THE ROLE OF FINANCIAL EFFICIENCY ON ECONOMIC CONVERGENCE IN EMERGING MARKETS

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THE ROLE OF FINANCIAL EFFICIENCY ON ECONOMIC CONVERGENCE IN EMERGING MARKETS

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ABSTRACT

THE ROLE OF FINANCIAL EFFICIENCY ON ECONOMIC CONVERGENCE IN EMERGING MARKETS

Göğebakan, Kemal Çağlar

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In this thesis, the role of financial efficiency on economic convergence is analyzed theoretically and empirically. In the first theoretical chapter, Solow framework is used to investigate the role of financial efficiency on economic growth. In this chapter, it is shown theoretically that, the effect of efficient financial sector on economic convergence is positive. In the second theoretical chapter, the same research question is investigated using the Ramsey framework. To our knowledge, there is no study on the role of financial efficiency on economic convergence in the Ramsey framework. In that respect, this chapter makes a significant contribution to the literature. In the third theoretical chapter, what we call Solovianized Romer model is presented and financial efficiency-growth nexus is investigated within this framework. Solovianized Romer framework is a mixture of Solow framework and Romer (1990) model, one of the best-known endongenous growth models. This chapter makes use of theory to show that efficient financial sector has a positive effect on economic growth convergence. In the empirical chapter, the role of banking sector and stock market efficiency in economic growth is investigated by testing both Solow and Solovianized framework. Dynamic GMM panel data methods are used for 34 emerging countries over the period 1985-2010. Both Solow and Solovianized framework reveal a statistically significant and positive effect of both banking sector and stock market efficiency on economic growth. The results obtained are consistent with studies in the literature which indicate that efficient financial markets provide opportunities to provide for more efficient risk sharing, and to decrease information and transaction costs, and increase economic growth. These results are supported by the theoretical background.

Keywords: Economic growth, convergence, financial efficiency, banking sector efficiency, stock market efficiency, dynamic panel

ÖZET

GELİŞMEKTE OLAN PİYASALARDA FİNANSAL ETKİNLİĞİN EKONOMİK YAKINSAMA ÜZERİNDEKİ ROLÜ

Göğebakan, Kemal Çağlar

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Bu tezde finansal etkinliğin ekonomik yakınsama üzerindeki rolü teorik ve ampirik olarak incelenmiştir. İlk teorik bölümde, finansal etkinliğin ekonomik büyümenin yakınsaması üzerindeki rolü Solow yapısı kullanarak incelenmiştir. Bu bölümde teorik olarak finansal etkinliğin ekonomik yakınsama üzerinde pozitif bir etkisi olduğu gösterilmiştir. İkinci teorik bölümde aynı araştırma sorusu Ramsey yapısı kullanılarak incelenmiştir. Bildiğimiz kadarıyla, finansal etkinliğin ekonomik yakınsama üzerindeki etkisi Ramsey yapısında incelenmemiştir. Bu bağlamda, bu bölümün kendisi literatüre bir katkıdır. Üçüncü teorik bölümde is Solovianized Romer denilen model tanıtılmış ve bu yapıda finansal etkinlik incelenmiştir. Solovianized Romer yapısı Solow yapısıyla en iyi bilinen içsel büyüme modellerinden olan Romer (1990)'ın birleşimidir. Bu bölümde de teorik olarak finansal etkinliğin ekonomik büyüme üzerinde pozitif bir etkisi olduğu gösterilmiştir. Uygulama bölümünde ise bankacılık sektörünün ve hisse senedi piyasalarının etkinliğinin ekonomik büyüme üzerindeki etkisi Solow ve Solovianized Romer modeli test edilerek incelenmiştir. Ekonometrik analiz 34 gelişmekte olan piyasada 1985-2010 yılları arasında dinamik panel veri yöntemleri

kullanılarak gerçekleştirilmiştir. Hem Solow hem de Solovianized Romer modellerinde bankacılık sektörünün ve hisse senedi piyasalarının etkinliğinin ekonomik büyüme üzerinde anlamlı ve pozitif etkisi olduğu gözlemlenmiştir. Literatürdeki çalışmalarda etkin finansal piyasaların etkin bir şekilde risk paylaşımı yapılmasına olanak sağlayarak ve bilgi ve taşıma maliyetini azaltarak ekonomik büyümeyi desteklediği belirtilmektedir. Elde edilen bulgular literatürdeki çalışmalarla tutarlılık göstermektedir. Bulgular aynı zamanda teorik olarak da desteklenmiştir.

Anahtar Kelimeler: Ekonomik büyüme, yakınsama, finansal etkinlik, bankacılık sektörü etkinliği, hisse senedi piyasası etkinliği, dinamik panel

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CHAPTER 1

INTRODUCTION

In the literature of economic growth, studies about the role of financial system development and structure have long predominated. Researchers have been developing this field continuously since the middle of the 19^{th} century. However, there is still an ongoing debate about the relationship between economic growth and financial markets, which makes an important area for both empirical and theoretical research.

The functions of financial system play a crucial role in the relationship between financial markets and economic growth. Primarily, financial system provides the intermediary role between savers (investors) and borrowers (debtors). By this means, real services like improving the effects of enforcement, transaction and information costs are accomplished. It also enables the exchange of goods and services. Financial system development has impact on economic growth by information procurement in the investment selection process. This function helps to enhance the efficiency of capital distribution and risk management (diversification). The other roles of the financial markets are monitoring of investments and the enforcement of corporate governance. To sum up, these major services have considerable effect on savings and investment behavior, and accordingly on economic growth.

The research area which investigates the role of financial sector efficiency on economic growth dates back to the study of Bagehot (1873), who firstly demonstrated the relationship. He drew attention to the possibility that industrialization in England was a result of the use of the financial system to mobilize productive financial capital. Another early study, Schumpeter (1911, 1934) led the way for future studies by focusing on the role of banking system on economic growth. Since these early studies, numerous articles had been published about the relationship between the efficiency of the different parts in the financial system and economic growth. However, all of these theoretical and empirical studies support different views and presents different implications.

There are several extended studies and views in the literature. According to Al-Yousif (2002) these can be grouped in to four categories. The first is the "supply leading" view, which emphasizes the positive impact of financial system on economic growth. Proponents of this view state that financial intermediaries enhance information about firms and economic conditions, an essential function which contributes to the increased effectiveness of capital allocation and accumulation. In consequence, marginal productivity of capital increases. In addition, the private saving rate is influenced by financial efficiency, thus economic growth rate increases accordingly. Hicks (1969), McKinnon (1973), Shaw (1973), Greenwood and Jovanovic (1990) are leading studies supporting "supply leading" relationship in this growing research field.

In the mid 1900s, the second view has emerged, is named "demand-leading" which is firstly demonstrated by Joan Robinson. Robinson (1952) argued that "where enterprise leads, finance follows". Following this view, the current paper confends that the demand for efficiency in financial markets from the important sectors in the economy is responsible for the evolution of the financial sysyem. Patrick (1966), another supporter of "demand-leading" view, analyses the relationship showing that financial efficiency of the system is enhanced by high economic growth.[1]

A third group of researchers propose the bi-directional relationship between financial development and economic growth. Demetrias and Hussein (1997), and Greenwood and Smith (1997) are supporters of this view.[2] They propose that financial markets efficiency increases economic growth and that economic growth promotes the formation of new financial markets.

In total contrast, another group of researchers, notably Lucas (1988), denies any causal relationship between economic growth and financial development. According to Lucas (1988), financial system-economic growth relationship is "over-stressed".

In spite of the lack of a solid theory on financial deepening-economic convergence dozens of empirical works have been produced studying financial issues and economic growth. In addition to this absence of a widely accepted theoretical background, these empirical works suffer from another critical drawback, relating to a conflict between two strands of research. Recall that two interrelated empirical research strands have come out from the neoclassical growth theory. The first strand of empirical studies aimed to determine the sources of international differences in income per capita. The second strand investigated whether low-income economies grow faster than the high-income ones due to diminishing marginal returns, as the neoclassical growth theory conjectures. This argument has quickly become dubbed

[1] For another important study supporting this view, see Ireland (1994)
[2] For another important study supporting this view, see Luintel and Khan (1997)

convergence analysis. Extensive research began in this area after Mankiw, Romer and Weil (1992)'s development of an empirical framework to test for convergence.[3]

The objective of this thesis is to contribute to the existing literature by presenting a precise link between theory and measurement based on Mankiw, Romer and Weil (1992). A major problem of the studies in the literature is the absence of the link between the theory and empirical studies. In this thesis we aim to develop a concrete theoretical link to make empirical research more meaningful. We will construct theoretical models investigating the influence of financial efficiency on economic convergence utilizing the Solow, Ramsey and Solovianized Romer framework. To our knowledge, there is no study on the role of financial efficiency on economic convergence in Ramsey framework. In that respect, this chapter represents a contribution to the literature. The convergence equations that are obtained in the Solow and Solovianized Romer frameworks will be tested empirically to validate the models.

In addition to the theoretical contribution, this research adresses another unexplored area. While most researches focus on developed countries, his research analyzes the role of financial efficiency on economic growth in 34 emerging countries listed on International Monetary Fund and Standard's and Poor's Emerging Markets Database The analysis is carried out using the panel data method of System-GMM. The lack of stability in these countries means that it is important to discover whether financial markets development in these countries has an effect on economic growth convergence.

[3] Henceforth, we will use MRW (1992) instead of Mankiw, Romer and Weil (1992).

The following parts of this thesis are organized as follows. Chapter 2 gives a detailed literature survey of the relationship between financial system and economic growth, considering both theoretical and empirical views. Chapter 3 presents the fundamental growth frameworks of Solow, Ramsey and Romer which will be used in the following chapters. Chapter 4 discusses the role of financial efficiency on economic growth in Solovian framework by constructing a theoretical convergence model. In Chapter 5, the role of financial sector efficiency is discussed in Ramsey framework. What makes Ramsey framework interesting is that, in addition to financial efficiency variable, the resulting convergence equation relies on parameter values of preferences and production technology, rather than saving rate and population growth rate. In Chapter 6, financial efficiency is investigated within a framework known as the Solovianized Romer model recently developed by Bayraktar-Saglam and Yetkiner (2012). This innovative framework derives an empirically useful equation out of Romer (1990), in which technological progress in decomposed into its components. In Chapter 7, the role of financial efficiency on economic growth convergence is investigated for 34 emerging countries over the period 1985-2010 via dynamic panel GMM techniques. Chapter 8 concludes the thesis by discussing the results of both Solow and the Solovianized Romer framework and discusses some considerations for future research.

CHAPTER 2

LITERATURE REVIEW

There have been numerous studies in the literature on the relationship between economic growth and financial sector since the first crucial study of Bagehot in the last quarter of 1800. One of these, The Lombard Street (1873) focused on the role of finance and banking system in the industrialization period of England. This book points out that the efficient use of the financial system is indispensable in deploying productive financial capital. Schumpeter (1911, 1934) is also a touchstone in the literature, which revealed a pioneering vision of the influence of the financial system on economic development. In this thesis, it is stated that the more efficient the functioning of the financial system functions, the higher the growth rate during the transitional period, and the higher the steady state level of income per efficient capita. The financial sector helps to recognize, choose and cash up the entrepreneurs, ameliorate risk and mobilize savings for the aim of economic development.

In this section, the broad literature on finance-growth nexus is discussed. First, theoretical studies are discussed in a subsection. Next, the empirical literature is examined in detail and the development of the data measurement and analysis techniques are shown. This section also investigates macro and micro level studies on the finance-growth nexus. The lack of a fundamental consensus in the literature on several issues on growth-financial efficiency means the research field is open to new studies.

2.1. LITERATURE REVIEW OF THEORETICAL STUDIES

The essential studies in the literature began with the theoretical research aimed at explaining connections between the financial system mechanism and economic development. Levine (1997, 2005) presents an extended literature survey about the theoretical background in finance-growth nexus. Levine (1997) attributes the development of the various financial contracts, markets and institutions to transaction and information costs. According to this theoretical approach, the financial system has some fundamental roles in stimulating economic growth, which enables trading, hedging, diversifying, pooling of risk and allocating resources more efficiently. Levine (1997) identifies two channels to promote growth. One is capital accumulation, which can be efficiently achieved by the banking system, and the other is the changing the rate of technological innovation. Levine (2005) also divided the functions of financial system influencing economic growth into five basic categories in order to facilitate the investigation of the theoretical literature. These are producing information about possible investments and allocating capital in this direction; monitoring investments and exerting corporate governance; facilitating trading, diversification and managing risk; mobilizing and pooling savings, and finally, easing the exchange of goods and services.

In the one of the earlier studies, Gurley and Shaw (1955) pointed out that credit supply is affected by financial intermediaries rather than money supply. Thus, financial intermediaries improve the process of generating investments from savings. Consequently, efficiency in all economic activities is achieved. McKinnon (1973) and Shaw (1973) also presented theoretical studies, arguing that financial system efficiency plays an important role in generating positive economic growth and development. Countries with well-developed financial sectors allocate capital in an effective way, and hence achieve higher economic growth and levels of development.

Levine (2005) states that financial contracts, markets and institutions have a function of risk amendment, and expresses this function in terms of three subcategories: liquidity risk hedging, cross-sectional risk diversification and intertemporal risk sharing. Levine (2005) indicated that the liquidity and economic development have an effect on each other, since in general a long-run commitment of capital is required in order to generate a high-return from a project. However, savers are not willing to accept the management of their savings for long term. Besides, Levine (2005) emphasizes the fact that the aim of cross-sectional diversification of risk by the financial sector is to promote economic development through improving allocation of resources and influencing savings rates. In addition to these two risk amelioration functions, the financial system also enables inter-temporal risk sharing by lowering contracting costs which is carried out by financial intermediaries.

A milestone in the theoretical literature is Diamond and Dybvig (1983), which emphasizes the concept of liquidity risk. In this paper, investors are offered two investment project choices: one with high return with illiquidity risk and one with low return with liquidity. Some investors become exposed to the shocks following the selection of the projects and request to get their savings before the illiquid project produces. Since there is a risk of illiquidity and that information cost to observe shocks, low return and liquid projects are preferred in investment process. Diamond and Dybvig (1983) states that the cost of information induces the emergence of a financial system.

Levine (1991) developed an endogenous growth model which is based upon Diamond and Dybvig (1983) and constructed a context for the relationship between liquidity and economic growth. This paper took stock markets into account, showing that they promote growth. There are three observed reasons for this relationship. First, the period of production is not hindered while stocks of the companies are traded in the market. Also, there are opportunities for agents to perform portfolio diversification. Last but not least, not only information costs but also transaction costs are decreased by the efficient use of stock markets, and this enhances faster steady-state growth.[4]

Value is added to Diamond and Dybvig's theoretical model by Bencivenga and Smith (1991) by considering financial intermediary extension. This is achieved by developing an endogenous growth model, which indicates that the development of financial intermediaries affects the real growth rates by transferring the savings to capital. Under this system, the banks also remove the liquidity risk. Thus, savers prefer to invest in the high-return illiquid assets. In addition to this, intermediaries minimize unnecessary capital liquidation and, hence, tend to increase growth rates. According to Boyd and Prescott (1986), financial intermediaries are able to lessen the information cost and enhance the resource allocation. Allen (1990) also presents a model describing the advantages of financial intermediaries in the context of economic growth, showing that intermediaries procure information on firms and supply this information for investors.

Greenwood and Jovanovic (1990) have contributed to the theoretical literature by examining the relation between financial intermediaries and economic development.

[4] See also Bencivenga *et al*. (1995).

Their model emphasizes the scarcity of resources, therefore intermediaries are able to provide preferable information for companies about shocks, optimize the resource allocation and improve economic growth.[5] Furthermore, Bencivenga and Smith (1993) states that financial intermediaries develop corporate governance and reduce credit rationing, leading to higher productivity, capital accumulation and economic growth.

As stated above, another risk improvement of a financial system mentioned in Levine (2005) is cross-sectional risk diversification. Acemoğlu and Zilibotti (1997) presents an important theoretical model which deals with the relationship between cross sectional risk diversification and economic growth. They indicate that in financial systems, where firms and investors make portfolio diversification of projects, economic growth is achieved. The growth rate is enhanced by the efficient reallocation of savings toward high return investments. Another contribution to this relationship is represented by King and Levine (1993b) which focuses on innovative activities in the economy. It is stated that the financial markets which enable cross-sectional risk diversification allows investment in innovative activities, which in turn enhances economic growth.[6]Lastly, Levine (2005) covers the third type of risk amelioration function carried out by financial markets, which is inter-temporal risk sharing. Allen and Gale (1997) emphasizes the importance of financial intermediaries rather than financial markets, suggesting that financial intermediaries minimize the contracting costs enhancing the inter-temporal risk sharing, thus foster economic growth.

[5] See also Grossman and Stiglitz (1980)
[6] See also Acemoglu et al (2006)

A theoretical contribution on economic growth-stock market development is made by Devereux and Smith (1994) and Obstfeld (1994). Devereux and Smith (1994) shows that to influence economic growth in a positive way, stock markets should become integrated to other financial markets and institutions. This is because, these markets mitigate international risk, and this diversification enables a high return investment, and subsequently economic growth. In Obstfeld (1994), a continuous-time stochastic model is presented that explains the influence of international risk diversification on expected growth of the consumption. The relationship between international risk sharing and economic growth derives from the channeling of the global portfolio from safe low-return investment to riskier high-return investment. Levine (1997) shows that stock markets have the potential to affect growth positively by increasing liquidity and reducing investment risk.

Another model of Michael Pagano (1993) develops an endogenous economic growth model explains the growth rate change by the percentage of savings channels to investment. He uses the AK model, in which technology has constant-returns-to-scale (CRTS), productivity is increasing function and K is the composite of physical and human capital. Pagano defines $1-\theta$ the proportion which goes to banks as spread of lending-borrowing and to broker/dealer fee and commission. This proportion reflects X-inefficiency of market power.[7] When financial development reduces this leakage of resources by increasing θ, it also increases growth rate. Financial services also enable the mobilization of resources, enhance risk sharing and reduce the origination costs. Thus, savings rates increase and investment is transferred to innovative and high-return projects.

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[7] X-inefficiency is the difference between efficient behavior of firms assumed or implied by economic theory and their observed behavior in practice. It occurs when technical-efficiency is not being achieved due to a lack of competitive pressure. The concept of X-inefficiency was introduced by Harvey Leibenstein.

In addition to these theoretical studies discussing the relationship between financial development and economic growth, there are debates about the comparative importance of bank-based and market-based financial systems in the area of financial economics among researchers including Goldsmith (1969); Stiglitz (1985); Boot and Thakor (1997); Allen and Gale (2000); Demirguc-Kunt and Levine (2001c); Demirgüç-Kunt and Maksimovic (2002); Beck and Levine (2004). In these papers, the theoretical models which present bank-based systems as the leading factor for economic growth deal with the shortcomings of market-based systems. The models which show the benefits of the market-based systems on affecting economic growth describe the imperfections in the financial system based upon the banking sector.

In the literature, it is stated that the functions of financial intermediaries, i.e. the components of the bank-based system, have a fundamental effect on economic growth rate. These functions are the procurement of information on firms, corporate governance, risk minimization, pooling of capital and easing of transactions. Stiglitz (1985) focuses on the issue of the free-riding in the stock markets which has an effect on individual investors. Therefore, if the stock market development overtakes the banking sector development, there will be lesser investment in innovative projects and economic growth will be restrained. Boot, Greenbaum and Thakor (1993) state that banks enhance corporatisation of the information they provide and construct long-run relationships with firms. By this means, they can create the incentives for innovative and high-return projects.[8]

Another reason for the researchers to support bank-based system is the issue of corporate governance. Schleifer and Vishny (1997) and Stiglitz (1985) believe that

[8] See also Gerschenkron (1962)

markets are not effective in monitoring managers, therefore insiders have better access to information than the outsiders. Another criticism comes from the "poison pills" of the existing managers. De Angelo and Rice (1983) points out that these actions devitalise the discipline mechanism of the stock markets and endanger the resource allocation, subsequently economic growth. Chakraborty and Ray (2004) constructs an endogenous growth model which compares bank-based and market-based financial systems. They come to the conclusion that banks are efficient in solving the problem of the insider trading and enable the control of this issue.[9]

Singh (1997) has underlined the idea of the inexpediencies of the stock markets on economic growth, arguing that stock market development may not be beneficial for economic growth for three reasons. To begin with, the volatility and arbitrariness of the stock market pricing process in most developing countries negatively influence investment efficiency. Secondly, the currency market and stock market have interactions, and some shocks induce macroeconomic instability and decrease long term growth rates. Lastly, stock market development can have predominance over the existing group-banking systems in developing countries.

To sum up, studies which are proponents of the bank-based system emphasize that financial systems that are based on stock markets are unable either to obtain information about firms or control the actions of the managers. Thus, the allocation of the resources, economic performance and development will be damaged. In contrast, bank-based systems bring solutions through effective corporate governance, enabling information on firms, risk sharing and pooling of investments, thus fostering economic growth.

[9] For the detailed discussion of the topic, see Grossman and Hart (1980), Jensen (1993) and Levine (2005).

There are considerable numbers of studies providing a theoretical background for the relationship between economic growth and stock market development. The researchers who support the essence of the market-based systems point out that the bank-based systems may involve intermediaries with such a high degree of influence over firms that this may cause negative effects. Allen and Gale (2000) mentions that in any country that firms and investors which are closely connected with the banks have the advantage in information gathering and processing. However, they also maintain that the inefficiency of the banks still exists even when there is no standard environment, in which indeterminate circumstances such as innovative investments and processes are encountered. They therefore conclude that stock markets minimize the ineffectiveness of the bank-based system and enhance economic growth.[10]

According to Levine (2005), another problem with banking-based financial system which is claimed by the supporters of stock markets is corporate governance. Black and Moersch (1998), and Wenger and Kaserer (1998) contend that bankers act in their own interests, not necessarily in the best interests of all creditors or society at large. Similarly, Rajan and Zingales (2002b) state that in response to adverse shocks that affect the economy unevenly, compared to bank-based systems, market-based systems will more effectively identify, isolate and bankrupt truly distressed firms and prevent them from damaging the overall economy.

To conclude, proponents of market-based financial systems claim that markets provide a richer set of risk management tools that permit greater customization of risk ameliorating instruments. As economies develop, they need better risk

[10] See also Allen and Gale (1999).

management tools for raising capital, and they may benefit from an environment that supports the evolution of market-based activities.

2.2. LITERATURE REVIEW OF EMPIRICAL STUDIES

In the literature of empirical studies, in spite of a few exceptions, there is a general consensus about the positive effect of financial system activities on economic growth. One of the first studies is Goldsmith (1969), viewed as the pioneer of the empirical area, who identified a positive correlation between efficiency of financial intermediaries and economic growth. Goldsmith (1969) indicates a positive relationship between the level of financial institutions' assets to Gross National Product (GNP) ratio and the output per person using data for 35 countries over the period 1860-1963. In the paper, it is shown that banks and non-financial institutions develop as economic growth is realized. Goldsmith (1969) also depicted the positive relationship between financial development and economic growth. However, this paper has some drawbacks. Firstly, the causal relationship between financial development and economic growth is not documented in the graphical illustrations. The other main shortcoming comes from data limitations. Goldsmith (1969) cannot deal with the cross-country evidence of this relationship because of this limitation.

Besides its shortcomings, Goldsmith (1969) is a guiding study for the other researchers in the empirical literature. Levine (2005) also makes a detailed review and critique on empirical literature of financial system efficiency and economic growth highlighting the importance of Goldsmith (1969) in the ongoing studies of this relationship. King and Levine (1993a, 1993b, 1993c) expand the cross-country study of Goldsmith (1969). They update the study by more than doubling the sample of country and extending the sample period to 1960-1989. In the paper, they investigate whether financial intermediary development has a statistically significant relationship with economic growth, capital accumulation and productivity growth. They find that the level of financial intermediary explains long-run economic growth. Although there are improvements in the paper, it has problems in methodology. First, it does not fully adress the causality issue which is stated in Goldsmith (1969). Moreover, King and Levine (1993a, 1993b) only deals with the one segment of the financial system, that is, the banks. There is a need to study other components of the financial system, such as stock markets, bond markets etc.

Research by Deidda and Fattouh (2002) develops a model and apply it to the data set obtained by King and Levine (1993a). In the model, there is a non-linear relationship between financial development and economic growth. They find the following: In low-income countries there is no relationship between financial development and growth; however, in high-income countries, the relationship is significant and positive.

As the empirical studies in the literature increase and the stock markets gain greater importance in financial system, investigating the role of stock markets on the economic growth and development became a necessity. The theoretical studies of this relationship are also driving factors for the researchers of the empirical side. Atje and Jovanovic (1993) and Levine and Zervos (1998) investigate the role of equity markets on economic growth. In addition to banking sector, their studies aim to show the potential crucial role of stock markets on economic growth.

Atje and Jovanovic (1993) conducted a cross-country survey of 40 countries over the period of 1980-1988. In the paper, the equity market indicator is the value of the stock markets divided by GDP. They come up with the result that there is a correlation between the stock market development and economic growth, whereas the effect of banking sector development has no significance.

Levine and Zervos (1998) focus on the individual role of the stock market on economic growth, capital accumulation and productivity growth. They use three liquidity measures (total value of shares trade divided by market capitalization, value traded ratio divided by stock market volatility, turnover ratio divided by stock return volatility), size (market capitalization divided by GDP) and activity (total value of shares trade divided by GDP) measures. For the indicator of banking sector development, they use bank credit to the private sector as a share of GDP. Their study indicates that both stock market liquidity and banking sector development has positive and significant relationship with economic growth, capital accumulation and productivity growth. Levine and Zervos (1998) made two important contributions to the existing empirical literature. First of all, they increased the number of stock market measures, by including liquidity, size and activity, and secondly they extended the sample size. Their study also shows that stock markets are important in fostering economic growth because they provide different services to those provided by banks. In their study, it is also worth noting that the size of stock markets has no influence on economic growth unlike market activity. The methodology of Levine and Zervos (1998) is ordinary least square (OLS) approach, which has certain shortcomings, including failing to control for country-fixed effects and simultaneity bias. Also, the causality issue has not been investigated.

The cross-country studies have certain drawbacks, especially regarding causality and country-specific details. Arestis and Demetriades (1997) is a time series study which investigates the causality issue between the financial development and economic growth. Using a Johansen cointegration analysis for United States and Germany, they find that there is no supply-sided relationship, i.e. financial development has no effect on economic growth in the United States. However, there is a demand-sided relationship, that is, economic growth positively affects banking system and stock market development positively. On the other hand, there is a supply-sided causality for Germany: development of banking system affects economic growth positively. Rousseau and Wachtel (1998) is another time series study on the relationship between financial intermediary development and economic performance. They exploit the historical data for five countries from 1870-1929. The paper undertakes Granger causality and Vector Error Correction Model (VECM) tests, finding evidence that financial intermediary development has positive effect on real sector activity.

Neusser and Kugler (1998) is a study which uses time series analysis for thirteen OECD countries over the period 1970-1991. In the paper, the importance of the role of the financial sector development for economic growth is investigated. They come up with the result that financial sector and GDP are cointegrated for many OECD countries not so much with manufacturing GDP but mostly with manufacturing total factor productivity (TFP). In the Granger-Causality test for each countries, they obtain mixed results. Financial sector activity causes manufacturing GDP for some countries, both manufacturing GDP and TFP are caused by financial sector for another group of countries. These results suggest a more complex picture than is apparent from cross-sectional evidence.

Hansson and Jonung (1997) investigate the long-run relationship between financial development and economic growth in Sweden between 1830 and 1990. The role of investment, education and technological progress are also accounted for in order to assess the relative importance of the development of the financial system for growth performance. It is found that the financial system had the greatest effect on economic growth between 1890 and 1939. From this evidence, the estimated contribution of the financial system to economic growth is shown to depend crucially on the time period studied and the variables included in the analysis.

Fase (2001) also investigates the relationship between the financial development and economic growth of the Netherlands in the period of 1900-2000, producing evidence which is consistent with Hansson and Jonung (1997) depending on this time period. There is a supply-sided causality from financial intermediation to economic growth until World War II in the Netherlands, and disappears afterwards.

Hondroyiannis *et al*. (2005) uses time series tools to prospect the relationship between the development of the banking system and the stock market and economic performance for Greece between 1986 and 1999. There is an evidence of bi-directional causality between financial development and long-run economic growth. In the paper, the stock market performance has less impact on economic growth rather than banking system development.

Even though all the cross-country studies discussed above made significant contributions, none addressed the issue of simultaneity bias. Investigation of simultaneity bias in empirical literature is conducted by using instrumental variables to extract the exogenous component of financial development. The instrumental variables influence the economic growth through only its link with financial development. With the help of the instrumental variable, the relationship between financial development and economic growth can be investigated by controlling for endogeneity.

The seminal studies Levine (1998, 1999) and Levine *et al*. (2000) use instrumental variable procedure. Their instrumental variable measures are legal origins of the countries which are used in La Porta *et al*. (1998). In this paper, it is proposed that legal origins which bring out laws protecting investor rights affect financial development positively. Levine (1999) shows the effect of cross-country differences on financial development and economic growth by using these measures as instrumental variable.

Levine *et al*. (2000) uses the dynamic panel data technique of Generalized Method of Moments (GMM) and cross-sectional instrumental variable (IV) estimator of legal rights of creditors on financial development. Through these techniques, they aim to resolve the potential biases that are caused by simultaneity, unobserved country-specific and omitted variable influence on the financial development economic growth relationship and the causality issue. Using a set of data collected from 74 developed and less developed countries for the period 1960-1995, they find evidence that exogenous components of financial intermediary development have positive correlation with economic growth.

Beck *et al*. (2000b) also uses a GMM (see Arellano and Bond 1991, and Arellano and Bover, 1995) and IV estimators to solve the problems in cross-country regressions. The panel data techniques have the advantage of exploiting both time-series and cross-sectional variation in data, and controlling for the potential endogeneity. They investigate the relationship between financial development and physical capital accumulation and total factor productivity. In this research, therefore Beck et al. (2000b) explores not only financial development relationship with economic growth, but also with sources of growth. The paper indicates that higher levels of financial development induce higher levels of economic growth and total factor productivity.

Rousseau and Wachtel (2000) improve the study of Levine and Zervos (1998) by using panel data econometric techniques. This research uses the annual data and panel difference estimator of Arellano and Bond (1991). In this paper, the effect of banking sector and stock markets on economic growth is jointly investigated. They focus on the role of stock market liquidity and find evidence that stock markets foster economic growth.

Beck and Levine (2004) undertake a study, which builds upon Rousseau and Wachtel (2000). They use data averaged over five-year periods to eliminate the effect of business cycle fluctuations and extend the sample in the period 1975-1998 in order to minimize the effect of Asian stock market boom in the 1990s on the results. In the paper, they find evidence that stock market capitalization is correlated with economic growth, which is consistent with the cross-country study of Levine and Zervos (1998). The results of Beck and Levine (2004) also show that exogenous components of both equity market and banking sector development have significant effects on economic growth.

Calderon and Liu (2004) conduct a research by using panel data from 109 developing and industrial countries in the period of 1960-1994. In the paper, Geweke decomposition test is performed which develops an approach to test the degree of dependence between financial development and economic growth. The paper has five important findings: (i) financial development generally causes economic growth, (ii) there is a coexistence of the Granger causality from financial development to economic growth, and from economic growth to financial development, (iii) financial deepening contributes more to causal relationships in the developing countries than in the industrialized countries, (iv) the longer the sampling interval, the larger the effect of financial development on economic growth, (v) financial deepening fosters economic growth both in terms of a more rapid capital accumulation and also productivity growth.

Christopoulos and Tsionas (2004) survey the long run relationship between financial depth and economic growth using fully modified (FM) OLS for 10 developing countries. In the paper, they make a criticism on the previous studies for not using cointegration properties of the data. They use time series unit root tests along with panel unit root tests to investigate the stationary properties of data. Moreover, the cointegration of Johansen (1988) and panel cointegration tests are performed. They take into account the “threshold effect” which affect stationary properties of data negatively and perform tests. They exploit FM OLS to deal with endogeneity, and allow consistency of the long run relation with the short run adjustment. Finally, the error correction model (ECM) is estimated for heterogeneous panels. The results of Christopoulos and Tsionas (2004) indicate that the only cointegration relationship is unidirectional causality from financial depth to economic growth. This result supports the supply-leading view.

Dawson (2008) investigates the relationship by using annual panel data for 44 developing countries for the period of 1974-2001. In the paper, three sources of growth equations are estimated. Two of them are theoretically consistent but the third used a common proxy for financial development. While theoretically consistent models indicate a positive significant relationship, the third equation, which is a proxy, gives a contradictory result. The paper gives policy advice for the measurement of financial development measurement and states that this issue is critical.

In summary, there is still no consensus on the methodology and direction of causality in the empirical literature. In the first group, cross-country studies that do not deal with the country specific issues, cannot solve the simultaneity bias and endogeneity problem. Causality is also a major problem remain unsolved. On the other hand, time series studies take the country-specific effects into consideration and explain the causal relationship. However, they rather consider a few number of countries and short time-intervals, which inherits some shortcomings. They also cannot resolve the simultaneity bias.

A major problem in all of these studies is the absence of the link between the theory and empirical studies. This dissertation aims to develop a concrete theoretical link to make empirical research more meaningful. Three theoretical models investigating the financial efficiency will be constructed in the following chapters: the Solovian framework, the Ramsey framework, and the Solovianized Romer framework. After this, the first and the third will be tested empirically in order to validate them.

CHAPTER 3

A GENERAL LOOK TO ECONOMIC GROWTH FRAMEWORKS

In this chapter, fundamental models of economic growth, which will be used to investigate the role of financial efficiency on economic growth in the transitional period and long run, will be discussed in detail. The first economic growth framework is the Solow Model, which is also the very first neoclassical economic growth model (cf., Solow (1956)). It is the fundamental model of neoclassical growth theory, which has been considered as a milestone in the development of the literature. The second model that we are going to discuss is the Ramsey Model, which is first constructed by Ramsey (1928) and formulated rigorously by Cass (1965) and Koopmans (1965). In this framework, the specification of consumer behavior is the key element, as the saving-consumption tradeoff is determined by optimizing households and firms in a competitive environment. The last model to be discussed is the so-called Romer Model, which models endogenous technological change (cf., Romer (1990)). It is one of the most important studies in the recent endogenous growth literature, which shows rigorously the role of technological change through horizontal product differentiation on economic growth. In the next subsections, we will present these models in detail respectively.

3.1. SOLOW MODEL

The neo-classical growth model, also known as the Solow–Swan growth model or exogenous growth model, is a class of economic models of long-run economic growth set within the framework of neoclassical economics Neoclassical growth models attempt to explain long run economic growth by looking at productivity, capital accumulation, population growth and technological progress.

To explain the Solow growth model, firstly let us define the production function as follows:

$$Y_t = F(K_t, L_t, A_t) \tag{3.1}$$

In this production function, Y denotes the total output production, K denotes the amount of physical capital stock, L denotes the labor stock, A denotes the technology and t denotes the time.

The model is neoclassical, so it is supply sided. There are 3 necessary conditions of neoclassical production function

1. Positive and diminishing marginal utility
2. Constant returns to scale/homogeneity of degree one
3. Inada conditions

The only production function that satisfies these conditions is homogeneity of degree one Cobb-Douglas function.

After defining the properties of neoclassical production function, let us define the Solow model. It is well-known that one of the most fundamental equations of macroeconomics is the equality of production (=income)-aggregate expenditure:

$$Y \equiv C + I + G + (X - M) \tag{3.2}$$

In equation (3.2), C denotes consumption, I denotes investment, G denotes government expenditures and $X - M$ denotes net export. To simplfiy equation, we assume that there is no government expenditure $(G = 0)$ and a closed economy $(X = 0,\ M = 0)$. As a result, equation will be $Y \equiv C + I$. In this economy, disposable income is equal to income. So, we will have an equation of $S \equiv I$. Also, if s is defined as saving rate, $S \equiv I = s \cdot Y$.

The last step of defining Solow model is to define physical capital accumulation dynamics. The relationship between gross capital change and net capital change is as follows:

$$\dot{K} \equiv I - \delta \cdot K \tag{3.3}$$

Since, as we have shown above, $I = s \cdot Y$, we can rewrite the equation (3.3) as follows:

$$\dot{K} \equiv s \cdot Y - \delta \cdot K \tag{3.4}$$

The relationship which is given in equation (3.4) is named as Fundamental Equation of Growth (FEG). This is a differential equation with one unknown. The equation can be also written as follows:

$$\dot{K} \equiv s \cdot F(K, L, A) - \delta \cdot K \tag{3.5}$$

Let us assume that the technology variable is exogenous as $(t) = A(0) \cdot e^{xt}$. The growth rate of this technology is x and it is named as labor-saving technology. $A \cdot L$

is named as effective labor and the labor rate is n. After defining $\tilde{k} = K/A \cdot L$ and $\dot{\tilde{k}} = \frac{d}{dt}\left(\frac{K}{A \cdot L}\right)$ and $s \cdot F\left(\tilde{k}, 1\right) = s \cdot f(\tilde{k})$, we obtain the following equation:

$$\dot{\tilde{k}} = s \cdot f\left(\tilde{k}\right) - (n + \delta + x) \cdot \tilde{k} \tag{3.6}$$

The equation (3.6) is Fundamental Equation of Growth per capita.

Equation (3.6) consists of two different solutions. These solutions are named as transitional period or short-run equilibrium and steady state or long-run equilibrium. The reason to transform equation (3.5) to (3.6) is comparison of growth performance of countries. For this comparison, we need income per capita.

Let us write equation (3.6) in growth form:

$$\frac{\dot{\tilde{k}}}{\tilde{k}} = \frac{s \cdot f\left(\tilde{k}\right)}{\tilde{k}} - (n + \delta + x) \tag{3.7}$$

The equation above is true for all time. Now assume that the expression in equation (3.7) has reached its steady state value:

$$\frac{\dot{\tilde{k}}_{ss}}{\tilde{k}_{ss}} = \frac{s \cdot f\left(\tilde{k}_{ss}\right)}{\tilde{k}_{ss}} - (n + \delta + x) \tag{3.8}$$

We know that, in steady-state, $\tilde{k}_{ss}$ grows in constant rate. So, after some calculations, we will have steady state solution of capital and output as:

$$\tilde{k}_{ss} = \left(\frac{s}{n + \delta + x}\right)^{\frac{1}{1-\alpha}} \tag{3.9a}$$

$$\tilde{y}_{ss} = \left(\frac{s}{n+\delta+x}\right)^{\frac{\alpha}{1-\alpha}} \qquad (3.9b)$$

3.1.1. GOLDEN RULE OF SAVINGS RATE

The golden rule of savings rate is the rate of savings which maximizes the steady state level or growth of consumption. We will now explain it in Solow model. As it can be seen in equation (3.8a), saving rate has positive effect on capital. However, the effect of saving rate on consumption is not always positive. Let us define the steady state consumption function as follows:

$$c_{ss}(s) = (1-s) \cdot y_{ss}(s) = (1-s) \cdot f(k_{ss}(s)) \qquad (3.10)$$

The consumption function consists of two parts: $(1-s)$ and $f(k_{ss})$. However, these two parts have opposite response to saving rate. According to first derivatives, first part has negative and second part has positive effect.

To find optimal saving rate, the first step is to check whether c_{ss} in equation (3.9) is concave or not. If one writes $\cdot f(k_{ss}(s)) = (n+\delta) \cdot f(k_{ss}(s))$, the equation (3.9) can be rewritten as:

$$c_{ss}(s) = f(k_{ss}(s)) - (n+\delta) \cdot f(k_{ss}(s))$$

The first and second derivatives are obtained as:

$$\frac{dc_{ss}}{ds} = [f'(k_{ss}) - (n+\delta)] \frac{dk_{ss}}{ds}$$

$$\frac{d^2 c_{ss}(s)}{ds^2} = f''(k_{ss}) \frac{d^2 k_{ss}}{ds^2}$$

Since $f''(k_{ss}) < 0$, $\frac{d^2 c_{ss}(s)}{ds^2} < 0$. So, after reaching steady state, there is a concave relationship between consumption function and saving rate. In other words, it can be said that consumption is increasing negatively to some level, then it is maximized at a certain saving rate level (this level is golden saving rate), then it begins to decrease as saving rate increases. If we equate the first derivative to zero, we can find golden saving rate:

$$[f'(k_{ss}) - (n + \delta)] \frac{dk_{ss}}{ds} = 0$$

$$f'(k_{ss}) = (n + \delta)$$

$$\alpha \cdot k_{ss}^{\alpha-1} = n + \delta$$

$$s_{golden} = \alpha$$

We can say that if saving rate is chosen equal to the production elasticity of capital, consumption is maximized at steady-state.

3.1.2. CONVERGENCE

The empirical part of economic growth consists of long term determinants of economic growth and convergence issues. This subject is also our research question which will be investigated in three frameworks.

There are two hypothesis of convergence. First one is absolute convergence. This hypothesis claims that poor economies tend to grow faster per capita than rich ones without conditioning on any characteristics of economies. This hypothesis has received mixed reviews when confronted with empirical data. Some studies reject the hypothesis of absolute convergence. It has now become clear that the composition of groups of countries play a critical role. The hypothesis fares better if more homogenous groups are examined.

What if there is heterogeneity across economies? Then steady states differ, so the second hypothesis should be considered. It is conditional convergence which has the main idea that an economy grows faster the further from its own steady-state value. The speed of convergence measures how rapidly an economy's output per effective worker approaches to its steady state value.

We will investigate the role of financial efficiency on economic convergence in the next three theoretical chapters by constructing some derivations and convergence equations. Because of this, we do not need to get into more details in this chapter.

3.2. RAMSEY MODEL

The Ramsey–Cass–Koopmans model or the Ramsey growth model is a neo-classical model of economic growth based primarily on the work of the economist and mathematician Frank P. Ramsey, with significant extensions by David Cass and Tjalling Koopmans.

The study "Mathematical Theory of Saving" which is written by Ramsey in 1928 gave the model its name and it is widely used in the literature. The most important contribution of this work is to define the saving-consumption tradeoff in an intertemporal environment. The real application of this model is made by Cass (1965) and Koopmans (1965) independently. In 1961, Soviet Pontryagin and a group of mathematicians had developed “Optimal Control Theory”. They had made an enhancement to “Calculus of Variations” by adding a constraint to the objective function and had defined two types of variables as stock and flow variables. Cass (1965) and Koopmans (1965) made a contribution by applying this method to the theory of economics. They solved the tradeoff between consumption and savings in dynamic and multiple-time. The Ramsey model differs from the Solow model in that it explicitly models the choice of consumption at a point in time and so endogenizes the saving rate.

Similar to Solow Model, this model also takes technology as exogenous and cannot explain the economic growth. However, it is very important for the growth literature by explaining the dynamics of new classical growth and endogenous growth. Because of this, investigating the theoretical framework of Ramsey model is crucial.

Let us start Ramsey model by defining utility function. Let us assume that, in an economy there is one good produced and all households are same. The overall utility in Ramsey framework is written as:

$$U(c_t) = \int_0^\infty e^{-\rho t} \cdot L_t \cdot u(c_t) dt \tag{3.11}$$

where $U(c_t)$ is overall utility, c_t, is per capita consumption, $u(c_t)$ is momentary utility, ρ is subjective rate of discount and $L_t = e^{nt}$ is population of a household, and n is the population growth rate. We assume that population and number of workers are identical, unless stated otherwise.

The important property of the momentary utility function is to be concave. This property can be defined mathematically as $u'(c) > 0$ and $u''(c) < 0$. We can say that "marginal utility is positive but decreasing". The other assumption of overall utility function is for all consumers have identical utility function.

To calculate overall utility $U(c_t)$, the momentary utilities of households are added from time zero ($t = 0$) to infinity ($t = \infty$). However, for the same good produced, utility is not same for all time. To be able to compare inter-temporal utilities, we need to eliminate the difference of choice which is driven by time. To this aim, subjective rate of discount, ρ, is used to compare inter-temporal utilities.

After the assumptions above, the overall utility function (3.11) takes a form as below:

$$U(c_t) = \int_0^\infty e^{-(\rho-n)t} u(c_t)\, dt \tag{3.12}$$

3.2.1. MARKET SOLUTION-PROBLEM OF HOUSEHOLDS

The market solution of Ramsey model includes optimization of households' utility. To solve this problem, let us write constrained optimization problem:

$$\begin{gathered} \text{Maximize } U(c_t) = \int_0^\infty e^{-(\rho-n)t} u(c_t)\, dt \\ subject\ to\ (\dot{assets/capita}) = (r-n)\cdot(assets/capita) + w - c \end{gathered} \tag{3.13}$$

where r is real interest rate, w is real wage. The equation has an interpretation as "the financial asset of a household increases with real interest on their assets and labor wages, decreases with consumption". This optimization problem can be solved with Hamiltonian method.[11]

3.2.2. MARKET SOLUTION-PROBLEM OF FIRMS

In the production side of general equilibrium model's market solution, producers (firms) are considered. From microeconomic theory, it is well-known that if a production function has a property of constant returns to scale, profit is zero. Also, with the same reason, (i) the number of firms in production side is undefined, (ii) since profit is zero in all periods, there is no need to solve the firm's dynamic profit maximization, static profit maximization is enough.

Let us assume that the firm has Cobb-Douglas production technology. So, the firm has a profit equation as follows:

$$\Pi = K^{\alpha} \cdot L^{1-\alpha} - w \cdot L - (r + \delta) \cdot K \quad (3.14)$$

In the equation (3.14) K denotes physical capital, L denotes labor force, w denotes wage, r denotes real interest rate, δ denotes depreciation rate. This unconstrained optimization problem can be solved by classical method by taking the first derivative of Π with respect to K and L.[12]

[11] The technical details and solution of this method will be covered in Chapter 4, while investigating role of financial efficiency on economic convergence in Ramsey framework.
[12] For the details, see advanced level economic growth textbooks.

3.2.3. SOCIAL PLANNER’S SOLUTION

In this subsection, social planner’s solution will be defined. The details of solution procedure are presented in Chapter 5, where we will investigate the role of financial efficiency on economic convergence in Ramsey framework. Let us introduce to the social planner’s solution. Firstly, social planner is a benevolent dictator, who seeks the interest of households. Secondly, he is the only power in the distribution of goods and allocation of factors of production. Since, households and firms make decision of usage of sources (labor, capital, time) by taking ‘directives’ from social planner, model does not need a market price information.

The social planner’s optimization problem is as follows:

$$\begin{aligned} &\text{Maximize } U(c_t) = \int_0^{\infty} e^{-(\rho-n)t} u(c_t)\, dt \\ &\quad subject\ to\ \dot{k} = y - c - (n+\delta)\cdot k \end{aligned} \tag{3.15}$$

This optimization problem can be solved by Hamiltonian method. The details will be given in Chapter 4.

3.2.4. CONVERGENCE AND LONG RUN SOLUTION

The convergence issue and long-run solution in Ramsey model is our main research question under imperfect financial sector. We will construct a theoretical model and make some derivations to obtain a convergence equation in Chapter 5. Because of this, we do not need to get into details in this chapter.

3.3. ROMER MODEL

The neoclassical growth model relies on exogenous technological progress as the engine of long-run growth. Romer (1990) was the first who formulated an explicit growth model with technical progress resulting from deliberate actions taken by private agents who respond to market incentives. It is the most important study which shows the effects of technological change that result in horizontal product differentiation on economic growth.

In Romer (1990) model, there are 3 sectors. These are final-good sector, intermediate-good sector and Research and Development (R&D) sector. In this model, two factors of production are human capital and intermediate-good. R&D produces new information/patent by using a part of human capital and prior information. These patents are sold to producers with fixed costs. The purchaser of patent is a monopolist. However, market of intermediate-good is monopolistically competitive. Intermediate-goods are produced by raw physical material. In the last step, by gathering intermediate-goods with the help of human capital which is not used in R&D, final good (GDP) is produced.

The details of sectors and specification of Romer Model will be presented and explained in detail by combining with Solow Model in Chapter 6. In this chapter, the framework named “Solovianized Romer” which is developed by Bayraktar-Sağlam and Yetkiner (2012) will be presented and the role of financial efficiency on economic convergence will be investigated respectively.

CHAPTER 4

CONVERGENCE UNDER IMPERFECT FINANCIAL SECTOR: SOLOW MODEL

4.1. INTRODUCTION

A fundamental idea in National Income Accounting is that gross saving is identical to gross investment, $S \equiv I$. Under exogenous saving assumption, where s is the exogenous saving rate, this identical relationship becomes $s \cdot Y = I$. The neoclassical growth theory in general, and the Solow model in particular, does also based on this fundamental idea. However, nobody can argue that the saving-investment channel is perfect in practice.

The Solow model is the main model of neoclassical growth theory, which has been accepted as a milestone in the development of the literature. It deals with the behavior of economic growth in the long-run based on the framework of neoclassical economics. This model is also named as exogenous growth model and is the extended version of Harrod–Domar model.[13] It makes a notable contribution by taking productivity growth in to the account.

Since this model is a part of neoclassical literature, it is supply-sided and built on the neoclassical production function. It is the first growth model which takes labor as a factor of production and adds the time-varying technology apart from capital and labor. The Solow framework has some fundamental assumptions which derive from

[13] This model expresses the growth rate of economy by the level of saving and productivity of capital. See Harrod (1939) and Domar (1946) for detailed information about the model.

the properties of the neoclassical production function. These are positive and diminishing marginal productivity, constant returns to scale and Inada conditions.[14]

The exogenous growth model of Solow reveals that, the saving rate is the primary determinant of economic growth in the transitional period. Because, in transitional period, economic growth is based on capital accumulation, which is determined by savings rate and depreciation. The sharing decision of the saving and consumption habits is given to the model, i.e. they are exogenous.[15] Due to this constant saving rate assumption, a number of concrete results are presented in a clear way. As stated above, saving rate of an economy represents the fraction of total output that the economy transfers to the investment. In other words, saving rate is accepted equal the investment rate, S(t)= I(t).

According to Solow model, in the long run, capital accumulation becomes less significant. Thus, the long run determinant of economic growth in the model is presented as the technological process. It is also given as exogenous to the system because of some technical constraints of the neoclassical assumptions. However, to observe the impacts of technology on economic growth and other macroeconomic variables, the exogenous integration of technology to the model is beneficial.

In the framework, the technology has a determined behavior and constant growth rate. It is assumed that the technology affects the labor and named as labor-saving

[14] In macroeconomics, the Inada conditions (named after Japanese economist Ken-Ichi Inada) are assumptions about the shape of a production function that guarantee the stability of an economic growth path in a neoclassical growth model.
[15] This assumption comes from the technical constraint. In 1956, Solow did not have a technique of solving this problem, because Pontryagin had not developed optimal control theory yet. For detailed information about this theory, see Pontryagin (1961).

(Harrod-Neutral)[16] technology. There is a necessity for labor-saving technological process. Because, in the neoclassical growth model with a constant rate of population growth, only labor-augmenting technological change turns out to be consistent with the existence of a steady state.[17]

There are debates about the exogenous growth model of Robert Solow, but all of these criticisms come from the researchers of endogenous growth. First of all, they argue that the using of exogenous savings rate in the model does not help to understand why capital accumulation and income per capita grow continuously. The model answers only the question of 'How?'. Also, although the technology is known to be the major determinants of the economic growth, the endogenous role of technological process cannot be modeled. However, this neoclassical growth model has undeniable significance for new growth theory. Because, from 1956 to 1986 due to technical constraints, theoretically endogenous growth could not be modeled and Solow model was used in many researches. Still, in theoretical research papers and economic growth textbooks Solow framework has importance. To sum up, the Solow neoclassical growth model, despite its age and recent enhancements in the endogenous growth literature, continues to be of great theoretical interest.

In the literature of economic growth, despite endogenous modeling of growth theory had been achieved, there was limited number of contributing empirical studies until early 1990s. However, in this decade, the empirical issues gained considerable importance. At the beginning of 2000s, there were more than 50 articles published in indexed economic journals. Nowadays, with the help of the developing econometric

[16] Technology can take different forms in production function. If it is $Y = F(K, A \cdot L)$, called as Harrod-Neutral Form. For detailed information, see Harrod (1942).
[17] See Economic Growth, Robert J. Barro and Xavier Sala-i Martin for technical details.

techniques and the availability of databases, there are thousands of articles published in these economic journals. It should be pointed out that, majority of these papers exploit the theoretical background of Solow framework.

Despite its theoretical shortcomings, which are the consequence of technical constraints, Solow model has substantial empirical power in the literature. Empirical part of neoclassical economic growth theory (i.e. Solow framework) consists of two major questions: ‘What are the determinants of long run behavior?’ and ‘Do low-income countries grow faster than high-income countries?’

To answer the first question, researchers made numerous studies stating the determinants of long run behavior of economic growth. According to the survey of Petrakos *et al.* (2007), in these studies, investment on physical and human capital, innovation and R&D, macroeconomic policies (such as inflation, fiscal policy and budget deficits), openness to trade, the institutional framework, geography, demographic trends, political and socio-cultural factors are presented to be determinants of economic growth, but there are no accurate results and findings.

The convergence analysis, i.e. whether low-income economies grow faster than the high income ones has been a considerable discussion in the empirics of growth. There are two hypothesis of convergence. First, the hypothesis that without there are no conditions on any other characteristics of economies- low-income countries grow faster per capita than high-income ones is called as *‘absolute convergence’*. This hypothesis gives better results if a homogenous group of economies are investigated. But if the countries do not have the same characteristics of economy, another convergence definition is required. That hypothesis is referred as *‘conditional* *convergence'* which takes the differences in the steady states of countries in to the account. This means, an economy grows faster the further it is from its own steady-state value. The initial studies about convergence were performed by Baumol (1986), Abramovitz (1986) and Long (1988).

To emphasize the great contributions, Mankiv, Romer and Weil (1992) and Barro and Sala-i Martin (1992)[18] can be said as breakthroughs in the research area of convergence. MRW (1992) investigates whether the neoclassical growth model has coherence with international variation in the standard of living. In their model, augmented Solow model - it includes accumulation of human capital besides the physical capital - has been estimated. In the paper, cross-country data is used and it is shown that the determinants of income per capita are constant population growth, accumulation of physical and human capital. They examined the implications of augmented Solow model for conditional convergence in standards of livings. In the paper, technology growth is also assumed to be constant (it is taken 0.02), i.e. technology is exogenous. This model is still used as fundamental empirical framework for the research papers investigating the role of convergence.

Islam (1995), Caselli *et al.* (1996) and Lee, Pesaran and Smith (1997) enhances the model of MRW (1992) by exploiting the techniques of panel data econometrics. In these studies, conditional convergence rates are found higher than MRW (1992) due to the benefits of panel data. Panel data techniques have some advantages over the cross-country regressions. It allows the control of unobserved heterogenity, correct the omitted variable bias and reduce the problem of collinearity between variables.

[18] MRW (1992) will be used for Mankiw, Romer and Weil (1992) and BSM (1992) will be used for Barro and Sala-i Martin (1992)

Other than these papers, Murthy and Chien (1997), Barro and Sala-i Martin (1992, 2003), Nonneman and Vanhoudt (1996) and Keller and Poutvarra (2005) studied on convergence issue. They also found higher convergence rate when compared to the model of MRW (1992). Still, in their model, technology and its determinants are taken as exogenous and they investigate the role of capital accumulation in convergence.

Bloom *et al.* (2002) presents a different approach from the studies of Islam (1995), Caselli *et al.* (1996) and Lee, Pesaran and Smith (1997) by emphasizing the non-constant rate of technology in each economy. In the paper, they mention the total factor productivity (TFP) is changing across the countries and these changes are continuous. They indicate that technological diffusion from the countries that have high level of technology to the countries that have low level of technology exists but not full convergence.

Although Solow model has many implications in empirical literature and on the other side there are numerous theoretical and empirical studies investigating the financial development (efficiency)-economic growth relationship, the theoretical link between them is lacking. There are so many econometric techniques developed and many country data are tested empirically, they do not mention the theoretical background behind. There is a need for the studies investigating the effects of financial efficiency on economic growth in a theoretical systematic way and test it empirically. The Solow framework is functional for developing and performing an empirical study.

In this chapter, our aim is to show the contribution of financial efficiency on the long run economic growth and on the convergence performance of a country by using the

Solow framework. We will undertake theoretical derivations to obtain a convergence equation to be tested empirically.

4.2. THE MODEL

Recall that framework the Fundamental Equation of Growth (FEG) in Solow framework is as follows:

$$\dot{K} = s \cdot Y - \delta \cdot K \tag{4.1}$$

where s is saving rate, δ is depreciation rate of capital, Y is GDP and K is physical capital. Throughout the text, we will assume that the aggregate production function is determined by a constant returns to scale (homogeneity of degree one) Cobb-Douglas production function. We will assume that the technology is in Harrod-neutral/ labor-saving form, and that the growth rate of technology is x. Under these assumptions, FEG will be as follows:

$$\dot{K} = s \cdot K^{\alpha}(A \cdot L)^{1-\alpha} - \delta \cdot K \tag{4.2}$$

Equation (4.2) is true whenever saving-investment identity does hold perfectly. What if the saving-investment channel is imperfect? All convergence studies employing Solow framework assumes that this identity does hold. In practice, however, it is hard to say that there is perfect channeling of savings to investment. One concrete example is under-mattress savings. People may save but not channel to financial sector. In that case, the saving-investment channel would be imperfect. As, in our model, we investigate the growth and convergence implications of imperfect or inefficient financial system, we need to incorporate this inefficiency to the Solow model. Assume now that $S \neq I$. In particular, let us assume that saving is function of $S = \emptyset(\gamma) \cdot s \cdot Y$, where $0 < \gamma < 1$. In that formulation, γ measures the degree of financial efficiency. As our aim is to develop a model that fits our empirical purposes, we will keep $\emptyset(\gamma)$ as simple as possible and assume that $\emptyset(\gamma)$ is linear in γ and that $0 < \emptyset'(\gamma) < 1$. In particular, we will assume that $\emptyset(\gamma) = \gamma$. So, saving is not fully transferred to investment and that the "leakage" is $1 - \gamma$.

Under imperfect financial efficiency, FEG will take the following form:

$$\dot{K} = \gamma \cdot s \cdot K^{\alpha} \cdot (A \cdot L)^{1-\alpha} - \delta \cdot K \tag{4.3}$$

Suppose that population growth rate is n and that the rate of technological progress is x. We also assume that initial values of population and technology are normalized to one. Then, equation (4.3) expressed in efficient capital per labor, $\tilde{k} = K/(A \cdot L)$, would be

$$\dot{\tilde{k}} = \gamma \cdot s \cdot \tilde{k}^{\alpha} - (n + \delta + x) \cdot \tilde{k} \tag{4.4}$$

Next, we let us find the steady state value capital per efficient capita, $\tilde{k}_{ss}$. First of all, under the steady state assumption of capital, equation (4.4) can be written as growth form:

$$\frac{\dot{\tilde{k}}_{ss}}{\tilde{k}_{ss}} = \gamma \cdot s \cdot \tilde{k}_{ss}^{\alpha-1} - (n + \delta + x) \tag{4.5}$$

Next, let us take the time derivative of both sides in equation (4.5). By definition, the time derivative of the left hand side is:

$$\frac{d}{dt}\left(\frac{\dot{\tilde{k}}_{ss}}{\tilde{k}_{ss}}\right) = 0$$

The time derivative of the right hand side is as follows:

$$\frac{d}{dt}\left(\gamma \cdot s \cdot \tilde{k}_{ss}^{\alpha-1} - (n+\delta+x)\right) = 0 \Rightarrow \gamma \cdot s \cdot (\alpha-1)\tilde{k}_{ss}{}^{\alpha-2} \cdot \dot{\tilde{k}}_{ss} = 0$$

As γ, s, $\alpha - 1$ and $\tilde{k}_{ss}^{\alpha-2}$ cannot be 0, $\dot{\tilde{k}}_{ss} = 0$ must hold. Using this condition in equation (4.5) does yield the steady state value of capital per efficient capita:

$$0 = \gamma \cdot s \cdot \tilde{k}_{ss}{}^{\alpha-1} - (n+\delta+x) \Rightarrow$$

$$\tilde{k}_{ss} = \left(\frac{\gamma \cdot s}{n+\delta+x}\right)^{\frac{1}{1-\alpha}} \tag{4.6}$$

4.2.1 THE ROLE OF FINANCIAL EFFICIENCY IN THE LONG RUN

In this subsection, the role of financial efficiency is investigated in the long run and the theoretical derivations are presented.

First of all we need to define $\tilde{y}_{ss}$ with the use of equation (4.6):

$$\tilde{y}_{ss} = \tilde{k}_{ss}^{\alpha} \quad \Rightarrow \quad \tilde{y}_{ss} = \left(\frac{\gamma \cdot s}{n+\delta+x}\right)^{\frac{\alpha}{1-\alpha}}$$

Steady state value of $\tilde{y}_{ss}$ is expressed in per effective worker, we need to express it in per worker form:

$$y_{ss} = A(0) \cdot e^{x \cdot t} \cdot \tilde{y}_{ss} \quad \Rightarrow$$

$$y_{ss} = A(0) \cdot e^{x \cdot t} \cdot \left(\frac{\gamma \cdot s}{n+\delta+x}\right)^{\frac{\alpha}{1-\alpha}}$$

After taking the natural logarithm of both sides, we obtain the following equation which represents the determinants of long-run economic growth, in our context especially financial efficiency:

$$Ln(y_{ss}) = Ln\left(A(0)\right) + x \cdot t + \frac{\alpha}{1-\alpha} \cdot Ln(s) + \frac{\alpha}{1-\alpha} \cdot Ln(\gamma) - \frac{\alpha}{1-\alpha} \cdot Ln(n + \delta + x) \qquad (4.7)$$

The equation above is the basic representation of our investigation, which aims to ascertain the role of financial efficiency in the long-run. From this simple equation, it can be interpreted as the financial efficiency has a positive influence on the economic growth. In the next subsection, the role of financial efficiency in convergence will be analyzed.

4.2.2 THE ROLE OF FINANCIAL EFFICIENCY IN CONVERGENCE

This subsection presents theoretical derivations of the effect of financial imperfection on the convergence equation of Solow framework. As a first step, we need to express equation (4.4) in the form of $\tilde{y} = \tilde{k}^{\alpha}$, as it is GDP that we are interested in. If we take the log differential of the production function, we find $\hat{\tilde{y}} = \alpha \cdot \hat{\tilde{k}}$ (recall that $\hat{\tilde{y}} = \dot{\tilde{y}}/\tilde{y}$ and $\hat{\tilde{k}} = \dot{\tilde{k}}/\tilde{k}$). Let us divide equation (3.4) by $\tilde{k}$:

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

$$\hat{\tilde{k}} = \gamma \cdot s \cdot \tilde{k}^{\,\alpha-1} - (n + \delta + x)$$

$$\frac{1}{\alpha}\cdot\hat{\tilde{y}} = \gamma\cdot s\cdot\tilde{k}^{\,\alpha-1} - (n+\delta+x)$$

$$\frac{1}{\alpha}\cdot\hat{\tilde{y}} = \gamma\cdot s\cdot\tilde{y}^{\,\frac{\alpha-1}{\alpha}} - (n+\delta+x)$$

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

Notably, $\hat{\tilde{y}} = \frac{dLn(\tilde{y})}{dt}$ and $e^{\frac{\alpha-1}{\alpha}\cdot Ln(\tilde{y})} = \tilde{y}^{\,\frac{\alpha-1}{\alpha}}$. After substituting these equivalents in the equation above, we obtain:

$$\frac{dLn(\tilde{y})}{dt} = \alpha\cdot\left[\gamma\cdot s\cdot e^{\frac{\alpha-1}{\alpha}\cdot Ln(\tilde{y})} - (n+\delta+x)\right] \equiv \emptyset\big(Ln(\tilde{y})\big) \qquad (4.8)$$

The right hand side of equation (4.8) depends only on $Ln(\tilde{y})$. Hence, we may define $\emptyset\big(Ln(\tilde{y})\big)$ as a short hand representation of it.

Recall that our aim is to derive an equation that fits for empirical convergence analysis. To this end, we need to use a linear regression equation. However, the differential equation given above does not fit, as it is not linear. Because of this, it should be linearized. A widely used linearization method is *log-linearization*. The last written equation above is the explicit form of the function $\emptyset(Ln(\tilde{y}))$. This function can be log-linearized by the approximation method of Taylor (1712).[19]

[19] Taylor's theorem gives an approximation of a k-times differentiable function around a given point by a k[th] order Taylor-polynomial. It is one of the central elementary tools in mathematical analysis. For analytic functions the Taylor polynomials at a given point are finite order truncations of its Taylor's series, which completely determines the function in some neighborhood of the point. The Taylor Approximation of a function f(x) is defined as follows: Let $k \geq 1$ be an integer and let the function f: **R** → **R** be k times differentiable at the point $a \in$ **R**. Then there exists a function h_k: **R** → **R** such that

$$f(x) = \sum_{i=1}^{k}\frac{f^{(i)}(a).(x-a)^i}{i!} + h_k(x).(x-a)^k, \ \lim_{x\to a} h_k(x) = 0.$$

Taylor's theorem is defined at k[th] order in its original theorem. Since we need to linearize the equation, we will use 1[st] order Taylor approximation.

In the differential equation above, equation (4.8), while applying 1[st] order Taylor approximation, the approximated function will be $\emptyset(Ln(\tilde{y}))$ and the fixed point will be steady state value $\tilde{y}_{ss}$. The general form of the approximation is as follows:

$$\frac{dLn(\tilde{y})}{dt} \approx \emptyset\big(Ln(\tilde{y}_{ss})\big) + \emptyset'\big(Ln(\tilde{y}_{ss})\big) \cdot \big(Ln(\tilde{y}) - Ln(\tilde{y}_{ss})\big)$$

The steps are defined already in the equation above. Firstly, the steady state value of function $\emptyset\big(Ln(\tilde{y})\big)$, and secondly the first-order derivative of $\emptyset\big(Ln(\tilde{y})\big)$ with respect to $Ln(\tilde{y})$ at steady state value $\tilde{y}_{ss}$ should be found.

The first step is to find the steady-state value of $\emptyset\big(Ln(\tilde{y})\big)$. The steady state value of Cobb-Douglas production function is $\tilde{y}_{ss} = \left(\frac{\gamma \cdot s}{n+x+\delta}\right)^{\frac{\alpha}{1-\alpha}}$. If we substitute this value into the function $\emptyset\big(Ln(\tilde{y})\big)$, we find that:

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

$$= \alpha \cdot \left[\gamma \cdot s \cdot e^{-Ln\left(\frac{\gamma \cdot s}{n+x+\delta}\right)} - (n+\delta+x)\right]$$

$$= \alpha \cdot \left[\gamma \cdot s \cdot \frac{n+x+\delta}{\gamma \cdot s} - (n+\delta+x)\right]$$

$$= \alpha \cdot [(n+\delta+x) - (n+\delta+x)] = 0$$

The second step is to find the first derivative value $\emptyset'\left(Ln(\tilde{y}\ )\right)$:

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

$$= \alpha \cdot \left[\gamma \cdot s \cdot \frac{\alpha-1}{\alpha} \cdot \tilde{y}^{\frac{\alpha-1}{\alpha}}\right]$$

Then, imposing the steady state value of $\tilde{y}_{ss}$ on the first-order derivative yields:

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

$$= \alpha \cdot \left[\gamma \cdot s \cdot \frac{\alpha-1}{\alpha} \cdot \frac{n+x+\delta}{\gamma \cdot s}\right]$$

$$= -(1-\alpha) \cdot (n+x+\delta)$$

If we substitute the values$\emptyset\left(Ln(\tilde{y}_{ss})\right)$ and $\emptyset'\left(Ln(\tilde{y}_{ss})\right)$ in the Taylor approximation, we obtain the following equation, which explains the growth rate of an economy:

$$\frac{dLn(\tilde{y})}{dt} \approx -(1-\alpha)(n+x+\delta) \cdot \left(Ln(\tilde{y}) - Ln(\tilde{y}_{ss})\right) \qquad (4.9)$$

The speed of convergence, β, measures how rapidly an economy's output per effective worker approaches to its steady state value.

$$\beta = -\frac{\frac{d\hat{\tilde{y}}}{dt}}{\frac{dLn(\hat{\tilde{y}})}{dt}} = -\frac{d\hat{\tilde{y}}}{dLn(\hat{\tilde{y}})} \approx -v$$

In equation (4.9) above, we have output per effective worker. But to use it in econometric applications, we need to express it in only per worker. This unit of measure does fit for empirical research. For conversion, let us first define $z = Ln(\tilde{y})$ and $b = v \cdot Ln(\tilde{y}_{ss})$. Then, we will obtain the following differential equation:

$$\dot{z} = -v \cdot z + b$$

This differential equation can be solved with the integrating factor method as follows: [20]

$$\{\dot{z} = -v \cdot z + b\} \cdot e^{vt}$$

$$z \cdot e^{vt} + v \cdot z \cdot e^{vt} = b \cdot e^{vt}$$

$$\frac{d}{dt}(z \cdot e^{vt}) = b \cdot e^{vt}$$

$$d(z \cdot e^{vt}) = b \cdot\ e^{vt} \cdot dt$$

$$z \cdot e^{vt} = \int b \cdot\ e^{vt} \cdot dt$$

$$z \cdot e^{vt} = \frac{b}{v} \cdot e^{vt} + const$$

$$z(t) = \frac{b}{v} + const \cdot e^{-vt}$$

$$Ln(\tilde{y}) = \frac{v \cdot Ln(\tilde{y}_{ss})}{v} + const \cdot e^{-vt}$$

$$Ln(\tilde{y}(t)) = Ln(\tilde{y}_{ss}) + const \cdot e^{-vt}$$

[20] If a differential equation in the form $\frac{dy}{dx} + P(x).y = Q(x)$ is homogeneous and seperable, it is very convenient to solve it. Clearly, the more interesting problems are those for which *Q(x)* is not the zero function. In addition to their applicability to significant problems, linear first-order equations are nice because you can always solve them explicitly and find the general solution. This is done by a clever technique, the use of something called an **integrating factor**—a special multiplier function that has been used to solve first-order linear equations since the late 1600s.

To find constant value in the equation, we should solve it for its initial value:

$$Ln(\tilde{y}(0)) = Ln(\tilde{y}_{ss}) + const$$

Then we can write the equation as follows:

$$Ln\big(\tilde{y}(t)\big) = Ln(\tilde{y}_{ss}) + (Ln\big(\tilde{y}(0) - Ln(\tilde{y}_{ss})\big) \cdot e^{-vt}$$

$$Ln\big(\tilde{y}(t)\big) = Ln\big(\tilde{y}(0)\big) \cdot e^{-vt} + Ln(\tilde{y}_{ss}) \cdot (1 - e^{-vt})$$

$$Ln\big(\tilde{y}(t)\big) - Ln\big(\tilde{y}(0)\big) = Ln\big(\tilde{y}(0)\big) \cdot (e^{-vt} - 1) + Ln(\tilde{y}_{ss}) \cdot (1 - e^{-vt})$$

$$Ln\left(\frac{Y(t)}{A(t)\cdot L(t)}\right) - Ln\left(\frac{Y(0)}{A(0)\cdot L(0)}\right) = Ln\left(\frac{Y(0)}{A(0)\cdot L(0)}\right) \cdot (e^{-vt} - 1) + Ln\left(\frac{\gamma \cdot s}{n+\delta+x}\right)^{\frac{\alpha}{1-\alpha}} \cdot (1 - e^{-vt})$$

$$Ln\left(\frac{Y(t)}{L(t)}\right) - Ln\left(\frac{Y(0)}{L(0)}\right) - Ln\big(A(t)\big) + Ln\,(A(0)) = \left(Ln\left(\frac{Y(0)}{L(0)}\right) - Ln(A(0))\right) \cdot (e^{-vt} - 1) + Ln\left(\frac{\gamma \cdot s}{n+\delta+x}\right)^{\frac{\alpha}{1-\alpha}} \cdot (1 - e^{-vt})$$

$$Ln\left(\frac{Y(t)}{L(t)}\right) - Ln\left(\frac{Y(0)}{L(0)}\right) - Ln\big(A(0)\big) - x \cdot t + Ln\,(A(0)) = \left(Ln\left(\frac{Y(0)}{L(0)}\right) - Ln(A(0))\right) \cdot (e^{-vt} - 1) + Ln\left(\frac{\gamma \cdot s}{n+\delta+x}\right)^{\frac{\alpha}{1-\alpha}} \cdot (1 - e^{-vt})$$

$$Ln\left(\frac{Y(t)}{L(t)}\right) - Ln\left(\frac{Y(0)}{L(0)}\right)$$

$$= x \cdot t + (1 - e^{-vt}) \cdot Ln\big(A(0)\big) - (1 - e^{-vt})$$

$$\cdot Ln\left(\frac{Y(0)}{L(0)}\right) + \frac{\alpha}{1-\alpha} \cdot Ln\left(\frac{\gamma \cdot s}{n + \delta + x}\right) \cdot (1 - e^{-vt})$$

$$Ln\left(\frac{Y(t)}{L(t)}\right) - Ln\left(\frac{Y(0)}{L(0)}\right) = \beta_0 - \beta_1 \cdot Ln\left(\frac{Y(0)}{L(0)}\right) + \beta_2 \cdot Ln(s) + \beta_2 \cdot Ln(\gamma) - \beta_2 \cdot Ln(n + \delta + x)$$

(4.10)

where $\beta_0 = x \cdot t + (1 - e^{-vt})$, $\beta_1 = (1 - e^{-vt})$, $\beta_2 = \frac{\alpha}{1-\alpha} \cdot (1 - e^{-vt})$.

The convergence equation derived above will be used in econometric application in Chapter 7 for panel data of emerging countries. Theoretically the equation's parameters are consistent. In particular, the way the effectiveness of financial sector γ takes place in the equation does make sense. Moreover, it is expected in the econometric application that the expected signs for parameters will be satisfied.

CHAPTER 5

CONVERGENCE UNDER IMPERFECT FINANCIAL SECTOR: RAMSEY MODEL

5.1. INTRODUCTION

This chapter undertakes the long run and convergence implications of imperfect financial sector on economic growth based on Ramsey growth model. In the next section, we will undertake theoretical derivations.

In Chapter 4, we developed a model describing the role of financial efficiency on economic growth by neoclassical (Solovian) growth model, tested it empirically and obtained some consistent results. In this chapter, this investigation is carried on within the Ramsey framework. There are some incentives for us to enhance a theoretical model in this framework and conduct an empirical research.

First of all, although Solow model has so many advantages in theoretical and empirical studies, as it is stated in Chapter 4, it has certain shortcomings. One of them is the exogenity of the savings rate, accordingly the ratio of savings to the gross domestic product. The model is not convenient for consumers to perform optimal decision-making and behave in this direction. In this framework, examination of the incentives' influence on the behavior of economy is not possible. In other words, in an economy, changes in interest rates, tax rates and other variables affect the behavior of the households, but neoclassical growth model does not enable us to observe these reactions.

Second, Ramsey framework provides a more detailed and solid theoretical background of economic growth process. It extends the Solow growth model by describing a path of consumption and determination of the saving rate with the help of optimization process between firms and households. It helps to express clearly the average level of saving rate and specify the direction of saving rate as the development of economy occurs. The conditions of optimization in Ramsey model prevent the inefficient over-saving that is possible in Solovian framework, but cannot prevent undersaving. Besides all these advantages, in this model the technology is also a given parameter, i.e. it is exogenous.

Our model investigates the financial efficiency concept and defines it by the proportion of savings of economy transferred to investment. The investigation may be worthwhile in Ramsey framework where this savings is not given to the model, i.e. it is derived by the optimization of firms and households with a budget constraint. It is also interesting to observe the effect of endogenous saving rates on transitional dynamics, i.e. the speed of convergence to the steady state. The endogenity of savings rate may also be beneficial for future extension of this model considering the possible policies.

5.2. THE MODEL

The overall utility in Ramsey framework is written as:

$$U(c_t) = \int_0^\infty e^{-\rho t} \cdot L_t \cdot u(c_t) dt \tag{5.1}$$

where $U(c_t)$ is overall utility, c_t, is per capita consumption, $u(c_t)$ is momentary utility, ρ is subjective rate of discount and $L_t = e^{nt}$ is population of a household, and

n is the population growth rate. We assume that population and number of workers are identical, unless stated otherwise.

In this chapter, we will use the social planner solution to construct our theoretical model.[21] In this framework, since it is an optimization problem, there exists a budget constraint. This constraint consists of Gross Domestic Product which has the form of Cobb-Douglas production function. It decreases by the consumption of households and the depreciation of the capital. It has the form stated below:

$$\dot{K} = K^{\alpha}(AL)^{1-\alpha} - c \cdot L - \delta K$$

We assume that financial efficiency is defined as in the previous chapter. Namely, we assume that only γ percent of gross saving is channeled to investment and hence $1 - \gamma$ is hold under-mattress. Each household aims to maximize its utility with respect to budget constraint under imperfect financial sector:

$$\begin{aligned} &\text{Maximize } U(c_t) = \int_0^{\infty} e^{-(\rho-n)t} u(c_t)\, dt \\ &subject\ to\ \gamma \cdot (K^{\propto}(AL)^{1-\propto} - c \cdot L) = \delta K + \dot{K} \end{aligned} \quad (5.2)$$

This is a dynamic constrained nonlinear optimization problem, which maximizes the utility of a household subject to budget constraint. Such dynamic problems of finding a control law for a given system such that a certain optimality criterion is achieved, can be solved by using Optimal Control Theory. This theory is an extension of the calculus of variations, a mathematical optimization method for deriving control policies.

[21] It is necessary to state that this method gives the same results with the market solution.

To solve the problem, the first step is to look at the sufficient conditions of Optimal Control Theory (for simplicity of framework, we ignored the necessary condition). So, we write the Hamiltonian equation as:

$$H = e^{-(\rho-n)t} \cdot \frac{c^{1-\theta}-1}{1-\theta} + \lambda\{\gamma \cdot (K^{\alpha}(A \cdot L)^{1-\alpha} - c \cdot L) - \delta \cdot K\} \tag{5.3}$$

The conditions for control (c), state (K) and co-state (λ) variables are stated below respectively:

$$\frac{\partial H}{\partial c} = 0 \Rightarrow e^{-(\rho-n)t} \cdot c^{-\theta} - \lambda \cdot \gamma \cdot e^{nt} = 0 \tag{5.4a}$$

$$\dot{\lambda} = -\frac{\partial H}{\partial K} \Rightarrow \dot{\lambda} = -\lambda \cdot (\gamma \cdot \alpha \cdot K^{\alpha-1}(AL)^{1-\alpha} - \delta) \tag{5.4b}$$

$$\dot{K} = \frac{\partial H}{\partial \lambda} \Rightarrow \dot{K} = \gamma \cdot (K^{\propto}(AL)^{1-\propto} - c \cdot L) - \delta \cdot K \tag{5.4c}$$

We may easily reduce the number of differential equation into two. To this end, let us first take the log differential of equation (5.4a):

$$-\rho - \theta \cdot \frac{\dot{c}}{c} = \gamma \cdot \frac{\dot{\lambda}}{\lambda} \Rightarrow \frac{\dot{c}}{c} = -\frac{1}{\theta} \cdot \left(\frac{\dot{\lambda}}{\lambda} + \rho\right) \tag{5.5}$$

Next, we substitute $\frac{\dot{\lambda}}{\lambda}$ into equation (4.5) and obtain the following differential equation:

$$\frac{\dot{c}}{c} = \frac{1}{\theta} \cdot \left(\gamma \cdot \alpha \cdot \tilde{k}^{\alpha-1} - \delta - \rho\right) \tag{5.6}$$

Equations (5.6) and (5.4c) construct the differential equation system. Before we study the solution of the model, it may be useful to transform these equations into per efficient capita to obtain a system that has a steady state. Let us define physical capital per efficient capita and consumption per efficient capita as follows:

$$\tilde{k} = \frac{K}{A.L}; \quad \tilde{c} = \frac{c}{A.L}$$

The latter implies the following:

$$\tilde{c} \cdot A = c \Rightarrow \tilde{c} \cdot e^{x \cdot t} = c \Rightarrow \dot{c} = \dot{\tilde{c}} \cdot e^{x \cdot t} + x \cdot \tilde{c} \cdot e^{x \cdot t} \Rightarrow \frac{\dot{c}}{c} = \frac{\dot{\tilde{c}}}{\tilde{c}} + x$$

If we rewrite equation above with the relation above, we obtain two differential equations of consumption per efficient capita and physical capital per efficient capita are as follows:

$$\frac{\dot{\tilde{c}}}{\tilde{c}} = \frac{1}{\theta}\left(\gamma \cdot \alpha \cdot \tilde{k}^{\alpha-1} - \delta - \rho - \theta \cdot x\right) \qquad (5.7a)$$

$$\dot{\tilde{k}} = \gamma \cdot \left(\tilde{k}^{\alpha} - \tilde{c}\right) - (n + x + \delta) \cdot \tilde{k} \qquad (5.7b)$$

We know from standard Ramsey model that the framework has a long-run equilibrium. As the way we introduced financial imperfectness does not change the qualitative nature of the model, the fact that the model yields a steady-state result should not change. Let us know show the long-run equilibrium values of $\tilde{c}$ and $\tilde{k}$. At steady-state, the equation of motion of consumption per efficient capita would be as follows:

$$\frac{\dot{\tilde{c}}_{ss}}{\tilde{c}_{ss}} = \frac{1}{\theta}\left(\gamma \cdot \alpha \cdot \tilde{k}_{ss}^{\alpha-1} - \delta - \rho - \theta \cdot x\right)$$

By definition, the growth rate of variables must be constant at the steady-state, which implies that the left hand side of the equation above should be zero, if there is a steady-state. Let us now take the time derivative of both sides:

$$\frac{d}{dt}\left(\frac{\dot{\tilde{c}}_{ss}}{\tilde{c}_{ss}}\right) = 0 \Rightarrow \frac{d}{dt}\left(\frac{1}{\theta}\left(\gamma \cdot \alpha \cdot \tilde{k}_{ss}^{\alpha-1} - \delta - \rho - \theta \cdot x\right)\right) = 0 \Rightarrow$$

$$\frac{1}{\theta}\left(\gamma \cdot \alpha \cdot \tilde{k}_{ss}^{\alpha-1} \cdot \frac{\dot{\tilde{k}}_{ss}}{\tilde{k}_{ss}}\right) = 0 \Rightarrow \dot{\tilde{k}}_{ss} = 0$$

We follow the same procedure for the equation of motion of capital per efficient capita at the steady state:

$$\frac{\dot{\tilde{k}}_{ss}}{\tilde{k}_{ss}} = \gamma \cdot \left(\tilde{k}_{ss}^{\alpha-1} - \frac{\tilde{c}_{ss}}{\tilde{k}_{ss}}\right) - (n + x + \delta)$$

$$\frac{d}{dt}\left(\frac{\dot{\tilde{k}}_{ss}}{\tilde{k}_{ss}}\right) = 0 \Rightarrow \frac{d}{dt}\left(\gamma \cdot \left(\tilde{k}_{ss}^{\alpha-1} - \frac{\tilde{c}_{ss}}{\tilde{k}_{ss}}\right) - (n + x + \delta)\right) = 0 \Rightarrow$$

$$\gamma \cdot (\alpha - 1) \cdot \tilde{k}_{ss}^{\alpha-1} \cdot \frac{\dot{\tilde{k}}_{ss}}{\tilde{k}_{ss}} - \left(\frac{\dot{\tilde{c}}_{ss} \cdot \tilde{k}_{ss} - \tilde{c}_{ss} \cdot \dot{\tilde{k}}_{ss}}{\tilde{k}_{ss}{}^{2}}\right) = 0 \Rightarrow$$

$$\frac{\dot{\tilde{c}}_{ss} \cdot \tilde{k}_{ss}}{\tilde{k}_{ss}{}^{2}} = 0 \Rightarrow \dot{\tilde{c}}_{ss} = 0$$

Then, we solve both equations with the obtained information and find the steady state values as follows:

$$0 = \frac{1}{\theta}\left(\gamma \cdot \alpha \cdot \tilde{k}_{ss}^{\alpha-1} - \delta - \rho - \theta \cdot x\right) \Rightarrow$$

$$\tilde{k}_{ss} = \left(\frac{\gamma \cdot \alpha}{\delta + \rho + \theta \cdot x}\right)^{\frac{1}{1-\alpha}} \qquad (5.8a)$$

$$0 = \gamma \cdot \left(\tilde{k}_{ss}^{\alpha-1} - \frac{\tilde{c}_{ss}}{\tilde{k}_{ss}}\right) - (n + x + \delta) \Rightarrow$$

$$\tilde{c}_{ss} = \left(\frac{\delta+\rho+\theta\cdot x}{\alpha} - (n + x + \delta)\right) \cdot \tilde{k}_{ss} \tag{5.8b}$$

Both of these solutions do show that the degree of financial efficiency has a positive impact on steady state capital $\tilde{k}_{ss}$ and steady state consumption $\tilde{c}_{ss}$. In particular, it is straightforward to show by taking first order derivatives:

$$\frac{\partial \tilde{k}_{ss}}{\partial \gamma} = \left(\frac{\gamma\cdot\alpha}{\delta+\rho+\theta\cdot x}\right)^{\frac{1}{1-\alpha}} \cdot \frac{\alpha}{\delta+\rho+\theta\cdot x} > 0$$

$$\frac{\partial \tilde{c}_{ss}}{\partial \gamma} = \left(\frac{\delta+\rho+\theta\cdot x}{\alpha} - (n + x + \delta)\right) \cdot \frac{\partial \tilde{k}_{ss}}{\partial \gamma} > 0$$

5.2.1 THE ROLE OF FINANCIAL EFFICIENCY IN LONG RUN

In this subsection, as we did in Chapter 4, we will research into the role of financial efficiency in the long run based upon the Ramsey framework and perform the theoretical derivations as needed.

We will go along with the similar steps as the Solovian framework to conduct this research. Primarily, steady state equation of income per capita $\tilde{y}_{ss}$ will be presented with the help of the equation (5.8a) which gives the steady state value of capital $\tilde{k}_{ss}$:

$$\tilde{y}_{ss} = \tilde{k}_{ss}^{\alpha} \quad \Rightarrow \quad \tilde{y}_{ss} = \left(\frac{\gamma \cdot \alpha}{\delta + \rho + \theta \cdot x}\right)^{\frac{\alpha}{1-\alpha}}$$

The second step is to express steady state value of $\tilde{y}_{ss}$ in per worker form, since it is expressed in per effective worker and this expression is not useful in empirical analysis:

$$y_{ss} = A(0) \cdot e^{x \cdot t} \cdot \tilde{y}_{ss} \quad \Rightarrow$$

$$y_{ss} = A(0) \cdot e^{x \cdot t} \cdot \left(\frac{\gamma \cdot \alpha}{\delta + \rho + \theta \cdot x}\right)^{\frac{\alpha}{1-\alpha}}$$

After taking the natural logarithm of both sides, we obtain the following equation which represents the determinants of long-run economic growth in Ramsey framework. In our context, we especially focus on the effect of financial efficiency:

$$Ln(y_{ss}) = Ln\left(A(0)\right) + x \cdot t + \frac{\alpha}{1-\alpha} \cdot Ln(\gamma) - \frac{\alpha}{1-\alpha} \cdot Ln(\delta + \rho + \theta \cdot x) \qquad (5.9)$$

The equation above is the basic representation of our investigation, which aims to ascertain the role of financial efficiency in the long-run. From this simple equation, it can be interpreted as the financial efficiency has also positive effect on the economic growth in Ramsey framework. In the next subsection, the role of financial efficiency in convergence will be analyzed.

5.2.2 THE ROLE OF FINANCIAL EFFICIENCY IN CONVERGENCE

After obtaining the steady state solutions, we need to find the behavior of growth rate and other variables along the transitional path from initial factor value to the steady state value. The procedure is the same as we apply in the Solow framework. However, we have two variables, i.e. two differential equations in the Ramsey model. So we need to work on both of them simultaneously.

First of all, we write equations in (5.8) in growth form:

$$\frac{\dot{\tilde{c}}}{\tilde{c}} = \frac{1}{\theta}\left(\gamma \cdot \alpha \cdot \tilde{k}^{\alpha-1} - \delta - \rho - \theta \cdot x\right) \tag{5.10a}$$

$$\frac{\dot{\tilde{k}}}{\tilde{k}} = \gamma \cdot \left(\tilde{k}^{\alpha-1} - \frac{\tilde{c}}{\tilde{k}}\right) - (n + x + \delta) \tag{5.10b}$$

Next, we express equations in (5.10) in logarithmic form:

$$\frac{dLn(\tilde{c})}{dt} = \frac{1}{\theta}\left(\gamma \cdot \alpha \cdot e^{-(1-\alpha)\cdot Ln(\tilde{k})} - (\delta + \rho + \theta \cdot x)\right)$$

$$\equiv \emptyset_2(Ln(\tilde{c}), Ln(\tilde{k})) \tag{5.11a}$$

$$\frac{dLn(\tilde{k})}{dt} = \gamma \cdot \left(e^{-(1-\alpha)\cdot Ln(\tilde{k})} - e^{Ln(\frac{\tilde{c}}{\tilde{k}})}\right) - (n + x + \delta)$$

$$\equiv \emptyset_3(Ln(\tilde{c}), Ln(\tilde{k})) \tag{5.11b}$$

As one may notice, the right hand sides of equations in (5.11) can compactly be expressed in terms of $Ln(\tilde{c})$ and $Ln(\tilde{k})$. Now, as we did in Chapter 4, we may use the Taylor's approximation method to linearize the system of equations:

$$\frac{dLn(\tilde{c})}{dt} = \emptyset_2\left(Ln(\tilde{c}_{ss}), Ln(\tilde{k}_{ss})\right) + \frac{\partial \emptyset_2\left(Ln(\tilde{c}_{ss}), Ln(\tilde{k}_{ss})\right)}{\partial Ln(\tilde{c}_{ss})} \cdot (Ln(\tilde{c}) - Ln(\tilde{c}_{ss}) +$$

$$\frac{\partial \emptyset_2\left(Ln(\tilde{c}_{ss}), Ln(\tilde{k}_{ss})\right)}{\partial Ln(\tilde{k}_{ss})} \cdot \left(Ln(\tilde{k}) - Ln(\tilde{k}_{ss}\right)$$

If we substitute $\tilde{c}_{ss}$ and $\tilde{k}_{ss}$, we get

$$\frac{dLn(\tilde{c})}{dt} = 0 + 0 \cdot (Ln(\tilde{c}) - Ln(\tilde{c}_{ss}) + \left\{\frac{1}{\theta} \cdot \left(-\gamma \cdot \alpha \cdot (1-\alpha) \cdot e^{-(1-\alpha)\cdot Ln(\tilde{k})}\right)\right\}\Big|_{\tilde{c}_{ss},\tilde{k}_{ss}} \cdot$$

$$(Ln(\tilde{k}) - Ln(\tilde{k}_{ss})$$

$$\frac{dLn(\tilde{k})}{dt} = \emptyset_3\left(Ln(\tilde{c}_{ss}), Ln(\tilde{k}_{ss})\right) + \frac{\partial\emptyset_3\left(Ln(\tilde{c}_{ss}), Ln(\tilde{k}_{ss})\right)}{\partial Ln(\tilde{c}_{ss})} \cdot (Ln(\tilde{c}) - Ln(\tilde{c}_{ss}) +$$

$$\frac{\partial\emptyset_3\left(Ln(\tilde{c}_{ss}), Ln(\tilde{k}_{ss})\right)}{\partial Ln(\tilde{k}_{ss})} \cdot (Ln(\tilde{k}) - Ln(\tilde{k}_{ss})$$

If we substitute $\tilde{c}_{ss}$ and $\tilde{k}_{ss}$, we get

$$\frac{dLn(\tilde{k})}{dt} = 0 + \left\{-\gamma \cdot \frac{\tilde{c}}{\tilde{k}}\right\}\Big|_{\tilde{c}_{ss},\tilde{k}_{ss}} \cdot (Ln(\tilde{c}) - Ln(\tilde{c}_{ss}) + \left\{\gamma \cdot \left(-(1-\alpha) \cdot e^{-(1-\alpha)\cdot Ln(\tilde{k})} +\right.\right.$$

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Hence, we obtain the following system of equations written in matrix form:

$$\begin{bmatrix} \frac{dLn(\tilde{c})}{dt} \\ \frac{dLn(\tilde{k})}{dt} \end{bmatrix} = \begin{bmatrix} 0 & -(1-\alpha) \cdot \frac{\delta+\rho+\theta\cdot x}{\theta} \\ \gamma \cdot \left((n+x+\delta) \cdot -\frac{\delta+\rho+\theta\cdot x}{\alpha}\right) & \varphi \end{bmatrix} \cdot \begin{bmatrix} (Ln(\tilde{c}) - Ln(\tilde{c}_{ss})) \\ (Ln(\tilde{k}) - Ln(\tilde{k}_{ss})) \end{bmatrix}$$

(5.12)

where $\varphi = \gamma \cdot \left(\left(1 - \frac{(1-\alpha)}{\gamma}\right) \cdot \left(\frac{\delta+\rho+\theta\cdot x}{\alpha}\right) - (n+x+\delta)\right)$

The determinant of the characteristic matrix of the system of equations equals

$$\gamma \cdot \left[(n + x + \delta) - \frac{\delta + \rho + \theta \cdot x}{\alpha}\right] \cdot (1 - \alpha) \cdot \frac{\delta + \rho + \theta \cdot x}{\theta}$$

We need to look at the sign of the characteristics matrix to check the saddle path stability. Since $n + x < \rho + \theta \cdot x$ (from the transversality condition) and $0 < \alpha, \gamma < 1$, the determinant is negative. This condition gives us a concrete result that two eigen-values of the system have opposite signs. This result is similar to original Ramsey model results. In other words, we found that our model, an extension of the Ramsey model with financial imperfection, has also saddle path stability.

Since the differential equation (5.12) consists of matrices, to express the matrix operations we will perform easily, we will need some definitions such as:

$$y = \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} Ln[\tilde{c}] \\ Ln[\tilde{k}] \end{bmatrix}, \quad \dot{y} = \begin{bmatrix} \dot{y}_1 \\ \dot{y}_2 \end{bmatrix} = \begin{bmatrix} \frac{dLn[\tilde{c}]}{dt} \\ \frac{dLn[\tilde{k}]}{dt} \end{bmatrix},$$

$$A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} = \begin{bmatrix} 0 & -(1 - \alpha) \cdot \frac{\delta+\rho+\theta \cdot x}{\theta} \\ \gamma \cdot \left((n + x + \delta) \cdot - \frac{\delta+\rho+\theta \cdot x}{\alpha}\right) & \varphi \end{bmatrix};$$

$$y_{ss} = -\begin{bmatrix} y_{1,ss} \\ y_{2,ss} \end{bmatrix} = -\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \cdot \begin{bmatrix} Ln[\tilde{c}_{ss}] \\ Ln[\tilde{k}_{ss}] \end{bmatrix}.$$

Thus we can express the differential equation (5.12) in compact form as stated below:

$$\dot{y} = A \cdot y + y_{ss} \tag{5.13}$$

The equation (5.13) is a linearized differential equation. However, the solution of the system is not as simple as of the Solow framework. In Solow model, since we have studied with one equation, the method is so straightforward. Here, we have a system of equations and we will use the method of *diagonalization* to find the solutions and speed of convergence.

The solution of the linearized differential equation (5.13) is performed with the help of matrix operations. Assume that an invertible nxn matrix V is defined and we can write an equation as $y = V \cdot z$ (or we can show it as $z = V^{-1} \cdot y$). Since the matrix V consists of constant values, the matrix equation of log-differentiated variables should be written as in form of $\dot{y} = V \cdot \dot{z}$ or $\dot{z} = V^{-1} \cdot \dot{y}$.

If we multiply both sides of the equation (5.13) by V^{-1}, we obtain the following equation:

$$V^{-1} \cdot \dot{y} = V^{-1} \cdot A \cdot y + V^{-1} \cdot y_{ss} \Rightarrow \dot{z} = V^{-1} \cdot A \cdot V \cdot z + V^{-1} \cdot y_{ss}$$

If we define $D = V^{-1} \cdot A \cdot V$ and $y'_{ss} = V^{-1} \cdot y_{ss}$, the equation (5.13) will have the following form:

$$\dot{z} = D \cdot z + y'_{ss} \tag{5.14}$$

According to the foundations of linear algebra, the matrix A and $D = V^{-1} \cdot A \cdot V$ have the same eigenvalues.[22] According to the theorem of linear algebra:

If there is a relationship between the between the invertible nxn matix V and the diagonal matrix D such as $D = V^{-1} \cdot A \cdot V$, then nxn matrix A is diagonalizable.

[22] For the proof, see any advanced level linear algebra textbook.

The theorem of linear algebra also states the conditions of diagonalization of the matrix A:

If nxn A matrix has n linearly independent eigenvector set, this matrix is *diagonalizable.*

We can infer that:

In the equation $V^{-1} \cdot A \cdot V = D$ each column of the matrix V will be the eigenvector of the matrix A.

We can find the eigenvalues and eigenvectors of the matrix D with the help of the matrix A. (Since they have the same eigenvalues and eigenvectors). We have the following theorem stated above:

If we have a scalar d and an equation such as $A \cdot x = d \cdot x$, then d is the eigenvalue and x is eigenvector of A

To find the eigenvalues of the matrix A, the equation above can be rewritten as

$(A - d \cdot I) \cdot x = 0$,where I is identity matrix.

Since $x = 0$ is not desired condition (if so, there is a trivial solution), the equation above will be valid if the value of the determinant is zero: $|A - d \cdot I| = 0$.

In our case

$$A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} = \begin{bmatrix} 0 & -(1-\alpha) \cdot \frac{\delta+\rho+\theta\cdot x}{\theta} \\ \gamma \cdot \left((n+x+\delta) \cdot -\frac{\delta+\rho+\theta\cdot x}{\alpha}\right) & \varphi \end{bmatrix}$$

$$|A - d \cdot I| = \begin{vmatrix} -d & -(1-\alpha) \cdot \frac{\delta+\rho+\theta \cdot x}{\theta} \\ \gamma \cdot \left((n + x + \delta) \cdot - \frac{\delta+\rho+\theta \cdot x}{\alpha} \right) & \varphi - d \end{vmatrix} = 0$$

We can find the roots $d_{1,2}$ of this equation by the operation of discriminant as indicated below:

$$d_{1,2} = \frac{\varphi \mp \Delta^{1/2}}{2}$$

$$\Delta = \left[\varphi^2 - 4 \cdot \gamma \cdot \left(\frac{\rho+\theta \cdot x+\delta}{\alpha} - (n + x + \delta) \right) \left((\rho + \theta \cdot x + \delta) \cdot \frac{1-\alpha}{\theta} \right) \right],$$

$$\varphi = \gamma \cdot \left(\left(1 - \frac{(1-\alpha)}{\gamma} \right) \cdot \left(\frac{\delta + \rho + \theta \cdot x}{\alpha} \right) - (n + x + \delta) \right)$$

After finding eigenvalues $d_{1,2}$, we can find the eigenvectors by solving the the matrix equation $(A - d \cdot I) \cdot x = 0$:

$$\begin{bmatrix} a_{11} - d_1 & a_{12} \\ a_{21} & a_{22} - d_1 \end{bmatrix} \cdot \begin{bmatrix} x_{11} \\ x_{21} \end{bmatrix} = 0 \qquad \begin{bmatrix} a_{11} - d_2 & a_{12} \\ a_{21} & a_{22} - d_2 \end{bmatrix} \cdot \begin{bmatrix} x_{12} \\ x_{22} \end{bmatrix} = 0$$

Since the determinant of the matrix $(A - d \cdot I)$ is zero, these eigenvectors are linearly dependent. So, we can write the second row of the matrix k times the first row such as:

$$V = \begin{bmatrix} 1 & 1 \\ k_1 & k_2 \end{bmatrix} \qquad V^{-1} = \frac{1}{|V|} \begin{bmatrix} k_2 & -1 \\ -k_1 & 1 \end{bmatrix} \qquad |V| = k_2 - k_1$$

As we defined above, there is a relationship such as $D = V^{-1} \cdot A \cdot V$. After defining the value of $y'_{ss} = V^{-1} \cdot y_{ss}$, we obtain the following equation system:

$$\dot{z}_1 = d_1 \cdot z_1 + y'_{1,ss}$$
$$\dot{z}_2 = d_2 \cdot z_2 + y'_{2,ss} \tag{5.15}$$

We can solve this equation system by the integrating factor method and obtain the following solutions:

$$z_1(t) = \frac{y'_{1,ss}}{-d_1} + co_1 \cdot e^{d_1 \cdot t}$$
$$z_2(t) = \frac{y'_{2,ss}}{-d_2} + co_2 \cdot e^{d_2 \cdot t} \tag{5.16}$$

Lastly, from the assumption of $y = V \cdot z$, we can find the solutions of the original equation:

$$y_1(t) = \left(\frac{y'_{1,ss}}{-d_1} + \frac{y'_{2,ss}}{-d_2}\right) + co_1 \cdot e^{d_1 \cdot t} + co_2 \cdot e^{d_2 \cdot t}$$
$$y_2(t) = cons + (co_1 \cdot sbt) \cdot e^{d_1 \cdot t} + (co_2 \cdot sbt) \cdot e^{d_2 \cdot t} \tag{5.17}$$

where $cons = \left(k_1 \cdot \frac{y'_{1,ss}}{-d_1} + k_2 \cdot \frac{y'_{2,ss}}{-d_2}\right)$

The solution above is the general form. If we substitute our values in the solution, the solutions for $Ln(\tilde{c}_t)$ and $Ln(\tilde{k}_t)$ can be written as:

$$Ln(\tilde{c}_t) = Ln(\tilde{c}_{ss}) + co_1/k_1 \cdot e^{d_1 \cdot t} + co_2/k_2 \cdot e^{d_2 \cdot t} \tag{5.18a}$$

$$Ln(\tilde{k}_t) = Ln(\tilde{k}_{ss}) + co_1 \cdot e^{d_1 \cdot t} + co_2 \cdot e^{d_2 \cdot t} \tag{5.18b}$$

where co_1 and $co_2$are arbitrary constants.

Since we look the speed of convergence in GDP per capita, we will focus on the solution of the capital stock. Firstly, we need to define the convergence rate, v_2, (remember that convergence rate in Chapter 4 was v_1) which corresponds to e_2 in the equations above. In the solution, since $e_1 > 0$ and $co_1 = 0$ must hold for the system to become stable. The other constant, co_2 is determined from the initial condition:

$$co_2 = Ln(\tilde{k}_0) - Ln(\tilde{k}_{ss})$$

After substituting $co_1 = 0$ and the value of co_2 and $e_2 = -v_2$ as convergence rate, we obtain a time path for $\tilde{k}_t$:

$$Ln(\tilde{k}_t) = (1 - e^{-v_2 \cdot t}) \cdot Ln(\tilde{k}_{ss}) + e^{-v_2 \cdot t} \cdot Ln(\tilde{k}_0) \quad (5.19a)$$

Since $Ln(\tilde{y}_t) = \alpha \cdot Ln(\tilde{k}_t)$, the time path for $Ln(\tilde{y}_t)$ can be written as:

$$Ln(\tilde{y}_t) = (1 - e^{-v_2 \cdot t}) \cdot Ln(\tilde{y}_{ss}) + e^{-v_2 \cdot t} \cdot Ln(\tilde{y}_0) \quad (5.19b)$$

The equation above describes the behavior of output per effective worker in time. However, for empirical purposes, as we did in Chapter 4, we need output per worker. The steps are given as follows:

$$Ln(\tilde{y}(t)) - Ln(\tilde{y}(0)) = Ln(\tilde{y}(0)) \cdot (e^{-v_2 t} - 1) + Ln(\tilde{y}_{ss}) \cdot (1 - e^{-v_2 t})$$

$$Ln\left(\frac{Y(t)}{L(t)}\right) - Ln\left(\frac{Y(0)}{L(0)}\right) - Ln(A(t)) + Ln(A(0))$$

$$= \left(Ln\left(\frac{Y(0)}{L(0)}\right) - Ln(A(0))\right)$$

$$\cdot (e^{-v_2 t} - 1) + Ln\left(\frac{\gamma \cdot \alpha}{\delta + \rho + \theta \cdot x}\right)^{\frac{\alpha}{1-\alpha}} \cdot (1 - e^{-v_2 t})$$

$$Ln\left(\frac{Y(t)}{L(t)}\right) - Ln\left(\frac{Y(0)}{L(0)}\right) =$$

$$x \cdot t + (1 - e^{-v_2 t}) \cdot Ln\big(A(0)\big) -$$

$$(1 - e^{-v_2 t})Ln\left(\frac{Y(0)}{L(0)}\right) + \frac{\alpha}{1-\alpha} \cdot Ln\left(\frac{\gamma \cdot \alpha}{\delta + \rho + \theta \cdot x}\right) \cdot (1 - e^{-v_2 t})$$

In the last step we obtain our equation to use in empirical research as:

$$\left(\frac{Y(t)}{L(t)}\right) - Ln\left(\frac{Y(0)}{L(0)}\right) = \beta_0 - \beta_1 . Ln\left(\frac{Y(0)}{L(0)}\right) + \beta_2 . Ln(\gamma) - \beta_2 . Ln(\delta + \rho + \theta \cdot x) \qquad (5.20)$$

,where $\beta_0 = x.t + (1 - e^{-vt}) \cdot Ln\big(A(0)\big) + \frac{\alpha}{1-\alpha} \cdot Ln(\alpha)$, $\beta_1 = (1 - e^{-vt})$,

$\beta_2 = \frac{\alpha}{1-\alpha} . (1 - e^{-vt})$.

Besides some differences, we obtained similar findings with the Solow framework. Also, in this convergence equation the efficiency of final sector has positive effect on economic convergence. In our study of imperfect financial sector under Ramsey Model, where we deal with consumer optimization, the convergence is also conditional, not absolute, as we found in Solow model.

CHAPTER 6

CONVERGENCE UNDER IMPERFECT FINANCIAL SECTOR: THE SOLOVIANIZED ROMER MODEL

6.1. INTRODUCTION

In this chapter, we will investigate our research question, the influence of financial efficiency on the long run economic growth and on the convergence performance by using the Solovianized Romer framework which is constructed by Bayraktar-Sağlam and Yetkiner (2012). In the paper, they incorporate two strands of theoretical growth literature, fundamental growth theory of Solow (1956) and endogenous technological change model of Romer (1990). They make a great contribution to the convergence literature. To do this, Bayraktar-Sağlam and Yetkiner (2012) develop a convergence equation in which the rate of technological change can differ across countries based on characteristics of R&D sector. Moreover, since in the literature researchers treat human capital same as the physical capital and this has drawbacks, they take the human capital in more elegant way. As a result, they improved the study of Mankiw, Romer and Weil (1992). Since the research Bayraktar-Sağlam and Yetkiner (2012) has made an important contribution to the convergence literature, it is worth to investigate the financial efficiency in this framework.

6.2. THE MODEL

6.2.1 SOLOVIANIZED ROMER MODEL

Before developing our theoretical model based on this framework, let us define the model constructed in Bayraktar-Sağlam and Yetkiner (2012) in detail. First of all, following Romer (1990), they present the production technology of additive characteristics:

$$Y = H_Y^{1-\alpha} \cdot \sum_{i=1}^{A(t)} X_i^{\alpha} \qquad 0 < \alpha < 1 \qquad (6.1)$$

where Y is final good (GDP), H_Y is the number of human capital (skilled labor) used in final good production, $1 - \alpha$ is the production elasticity of human capital, X_i are intermediate goods and $A(t)$ is the number of intermediate goods produced at time t.

In addition, there is an assumption considering the allocation of human capital H_Y between the final good and R&D sector as follows:

$$H_Y = \theta_Y \cdot \bar{H} \text{ and } H_{R\&D} = \theta_{R\&D} \cdot \bar{H} \qquad (6.2)$$

where H_Y and $H_{R\&D}$ are numbers of human capital work in the final good and R&D sector respectively, θ_Y and $\theta_{R\&D}$ are shares of respective human capital, and $\bar{H}$ is the constant stock of human capital. There is an assumption of $\theta_Y + \theta_{R\&D} = 1$.

The difference of the model constructed in Bayraktar-Sağlam and Yetkiner (2012) is the allocation of human capital between the final good and R&D sector. In Romer (1990), the allocation is assumed to be endogenous. However, to be utilizable in empirical growth studies, i.e. in our dissertation, their assumption is the exogenous tradeoff. Hence, θ_Y and $\theta_{R\&D}$ are constant.

They define the profit function and make profit maximization for three sectors: final good, intermediate-good and R&D sector. First of all, for final good sector, they make perfect competition assumption and write profit equation as:

$$\Pi_Y = \overline{H} \cdot \left[\theta_Y^{1-\alpha} \cdot \sum_{i=1}^{A(t)} x_i^\alpha - w_Y \cdot \theta_Y - \sum_{i=1}^{A(t)} p_i \cdot x_i\right] \tag{6.3}$$

where x_i are intermediate goods in per capita, w_Y is the real wage for human capital in final good sector, and p_i is the cost of intermediate good i. The first order profit maximization conditions are found as:

$$\frac{\partial \Pi_Y}{\partial H_Y} = (1-\alpha) \cdot \theta_Y^{-\alpha} \cdot \sum_{i=1}^{A(t)} x_i^\alpha - w_Y = 0 \tag{6.4a}$$

$$\frac{\partial \Pi_Y}{\partial X_i} = \alpha \cdot \theta_Y^{1-\alpha} \cdot x_i^{\alpha-1} - p_i = 0 \qquad \forall i \tag{6.4b}$$

The given first order profit maximization conditions are inverse demand functions of skilled labor in final good sector and intermediate good i.

Then they define intermediate-good sector. The basic assumption in intermediate-good sector is the producers only use raw capital for intermediate good production. This can be depicted as $K_i = X_i$ (or $k_i = x_i$ in per capita), where K_i is amount of raw capital used in production of intermediate good i. Raw material has a rent cost of $r' = r + \delta$, where r is the real rate of interest and δ is depreciation. Another assumption is monopoly power of intermediate good producers since the patent of the product belongs to it. The sellers also face a downward-sloping demand curve (6.4b)

After the assumptions above, the profit maximization of the i^{th} monopolist is constructed as:

$$\Pi_Y = \overline{H} \cdot [p_i \cdot x_i - r' \cdot x_i] \tag{6.5}$$

The first order profit maximization condition can be written as:

$$\frac{\partial \Pi_i}{\partial p_i} = x_i + p_i \cdot \frac{dx_i}{dp_i} - r' \cdot \frac{dx_i}{dp_i} = 0 \qquad (6.6)$$

If we rearrange the equation (6.6), we obtain the following equation from the definition of elasticity:

$$p_i = r' \cdot \frac{e_{x_i}}{1 + e_{x_i}}$$

Since the price elasticity of intermediate good x_i $\left(e_{x_i}\right)$ is $\frac{1}{\alpha - 1}$ which can be obtained from the equation (6.4b), they find the identical price for maximizing the profit as follows:

$$p_i = p = \frac{r'}{\alpha} \qquad (6.7a)$$

After substituting the price information in equation (6.4b) they also find the identical quantities across intermediaries:

$$x_i = x = \theta_Y \cdot \left(\frac{\alpha^2}{r'}\right)^{\frac{1}{1-\alpha}} \qquad (6.7b)$$

Since the price and quantity is identical profit is also identical across intermediaries:

$$\pi_i = \pi = \frac{\Pi_i}{\bar{H}} = (1 - \alpha) \cdot \alpha \cdot \theta_Y^{1-\alpha} \cdot x^{\alpha} \qquad (6.7c)$$

Since the price, quantity and profit are identical across intermediaries, Sağlam and Yetkiner (2012) present the relationship between total amount of raw material and total amount of intermediate good as follows:

$$K = \sum_{i=1}^{A(t)} K_i = \sum_{i=1}^{A(t)} X_i = X \cdot A \text{ or } k = \sum_{i=1}^{A(t)} k_i = \sum_{i=1}^{A(t)} x_i = x \cdot A \tag{6.8}$$

Then they substitute this information in (5.1) and obtain an output equation in intermediate-good sector as:

$$y = \theta_Y^{1-\alpha} \cdot x^{\alpha} \cdot A \quad \text{or} \quad y = \theta_Y^{1-\alpha} \cdot k^{\alpha} \cdot A^{1-\alpha} \tag{6.9}$$

It can be seen that, in the steady state, y and k grow at the rate of A. The steady state value of r is discussed in R&D sector.

Bayraktar-Sağlam and Yetkiner (2012) define the knowledge production which is developed in Romer (1990), but the difference is the components are known. The knowledge production function is as follows:

$$\dot{A} = \eta \cdot H_{R\&D} \cdot A$$

From the equation (6.2), the growth rate of knowledge accumulation is stated below:

$$\hat{A} = \eta \cdot \theta_{R\&D} \cdot \overline{H} \equiv g$$

They assume that the R&D sector is a perfectly competitive sector. The profit equation can be written as:

$$\Pi_{\mathrm{R\&}D} = \mathrm{V}_{\mathrm{R\&}D} \cdot \eta \cdot H_{R\&D} \cdot A - w_{R\&D} \cdot H_{R\&D} \tag{6.10}$$

where $\mathrm{V}_{\mathrm{R\&}D}$ is the value of patent, η is the efficiency of R&D sector and $w_{R\&D}$ is the real wage rate in the R&D sector. The first order profit maximization condition can be written as follows:

$$\frac{\partial \Pi_{R\&D}}{\partial H_{R\&D}} = V_{R\&D} \cdot \eta \cdot A - w_{R\&D} = 0 \qquad (6.11)$$

Bayraktar-Sağlam and Yetkiner (2012) express $V_{R\&D}$ in a simple way to continue the research. The valuation of some asset is taking the present value of all cash flows it generates until its maturity. From this information, they define the value of a patent, $V_{R\&D}$, as the present value of all profits derived from this patent and its functional form is given as:

$$V_{R\&D,i}(t) = \int_1^{\infty} \pi \cdot L \cdot e^{-\int_t^{\tau} r(s)ds} \cdot d\tau = \frac{\pi(t)}{r(t)-n} = \frac{\bar{H} \cdot \pi(t)}{r(t)} \qquad (6.12)$$

where $\pi = \pi_i = \Pi_i / H$

$V_{R\&D,i}(t) \cdot r(t) = \bar{H} \cdot \pi(t)$ is an arbitrage rule which states that the value of the patent in the financial market at time t must be equal to the profit derived from the patent at time t. Since $\pi = \pi\,(r, \theta_t)$, this arbitrage rule is valid if r is constant, which is true at steady state. Then they substitute the value of $V_{R\&D}$ in the first order profit maximization condition, obtain the real wage rate in the R&D sector as:

$$w_{R\&D} = \frac{\bar{H} \cdot \pi(t)}{r(t)} \cdot \eta \cdot A \qquad (6.13)$$

6.2.2 MAIN MODEL

Now we can construct our model based on Solovianized Romer model of Bayraktar-Sağlam and Yetkiner (2012). Assume that consumption-saving tradeoff is exogenous within the Solow framework. This assumption will be incorporated with the model in Romer (1990). Recall again that perfect capital accumulation process is defined by:

$$\dot{K} = s \cdot Y - \delta \cdot K \tag{5.14}$$

However, if there is some financial inefficiency, that is $\gamma \cdot S = I$, and production function as in equation (6.1), we can substitute them in to the equation (6.11). The capital accumulation equation is obtained as follows:

$$\dot{K} = \gamma \cdot s \cdot H_Y^{1-\alpha} \cdot \sum_{i=1}^{A(t)} X_i^{\alpha} - \delta \cdot K \tag{6.15}$$

Since $\sum_{i=1}^{A(t)} X_i^{\alpha} = A \cdot x_i^{\alpha}$ by equation (6.8), we can rewrite the accumulation equation in the following form:

$$\dot{K} = \gamma \cdot s \cdot H_Y^{1-\alpha} \cdot A \cdot x_i^{\alpha} - \delta \cdot K$$

If the equation (6.15) expressed in efficient capital per human capital, $\tilde{k} = K/(A.\overline{H})$, after defining knowledge growth rate as $\hat{A} = \eta \cdot \theta_{R\&D} \cdot \overline{H}$:

$$\dot{\tilde{k}} = \gamma . s . \theta_Y^{1-\alpha} \cdot \tilde{k}^{\alpha} - (\delta + g) . \tilde{k} \tag{6.16}$$

will be found.

We can express the equation (5.16) as follows:

$$\frac{\dot{\tilde{k}}}{\tilde{k}} = \gamma . s . \theta_Y^{1-\alpha} \cdot \tilde{k}^{\alpha-1} - (\delta + g)$$

$$\hat{\tilde{k}} = \gamma . s . \theta_Y^{1-\alpha} \cdot \tilde{k}^{\alpha-1} - (\delta + g) \tag{6.17}$$

Next, we let us find the steady state value capital per efficient capita, $\tilde{k}_{ss}$. First of all, under the steady state assumption of capital, equation (5.17) can be written as growth form:

$$\hat{\tilde{k}}_{ss} = \gamma.s.\theta_Y^{1-\alpha} \cdot \tilde{k}^{\,\alpha-1} - (\delta+g) \quad (6.18)$$

Next, let us take the time derivative of both sides in equation (5.18). By definition, the time derivative of the left hand side is:

$$\frac{d}{dt}\left(\hat{\tilde{k}}_{ss}\right) = 0$$

The time derivative of the right hand side is as follows:

$$\frac{d}{dt}\left(\gamma.s.\theta_Y^{1-\alpha} \cdot \tilde{k}^{\,\alpha-1} - (\delta+g)\right) = 0 \Rightarrow$$

$$\gamma.s.(\alpha-1).\theta_Y^{1-\alpha} \cdot \tilde{k}^{\,\alpha-2} = 0$$

By definition, γ, s, $\alpha-1$, $\theta_Y^{1-\alpha}$ and $\tilde{k}_{ss}^{\alpha-2}$ cannot be 0. So, the necessary condition will be $\dot{\tilde{k}}_{ss} = 0$. Using this condition in equation (5.18) does yield the steady state value of capital per efficient capita:

$$0 = \gamma.s.\theta_Y^{1-\alpha} \cdot \tilde{k}^{\,\alpha-1} - (\delta+g) \Rightarrow$$

$$\tilde{k}_{ss} = \theta_Y \cdot \left(\frac{\gamma \cdot s}{\delta+g}\right)^{\frac{1}{1-\alpha}} \quad (6.19a)$$

This can be interpreted as the supply of per efficient capita in the model. Bayraktar-Sağlam and Yetkiner (2012) defines also demand for capital. From equation (6.18), it can be inferred that $\widetilde{k} = x$. So, at steady state capital accumulation has still transitional dynamics. We will obtain the following relation from this inference at the steady state:

$$\theta_Y \cdot \left(\frac{\gamma \cdot s}{\delta + g}\right)^{\frac{1}{1-\alpha}} = \left(\frac{\alpha^2}{r'_{ss}}\right)^{\frac{1}{1-\alpha}} \Rightarrow r'_{ss} = \frac{\alpha^2 \cdot (\delta + g)}{\gamma \cdot s} \tag{6.19b}$$

We can see from equation (6.19b), r'_{ss} is negatively correlated with financial efficiency and saving rate, and positively correlated with exogenous growth rate.

6.2.2.1 THE ROLE OF FINANCIAL EFFICIENCY IN THE LONG RUN UNDER SOLOVIANIZED ROMER MODEL

In this subsection, the role of financial inefficiency is investigated based on Solovianized Romer model of Bayraktar-Sağlam and Yetkiner (2012) in the long run and the theoretical derivations are presented.

First of all we need to define $\widetilde{y}_{ss}$ with the use of equation (6.19a):

$$\widetilde{y}_{ss} = \widetilde{k}_{ss}^{\alpha} \quad \Rightarrow \quad \widetilde{y}_{ss} = \theta_Y \cdot \left(\frac{\gamma \cdot s}{\delta + g}\right)^{\frac{\alpha}{1-\alpha}} \tag{6.20}$$

Steady state value of $\widetilde{y}_{ss}$ is expressed in per effective human capital, we need to express it in per human capital form:

$$y_{ss} = A(0) \cdot e^{g \cdot t} \cdot \widetilde{y}_{ss} \quad \Rightarrow$$

$$y_{ss} = A(0) \cdot e^{g \cdot t} \cdot \left(\frac{\gamma \cdot s}{\delta + g}\right)^{\frac{\alpha}{1-\alpha}}$$

After taking the natural logarithm of both sides, we obtain the following equation which represents the determinants of long-run economic growth, in our context especially financial inefficiency:

$$Ln(y_{ss}) = Ln\left(A(0)\right) + Ln\,(\theta_Y) + g \cdot t + \frac{\alpha}{1-\alpha} \cdot Ln(s) + \frac{\alpha}{1-\alpha} \cdot Ln(\gamma) - \frac{\alpha}{1-\alpha} \cdot Ln(\delta + g) + \varepsilon \tag{6.21}$$

The equation above is the basic representation of our investigation, which aims to ascertain the role of financial inefficiency in the long-run. From this simple equation, it can be interpreted as the financial efficiency has a positive influence on the economic growth. This equation which is based upon Solovianized Romer model of Bayraktar-Sağlam and Yetkiner (2012) is a three sector structure of Romer framework and is richer than the one sector Solow framework, which strengthens our research. In the next subsection, the role of financial efficiency in convergence will be analyzed.

6.2.2.2 THE ROLE OF FINANCIAL EFFICIENCY IN CONVERGENCE UNDER SOLOVIANIZED ROMER MODEL

This subsection presents theoretical derivations of the effect of financial imperfection on the convergence equation of Solow framework. As a first step, we need to express equation (6.19a) in the form of $\tilde{y} = \tilde{k}^{\alpha}$, as it is GDP that we are interested in. If we take the log differential of the production function, we find $\hat{\tilde{y}} = \alpha \cdot \hat{\tilde{k}}$ (recall that $\hat{\tilde{y}} = \dot{\tilde{y}}/\tilde{y}$ and $\hat{\tilde{k}} = \dot{\tilde{k}}/\tilde{k}$). Let us divide equation (6.16) by $\tilde{k}$:

$$\frac{\dot{\tilde{k}}}{\tilde{k}} = \gamma . s . \theta_Y^{1-\alpha} \cdot \tilde{k}^{\,\alpha-1} - (\delta + g)$$

$$\hat{\tilde{k}} \quad = \gamma . s . \theta_Y^{1-\alpha} \cdot \tilde{k}^{\,\alpha-1} - (\delta + g)$$

$$\frac{1}{\alpha} \cdot \hat{\tilde{y}} = \gamma . s . \theta_Y^{\frac{1-\alpha}{\alpha}} \cdot \tilde{k}^{\,\alpha-1} - (\delta + g)$$

$$\frac{1}{\alpha} \cdot \hat{\tilde{y}} = \gamma . s . \theta_Y^{\frac{1-\alpha}{\alpha}} \cdot \tilde{y}^{\frac{\alpha-1}{\alpha}} - (\delta + g)$$

$$\hat{\tilde{y}} = \alpha \cdot \left[\gamma . s . \theta_Y^{\frac{1-\alpha}{\alpha}} \cdot \tilde{y}^{\frac{\alpha-1}{\alpha}} - (\delta + g) \right]$$

Notably, $\hat{\tilde{y}} = \frac{dLn(\tilde{y})}{dt}$ and $e^{\frac{\alpha-1}{\alpha} \cdot Ln(\tilde{y})} = \tilde{y}^{\frac{\alpha-1}{\alpha}}$. After substituting these equivalents in the equation above, we obtain:

$$\frac{dLn(\tilde{y})}{dt} = \alpha \cdot \left[\gamma . s . \theta_Y^{\frac{1-\alpha}{\alpha}} e^{\frac{\alpha-1}{\alpha} \cdot Ln(\tilde{y})} - (\delta + g) \right] \equiv \emptyset_4\big(Ln(\tilde{y})\big) \qquad (6.22)$$

The right hand side of equation (6.22) depends only on $Ln(\tilde{y})$. Hence, we may define $\emptyset_4\big(Ln(\tilde{y})\big)$ as a short hand representation of it.

In the differential equation above, equation (6.22), while applying 1st order Taylor approximation, the approximated function will be $\emptyset_4\big(Ln(\tilde{y})\big)$ and the fixed point will be steady state value $\tilde{y}_{ss}$. The general form of the approximation is as follows:

$$\frac{dLn(\tilde{y})}{dt} \approx \emptyset_4\big(Ln(\tilde{y}_{ss})\big) + \emptyset_4'\big(Ln(\tilde{y}_{ss})\big) \cdot \big(Ln(\tilde{y}) - Ln(\tilde{y}_{ss})\big)$$

The steps are the same as we did in Chapter 4. The first step is to find the steady-state value of $\emptyset_4\big(Ln(\tilde{y})\big)$. The steady state value of Cobb-Douglas production function is $\tilde{y}_{ss} = \theta_Y \cdot \left(\frac{\gamma \cdot s}{\delta + g}\right)^{\frac{\alpha}{1-\alpha}}$. If we substitute this value into the function $\emptyset_4\big(Ln(\tilde{y})\big)$, we find that:

$$\emptyset_4\big(Ln(\tilde{y}_{ss})\big) = \alpha \cdot \left[\gamma \cdot \theta_Y^{\frac{1-\alpha}{\alpha}} \cdot s \cdot e^{\frac{\alpha-1}{\alpha} \cdot \frac{\alpha}{1-\alpha} \cdot Ln\left(\frac{\gamma \cdot s}{\delta+g}\right) + \frac{\alpha}{1-\alpha} \cdot Ln(\theta_Y)} - (\delta + g)\right]$$

$$= \alpha \cdot \left[\gamma \cdot \theta_Y^{\frac{1-\alpha}{\alpha}} \cdot \theta_Y^{\frac{\alpha}{1-\alpha}} \cdot s \cdot e^{-Ln\left(\frac{\gamma \cdot s}{\delta+g}\right)} - (\delta + g)\right]$$

$$= \alpha \cdot \left[\gamma \cdot s \cdot \frac{g+\delta}{\gamma \cdot s} - (\delta + g)\right]$$

$$= \alpha \cdot [(\delta + g) - (\delta + g)] = 0$$

The second step is to find the first derivative value $\emptyset_4'\left(Ln\big(\tilde{y}\ \big)\right)$:

$$\emptyset_4'\big(Ln(\tilde{y})\big) = \alpha \cdot \left[\gamma \cdot s \cdot \theta_Y^{\frac{1-\alpha}{\alpha}} \cdot \frac{\alpha - 1}{\alpha} \cdot e^{\frac{\alpha-1}{\alpha} \cdot Ln(\tilde{y}\,)}\right]$$

$$= \alpha \cdot \left[\gamma \cdot s \cdot \theta_Y^{\frac{1-\alpha}{\alpha}} \cdot \frac{\alpha - 1}{\alpha} \cdot \tilde{y}^{\frac{\alpha-1}{\alpha}}\right]$$

Then, imposing the steady state value of $\tilde{y}_{ss}$ on the first-order derivative yields:

$$\emptyset_4'\big(Ln(\tilde{y}_{ss})\big) = \alpha \cdot \left[\gamma \cdot s \cdot \theta_Y^{\frac{1-\alpha}{\alpha}} \cdot \frac{\alpha - 1}{\alpha} \cdot \left[\theta_Y \cdot \left(\frac{\gamma \cdot s}{g + \delta}\right)^{\frac{\alpha}{1-\alpha}}\right]^{\frac{\alpha-1}{\alpha}}\right]$$

$$= \alpha \cdot \left[\gamma \cdot s \cdot \theta_Y^{\frac{1-\alpha}{\alpha}} \cdot \theta_Y^{\frac{\alpha}{1-\alpha}} \cdot \frac{\alpha - 1}{\alpha} \cdot \frac{g+\delta}{\gamma \cdot s}\right]$$

$$= -(1-\alpha)\cdot(\delta+g)$$

If we substitute the values $\emptyset_4\big(Ln(\tilde{y}_{ss})\big)$ and $\emptyset'_4\big(Ln(\tilde{y}_{ss})\big)$ in the Taylor approximation, we obtain the following equation, which explains the growth rate of an economy:

$$\frac{dLn(\tilde{y})}{dt} \approx -(1-\alpha)(\delta+g)\cdot\Big(Ln(\tilde{y})\text{–}Ln(\tilde{y}_{ss})\Big) \qquad (6.23)$$

where $v = -(1-\alpha)(\delta+g)$ is convergence rate

The solution procedure for the differential equation (5.23) is as follows:

$$Ln\big(\tilde{y}(t)\big) = Ln(\tilde{y}_{ss}) + (Ln\big(\tilde{y}(0) - Ln(\tilde{y}_{ss})\big)\cdot e^{-vt}$$

$$Ln\big(\tilde{y}(t)\big) = Ln\big(\tilde{y}(0)\big)\cdot e^{-vt} + Ln(\tilde{y}_{ss})\cdot(1-e^{-vt})$$

$$Ln\big(\tilde{y}(t)\big) - Ln\big(\tilde{y}(0)\big) = Ln\big(\tilde{y}(0)\big)\cdot(e^{-vt}-1) + Ln(\tilde{y}_{ss})\cdot(1-e^{-vt})$$

$$Ln\left(\frac{Y(t)}{A(t)\cdot\overline{H}(t)}\right) - Ln\left(\frac{Y(0)}{A(0)\cdot\overline{H}(0)}\right)$$
$$= Ln\left(\frac{Y(0)}{A(0)\cdot\overline{H}(0)}\right)\cdot(e^{-vt}$$
$$-1) + Ln\left(\theta_Y\cdot\left(\frac{\gamma\cdot s}{\delta+g}\right)^{\frac{\alpha}{1-\alpha}}\right)\cdot(1-e^{-vt})$$

$$Ln\left(\frac{Y(t)}{\overline{\overline{H}}(t)}\right) - Ln\left(\frac{Y(0)}{\overline{\overline{H}}(0)}\right) - Ln\big(A(t)\big) + Ln\ (A(0))$$

$$= \left(Ln\left(\frac{Y(0)}{\overline{\overline{H}}(0)}\right) - Ln(A(0))\right)$$

$$\cdot (e^{-vt} - 1) + Ln\ \left(\theta_Y \cdot \left(\frac{\gamma \cdot s}{\delta + g}\right)^{\frac{\alpha}{1-\alpha}}\right) \cdot (1 - e^{-vt})$$

$$Ln\left(\frac{Y(t)}{\overline{\overline{H}}(t)}\right) - Ln\left(\frac{Y(0)}{\overline{\overline{H}}(0)}\right) - Ln\big(A(0)\big) - x \cdot t + Ln\ (A(0))$$

$$= \left(Ln\left(\frac{Y(0)}{\overline{\overline{H}}(0)}\right) - Ln(A(0))\right)$$

$$\cdot (e^{-vt} - 1) + Ln\ \left(\theta_Y \cdot \left(\frac{\gamma \cdot s}{\delta + g}\right)^{\frac{\alpha}{1-\alpha}}\right) \cdot (1 - e^{-vt})$$

$$Ln\left(\frac{Y(t)}{\overline{\overline{H}}(t)}\right) - Ln\left(\frac{Y(0)}{\overline{\overline{H}}(0)}\right)$$

$$= x \cdot t + (1 - e^{-vt}) \cdot Ln\big(A(0)\big) - (1 - e^{-vt})$$

$$\cdot Ln\left(\frac{Y(0)}{\overline{\overline{H}}(0)}\right) + \frac{\alpha}{1-\alpha} \cdot\ Ln\ (\theta_Y)\ + \frac{\alpha}{1-\alpha} \cdot\ Ln\ \left(\frac{\gamma \cdot s}{\delta + g}\right) \cdot (1$$

$$- e^{-vt})$$

$$Ln\left(\frac{Y(t)}{\overline{\overline{H}}(t)}\right) - Ln\left(\frac{Y(0)}{\overline{\overline{H}}(0)}\right) = \beta_0 + \beta_1 \cdot Ln\left(\frac{Y(0)}{\overline{\overline{H}}(0)}\right) + \beta_2 \cdot Ln\ (\theta_Y) + \beta_3 \cdot Ln(s) + \beta_3 \cdot$$

$$Ln(\gamma) + \beta_4 \cdot Ln(\delta + g)$$

(6.24)

where $\beta_0 = x \cdot t + (1 - e^{-vt})$, $\beta_1 = -(1 - e^{-vt})$, $\beta_2 = -\beta_1$ $\beta_3 = -\frac{\alpha}{1-\alpha} \cdot (1 - e^{-vt})$, $\beta_4 = -\beta_3$

The convergence equation derived above will be used in econometric application in Chapter 7 for panel data of emerging markets. Theoretically the equation's parameters are consistent. In particular, the way the efficiency of financial sector γ takes place in the equation does make sense.

CHAPTER 7

DATA, METHODOLOGY AND FINDINGS

7.1. DATA

In empirical analysis, data is obtained from World Development Indicators database, OECD database and Barro-Lee Education database. The data set is composed of 34 emerging markets. This classification is made according to International Monetary Fund and Standard and Poor's Emerging Markets database. However, not all of the countries in these markets are considered in our analysis. Some countries are eliminated due to the lack of data. In addition, the missing stock market efficiency and R&D data which belongs to the markets defined above has limited our sample to 1985-2010. Table 1 shows the sample of countries in emerging markets.

For financial efficiency indicator in our theoretical model, we analyze the activity of two participants in financial system: banking sector and stock markets. The other components are not taken into the analysis because of the same problem of limited data for panel analysis.

Based on Levine and Zervos (1998), banking sector efficiency is proxied by the value of deposit money bank credits to the private sector divided by GDP. This measure of banking sector efficiency excludes credit issued by the government and the central bank and excludes credits issued to the government and public enterprises. According to LZ, this banking sector efficiency indicator is better

Table 1 Countries in the Sample

Emerging Countries				
Argentina	Egypt	Lithuania	Peru	Thailand
Brazil	Hong Kong	Malaysia	Philippines	Tunusia
Chile	Hungary	Mexico	Saudi Arabia	Turkey
China	India	Morocco	Slovak Republic	Trindad Tobago
Crotia	Indonesia	Nigeria	Slovenia	Uruguay
Colombia	Israel	Oman	South Africa	Venezuella
Czech Republic	Jordan	Pakistan	Sri Lanka	

because nongovernmental financial intermediaries that are allocating credit to private firms are more likely to improve the efficiency of transferring saving to the investment than intermediaries that allocate money to the government and public enterprises. The data set which consists of this indicator comes from the World Bank Financial Structure Database.

Another important component of financial system that affects the financial efficiency in our model is stock market. In the analysis, following Levine and Zervos (1998), we measure the activity of stock market by value traded ratio. The value-traded ratio is calculated by dividing the total value of domestic equities traded on domestic exchanges by GDP. Stocks traded refers to the total value of shares traded during the period. This indicator shows whether market size is matched by trading.

In the empirical literature investigating the relationship between stock market efficiency and economic growth, three measures are used mostly. These are market capitalization, turnover and total value-traded ratio. The preferable efficiency indicator is value-traded ratio. Levine and Zervos (1998) and Levine (2002) state that market capitalization is not a good predictor of economic growth. According to Rousseau and Wachtel (2000), total value traded ratio is more efficient measure of stock market development than capitalization ratio. The turnover ratio, the value of total shares traded divided by average real-market capitalization, has been mainly used as a measure of stock market development in cross-sectional studies. Rousseau and Wachtel (2000) state that, changes in the degree of turnover will reflect short-term fluctuations and that this ratio is a less useful measure in dynamic specifications. We take dataset of value traded ratio for emerging and developed countries from World Bank Financial Structure Database.

We use the real Gross Domestic Product (GDP) per head of population aged 15-64 years expressed in 2000 purchasing power parities for an indicator of economic growth. The data set is taken from World Development Indicators database.

The share of saving in GDP is used as a proxy for saving rate.[23] The source of this data is the World Bank Development Indicators database.

With the aim of consistency with our theoretical growth convergence model, we make use of working age population growth rate instead of raw population growth rate. This data set is obtained by our own calculations by calculating the growth rates of labor force. Data of labor force for the countries in our sample is taken from World Development Indicators database and growth rates are calculated accordingly.

[23] In the literature, the share of investment in GDP is used as a proxy, but in this dissertation saving-investment equality is not taken into the account.

The share of R&D expenditure in GDP and the share of R&D personnel in labor force are used as proxies for technology. The corresponding data are taken from OECD Science and Technology Indicators database and World Bank Science and Technology database.

The human capital accumulation is measured by secondary school attainment rates. These rates are from 2010 version of Barro-Lee Education dataset.

The descriptive statistics belongs to the sample of Emerging Markets are shown in Table 2:

Table 2 Descriptive Statistics for Sample of Emerging Countries

Variables	**Mean**	**Standard Deviation**	**Min**	**Max**
Real GDP per capita	5680	3695	625	18935
Share of Saving in GDP	23.2	7.43	13.5	51.6
Total Value Traded ratio	19.4	26.5	0.11	123.3
Private Credits to GDP ratio	50.3	36.7	4.06	150.3
Secondary School Attainment rates	39.04	15	13.8	79.9
The share of R&D expenditure in GDP	0.69	0.68	0.02	3.1
The working age population growth rate	2.18	1.06	-1.41	3.9

7.2. EMPIRICAL METHODOLOGY AND FINDINGS

The empirical studies in the literature of relationship between financial development and economic growth mainly focus on three econometric methodologies. These are pure cross-country regressions, time-series studies, and panel data techniques which combine both analyzing methodologies. However, first two methodologies have certain shortcomings.

In the empirical analysis, we use panel data techniques due to the remarkable advantages when compared with purely cross-country and time series approaches. A panel data regression differs from a regular time-series or cross-section regression in that it has a double subscript on its variables. Consider the panel regression below to explain the advantages:

$$y_{it} = \alpha + X'_{it}\beta + \mu_i + u_t + \varepsilon_{it}, \quad i = 1, \dots, N; \quad t = 1, \dots., T; \tag{7.1}$$

where y represents economic growth, X'_{it} represents a set of explanatory variables, μ_i is an unobserved country specific effect, u_t is the time-specific effect, and i and t represent country and time period, respectively.

Levine (2005) states that there are three certain benefits of using panel data in the empirical literature. First, panel data techniques exploit both the time-series and cross-sectional variation in data. Second, since the unobserved country-specific effect, μ_i, is part of the error term, its correlation with explanatory variables results in biased estimation of the coefficients. Due to the use of panel data techniques, biased estimates are eliminated. Third benefit is a solution to the endogeneity problem of regressors in pure cross-country regression. The panel data estimator uses instruments based on lagged values explanatory variables to control the endogeneity of all regressors.

In order to investigate the role of financial efficiency on economic growth, we conducted our econometric analysis based on the Solow and Solovianized Romer framework 34 emerging countries over the period 1985-2010. According to the previous studies in growth convergence literature, we transformed our data set into five-year averages over the time period to eliminate the cyclical effect.

Ramsey Model remains a theoretical contribution, because three determinants of economic growth; which are subjective rate of discount, depreciation and technology rate; in the framework are assumed to be constant. This assumption is a restriction for us to conduct a significant empirical research.

7.2.1 EMPIRICAL ANALYSIS IN SOLOW FRAMEWORK

In this section, we test the theoretical model in Chapter 4 to investigate the role of financial efficiency on the long-run economic growth. The model to be estimated has the following form:[24]

$$\begin{aligned} ln\, y_{it} - ln\, y_{it-1} \\ &= \beta_1 ln\, y_{it-1} + \beta_2 ln\, s_{it} + \beta_3 ln\, FE_{it} + \beta_4 ln\, [n_{it} + x\ + \delta] + \mu_i + u_t \\ &+ \varepsilon_{it} \end{aligned} \quad (7.2)$$

In the equation above, the dependent variable is the change in the logarithm of growth in real GDP per head of population aged 15-64 expressed in 2000 purchasing power parities. The lagged dependent variable is the logarithm of growth in real GDP per head of population aged 15-64 expressed in 2000 purchasing power parities. The logarithm of s_{it} represents the gross saving for the corresponding country. The

[24] Depreciation and technology growth rate are assumed to be 0.03 and 0.02 respectively as in MRW (1992)

logarithm of FE_{it} stands for financial efficiency, which is proxied by private credits provided by banks to GDP for banking sector, hereafter PRIVATECREDIT, and traded value over GDP for stock market, hereafter TRADEDVALUE. The term $ln\,[n_{it} + x\ + \delta]$ is the logarithm of working age population growth, technology growth, and depreciation rate. Depreciation and technology growth rate are assumed to be 0.03 and 0.02 respectively as in MRW (1992). μ_i is an unobserved country specific effect, u_t is a time-specific effect, ε_{it} is the time-varying error term and β_1,… β_4 are parameters to be estimated.

The expected signs for parameters are as follows:

β_1 should be negative to express the conditional convergence,

β_2 should be positive, because saving has positive effect on economic convergence,

β_3 should be positive, because according to our theoretical model constructed, we obtained positive effect of financial efficiency on economic convergence,

β_4 should be negative according to our theoretical model.

Equation (7.2) is an example of dynamic panel data model. Many economic relationships are dynamic in nature and one of the advantages of panel data is that they allow researcher to better understand the dynamics of adjustment. These dynamic relations are characterized by presence of a lagged dependent variable among the regressors. It has the following general form:

$$y_{it} = \ \delta y_{it-1} + \ X'_{it}\beta + \mu_i + v_t + u_{it}, \quad i = 1, \dots, N; \quad t = 1, \dots., T; \qquad (7.3)$$

where δ is a scalar, X'_{it} is $1 \times K$, β is $K \times 1$. $\mu_i \sim IID(0, \sigma_\mu^2)$ and $v_t \sim IID(0, \sigma_v^2)$.

Although dynamic panel data models which have a form as in equation (7.3) bring certain advantages, there are some restrictions while applying econometric methods.

First of all, inclusion of lagged dependent variable introduces a basic problem. Since y_{it} is a function of μ_i, its lagged value y_{it-1} is also a function of μ_i. As a result, y_{it-1} as a right-hand regressor is correlated with the error term. This problem makes method of ordinary least squares (OLS) biased and inconsistent even if the v_{it} are not serially correlated. Within Groups estimator makes a transformation that wipes out μ_i, but $y_{i,t-1} - \bar{y}_{i,t-1}$, where $\bar{y}_{i,t-1} = \sum_{t=2}^{T} {y_{i,t-1}}/{(T-1)}$ is still correlated with $v_t - \bar{v}_t$ even if $v_t$are not serially correlated. Nickell (1981) showed that Within Groups estimator is biased of $O(\frac{1}{T})$. A researcher cannot remove this bias if panel data set consists of "small T, large N" as in our model which contains 5 time periods and 34 countries.

Second, in our model, explanatory variables, such as saving rate, financial efficiency and the sum of working age population growth, technology growth, and depreciation rate, are not exogenous, meaning correlated with past and possibly current realizations of the error. This endogeneity problem of does remain in Ordinary Least Squares and Within Groups methods.

Arellano-Bond (1991) and Arellano-Bover (1995)/Blundell and Bond (1998) proposed solutions to these problems in dynamic panel framework by using Generalized Method of Moments estimator of Hansen (1982).

To define Generalized Method of Moments, let us consider the endogeneity problem in the following equation:

$$y_{it} = X'_{it}\beta + u_{it}$$

such as $E(X'_{it}u_{it}) \neq 0$. A set of additional variables is necessary for consistent estimation, which brings the following moment condition:

$$E(z_{it}u_{it}) = 0 \qquad (7.4)$$

The set of variables z_{it} is called *instrumental variable*. An instrument is a variable that does not itself belong in the explanatory equation and is correlated with the endogenous explanatory variables, conditional on the other covariates. Simple instrumental variable estimator, with as many instruments as explanatory variables, can solve the moment condition (7.4).

However, if there are more instruments than regressors, then the equations outnumber the unknowns and the system usually cannot be solved. The coefficient set β will be overidentified. Generalized Method of Moments brings a solution to this situation by exploiting orthogonality conditions.[25]

Arellano-Bond (1991) transformed all regressors by differencing and uses Generalized Method of Moments. This method is called Difference GMM. Casseli, Esquivel and Lefort (1996) introduced this approach to the growth literature. There is a fundamental idea behind this approach. It takes first-differences to remove unobserved time-invariant country-specific effects and then instruments the right

[25] For details, see Hansen (1982)

hand-side variables in the first differenced equations using levels of the series lagged two periods or more, under the assumption that the time-varying disturbances in the original levels equations are not serially correlated.

This procedure solves omitted variable problem, endogeneity problem and allows consistent estimation even in the presence of measurement error. However, the method proposed by Arelano-Bond (1991) has some problems. If time series are persistent and the number of time series observations are small, as in our panel data set, lagged levels of the variables are weak instruments for subsequent first-differences (Blundell and Bond (1998,2000), Blundell *et al.* (2000)).

Arellano-Bover (1995)/Blundell and Bond (1998) enhances the Arellano-Bond estimator by making an additional assumption. It consists of a joint estimation of the equations in first-differences and levels. For the equations in first-differences, the lagged levels of the regressors and for the equations in levels, the lagged first-differences of the explanatory variables are used. This approach allows the introduction of more instruments and improves efficiency. It builds a system of two equations and called System GMM.

We estimated equation (7.2) by using the method of System GMM since according to Blundell *et al.* (2000), it has certain advantages when compared to Difference-GMM. First of all, it gives consistent and efficient estimates, even in the presence of measurement error and endogenous regressors. Second, it suits the short time dimension panel data sets. Third, this method is recommended in estimating empirical growth models.

According to Blundell *et al.* (2000), there are three conditions for the System-GMM estimator to be consistent. First, there should be no serial correlation in the error term. Second, the instruments should not be correlated with the error term. Third, the number of cross section units should be larger than the number of instruments.[26]

To check the first condition, Arellano-Bond test for serial correlation is performed. The hypothesis test for this test is as follows:

H_0: $There\ is\ no\ serial\ correlation\ in\ the\ error\ term$

H_1: $There\ is\ \ serial\ correlation\ in\ the\ error\ term$

The correct specification and the validity of instruments are checked by Hansen test of over-identifying restrictions. The hypothesis test for this test is as follows:

H_0: $There\ are\ more\ instruments\ than\ regressors\ (overidentification)$

H_1: $The\ number\ of\ instruments\ is\ equal\ to\ our\ lower\ than\ the\ number\ of\ regressors\ (identification\ or\ underidentification)$

7.2.1.1 ESTIMATION RESULTS IN SOLOW FRAMEWORK

System-GMM estimation results are presented in Table 3 below. [27] In the first regression, the role of stock market efficiency on economic growth was investigated. Second regression was run to see the role of banking sector efficiency on economic growth. Time dummies are included in both regressions estimations. Heteroscedasticity-consistent standard errors are in parentheses. ***,** and * show that the coefficient is significant at 1, 5 and 10 percentage, respectively. The

[26] In the analysis, the command of collapse is used in Stata (v.11) as mentioned in Roodman (2009)
[27] Roodman (2009) “xtabond2” command was used in Stata (v.11) for the system GMM estimations. Windmeijer (2005) is implemented for the small sample correction.

$Ln(y_{i,t-1})$ is treated as predetermined variable[28] and $Ln(s_{i,t})$, $Ln(n_{i,t} + x + \delta)$ and $Ln(FE_{i,t})$ are treated as endogenous variables.

According to first regression, in which the financial efficiency variable is traded value over GDP, all the variables are significant and have expected sign as in the theoretical model. The negative coefficient of lagged dependent variable shows that there is a conditional convergence of growth which supports the theory. The expected sign of other variables and their significancy shows the strong link between theoretical and empirical work and suitability of data set.

In the regression that stock market efficiency has positive effect on economic growth convergence at 5% significant level. It can be inferred that, in emerging markets stock market efficiency improves the mechanism of transferring savings to investment. As the stock market becomes more efficient, more economic growth will be achieved.

In the second regression, we estimated the role of banking sector efficiency on economic growth. The results for other variables are similar as the first regression. There is an also conditional convergence. In addition, the coefficients have expected sign and are significant.

The results show that banking sector efficiency has positive effect on economic growth convergence at 10% significant level. This result is also consistent with our theoretical model.

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[28] Predetermined variables are variables that were determined prior to the current period. In econometric models this implies that the current period error term is uncorrelated with current and lagged values of the predetermined variable but may be correlated with future values. This is a weaker restriction than strict exogeneity, which requires the variable to be uncorrelated with past, present, and future shocks.

Table 3 Estimation Results of Solow Model for Emerging Countries

Dependent Variable : log differences in real GDP per working person		
	Model 1	**Model2**
Constant	0.599* (0.322)	0.616** (0.277)
$Ln(y_{it-1})$	-0.108*** (0.033)	-0.084*** (0.026)
$Ln(s_{it})$	0.262*** (0.084)	0.203*** (0.063)
$Ln(FE_{it})$ (PRIVATECREDIT/GDP)		0.083* (0.047)
$Ln(FE_{it})$ (VALUETRADED/GDP)	0.033** (0.014)	
$Ln(n_{it} + x + \delta)$	-0.398*** (0.114)	-0.275*** (0.094)
Implied v	0.005	0.004
Number of Observations	131	131
Number of Groups	34	34
Number of Instruments	21	25
Hansen test p value	0.09	0.069
AR(2) test p value	0.372	0.678

Time dummies are included in both regressions estimations.

Heteroscedasticity-consistent standard errors are in parentheses. ***,** and * show that the coefficient is significant at 1, 5 and 10 percentage, respectively.

The $Ln(y_{i,t-1})$ is treated as predetermined variable and $Ln(s_{i,t})$, $Ln(n_{i,t} + x + \delta)$ and $Ln(FE_{i,t})$ are treated as endogenous variables.

Hansen test is performed to check over-identifying restrictions at 5% significance level. Since p values are greater than 0.05, model is overidentified.

AR(2) test is performed to check for serial serial corelation in error term at 5% significance level. Since p values are greater than 0.05, there are no serial corelations in error term

These results are as expected for two reasons. First, the model has theoretical background. There is a connection between theory and empirics. Second, since emerging markets do not have stable economies yet, banking and stock market efficiency affect the convergence of economic growth.

7.2.2 EMPIRICAL ANALYSIS IN SOLOVIANIZED ROMER FRAMEWORK

In this section, we investigate the role of financial efficiency on long run economic growth in Solovianized Romer Framework developed by Bayraktar Sağlam and Yetkiner (2012). The theoretical background is given in Chapter 5. The model to be estimated has the following form:[29]

$$\begin{aligned} ln\, y_{it} - ln\, y_{it-1} &= \beta_1 ln\, y_{it-1} + \beta_2 ln\, s_{it} + \beta_3 ln\, FE_{it} + \beta_4 ln\, h_{it} \\ &+ \beta_5 ln\, [n_{it} + g_{it} + \delta] + \mu_i + u_t + \varepsilon_{it} \end{aligned} \quad (7.5)$$

In the equation above, the dependent variable is the change in the logarithm of growth in real GDP per head of population aged 15-64 expressed in 2000 purchasing power parities. The lagged dependent variable is the logarithm of growth in real GDP per head of population aged 15-64 expressed in 2000 purchasing power parities. The logarithm of s_{it} represents the gross saving for the corresponding country. The logarithm of h_{it} represents the human capital accumulation. The logarithm of FE_{it} stands for financial efficiency, which is proxied by private credits provided by banks to GDP for banking sector, denoted by PRIVATECREDIT, and traded value over

[29] Depreciation rate is assumed to be 0.03 as in MRW (1992)

GDP for stock market, denoted by TRADEDVALUE. The term $ln\ [n_{it} + g_{it}\ + \delta]$ is the logarithm of working age population growth, technology growth, and depreciation rate. In contrast to the classical Solow model, technology rate, g_{it} is not constant. It is proxied by the share of R&D expenditure in GDP. Depreciation rate is assumed to be 0.03 as in MRW (1992). μ_i is an unobserved country specific effect, u_t is a time-specific effect, ε_{it} is the time-varying error term and $\beta_1,\dots\ \beta_4$ are parameters to be estimated.

The expected signs for parameters are as follows:

β_1 should be negative to express the conditional convergence,

β_2 should be positive, because saving has positive effect on economic convergence,

β_3 should be positive, because according to our theoretical model constructed, we obtained positive effect of financial efficiency on economic convergence,

β_4 should be positive, because human capital accumulation has positive effect on economic convergence according to our theoretical model.

β_5 should be negative according to our theoretical model.

7.2.2.1 ESTIMATION RESULTS IN SOLOVIANIZED ROMER FRAMEWORK

System-GMM estimation results in Solovianized Romer Framework are presented in Table 4 below. We ran 4 regressions. First two regressions investigate the role of stock market efficiency. In the other two regressions, banking sector efficiency is included. The regressions were run with human capital and without human capital.

Time dummies are included in both regressions estimations. Heteroscedasticity-consistent standard errors are in parentheses. ***,** and * show that the coefficient is significant at 1, 5 and 10 percentage, respectively. The $Ln(y_{i,t-1})$ is treated as predetermined variable and $Ln(s_{i,t})$, $Ln(n_{i,t} + g_{i,t} + \delta)$, $Ln(h_{i,t})$ and $Ln(FE_{i,t})$ are treated as endogenous variables.

According to the first regression, in which the financial efficiency variable is traded value over GDP, the variables except human capital and stock market efficiency are significant and have expected sign as in the theoretical model. The negative coefficient of lagged dependent variable shows that there is a conditional convergence of growth which supports the theory.

In the second regression, human capital is excluded from the equation. It is found that stock market efficiency has positive effect on economic growth convergence at 10% significant level. It can be inferred that, in emerging markets stock market efficiency improves the mechanism of transferring savings to investment. As the stock market becomes more efficient, more economic growth will be achieved.

In the both third and fourth regression, banking sector efficiency has positive effect on economic growth. In the third regression, where human capital is included the role of banking sector efficiency on economic growth is 5% significant. The other regression indicates that banking sector efficiency on economic growth is 1% significant. The negative coefficient of lagged dependent variable shows that there is a conditional convergence of growth which supports the theory. However, we found no significancy of human capital in any regressions.

Table 4 Estimation Results of Solovianized Romer Model for Emerging Countries

Dependent Variable : log differences in real GDP per working person				
	Model 3	**Model 4**	**Model 5**	**Model 6**
Constant	0.374 (0.771)	0.110 (0.541)	0.726 (0.653)	0.381 (0.489)
$Ln(y_{it-1})$	-0.116*** (0.034)	-0.105*** (0.025)	-0.085*** (0.033)	-0.072*** (0.025)
$Ln(s_{it})$	0.183** (0.08)	0.226*** (0.071)	0.162** (0.061)	0.196***1 (0.054)
$Ln(FE_{it})$ (PRIVATECREDIT/GDP)			0.083** (0.034)	0.116*** (0.04)
$Ln(FE_{it})$ (VALUETRADED/GDP)	0.026 (0.02)	0.035* (0.018)		
$Ln(h_{it})$	0.151 (0.134)		0.133 (0.085)	
$Ln(n_{it} + g_{it} + \delta)$	-0.46** (0.17)	-0.513*** (0.143)	-0.245* (0.141)	-0.31*** (0.11)
Implied v	0.005	0.005	0.004	0.003
Number of Observations	128	128	128	128
Number of Groups	34	34	34	34
Number of Instruments	25	21	29	25
Hansen test p value	0.146	0.145	0.181	0.103
AR(2) test p value	0.806	0.694	0.598	0.653

Time dummies are included in both regressions estimations. Heteroscedasticity-consistent standard errors are in parentheses. ***,** and * show that the coefficient is significant at 1, 5 and 10 percentage, respectively. The $Ln(y_{i,t-1})$ is treated as predetermined variable and $Ln(s_{i,t})$, $Ln(n_{i,t} + x + \delta)$ and $Ln(FE_{i,t})$ are treated as ndogenous variables. Hansen test is performed to check over-identifying restrictions at 5% significance level. Since p values are greater than 0.05, model is overidentified. AR(2) test is performed to check for serial serial corelation in error term at 5% significance level. Since p values are greater than 0.05, there are no serial corelations in error term

CHAPTER 8

CONCLUSION

The relationship between financial efficiency and economic growth has been investigated by many researchers in the literature. There are several research papers which have used different measures of financial efficiency and various econometric techniques to indicate the relationship. However, there is no consensus on the role of the financial efficiency on economic growth.

In spite of the absence of solid theory on financial efficiency-economic convergence in the literature, there are many empirical studies that have been produced to study the relationship between financial issues and economic growth. The lack of a widely accepted theoretical background is a drawback for these empirical studies. In this thesis, this research question is investigated by providing a link between theory and empirics based on Mankiw, Romer and Weil (1992), referred to as MRW (1992).

In contrast to the many studies analyzing developed countries, other groups of countries have not been investigated at a sufficient level. To this end, in this thesis, the role of financial efficiency on economic growth is analyzed for emerging countries. As these groups of countries have not yet reached stability (long-run equilibrium) in their economy, it is important to determine whether the financial markets development in these countries has any effect on economic convergence.

In the second chapter, a detailed literature review about the relationship between financial development and economic growth is given, illustrating the wide variety of theoretical studies that investigate the effect of different parts of financial system on economic growth, and the different results they find.

In the third chapter, there is a detailed presentation and explanation of the fundamental models of economic growth -Solow, Ramsey and Solovianized Romer- which are used to investigate the role of financial efficiency on economic convergence.

In the fourth chapter, the theoretical background about the role of financial markets' efficiency on economic growth is shown in Solow framework, which has been accepted as a major breakthrough in the development of the growth literature. Theoretical derivations are undertaken and a convergence equation is obtained to test empirically. According to the theory, financial efficiency has a positive effect on economic growth.

In the fifth chapter, this investigation is made in Ramsey framework and theoretical derivations are made to show the effect of financial efficiency on economic growth convergence. What makes Ramsey framework interesting is that the resulting convergence equation relies on parameter values of preferences and production technology, rather than saving rate and population growth rate, in addition to financial efficiency variable. This chapter makes a theoretical contribution to the literature that financial efficiency has a positive effect on economic growth.

In the sixth chapter, what we call the Solovianized Romer model is presented and financial efficiency is investigated in the framework. Bayraktar-Saglam and Yetkiner (2012) recently developed a framework, which they call Solovianized Romer model. The novelty in this framework is that they derive an empirically useful equation out of Romer (1990), in which technological progress in decomposed into its components. According to this model, theoretically, the effect of financial efficiency on economic growth is positive.

In the seventh chapter, the convergence equations obtained in Solow and Solovianized Romer framework are tested empirically with emerging markets data for the period 1985-2010. The financial efficiency of banking sector and stock market is analyzed. This analysis is made via GMM dynamic panel data techniques which have many advantages over cross-country and time-series approaches. In Solow framework, the results show consistency with theory. Firstly, the role of banking sector efficiency is investigated in Solow framework and positive effect on economic growth is obtained, and found to be significant at 10% level. Secondly, the efficiency of stock market on economic growth is analyzed and it is found that the effect is positive and 5% significant. In the Solovianized Romer Framework, four models are used to analyze the role of financial efficiency on economic growth. In the first two models, the role of banking efficiency is investigated, by including and excluding human capital variable, respectively. In the first model, positive and 5% significant effect is obtained. In the second model, the effect is also positive and 1% significant. In the last two models, the role of banking efficiency is investigated by including and excluding human capital variable, respectively. In the third model, the effect of stock market efficiency on economic growth is positive but not significant. In the fourth model, the effect is also positive and significant at 10% level. These results are also consistent with theoretical framework.

To summarize, the results obtained are consistent with the studies of Pagano (1993) and Levine (2005), which indicate that efficient financial markets provide opportunities for more efficient risk sharing, more efficient transfer saving to investment efficiently and for decreasing information and transaction costs, and increasing economic growth. Moreover, our results are supported by the other studies in the literature that are investigating the role of financial development on economic growth in emerging markets.

In the future, we plan to elaborate financial efficiency through decomposing financial markets. In particular, financial markets do not have similar mechanisms in an economy. For example, the function of banking sector is completely different than the derivative markets. In this respect, it is important to understand the differing roles of various financial markets/ tools on economic growth. The derivative market is one that requires the most urgent attention because of the relative lack of studies analyzing the derivative market efficiency-economic growth relationship. The role of efficiency of derivatives market on economic growth could be tested on the basis of our constructed theoretical models as a future research. We expect that developed derivative markets promote economic growth by easing risk sharing.

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