Hacettepe University Graduate School of Social Sciences

Department of Economics

ECONOMIC GROWTH, RURAL-URBAN MIGRATION, AND FERTILITY DECLINE IN TÜRKİYE

Gülnur ACAR

Master's Thesis

Ankara, 2024

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ACCEPTANCE AND APPROVAL

The jury finds that Gülnur ACAR has on the date of 05.06.2024 successfully passed the defense examination and approves her Master's Thesis titled "Economic Growth, Rural-Urban Migration, and Fertility Decline in Türkiye".

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Gülnur ACAR

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ABSTRACT

ACAR, Gülnur. *Economic Growth, Rural-Urban Migration and Fertility Decline in Türkiye*, Master's Thesis, Ankara, 2024.

This thesis aims to explain the role of economic growth and time cost of reproduction in fertility decline in rural and urban regions of Türkiye between 1978 and 2021 under the assumption of same fertility preferences in both regions. To do this, we construct a simple two-region model with endogenous technology and endogenous fertility. The production side of the model follows Lucas (2009). On the consumption side, households in both rural and urban regions choose optimal fertility levels depending on the time cost of reproduction and income per household. We design a benchmark calibration algorithm that allows us to match regional fertility levels and rural-urban fertility differences as well as rural-urban population shares. With such a calibration exercise, we obtain the dynamics of some unobserved regional variables: income levels and time cost of reproduction. The first major result of the thesis is that the fertility rates are higher in rural areas than in urban areas. However, both regions show a similar trend of decreasing fertility rates most of the period as economic growth rises. The technological progress promotes higher income and causes to decline in fertility rates for both regions. But the rise in per capita income in urban regions is greater than that of rural regions. Finally, we found that the time cost of reproduction is higher in urban regions than rural regions. These differences are also another factor causing the differences in fertility levels across regions. Besides, the household income levels in both regions are the primary determinant of fertility decline. The results of the study have important implications for catching-up the frontier country, establishing sustainable economic growth, and reducing the regional differences.

Keywords

Economic Growth, Rural and Urban Population, Fertility Decline, Time Cost of Reproduction, Catching-up, Technological Progress

ÖZET

ACAR, Gülnur. *Türkiye' de Ekonomik Büyüme, Kır'dan Kente Göç ve Doğurganlık Düşüşü*, Yüksek Lisans, Ankara, 2024.

Bu tezin amacı, 1978-2021 yılları arasında Türkiye'de kırsal ve kentsel bölgelerde doğurganlık düşüşünde iktisadi büyüme ile üremenin zaman maliyetinin rolünü doğurganlık tercihlerinin her iki bölgede de aynı olduğu varsayımı altında araştırmaktır. Bu amaçla, teknoloji ve doğurganlığın içsel olduğu basit iki bölgeli bir model kullanılmıştır. Modelin üretim tarafı Lucas (2009)'dan alınmıştır. Tüketim tarafında ise hem kırsal hem de kentsel bölgelerde hane halkları, üremenin zaman maliyeti ve hane başına gelire bağlı olarak optimal doğurganlık seviyelerini belirlemektedir. Analizi gerçekleştirmek için, bölgesel doğurganlık düzeyleri ile kır-kent doğurganlık farklılıklarını ve kır-kent nüfus paylarını eşleştirmemizi sağlayan bir karşılaştırmalı kalibrasyon algoritması tasarlanmıştır. Bu kalibrasyon uygulaması sonucunda, gelir düzeyleri ile üremenin zaman maliyeti gibi hiçbir kaynakta elde edilemeyen bölgesel değişkenlerin dinamikleri de ortaya konulmuştur. Tezimizin ilk önemli sonucu, doğurganlık oranlarının kırsal bölgelerde kentsel bölgelere göre daha yüksek olduğudur. Ancak her iki bölgede ekonomik büyümeye bağlı olarak dönemin çoğunda doğurganlık oranlarında benzer bir düşüş eğilimi gözlenmektedir. Teknolojik ilerleme gelir artışına ve her iki bölge için de doğurganlık oranlarının düşmesine neden olmaktadır. Ancak kentsel bölgede kişi başına gelirdeki artış kırsal bölgeden daha fazladır. Son olarak, kentsel bölgelerde üremenin zaman maliyetinin kırsal bölgelere göre daha yüksek olduğu gözlenmektedir. Bu farklılık da bölgeler arasında doğurganlık düzeylerinin farklılaşmasına neden olan bir diğer faktördür. Her iki bölgede de hane halkı gelir düzeyi doğurganlık düşüşünün temel belirleyicisidir. Çalışmanın sonuçları, teknolojide ileri ülkenin yakalanması, sürdürülebilir ekonomik büyümenin sağlanması ve bölgesel farklılıkların azaltılması için önemli çıkarımlara sahiptir.

Anahtar Kelimeler

Ekonomik Büyüme, Kır ve Kent Nüfusu, Doğurganlık Düşüşü, Üremenin Zaman Maliyeti, Teknolojik İlerleme

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LIST OF ABBREVIATIONS

DTF	**:** Distance to Frontier
GDP	**:** Gross Domestic Product
HUIPS	**:** Hacettepe University Institute of Population Studies
MATLAB	**:** Matrix Laboratory
R&D	**:** Research and Development
TDH	**:** Turkey Demographic Health Survey
TFP	**:** Total Factor Productivity
TFR	**:** Total Fertility Rate
TFS	**:** Turkish Fertility Survey
TURKSTAT	**:** Turkish Statistical Institute
USA	**:** United States of America
WDI	**:** World Development Indicators

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INTRODUCTION

Most of the studies examining the relationship between economic growth and demographic transition has focused on the effects of demographic transition on the economic growth. This demographic transition refers to movements of high birth and death rates towards low and stable levels. As Lee & Reher (2011) note, this transition emerged with the Industrial Revolution and subsequent urbanization. In other words, while high death and birth rates were observed in pre-modern era of societies, those experienced modernization progress these two rates are at low as refers to in post-modern regime (Kirk, 1996).

Demographic transition has significant implications for various aspects of society, particularly in terms of population structure and growth rates. As countries undergo this transition, changes in fertility rates become evident, significant decline in fertility rates, reflecting broader socio-economic transformations.

This decline in fertility rates differ across the urban and rural regions. Thus, this thesis aims to investigate the effects of economic growth and time cost of reproduction on fertility decline across the regions and show how they create different effects in both regions of Türkiye between 1978 and 2021. For this aim, we construct a simple two-region model with endogenous technology and endogenous fertility and use model-based calibration exercises and carry out counterfactual experiments. Out of all calibration exercises and experiments, we obtain significant results that help us to understand the effects of economic growth and reproduction costs on differences in fertility declines across the regions. These results have important implications for policy makers, academics and regulators.

This thesis consists of five chapters and conclusion. In the first chapter we summarize the recent developments in demographic transition in Türkiye. In the second chapter, we present the related literature. In the third chapter, we explain the model economy. In the fourth, we carry out calibration exercise to adopt the benchmark paths for Türkiye. In chapter five, we conduct three counterfactual experiments on technological progress and economic growth, fertility preferences, and time cost of reproduction to provide answers to research questions. In conclusion, the major results of the thesis and their policy implications are discussed.

CHAPTER 1

DEMOGRAPHIC TRANSITION IN TÜRKİYE

Today, demographic transition has spread to nearly every part of the world. This transition initially emerged in developed countries during the industrialization period. As emphasized in Canning (2011, p.360), *"The story of the modern world is often told as a story of the Industrial Revolution driven by technological advances in manufacturing."* After that, as a result of urbanization in developing countries, and the increasing of their industrial activities, they have been started to experience the demographic transition.

Similar to developed and developing countries, the patterns of demographic transition in Türkiye involve changes in mortality and fertility rates as well as the rate of population growth. Figure 1 illustrates the developments in birth and death rates of Türkiye during 1960 and 2020 on a 5-year basis. The data is sourced from the World Development Indicators (WDI) of World Bank (2024). Death rates in Figure 1 are the crude death rates per 1,000 people indicating *"the number of deaths occurring during the year, per 1,000 population estimated at midyear"*. Similarly, birth rates are crude birth rates and calculated as per 1,000 people (WDI, 2024).

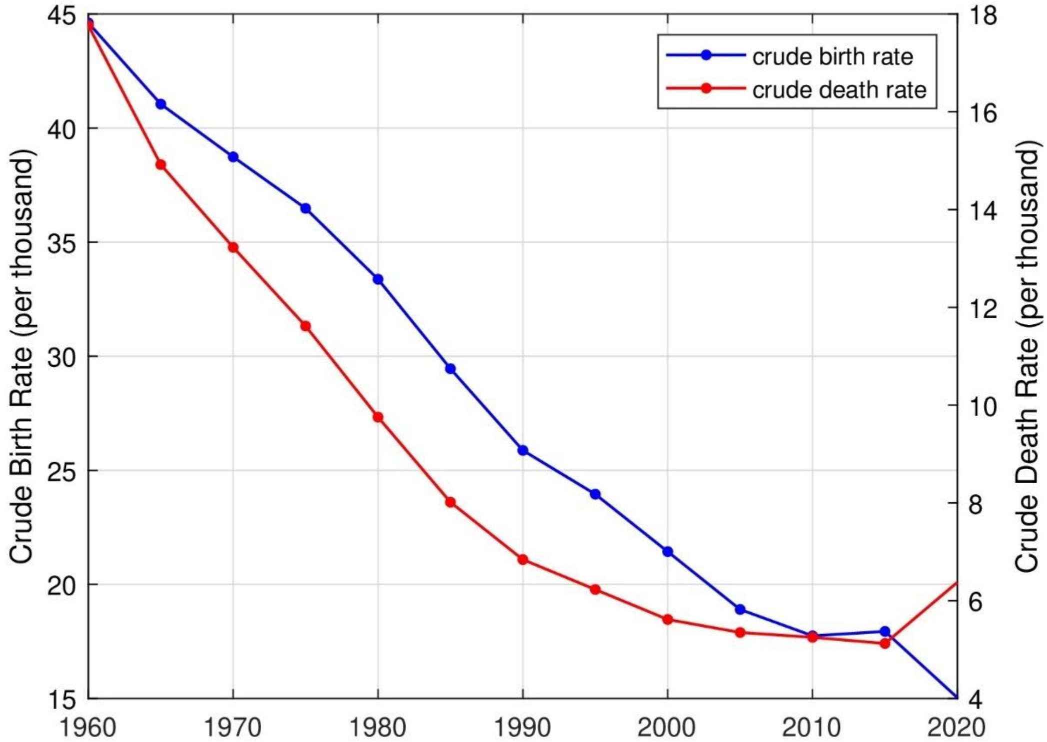

Figure 1. Crude Birth and Death Rate in Türkiye, 1960-2020 in 5 years

Source: World Development Indicators, World Bank, 2024

As is seen clearly in Figure 1, crude death rates have been falling every five years since 1960 except after 2015. On the other hand, the cured birth rates have been falling also, except for a slight increase after 2010. All these developments show that there is a significant demographic change in Türkiye. Figure 2 further illustrates the trends in population size and growth rate in Türkiye from 1927 to 2020, based on the data provided by the Population and Housing Census of 2021 conducted by Turkish Statistical Institute (TURKSTAT).

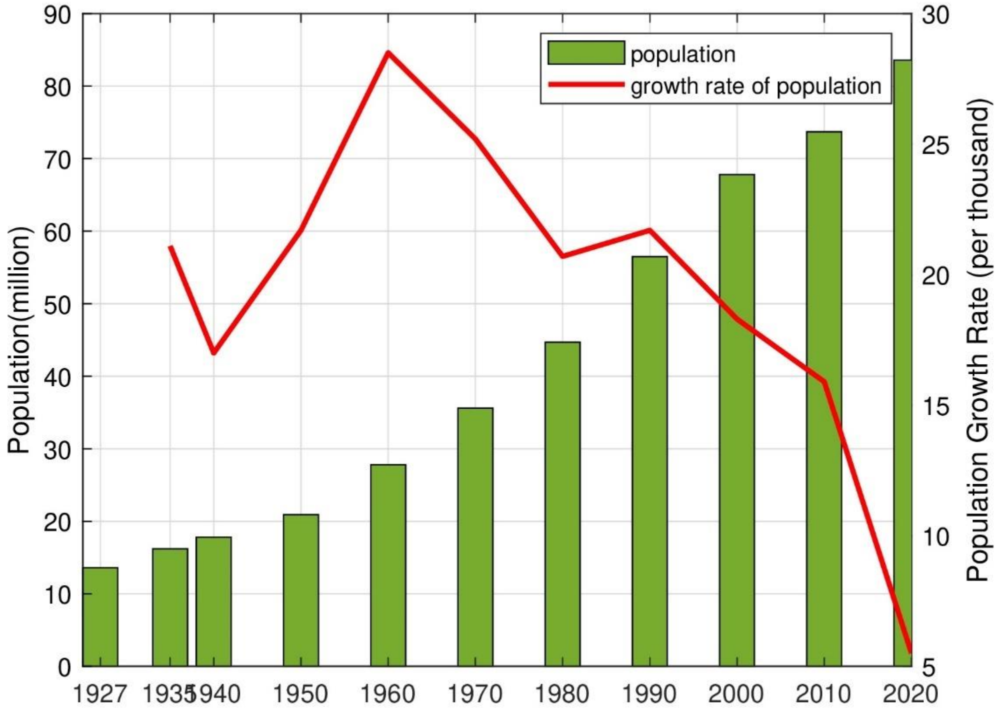

Figure 2. Population Size and Growth Rate in Türkiye, 1927-2020

Source: Turkish Statistical Institute (TURKSTAT) (2022a; 2022b)

As is seen in Figure 2, a significant surge in population growth rate is observed between 1940 and 1960, followed by a consistent decline thereafter, except for a brief upturn between 1980 and 1990. Notably, post-2010, a pronounced acceleration in the declining population growth rates is discernible. Overall, Türkiye's demographic window of opportunity is expected to extend until 2040, despite rapid transformation over the past 50-60 years (Attar, 2013b).

The current total fertility rate (TFR), which represents the average number of children born during woman's reproductive years, in Türkiye stands at 1.51 (TURKSTAT, 2023) that is below the replacement level of 2.1. Regional disparities in TFR are evident, with rural areas exhibiting a higher rate of 2.8 compared to urban areas with 2.2, as revealed in the Turkey Demographic and Health Survey (TDHS-2018) (Hacettepe University Institute of Population Studies, 2019). Moreover, survey shows that wealthier women (the highest wealth quintile) tend to have fewer children, with an average of 1.9 children in compared to 3.3 children in the lowest wealth quintile. This can be seen as an indication of falling fertility with an increase in wealth. Additionally, the survey found that highest

TFR is observed among women with incomplete primary education or no education and the lowest TFR is observed among women with high school or higher education.

According to Dyson (2011), the reduction in fertility rate is closely associated with the accelerated pace of urbanization. Classical demographic transition theory explains changes in fertility rates by highlighting the impact of the growing urban-industrial society. Additionally, urbanization occurring within the transition of the workforce from agriculture to industry and the service sector is an inevitable outcome of economic development. In other words, as nations develop, while the gross domestic product (GDP) share of agriculture sector falls, the share of both industrial and services sectors increase.

According to the World Bank (2021) it is widely recognized that the future belongs to urban areas. For example, while in 2018, more than 55% of the world's population resided in cities; by 2050, this number is expected to rise to two-thirds. Developing nations are rapidly urbanizing, while developed countries have almost completed this process (Gu, 2019). Likewise, among other developing countries, Türkiye is also experiencing a similar phenomenon.

At the same time, we observe two additional significant developments taking place in Türkiye. The first, the share of the urban population is converging to unity. Rural-urban differences in observed fertility are also closing. Second, economic growth continues in the long run as well, and both urban and rural income per capita levels are growing.

Based on these facts and developments, the main objective of this thesis is to understand the economic foundations of fertility dynamics and rural-urban fertility differentials in Türkiye.

The thesis poses and answers various research questions to achieve this objective:

- How does the income-fertility relationship differ in rural and urban regions?

- How does technological progress determine rural-urban income differences and affect the dynamics of rural-to-urban migration?
- What is the role of reproduction costs on fertility preferences?

To answer these questions, the thesis constructs and studies a simple two-region model with endogenous technology and endogenous fertility. The production side of the model follows Lucas (2009) where urban regions adopt foreign technologies, and rural regions benefit from technology adoption through urban-to-rural productivity spillovers. On the consumption side, households in both rural and urban regions choose optimal fertility levels depending on the time cost of reproduction and income per household.

To study such a model for the Turkish context, we design a benchmark calibration algorithm that allows us to match regional fertility levels and rural-urban fertility differences as well as rural-urban population shares. With such a calibration exercise, we can also infer the dynamics of some crucial but unobserved regional variables: income levels and reproduction costs.

With this backdrop, our thesis makes three major contributions to the existing literature. First, to the best of our knowledge, this is the first study examining the effects of income levels on fertility decline across rural and urban regions in Türkiye. By constructing a model in which technology, and fertility are endogenous and using macroeconomic data, we estimate the unobservable variable of the per capita income levels in both regions, which are not accessible in any data source. Also, this estimation of per capita income levels is dependent on the Lucas (2009) and share of rural population as well as changes in overall per capita income level in Türkiye. Second, the thesis also explores the role of the time cost of reproduction variable in differences in declining fertility rates across these regions. Since there is no observable data on this variable, we estimate it using our model-based calibration. This aspect of the research is particularly valuable since there is currently no work on examining the time cost of reproduction in Türkiye. In this respect, our thesis can have the potential to trigger the studies analyzing the role of the time cost of reproduction. Finally, constructing a benchmark calibration path leading us to design various counterfactual experiments, and we provide evidence to answer the aforementioned research questions. In one set of experiments, we alter the dynamics of technological progress and investigate effects on regional income and fertility levels. In another set of experiments, we simulate the model with alternative constructions of fertility preferences. Finally, we also experiment with reproduction costs to see how decisive these costs are for the observed fertility levels in rural and urban regions.

Based on these experiments and calibration exercise, we obtain the following results. The first major results of our thesis are that the fertility rates are higher in rural areas than in urban areas. However, both regions show a similar trend of decreasing fertility rates over the years, which stabilizes by the end of the period (2015-2020). As we found that the negative effects of economic growth on fertility decline are more pronounced in urban regions compared to rural areas. This suggests that households tend to have fewer children as they become wealthier, with urban regions showing a comparatively greater impact.

We have also investigated the relationship between economic growth and demographic trends in Türkiye. Based on counterfactual experiments using "what-if" questions, we obtained the following results. Our findings indicate that technological progress has a greater impact on output in urban regions compared to rural regions. As urban areas adopt the technology from a frontier economy, these technological benefits spillover to rural areas. Consequently, fertility decline is more significant in urban regions due to the larger increases in income levels there. Although all regions experience an improvement in their economic well-being, the rise in per capita income is more pronounced in urban areas, leading to increased income inequality between urban and rural regions.

Moreover, the result of the counterfactual experiments regarding the effects of the fertility preferences parameter, which determines how many children household will have, show that the decision to have more or less children in rural regions are more affected than that of urban regions. Finally, the impact of the time cost of reproduction on the fertility rate has changed over time for both rural and urban regions. The effect of reproduction costs on fertility decline in urban regions are higher than rural regions. The counterfactual experiments show that until 2000, reproduction costs led to a decrease in fertility rates. However, after that period, it caused an increase in fertility rates for rural regions.

Similarly, while it contributed to the declining fertility rate until around 2005, it increased fertility rates for urban regions after that year. This indicates that the value of the time cost of reproduction first increases until around mentioned time and then shows a decreasing trend up until 2021 for Türkiye. In addition, while the cost of reproduction played a role in declining in fertility rates between 1978 and approximately 2005, after that time, the income levels are the primary factor in declining in fertility rates.

All these results imply that young population could benefit from declining fertility rates, since there will be more jobs available to them. Thus, this could open up opportunities in various work areas for young population. Additionally, Türkiye needs to focus on improving its technology level, as it currently lags behind to close the gap between frontier country.

CHAPTER 2

RELATED LITERATURE

This chapter consists of three parts. The first part explains Malthus's view on the relationship between population and economic growth. The second part state the importance of total factor productivity (technology) in economic growth. The third part presents the discussion about the relationship between urbanization and fertility.

2.1. MALTHUS'S VIEW ON THE RELATIONSHIP BETWEEN POPULATION AND ECONOMIC GROWTH

In the late eighteenth century, Malthus is the first researcher studying on the relationship between population and economic growth. His theory is presented in his book titled as "An Essay on the Principle of Population". Malthus (1798) explains why nations should be concerned about their increasing population based on the idea that food production grows in arithmetic sequences while population growth occurs in geometric ratio. In other words, food cultivation is subject to diminishing returns due to the fixed factor of agricultural land. Malthus calculated that food would double every 25 years while the population would continue to grow larger. This will eventually lead to shortage of food. However, Malthus (1798) has proposed two checks to address this issue: positive and preventive. Positive checks refer to the occurrence of natural disasters, famine, and war that bring the population size to a level where it balances with the available food. Preventive checks occur when the effects of these disasters discourage people from getting married and having children. This results in the population returning to a balanced level where the available food is enough to sustain the population. Malthus believes that these checks are necessary to maintain a balance between population growth and food supply. Additionally, Malthus suggests that increase in a country's production level and demand for labor improves the economic conditions of laborers, encouraging them to marry and have children until the increased production is enough to feed the growing population.

Roncaglia (2005) explains the Malthus's ideas about the wages and food briefly. When the wages of most workers are higher than the minimum level required for basic needs, population will start to increase, and agricultural productivity cannot keep up with the demand, resulting in a rise in food prices and a decrease in real wages, leading back to the minimum subsistence level. Conversely, if the wage rate is lower than the subsistence level, the population will decrease due to rise in mortality and declining in birth rates. The declining population will cause a decreasing total demand for goods, leading to a fall in prices for the goods and a rise in real wages. According to Roncaglia (2005), Malthus is not the first researcher to explain this relationship. Indeed, what he has done is that Malthus explains it in a way that is consistent with population principles.

On the other hand, according to Rahman (2018), Malthusian theory of population is no longer valid in today's world, because of two main reasons. The first, instead of increasing, there is a decline in population growth rate in almost everywhere. The second, unlike Malthus, it is hard to say that there is a food shortage. In many countries, particularly in Western nations, the growth rate of population decreased during the late nineteenth and early twentieth centuries. At the time the Malthusian population theory invented, the Industrial Revolution had just begun in England. Also, the Industrial Revolution and advancements in science and technology have increased food production capacities (Rahman, 2018). Thus, within the Industrial Revolution many countries have experienced rapid economic growth including Japan and some Asian countries. There has been a significant demographic transition in these countries. For example, there have been decline in mortality and fertility rates as per capita income is no longer stagnant (Ehrlich & Kim, 2005).

2.2. STUDIES ON THE RELATIONSHIP BETWEEN TOTAL FACTOR PRODUCTIVITY AND ECONOMIC GROWTH

The growth accounting literature constructs a model that represents a country's factor accumulation and Total Factor Productivity (TFP) (2.1) and aims to calculate the contribution of productivity to the country's per capita output. At the same time, it determines the amount of contributions of labor and capital (these are part of the factor accumulation). Roberson (1988) highlights that many studies also use growth accounting analysis to identify the contributions of capital and labor inputs. Moreover, growth accounting is highly effective for determining whether the growth is caused primarily by input expansion or technological progress. Furthermore, growth accounting is a prominent tool for measuring the contribution of various economic drivers to economic growth by their effects on Total Factor Productivity (TFP) growth (Gong, 2020). Mainly, by using growth accounting approach, one can provide the comprehensive understanding of the strengths and weaknesses of the countries' growth performance (Crafts & Woltjer, 2021). Equation 2.1 presents the relationship between output and factor accumulation and total factor productivity.

$$y = F\{k, h, A\} \tag{2.1}$$

where y is output per worker, k is per worker capital, h is per worker human capital and A is the total factor productivity. Following Equation (2.1), we constructed two production functions in this thesis. One for rural regions; the other for urban regions. By using these production functions, we will be able to analyze the components of per capita income for both regions.

The analysis of growth accounting begins with Solow's (1956) work that constructs the neoclassical growth theory, where technology is considered exogenous. By conducting decomposition analyses, the author concludes that differences in capital stocks cause differences in income levels across nations. The main idea presented in his work is that low-income countries have the potential to catch up with high-income countries. This is because rich countries would eventually experience diminishing returns of capital accumulation, while poor countries would experience higher returns of capital accumulation since the level of capital accumulation is low in those countries. Therefore, developing countries can follow the growth paths of high-income countries and eventually converge to them.

However, in the late 1980s, endogenous growth theories were exploited, with Romer (1986) and Lucas (1988) being pioneers. They show that technology is determined within the model compared to the Solow (1956) assumption. Thus, the level of technology could be different in all countries. These studies also demonstrate that human capital is essential to determine output levels. It affects labor productivity and the use of developments in technology. The importance of these studies lies in understanding why technology varies among countries and the role of technology in the production function.

Hanel & Niosi (1988) add that endogenous growth model basically assumes that an economy's aggregate output is determined not only by the quantity of inputs (human capital, physical capital, and labor) used by firms but also by the stock of outcomes from research and development (R&D) performed by all firms in the economy. The study of Shahabinejad et al. (2013) decomposes productivity into technical efficiency and technological change. The research found that technological changes have a more significant impact on productivity growth than technical efficiency in South Korea during the period of 2000-2010.

According to Caselli’s (2005) survey data, poor countries make better use of physical capital than rich countries, whereas rich countries make better use of human capital. Additionally, Hall and Jones (1999) emphasized that differences in capital accumulation, educational attainment, and productivity cause income variation between countries. They impose that physical capital and educational attainment can only explain, to some extent, differences in income levels across countries. However, productivity explains the bulk of these differences. Mainly, productivity or TFP is called a residual because factor inputs’ contributions could account for the total output, but TFP does not. Thus, subtracting these contributions, there are remaining values in the total output, and that contribution comes from the TFP.

Studies followed by Caselli (2005) and Hsieh & Klenow (2010) highlight that inputs of physical capital, human capital, and TFP are the proximate determinants of income levels. Their research indicates that TFP contributes more than other inputs to occurring outcomes. These authors conclude that differences in TFP, at least 50%, explain the per capita income variation across countries. In addition, Khan (2009) analyzes the determinants of income differences across countries. He stresses that TFP explains between 50% and 75% of this disparity. Among all, Caselli (2016) compared the poorer countries with the United States of America (USA). He finds the main reason for the income disparity: in poorer countries, physical and human capital is low, and their efficiency is less.

The recent study by Gallardo-Albarrán & Inklaar (2021) indicates that TFP has an extraordinary contribution to aggregate output. Many studies, including those, suggest that TFP is the most important determinant of diverse income levels across nations. The research by Córdoba & Ripoll (2008) shows that the level of productivity is primarily determined by the accumulation of physical and human capital that findings contradict the previous studies. Therefore, in this thesis, we calibrated the TFP for Türkiye and shows the driver of the growth rate is determine by the growth rate of TFP. We also construct the source of the TFP in Türkiye mainly is determined by the technology adoption.

The most important feature of technology is making human life more manageable. Innovations is one of the sources of technology. These innovations are involving the developments of new products, production processes, and organizational management. On the other hand, countries can adopt technology from other countries. Adoption means transferring created technology. Comin & Hobijn (2010) conducted a study on the adoption lags of 15 technologies across 166 nations from 1820 to 2003. Their findings indicate that the differences in adoption lags between countries for these technologies contribute to at least 25% of the variance in per capita income across the studied nations. This highlights the importance of this issue. On the other hand, Comin & Mestieri (2018) analyze the adoption of 25 technologies in 132 countries in the past 200 years. Their model exposes that adoption lags between rich and poor countries have converged, whereas penetration rates have diverged. Authors underlined differences in the distribution of the technology diffusion contribute to 80% of the global income divergences.

Acemoglu & Dell (2010) indicate the technology adoption and technological know-how determine the production efficiency level. Adopting new technology raises questions, such as whether countries use this technology effectively. The notion of the absorptive capacity is the answer to this question. Because it indicates the usage level from adopting the new technology, the literature shows that this situation depends on some variables. For instance, Asif & Lahiri (2021) emphasize that learning by doing, a component of human capital, is the most important variable in determining the level of technology adoption. According to Madsen (2014, p. 690):

> Simulations of the model showed that education has contributed about 146% to labor productivity over the past 140 years for the average country, where the increase in educational attainment has contributed to 18.9% productivity advances while the interaction between educational attainment and [distance to frontier] DTF has contributed 127% to productivity advances.

Lucas (2009) stresses that the transition of technology parameter is the primary driving factor to an overall increase per income level, e.g., in South Korea, Thailand, and Indonesia. More generally, there is an interaction between the local environment, human capital, and technology adoption (Stokey, 2015). In other words, having high-skill workers increase the returns from adoption. Similarly, educational attainment interacts with frontier technology (Madsen, 2014). Increasing the size of educational attainment increases the uses of the new technology adoption.

We apply catching-up analysis for Türkiye to understand the role of technology adoption for backward countries in catching up within the frontier economy in this thesis. According to Madsen et al. (2010), developing countries can catch up with leading countries in terms of technology level by investing in R&D and education that helps in technology adoption, as they have immense potential to do so. Besides, there is a discussion about why backward countries stay to be backwardness. Barro & Sala-i-Martin (1997) explain that follower countries prefer to keep adopting technologies because making an invention is much more expensive. However, Acemoglu et al. (2006) suggest that when countries get closer to the technology frontier, they become more likely to innovate. Therefore, closing the gap with the leading economies is crucial for countries to develop their innovation capabilities. Benhabib et all. (2014) theoretically discuss how agents decide stages of imitation and innovation. As the benefits of being a backward economy decrease, countries like South Korea face the challenge of shifting towards innovation once they have caught up with the leading economies. However, in this thesis, we find that Türkiye fail to catch-up the frontier economy. In other words, during the period of 1978-2021, the productivity gap between Türkiye and frontier country remains high and there is no tendency that the gap will be closed.

Human capital is also considered as one of the crucial inputs in the production process. It is well known that human capital is the cognitive ability that makes the person more productive. Human capital sources include educational attainment, job training, experience, and good health. Nelson & Phelps (1966) emphasize the role of education in enhancing the ability and using information to perform jobs well thereby it positively effects the adaptation of new technology.

According to Galor & Tsiddon (1997) human capital of the persons consists of their parent's human capital and investment in human capital. Since the increase in human capital has been becoming so important, to find a good job and secure good level of income, it will also have some consequences in fertility preferences in Türkiye. She has been experiencing fertility decline in recent years it is more pronounce in the urban regions. These decline in fertility is related to have more educated children and to earn more income which requires high quality of labor and forces people to reconsider their decisions about the reproduction costs. As Barro (1991) emphasized, a higher level of human capital leads to a decrease in the fertility rate. Also, Becker et al. (1990) indicate that societies with abundant human capital experience higher rates of return on the investment of human capital. Consequently, societies with limited human capital tend to increase family size. In general, increasing expenditure on children, leads to better quality of the children, which highlights the quantity-quality trade-off for children (Becker, 1960).

On the other hand, there are important studies finding the TFP as a one of the main drivers of economic growth for Türkiye. For example, according to Çiçek & Elgin (2011), raising the total factor productivity (TFP) level contribute to the output growth at most portion, as shown by growth accounting analysis and a dynamic general equilibrium model. In similar, İsmihan and Metin Ozcan (2009) analyze the sources of growth in Türkiye between 1960 and 2004. Their findings suggest that TFP and capital accumulation are the primary drivers of growth, with TFP contributing 20% to output per worker during this period. This highlights the significance of TFP in Türkiye's economic growth. Furthermore, the result show that TFP is positively influenced by exports, as the transfer of knowledge from abroad contribute to the TFP level. Imrohoroğlu et al. (2014) examine the per capita income differences between Türkiye and other countries of similar development. Their result show that Türkiye has lower productivity in the agricultural sector than that of peer countries. They emphasize that the average productivity growth from 1968 to 1978 in the agriculture sector of Türkiye was only 1.76%. The authors conclude that if Türkiye had experienced the same level of agricultural productivity growth as Spain, the employment rate in agriculture would have dropped more quickly, and the overall per capita GDP would have increased significantly. Results of this study will create important directions and lessons for our thesis. Finally, according to Attar (2013a), Türkiye’s economic growth in the near future will be driven primarily by technological advancement. However, due to the slow pace of technological progress, population aging is likely to cause a growth slowdown.

2.3. THE RELATIONSHIP BETWEEN URBANIZATION AND FERTILITY

In this subsection, we present studies on the relationship between economic growth and fertility, followed by studies on the relationship between urban-rural migration, economic growth, and fertility.

2.3.1. The Studies on the Relationship Between Economic Growth and Fertility

The first economics analysis of the fertility lies in the work of the Becker (1960). He introduced the concept of children as durable consumption goods. He argued that as family’s income increases, both the number of children and the amount spent on them increase. However, he noted that increasing the income level of families will affect the quality of children more than the quantity of them since the quality of children has a higher elasticity than that of number of children. In addition, wealthy families and countries tend to have fewer children as they focus on the quality of children rather than the quantity. The spending of the quality of the children indicates the improving human capital sources of the children such as given good-education, well-nutrition, and based on cognitive abilities for children. The author also underlines the main reason of the rural areas have more children than urban areas is the lower expenditure on children i.e., rise the number of children in rural areas. In short, the study of the Becker (1960) highlights the economic nature of children, with families make trade-off between quality and quantity of children since children provide utility to their parents.

After Becker's (1960) study, Barro & Becker (1989) developed an economic model based on the relationship between economic growth, and fertility. Their analysis yielded several results. One of the crucial results of their study is that the rate of growth in per capita consumption is accelerated by technological progress. Under the conditions that technological progress is "Harrod neutral" and fertility responds positively to income increases, then faster technological progress will decrease fertility and population growth. However, if fertility decreases as income rises, more rapid technological progress may actually increase fertility and population growth rates.

There are also many empirical studies conducted to understand the relationship between economic development and the fertility rate. For example, by using unit-root and cointegration tests on a balanced panel consisting of 72 countries, Hafner & Mayer-Foulknes (2013) indicates that there is a causal relationship between high income, high human development, and low fertility rates in the long run. Given the dual nature of the relationship between fertility decline and economic growth, the literature predominantly focuses on how fertility decline impacts per capita income level and most of the studies find that the higher fertility rate effects inversely nation's per capita income level. For instance, the analysis of the reduction in fertility to the growth rate of Nigeria shows that it will increase the country's per capita income level to the point 5.6 over the 20 years period (Ashraf et al., 2013). Brander & Dowrick (1994) analyze the 107 nations from 1960 to 1985. Their findings indicate that high birth rates tend to reduce economic growth, whereas lower birth rates have a significant positive influence on per capita income growth in the medium-term.

Becker et al. (1990) study the relationship between the economic growth and the population and concludes that an increase in population leads to a decrease in per capita income due to diminishing returns. However, there is little evidence to suggest that a rise in population in more developed economies has the same effect. Their analysis shows the positive and negative effects of population on production. That is to say, on one hand, population growth may negatively impact productivity due to diminishing returns from increased use of natural resources. On the other hand, larger populations promote higher specialization and greater investment in knowledge, which is facilitated in part by larger and more important cities. Therefore, the overall relationship between increasing population and per capita income largely depends on whether the incentives for human capital and knowledge expansion outweigh the diminishing returns on natural resources.

There are limited number of studies investigating the relationship between economic growth and fertility in Türkiye. For example, Ozboy Das (2020) uses Autoregressive Distribute Lag (ARDL) cointegration method to find the what kind of relation exist between level of per capita income and fertility in Türkiye for the period 1960-2016. The results of the study shows that a negative relation exists between them. Moreover, Ergöçmen (2012) highlight the Türkiye’s fertility rate is very close to the replacement level, at a rate of 2.16 that indicates the further questions such as which factors effects the fertility decision in Türkiye. According to Koç et al. (2010), various socioeconomic factors such as rising education levels, labor force participation rates, and income levels have contributed to the reduction in fertility levels in Türkiye. Çağatay et al. (2015) investigates the fertility preferences and conclude that there exist various factors determine the changes fertility preferences in Türkiye such as age, education, marital status, and socioeconomic status. The authors conducted the survey analysis and observed that the factors affecting changes in fertility preferences among women in Türkiye are similar across different socio-demographic groups. For instance, women living in urban areas with a high standard of living who have not yet achieved their desired number of children consider improved economic conditions, child allowances, and support for childcare to be important. On the other hand, regulations related to working life, such as the right to early retirement, shorter working hours, and extended breastfeeding periods, are seen main factors for women who participate in the labor force. Therefore, it appears that Türkiye's fertility rate decline is more influenced by socioeconomic factors (Yaşıt, 2007).

2.3.2. The Studies on the Relationship Between Urban-Rural Migration, Economic Growth and Fertility

In the recent years, another important demographic change that can have the potential to have an effect on economic growth and is also affected by economic growth is the transition from rural to urban regions. We know that urbanization is the process that involves the movement of larger numbers of people, who change their living arrangements from the village to the cities. This process is often driven by rural-to-urban migration within the country. The reason behind this migration is that urban regions of the country provide higher opportunities for their citizens, such as the potential to participate in the labor force, better conditions in the work places, higher wages, accessible health care, and to get higher quality education and nutrition for their children.

According to studies in the existing literature, the main driving factor behind the urbanization is economic development. As Quan (2014) emphasized, there is a close relationship between economic growth and urbanization. Dyson (2011) indicated that there is an acceleration in urbanization as a result of the transition of the workforce from agriculture to industry, and the service sector is a typical phenomenon that comes along with economic development. Urbanization is the changes of the majority of the working population from farmers to a non-rural population, increasing the urban population (Gu, 2019).

Liu et al. (2015) and Nguyen & Nguyen (2018) claim that urbanization promotes economic growth. Also, Nguyen & Nguyen (2018) concludes that the relationship between urbanization and economic growth is non-linear. We know that urban regions play a crucial role in Türkiye’s economic development process. The production in urban areas is approximately four times higher than in rural areas, despite the fact that the population in urban areas is only 2.26 times higher than in rural areas (World Bank Group, 2017). This indicates that productivity is higher in urban areas. In addition, urban areas have significantly contributed to Türkiye’s economic growth in recent years, accounting for an average of around 77% of annual economic growth between 2000 and 2014 (World Bank Group, 2017). The study shows that increasing urban agglomeration by 10% raises average worker productivity by around 0.7% and 1% in the 50 largest USA metropolitan areas, demonstrating productivity advantages from agglomeration economies (Melo et al., 2017).

The study of the Brunt & García-Peñalosa (2022) focuses on the causal relationship between urbanization and productivity growth. The study highlights that when rural workers relocate to cities, the accompanying urbanization causes technical progress and productivity growth. Urban density promotes knowledge sharing and innovation, resulting in a positive feedback loop between city size and productivity that drives continuous economic expansion (Brunt & García-Peñalosa, 2022).

However, it is better to look at the two-way relations between rural-urban migration and economic development. Lucas (2004) presents the theoretical framework of it and emphasizes that internal migration is a crucial element that drives the country’s economy towards sustained economic growth. He highlights that rural-urban migration is urbanization, and unlike developed nations, low-income countries began experiencing it during the post-war period. For instance, the author shows that the during the Industrial Revolution, the proportion of the British population living in rural areas dropped from 50% in 1850 to 11% in 1998. Additionally, the contribution of the workforce in agriculture decreased from 21% in 1851 to 7% in 1911 and 2% in 1995. Moreover, this process should be kept in mind as the movement of labor from a land-intensive technology to a human capital-intensive technology. Therefore, cities play a significant role as places where new immigrants can learn the skills necessary for current industrial technology (Lucas, 2004).

On the other hand, starting in the 1950s, Türkiye experienced a significant movement of people from rural to urban areas. This was due to push factors in rural areas and pull factors in urban areas, primarily related to economic factors. In the 1920s, 80% of Türkiye's population lived in rural areas, but by the 1950s, the majority lived in urban areas. This shift was extremely decelerated by liberal economic policies that were implemented in the 1980s, which required more labor in the service and industrial sectors. Thus, Türkiye experienced a rapid increase in rural-to-urban labor migration again at that time period. It is important to note that the transfer of labor from agriculture to industry and service sectors was happening in parallel with Türkiye's urbanization process (Koç et al., 2010). The study of Sancar & Sancar (2017) shows that the between 1990 and 2014, Türkiye's GDP per capita was positively influenced by the high population density in urban areas.

Classical demographic transition theory explains changes in fertility rates by highlighting the impact of the growing urban-industrial society. This theory suggests that economic factors play a crucial role in fertility changes, such as the rise in income levels and the proportion of factory workers, which leads to declining fertility. Moreover, the theory highlights that the urban areas typically have lower fertility rates than rural regions and decline in fertility rates start earlier in urban regions than rural regions (Dyson, 2011).

On the other hand, according to traditional economic theory, when a country is in its initial stage of economic growth, it often experiences a high fertility rate. However, as the economy develops over time, the fertility rate decreases. This relation also is explained by the unified growth theory that uses the technological progress are the main sources for this development and fertility decline. Empirical research has supported this view and has found that economic growth is typically accompanied by a higher fertility rate at the beginning, but as the growth accelerates, the fertility rate declines (Li, 2016).

The impact of economic growth on a country's fertility rate varies depending on the country's developmental levels. For example, economic growth has a negative effect on fertility rates in rich countries (Li, 2016). Dündar (2022) examines fertility behaviors in regions of Türkiye where the fertility rates are relatively high. The study reveals that factors such as women's employment rates, and per capita gross domestic product negatively impact fertility preferences in these regions.

Finally, there is a significant difference in fertility rates between urban and rural areas. One reason for this is the higher cost of raising children in cities. In rural areas, children can be self-employed by working on their parents' farm and as a result, are less costly. Furthermore, the growth of industries in urban areas leads to higher labor productivity and, therefore, boosts rural-urban migration (Yegorov, 2003). Based on this related literature review, we can conclude that there is a gap in the existing literature studying the effects of economic growth on fertility rates across the rural and urban regions of Türkiye. Moreover, no study investigates the impact of time cost of reproduction on fertility rates across these regions in Türkiye. Our thesis fills these gaps. Also, assuming endogenous technology, our study is the leading the study explaining the economic and demographic differences between urban and rural regions with this endogenous technology utilizing the model-based calibration.

CHAPTER 3

MODEL ECONOMY

In this chapter, we construct our model economy. Our model is a simple two region model. In this simple model, we assume that both technology and fertility are endogenous. In addition, our simple model has two sides: The production and consumption sides. We start with explaining general framework of model.

3.1. OVERVIEW

In the model, the time is discrete and goes to infinity $t \in \{0,1,\ldots\}$. Also, we assume that there is no government, no capital accumulation and the economy is closed following Lucas (2009).

The model has two regions, namely rural and urban. We develop a simple model explaining the effect of fertility decline on the household size. In our analysis, we use the per capita variables as in Lucas (2009). Since per capita income level in these regions are not directly observable, we have to model them by using the dual economy model in Lucas (2009), where we determine the characteristics of economy in both rural and urban areas.

The households make preferences between consumption and fertility. Since individuals have a unit-time endowment, they spend it between working and reproduction. Further, we assume that the reproduction is asexual. In such an environment, fertility has only a time cost for the household. Thus, by solving the household's decision problems, we can determine their optimal fertility preferences.

We create two production technologies in different regions. Output in each production technology is expressed in per capita terms. We also have two technology (productivity) equations, one for Türkiye and the other for frontier economy. These equations are important for the growth and catching up analysis. Finally, we conclude this section by presenting the dynamics of the model.

3.2. FERTILITY AND CONSUMPTION

The households from both regions obtain utility V_{it} from consumption c_{it}, and fertility n_{it}, where the lower subscript *i* indicates the region in which the household resides. Specifically, i=u denotes the urban region, while i=r denotes the rural region at time *t*. The household's utility function can be expressed as follows:

$$V_{it} = c_{i,t} + \phi \text{In}\left(n_{i,t} - 1\right) \tag{3.1}$$

Where $\phi > 0$ is a preference parameter that governs the marginal utility of the reproduction.

In Equation (3.1) the reason of the using natural logarithm is to show that utility function is subject to diminishing marginal utility of fertility. Also in this utility function, preferences are non-homothetic which implies that changes in income do not lead to proportional changes in fertility preferences or consumption patterns. Finally, the fertility level cannot be less than 1, since it represents the average number of children, and it is biologically or practically impossible to have less than one child.

The budget constraint of the household in region *i* is given by

$$c_{i,t} = y_{i,t}\left(1 - z_{i,t} n_{i,t}\right) \tag{3.2}$$

Both y_t and z_t differ across regions; y_t is real income per hour and determined endogenously, whereas z_t is represents the unit-time cost of reproduction and determined exogenously. The time cost of reproduction refers to the amount of time parents need to spend on activities such as pregnancy, childbirth, and childcare.

Household i aims to maximize utility (3.1) subject to the budget constraint (3.2). After substituting (3.2) in (3.1), the problem of household i can be described as in

$$\max_{n_{i,t}} \; y_{i,t}\left(1 - z_{i,t}n_{i,t}\right) + \phi \ln\left(n_{i,t} - 1\right) \tag{3.3}$$

Given (y, z) and using the first order condition (FOC), the solution of household's i problem is

$$-y_{i,t}z_{i,t} + \frac{\phi}{n_{i,t}-1} = 0$$

$$\frac{\phi}{n_{i,t}-1} = -y_{i,t}z_{i,t}$$

$$n_{i,t} - 1 = \frac{\phi}{y_{i,t}z_{i,t}}$$

$$n_{i,t} = 1 + \frac{\phi}{y_{i,t}z_{i,t}} \tag{3.4}$$

Furthermore, this problem satisfies the second order condition (SOC), since the objective function is strictly concave in $n_{i,t}$. This condition is shown as

$$\frac{d}{dn_{i,t}}\left[-y_{i,t}z_{i,t} + \frac{\phi}{n_{i,t}-1}\right] < 0 \text{ for all } n_{i,t} \tag{3.5}$$

Equation (3.5) implies that there is a negative relationship between fertility and both per capita income and the unit-time cost of reproduction. In simpler terms, an increase in either per capita income or the unit-time cost of reproduction leads to a decline in fertility rates, as indicated by (3.6).

$$\frac{\partial n}{\partial y} < 0 \quad \frac{dn}{dz} < 0 \tag{3.6}$$

3.3. PRODUCTION AND INCOME

In this subsection, we introduce the production technologies of our model. The model has rural and urban sectors in production technologies. To identify these production technologies, we rely on Lucas (2009), and each output is defined as a per capita term.

In addition, productivity in the rural sector depends on the urban sector, which is designed to catch up to the world frontier. Thus, both sector produces the same output what we call as GDP. Finally, we assume markets are perfectly competitive.

The model has two important variables: x_t, and A_t. As in Lucas's (2009) and Attar's (2018a) work, the role of these variables and the structure of the production technologies are exactly the same for our model. $x_t \in [0,1]$ is the control-like variable representing the fraction of the population (and labor force) working in the rural sector, while $A_t \in (0, +\infty)$ is the endogenous state variable representing productivity level in the urban sector. For a given x_t, and A_t the level of production per capita in the rural and the urban sectors respectively satisfy

$$y_{rt} = \zeta A_t^{\xi} x_t^{\theta} \qquad \zeta > 0 \quad \xi, \theta \in (0,1) \tag{3.7}$$

and

$$y_{ut} = A_t(1 - x_t) \tag{3.8}$$

Where y_{rt}, and y_{ut} denote the real GDP per person in rural regions and in urban regions respectively the former subject to decreasing returns to scale and the latter subject to constant returns to scale. Concerning (3.7), ζ is a parameter that positively impacts labor productivity in the rural sector and the labor share in rural sector is denoted by θ. Additionally, productivity growth in the urban sector can boost labor productivity in the rural sector by the spillover parameter ξ. On the other hand, (3.8) determined by the variables of the productivity level, and percentage of the urban population (and labor force) respectively denoted by A_t, and $1 - x_t$.

After establishing our model, we use it to solve the allocation problem of the model economy by assuming perfect labor mobility between regions, as in Lucas (2009). In other words, an optimal level of x_t maximizes total output at t is given by

$$\max_{x_t} \; \zeta A_t^{\xi} x_t^{\theta} + A_t(1 - x_t) \tag{3.9}$$

Therefore, the unique (interior) solution of (3.9) is demonstrated as follow.

$$\theta\zeta A_t^{\xi} x_t^{\theta-1} - A_t = 0$$

$$\theta\zeta A_t^{\xi} x_t^{\theta-1} = A_t$$

$$\theta\zeta A_t^{\xi-1} = x_t^{1-\theta}$$

$$x_t = \left(\frac{\theta\zeta}{A_t^{1-\xi}}\right)^{\frac{1}{1-\theta}} \tag{3.10}$$

Again, as shown in (3.11), SOC is satisfied.

$$\frac{d}{dx_t}\left[\theta\zeta A_t^{\xi} x_t^{\theta-1} - A_t\right] < 0 \tag{3.11}$$

According to (3.10), if the economy experiences growth (through growing A_t), and the spillover parameter is less than one ($\xi < 1$), then the share of employment in rural areas will decrease. This leads to the process of urbanization in the economy.

3.4. GROWTH AND CATCHING-UP

This subsection presents the dynamics of growth and catching-up process of the model economy. The primary source of growth is technology adoption, which is discussed using the term "catching up analysis."

Simply, catching up is a process that is implemented by late-industrializing countries. It involves the transfer of technology from advanced countries. According to Wang (2007), through the adoption of technology and technological learning, late-industrializing countries can catch up with the advanced countries that initially transported their technology to them. In summary, the objective of using this economic model is to show how convergence will take place with the more technologically advanced countries. Furthermore, the productivity gap between backward country and frontier country will impact the productivity growth, which our model captures.

Following Lucas (2009), we assume that A_t grows as a result of technology adoption (or catching up). The law of motion for A_t is given as follow:

$$A_{t+1} = A_t + \mu(1 - x_t)^{\psi} A_t^{\lambda} \bar{A}_t^{1-\lambda} \tag{3.12}$$

In (3.12), $\bar{A}_t$ is frontier country's productivity where USA is taken as frontier country, and it grows at the rate μ i.e., shown in (3.13).

$$\bar{A}_{t+1} = (1 + \mu)\bar{A}_t \tag{3.13}$$

Also, $\bar{A}_0 > 0$, and the value of it is given.

To find the gross growth rate, we divide the (3.12) by A_t.

$$\frac{A_{t+1}}{At} = 1 + \mu(1 - x_t)^{\psi} A_t^{\lambda-1} \bar{A}_t^{1-\lambda} \tag{3.14}$$

After simplifying the (3.14), we can get the final equation of the gross growth rate as in (3.15):

$$\frac{A_{t+1}}{At} = 1 + \mu(1 - x_t)^{\psi} \left(\frac{\bar{A}_t}{A_t}\right)^{1-\lambda} \qquad \psi > 0,\ \lambda \in (0,1) \tag{3.15}$$

In (3.15) we assume that initial value of A_t, which is A_0, is positive.

The right-hand side of (3.15) reflects different dynamics, which are explained below.

- The term $(1 - x_t)^{\psi}$ shows the urban agglomeration effect. It implies that the lower value of x_t, the faster the productivity growth. In other words, urban agglomeration is the result of rural-urban migration that increase the population of urban regions. Thus, it increases the labor forces in those areas. As is seen in the equation (3.15), the term of agglomeration contributes to the productivity growth rate, thus increases in this term increase productivity in urban regions. As a result, it leads to an increase in the income level of this region.

- The term $\left(\frac{\bar{A}_t}{A_t}\right)^{1-\lambda}$ represents the distance to frontier effect. The larger distance to the frontier ($\bar{A}/A$ bigger) implies faster productivity growth. This phenomenon is referred as the "advantage of backwardness," which was explored by Gerschenkron (1962).

Finally, the following assumption tells us how the model economy's catching up ends:

- If productivity levels are equal in model and frontier economy, $A_t = \bar{A}_t$ and also all labors work in urban regions, $x_t = 0$, then A_t will grow at the rate of μ.

3.5. DYNAMICS

Models that incorporate the time factor are typically referred to as dynamic models. In dynamic models, all variables of the economic process are assumed to depend on time (Safiullin & Safiullin, 2018).

The equilibrium dynamics of our model is explained in (3.16-3.23). Since they show how the model will evolve in time, these equations are used to determine the benchmark paths of model economy for Türkiye.

(3.16) shows the inverse relation between x_t and A_t. The x_t represents population share in rural regions and A_t is the productivity (technology). (3.16) indicates that the increasing productivity cause the decline of the share of the rural population.

$$x_t = \left(\frac{\theta\zeta}{A_t^{1-\xi}}\right)^{\frac{1}{1-\theta}} \tag{3.16}$$

Equations of (3.17), (3.18), and (3.19) show the determination of the per capita GDP level in rural, urban regions and whole country respectively. As is seen in (3.17) - (3.19), decrease in the rural population share x_t increases the urban population share $1 - x_t$ and will result in higher per capita GDP level in urban regions and lower per capita GDP level in rural region.

$$y_{rt} = \zeta A_t^{\xi} x_t^{\theta} \tag{3.17}$$

$$y_{ut} = A_t(1 - x_t) \tag{3.18}$$

$$y_t = y_{rt} + y_{ut} \tag{3.19}$$

Equations (3.20), and (3.21) respectively demonstrate that fertility rates in rural and urban regions are determined endogenously. Additionally, as evident in these equations, there is no lag or lead relationship between fertility levels, per capita income, and reproduction costs.

$$n_{r,t} = 1 + \frac{\phi}{y_{r,t} z_{r,t}} \tag{3.20}$$

$$n_{u,t} = 1 + \frac{\phi}{y_{u,t} z_{u,t}} \tag{3.21}$$

The (3.22) shows the frontier country's productivity level and (3.23) represents the productivity equation of the model economy.

$$\bar{A}_{t+1} = (1 + \mu)\bar{A}_t \tag{3.22}$$

$$A_{t+1} = A_t + \mu(1 - x_t)^{\psi} A_t^{\lambda} \bar{A}_t^{1-\lambda} \tag{3.23}$$

Since $1 + \mu$ is the gross growth rate of productivity of frontier economy, it grows at the constant growth rate.

As is seen in (3.23), the productivity of the model economy is determined endogenously. The value of the productivity at $t + 1$ depends on the values of the variables in period t.

Furthermore, according to (3.23), the model economy could increase the productivity level via technology adoption, and urban agglomeration.

Finally, dividing (3.23) by its previous period value gives the model economy's growth rate and shows the how distance to frontier effects it. By comparing the values of the (3.22), and (3.23) at each year in analysis period, we will apply the catching up analysis.

CHAPTER 4

CALIBRATION AND THE BENCHMARK PATH

The main aim of this chapter is to assess the empirical performance of the model economy for Türkiye. In this chapter we basically focus on the performance of the fertility differences across regions, changes in fertility and rural population, as well as the relation between fertility and economic growth. Moreover, we aim to show that the fertility is affected by the income levels and the time cost of the reproduction in regions. To do this, we carry out the calibration exercise and show the results of the benchmark paths of the model economy.

4.1. DATA SOURCES

We obtain the data used in the study from three primary sources. These are the World Development Indicators (WDI) compiled by the World Bank, the Turkish Fertility Survey (TFS), and the Turkey Demographic and Health Survey (TDHS), which are conducted by the Hacettepe University Institute of Population Studies (HUIPS). This institution has conducted the same nationwide survey in every five years since 1968.

World Development Indicators provide comprehensive data on countries' economic development and quality of life. On the other hand, the Turkey Demographic and Health Survey provides data on Türkiye's demographic structure, such as fertility levels and trends.

For this study, we gather data on the total, rural, and urban population. By using this data, we calculate the rural population share x_t as a proxy for rural employment share x_t. Also, we use the data on GDP, which is expressed in constant 2015 USA dollar to calculate the per capita real GDP level which is the observed values of y_t. All of these data are extracted from the WDI (World Bank, 2024) within the period 1978-2021.

Additionally, we collected the data on the Total Fertility Rate (TFR), which indicates the average number of births per woman between the ages of 15 and 49 to model the time cost of fertility z_t for the period 1978-2021. Another reason to use this data is to obtain the paths in fertility decline for rural and urban regions based on the dynamics of the model. These data taken from TFS for the year 1978 and TDHS for the years 1993, and 2013 (HUIPS, 1979; 1994; 2014). Lastly to understand the model's power to explain the fertility decline during analysis period, we use the TFR data obtained from TDHS-1998, TDHS-2003, TDHS-2008, and TDHS-2018 (HUIPS, 1999; 2004; 2009; 2019). Table 1 provides a description of each variable and its data source.

Table 1. Data Sources

Data Sources	***Variables***	***Years***
World Development Indicators (World Bank, 2024)	-Total Population -Rural Population -Urban Population -Gross Domestic Product (GDP) at constant 2015 USA $	1978-2021
Turkish Fertility Survey Turkey Demographic and Health Survey (HUIPS, 1979; 1994; 1999;2004; 2009; 2014;2019)	-Total Fertility Rate (TFR)	-1978 -1993 -1998 -2003 -2008 -2013 -2018

4.2. STRUCTURAL PARAMETERS

Our model economy has seven structural parameters. These are represented in Table 2. The values of five parameters ($\xi, \theta, \mu, \lambda, \psi$) are taken from the Lucas (2009) (see Table 2). In Lucas (2009), 112 countries, which are mostly developing countries, are analyzed and we used this study's parameters for Türkiye. Thus, it is useful to explain the role of these parameters for the simulation of the model.

Table 2. Benchmark Parameters and Initial Values of the Model

Benchmark Parameters, and Initial Values	***Symbol***	***Support***	***Value***	***Target/Comment/Source***
Productivity spillover parameter	ξ	(0,1)	0.75	Lucas (2009)
Labor share for the rural technology	θ	(0,1)	0.6	Lucas (2009)
Exogenous productivity	ζ	(0,+∞)	9.9067	Initial value (y_0)
Fertility preference parameter	ϕ	(0,1)	1	Normalization
Frontier economy growth rate	μ	(0,+∞)	0.02	Lucas (2009)
Relative productivity, elasticity	λ	(0,1)	0.35	Lucas (2009)
Urban agglomeration, parameter	ψ	(0,+∞)	1	Lucas (2009)
Initial rural population share	x_0	-	0.5707	1978 data
Initial real GDP per capita	y_0	-	4227.7057	1978 data
Initial productivity, urban	A_0	-	3062.534	Initial value (x_0)
Initial distance to frontier	$(\bar{A}_0/A_0)$	-	1/0.18	Matching the growth process of Türkiye in the analyzing period
Initial productivity, frontier economy	$\bar{A}_0$		17014.0778	Initial value (A_0) and Initial distance to frontier value ($\bar{A}_0/A_0$)

We will start with θ. It is the labor share parameter for the rural technology. In the second line of Table 2, it is given as $\theta = 0.6$. Increasing value of it indicates that rural technology is becoming more labor intensive.

Another structural parameter that we took from Lucas (2009) is the frontier economy growth rate (μ). The value is the 0.02, which equals USA average growth rate. We use the gross growth rate $1 + \mu$ in the simulations.

The last two structural parameters that we will use from Lucas (2009) are the productivity growth elasticity term ($\lambda = 0.35$) and urban agglomeration parameter ($\psi = 1$). The former assesses the impact of the distance to frontier on productivity growth rates in the Turkish economy, while the latter examines agglomeration effects on productivity growth rates. This agglomeration arises from urbanization resulting from migration. Therefore, an increase in the labor share in the urban sector contributes to the country's economic growth rate.

In the simulation, we need to calibrate the structural parameter ζ to match the initial real GDP per person y_0 and calibrate the initial level of productivity variable A_0 to match the initial share of rural population x_0 for Türkiye. Through this calibration exercise, we derive the rural population share and real GDP per capita for the period of 1978-2021.

Given the benchmark parameters (θ, ξ) and the model equations of y_0 specifically (4.1) shows how we calibrate the ζ.

$$\zeta = \left\{(y_0)\left\{\left(\frac{\theta}{x_0^{1-\theta}}\right)^{\frac{\xi}{1-\xi}}(x_0^{\theta}) + \left(\frac{\theta}{x_0^{1-\theta}}\right)^{\frac{\xi}{1-\xi}}(1 - x_0)\right\}^{-1}\right\}^{1-\xi} \tag{4.1}$$

Given the benchmark parameter θ, ξ, the calibrated benchmark parameter ζ, and x_0 specifically (4.2) shows the calibration equation of A_0.

$$A_0 = \left(\frac{\theta\zeta}{x_0^{1-\theta}}\right)^{\frac{1}{1-\xi}} \tag{4.2}$$

The last parameter in our simulation model is the fertility preference parameter ϕ which controls the marginal utility of reproduction. We normalize this parameter to unity in both regions to maintain the generality of the simulation model.

To derive the growth path of Türkiye in the simulation, we have adjusted the initial distance to the frontier, $\bar{A}_0/A_0$ to the $(1/0.18)$. Thus, we determine the value of the initial frontier productivity $\bar{A}_0$ to match the country's growth process, as shown in (4.3).

$$\bar{A}_0 = (1/0.18) * A_0 \tag{4.3}$$

4.3. RURAL AND URBAN INCOME LEVELS

In the model economy, it is assumed that the fertility rate is determined by income level and the value of time cost of reproduction, z_t under the same fertility preferences across regions, ϕ. However, since there is no per capita income data available at the regional levels, we estimate it by model-based calibration for 1978 and 2021 period. After estimating the regional income levels, we use them to analyze their effects on fertility levels.

Inputs of the output per capita in rural region are that parameters of ζ, ξ, θ and A_t. Using the calibrated results of the ζ and A_0, and the Lucas (2009)' results of ξ, θ, we determine the evolution of the rural per capita income $y_{r,t}$ from 1978 to 2021. The output per capita in the urban regions depends on the variables A_t and x_t. By using the initial values of A_0 and x_0 , we determine the evolution of the urban region's per capita income $y_{u,t}$.

Finally, as urban sector adopts the technology from the world frontier economy thereby enhancing its productivity level A_t, the rural sector takes advantage of it owing to the productivity spillover parameter ξ. The rural sector increases its output per capita level but never rise the above the value of the urban sector's per capita output. The reason for these results is the fact that $\xi \in (0,1)$ and $A_t \in (0, +\infty)$ and the existence of the decreasing returns to scale in the rural sector's production function.

4.4. RURAL AND URBAN FERTILITY LEVELS

Despite the fact that the rural side has higher fertility than that of urban in Türkiye, we do not see any increase in its value above the 1993 value according to the TDHS. The TFR data shows that its value is 3.1 in 1993 and 2.8 in 2018 (HUIPS, 2019).

In the model, fertility levels are affected by the income levels and the time cost of reproduction in the rural and urban regions respectively $y_{r,t}, y_{u,t}, z_{r,t}, z_{u,t}$. Among the equations, there exists ϕ parameter which represents the fertility preferences. In the benchmark model, we normalize this to 1 so that there are no differences in fertility preferences across regions. Since there exists asexual reproduction, the simulated model is multiplied by two (Attar, 2018b).

To match the observed data of the rural and urban fertility for the entire period, first, with the help of the regions' fertility equations, we construct the time cost of reproduction in rural $z_{r,t}$ and urban regions $z_{u,t}$ given in (4.4) and (4.5) respectively, since we have no observable data of them.

$$z_{r,t} = \frac{\phi}{y_{r,t}(n_{r,t}-1)} \tag{4.4}$$

$$z_{u,t} = \frac{\phi}{y_{u,t}(n_{u,t}-1)} \tag{4.5}$$

Given the values of the ϕ, $y_{r,t}$, $y_{u,t}$ in above and the values of $n_{r,t}$ $n_{u,t}$ from the data on TFR (TFS-1978; TDHS-1993; TDHS-2013) we calculate the $z_{r,t}$, and $z_{u,t}$ for the years 1978, 1993 and 2013. Using these results, we fit $z_{r,t}$, and $z_{u,t}$ with the help of the curve fitting toolbox in the Matrix Laboratory (MATLAB) for the entire history. Additionally, we use only these data as targeted values to assess whether the benchmark paths of fertility levels are matching with the existing fertility levels.

Now we have all inputs values for the fertility model in regions. Specifically, the values of ϕ, $y_{r,t}$ and, $z_{r,t}$ for the rural region and the values ϕ, $y_{u,t}$,and $z_{u,t}$ for the urban regions. As a result, we could determine the benchmark values of the fertility levels in rural $n_{r,t}$, and urban regions $n_{u,t}$ for the entire period but before that we multiplied the model equations of fertility with two since the model assumes one person creates n children in reality, two persons. The benchmark equations of $n_{r,t}$, and $n_{u,t}$ are shown in (4.6), (4.7) respectively.

$$n_{r,t} = \left(1 + \frac{\phi}{y_{r,t} z_{r,t}}\right) * 2 \tag{4.6}$$

$$n_{u,t} = \left(1 + \frac{\phi}{y_{u,t} z_{u,t}}\right) * 2 \tag{4.7}$$

4.5. BENCHMARK PATHS

This subsection provides the main findings of our analysis. Overall, the benchmark of the model is given in the Figure 3, 4, and 5. Importantly, Figure 3, and 5 observes the model and data sequences. Figure 6 shows the relationship between economic growth and fertility rates. Finally, Figure 7 and 8 display the benchmark paths of real per capita income level and time cost of reproduction respectively in both regions. The top panel in Figure 3 compares the simulation results and the data values of the rural population share.

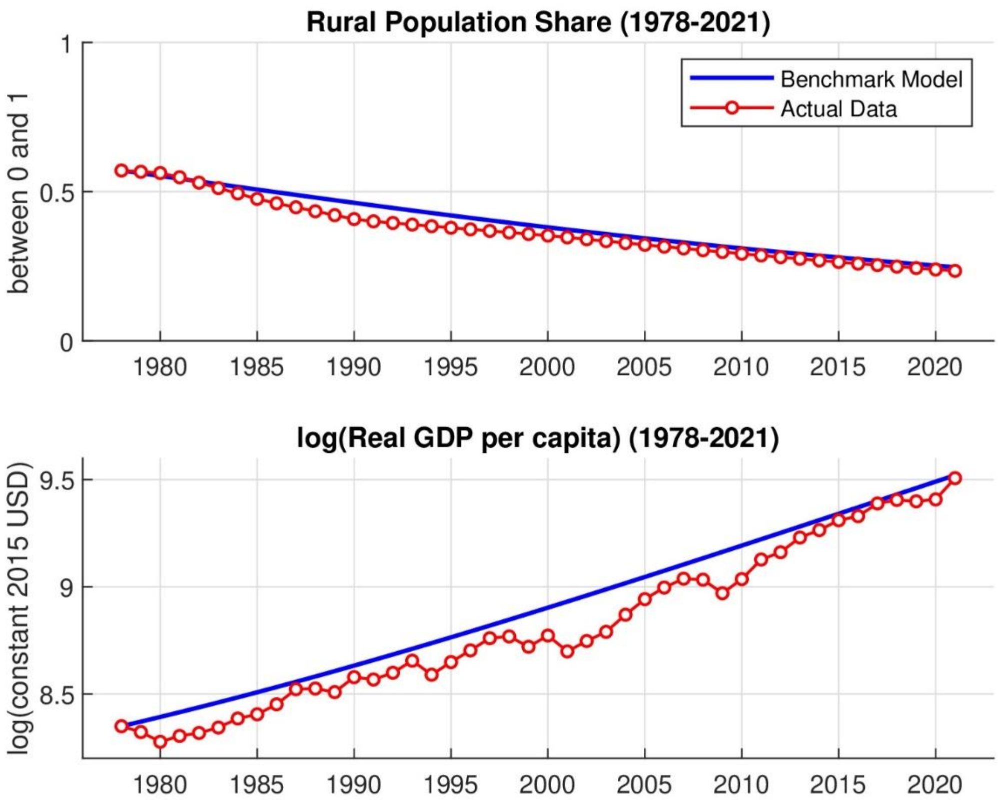

Figure 3. Türkiye Benchmark of Rural Population Share and Real GDP per capita

Note: Blue line represents the model result for share of rural population and real GDP per capita in terms of logarithmic during analyzing period. The red line shows the actual data. By comparing model outcomes with the actual data, gives the how well our model fits the data. As it is seen in the top figure our model fits the data well while in the below figure our model express the higher result for the real GDP per capita level but along the period is matched the data therefore the results of the model are good.

As is seen clearly in first graph of the Figure 3, the model is quite matching the actual data except the years in between 1985 and 1995. In these years, the benchmark shows the higher value of the rural population share than the actual data. On the other hand, according to second graph in Figure 3, the benchmark value of the real GDP per capita exhibits a higher economic growth performance than the Türkiye's actual growth. It is challenging to assert that the model precisely matches the actual data, particularly evident in the periods of 1980-1985 and 2000-2005, during which Turkey's economic performance slowed down. However, overall, the difference between the model and the observations is not significant. This indicates a strong performance of our benchmark model. Figure 4 displays the productivity trends of Türkiye and the frontier country (USA) for the period 1978-2021.

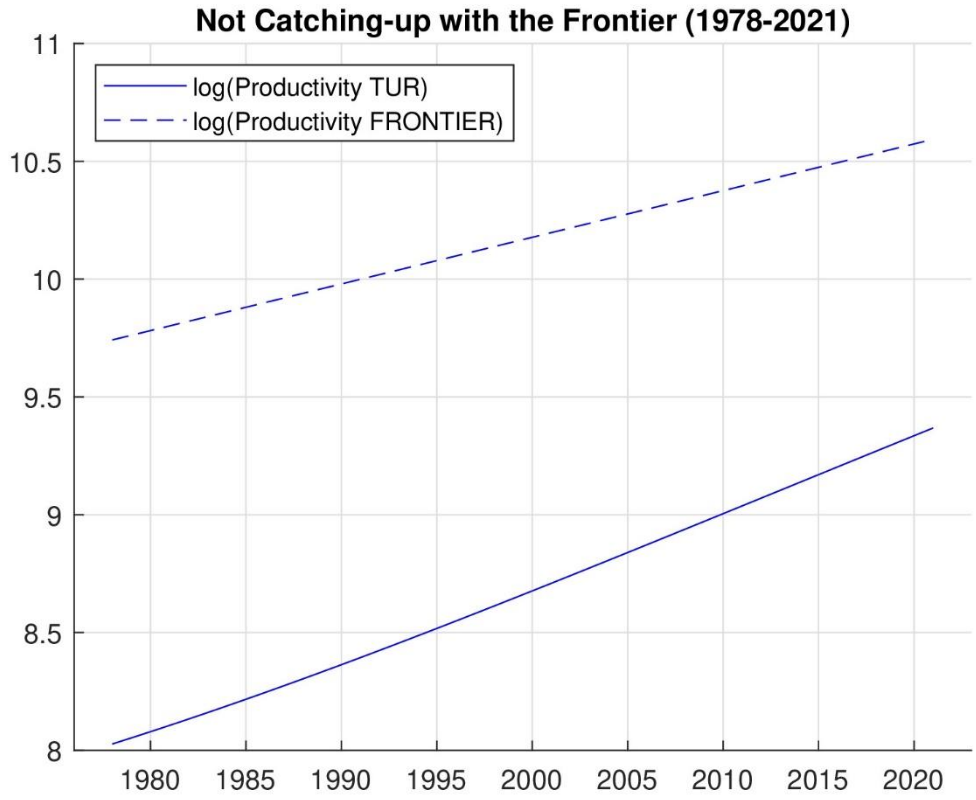

Figure 4. Productivity Türkiye and Frontier Economy

Note: The dashed line represents the frontier country's (USA) productivity level and the solid line represent the Türkiye between 1978-2021. It is clear that Türkiye is not catch up the USA in analysis period.

As Türkiye is a lagging country, she adopts the technology from the frontier country, thereby increasing her productivity level. As is seen clearly in Figure 4, although Türkiye has closed some portion of the productivity gap with the frontier country, a large gap remained in productivity during the examination period. Therefore, Türkiye failed to catch up with the frontier country. Figure 5, shows the results for the fertility rates.

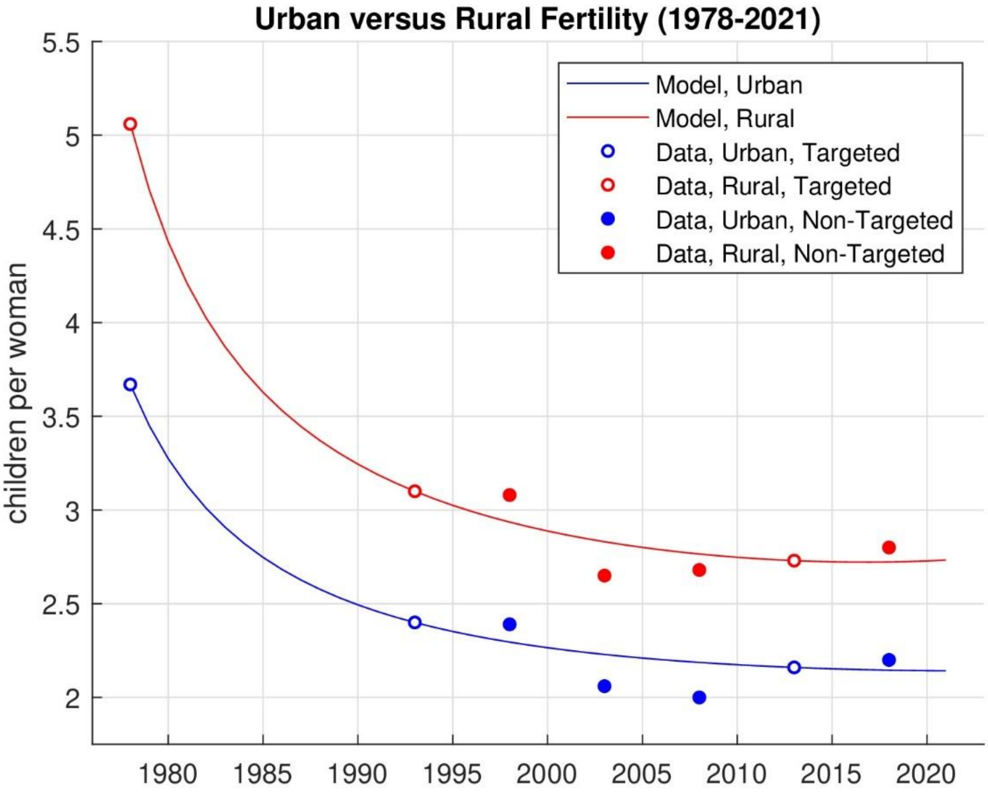

Figure 5. Model versus Data: Fertility Across Regions in Türkiye

Note: The red line is representing the rural fertility rate while blue line represents the urban regions fertility rate. As it is seen, rural regions have higher fertility rate than that of urban regions in analysis period. The model matches the targeted data better than the non-targeted data.

Based on Figure 5, it is reasonable to conclude that the fertility model aligns well with the targeted data for both rural and urban regions. Therefore, the model effectively explains fertility dynamics. Additionally, incorporating non-targeted data sources enhances the reliability of our model, as their values closely align with the benchmark. Another important observation we can make based on Figure 5 is that the trends of the fertility in the entire horizon are decreasing in both regions and is seems to be stabilize at the end of the periods i.e., 2015-2020. Finally, even fertility rates differ between urban and rural areas, they have the similar patterns of declining fertility rates for all years (1978-2021). Figure 6 shows the results of the relationship between economic growth and fertility decline in both rural and urban regions.

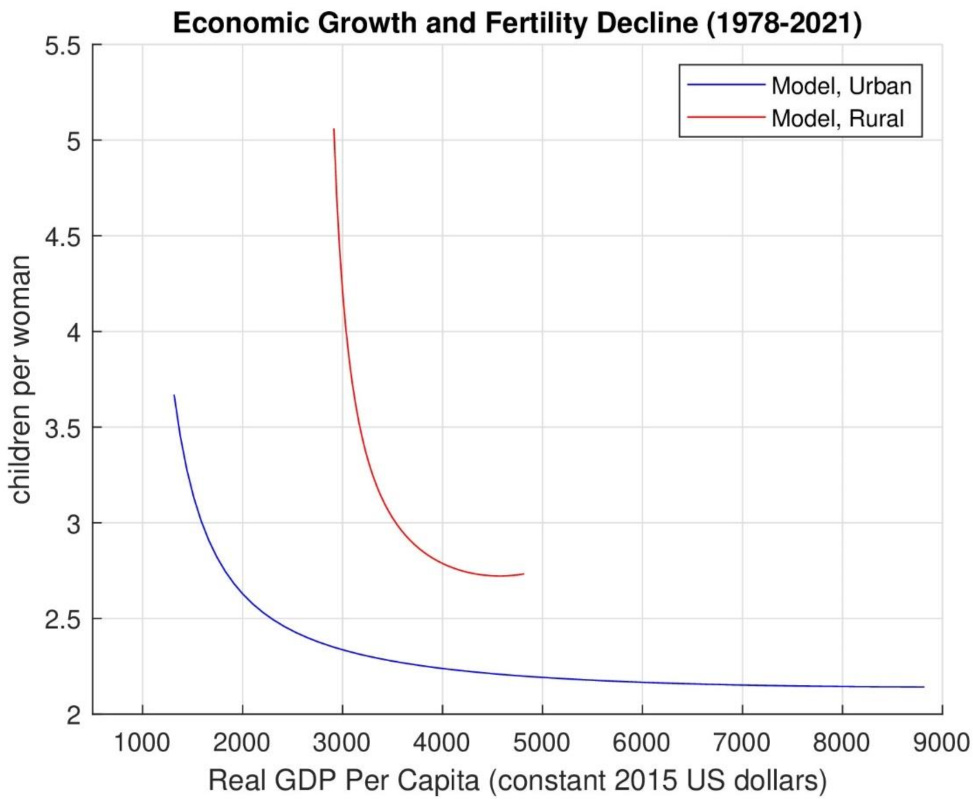

Figure 6. Economic Growth and Fertility Relation in Türkiye

Note: The blue line is belonged to urban regions while the red line is belonged to rural regions. According to figure, the relation between economic growth and fertility rate is inverse. There is a sharp decrease fertility rate in response to increasing per capita income for rural region. The main reason in differences in declining fertility rates is differences in income levels between regions.

Figure 6 shows that the paths of the relationship between fertility decline and economic growth are similar for both regions. But at the same time, there is a clear difference between the size of the decline in fertility rates with respect to economic growth across regions. As is seen in Figure 6, parallel to our one of main assumptions, there is an inverse relationship between economic growth and fertility. This inverse relationship tells us that when the households become richer, they prefer to have less children. Also, these findings are mostly valid for the urban households, since as is seen in Figure 6, there is a sign of increasing trends in the rural fertility when the real GDP per capita is between 4000-5000 in recent years. On the other hand, decline in fertility rates for urban regions are approaching to 2 over the high-income levels. Therefore, income differences between regions play key role in explaining the differences in decline in fertility rates. That is the important results of the model-based calibration.

To provide further evidence for the role of income differences in fertility declines across the regions, we have to also focus on changes in $y_{u,t}$ and $y_{r,t}$ variables as well as $z_{u,t}$ and $z_{r,t}$ variables. Figure 7 shows the benchmark of the real per capita income levels in urban and rural regions based on model-based calibration, since this is the major contribution of our thesis.

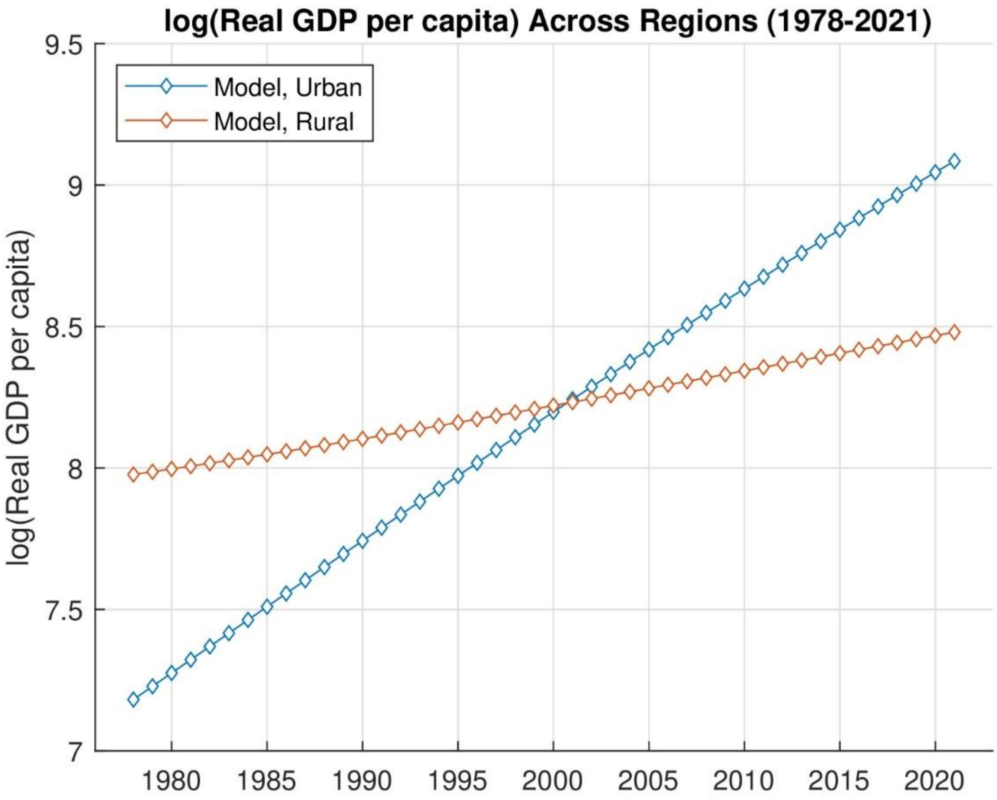

Figure 7. Benchmark of the Real per capita Income Levels Across Regions in Türkiye

Note: The blue line shows the per capita income level for urban regions and the red line for the rural regions. Starting from 1978 until 2000, rural regions have higher per capita income level than urban regions. After that time, per capita income level in urban regions grows faster than that of rural regions.

As is seen clearly in Figure 7, starting from 1978 until 2000, rural regions have higher real per capita income levels than urban regions. However, after 2000, the real per capita income level in urban regions surpassed that of rural regions because the income in urban regions has consistently grown at a faster rate than in rural regions. This continuous and faster growth in urban income has led to a widening income gap between urban and rural areas. This widening of income differences can be used as the main factor explaining the differences in fertility declines between the regions shown in Figure 6. Finally, these results support the view that productivity promotes faster economic growth, as urban regions have consistently shown upward trends. To explain the differences in fertility, decline between regions, we have to also compare the paths of $z_{u,t}$ and $z_{r,t}$. Figure 8 shows the time cost of reproduction paths of in urban and rural regions with respect to model-based calibration results.

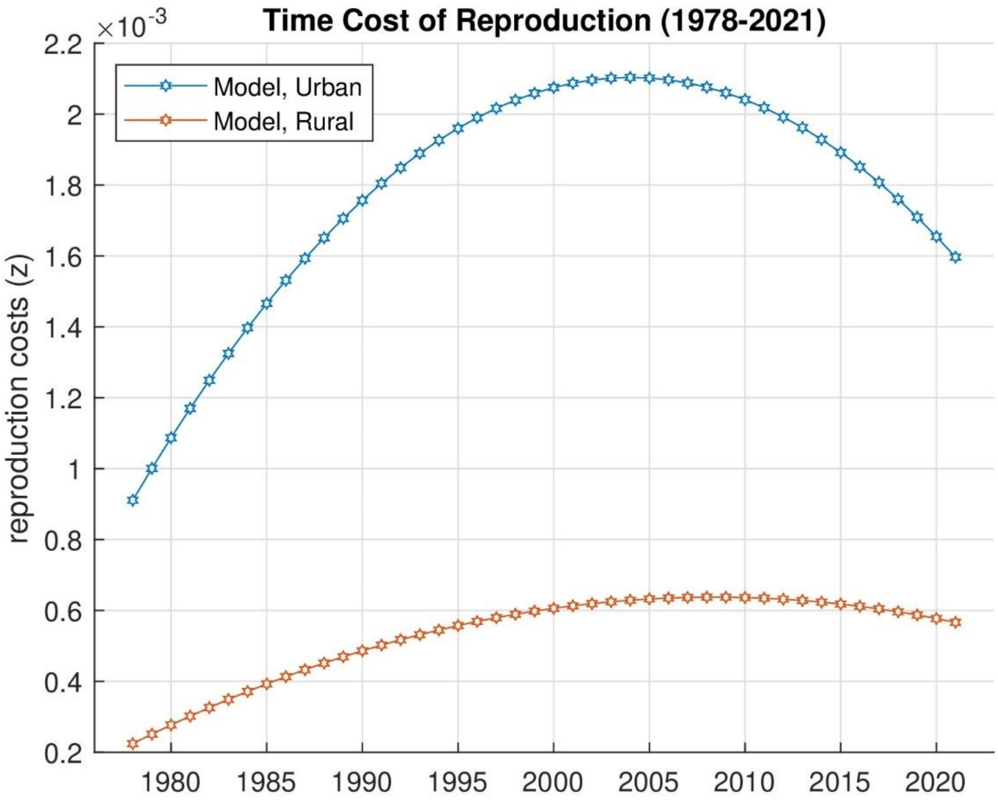

Figure 8. Benchmark of the Time Cost of Reproduction Across Regions in Türkiye

Note: The blue line represents the urban regions and the red line represent the rural regions for the time cost of reproduction. The time cost of reproduction has an inverse U-shape in both regions. Change in time cost of reproduction pattern is more obvious for urban than the rural regions.

According to Figure 8, even though the findings show that the reproduction are more costly in urban regions than rural regions for the entire period, the paths are similar in both regions: they increase first, reaches a maximum and then starts decreasing. While the reproduction cost in urban region reached its maximum value at 2005, it reached its highest value for rural region in later 2010. These paths of reproduction costs also support one our main conclusions that income differences between regions are primary cause of differences in fertility rates across the regions.

CHAPTER 5

COUNTERFACTUAL EXPERIMENTS

This chapter presents the results of the counterfactual experiments using a simulation model. The main aim of these experiments is to obtain the effects of technological progress on rural-urban income, rural-urban population share, and the fertility. Also, assuming that technology and income side remain unaltered, we examine the effects of fertility preferences. Lastly, we look at the effects of change in reproduction cost. To do this, we allow each benchmark parameter to change and assume that the remaining parameters of our model is given. And then, we try to find out what happens to fertility differences between regions and their sources. Thus, to conduct these experiments, in each one, values of the three benchmark parameters (ξ, λ, θ) and the variable $(\bar{A}_t/A_t)$ are changed and the values $y_{r,t}$ $y_{u,t}$ remain at their initial level. Since we already define each equation of our model which shows the effects of change in a given benchmark parameter in chapter 3, these are determined their own function, we use these equations to simulate an alternative history in the periods 1978-2021 for Türkiye.

We have organized all experiments in three groups. These are technological progress and economic growth, fertility preferences and reproduction cost. In the first group of experiments, we analyze the effects of the changes in technological progress and economic growth on the share of rural population, per capita output, and the urban to rural per capita output ratio. In the second group of experiments, we analyze the effects of fertility preferences. In the last group of experiments, we try to examine the effects of time cost of reproduction.

5.1. TECHNOLOGICAL PROGRESS AND ECONOMIC GROWTH

First aim of this subsection is to understand the role of the technological progress on the share of rural population, total per capita income level, and the urban to rural per capita income level that gives us the point about the income-equality between these regions. The second is that within the changes of the population and income levels, we search the how these changes affect the regions fertility decisions. Thus, starting the changes of technology progress in the economy the changes occur in the country's demographic structure via the changes their fertility preferences make our experiments interesting.

In this subsection, we conducted three counterfactual experiments by changing the values of three structural parameters (ξ, λ, θ) and the relative productivity ratio $(\bar{A}_t/A_t)$ that affect technological progress and economic growth of the country. Table 3 displays the benchmark and experimental parameter values.

Table 3. Counterfactual Experiments under the Technological Progress and Economic Growth

Experiment	***Benchmark Value***	***Experiment Value***	***Percentage Change (%)***
Higher Productivity in Rural Sector (higher ξ)	0.75	0.85	↑13.33
Faster Productivity Growth in Urban Sector (larger $\bar{A}_t/A_t$)	5.55	10	↑80.18
Higher Elasticity of Productivity growth (lower λ)	0.35	0.2	↓42.86

By using these parameters in Table 3, we derive the results shown in following figures.

5.1.1. The Counterfactual Experiments of Effects of the Productivity Spillover Parameter

The first experiment is carried out by using the larger spillover parameter $\xi = 0.85$, i.e., increasing 13.33% relative to the benchmark value of the country given in the first column of Table 3. Clearly, the rural sector's productivity is affected by the productivity of the urban sector with the help of this structural parameter. Thus, increasing value of ξ means that the rural sectors absorb more productivity from urban sector. In other words, it benefits from the rising productivity of urban sector. The results of that counterfactual experiments are now in order in Figure 9.

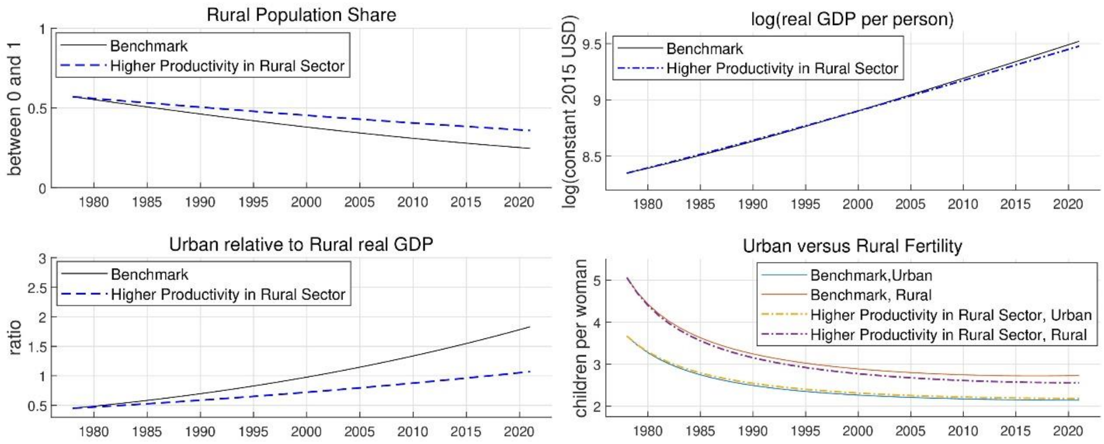

Figure 9. Counterfactual Experiment: Effects of the Productivity Spillover Parameter, 1978-2021

Note: These figures represent the effects of productivity spillover parameter (ξ) on rural population share, per capita real GDP, relative regional per capita incomes, and urban and rural fertility levels. The effects on rural population share and relative regional per capita incomes are larger. The smaller effects on other two variables.

In Figure 9, we observe that an increase in rural sector productivity leads to a rise in the rural population share in all years compared to the benchmark in Türkiye (see first upper left graph in Figure 9). However, we see similar trends in both the benchmark and the experiment, i.e., a decrease in the share of the rural population within years. In the experiment, however, the rate of decline slows down during the experiment years, implying that increasing rural sector productivity slows down the migration from rural to urban regions in Türkiye.

With the increase in productivity and labor in rural region, we expect growth in the rural sector's output (see lower left graph in Figure 9). As a result, the ratio of the urban-to-rural real GDP per capita becomes closer than the benchmark, leading to more equality between regions for the country. However, for the total real GDP per capita, we see a slight decrease from around 2005 and continuing for the remaining years (see upper right graph in Figure 9). This is because there are fewer people located in urban regions than the benchmark, resulting in lower utilization of technology adoption and a decrease in the outcome level.

As expected, increase in the labor productivity in the rural sector leads to a decline in the preference for children. This is because having a child becomes costly, as individuals' income levels increase. Thus, we observe a decline in the number of children born in these periods. On the other hand, we observe an increase in fertility in an urban region. This is because a reduction in income leads to decrease in the cost of reproduction for individuals, thus they enjoy having more children (see lower right graph in Figure 9).

5.1.2. The Counterfactual Experiments of Effects of the Distance to Frontier

For the second group of experiments, we aim to see the effects of faster productivity growth in urban sector (larger distance to frontier) on rural-urban income, rural population share and fertility. For carry out these experiments, we would like observe what happens when the Türkiye had increased the level of technological adoption. Therefore, we increased the value of the distance to frontier relative to the benchmark level to see if there is any case of the advantage of backwardness. The results of these experiments in given in Figure 10.

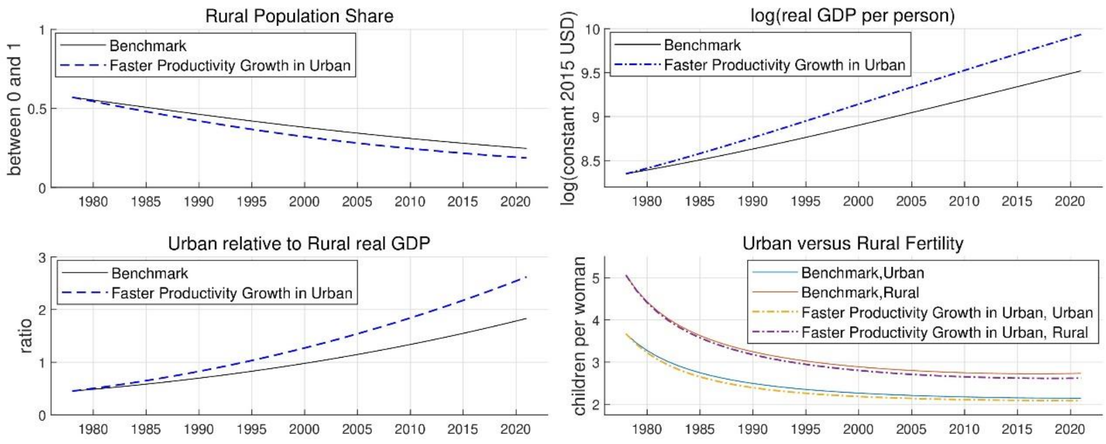

Figure 10. Counterfactual Experiments: Effects of the Distance to Frontier, 1978-2021

Note: These figures represent the effects of faster productivity growth in urban region on rural population share, per capita real GDP, relative regional per capita incomes, and urban and rural fertility levels. The effects on larger on relative regional per capita incomes, total real GDP per person. Relatively smaller effect on rural population ratio.

As is seen in upper left graph in Figure 10, the larger distance frontier causes falls in the rural population share implying that rural-to-urban migration becomes slightly faster.

Also, upper right graph in Figure 10 shows the total real GDP level is higher than the benchmark over the years, implying that becoming a more lagging country can be an advantage. However, faster productivity growth in the urban sector leads to higher inequality between regions, because the distance of the real GDP per capita between the urban and rural sectors expands more compared to the benchmark. Nevertheless, the spillover parameter ensures that productivity growth in the urban sector also spills over to the rural sector, leading to an increase outcome in rural areas as well. This means that even increasing inequality between regions, those people in both regions are better off than the benchmark year.

Finally, we analyzed the effects of the technological progress via the country adopts technology rapidly on the fertility rate across regions and lower right graph in Figure 10 shows that fertility rate is lower than the benchmark level in both urban and rural regions over the years. This indicates that households prefer to work more than reproduce.

Why do households prefer to work more? The reason for this preference results from the fact that the opportunity cost of having more children will increase as household give up more income. Thus, as a result of this experiments, as Türkiye adopt technology rapidly from frontier country, there will more migration from rural to urban regions and fertility rate will decline.

The one last thing that we need to clear in this experiment is that the effects of spillover parameter on the rural sector output. Following the initial increase in productivity in the urban region, we will observe fertility decline in rural regions with a lagged effects because of the spillover parameter.

5.1.3. The Counterfactual Experiments of the Effects of Higher Elasticity of Productivity Growth

The third experiments analysis the effects of the elasticity of productivity growth on the same outcomes mentioned in the above. As is seen in the third column of Table 3, the experimental value of $\lambda = 0.2$ that indicates the faster productivity growth than the benchmark. Also, λ could be named as a catching up parameter, therefore we could comment that this parameter manages the effects of the distance to frontier but in an inverse relation because power of the relative productivity ratio is $1-\lambda$. Therefore, the lower value of λ increase the effectiveness of the distance to frontier on the productivity growth. Because as decreasing the value of this parameter increases the term of the $1-\lambda$, it shows that what happens to Türkiye's productivity growth when 1% increases in the relative productivity ratio. Figure 11 shows the results of these experiments.

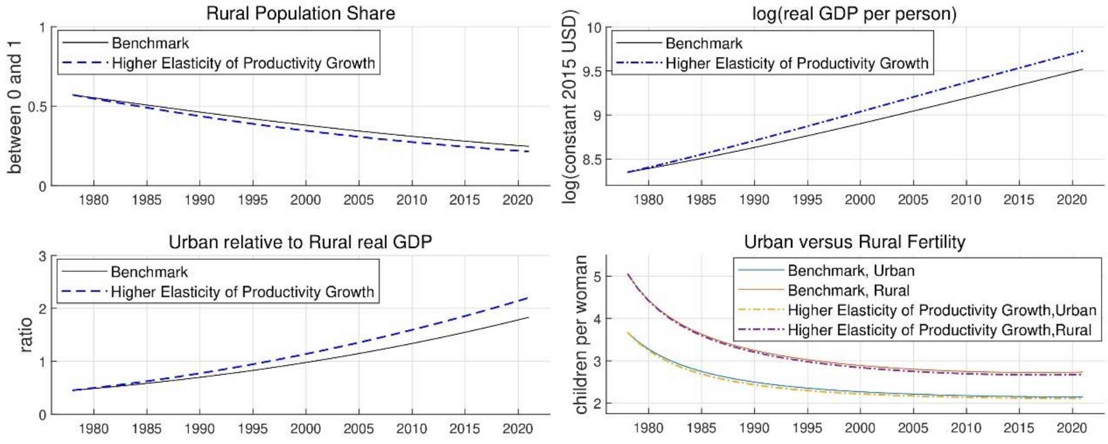

Figure 11. Counterfactual Experiments: Higher Elasticity of Productivity Growth, 1978-2021

Note: these figures represent the effects of higher elasticity growth on rural population share, per capita real GDP, relative regional per capita incomes, and urban and rural fertility levels. The effects of higher elasticity of productivity growth $(1-\lambda)$ are relatively smaller for all areas.

First of all, the higher elasticity of productivity growth causes falls in the rural population share accelerating the rural-to-urban migration. Also, the higher elasticity of productivity growth, the larger the difference in income levels between rural and urban regions. Lastly, the higher elasticity of productivity growth, the higher the fertility decline. When we compare the results of last two experiments, we can conclude that the effects of higher elasticity of productivity growth is relatively smaller than that of distance to frontier. In other words, since the distance to frontier is more effective increasing the output than the elasticity of productivity growth.

The overall conclusion of these counterfactual experiments is that advances in technological progress causes the higher economic growth rate in urban sector, the larger rural-to urban migration and as a result increases the inequality between regions. On the other hand, there is declining trend in fertility rate in both regions.

5.2. FERTILITY PREFERENCES

This subsection aims to analyze the effects of the change in fertility preferences on the fertility rates of the regions in Türkiye. Therefore, in this alternative model we have changed only one parameter ϕ since it controls the fertility preferences. Therefore, the technology and the income levels of this alternative model remain the same as in benchmark. Table 4 shows the counterfactual experiments under fertility preferences.

Table 4. Counterfactual Experiments under the Fertility Preferences

Experiment	***Benchmark Value***	***Experiment Value***	***Percentage Change (%)***
Higher Fertility Preference in Rural Region (higher ϕ)	1	1.25	↑25
Lower Fertility Preference in Urban Region (lower ϕ)	1	0.75	↓25

In Table 4, we are seeing that the value of ϕ in rural regions, which is higher than the urban regions. Thus, rural side enjoys having more child whereas urban side enjoys having less child. In that situation, we are expected that Türkiye face the higher fertility rate in rural while facing lower rate of fertility in urban. The results of these experiments are shown in the Figure 12.

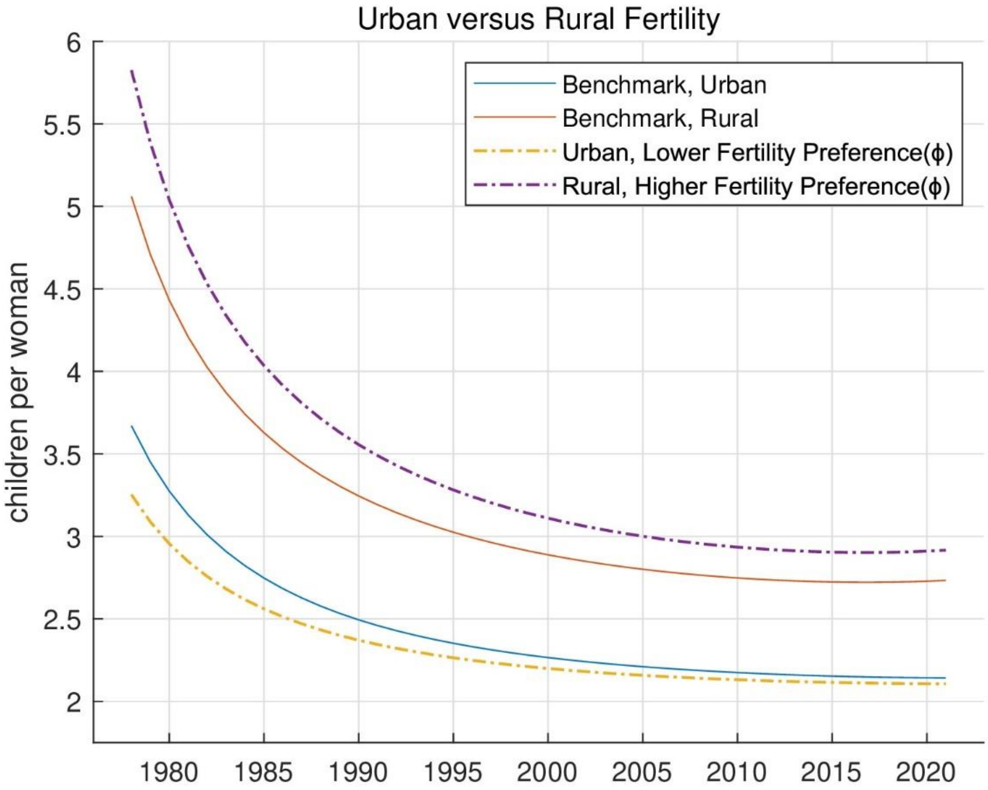

Figure 12. Counterfactual Experiment: Effects of the Fertility Preferences, 1978-2021

Note: In this figure, changes in fertility preferences are shown. As we increase the preference parameter (ϕ) for rural regions and the decrease for urban regions in the same portions, the rural regions are responded it more.

Figure 12 shows that the experiments line of the fertility rate in rural regions stays above the benchmark whereas for the urban region is below the benchmark. However interesting story is that the even changes in fertility preferences parameter is the same amount for both regions but the effects of it differs. For example, as is seen Figure 12, the same 25% increase in this parameter for rural regions causes the more effects than the 25% decrease in this parameter in urban regions the fertility rates. Overall, the shapes of them are not different that is in both regions the effects of this parameter are stronger in the initial years that is until 1995. After that year we see the it is converged to the benchmark paths for the urban whereas for the rural is not getting closer to the benchmark value.

5.3. REPRODUCTION COSTS

This subsection analysis the effects of the reproduction costs on the fertility rate in both rural and urban regions by assuming that fertility preferences, ϕ parameter, are same for both regions. Since fertility rates determined by the household's income level and the reproduction costs, we have to isolate the effects of the latter as a nature of these experiments. To do it, we decided that if the regions income level stays always in the initial level, we see the effects of the reproduction costs. Thus, all other variables stay as in benchmark value, and we use the initial income level, which is 1978 value of income. By doing this, we will isolate the effects of the reproduction costs. Table 5 shows how we carry out the counterfactual experiments of the reproduction costs.

Table 5. Counterfactual Experiments under the Time Cost of Reproduction

Experiment	***Benchmark Value***	***Experiment Value***
The impact of the time cost of reproduction on the fertility rate in rural regions. *(Value of income level remains constant for all period which is equal to initial level per capita income $y_{r,1978}$)*	Values of $y_{r,t}$, 1978-2021	2912.93, (1978-2021)
The impact of the time cost of reproduction on the fertility rate in urban regions. *(Value of income level remains constant for all period which is equal to initial level per capita income $y_{u,1978}$)*	Values of $y_{u,t}$, 1978-2021	1314.78, (1978-2021)

When we obtain the effects of time cost of reproduction in both regions, we will assume that there will no change in income level. We make this assumption to focus on the effects of reproduction costs on the fertility rates. Figure 13 shows the results of these experiments.

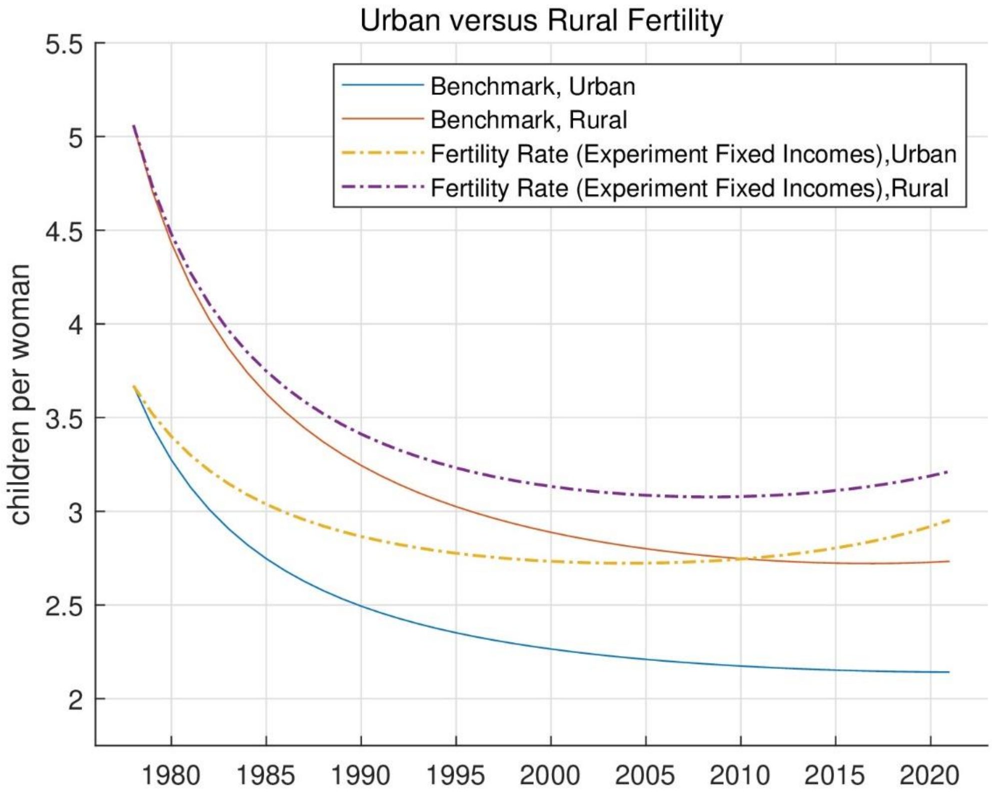

Figure 13. Counterfactual Experiment: Effects of the Time Cost of Reproduction, 1978-2021

Note: In this experiment we isolate the effects of the time cost of reproduction by fixing income levels at 1978 for all period to see the role of the time cost of reproduction. Fertility rate has a U-shape. Time cost of reproduction increased around for urban 2010 and for rural 2005.

In Figure 13, we can see that the fertility rate has a U-shape. This shape is interesting because it illustrates how the cost of reproduction impacts the fertility rate over time. The results indicate that until around 2005 for rural region and around 2000 for urban region, the cost of reproduction has caused decline in fertility rates. For rural region before 2005, since there was an increasing trend in the time cost of reproduction, there is decrease in fertility rate. On the other hand, after 2005, fertility rates started to increase, since there is a decrease in the time cost of reproduction. We see the same change in urban region for same reason after 2000. Based on these findings, we conclude that household income levels in both regions are the main determinant of fertility decline. In other words, while the cost of reproduction played a role in determining fertility decline between 1978 and 2005, income levels are the main factor for the fertility decline after 2000 and 2005 for urban and rural regions respectively. In summary, our experiment and benchmark paths show that household income levels, rather than the cost of reproduction, are the most significant factor in the decline of fertility rates in both regions under the assumption of the same fertility preferences across regions.

CONCLUSION

In this thesis, we aim to comprehensively understand the dynamics between economic growth measured as the change in real GDP per person and trends in fertility decline in Türkiye between 1978 and 2021 for rural and urban regions based on the assumption of the same fertility preferences in both regions. For this aim, we construct the economic model, carry out calibration exercises, and applying counterfactual experiments. By doing that, we examine the effect of income levels on fertility across rural and urban regions in Türkiye. In this respect, we estimate the unobservable variable of the per capita income levels in both regions. The thesis also explores the role of the time cost of reproduction variable in fertility rates across these regions. Since there is no observable data on this variable, we estimate it using a model and calibration exercises.

The results of Chapter 4 show that in Türkiye remind us the certain facts of Türkiye's demographic structure. For example, we found that the fertility rates are higher in rural areas than in urban areas. Also, we proved that both regions show a similar trend of decreasing fertility rates over the years, which stabilizes by the end of the period (2015-2020). The relationship between economic growth and fertility is inverse, meaning households tend to have fewer children as they become richer. This trend is more prevalent in urban households, but there has been a recent increase in fertility rates in rural areas.

According to the results of Chapter 5, the technological progress promotes higher income and declines fertility rates for both regions, but urban areas enjoy higher per capita income than rural ones. In such a case, even regions are better off than the initial, the country experiences higher income inequality than the initial. That is one of the interesting results of the study.

Moreover, the effects of fertility preferences are more significant in rural regions than the urban regions. This is because of the fact that rural households see the children as a new member of their workforce and one of the new sources of income.

We have obtained significant results regarding the impact of the time cost of reproduction. Until 2000 in urban regions and 2005 in rural regions, the cost of reproduction was increasing, leading to a decrease in fertility rates. However, over the last two decades, the cost of reproduction has been declining, resulting in an increase in fertility rates in both regions. Consequently, we can conclude that during this period, the decline in fertility rates is primarily due to the rising household income levels. In other words, the household income levels in both regions are the primary determinant of fertility decline.

The results of our thesis support the view that there is a significant demographic change taking place in Türkiye. Particularly the findings of study support the views of classical demography transition theory which suggest that industrialization and urbanization are the main factors in declining fertility levels in the modern world. Also, these developments are taking place in accordance with the implications of modern growth theories.

The results of study have many important implications for economic growth, demographic change and rural and urban development policies of Türkiye. First of all, the results remind us that to catch up with the frontier country, Türkiye needs to enhance its capacity to adopt technology and develop policies to promote technology transfer activities. To achieve this, the country should create new industrialization and technological adoption policies. Once the appropriate combination of policies is chosen, Türkiye should also implement demographic policies to take advantage of the recent acceleration in migration from rural to urban regions and the declining fertility rates in both regions.

In this thesis, there exists some limitations. First of all, all of our findings depend on the dynamics of the model that we constructed. For example, even though the per capita income levels that we derived for both regions are independent of demographic factors, they are dependent on the two crucial factors which are model of Lucas (2009) and share of rural population ratio as well as changes in overall per capita income level in Türkiye. Another limitation of thesis comes from the fact we have made some restrictive assumptions about in the consumption-fertility model assuming that fertility preferences are same for both regions. Thus, this study can be extended and developed by applying the same analysis to micro data (household data) so that we will have the ability to decompose the fertility preferences parameter ϕ across the regions.

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APPENDIX 1: PER CAPITA GDP ACROSS REGIONS

Table 6. Benchmark Results for the per capita Income Levels of the Rural and Urban Regions

Years	Real Per Capita GDP in Rural Region	Real Per Capita GDP in Urban Region
1978	2912.93	1314.78
1979	2941.29	1377.92
1980	2970.42	1444.12
1981	3000.32	1513.52
1982	3030.99	1586.23
1983	3062.45	1662.4
1984	3094.69	1742.16
1985	3127.71	1825.67
1986	3161.51	1913.06
1987	3196.1	2004.48
1988	3231.48	2100.09
1989	3267.64	2200.05
1990	3304.58	2304.51
1991	3342.31	2413.63
1992	3380.82	2527.6
1993	3420.1	2646.57
1994	3460.16	2770.72
1995	3500.98	2900.23
1996	3542.58	3035.29
1997	3584.94	3176.06
1998	3628.05	3322.75
1999	3671.92	3475.55
2000	3716.54	3634.65
2001	3761.9	3800.25
2002	3807.99	3972.56
2003	3854.82	4151.78
2004	3902.38	4338.12
2005	3950.66	4531.8
2006	3999.66	4733.03
2007	4049.36	4942.04
2008	4099.77	5159.06
2009	4150.88	5384.31
2010	4202.68	5618.03
2011	4255.17	5860.46
2012	4308.34	6111.85
2013	4362.19	6372.43
2014	4416.71	6642.46
2015	4471.9	6922.2
2016	4527.75	7211.92
2017	4584.25	7511.87
2018	4641.4	7822.33
2019	4699.21	8143.57
2020	4757.65	8475.88
2021	4816.73	8819.54

APPENDIX 2: FERTILITY RATES ACROSS REGIONS

Table 7. Benchmark Results of the Fertility Rates for Rural and Urban Regions

Years	Fertility Rates in Rural Region	Fertility Rates in Urban Region
1978	5.0605	3.67
1979	4.7081	3.4504
1980	4.4312	3.2739
1981	4.208	3.1295
1982	4.0243	3.0093
1983	3.8706	2.908
1984	3.7401	2.8216
1985	3.628	2.7472
1986	3.5307	2.6827
1987	3.4456	2.6263
1988	3.3706	2.5768
1989	3.3041	2.5329
1990	3.2446	2.4939
1991	3.1914	2.4592
1992	3.1434	2.428
1993	3.1	2.4
1994	3.0607	2.3747
1995	3.0249	2.3518
1996	2.9924	2.3311
1997	2.9626	2.3123
1998	2.9355	2.2951
1999	2.9106	2.2795
2000	2.8879	2.2652
2001	2.8671	2.2521
2002	2.848	2.2402
2003	2.8307	2.2292
2004	2.8148	2.2192
2005	2.8004	2.21
2006	2.7874	2.2015
2007	2.7757	2.1938
2008	2.7652	2.1868
2009	2.7559	2.1803
2010	2.7477	2.1744
2011	2.7407	2.1691
2012	2.7348	2.1643
2013	2.7299	2.16
2014	2.7262	2.1561
2015	2.7236	2.1527
2016	2.7221	2.1498
2017	2.7218	2.1473
2018	2.7226	2.1453
2019	2.7247	2.1437
2020	2.7281	2.1426
2021	2.733	2.142

APPENDIX 3: TIME COST OF REPRODUCTION ACROSS REGIONS

Table 8. Benchmark Results of the Time Cost of Reproduction for Rural and Urban Regions

Years	Time Cost of Reproduction in Rural	Time Cost of Reproduction in Urban
1978	0.000224	0.000911
1979	0.000251	0.001001
1980	0.000277	0.001087
1981	0.000302	0.001170
1982	0.000326	0.001249
1983	0.000349	0.001325
1984	0.000371	0.001397
1985	0.000393	0.001466
1986	0.000413	0.001531
1987	0.000432	0.001593
1988	0.000452	0.001651
1989	0.000469	0.001706
1990	0.000486	0.001757
1991	0.000502	0.001805
1992	0.000517	0.001849
1993	0.000532	0.001889
1994	0.000545	0.001926
1995	0.000557	0.00196
1996	0.000569	0.00199
1997	0.000580	0.002017
1998	0.000589	0.002040
1999	0.000598	0.002059
2000	0.000606	0.002075
2001	0.000613	0.002087
2002	0.000619	0.002096
2003	0.000625	0.002102
2004	0.000629	0.002104
2005	0.000633	0.002102
2006	0.000635	0.002097
2007	0.000637	0.002088
2008	0.000638	0.002076
2009	0.000637	0.002060
2010	0.000637	0.002041
2011	0.000635	0.002018
2012	0.000632	0.001992
2013	0.000628	0.001962
2014	0.000624	0.001929
2015	0.000618	0.001892
2016	0.000612	0.001851
2017	0.000605	0.001808
2018	0.000596	0.001760
2019	0.000587	0.001709
2020	0.000577	0.001655
2021	0.000567	0.001597

APPENDIX 4: UTILITIES ACROSS REGIONS

Table 9. Regional Utilities Obtained from the Model

Years	Rural Regions Utility	Urban Regions Utility
1978	2911.2	1311.7
1979	2939.4	1374.4
1980	2968.3	1440.2
1981	2997.9	1509.1
1982	3028.4	1581.4
1983	3059.7	1657.1
1984	3091.7	1736.3
1985	3124.5	1819.3
1986	3158.2	1906.2
1987	3192.6	1997.1
1988	3227.8	2092.1
1989	3263.8	2191.5
1990	3300.5	2295.3
1991	3338.1	2403.8
1992	3376.5	2517.1
1993	3415.6	2635.4
1994	3455.5	2758.9
1995	3496.2	2887.7
1996	3537.6	3022.1
1997	3579.9	3162.1
1998	3622.9	3308.0
1999	3666.6	3460.1
2000	3711.1	3618.4
2001	3756.3	3783.2
2002	3802.3	3954.7
2003	3849.0	4133.1
2004	3896.5	4318.7
2005	3944.7	4511.5
2006	3993.6	4712.0
2007	4043.2	4920.2
2008	4093.6	5136.4
2009	4144.6	5360.9
2010	4196.3	5593.9
2011	4248.8	5835.6
2012	4301.9	6086.3
2013	4355.7	6346.2
2014	4410.2	6615.6
2015	4465.4	6894.8
2016	4521.2	7184.0
2017	4577.7	7483.5
2018	4634.9	7793.6
2019	4692.7	8114.5
2020	4751.2	8446.6
2021	4810.3	8790.1

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SUPERVISOR'S APPROVAL

APPROVED
Assoc. Prof. Dr. Mustafa Aykut ATTAR

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