cdot e^{x \cdot t}$. Given a closed economy without government, macroeconomic equilibrium implies that output Y_t is equal to aggregate expenditure, $AE_t = C_t + I_t$. As Y_t is allocated between consumption expenditure and private saving, S_t^p, the macroeconomic equilibrium implies $S_t^p = I_t$. The macroeconomic equilibrium, under the assumptions that private saving is a fixed proportion of income, s, and that gross investment is net investment plus depreciation, leads to $s \cdot Y_t = \dot{K}_t + \delta \cdot K_t$. Following the standard procedure, it has been shown in the previous section that $\frac{\dot{\tilde{y}}_t}{\tilde{y}_t} = \alpha \cdot \left[s \cdot \tilde{y}_t^{\frac{\alpha-1}{\alpha}} - (n+\delta+x)\right]$ where $\tilde{y}_t = \frac{Y_t}{A_t \cdot L_t}$. As the macroeconomic equilibrium implies $C_t = (1-s)Y_t$, this equation can be expressed as following:

$$\frac{\dot{\tilde{c}}_t}{\tilde{c}_t} = \alpha \cdot \left[s \cdot (1-s)^{\frac{1-\alpha}{\alpha}} \tilde{c}_t^{\frac{\alpha-1}{\alpha}} - (n+\delta+x)\right] \tag{21}$$

where $\tilde{c}_t = \frac{C_t}{A_t \cdot L_t}$ and $\tilde{c}_{ss} = (1-s)\tilde{y}_{ss}$, where $\tilde{y}_{ss} = \left(\frac{s}{n+\delta+x}\right)^{\frac{\alpha}{1-\alpha}}$ by using the Taylor series approximation, one ends up with:

$$\frac{dLn[\tilde{c}_t]}{dt} \approx -(1-\alpha)(n+\delta+x)\left[Ln[\tilde{c}_t] - Ln[\tilde{c}_{ss}]\right] \tag{22}$$

Let's define $v = (1-\alpha) \cdot (n+\delta+x)$ as we did before. We assume that $Ln[\tilde{c}_t] < Ln[\tilde{c}_{ss}]$ so that the model economy will converge to steady state consumption from the left side. In other words, consumption will be under long-run consumption at any finite “t”. Under this assumption, the second term on the right side of equation (22) is negative, so $-v \cdot (Ln[\tilde{c}_t] - Ln[\tilde{c}_{ss}])$ will be positive. Furthermore, how much the difference between $Ln[\tilde{c}_t]$ and $Ln[\tilde{c}_{ss}]$ is higher, the value of $-v \cdot (Ln[\tilde{c}_t] - Ln[\tilde{c}_{ss}])$ will be higher respectively. Since the left side of equation (22) is the growth rate of efficient consumption, countries whose consumption is closer (more distant) to steady state consumption level will have a lower (higher) growth rate. Therefore, convergence speed (convergence rate) indicates the pace to which an economy approaches its steady state consumption level. By using the above equation:

$$CR = \frac{d\hat{c}_t}{dLn[\tilde{c}_t]} = \frac{\frac{d\hat{\tilde{c}}_t}{dt}}{\frac{dLn[\tilde{c}_t]}{dt}} = \frac{\dot{g}}{g} \approx -v \qquad (23)$$

Hence, in this case, convergence speed represents the change in the growth rate of consumption.

Although the equation $-v \cdot (Ln[\tilde{c}_t] - Ln[\tilde{c}_{ss}])$ is linear, it is still in differential equation form. In order to solve this differential equation, we define $z_t = Ln[\tilde{c}_t]$ and $b = v \cdot Ln[\tilde{c}_{ss}]$ therefore we obtain $\dot{z}_t = -v \cdot z_t + b$. Then, we use integrating factor method to solve the equation. The starting point is to multiply both sides by $e^{v \cdot t}$.

$$\dot{z}_t + v \cdot z_t = b \Rightarrow$$

$$(\dot{z}_t + v \cdot z_t) \cdot e^{v \cdot t} = b \cdot e^{v \cdot t} \Rightarrow$$

$$\dot{z}_t \cdot e^{v \cdot t} + v \cdot z_t \cdot e^{v \cdot t} = b \cdot e^{v \cdot t} \Rightarrow$$

$$\frac{d}{dt}(z_t \cdot e^{v \cdot t}) = b \cdot e^{v \cdot t} \Rightarrow$$

$$\int d[z_t \cdot e^{v \cdot t}] = \int b \cdot e^{v \cdot t} \cdot dt \Rightarrow$$

$$z_t \cdot e^{v \cdot t} = \frac{b}{v} \cdot e^{v \cdot t} + constant \Rightarrow$$

$$z_t = \frac{b}{v} + const \cdot e^{-v \cdot t} \Rightarrow$$

$$Ln[\tilde{c}_t] = \frac{v \cdot (Ln[\tilde{c}_{ss}])}{v} + const \cdot e^{-v \cdot t} \Rightarrow$$

$$Ln[\tilde{c}_t] = \big[Ln[\tilde{c}_{ss}]\big] + const \cdot e^{-v \cdot t} \qquad (24)$$

For t=0, the above equation gives the value of *const* from the $Ln[\tilde{c}_0] = Ln[\tilde{c}_{ss}] + const$. In other word, $Ln[\tilde{c}_0] - Ln[\tilde{c}_{ss}] = const$.

$$Ln[\tilde{c}_t] = Ln[\tilde{c}_{ss}] + (Ln[\tilde{c}_0] - Ln[\tilde{c}_{ss}]) \cdot e^{-v \cdot t} \Rightarrow$$

$$Ln[\tilde{c}_t] = Ln[\tilde{c}_0] \cdot e^{-v \cdot t} + (1 - e^{-v \cdot t}) \cdot Ln[\tilde{c}_{ss}] \Rightarrow$$

$$Ln[\tilde{c}_t] - Ln[\tilde{c}_0] = -Ln[\tilde{c}_0] + Ln[\tilde{c}_0] \cdot e^{-v \cdot t} + (1 - e^{-v \cdot t}) \cdot Ln[\tilde{c}_{ss}]$$

$$Ln[\tilde{c}_t] - Ln[\tilde{c}_0] = -(1 - e^{-v \cdot t}) \cdot Ln[\tilde{c}_0] + (1 - e^{-v \cdot t}) \cdot Ln[\tilde{c}_{ss}] \qquad (25)$$

Following Islam (1995), let us suppose initial time is $t = t_1$. In this case the equation becomes:

$$Ln\big[\tilde{c}_{t_1}\big] = Ln[\tilde{c}_{ss}] + const \cdot e^{-v \cdot t_1} \Rightarrow$$

$$const = \big\{Ln\big[\tilde{c}_{t_1}\big] - Ln[\tilde{c}_{ss}]\big\} \cdot e^{v \cdot t_1} \qquad (26)$$

Then, we assume $t_2 > t_1$ and $\tau = t_2 - t_1$. The new version of the equation is as follow:

$$Ln\big[\tilde{c}_{t_2}\big] = Ln[\tilde{c}_{ss}] + const \cdot e^{-v \cdot t_2} \Rightarrow$$

$$Ln\big[\tilde{c}_{t_2}\big] = Ln[\tilde{c}_{ss}] + \big\{Ln\big[\tilde{c}_{t_1}\big] - Ln[\tilde{c}_{ss}]\big\} \cdot e^{v \cdot t_1} \cdot e^{-v \cdot t_2} \Rightarrow$$

$$Ln\big[\tilde{c}_{t_2}\big] = (1 - e^{-v \cdot \tau}) Ln[\tilde{c}_{ss}] + Ln\big[\tilde{c}_{t_1}\big] \cdot e^{-v \cdot \tau} \Rightarrow$$

$$Ln\big[\tilde{c}_{t_2}\big] - Ln\big[\tilde{c}_{t_1}\big] = -(1 - e^{-v \cdot \tau}) \cdot Ln\big[\tilde{c}_{t_1}\big] + (1 - e^{-v \cdot \tau}) Ln[\tilde{c}_{ss}] \qquad (27)$$

Equation (27) is the solution of the linearized differential equation. However, the variable of “consumption per effective capita” $\tilde{c}_t$ and it’s initial and steady state values are variables whose usage is not meaningful in practice. “The consumption per capita" variable c_t is more suitable variable for economic analysis. Therefore, it is necessary to turn the equation into per capita consumption where $\tilde{c}_t = \frac{C_t}{A_t \cdot L_t}$, $\tilde{c}_{ss} = (1-s)\tilde{y}_{ss}$ and $\tilde{y}_{ss} = \left(\frac{s}{n+\delta+x}\right)^{\frac{\alpha}{1-\alpha}}$:

$$
\begin{aligned}
&Ln\left[\frac{C_{t_2}}{A_{t_2} \cdot L_{t_2}}\right] - Ln\left[\frac{C_{t_1}}{A_{t_1} \cdot L_{t_1}}\right] \\
&\qquad = -(1-e^{-v\cdot\tau}) \cdot Ln\left[\frac{C_{t_1}}{A_{t_1} \cdot L_{t_1}}\right] + (1-e^{-v\cdot\tau}) \\
&\qquad \cdot Ln\left[(1-\mathrm{s}) \cdot \left[\frac{s}{n+\delta+x}\right]^{\frac{\alpha}{1-\alpha}}\right] \Rightarrow
\end{aligned}
$$

$$
\begin{aligned}
&Ln\left[\frac{C_{t_2}}{L_{t_2}}\right] - Ln\left[\frac{C_{t_1}}{L_{t_1}}\right] - Ln(A_{t_2}) + Ln(A_{t_1}) \\
&\qquad = -(1-e^{-v\cdot\tau}) \cdot Ln\left[\frac{C_{t_1}}{L_{t_1}}\right] + (1-e^{-v\cdot\tau}) \cdot Ln(A_{t_1}) \\
&\qquad + (1-e^{-v\cdot\tau}) \cdot Ln\left[(1-\mathrm{s}) \cdot \left[\frac{s}{n+\delta+x}\right]^{\frac{\alpha}{1-\alpha}}\right]
\end{aligned}
\qquad (28)
$$

As A_t is defined as $A_t = A_0 \cdot e^{x \cdot t}$, then $A_{t_1} = A_0 \cdot e^{x \cdot t_1}$ and $A_{t_2} = A_{t_1} \cdot e^{x \cdot t_2}$. Let us put the former equation in its place within the latter equation, $A_{t_2} = A_0 \cdot e^{x \cdot t_1} \cdot e^{x \cdot t_2}$. At the end, we reach these equations: $Ln(A_{t_2}) = Ln(A_0) + x \cdot t_1 + x \cdot t_2$ and $Ln(A_{t_1}) = Ln(A_0) + x \cdot t_1$. By substituting the new equations, we can rewrite equation (28) as follow:

$$
\begin{aligned}
&Ln\left[\frac{C_{t_2}}{L_{t_2}}\right] - Ln\left[\frac{C_{t_1}}{L_{t_1}}\right] - x \cdot t_2 \\
&\qquad = -(1-e^{-v\cdot\tau}) \cdot Ln\left[\frac{C_{t_1}}{L_{t_1}}\right] + (1-e^{-v\cdot\tau}) \cdot [Ln(A_0) + x \cdot t_1] \\
&\qquad + (1-e^{-v\cdot\tau}) \cdot Ln(s)^{\frac{1}{1-\alpha}} - (1-e^{-v\cdot t}) \cdot Ln(n+\delta+x)^{\frac{\alpha}{1-\alpha}}
\end{aligned}
$$

$$\begin{aligned} Ln\left[\frac{C_{t_2}}{L_{t_2}}\right] - Ln\left[\frac{C_{t_1}}{L_{t_1}}\right] &= x \cdot t_2 - (1 - e^{-v\cdot\tau}) \cdot Ln\left[\frac{C_{t_1}}{L_{t_1}}\right] + (1 - e^{-v\cdot\tau}) \\ &\quad \cdot [Ln(A_0) + x \cdot t_1] + (1 - e^{-v\cdot\tau}) \cdot \frac{1}{1-\alpha} \cdot Ln[s] \\ &\quad - (1 - e^{-v\cdot\tau}) \cdot \frac{\alpha}{1-\alpha} \cdot Ln[n + \delta + x] \end{aligned} \tag{29}$$

If we consider as $\beta_0 = x \cdot (t_2 - e^{-v\cdot\tau} t_1) + (1 - e^{-v\cdot\tau}) \cdot Ln(A_0), \beta_1 = -(1 - e^{-v\cdot\tau}), \beta_2 = \frac{1}{1-\alpha} \cdot (1 - e^{-v\cdot\tau})$ and $\beta_3 = -\frac{\alpha}{1-\alpha} \cdot (1 - e^{-v\cdot\tau})$ the equation becomes as:

$$Ln[c_{t_2}] - Ln[c_{t_1}] = \beta_0 + \beta_1 \cdot Ln[c_{t_1}] + \beta_2 \cdot Ln[s] + \beta_3 \cdot Ln[n + \delta + x]$$

$$\begin{aligned} Ln[c_{i,t_2}] - Ln[c_{i,t_1}] &= \beta_0 + \beta_1 \cdot Ln[c_{i,t_1}] + \beta_2 \cdot Ln[s_{i,t_1-t_2}] + \beta_3 \cdot Ln[n_{i,t_1-t_2} + 5\%] \\ &\quad + \varepsilon_{it} \end{aligned} \tag{30}$$

Equation (30) will be estimated since this form is more suitable for dynamic panel data estimation.

CHAPTER 4: DATA AND METHODOLOGY

4.1 Data Collection and Descriptive Statistics

In order to estimate per capita consumption convergence equation derived in the previous section, equation (30), we utilize a panel data set of 156 countries over 50 years commencing in 1970. The estimations are implemented using the econometric software Stata.[4] The corresponding variables are real per capita consumption (c_{it}), real per capita income (gdp_{it}), population growth rate (n_{it}), and gross capital formation ($s_{K_{it}}$). The data are compiled from Penn World Table 10.0 database. They are not available on per capita basis so variables are divided by population for getting per capita level. Because of the incomplete data prior to 1970, countries that had complete data from 1970 to 2019 were used to study convergence in consumption.

Per capita consumption (c_{it}) stands for real consumption per capita which is calculated by dividing real consumption of households and government at constant 2017 national prices (in million 2017 US$) by population (in millions). Per capita income (gdp_{it}) stands for GDP per capita which is calculated by dividing real gross domestic product at constant 2017 national prices (in million 2017 US$) by population (in millions). Annual population growth rate (n_{it}) is computed by the following formula:

$$ln\left(pop_{i,t}\right) - \ln(pop_{i,t-1}) \qquad (31)$$

Additionally, the formula is augmented by 0.05, and then multiplied by 100. Mankiw, Romer, and Weil (1992) posit 0.05 as a plausible assessment of the value of the depreciation rate and the technological growth rate ($\delta + x$) since these variables are time and country invariant variables. Caselli, Esquivel, and Lefort (1996) try as an alternative measure 0.07 instead of 0.05 and there was not a substantive difference in results. Hence, we follow MRW (1992) in opting for 0.05. The last explanatory variable is the saving rate ($s_{K_{it}}$) and share of gross capital formation at current purchasing power parities expressed in percentage is used as a proxy of it. Because all variables are expressed in constant purchasing power parity (PPP) dollars (in real

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[4] Useful Stata commands that are run for the estimations are presented in the appendix part for interested readers.

terms), there is no necessity for deflating them. Moreover, expressing GDP per capita and consumption per capita at current purchasing power parities provides an elimination of the price level differences among countries.

Considering the convergence equation in equation (30), we used all variables in natural logarithm because the standard deviation of per capita consumption and per capita income is higher than the other variables in the dataset. Table 1 tabulates the descriptive statistics of the logarithmic form of the variables, their three-year average between 1970 and 2019. Given Islam (1995), computing three-year averages is so important to avoid serial correlation problem, and to exclude business cycles fluctuations and short-term shocks. Taking three-, four-, or five-year averages, namely the span-data approach, has been successfully implemented in the convergence literature (Islam, 1995; Caselli et al., 1996; Bond et al., 2001, Bonnefond, 2014). Using time intervals is also important for the one of the system GMM conditions which requires that cross sectional dimension must be larger than the time dimension (N>T). Implementing three-year span data on 50 years yields 16 time points. Therefore, the ultimate dataset involves 156 countries and 16 time points, which is in line with N>T condition of the system GMM methodology.

Table 1 reports descriptive statistics of variables. In these results, the summary statistics are calculated separately by income groups. The differences in the mean and spread of the data for each income group can be easily detected. The standard deviation indicates how much the data deviate from the mean. A higher standard deviation value implies more spread in the data. For example, the highest standard deviation of consumption per capita belongs to the upper middle-income sample, 0.725. Most of the observations for the upper middle-income sample are more widely spread than for other income groups. Moreover, the high-income sample has the highest mean of consumption per capita and the least variation among countries in terms of consumption. Most of the observations for the high-income sample have the highest mean among other income groups.

Table 1. Descriptive statistics of data (in natural logarithm form)

	Variable	Obs	Mean	Std. Dev.	Min	Max
Global Sample	Ln ($c_{i,t}$)	2,623	8.722	1.155	5.499	11.285
	Ln ($gdp_{i,t}$)	2,623	8.948	1.280	5.622	12.192
	Ln ($s_{K_{it}}$)	2,623	2.950	0.565	0.021	5.129
	Ln ($c_{i,t-\tau}$)	2,468	8.696	1.153	5.499	11.284
	Ln (n_{it})	2,622	6.879	1.542	– .575	22.226
High-Income Countries	Ln ($c_{i,t}$)	935	9.891	.560	8.015	11.284
	Ln ($gdp_{i,t}$)	935	10.225	.722	7.852	12.192
	Ln ($s_{K_{it}}$)	935	3.251	.360	1.603	5.129
	Ln ($c_{i,t-\tau}$)	880	9.866	.563	8.015	11.285
	Ln (n_{it})	935	6.428	1.978	-.575	22.226
Upper Middle-Income Countries	Ln ($c_{i,t}$)	646	8.721	.725	5.787	9.958
	Ln ($gdp_{i,t}$)	646	8.965	.721	5.664	10.640
	Ln ($s_{K_{it}}$)	646	2.931	.459	.0208	4.065
	Ln ($c_{i,t-\tau}$)	608	8.689	.720	5.787	9.958
	Ln (n_{it})	646	6.697	1.223	.875	12.547
Lower Middle-Income Countries	Ln ($c_{i,t}$)	646	7.922	.580	6.344	9.285
	Ln ($gdp_{i,t}$)	646	8.069	.623	6.303	9.489
	Ln ($s_{K_{it}}$)	646	2.830	.611	.783	4.516
	Ln ($c_{i,t-\tau}$)	608	7.890	.568	6.344	9.264
	Ln (n_{it})	646	7.279	.998	2.388	15.589
Low-Income Countries	Ln ($c_{i,t}$)	396	7.269	.561	5.498	8.728
	Ln ($gdp_{i,t}$)	396	7.339	.658	5.622	9.436
	Ln ($s_{K_{it}}$)	396	2.461	.618	.517	3.823
	Ln ($c_{i,t-\tau}$)	372	7.254	.566	5.499	8.728
	Ln (n_{it})	395	7.593	1.071	-.052	12.427

After presenting the descriptive statistics of the variables, we can now investigate convergence behavior in consumption. The simplest way to examine convergence behavior in consumption is to plot the initial level of per capita consumption (consumption level in 1970) against the average growth rate of per capita consumption over the period. An exploration of Figure 2 suggests a weak negative relationship between the initial level of per capita consumption and the average growth rate of per capita consumption for spanning the world from 1970 to 2019.

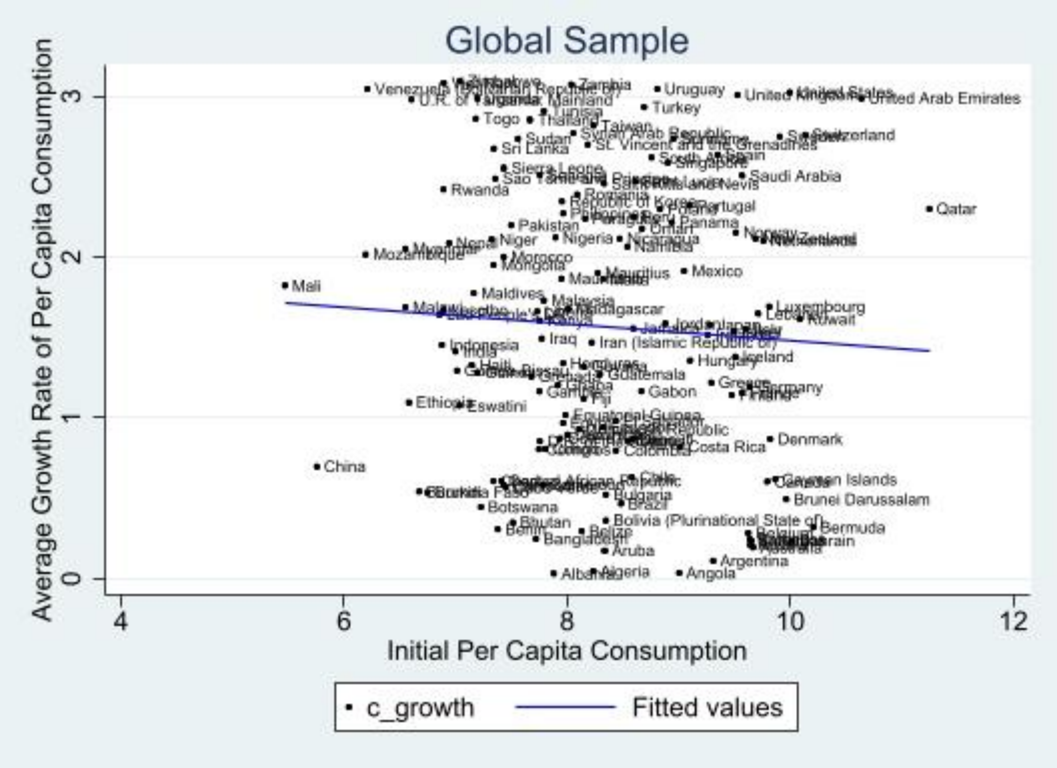

Figure 2. Unconditional convergence in consumption for the global sample

The slightly downward sloping line in figure 2 represents a possible convergence in consumption within the global sample. The reason of slightly downward sloping can be attributed to the fact that the global sample includes countries heterogeneous in many senses, such as income, saving rate, population growth rate. For example, there are 56 high-income countries while there are 24 low-income countries. Economic theory suggests that countries homogenous in economic fundamentals would show a stronger convergence behavior. A clear example of this argumentation is Figure 3 below, which presents the initial consumption level against the average growth rate of consumption for high-income countries.

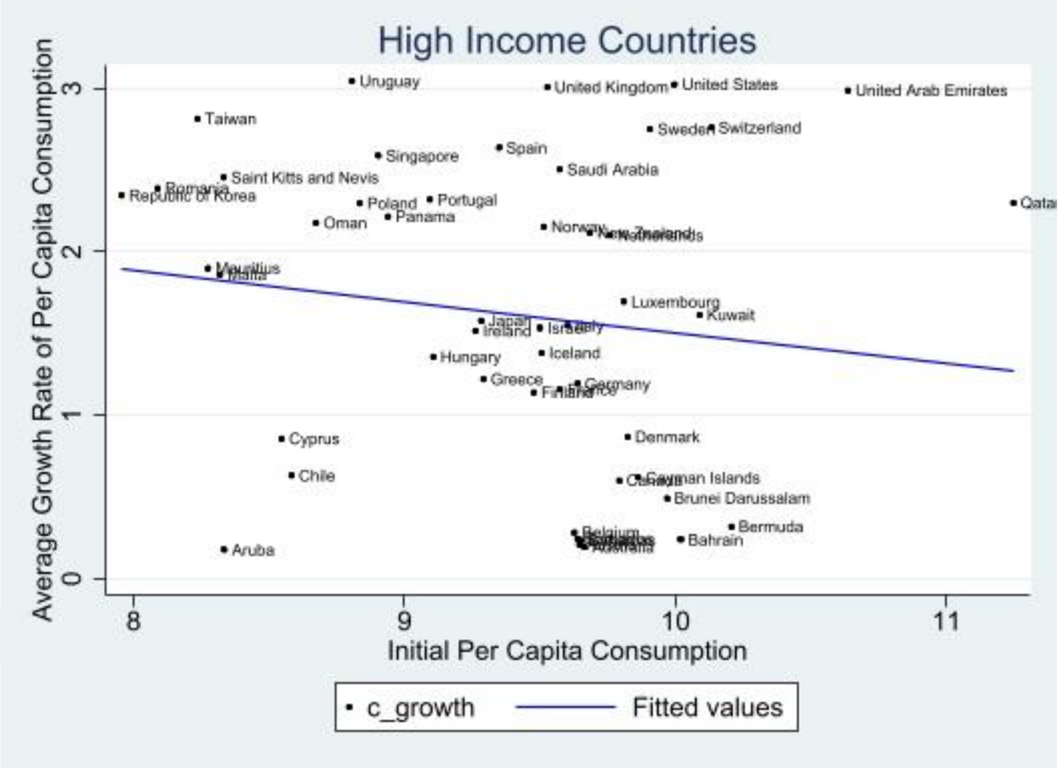

Figure 3. Unconditional convergence in consumption for the high-income sample

As can be seen from figure 3, slope of the simple regression line between the initial consumption level against the average growth rate of consumption of high-income countries is steeper than the global sample, cf., figure 2. This result is consistent with the literature presuming that countries similar in fundamentals would converge more strongly (in income or consumption).

Figure 4 exhibits the simple regression of the low-income countries. Unsurprisingly, it is upwardly sloping, as these countries are less homogenous in economic fundamentals.

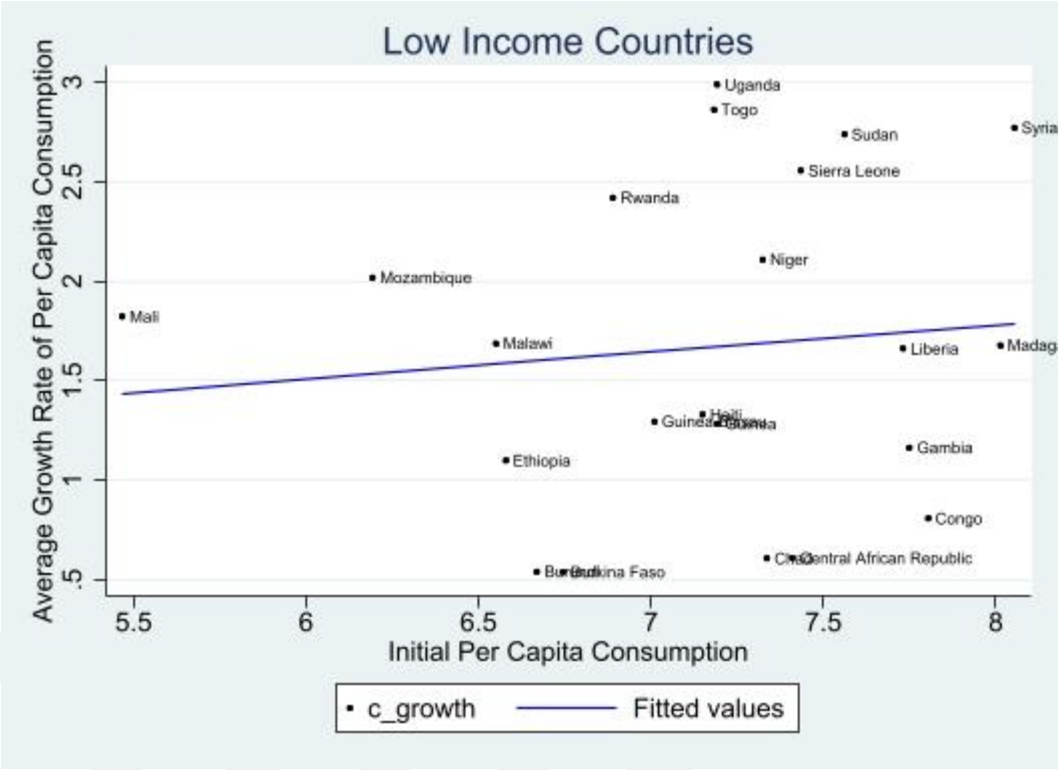

Figure 4. Unconditional convergence in consumption for the low-income sample

Simple regression analyses of initial consumption level against the average growth rate of consumption for various income groups and the global sample, one can argue that consumption convergence may be expected in more homogenous country groups and even for the global sample. In section 5, we will present rigorous analyses (system GMM estimations) a more detailed assessment and we will show that there exists consumption convergence in homogenous countries.

4.2 Panel Data Analysis

Panel data also named longitudinal data is composed of pooling of observations on a cross-sectional dimension as well as time dimension (Baltagi, 2013). Basically, panel data involves both cross-section and time-variant data at the same time, which provides the use of all available informative data. Hence, panel data analysis is a statistical method which is commonly applied to analyze two-dimensional data generally sourced over time and over the same cross-sections. A regression can be carried out on these two dimensions.

The first advantage of panel data analysis is that it takes into account of individual heterogeneity as opposed to pooled OLS. By including dummies for all i's into the regression, panel data controls for the unobserved heterogeneity across countries (u_i). As a second advantage, panel data enables us to analyze changes over time. Then, it decreases the collinearity problem which occurs when variables have a high correlation with each other. Collinearity between variables might give rise to exaggeration within the variance of at least one estimated regression coefficient. Also, it might cause some regression coefficients to have a reverse sign. Lastly, panel data analysis provides more degree of freedom as an advantage.

Due to the advantages mentioned above, using panel data analysis rather than pooled OLS is reasonable since it provides less collinearity, more degree of freedom, elimination of individual heterogeneity, etc. General form of pooled OLS which does not take into consideration of individual heterogeneity:

$$y_{it} = \beta_0 + \beta x_{it} + \varepsilon_{it} \tag{32}$$

On the contrary, panel model usually takes into account of individual heterogeneity by dividing the error term into two terms:

$$\varepsilon_{it} = u_i + v_{it} \tag{33}$$

where u_i is a time constant observable or unobservable individual specific effect and v_{it} is idiosyncratic term. General linear panel data model:

$$y_{it} = \beta_0 + \beta x_{it} + u_i + v_{it} \tag{34}$$

OLS ignores time constant observable or unobservable individual-specific effects within u_i since it assumes that that variation across countries is random and uncorrelated with the regressors ($Cov(u_i|x_{it}) = 0$). This is a significant lack of OLS because it is biased and inconsistent ($Cov(u_i|x_{it}) \neq 0$). If differences across countries are suspected to have some effects on the dependent variable, then a random effect model (also called random intercept or partial pooling model) should be applied. Random effect is a weighted average of the estimates produced by the between and within estimators. In order to determine which model (pooled OLS or random effect model) should be applied to the panel data, we utilize Breusch and Pagan Lagrangian multiplier test for random effects. Considering Breusch and Pagan Lagrangian multiplier test results, if p-value is significant then we have to proceed with panel data analysis, which means the rejection of the null hypothesis that indicates no variation and indifferent variances. In other words, this demonstrates the acceptance of the alternative hypothesis which indicates the presence of a panel effect. On the other hand, differently from random-effects model, fixed effects model assumes that time-invariant properties of countries are certainly collinear with time dummies of countries. Fixed effects model examines the reasons for changes within a country. Therefore, the model transforms variables by taking their time averages. A variable's all values in the sample period are gathered and divided by the number of years.

$$\bar{y}_{it} = \beta\bar{x}_{it} + u_i + \bar{v}_{it} \qquad (35)$$

If we differentiate the equation, u_i disappears.

$$\bar{y}_{it} - \bar{y}_{it-1} = \beta(\bar{x}_{it} - \bar{x}_{it-1}) + u_i - u_i + \bar{v}_{it} - \bar{v}_{it-1} \qquad (36)$$

The model checks overall time-constant differences between the countries. It is always consistent under the alternative hypothesis $H_a\colon Cov(U_\mathrm{i}, X_{it}) \neq 0$ whereas it is less efficient under the null hypothesis $H_0\colon Cov(U_\mathrm{i}, X_{it}) = 0$ which reflects neglecting of variation across units.

While making decision between fixed effects model and random effects model, we should utilize Hausman and Taylor’s specification test. Hausman and Taylor’s specification test accepts the null hypothesis indicating the consistency of random effects model when p-value of the test is greater than 0.05. The test rejects the null hypothesis (H_0) and accepts the alternative hypothesis indicating the consistency of fixed effects model when p-value is lower than 0.05.

4.3 System GMM Approach

The GMM methods (first-difference and system GMM) have become prevalent in the growth literature over the last decades (Bond et al., 2001; Caselli et al., 1996; Hoeffler, 2002; Islam, 1995). As mentioned in the previous section, there exist conventional panel-data estimators, namely panel OLS, within-groups or between-groups and random effects estimators, they suffer particularly from dynamic panel bias. To exemplify, OLS estimation produce upwardly biased coefficients with country-specific (fixed) effects that are constant over time (Hsiao, 1986), and within-groups results in highly downwardly biased coefficients in short panels (Judson and Owen, 1999; Nickell, 1981). The reliable and consistent parameters estimated with OLS levels and within-groups can be considered as lower and upper bounds, respectively (Blundell and Bond, 1998). GMM estimators are beneficial not only due to addressing dynamic panel bias but also due to having superior finite sample properties in addressing fixed effects and endogeneity of regressors (Bond et al., 2001).

In a dynamic panel model, the GMM methods provide control for the endogeneity of the lagged response variable. Endogeneity broadly means that independent variables are correlated with the error term in a model (Wooldridge, 2009). In other words, the independent variables are not completely exogenous, which denotes that they have correlation with possibly current accruement of the error term and past events. Correlation between independent variables and the error term can emerge not only because of endogeneity but also because of an unobserved or omitted variables' confounding effect on both explanatory and response variables. However, the GMM methods control for omitted variables bias and unobserved panel heterogeneity. Assume the linear regression model with an endogenous regressor:

$$y = X'\beta + u \qquad (37)$$

where y and u are $N\ x\ 1$ vectors, β is a $K\ x\ 1$ vector of unknown parameters and X is a $N\ x\ K$ matrix of explanatory variables. By reason of the assumption of endogeneity, we assume that there is a $N\ x\ L$ matrix Z where L is greater than K. The Z matrix is assumed to involve a set of variables that are highly correlated with X but orthogonal to u (i.e., a set of valid instruments). Being orthogonal refers to being statistically independent.

In GMM framework, N, which represents number of cross-sections or groups must be greater than T, which represents time span. On the other hand, GMM exploits instrumental variable (IV) estimation. However, number of instruments (Z) must be equal to or lower than number of groups (N). Finally, instruments (Z) must be exogenous which can be demonstrated by $E(Z'u) = 0$.

First- difference GMM corrects endogeneity by transforming all variables in the dynamic panel data model into first differences. By taking first difference, it removes unobserved, country-specific effects and omitted variable bias. Additionally, it supports to eliminate arbitrarily distributed fixed effects. The initial model of the difference GMM:

$$lnY_{it} = \beta_1 lnY_{it-1} + \beta_2 X'_{it} + (u_i + v_{it}) \quad (38)$$

By first differencing, the regressors are transformed and the fixed effect is eliminated. However, the problem of endogeneity still continues even if the regressors do not vary with time anymore. The transformed model of difference GMM:

$$\Delta lnY_{it} = \beta_1 \Delta lnY_{it-1} + \beta_2 \Delta X'_{it} + \Delta v_{it} \quad (39)$$

$$\Delta\varepsilon_{it} = \Delta u_i + \Delta v_{it}$$

$$\varepsilon_{it} - \varepsilon_{it-1} = (u_i - u_i) + (v_{it} - v_{it-1}) = \Delta v_{it} \quad (40)$$

Now, unobserved fixed effects are subtracted from the equation since they are invariant between periods by assumption. [$E(u_{i,t}\, u_{i,s}) = 0$ for $t \neq s$,]. Also, the first-differenced lagged response variable is instrumented with its previous levels and now alterations in the response variable are assumed to be represented by equation (39).

In order to estimate convergence of per capita consumption, we exploit System Generalized Method of Moments (henceforth, system GMM) which is coined by Arellano and Bover (1995), and Blundell and Bond (1998). System GMM corrects endogeneity by introducing more instruments to dramatically improve efficiency of estimator. It also transforms the instruments to make them uncorrelated (exogenous) with the fixed effects. It removes the average of all future existing observations of a variable rather than removing the previous observation from the present one. It reduces data loss even if you have many gaps in your data because it can be easily computed for all observations excepting the final one for each individual (Arellano and Bond, 1991). The initial model of system GMM:

$$lnY_{it} = \beta_1 lnY_{it-1} + \beta_2 X'_{it} + (u_i + v_{it}) \quad (41)$$

Assume this equation is a random walk model and Y is persistent. If time period is short, the implementation of the difference GMM estimator probably will generate insufficient and biased estimation of β_1 in finite samples because of poor performance of the difference GMM attributed to the use of poor instruments (Blundell and Bond, 1998). The approach involves the exploitation of a larger number of instruments (moment conditions). However, on the basis of Monte Carlo evidence, if the time period is short and the response variable is persistent, the small sample bias is attenuated thanks to gain in precession.

In the presence of heteroscedasticity and serial correlation, a two-step system GMM estimator should be used by generating a weighting matrix using residuals from the first step. However, in finite samples such standard errors are prone to be downward biased and the conventional approach by practitioners in such circumstances is to use what is known as the Windmeijer adjustment to correct for such small sample bias.

According to the rule-of-thumb recommended by Bond (2001), pooled OLS and the LSDV approach (i.e., using the 'within' or fixed effects approach) should be used in the beginning in order to estimate the dynamic model. The fixed effects estimation for β_1 should be classified as a lower-bound estimate, while the pooled OLS estimation should be regarded as an upper-bound estimate. In the case of the difference GMM estimation close to or below the fixed effects estimation, the previous estimation is downward biased for sure owing to weak instrumentation. Hence, one should opt for a system GMM estimator instead of the difference GMM estimator.

J test (Hansen, 1982) and Sargan's test (Sargan, 1985) examine the null hypotheses of the overall validity of the instruments used in GMM. Therefore, the tests are reliable controls of over-identifying restrictions. If rejection of these null hypotheses cannot be attained, the choice of the instruments is supported.

The second characteristic of GMM is the value of AR (2). The AR (2) value examines the null hypothesis which indicates no second-order serial autocorrelation of the error terms. If the value of AR (2) is bigger than 0.05, we are unable to reject the null hypothesis. Hence, we attain correctly specified moment conditions and the serially uncorrelated error term.

CHAPTER 5: EMPIRICAL RESULTS

The main purpose of this thesis is to elucidate whether countries have become similar in their volume of consumption over the past 50 years, and to explore the speed and mechanism of this convergence. To this end, we will run three dynamic panel equations. Before beginning, some of the assumptions we make need to be mentioned. First of all, in all the estimates below, we assume that the per capita consumption of the previous period was predetermined. GDP per capita and the saving rate are being treated as endogenous since they are likely to be correlated with consumption per capita. In the light of theoretical and empirical evidences, the saving rate and the per capita consumption level are assumed to be straightly related to the level of income. However, there is no strict consensus on whether the population growth rate should be treated as exogenous or endogenous. There are studies in the literature that accept both the exogenous population growth rate and the endogenous population growth rate. In the Solovian framework, the population growth rate and the saving rate are accepted as exogenous as we have done during the derivation of consumption convergence model. However, we accept the saving rate as endogenous while estimating models. We estimate two regressions; one with the endogenous population growth rate and one with the exogenous population growth rate. Then, we compare which regression gives better results. Additionally, all endogenous variables are instrumented with their appropriate lagged values. This helps to eliminate the problem of the endogeneity of the set of explanatory variables. By including dummy variables of years in all regressions, worldwide shocks that are likely to affect the behavior of the variables are excluded.

In order to measure unconditional and conditional convergence in per capita consumption the three dynamic panel equations mentioned earlier will be estimated. These equations are as follows:

$$Ln\left[c_{t_2}\right] = \beta_0 + \beta_1 \cdot Ln\left[c_{t_1}\right] \qquad (42)$$

$$Ln\left[c_{t_2}\right] = \beta_0 + \beta_1 \cdot Ln\left[c_{t_1}\right] + \beta_2 \cdot Ln[s] + \beta_3 \cdot Ln[n + \delta + x] \qquad (43)$$

$$Ln\left[c_{t_2}\right] = \beta_0 + \beta_1 \cdot Ln\left[c_{t_1}\right] + \beta_2 \cdot Ln[s] + \beta_3 \cdot Ln[n + \delta + x] + \beta_4 \cdot \ln(gdp_{it}) \tag{44}$$

The left-hand side (hereafter, LHS) of the equations $Ln\left[c_{t_2}\right]$ is the 3-year average of per capita consumption in natural logarithm form. Determinants of convergence in per capita consumption take place on the right-hand side (hereafter, RHS). β_1 is the coefficient for previous 3-year span per capita consumption in natural logarithm form, $Ln\left[c_{t_1}\right]$. This coefficient is theoretically expected to be higher than 0 and lower than 1, which would be consistent with the concept of convergence. The coefficient of the saving rate β_2 is the natural logarithm of share of gross capital formation at current purchasing power parities expressed in percentages. This coefficient is theoretically expected to be positive. β_3 is the coefficient for the population growth rate augmented by 5%, and expressed in percentage. This coefficient is theoretically expected to be negative. Lastly β_4 is the coefficient for GDP per capita in logarithm form and it is expected to be positive.

Equation (42) in logarithmic form implies absolute (unconditional) convergence if the coefficient β_1 is lower than 1 and greater than zero. This implies that a 1% difference in per capita consumption from the lowest level of consumption within the previous period would lead to a difference of less than 1% in the current period. The concept of absolute convergence signifies that countries have become relatively similar in terms of per capita consumption over time. For example, one-step system GMM results of 3-year span data for the global sample for the period 1970-2019 are presented in Table 2. The first column shows whether unconditional convergence exists. As can be seen, estimated β_1 is statistically significant at 1% level and it is greater than 1, which indicates unconditional divergence in consumption. A one percent difference from the lowest consumption level in the previous period leads to a 1.12 percent difference from the lowest consumption level in the current period. The concept of unconditional (absolute) divergence signifies that countries have become relatively dissimilar in terms of per capita consumption over time.

Table 2. One-step system GMM estimations for the global sample (1970 – 2019)

	Global Sample				
	(1)	(2)		(3)	
Ln $(c_{i,t-\tau})$	1.120*** (.055)	.970*** (.018)	1.022*** (.028)	.810*** (.083)	.795*** (.088)
Ln $(s_{K_{it}})$		.084*** (.030)	.116*** (.017)	.055** (.027)	.089** (.038)
Ln $(n_{it}+x+\delta)$		-.016 (.025)	-.002 (.006)	-.024* (.013)	-.014*** (.005)
Ln (gdp_{it})				.155** (.076)	.169** (.083)
Constant	-1.030** (.504)	.176 (.343)	-.483* (.280)	.334* (.183)	.148 (.153)
Implied Convergence Rate	-0.0378	0.0101	-0.0072	0.0702	0.0766
# of groups	156	156	156	156	156
# of instruments	19	28	33	36	32
F-test					
AR (1) test	0.000	0.000	0.000	0.000	0.000
AR (2) test	0.342	0.468	0.484	0.376	0.482
Hansen-stat	0.672	0.526	0.550	0.525	0.322
Diff – Hansen-stat	0.379	0.250	0.401	0.150	0.108

Note. The superscripts ***, ** and * denote the significance at 1%, 5% and 10% level, respectively.

Secondly, we obtain equation (43) by adding the saving rate and the population growth rate augmented by 5% into equation (42). Then, we test conditional convergence in per capita consumption by estimating equation (43). The estimated coefficient of the saving rate is statistically significant at 1% level and positive. However, the estimated coefficient of $Ln(n_{it}+x+\delta)$ is statistically insignificant and has a negative sign. The positive sign of the saving rate is consistent with the economic theory. Economic theory claims that consumption and saving rate are positively related while consumption and augmented population growth rate are negatively related. The second column of Table 2 is divided into two. In the first one, the population growth rate is included in the regression, assuming it is endogenous. In the second one, it is included in the regression, assuming it is exogenous. There exists a consumption convergence across the global sample at the speed of 0.0101 when the population growth rate is accepted as endogenous. However, there exists a consumption divergence across the global sample with the speed of 0.0072 when the population growth rate is taken as exogenous. In both cases, the estimated coefficient of the population growth rate is insignificant. When the population growth rate changes from endogenous to exogenous, the value of its coefficient decreases from 0.016 to 0.002. The coefficient of the saving rate increases from 0.084 to 0.116 although the significance level does not change.

Finally, we test equation (44), which includes the control variable GDP per capita in logarithmic form. The third column of Table 2 is divided into two. The first one shows the results with the endogenous population growth rate. The second one indicates the results with the exogenous population growth rate. The inclusion of GDP per capita variable into the model contributed more to the consumption convergence speed in both cases compared to previous runs. The speed of consumption convergence increases from 0.0101 to 0.0702, considering the endogenous population growth rate. The speed of convergence increases from 0.0702 to 0.0766 when the exogenous population growth rate is considered. The significance level of the estimated coefficient of the population growth rate improves from 10% to 5% even though the value of its coefficient decreases from 0.024 to 0.014. The second advantage of taking the population growth rate as exogenous is that the value of the coefficient of the saving rate increases from 0.055 to 0.089. The significance level of its coefficient remains same at 5%. Similarly, the estimated coefficient of GDP per capita increases from 0.155 to 0.169 at the same significance level, 5%. One can conclude that the inclusion of GDP per capita contributes significantly to the convergence in consumption for the global sample in both cases. As it is theoretically and empirically asserted, per capita consumption is positively correlated with per capita income (Blandford, 1984; Connor, 1994). Our results are consistent with this argument.

To sum up, even though there is a consumption divergence in the unconditional regression for the global sample, there exists a consumption convergence in conditional runs. This indicates that the fundamentals (the saving rate and the population growth rate augmented by 5%) are substantially different among the global sample. Particularly, considering the population growth rate as exogenous and endogenous separately yields different results. It is observed that taking the population growth rate as exogenous generates more efficient results. Moreover, the highest consumption convergence speed is observed when income per capita added into the regression as a control variable.

The consistency of the system GMM estimators is ensured by testing the identifying assumption that whether the past values of the response and the explanatory variables are valid instruments in the three regressions. In order to test this assumption, we draw upon the standard Hansen test for over-identifying restrictions. The null hypothesis of this test assumes that the instrumental variables are not correlated with the residual. To fail to reject this hypothesis strengthens the choice of the instruments. As seen in Table 2, the p-values associated with the null hypothesis for all estimations take a place in the acceptance region. Hence, we are unable to reject the fact that the instrumental variables are uncorrelated with the residual. In other words, there is no correlation between the instrumental variables and the error term.

Furthermore, the consistency of the estimations for the global sample is ensured by controlling whether there is serial autocorrelation in the error terms. In this case, we exploit Arellano-Bond test. The null hypothesis of this test assumes that there is no $\tau -$ order serial autocorrelation in the error terms. The p-values of AR (2) presented in the eleventh row of Table 2 are in the acceptance region of the null hypothesis.

Another important issue to check the consistency of the estimates is to test the validity of additional moment conditions. The test used for controlling this validity is Difference-in-Hansen test. The thirteenth row of Table 2 involving the p-values of Difference-in-Hansen test reports that the null hypothesis is accepted. In other words, the validity of the additional moment conditions is satisfied for the three regressions.

The last point of controlling the consistency is to control the rule of thumb which requires that the number of instruments is smaller than or equal to the number of groups. We have 156 countries for the number of groups and the number of instruments varies from 19 to 38. Therefore, this rule is satisfied for the three regressions of the global sample. Consequently, all test results confirm robustness and consistency of the system GMM estimators in terms of the expected signs and the significance levels of the lagged dependent variable and the validity of instruments set.

However, the global sample results look like erratic because of the heterogeneous dispersion of countries within the sample. Therefore, we have grouped countries according to their income levels based upon World Bank country classification. Accordingly, the countries are decomposed into four groups as high income, upper middle-income, lower middle-income, and low-income countries. Table 3 reports one-step system GMM estimations of 3-year span data for the high-income countries for the period 1970-2019. Contrary to the unconditional divergence regression result of the global sample, unconditional consumption convergence is observed for the high-income countries. Also, a remarkable implied convergence speed, about 0.0296, is observed. The inclusion of the saving rate and the population growth rate decreases the implied convergence speed from 0.0296 to 0.0227 when the population growth rate is accepted as endogenous. On the other hand, considering the population growth rate as exogenous generates the implied convergence speed as 0.0263; this rate is faster than the result under the endogenous population growth rate, even though the speed is still smaller than the unconditional regression. In the conditional regression, the estimated coefficient of the saving rate is significant at 1% significance level regardless of whether the population growth rate is exogenous or endogenous. Although the change is rather thin, the positive effect of its coefficient increases from 0.162 to 0.167. On the other hand, the significance level of the estimated coefficient of the population growth rate switched from 5% to 1%. Importantly, the negative effect of its coefficient increases from 0.016 to 0.107.

Table 3. One-step system GMM estimations for the high-income sample (1970 – 2019)

High-Income Countries					
	(1)	(2)		(3)	
Ln ($c_{i,t-\tau}$)	.915*** (.034)	.934*** (.028)	.926*** (.028)	.686*** (.058)	.663*** (.051)
Ln ($s_{K_{it}}$)		.162*** (.040)	.167*** (.039)	.100*** (.025)	.104*** (.028)
Ln ($n_{it} + x + \delta$)		-.016** (.007)	-.107*** (.003)	-.015** (.008)	-.019*** (.005)
Ln (gdp_{it})				.178*** (.053)	.211*** (.056)
Constant	.901** (.348)	.289 (.306)	.318 (.320)	1.081*** (.293)	.984*** (.338)
Implied Convergence Rate	0.0296	0.0227	0.0263	0.1256	0.1370
# of groups	56	56	56	56	56
# of instruments	19	25	23	28	26
F-test					
AR (1) test	0.000	0.000	0.000	0.001	0.001
AR (2) test	0.547	0.898	0.963	0.673	0.599
Hansen-stat	0.412	0.126	0.182	0.393	0.308

Table 3 (continued). One-step system GMM estimations for the high-income sample (1970 – 2019)

Diff – Hansen-stat	0.804	0.228	0.357	0.491	0.122

Note. The superscripts ***, ** and * denote the significance at 1%, 5% and 10% level, respectively.

Finally, the inclusion of GDP per capita makes a noticeable contribution to the convergence speed. Considering the population growth rate as endogenous, the contribution is approximately 0.1256. Considering the population growth rate as exogenous, the contribution is approximately 0.1370. As seen in the third column of Table 3, again, the significance level of the population growth rate improves from 5% to 1% and the negative effect of its coefficient increases slightly from 0.015 to 0.019. Similarly, the significance level of the saving rate remains same at 1% but the positive effect of its coefficient increases slightly from 0.1 to 0.104 when the population growth rate is taken as exogenous. Consequently, the saving rate and the population growth rate have a retarding effect on convergence process in consumption for the high-income sample. On the other hand, GDP per capita has an accelerator effect on convergence process in consumption for the high-income sample. These results are valid in both cases whether the population growth rate is exogenous or endogenous. It is obviously seen that the more efficient results are obtained while accepting the population growth rate as exogenous.

The consistency of the system GMM estimators for the high-income sample is robust and proven by the Hansen test. The Hansen test results show that there is no correlation between the instrumental variables and the residual. The instruments used in all three regressions are valid. Moreover, the Difference-in-Hansen test indicates that the validity of the additional moment conditions is satisfied for all three regressions. The Arellano-Bond test also confirms that there is no second order serial autocorrelation in the error terms, as can be seen at the thirteenth column of Table 3. Lastly, the rule of thumb is satisfied since we have 56 high income countries for the number of groups while the number of instruments ranges from 19 to 28.

Table 4. One-step system GMM estimations for the upper middle-income sample (1970 – 2019)

	Upper Middle-Income Countries				
	(1)	(2)		(3)	
Ln $(c_{i,t-\tau})$	.801*** (.160)	.844*** (.092)	.833*** (.153)	.748*** (.073)	.735*** (.080)
Ln $(s_{K_{it}})$		.107** (.043)	.076** (.031)	.090** (.039)	.089** (.043)
Ln $(n_{it} + x + \delta)$		.011 (.027)	-.012* (.007)	-.008 (.010)	-.025*** (.007)
Ln (gdp_{it})				.251*** (.070)	.237*** (.069)
Constant	1.768 (1.338)	1.009 (.766)	1.360 (1.277)	-.193 (.555)	.169 (.475)
Implied Convergence Rate	0.0740	0.0565	0.0609	0.0968	0.1026
# of groups	38	38	38	38	38
# of instruments	31	36	29	28	29
F-test					
AR (1) test	0.019	0.007	0.023	0.009	0.008
AR (2) test	0.147	0.113	0.109	0.111	0.101
Hansen-stat	0.142	0.319	0.107	0.695	0.273
Diff – Hansen-stat	0.168	0.365	0.351	0.770	0.600

Note. The superscripts ***, ** and * denote the significance at 1%, 5% and 10% level, respectively.

Table 4 displays one-step system GMM estimations of 3-year span data for the upper middle-income sample for the period 1970–2019. As observed in the first column, the estimated coefficient of the lagged dependent variable is statistically significant at 1% and it is between 0 and 1, which signifies unconditional convergence in consumption. The implied convergence rate is 0.074 and it is greater than the implied convergence rate of the high-income sample, 0.0296. The interpretation of this can be attributed to the assumption of the neoclassical growth model, that countries relatively farther from their steady-state level will experience acceleration in growth. Put it differently, the convergence rate of the upper middle-income being higher makes sense since they are relatively farther from their steady-state level compared to the high-income countries that are closer their steady-state level. However, the consistency of the unconditional convergence regression should be questioned. There is no first-order serial correlation in the error terms at 1% significance level, which is required. As presented in the tenth row of Table 4, the AR (1) test has a p-value of

0.019. This represents significance at 5% significance level and so the consistency of the test is still valid. There is no second-order serial correlation in the error terms as the p-value of AR (2) indicates. The p-values of both the Hansen test and the Difference-in-Hansen test are in the acceptance region of the null hypothesis. These results came out as intended. Despite the insignificance of AR (1) test at 1%, the consistency of the system GMM estimators for the unconditional convergence regression is still valid owing to the significance at 5%.

In the second column, the saving rate and the population growth rate are included into the model. The inclusion of the saving rate and the population growth rate decreases the implied convergence rate from 0.074 to 0.0565 in the regression with the endogenous population growth rate. The inclusion of the saving rate and the population growth rate decreases the implied convergence rate from 0.074 to 0.061 in the regression with the exogenous population growth rate. Similar results emerged in the high-income sample. The estimated coefficient of the saving rate is statistically significant at 5% level in both cases. However, the impact of its coefficient declines from 0.107 to 0.076 in the regression where the population growth rate is accepted as exogenous. Moreover, the estimated coefficient of the population growth rate becomes significant at 1%, and its sign changes from positive to negative. Although it seems that the results of the regression where the population growth rate is considered as exogenous are more efficient, AR (1) test has a p-value of 0.023, which implies insignificance at 1%. Therefore, one can conclude that it is more reasonable for regression #2 to consider the population growth rate as endogenous.

The last variable included into the model is GDP per capita. Adding GDP per capita makes a noticeable difference by contributing an increase in the implied convergence rate. The estimated coefficient of GDP per capita is statistically significant at 1% and positive. However, taking the population growth rate as exogenous causes the impact of the coefficient of GDP per capita to decrease from 0.0251 to 0.0237. Similarly, the estimated coefficient of the saving rate is statistically significant at 1% and positive but the value of its coefficient decreases slightly with the assumption of exogenous population growth rate. As can be seen in the third column of Table 4, assuming the population growth rate as exogenous generates more efficient estimation results. The consistency tests of both regressions (performed for the upper middle-income sample) are provided by Arellano-Bond test, Hansen J test, and Difference-in-Hansen test. All tests' p-values are in the acceptance region of the null hypothesis, which depicts the robustness of the estimators.

Table 5. One-step system GMM estimations for the lower middle-income sample (1970 – 2019)

Lower Middle-Income Countries					
	(1)	(2)		(3)	
Ln $(c_{i,t-\tau})$	1.04*** (.034)	.965*** (.036)	1.041*** (.034)	.778*** (.077)	.778*** (.103)
Ln $(s_{K_{it}})$		.049* (.025)	.046** (.020)	.013 (.042)	.0144 (.035)
Ln $(n_{it} + x + \delta)$		-.008 (.020)	-.018* (.011)	-.035*** (.012)	-.016** (.007)
Ln (gdp_{it})				.174** (.084)	.189** (.085)
Constant	-.225 (.280)	.315 (.301)	-.223 (.312)	.667** (.306)	.408 (.260)
Implied Convergence Rate	- 0.0131	0.0119	-0.0134	0.0837	0.0837
# of groups	38	38	38	38	38
# of instruments	24	34	37	28	32
F-test					
AR (1) test	0.004	0.003	0.007	0.009	0.009
AR (2) test	0.173	0.192	0.202	0.204	0.217
Hansen-stat	0.454	0.138	0.139	0.220	0.405
Diff – Hansen-stat	0.342	0.123	0.484	0.213	0.136

Note. The superscripts ***, ** and * denote the significance at 1%, 5% and 10% level, respectively.

As we move to the lower middle-income countries sample, differently from the previous estimates performed for the high-income and the upper middle-income countries cases, the coefficient of the lagged dependent variable is statistically significant at 1% significance level but it is greater than 1, which signifies unconditional divergence in consumption. As presented in Table 5, the lower middle-income countries are unconditionally diverging in terms of consumption at the pace of 0.0131. This situation affirms our hypothesis that higher income levels lead countries to converge at higher rates. The inclusion of the saving rate and the population growth rate yields different results based upon the choice between the exogenous and the endogenous population growth rate. When the endogenous population growth rate is accepted, there exists a consumption convergence at a rate of 0.0119. In this regression, the estimated coefficient of the saving rate is statistically significant at 10% and positive. However, the estimated coefficient of the population growth rate is not statistically significant. On the other hand, accepting the population growth rate as exogenous causes a conditional divergence in consumption at a rate of 0.0131. In this regression, the estimated coefficient of the population growth rate becomes significant at 10%. Also, the significance of the saving rate increases from 10% to 5%.

Lastly, the inclusion of GDP per capita results in consumption convergence for the lower middle-income countries. The implied rate of convergence is 0.0837 and it does not change no matter how the population growth rate is accepted, exogenous or endogenous. The estimated coefficient of GDP per capita is statistically significant at 5% and positive in both cases. The estimated coefficient of the saving rate is insignificant in both cases. Differently for this time, the significance of the estimated coefficient of the population growth rate is better in the endogenous regression. As a result, one might conclude that increasing in GDP per capita will have a positive effect on convergence process in consumption level of the lower middle-income countries explicitly. The rule of thumb is satisfied since the number of groups is 38 and the number of instruments ranges from 24 to 37. There is no second-order serial autocorrelation in the error terms as AR (2) test indicated. The validity of the instruments is satisfied by the Hansen test. The validity of additional moment conditions is satisfied by the Difference-in-Hansen test. Therefore, the consistency of system GMM estimators for the lower middle-income countries is robust and valid.

The last income group we examine whether there is a convergence in consumption is the low-income countries. In the first column of Table 6, it is clearly seen that there exists an absolute divergence in consumption with the highest implied divergence rate of 0.0188. It means that the low-income countries are unconditionally diverging in terms of consumption at a rate of 0.0188. The estimation is consistent as the tests' p-values show. The Hansen test depicts that the instruments used are valid. Difference in Hansen test confirms the validity of the additional moment conditions. AR (1) test result is significant at 5% significance level. The number of groups is higher than the number of instruments. As a result, the unconditional regression for the low-income countries is robust and consistent.

Table 6. One-step system GMM estimations for the low-income sample (1970 – 2019)

Low-Income Countries					
	(1)	(2)		(3)	
Ln $(c_{i,t-\tau})$	1.058*** (.110)	1.080*** (.154)	.826*** (.129)	.953** (.409)	.514* (.262)
Ln $(s_{K_{it}})$		.048 (.058)	.064 (.053)	-.064 (.055)	-.0244 (.043)
Ln $(n_{it}+x+\delta)$		.030 (.021)	.025* (.013)	-.070 (.066)	.022** (.009)
Ln (gdp_{it})				.050 (.298)	.322 (.190)
Constant	-.404 (.820)	-.920 (1.352)	.961 (1.068)	.698 (1.345)	1.112 (.739)
Implied Convergence Rate	- 0.0188	- 0.0256	0.0637	0.0160	0.2218
# of groups	24	24	24	24	24
# of instruments	21	22	21	24	23
F-test					
AR (1) test	0.012	0.010	0.009	0.065	0.105
AR (2) test	0.103	0.112	0.121	0.167	0.134
Hansen-stat	0.498	0.177	0.611	0.971	0.608
Diff – Hansen-stat	0.736	0.177	0.611	0.971	0.608

Note. The superscripts ***, ** and * denote the significance at 1%, 5% and 10% level, respectively.

In the second column of Table 6, the saving rate and the population growth rate are included into the model. The estimated coefficient of the lagged dependent variable is significant at 1% and higher than 1, which indicates a consumption divergence at a rate of 0.0256 in the regression with the endogenous population growth rate. However, the estimated coefficients of the saving rate and the population growth rate is not significant at any significance level. The coefficient of the population growth rate is positive. According to the Solovian framework, this coefficient is supposed to be negative. Even though remaining tests are in the acceptance region of the null hypothesis, AR (1) is in the rejection region of the null hypothesis at 1%. When the population growth rate is considered as exogenous, the first change is in the coefficient of the lagged dependent variable. The coefficient becomes smaller than 1, which represents a consumption convergence at a rate of 0.0637. The second change is in the coefficient of the population growth rate. The coefficient becomes significant at 10% but the value of it decreases from 0.03 to 0.025. The last change is in the AR (1) test, which becomes significant at 1%. Accepting the population growth rate as exogenous provides more effective results than accepting it as endogenous. The consistency of both models is doubtful since the expected signs and significance levels are not at the values we aim to achieve.

In the third column of Table 6, GDP per capita is included into the model. However, all three explanatory variables are not significant in the regression with the endogenous population growth rate. Only the coefficient of the lagged variable is significant at 5%. The number of groups is equal to the number of instruments. AR (1) test is significant at 10%, which lessens the consistency of the model. Moreover, the coefficient of the saving rate is negative, which does not comply with the Solovian framework. Although the coefficient of the population growth rate becomes significant at 5%, the coefficient of the lagged variable becomes significant at 1% in the model with the exogenous population growth rate. AR (1) test shows that the model is not robust and consistent. One can conclude that the regression 3 cannot explain the convergence process very well. This can be attributed to that the low-income countries allocate an average of 95.38% of their income to consumption. This proportion is quite high. Hence, capital accumulation occurs very little since the marginal propensity to save is quite low. Low-income countries do not fall under the category of consumerist society.

CHAPTER 6: CONCLUSION

Economic theory suggests that the further (closer) countries are from (to) its long run equilibrium value of income per capita, the higher (the slower) growth rate of per capita income due to the law of diminishing returns applies to physical capital for given other factors of production. A natural extension of the law is for a group of countries similar in 'fundamentals': the per capita income of similar countries will converge to each other in the long run. In this direction, we argue that convergence in consumption would be possible due to the law of diminishing marginal utility. Under the assumptions of identical consumer utility function and homogenous time preference, the countries further from their steady state values of consumption per capita will grow faster than those closer to their steady states. Unlike the existing literature on the subject, which studies the issue at product level data collected for a country or for country clubs, we have studied the issue by using macro level data. For this reason, we draw upon the dynamic panel data approach to construct the empirical analyses since unobserved country-specific effects can be eliminated by this approach.

This thesis has concentrated on the convergence in per capita consumption across the globe. For the sake of consistency, the income groups have been separately studied as well. Convergence equation obtained in the theoretical part were tested empirically by using one-step system GMM approach on a panel data set consisting of 156 countries over the period inclusive 1970 to 2019. We have estimated both absolute (unconditional) and conditional convergence in accordance with the economic growth literature following Islam (1995). The empirical results of the thesis reveal strong evidence towards an unconditional convergence in per capita consumption for the high-income countries and the upper middle-income countries within their own income groups. However, we found no unconditional convergence for the global sample. Probably, the reason of this is income differences. Additionally, there is no unconditional convergence for the lower middle-income and low-income samples as well. Conditional consumption convergence has been observed for all of the four groups after including income per capita into the model even though the results for the low-income sample are not consistent due to the violation of the related validity tests. Moreover, we have also observed that the implied rate of convergence for the upper middle-income sample is considerably higher than that of the high-income sample.

This is an indicator of that a 1% percent difference in per capita consumption in the previous period yields a 0.915% difference for the high-income countries while a 0.801% difference for the upper middle-income countries. It can be inferred that the initial value of consumption is inversely related to the growth rate of consumption. The impact of the saving rate and the population growth rate (even accepted as exogenous and endogenous separately) is slightly retarding of the implied convergence rate for the both income groups. The main finding of the thesis suggests that including income per capita into the model make a catalyzer effect on the implied convergence rate of the high income and the upper middle-income countries. Moreover, adding income per capita has led to a conditional convergence in consumption for the global, low income, and lower middle-income countries. The absence of second order serial autocorrelation and the validity of instruments have been satisfied. So, our results are robust and consistent as the validity tests indicate. As a conclusion, our policy implication is that income should be equally redistributed, which has a valuable effect on the increase in the speed of consumption convergence. In other words, increase in income leads countries to converge in consumption per capita at faster rate. For this purpose, population planning and savings incentive policies will improve countries in terms of consumption. Also, policies that foster redistribution of income and discourage rising poverty should be supported. If consumption convergence does occur at a high rate, this would increase welfare of household. It would prompt efficient reallocation of human welfare.

This study contributes to the literature in two-fold. First, we develop a novel theoretical framework for consumption convergence by extending the standard income convergence model. This provides an intriguing and conceptually testable empirical model for consumption convergence. Second, to best of the authors’ knowledge, this is the first study that investigates the aggregate consumption convergence on a global scale along with a long period of time inclusive 1970 to 2019. This period is quite long and, to best of the authors' knowledge, there is no study covering such a long period while focusing on consumption convergence theory.

Finally, this thesis reveals opportunities for future studies of consumption convergence. For example, in order to improve this thesis results, one could estimate the models with more control variables such as openness and income inequality index etc. According to Williamson (1996), the open economy forces such as trade cause to decrease in commodity prices so countries that have high trade barriers are less likely to be a part of the convergence in income. We argue that this is same for consumption convergence. Therefore, testing the impact of openness on consumption convergence could be useful for corroborating this assumption.

REFERENCES

Aizenman, J. and Brooks, E. (2008). *Globalization and Taste Convergence: the Cases of Wine and Beer.* Review of International Economics, 16(2), 217-233.

Arellano, M. and Bond, S. (1991). *Some tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations.* Review of Economic Studies, 277-297.

Baltagi, B. H. (2005). *Econometric Analysis of Panel Data (Third Edition b.).* England: John Wiley & Sons, Ltd.

Barro, R. J., Sala-I-Martin, X., Blanchard, J. O. and Hall, R. E. (1991). *Convergence Across States and Regions.* Brookings Papers on Economic Activity, 1991(1), 107-182.

Blandford, D. (1984). *Changes in food consumption patterns in the OECD area.* European Review of Agricultural Economics, 11(1), 43-65.

Blundell, R. and Bond, S. (1998). *Initial conditions and moment restrictions in dynamic panel data models.* Journal of Econometrics, 115-143.

Buongiorno, J. (2009). *International trends in forest products consumption: is there convergence?* International Forestry Review(11(4)), 490-500.

Carruth, A., Gibson, H. and Tsakalotos, E. (1999). *Are Aggregate Consumption Relationships Similar Across the European Union?* Regional Studies(33:1), 17-26.

Caselli, F., Esquivel, G. and Lefort, F. (1996). *Reopening the Convergece Debate: A New Look at Cross-Country Growth Empirics.* Journal of Economic Growth, 363-389.

De Mooij, M. (2003). *Convergence and divergence in consumer behaviour: implications for global advertising.* International Journal of Advertising, 22:2, 183-202.

De Mooij, M. and Hofstede, G. (2002). *Convergence and divergence in consumer behavior: implications for international retailing.* Journal of Retailing(78), 61-69.

Dholakia, U. M. and Talukdar, D. (2004). *How Social Influence Affects Consumption Trends in Emerging Markets: An Empirical Investigation of the Consumption Convergence Hypothesis.* Psychology and Marketing, Vol. 21(10), 775-797.

Elsner, K. and Monika, H. (1998). *Convergence of food consumption patterns between Eastern and Western Europe.* Discussion Paper(No. 13), 3-43.

Gil, J. M., Gracia, A. and Pérez y Pérez, L. (1995). *Food consumption and economic development in the European Union.* Europen Review of Agricultural Economics(22 (1995)), 385-399.

Goldberg, P. K. and Verboven, F. (2005). *Market integration and convergence to the Law of One Price: evidence from the European car market.* Journal of International Economics(65), 49-73.

Gracia, A. and Albisu, L. M. (2001). *Food Consumption in the European Union: Main Determinants and Country Differences.* Agribusiness, Vol. 17 (4), 469-488.

Herrmann, R. and Röder, C. (1995). *Does food consumption converge internationally? Measurement, empirical tests and determinants.* European Review of Agricultural Economics(22 (1995)), 400-414.

Holmes, A. and Anderson, K. (2017). *Convergence in National Alcohol Consumption Patterns: New Global Indicators.* Journal of Wine Economics, 12(2), 117-148.

Islam, N. (1995). *Growth Empirics: A Panel Data Approach.* The Quarterly Journal of Economics, 1128-1170.

Judson, R. A. and Owen, A. L. (1999). *Estimating dynamic panel data models a guide for macroeconomists.* Economics Letters, 9-15.

Kónya, I. and Ohashi, H. (2007). *International Consumption Patterns among High-income Countries: Evidence from the OECD Data.* Review of International Economics, 15(4), 744-757.

Meng, M., Payne, J. E. and Lee, J. (2013). *Convergence in per capita energy use among OECD countries.* Energy Economics(36), 536-545.

Michail, N. A. (2020). *Convergence of consumption patterns in the European Union.* Empirical Economics(58), 979-994.

Mohammadi, H. and Ram, R. (2012). *Cross-country convergence in energy and electricity consumption, 1971-2007.* Energy Economics(34), 1882-1887.

Nickell, S. (1981). *Biases in Dynamic Models with Fixed Effects.* Econometrica, 49(6), 1417-1426.

Roodman, D. (2009). *How to do xtabond2: An introduction to difference and system GMM in Stata.* The Stata Journal(Number 1), pp.86-136.

Smith, D., Solgaard, H. and Beckmann, S. (1999). *Changes and trends in alcohol consumption patterns in Europe.* Journal of Consumer Studies & Home Economics(23(4)), 247 - 260.

Waheeduzzaman, A. N. (2011). *Are Emerging Markets Catching Up With the Developed Markets in Terms of Consumption?* Journal of Global Marketing(24:2), 136-151.

Wan, G. H. (2005). *Convergence in food consumption in Rural China: Evidence from household survey data.* China Economic Review(16), 90-102.

Williamson, J. G. (1996). *Globalization, Convergence, and History.* The Journal of Economic History, Vol. 56(No. 2), 277-306.

Wooldridge, J. M. (2001). *Applications of Generalized Method of Moments Estimation.* Journal of Economic Perspectives, Volume 15(Number 4), 87-100.

Wooldridge, J. M. (2009). *Introductory Econometrics: A Modern Approach (Fourth ed.). Australia: South-Western.* Journal of Economic Perspectives, Volume 15(Number 4), p.87-100.

APPENDICES

Appendix A – Description of Variables

Appendix A offers a detailed description of all the variables used in the thesis.

$\ln(c_{i,t})$: Natural logarithm of real per capita consumption. It is calculated through dividing real consumption of households and government at constant 2017 national prices (in million 2017 US$) by population (in millions). It is defined as *“lnc”* in Stata.

$\ln(c_{i,t-\tau})$: Natural logarithm of average real per capita consumption for the previous three years. It is calculated by the command of l.lnc through Stata. It is labelled as *“l_lnc”*.

$\ln(gdp_{it})$: Natural logarithm of real per capita income. It is calculated through dividing real gross domestic product at constant 2017 national prices (in million 2017 US$) by population (in millions). It is defined as *“lngdp”* in Stata.

$\ln(s_{K_{it}})$: Natural logarithms of gross capital formation. It stands for the saving rate and it is calculated through multiplying share of gross capital formation at constant purchasing power parities expressed in percentages. It is defined as *“lns”* in Stata.

$\ln(n_{it} + x + \delta)$: Natural logarithm of the population growth rate augmented by 0.05 representing technology growth rate and the depreciation rate. It is defined as *“lnxd”* in Stata.

Appendix B – Stata Commands

Appendix B presents commands of estimations performed in the thesis.

```
gen c = rconna/pop
gen gdp = rgdpna/pop
gen s = csh_i * 100
gen lnc = ln(c)
gen lngdp = ln(gdp)
gen lns = ln(s)
egen id = group(country)
xtset id year
gen lnpop = ln(pop)
gen l_lnpop = l.lnpop
gen xd = lnpop – l_lnpop
gen aug_xd = xd + 5
gen xd2 = aug_xd * 100
drop if year < 1970
egen ig = group(incomegroup)
gen period = floor ((year – 1970) / 3)
collapse id ig lnc lns lngdp xd, by (country period)
sort id period
gen p0=(period==0)
gen p1=(period==1)
```

```
gen p2=(period==2)

gen p3=(period==3)

gen p4=(period==4)

gen p5=(period==5)

gen p6=(period==6)

gen p7=(period==7)

gen p8=(period==8)

gen p9=(period==9)

gen p10=(period==10)

gen p11=(period==11)

gen p12=(period==12)

gen p13=(period==13)

gen p14=(period==14)

gen p15=(period==15)

gen p16=(period==16)

tsset id period

xtabond2 lnc l.lnc p0-p16, gmm (l.lnc, lag (2 3) collapse equation(both)) iv (p0-p16, eq(both)) robust small ar (3)
```

Appendix C – List of Countries

C.1. List of countries included in the global sample

Albania
Algeria
Angola
Antigua and Barbuda
Argentina
Aruba
Australia
Austria
Bahamas
Bahrain
Bangladesh
Barbados
Belgium
Belize
Benin
Bermuda
Bhutan
Bolivia (Plurinational State of)
Botswana
Brazil
British Virgin Islands
Brunei Darussalam
Bulgaria
Burkina Faso
Burundi
Cabo Verde
Cambodia
Cameroon
Canada
Cayman Islands
Central African Republic
Chad
Chile
China
China, Hong Kong SAR
China, Maoao SAR
Colombia
Comoros
Congo
Costa Rica
Côte d'Ivoire
Cyprus
D.R. of the Congo
Denmark
Djibouti
Dominica
Dominican Republic
Ecuador
Egypt
El Salvador
Equatorial Guinea
Eswatini
Ethiopia
Fiji
Finland
France
Gabon
Gambia
Germany
Ghana
Greece
Grenada
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hungary
Iceland
India
Indonesia
Iran (Islamic Republic of)
Iraq
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kenya
Kuwait
Lao People’s DR
Lebanon
Lesotho
Liberia
Luxembourg
Madagascar
Malawi
Malaysia
Maldives
Mali
Malta
Mauritania
Mauritius
Mexico
Mongolia
Morocco
Mozambique
Myanmar
Namibia
Nepal
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
Norway
Oman
Pakistan
Panama
Paraguay
Peru
Philippines
Poland
Portugal
Qatar
Republic of Korea
Romania
Rwanda
Saint Kitts and Nevis
Saint Lucia
Sao Tome and Principe
Saudi Arabia
Senegal
Seychelles
Sierra Leone
Singapore
South Africa
Spain
Sri Lanka
St. Vincent and the Grenadines
Sudan
Suriname
Sweden
Switzerland
Syrian Arab Republic
Taiwan
Tajikistan
Thailand
Togo
Trinidad and Tobago
Tunisia
Turkey
Turks and Caicos Islands
U.R. of Tanzania: Mainland
Uganda
United Arab Emirates
United Kingdom
United States
Uruguay
Venezuela (Bolivarian Republic of)
Viet Nam
Yemen
Zambia
Zimbabwe

C.2. List of countries included in the high-income sample

Antigua and Barbuda	France	Portugal
Aruba	Germany	Qatar
Australia	Greece	Republic of Korea
Austria	Hungary	Romania
Bahamas	Iceland	Saint Kitts and Nevis
Bahrain	Ireland	Saudi Arabia
Barbados	Israel	Seychelles
Belgium	Italy	Singapore
Bermuda	Japan	Spain
British Virgin Islands	Kuwait	Sweden
Brunei Darussalam	Luxembourg	Switzerland
Cayman Islands	Malta	Taiwan
Canada	Mauritius	Trinidad and Tobago
Chile	Netherlands	Turks and Caicos Islands
China, Hong Kong SAR	New Zealand	United Arab Emirates
China, Maoao SAR	Norway	United Kingdom
Cyprus	Oman	United States
Denmark	Panama	Uruguay
Finland	Poland	

C.3. List of countries included in the low-income sample

Burkina Faso	Guinea-Bissau	Rwanda
Burundi	Haiti	Sierra Leone
Central African Republic	Liberia	Sudan
Chad	Madagascar	Syrian Arab Republic
Congo	Malawi	Tajikistan
Ethiopia	Mali	Togo
Gambia	Mozambique	Uganda
Guinea	Niger	Yemen

C.4. List of countries included in the lower middle-income sample

Algeria	Egypt	Nepal
Angola	El Salvador	Nicaragua
Bangladesh	Eswatini	Nigeria
Benin	Ghana	Pakistan
Bhutan	Honduras	Philippines
Bolivia (Plurinational State of)	India	Sao Tome and Principe
Cabo Verde	Kenya	Senegal
Cambodia	Lesotho	Sri Lanka
Cameroon	Lao People’s DR	Tunisia
Comoros	Mauritania	U.R. of Tanzania: Mainland
Côte d'Ivoire	Mongolia	Zambia
D.R. of the Congo	Morocco	Zimbabwe
Djibouti	Myanmar	

C.5. List of countries included in the upper middle-income sample

Albania	Fiji	Mexico
Argentina	Gabon	Namibia
Belize	Grenada	Paraguay
Botswana	Guatemala	Peru
Brazil	Guyana	Saint Lucia
Bulgaria	Indonesia	South Africa
China	Iran (Islamic Republic of)	St. Vincent and the Grenadines
Colombia	Iraq	Suriname
Costa Rica	Jamaica	Thailand
Dominica	Jordan	Turkey
Dominican Republic	Lebanon	Venezuela (Bolivarian Republic of)
Ecuador	Malaysia	Viet Nam
Equatorial Guinea	Maldives	