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ESSAYS ON HEALTH AND ECONOMIC DEVELOPMENT NEXUS: NEW EVIDENCE FROM A PANEL OF COUNTRIES

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ESSAYS ON HEALTH AND ECONOMIC DEVELOPMENT NEXUS: NEW EVIDENCE FROM A PANEL OF COUNTRIES

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Approval of the Graduate School of Social Sciences

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ABSTRACT

ESSAYS ON HEALTH AND ECONOMIC DEVELOPMENT NEXUS: NEW EVIDENCE FROM A PANEL OF COUNTRIES

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This empirical study investigates the effects of health on economic development that include linear, quadratic and cubic specifications for the periods 1940-1980, 1940-2009, and 1980-2009. This study tries to bring out different characteristics of the effects of health on economic growth. Hence, different periods are used depending on short and long-terms of life expectancy, body mass index, and systolic blood pressure as proxy variables for health to investigate effect of health on gross domestic product per capita. These health proxies have common characteristic of being age-dependent. Therefore, these specifications enable us to examine different dimensions of wealth-health nexus. The economic development proxy variables used are years of schooling (human capital), GDP per person engaged, manufacturing value added per person engaged (productivity), and gross domestic savings. The ordinary least squares, fixed-effects and generalized method of moments (Arellano-Bond) estimation are used for 10 yearly and balanced panel data for the 1940-1980 and 1940-2009 periods, and 5 yearly and balanced panel data for the 1980-2009 period for 47 countries. Also, for all these periods, long-difference estimation by OLS and instrumental variable estimation are utilized. Our empirical results with different health proxy variables used are generally consistent with each other. More clearly, there is a non-linear and non-monotonic association between all health proxy variables and economic development proxy variables. As a conclusion, our empirical results provide significant evidence that preserving human physiological health functions reinforces economic growth and other important indicators.

Keywords: Economic Development, Science and Technology, Health, Life Expectancy at Birth, BMI and SBP.

ÖZ

SAĞLIK VE İKTİSADİ GELİŞİM İLİŞKİSİ ÜZERİNE MAKALELER: ÜLKE PANEL VERİSİ İLE YENİ BULGULAR

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Bu ampirik çalışmada, 1940-1980, 1940-2009 ve 1980-2009 dönemleri için birinci, ikinci ve üçüncü dereceden denklemler içeren modeller kullanılarak sağlığın iktisadi gelişmeye olan etkileri incelenmektedir. Bu çalışma, iktisadi büyüme ve sağlık ilişkisinin farklı boyutlarını ortaya çıkarmaya çalışmaktadır. Bu nedenle, sağlığın, iktisadi gelişmeye olan etkilerinin araştırılması için sağlık değişkenleri olarak beklenen yaşam süresi (BYS), beden kitle indeksi (BKİ) ve sistolik kan basıncı (SKB) kullanılmıştır. Ayrıca ilişkinin incelenmesinde kısa ve uzun dönem zaman süreleri esas alınmıştır. Bu temsili sağlık değişkenlerinin en önemli ortak özelliği yaşlanmayla güçlü bağlarının bulunmasıdır. Temsili sağlık değişkenlerinin bu ortak özelliği, gelir ve sağlık ilişkisinin farklı boyutlarını incelememize imkân vermektedir. Bahse konu ilişkinin, eğitim süresi (beşerî sermaye), katılan kişi başına düşen gayri safi yurtiçi hasıla, katılan kişi başına üretim katma değeri (verimlilik) ve gayri safi yurtiçi tasarruflar olarak genişletilmesi suretiyle de gelir ve sağlık arasındaki bağa ilişkin temel bir ortak görüşe ulaşılmıştır. Regresyon, sabit-etki ve genelleştirilmiş moment metodu (Arellano-Bond) tahmin araçları kullanılarak 47 ülke için 1940-1980 ve 1940-2009 dönemi için 10'ar yıllık ve 1980-2009 dönemi için 5’er yıllık dengeli panel verileri kullanılarak hesaplamalar yapılmıştır. Ayrıca, tüm bu dönemler için, regresyon ve araç değişken hesaplayıcısı ile uzun dönem-fark tahmini yöntemi kullanılmıştır. Farklı temsili sağlık değişkenlerini ihtiva eden bu çalışmanın ampirik sonuçları genellikle birbirleriyle tutarlı bulunmuştur. Daha açık olarak, tüm bağımlı temsili iktisadi gelişme değişkenleri ve temsili sağlık değişkenleri arasında doğrusal ve tekdüze olmayan bir ilişki bulunmuştur. Sonuç olarak, ampirik sonuçlarımız insan fizyolojik sağlık fonksiyonlarının korunmasının iktisadi büyümeyi güçlendirdiğine dair önemli kanıtlar sunmaktadır.

Anahtar Kelimeler: İktisadi Gelişme, Bilim ve Teknoloji, Sağlık, Doğuşta Beklenen Yaşam Süresi, BKİ ve SKB.

To the Memory of my father Ahmet,

and to my mother Nefise,

and to braveheart people as like them

who never leave alone their loved one

who has to live in the darkness of

the out of the borders of Medical Sciences,

and to all people who care for all of them.

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LIST OF ABBREVIATIONS

AR	Autoregressive
BMI	Body Mass Index
CIs	Confidence Intervals
Cov	Covariance
DES	Dietary Energy Supply
EGMM	Efficient Generalized Method of Moments
FE	The Fixed Effects
GDP	The Gross Domestic Product
GMM	The Generalized Method of Moments
H_0	A Null Hypothesis
IVs	The Instrumental Variables
JNC	The Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure
kg/m^2	Kilogram/Square Meter
LE	Life Expectancy at Birth
lim	Limit
ln	The Natural Logarithm
Log	The Natural Logarithm
Log GDP	The Natural Logarithm of GDP per capita
LoMs	Law of Motions
lpoly	Local Polynomial
MPC	Marginal Propensity to Consume
mm Hg	Millimeter of Mercury
OECD	The Organization for Economic Co-operation and Development
OLS	The Ordinary Least Squares
OSD	Onchocercal Skin Disease
∂	A Partial Derivative

RESET	Regression Equation Specification Error Test
SBP	Systolic Blood Pressure
STP	Science and Technology Policy
TPs	Turning Points
2SLS	Two-Stage Least Squares Regression
UN	The United Nations
USA	The United States of America
WHO	The World Health Organization
χ^2	Chi-Squared Statistics

CHAPTER 1

INTRODUCTION

The effects of health on wealth have been investigated in many studies using different proxy variables. The reason behind conducting these studies to reveal these effects may be the complexity of the effects of health on wealth.

The summation of the results of these studies bring us to the point that we make a choice between the approaches of the Neo-liberal models and endogenous economic growth models via returns to investment in health, which are different in these models as expressed in Husain et al. (2014). The unexpected explanation for this dilemma comes from Azomahou et al.'s (2009) study. Azamadou et al. (2009) demonstrate that if an individual makes enough savings, a positive linkage develops between economic growth and good health status.

As we infer from this result, as far as the young people in the economy are concerned, if an individual does not have enough savings, there can be a negative association between economic growth and good health status. The elderly with bad health status cannot support economic growth positively as a result of the increasing expenditure on their health and the education of their kids. They tend to spend more rather than save. At this point, it can be said that long lifespan seems to have a positive effect on economic development but it has a gradually decreasing effect on savings rate. These findings define the conflicting view between the Neo-liberal models and endogenous growth models. This conflicting view may increase the complexity of the association between economic growth and health. From this perspective, we believe that we should combine individual good health and savings in the economy. When we achieve to combine them, we may protect and prolong individual good health in these economic circumstances. In our perspective, all these efforts will provide us with positive effects of health on economic growth in both the short and long run. But first, we should understand the dimensions of this conflicting view.

This study attempts to make a contribution to the literature by elaborating on this conflicting view. The studies mentioned above give us inspirational motive and guidance for our research. The studies in the literature provide significant knowledge about the characteristics of economic growth and health association. For example, Husain et al. (2014) indicate that most of the studies take life expectancy at birth (LE) as a proxy for health rather than other dimensions of health. They also used LE as a proxy for health in their study by recognizing the limitation of this variable. For them, LE measures only "mortality" rather than other dimensions of health such as "morbidity", "disability", and "discomfort" (Husain et al., 2014: 128). At the same time, they explain that the effect of this variable on economic growth is very strong.

Hence, we use different periods changing between short to long-term and the proxy variables for health, namely LE, BMI, and SBP to investigate the effect of health on gross domestic product (GDP) per capita. By utilizing BMI and SBP as proxy variables, we seek to observe "morbidity", "disability", and "discomfort" (Husain et al., 2014: 128) dimensions of health to some a certain extent in these estimations. At the same time, these health proxies share a common character as they all have age-dependent dimensions. Therefore, these specifications enable us to examine different dimensions of the wealth-health nexus. Consequently, we expect to reach a basic common opinion about wealth-health association by expanding wealth proxy variables to years of schooling (human capital), GDP per person engaged, manufacturing value added per person engaged (productivity), and gross domestic savings.

We utilize panel data for 47 countries. There are increments in longevity, economic growth, and human capital in all these countries from 1940 to 2009. Also, it is seen that BMI rises without exception in these countries from 1980 to 2009. SBP increases only in 8 countries for the 1980-2009 period. GDP per person engaged increases in 39 countries from 1980 to 2009. Productivity improves only in 18 countries in the 1980-2009 period. Gross domestic savings increase in 29 countries from 1980 to 2009.

We demonstrate the differences in estimated coefficients based on the model restrictions in our result tables. We use OLS, FE and GMM (Arellano-Bond) estimators with 10 yearly and balanced panel data for the 1940-1980 and 1940-2009 periods, and 5 yearly and balanced panel data for the 1980-2009 period for 47 countries. Also, for all these periods, we make long-difference estimation with OLS and instrumental variable (IV) estimator.

In this study, we present the effect of health on wealth with LE, BMI, and SBP proxy variables in three chapters (Chapter 4, Chapter 5 and Chapter 6) respectively. Then, we give conclusions and provide policy recommendations in Chapter 7. Also, in Chapter 7, we share our perspectives and opinions on Science and Technology Policy Issues related with our policy recommendations. Besides, we give the synopsis of the contributions of this study in Chapter 7.

1.1.Scope

This study covers health proxy variables of LE, BMI, and SBP, and economic development proxy variables of gross domestic product (GDP) per capita, years of schooling (human capital), GDP per person engaged, manufacturing value added per person engaged (productivity), and gross domestic savings.

Within the scope of the thesis, we investigate the association between, for example, GDP per capita and LE. We do not investigate the causality between these variables. This investigation is left for future studies.

We follow the base sample data structure in Acemoglu and Johnson (2007: 939, 979-980) for 47 countries from the beginning of the 1940-1980 period due to historical reliable data consideration. Hence, there are 47 countries in our panel data and three periods to examine the linkage between economic development and health. These periods are 1940-1980, 1940-2009 and 1980-2009. The 1940-1980 period has been used in Hansen (2012), Desbordes (2011), Cervellati and Sunde (2009), and Acemoglu and Johnson (2007). The 1980-2009 period is used in Husain et al. (2014). These two periods have relatively short period characteristics. We move further and include the 1940-2009 period, which is the combination of these two periods as having relatively long period specification. The short- and the long-term may have different results for the same events in economics.

The historical reliable data consideration of these 47 countries provides us two different economic policy applications for the 1940-1980 period and the 1980-2009 period as Keynesian and Neo-liberal economics respectively. As a result, the 1940-2009 period that provides us unique combined specification of these two different economic policies implemented in this duration.

According to Jahan et al. (2014), in Keynesian economics, aggregate demand is accepted as the main engine in economy. Aggregate demand includes the gross of the expenditures made by commercial activities, households, and the government. Public policies should accomplish full employment and price sustainability as there is no self-balancing function in free markets that provide full employment. Deficiency in total demand may lead to a rise in unemployment.

Total production as goods and services of the economy is the gross of consumption, investment, public procurements, and net exports. Demand increment comes from one of these four elements. However, recessionary movements in economy decrease consumer confidence and then their purchase. Less consumer spending creates less investment in commercial activities since firms cut their productions depending on this decreased demand. The government should fix this inadequate demand problem in economy.

According to Keynesian economics, three principles drive economy. The first principle is that the public and the private decisions affect aggregate demand. Decisions of the private firms affect macroeconomy negatively. Thus, Keynesian economics follows mixed economy which is driven mostly by private and partly by public sectors.

The second principle is that supply and demand changes slowly affect prices and wages, which causes labor shortages or surpluses periodically.

Based on the third principle, aggregate demand changes cause a vigorous short-run effect on real production and employment, but not on prices. In Keynesian economics, prices are to a certain degree inelastic. Change in the expenditure of any element affects production. For example, public spending increment causes output increase rather than price increase. There is also a multiplier effect, indicating that if fiscal multiplier is higher than one, one monetary unit increase in the economy causes more than one unit of increase in the output.

In Keynesian economics, there are fiscal policies that are utilized against economic fluctuations. Contrary to a balanced government budget approach, public deficit spending can be utilized for labor-intensive facility works to increase employment and make wages stable during economic recession. Also, tax increment is used to avoid inflationary motive and to stabilize highly raised demand.

Monetary policies are implemented in Keynesian economics to motivate economy. For instance, interest rates are decreased to stimulate investment. There is a liquidity trap in which money stock increase cannot lead to a decrease in interest rates. Thus, production and employment cannot be raised.

According to Keynesian economics, even the short-run problem in economy is also solved by public intervention. The government should not wait for the market mechanism to fix the problem in the longer period.

According to Thorsen and Lie (2010), resource allocation efficiency is the primary consideration of the economic mechanism. According to Neo-liberal economics, the market system is the most effective course of action to distribute resources. Public intervention weakens this perfectly balanced system of the market and decreases the efficiency of economic resource allocation.

Neo-liberal doctrine suggests that enhancing individual entrepreneurial wisdom and capabilities by securing free trade, free markets, and property rights in the institutional form can promote human well-being. Public responsibility is to build and to secure these foundations so that they function correctly.

In Neo-liberal economics, the monetary unit should be kept in quality and integrity by the government. Defense capabilities, police work, and legal frameworks should be founded to guarantee private property rights and an adequately functioning market mechanism. If there is no market mechanism for water supply, education, medical services, social security or ecological problems, the public should provide these services. However, public intervention to market mechanism should be lowest in degree to avoid distortion in the market and price speculation.

In Neo-liberal economics, there are complementary policies such as deregulation, extensive tax reduction, and privatization. In this doctrine, individuals bear responsibilities for their freely made decisions and actions in the market mechanism. Lack of equality and social discrimination are morally admitted if they are a consequence of an individual's free choices.

In Neo-liberal doctrine, reforms and individual and entrepreneurial freedoms should be secured by institutions against the pressure of the democratic process by replacing this process with the rule of experts or legal instruments.

There are different birth rate movements for the periods 1940-1980 and 1980-2009. According to Figure 2.1, the birth rate of 47 countries is less than 30/1000 for the 1940-1980 period, followed by 53.2, 55.3, 48.9, 48.9 and 61.7 in years 1940, 1950, 1960, 1970 and 1980, respectively. The birth rate decreases in the 1940-1950 period, first, and, then increases during the period 1950-1970, and, later, starts to decrease in the 1970-1980 period. According to this figure, the birth rate of 47 countries is less than 30/1000 for the 1980-2009 period and is 67.1, 76.6, 93.6, and 97.9 in the years 1980, 1990, 2000 and 2009, respectively. It is observed that in the 1980-2009 period, birth rate decreases in a linear trend.

For the 1940-1980 and 1940-2009 periods, depending on historical reliable data consideration, GDP per capita and years of schooling are used as dependent variables. The explanatory variable is LE as one of the health proxy variables. For the 1980-2009 period, considering the availability of reliable historical data, GDP per capita, years of schooling (human capital), GDP per person engaged, manufacturing value added per person engaged (productivity), and gross domestic savings are used as dependent variables, and LE, BMI, and SBP are used as health proxy variables and explanatory variables. The economic development proxy variables are selected from growth indicators according to their strong association with economic growth in robustness tests. These health proxy variables are chosen because of their age-dependency and embeddedness in LE.

Balanced panel data are used for 47 countries in the estimations for these periods. These 47 countries were also used in the studies of Acemoglu (2007), Cervellati and Sunde (2009) and Desbordes (2011). These countries are listed according to their regions: Argentina, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, and Venezuela in South America; Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama in Central America; Canada, Mexico, and the United States of America in North America; Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom in Europe; Bangladesh, China, India, Indonesia, Malaysia, Myanmar, Pakistan, Philippines, South Korea, Sri Lanka, and Thailand in Asia; Australia; New Zealand in the Southwestern Pacific Ocean.

1.2. Research Questions

What is the effect of health on economic development? This question is our core issue in this study. We use, in general term, Azomahou et al.'s (2009) study as a guide to investigate this question. According to the assumptions of Azomahou et al. (2009), people at different ages will have alternative active planning and use different saving options. These saving preferences determine the direction of the association between LE and GDP per capita growth. This association should be tested using different health proxy variables to understand the dimensions of these linkages. Then, we borrow our assumption from the medical literature that there is a strong association between aging and BMI and, also, SBP. Thus, people at different ages may have very close BMI measurements and SBP results. These close linkages provide us two new replacements of life expectancy as health status proxies. These are SBP and BMI. Then, we divide our two core terms as health and economic development into sub-three health proxy variables and sub-five economic development proxy variables that are called engines of economic growth. Thus, we have fifteen questions that are grouped in three main sections according to their health topics as the explanatory variables.

1.2.1. The Questions Related with Longevity and Economic Development

These questions are analyzed for three different periods as 1940-1980, 1940-2009, and 1980-2009. The questions related with longevity and economic development are investigated in Chapter 4. The main question in Chapter 4 is "What is the impact of

LE on GPD per capita growth?”. Other questions based on growth engines and their longevity associations are utilized so as to examine the main question findings. The first of these questions aims to examine the association between human capital and longevity: What is the link between years of schooling (human capital) and LE? The second question relates to GDP per person engaged and longevity: What is the association between GDP per person engaged and LE? The third question is associated with productivity and longevity: What is the linkage between manufacturing values added per person engaged (productivity) and LE? The fifth question is linked to savings and longevity: What is the association between gross domestic savings and LE?

1.2.2. The Questions Related with Nutrition and Economic Development

These questions are investigated for the 1980-2009 period due to data limitation. The questions related with nutrition and economic development are investigated in Chapter 5. The main question in this chapter is “What is the impact of body mass index (BMI) on economic growth?”. Other questions regarding growth engines and nutrition association are posed to examine this main question. The first question is related with human capital and nutrition: What is the effect of BMI on human capital? The second sub-question is associated with GDP per person engaged and nutrition: What is the association between GDP per person engaged and BMI? The third question is related with productivity and nutrition: What is the effect of BMI on productivity? The final question is linked to savings and nutrition: What is the association between gross domestic savings and BMI?

1.2.3. The Questions Related with the Vascular Health and Economic Development

Due to data limitations, these questions are interrogated for the 1980-2009 period only. The questions related with vascular health and economic development are investigated in Chapter 6. The main question in this chapter is “What is the impact of systolic blood pressure (SBP) on economic growth?". Other questions regarding the association between growth engines and vascular health are used to examine the main question. The first of these questions is related with human capital and vascular health: What is the linkage between human capital and SBP? The second question is linked to GDP per person engaged and vascular health: What is the connection between GDP per person engaged and SBP? The third question is associated with productivity and vascular health: What is the association between productivity and SBP? The last question is related with savings and vascular health: What is the association between gross domestic savings and SBP?

1.3. Essays

1.3.1. The Impact of Life Expectancy on Economic Development, Human Capital, GDP per Person Engaged, Productivity and Gross Domestic Savings

In Chapter 4, we investigate the association between GDP per capita and LE in models that include linear, quadratic and cubic specifications for the periods 1940-1980, 1940-2009, and 1980-2009. We use predicted mortality, age 1-5, age 5-14, age 65-69, age 80-84, and crude survival probabilities, and measles vaccine coverage percent as the instrumental variables in instrumental variable (IV) estimations.

In this chapter, we verify the findings of Cervellati and Sunde (2009) (and enlarging findings with quadratically specified long difference estimation), and Desbordes (2011) and Hansen (2012). We also verify nonparametric estimation finding in Azomahou et al.'s (2009) study as they find the convex and concave-shaped association between GDP per capita growth and LE. In the model for quadratic specification, we find that there is a non-monotonic and a non-linear association between GDP per capita and LE. We provide evidence that there is a U-shaped association for the 1940-1980 and 1940-2009 periods. However, we find an inverted U-shaped linkage for the 1980-2009 period. We confirm the findings of Desbordes (2011) and Hansen (2012) that the effect of LE on GDP per capita may change during the process of economic development. We include non-linearity for health in our models based on Hansen's suggestion.

The effect of life expectancy on human capital is also examined for 1940-1980, 1940-2009, and 1980-2009 periods. We provide evidence that there is an inverse U-shaped association between years of schooling (human capital) and LE during all these periods. In addition, we investigate the linkage between GDP per person engaged, manufacturing value added per person engaged (productivity), gross domestic savings and LE only for the 1980-2009 period due to data limitations. We find that the effect of LE on all these dependent variables follows an inverse U-shaped curve for the 1980-2009 period.

In the model with cubic specification, we find evidence that the association between per capita GDP and LE is concave-convex-shaped for the 1940-1980 period. However, we find that the association between human capital and LE follows a convex-concave-shaped curve for this period. We find convex-concave-shaped linkages between GDP per capita and LE, and human capital and LE for the period 1940-2009. The convex-concave-shaped curve is observed for per capita GDP and LE association for the 1980-2009 period. These results are similar to Azomahou et al.'s (2009) empirical findings for the association between GDP per capita growth and LE. This non-linear and non-monotonic association is also observed for human capital and LE, GDP per person engaged and LE, and productivity and LE in this period. In the association between gross domestic savings and LE, the coefficients of the linear, the quadratic, and the cubic terms are insignificant. To conclude, our empirical results offer significant evidence that preserving human physiological health functions reinforces economic development by possessing enough savings.

1.3.2. The Impact of Body Mass Index (BMI) on Economic Growth, Human Capital, GDP per Person Engaged, Productivity and Gross Domestic Savings

In Chapter 5, we examine the association between GDP per capita and BMI for the 1980-2009 period. We consider only this period due to data limitations. We utilize crude survival, and age 75-79 survival probabilities as the instrumental variables in IV estimations. In this study, we consider using BMI to overcome the limitation of LE as the proxy for health. Due to its close link with aging, we assume that the effect of BMI as a physiological health function is embedded in LE. Our weak identification test results provide evidence that there is a robust association between BMI and the age-specific survival probabilities used as the instrumental variables in this study. In quadratic specification, our findings support the non-linear and non-monotonic association between GDP per capita and BMI. Put differently, we find an inverted U-shaped association between GDP per capita and BMI.

We also study the connection between BMI and years of schooling (human capital), GDP per person engaged, manufacturing value added per person engaged (productivity), and gross domestic savings. Our quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between all dependent variables and BMI for the 1980-2009 period. In cubic specification, we find that the association between GDP per capita and BMI is first convex, and then concave-shaped. This result is also valid for the association between GDP per person engaged and BMI, and productivity and BMI for the 1980-2009 period. As far as the association between human capital and BMI, and gross domestic savings and BMI are concerned we find that the coefficients of the linear, quadratic, and cubic terms are insignificant.

Our empirical results in Chapter 5 are generally consistent with the findings on per capita GDP -LE association. These findings provide evidence that the effect of BMI as a human physiological function is embedded in LE through aging. As a result, our empirical findings demonstrate significant proof that healthy mean population BMI level enhances economic development as a result of making enough savings.

1.3.3. The Impact of Systolic Blood Pressure (SBP) on Economic Growth, Human Capital, GDP per Person Engaged, Productivity and Gross Domestic Savings

In Chapter 6, we analyze the association between GDP per capita and SBP for the 1980-2009 period. We consider only this period due to data limitations. The instrumental variables we use are crude survival, and age 75-79 survival probabilities in the instrumental variable (IV) estimations. To eliminate the limitations of the LE as a proxy for health, we consider using SBP in this chapter. We assume that the effect of SBP as physiological health function is embedded in LE due to its strong association with aging. Thus, the weak identification test results show evidence that there is a close association between SBP and the age-specific survival probabilities used as the instrumental variables. In quadratic specification, our findings support the non-linear and non-monotonic association between GDP per capita and SBP. More clearly, we find an inverted U-shaped association between GDP per capita and SBP.

We also study the connection between years of schooling (human capital), GDP per person engaged, manufacturing value added per person engaged (productivity), gross domestic savings and SBP. Other quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between all other dependent variables and SBP for the 1980-2009 period. In cubic specification, we find that the linear term is omitted; the coefficients of the quadratic and the cubic terms are significantly different from "0"; and they are positive and negative respectively for the association between GDP per capita and SBP. Hence, we suggest that cubic specification estimation results share the same findings with quadratic specification estimations of the association between GDP per capita and SBP for the 1980-2009 period. This result is also valid for the association between human capital and SBP in cubic specification. Furthermore, other cubic functional specification estimation results obtained from our study suggest that there is first convex-, and then concave-shaped association between GDP per person engaged and SBP, and productivity and SBP for the 1980-2009 period. For the association between gross domestic savings and SBP, we find that the coefficients of the linear, the quadratic, and the cubic terms are insignificant.

Our empirical results in this chapter are generally similar to the findings regarding the GDP per capita-LE association. These findings support our assumption that the effect of SBP as a human physiological health function is embedded in LE through aging. As a conclusion, our empirical results offer significant evidence that healthy mean population SBP level promotes economic development through enough savings.

1.4. Conclusion

We aim to determine the dimensions of the conflicting views of the Neo-liberal models and endogenous growth models by investigating the returns to investment in health in Chapter 4, Chapter 5 and Chapter 6. The results shared in this study reveal that there can be positive returns to investment in health by achieving the combination between good health and savings of an individual in any economic circumstance. Policy recommendations are provided in Chapter 7 related with these empirical findings, and the theoretical assumptions of the study and the literature. In the next two chapters, we present the Methodology (Chapter 2) and Data and Empirical Specifications (Chapter 3) that help follow our estimation results.

CHAPTER 2

METHODOLOGY

2.1. Non-linearity Issue in Theoretical, Empirical and Graphical Considerations

The non-linear aspect of the association between GDP per capita and life expectancy (LE) was previously investigated by Cervellati and Sunde (2009). They suggest the birth rate of 30 per thousand as a criterion for demographic transition. The countries above this criterion exhibit a negative association between GDP per capita and LE, while those below this criterion exhibit a positive association. According to Cervellati and Sunde (2009), the association between GDP per capita and LE is linear. The non-linearity in the estimation results comes from the number of countries that exhibit or do not exhibit demographic transition in a selected sample to be investigated. They also demonstrate this association in linear specification with the empirical estimations in different sample groups of countries that are determined according to their criteria.

Figure 2.1 demonstrates the rate of the 47 countries that experience demographic transition with less than 30/1000 birth rate depending on Cervellati and Sunde (2009). All these countries are also used in Cervellati and Sunde's (2009) study. During demographic transition, the rate of growth of population declines. Figure 2.1 leads to the perception that decreased rate of population growth causes an increase in GDP per capita uniformly, ceteris paribus.

However, Kelley and Schmidt (1995: 553) find that the effect of lagged births initially begins negative, and then, turns into positive. In addition, the effect of the lagged births was large in the 1980s. In the 1980s, the positive impact of past births (presumably labor-factor) decreased the negative impact of new births (most likely savings) by half (–0.34 against 0.17). They point out that this finding should eliminate the perception that births have identically negative impact on economic growth. The impacts of births also demonstrate variation across short and long periods. Thus, Kelley and Schmidt (1995) infer that growth of population includes both positive and negative elements for economic growth.

The findings of Kelley and Schmidt (1995) further suggest that there should be other factors in the process of development to explain these non-linear and non-monotonic results such as different saving tendencies of younger and elder individuals. These explanations are suggested in Azomahou et al.'s (2009) study. Indeed, for the 1940-1980 period (relatively short period of time), life expectancy has a positive effect on GDP per capita initially, but for the 1940-2009 period (relatively long period of time), this positive effect turns into negative initially according to our cubic specification estimations in Chapter 4.

At this point, Azomahou et al. (2009) demonstrate that there is a convex-concave-shaped association between GDP per capita growth and LE through saving preferences due to the difference between time preference rates of younger and elder individuals. Therefore, the suggestion of Cervellati and Sunde (2009) that there are criteria that lead to the linear positive association between GDP per capita and LE through demographic transition should be examined. By executing these examination estimations, we expect to observe changes concerning the effect of LE on economic growth by linear, quadratic and cubic specifications using 16 post-transitional countries in Cervellati and Sunde's (2009) study.

Thus, we decide to estimate Table 2.1 in linear, quadratic and cubic specifications for the 1940-1980 period in the panel of post demographic transitional 16 countries that have less than 25/1000 birth rate with the variables and data used by Cervellati and Sunde (2009).

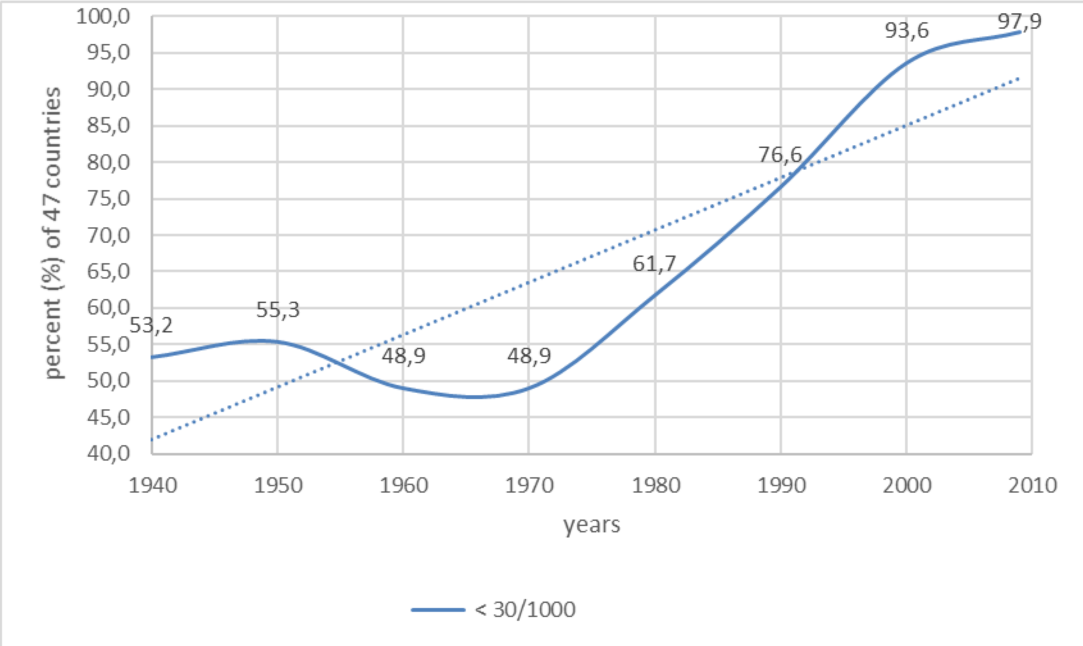

Figure 2.1. The Percentage Change in the Birth Rate of 47 Countries as less than 30/1000 for the Period 1940-2009.
Source: Prepared by the Author[1].

In Table 2.1, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level, indicating that in Table 2.1, there is no functional form misspecification.

According to the weak identification test statistics, predicted mortality and its squared and cubed values are valid instruments excluding Column (6) in Table 2.1, which satisfies the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock, 1997). Although the Stock and Yogo (2005) critical values are not available for Column (6), this problem is solved by applying this rule of thumb.

Weak identification test statistics for Column (4) in Table 2.1 is less than 5.53, which represents 25% maximal IV magnitude in the Stock and Yogo (2005) critical values. The first stage F statistics of this estimation is also found as 3.4 for the same countries as seen in Column (7) of Table 4 in Cervellati and Sunde's (2009: 33)

[1] See Appendix A for the data sources and construction of Figure 2.1.

study. The endogeneity test of LE fails to be rejected in Table 2.1 at 5 % or higher significance level. Thus, the OLS gives consistent and relatively more efficient estimates.

Table 2.1

Long-Difference Estimations for the Association between per Capita GDP and Life Expectancy for the 1940-1980 Period in Post-Transitional Countries Having Birth Rate less than 25/1000 in Cervellati and Sunde (2009:41) with Data in Acemoglu And Johnson (2007) by Linear, Quadratic and Cubic Estimations

	log GDP					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (predicted mortality)
log life expectancy at birth	1.73***	−169.90**	1077.56	1.79**	−182.80***	479.12
	(0.46)	(70.99)	(810.22)	(0.88)	(57.56)	(1610.07)
(log life expectancy at birth)^2	-	21.08**	−280.08	-	22.61***	−138.94
		(8.70)	(199.99)		(7.03)	(397.11)
(log life expectancy at birth)^3	-	-	24.22			13.14
			(16.46)			(32.64)
Number of observations	16	16	16	16	16	16
Number of countries	16	16	16	16	16	16
R-squared	0.29	0.59	0.64	0.29	0.57	0.62
F test *p*-value	0.00	0.00	0.00	0.08	0.00	0.00
Weak identification test statistic	-	-	-	3.44	9.35	1.22
Endogeneity test *p*-value	-	-	-	0.94	0.66	0.43
Hansen J statistic	-	-	-	e.e.i.	e.e.i.	e.e.i.
Wald RESET test *p*-value	-	0.14	-	-	-	-
C (2nd polynomial) RESET test *p*-value	0.81	0.05	-	0.27	0.68	-
C (3rd polynomial) RESET test *p*-value	0.92	n.r.	n.r.	0.43	0.53	0.65
C (4rd polynomial) RESET test *p*-value	-	-	n.r.	-	-	n.r.
Turning points (1)	-	56.31	-	-	56.95	-
(2)	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940 and 1980. GDP is GDP per capita. The dependent variable is the log GDP per capita. In Column (4) predicted mortality, and in Column (5) predicted mortality and its squared value are used as the instrumental variables as they are used in Desbordes (2011). In Column (6) predicted mortality, its squared, and cubed values are used as the instrumental variables in the estimation. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." "n.r." means "not reported" by the test. In (4), Stock-Yogo weak ID test critical value is 16.38. In (5), Stock-Yogo weak ID test critical value is 7.03. In (6), Stock-Yogo weak ID test critical value is not available. Mean turning point of the estimations in (2), and (5) Columns is 56.63.

In linear specification for the 1940-1980 period, Columns (1) and (4) in Table 2.1 report the estimation results of the Model (3.2.1). In linear specification, in the Model (3.2.1), α_2 and α_3 are restricted to be zero. We find that the coefficient of ln LE is positive at 5% or higher significance level in Columns (1) and (4) in Table 2.1. For comparison, we find exact results in Columns (7) of Table 2 and in Table 4 in Cervellati and Sunde (2009: 31 and 33) and in Columns (1) and (4) of Table 2.1 in our study, respectively. However, in Desbordes (2011), this coefficient is negative at 1% significance level. In Hansen (2012), this coefficient is not significantly different from "0" with a negative sign. Hence, our linear functional specification estimation results are consistent with the specification results of Cervellati and Sunde for the 1940-1980 period.

In quadratic specification for the 1940-1980 period, Columns (2) and (5) in Table 2.1 report the estimation results of the Model (3.2.1). In quadratic specification, in the Model (3.2.1), α_3 is restricted to be zero. We find that the coefficients of the linear and the quadratic terms are both significantly different from zero at 5% or higher significance level, and they are negative and positive respectively. These results are similar to the findings of Desbordes (2011) and Hansen (2012) in quadratic functional specification estimations for the 1940-1980 period. Coefficients of the linear and quadratic terms are found negative and positive at 5% or higher significance level, respectively. Our estimated turning points[2] are within the range of 56.31.90-56.95 years in Columns (2) and (5) in Table 2.1. Turning points of Desbordes and Hansen are within the range of 43.23-49.91 years for the 1940-1980 period. Thus, our quadratic functional specification estimation results suggest that there is a non-monotonic and a U-shaped association between per capita GDP and LE for the 1940-1980 period in the panel of post demographic transitional 16 countries that also have less than 25/1000 birth rate in Cervellati and Sunde's (2009: 41) study. This result is consistent with the findings of Desbordes (2011) and Hansen (2012).

In cubic specification for the 1940-1980 period, Columns (3) and (6) in Table 2.1 report the estimation results of Model (3.2.1). We find that the coefficients of the linear, quadratic, and cubic terms are insignificant. Hence, turning points are not estimated for this cubic specification model.

These quadratic and cubic estimation results in Table 2.1 are consistent with Kelley and Schmidt's (1995) findings that births have no identical effects on the process of economic growth. Kelley and Schmidt's (1995) findings and our estimation results in Table 2.1 lead us to the notion of Azomahou et al. (2009) for the association between economic growth and demographic transition. According to Azomahou et al. (2009), increasing crude birth rate has negative effects on economic growth through negative

[2] Quadratic specification turning point (TP) is estimated by following the formula: $TP = \exp\left(\left|\frac{\hat{\beta}_1}{2\hat{\beta}_2}\right|\right)$.

dependency rate on saving. This situation decreases economic growth. For this reason, the effect of birth rate on economic growth cannot be underestimated. However, demographic change influences economic growth in a complicated process.

Recently, the non-linear characteristics of the association between GDP per capita and life expectancy (LE) are also considered by Derbordes (2011) and Hansen (2012), who worked on this association at about the same time. Then, Husain et al. (2014) added cubic transformations for nonlinear specifications.

Desbordes used a sample of 47 countries for the 1940-1980 period which was originally used by Acemoglu and Johnson (2007) and showed that the linear (in LE) model employed by the latter authors are afflicted with functional form misspecification. He instead used a quadratic (in LE) function which was favored by the data. He suggested that the effect of LE on GDP per capita is influenced by each country's initial level of LE. Hansen independently reached a similar conclusion. He used a panel data from a sample of 119 countries also for the 1940-1980 period. He concluded that when studying the LE-GDP per capita association, a form of non-linearity in LE should be used in the estimation process. Hansen also found a quadratic U-shaped association between per capita GDP and LE.

Husain et al. used panel data from a sample of 216 countries for the 1980-2009 period by introducing lags and adding data from 1960 to 1979 to analyze the effect of LE on GDP per capita in the model that is specified by cubic transformation. They find an N-shaped non-linear association between GDP per capita and LE. They also suggest that the shape of the association may be inverse U-shaped by introducing reverse causality into their cubic specification model.

In our opinion, a highly significant contribution is made to this topic by Azomahou et al. (2009) considering the theoretical and empirical dimensions. On the historical panel data of eighteen countries from 1820 to 2005, they provide empirical and theoretical findings regarding the nonlinear association between GDP per capita growth rate and LE. According to the assumptions in Azomahou et al.'s (2009) study, people at different ages will have different active planning and use different saving approaches. Older people tend to save less than relatively younger individuals because of the high rate of time preference in their choices. These saving preferences determine the direction of the association between life expectancy and GDP per capita. They explain the empirical findings regarding the non-linear and non-monotonic association between wealth and health with theoretical models in evolutionary steps. These evolutionary steps of their approach are explained in the following section in this chapter. They demonstrate that the GDP per capita growth rate increases with life expectancy at birth. However, the association between GDP per capita growth rate and LE changes according to the values of LE. There is convexity at lower LE levels and concavity at greater LE levels.

Due to the historical data limitations for 47 countries, we prefer to follow both Desbordes (2011) and Hansen (2012) specifications by also adding the cubic transformation of these restrictions as in Husain et al. (2014) to our models. Our empirical results coincide with the empirical findings (turning point-1s are around 49.03-51.07 years; turning point-2s are around 63.46-65.70 years) of Azomahou et al. (on pages 208-209) as seen in Figures 5 and 6 in their study. These overlaps are demonstrated explicitly in Figure 2.2 of our study. Turning points are estimated by GMM (Arellano-Bond) in cubic functional specification in Figure 2.2. These inflection points are depicted by the vertical lines dashed in red, solid in blue, and dashed in green colors for the periods 1940-1980, 1940-2009, 1980-2009, respectively.

Attempting to measure other dimensions of health like morbidity, disability and discomfort rather than only mortality, we also consider using BMI and SBP as health proxy variables in this study. We assume that the effects of BMI and SBP as the human physiological functions are embedded in LE due to their close association with aging. Thus, the weak identification test results provide evidence that there are vigorous associations between BMI and SBP, and the age-specific survival probabilities used as the instrumental variables in this study.

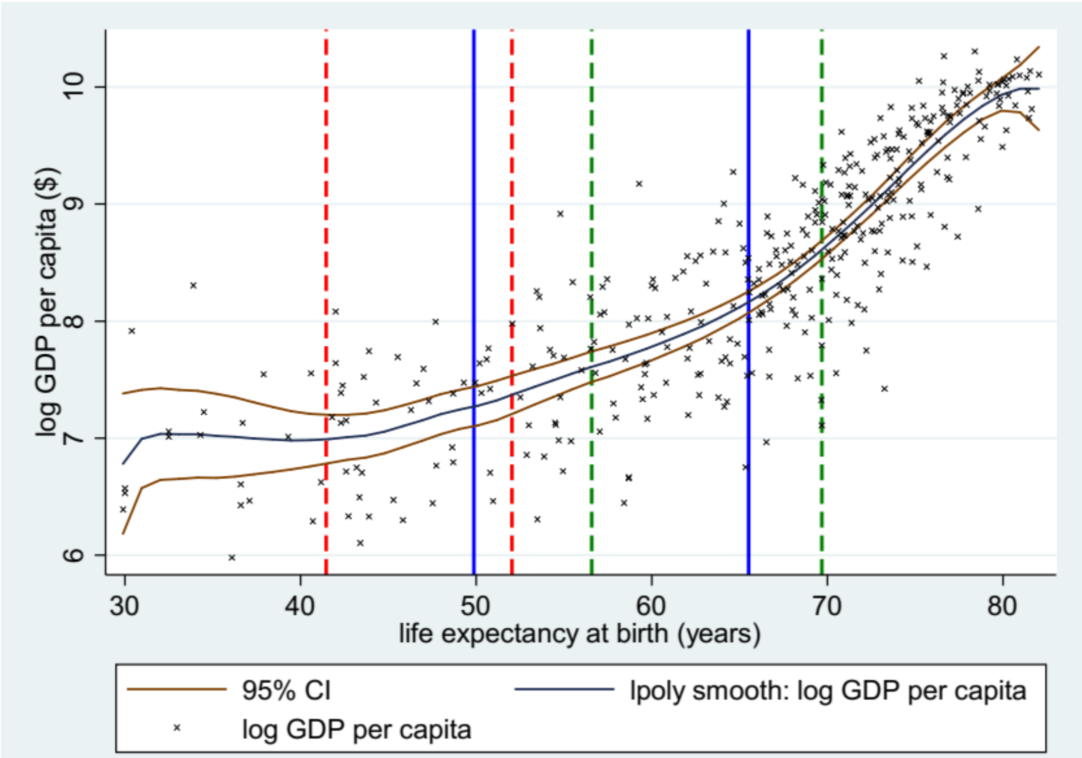

Figure 2.2. Local Cubic Polynomial Smooth Plots with Confidence Intervals (CIs) of GDP per Capita and Life Expectancy of 47 Countries for the Period 1940-2009.

Source: Prepared by the Author.

Figure 2.3 demonstrates that there is a convex-concave-shaped association between GDP per capita and BMI for the 1980-2009 period in GMM (Arellano-Bond) in cubic specification in Chapter 5. The turning points (TPs) are estimated as 19.88-25.93 kg/m^2 (kilogram/square meter) and demonstrated with blue vertical lines in the figure. According to the BMI classification of the World Health Organization (WHO), the normal range is 18.50-24.99 kg/m^2.

Figure 2.3 suggests that the convex-concave-shaped association between GDP per capita and BMI is similar to Figure 5 and Figure 6 in Azomahou et al.'s (2009: 208-209) study and Figure 2.2 in our study. The only difference between these Figures and our Figure 2.3 is the scale of the turning points which are in BMI units.

However, this result is not surprising because BMI has a close association with age-dependent survival probabilities according to the weak identification test results in our estimations in Chapter 5. Moreover, we observe the similar convex (roughly)-concave-shaped curve in Figure 2 in Kedir's (2009: 67) study, which depicts the non-parametric regression results between wages and BMI for the 1994-2000 period.

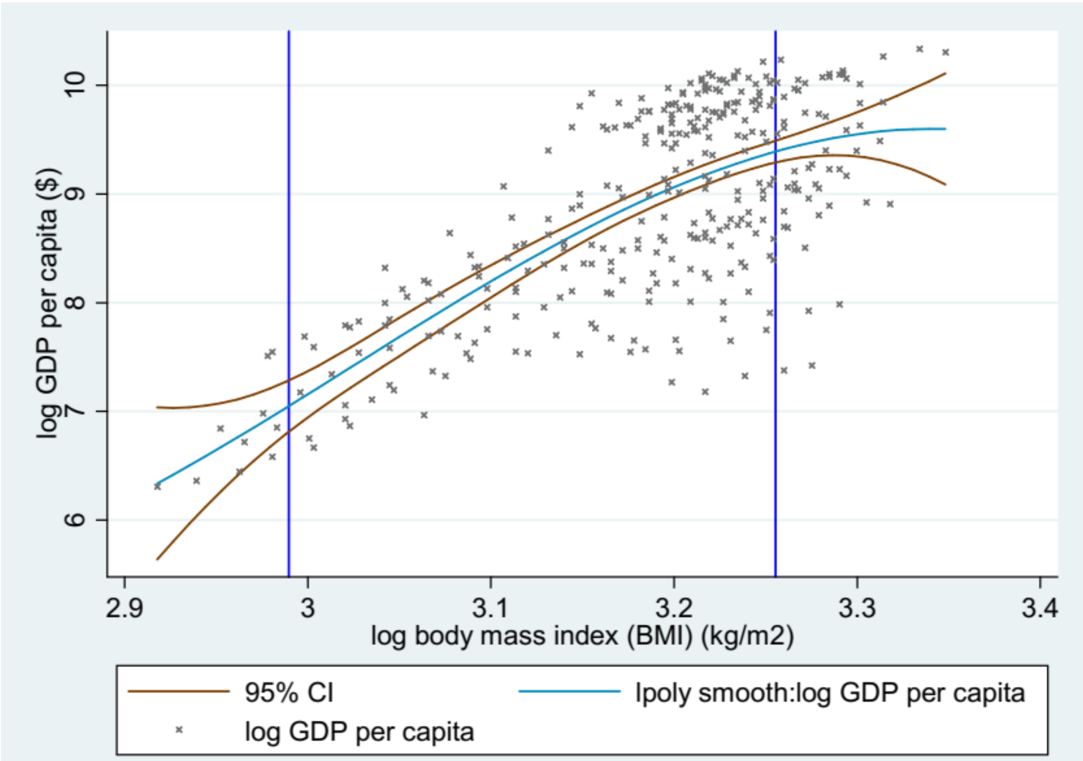

Figure 2.3. Local Cubic Polynomial Smooth Plots with Confidence Intervals (CIs) of GDP per Capita and Body Mass Index of 47 Countries for the 1980-2009 Period.

Source: Prepared by the Author.

Figure 2.4 demonstrates that there is a convex-concave-shaped association between GDP per capita and SBP. We find a similar sign in the coefficients of this convex-concave-shaped curve. However, the coefficients are insignificant. For this reason, the turning points are given according to category criterions in JNC 6 (1997:10) and JNC 7 (2003:12). The normal range is accepted as "less than 130 mm Hg."; and "130-139 mm Hg." is accepted as "high normal" in JNC 6 (1997:10). However, in JNC 7 (2003:12), the normal range is "less than 120 mm Hg."; and "120-139 mm Hg." is categorized as "prehypertension". In sum, this convex-concave-shaped curve in Figure 2.4 in our study suggests that the link between GDP per capita and SBP is roughly similar to Figures 5 and 6 in Azomahou et al.'s (2009: 208-209) study and Figures 2.2 and 2.3 in our study. This result is expected since SBP has a close association with age-dependent survival probabilities according to our weak identification test results in Chapter 6.

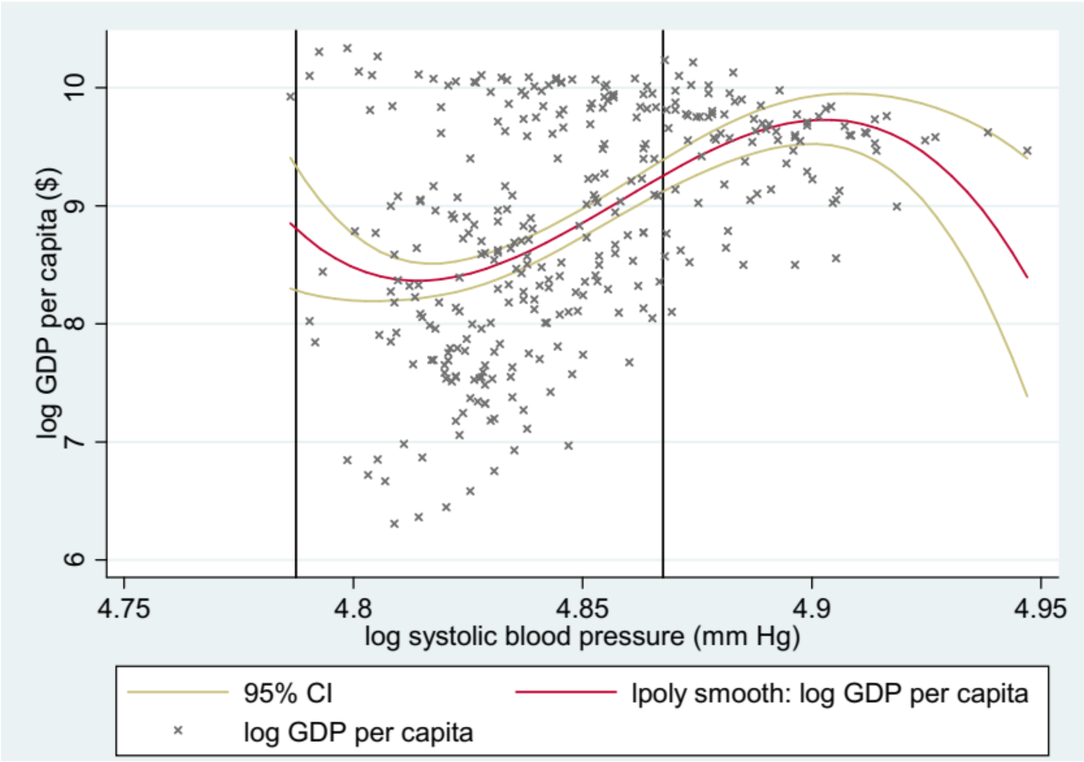

Figure 2.4. Local Cubic Polynomial Smooth Plots with Confidence Intervals (CIs) of GDP per Capita and Systolic Blood Pressure of 47 Countries for the 1980-2009 Period with Constant Points 120-130 mm Hg (Millimeter of Mercury) Marked by Black Vertical Lines.

Source: Prepared by the Author.

2.2. The Evolution of Azomahou- Boucekkine-Diene Model

We follow Azomahou et al. (2009) closely, but we use our own notation. What letters refer to is presented in Appendix B. Azomahou et al. (2009) empirically find an original shape of nonlinearity regarding the association between economic growth and health (LE). They demonstrate that the association between economic growth and LE is convex-shaped in low values of LE. However, this association turns into a concave-shaped curve in high enough values of LE. In their theoretical model, they use a combination of the assumptions as life-cycle behavior and survival probabilities due to different life spans, active planning processes, and saving decisions of individuals at different ages. By following the evolutionary path in their model, Azomahou et al. provide significant proof for the convex-concave-shaped association between economic growth and LE both empirically and experimentally. In their study, they demonstrate the evolution of their model with thirteen propositions, one corollary and thirty-four equations from (2.2.1.1) to (2.2.3.17).

2.2.1. Using the Model of Benchmark to Combine Blanchard and Romer

First, Azomahou et al. (2009) combine the basic structures of Blanchard (1985) and Romer (1986).

As far as demographics is concerned, Azomahou et al. (2009) have the following assumption. A cohort is born at every instant. A constant instant likelihood of death equals to $m > 0$. This is valid for each member of any generation. Hence, there is a likelihood $e^{-m(s-\gamma)}$ of surviving at $s > \gamma$, which designates an agent born at γ. $1/m$ constantly equals to LE. Azomahou et al. (2009) follow a constant growth rate of population. This approach equals to $h \geq 0$ at any date. This issue is indicated with $L(s)=e^{hs}$. There is a term as the magnitude of a generation born in γ at time $s \geq \gamma$. This approach is denoted by $P(\gamma, s)$. There is a special mortality assumption. Azomahou et al. (2009) follow $P(\gamma, s) = P(\gamma, \gamma)\, e^{-m(s-\gamma)}$ according to this assumption. In addition, according to Azomahou et al. (2009), there is $(m + h)\, e^{h\gamma}$. At time γ, these terms should indicate the early magnitude of the generation born. These terms should satisfy the magnitude of the total population.

$$\int_{-\infty}^{s} P(\gamma, s)d\gamma = \int_{-\infty}^{s} P(\gamma, \gamma)e^{-m(s-\gamma)}d\gamma = e^{hs}$$

As far as consumers are concerned, Azomahou et al. (2009) have the following assumption. The utility function has the standard logarithmic form. Thus, the utility of the intertemporality equation is presented as

$$\int_{\gamma}^{\infty} ln\, W\ (\gamma, s) e^{-(m+\delta)(s-\gamma)} ds\ , \tag{2.2.1.1}$$

where an individual belongs to generation γ at time s. The individual consumes $W\,(\gamma, s)$. The intertemporal discount rate of the utility is denoted by δ. $Z\,(\gamma, s)$ is the amount of wealth. Each individual has $Z\,(\gamma,\ s)$, which equals to the sum of the accumulated excess of non-interest earnings over outlays of consumption and interest charges as accumulated at time s. Agents have no motive of bequest. They are restricted to sustain wealth status as positive. If an agent is alive, he or she gets a defrayment from insurance companies. There is direct observation for individual age. An individual aged $s - \gamma$ has to confront an interest annuity rate, which is the sum of two concepts. One of them is interest rate of the world, z, at each unit of time. The other one is agent instant death probability $(z\,(s) + m)\ Z\,(s - \gamma)$ at each unit of time. Agent's wealth is confiscated by insurance firms after the death of the agent. According to Azomahou et al. (2009), all agents provide all their available time. Individuals get their payment at the wage rate, $q\ (s)$. This happens for every date s as regularized to one. The budgetary restriction according to these assumptions is:

$$\dot{Z}\,(\gamma, s) = (z\,(s)+m)\ Z\,(\gamma, s) + q\,(s) - W\,(\gamma, s), \tag{2.2.1.2}$$

and

$$\lim_{s\rightarrow\infty} Z(\gamma, s)\ e^{-\int_{v}^{s}[z(b)+m]db} = 0.$$

The given initial condition is $Z\ (\gamma,\ \gamma)$. The equation (2.2.1.1) is maximized by the consumer under the influence of (2.2.1.2). The assumption is that $Z\ (\gamma,\ \gamma) = 0$ for every γ. The equation of Hamiltonian is associated by following:

$$N = ln\ W\,(\gamma, s)\ e^{-(m+\delta)(s-\gamma)} + \kappa\ [(z\ (s) + m)\ Z\ (\gamma, s) + q\ (s) - W\ (\gamma, s)],$$

These are associated with variable of the state Z (.). κ is the variable of the co-state.

The results of the first order conditions are:

$$\frac{\partial N}{\partial W(\gamma, s)} = 0 \Leftrightarrow \frac{1}{W(\gamma, s)} e^{-(m+\delta)(s-\gamma)} = \kappa$$

$$\frac{\partial N}{\partial Z(\gamma, s)} = -\dot{\kappa} = \kappa[z(s) + m] \Rightarrow \frac{\dot{\kappa}}{\kappa} = -[z(s) + m]$$

$$\frac{\partial N}{\partial \kappa} = \dot{Z} = [z(s) + m] Z(s, \gamma) + q(s) - W(s, \gamma).$$

The optimal consumption is provided using these given equations as

$$\frac{\partial W(\gamma, s) / \partial s}{W(\gamma, s)} = \frac{\dot{W}(\gamma, s)}{W(\gamma, s)} = z(s) - \delta. \quad (2.2.1.3)$$

The well-known Euler equation is shown in (2.2.1.3). It shows the behavior of optimal consumption over unit of time. The gap between the rate of time preference and the interest rate determines the consumption optimal path, which is demonstrated in this equation. Furthermore, there is optimal expenditure behavior in time, which settles the proportionality property within Blanchard–Yaari structures. Hence, the aggregation properties of the model are demonstrated. The following model demonstrates these properties:

$$W(\gamma, s) = (m + \delta) [Z(\gamma, s) + C(\gamma, s)], \quad (2.2.1.4)$$

where

$$C(\gamma, s) = \int_{s}^{\infty} q(\sigma) e^{-\int_{s}^{\sigma} [z(v)+m] dv} d\sigma.$$

Human wealth at s of an individual born at γ is denoted by $C(\gamma, s)$. Labor income future flow is indicated by the present value in $C(\gamma, s)$, which is acquired by integrating the equation (2.2.1.2) and which shows the dynamic budget restriction of the agent. Next, the outcomes of aggregation, which are based on the general formula and which depend on any vintage variable $b\ (\gamma, s)$, are derived. Aggregate magnitude $B(s)$ is determined by these derivations:

$$B(s) = \int_{-\infty}^{s} b(\gamma, s)P(\gamma, s)d\gamma,$$

Azomahou et al. (2009) denote $P\ (\gamma,\ s)$. This term includes the magnitude of the cohort γ at time s. In their approach, the term W signifies aggregate consumption. The term C shows aggregate human wealth. Also, the term Z indicates aggregate nonhuman wealth. These terms are produced by law of motions (LoMs) with growth of population.

$$\dot{Z}\ (s) = (h + z - \delta)\ W\ (s) - (m + h)\ (m + \delta)\ Z\ (s),$$

$$\dot{C}\ (s) = [z + m]\ C\ (s) - e^{hs}\ q\ (s) \qquad (2.2.1.5)$$

and

$$\dot{Z}\ (s) = z\ Z\ (s) + e^{hs}\ q\ (s) - W\ (s).$$

The term w indicates per capita consumption, while d signifies per capita human wealth. In addition, t represents per capita nonhuman wealth. These terms are also obtained from LoMs.

$$\dot{w}\ (s) = (z - \delta)\ w\ (s) - (m + h)\ (m + \delta)\ t\ (s),$$

$$\dot{d}\ (s) = (z + m - h)\ d\ (s) - q\ (s) \qquad (2.2.1.6)$$

and

$\dot{t}(s) = (z - h)\, t(s) + q(s) - w(s).$

As far as the firms are concerned, Azomahou et al. (2009) consider a closed economy, which is also used by Blanchard (1985). However, there are differences between the approaches of Azomahou et al. (2009) and Blanchard (1985). Azomahou et al. (2009) combine the engine of endogenous growth, which was formulated by Romer (1986). This engine of growth is known as learning-by-doing. Capital is accumulated by firms, which become expert in using these machines. Then, firms start to produce more and more, which increases their productivity. Hence, there is both productivity growth and economic growth in this model, and both are the by-products of accumulation of capital. Azomahou et al. (2009) have a nonzero growth of population in their model, which is in contrast to Romer's framework. There is also the associated scale effect. Thus, they cannot incorporate exactly the same externality. In Romer's model, externality is employed to have balanced growth paths.

There is an assumption for the externality term, which is proportional to the capital to labor ratio. The term *j* represents a firm, which obtains the production function as:

$Y_j = X\,(K_j)^{\eta}(A\,L_j)^{1-\eta},\ 0 < \eta < 1,$

η depicts the capital share, while H represents the identical and perfectly competitive firms. These properties are the assumption of Azomahou et al. (2009) related to this term. K_j is the capital factor of firm j. Also, L_j is the labor factor of firm j. The technical improvement is denoted by the term A. This term is assumed to belong to the whole economy and includes the knowledge stock. In addition, this term is outside the control of any firm.

In Azomahou et al. (2009), the term A is assumed to be the increasing function of the aggregate capital-labor ratio. This is assumed as $A = \frac{K}{L}$ for simplicity where:

$K = \sum_{j=1}^{H} K_j$ and $L = \sum_{j=1}^{H} L_j$.

In Azomahou et al. (2009), there are also identical firms. This gives $K = HK_j$ and $L = HL_j$. There is also assumption for depreciation of capital, the rate of which is 0. Then, the profit function is $\varsigma_j = Y_j - q\, L_j - z\, K_j$ for a price-taker firm representative *j.* This gives the conditions of tradition. It is used for profit maximization with K_j and L_j as

$$\frac{\partial \varsigma_j}{\partial K_j} = \eta\, X \left(\frac{K}{H}\right)^{\eta-1} \left(A\,\frac{L}{H}\right)^{1-\eta} - r = 0 \qquad (2.2.1.7)$$

$$\frac{\partial \varsigma_j}{\partial L_j} = (1-\eta)\, X \left(\frac{K}{H}\right)^{\eta} A^{1-\eta} \left(\frac{L}{H}\right)^{-\eta} - q = 0, \qquad (2.2.1.8)$$

$A = \frac{K}{L}$ is the given externality. These produce $z = \eta\, X$. Also, it gives $q = (1-\eta)\, X\, k$. k is the capital–labor ratio.

Nonhuman wealth equals to aggregate capital stock. This equality occurs both at equilibrium and in a closed economy. In equations, $t = k$. This equality is used for per capita terms. Generally, there is the engine in one-sector growth models, which is the accumulation of capital. There are two equations to reduce the model dynamics, which occur at general equilibrium and which are based on aggregate consumption and physical capital. In addition, Azomahou et al. (2009) reorganize Equation (2.2.1.6) to obtain:

$$\dot{w}\,(s) = (z - \delta)\, w\,(s) - (m + h)\,(m + \delta)\, k\,(s), \qquad (2.2.1.9)$$

with $z = \eta\, X$. Also, $q = (1-\eta)\, X\, k$. These terms are the optimality conditions, which clear up the compact form of k in LoMs. These properties can be reorganized as

$$\dot{k}(s) = (X - h)\,k(s) - w(s). \tag{2.2.1.10}$$

The balanced growth formulations, on the other hand, are demonstrated in (2.2.1.9) and (2.2.1.10).

Azomahou et al. (2009: 213) use the term growth paths of balance. They also utilize the term growth path of steady-state. Both these terms are used interchangeably. Then, they describe growth paths of steady-state and deal with the one-sector model. For them, the growth path of steady-state concept is simple. There is consumption per capita and capital per capita. These terms, which are represented as g, grow and their growth rates are at the same constant. In addition, there is theory of endogenous growth, in which Azomahou et al. (2009) face unpredictability. This problem occurs as far as the long-term level of the variables is concerned in equations (2.2.1.9) - (2.2.1.10). These equations do not compute the long-term levels of both variables and the growth rate of g. Thus, Azomahou et al. (2009) use the reduction method of traditional dimension and focus on two variables. One of them is, $\frac{w}{k} = B,$ the ratio consumption to capital. The other is, $g = \frac{\dot{w}(s)}{w(s)} = \frac{\dot{k}(s)}{k(s)}$, the growth rate. Then, they reorganize the equations (2.2.1.9) – (2.2.1.10). This arrangement occurs at growth path of steady-state considering these two variables. They get:

$$g = (z - \delta) - (m + h)\,(m + \delta)\,B^{-1} \tag{2.2.1.11}$$

and

$$g = X - h - B. \tag{2.2.1.12}$$

Azomahou et al. (2009) assume that $m = 0$. They reorganize the structure of traditional demographic in growth theory according to this assumption and using zero capital depreciation. Also, they utilize counterpart outcomes. However, they leave this assumption. They accept that $m \neq 0$. There are positive solutions for the equations (2.2.1.11) – (2.2.1.12). Azomahou et al. (2009) introduce $z > \delta$. These terms mean that the impatience rate should be less than the private return to capital accumulation. Also, they present $X > h$. These terms indicate that the rate of population growth should be less than the productivity parameter X.

These assumptions are acceptable. They also assume that $\delta > h$. This is also a very acceptable assumption in theory of growth. Azomahou et al. (2009) utilize algebra math and demonstrate, g, the long-term growth rate in a second-order polynomial. Thus, g should produce solution for this order level. This is used in Aisa and Pueyo (2004) as well.

$$-g^2 + g\,(X - h + z - \delta) + (X - h)\,(\delta - z) + (m + h)\,(m + \delta) = 0. \qquad (2.2.1.13)$$

However, there is a difference between Aisa and Pueyo (2004) and Azomahou et al. (2009). Aisa and Pueyo (2004) describe the related properties. Azomahou et al. (2009), on the other hand, introduce Proposition A and its proof.

Proposition A: *There are two rigorously positive values for,* g, *the long-term growth rate. These are demonstrated by the given model as* $(X - h)\,(z - \delta) > (m + h)\,(m + \delta)$. *Yet, consistent with consumption to capital ratio that is positive one is the lower one. This is merely a single value.*

PROOF: See Azomahou et al. (2009: 214-215)

At this point, Azomahou et al. (2009) make two comments. First, they consider that the apparent multiplicity is fabricated, which stems from second-order polynomial equation. There is a different result in Aisa and Pueyo (2004). They obtain two distinct and positive values for g. There is the ratio consumption to capital positivity. The highest value of g is not suitable for this positivity. Second, in Azomahou et al. (2009) sufficient conditions exist. But these conditions are not constraining enough.

There are equations as $(X - h)\ (z - \delta) > (m + h)\ (m + \delta)$. Or, there are equations as $(X - h)\ (X - \delta) > (m + h)\ (m + \delta)$. These equations should provide higher X value (productivity). At the same time, m, h and δ lead to lower values in general. There is low X (productivity) values and high m (mortality) values. These two conditions generate negative growth. According to Azomahou et al. (2009), their model works in these conditions and there is the model for the association between economic growth and LE. This model is characterized in the following proposition:

Proposition B: *Especially, g^u is a rigorously diminishing, rigorously convex function of m. There is a rigorously raising, rigorously concave function of LE. This function is the single suitable long-term growth rate of the economy. These conditions are covered by the assumptions of Proposition A.*

PROOF: See Azomahou et al. (2009: 215)

According to Azomahou et al. (2009), the model of benchmark of Blanchard (1985) includes the model of perpetual youth. Also, it utilizes the conditions of engine of the model of learning-by-investing of Romer (1986). These models provide a simple overview of the association between economic growth and LE. There is no difference between countries regarding this association. The observed sample includes low LE and high LE countries, and the association is monotonic and concave-shaped. Azomahou et al. (2009) consider excluding the perpetuality of the youth and introduce age dependency of labor income into their model. Then, they utilize the survival probabilities of age dependency in their model. They demonstrate that there is, h, the growth of population. This term has no significant role in forming the association between growth and LE. They take the growth of population as 0 $(h = 0)$. Then, they assign one for total population. Thus, the aggregate and per-capita variables correspond to each other.

2.2.2. Considerations on the Model with Naturalistic Age-Dependent Wages

There is an assumption for the term wage $q(s)$ at time s in Azomahou et al. (2009). This wage term should be related with an individual's age. In the previous model, it is assumed that wage is not related with age, which is not natural. Now, Azomahou et al. (2009) utilize age dependency of labor income.

Azomahou et al. (2009) introduce new enlargement for the model of benchmark. They apply a replacement for the production function, which is demonstrated below.

$$Y_j = X\,(K_j)^{\eta}\,(A\,\tilde{L}_j)^{1-\eta},\ 0 < \eta < 1,$$

$\tilde{L}_j$ is obtained at any time s in

$$\tilde{L}_j(s) = \int_{-\infty}^{s} \Gamma\,(s-\gamma)\ L_j\,(\gamma, s)\,d\gamma$$

$$\Gamma\,(s-\gamma) = t_1 e^{-\zeta_1(s-\gamma)} + t_2 e^{-\zeta_2(s-\gamma)}\,,$$

Azomahou et al. (2009) find that t_1, ζ_1 and ζ_2 are positive parameters, while t_2 is negative. Hence, they state that the term $\tilde{L}_j$ provides the concept of age-dependent effective labor. There is an age weighting function $(s-\gamma)$. They get this function from Faruqee et al. (1997). They also introduce the first exponential term in $(s-\gamma)$. In this way, they demonstrate the step by step decrease in labor due to aging. They use the second term to produce the other influence. They indicate the positive effects of experience, especially of longer life. For this reason, L_j $(\gamma,\ s)$ provides the magnitude of the workers. At time s, this magnitude covers the age $s-\gamma$.

Age weights are used in Faruqee et al. (1997) with the term $(s-\gamma)$. Azomahou et al. (2009) want to see $(s-\gamma)$ rising initially with age. Then, they demonstrate its decrease after some time. Then, they want to observe the positive effect of experience, which is controlled by labor decrease. This decrease stems from aging. This path should be guaranteed. There should be the appropriate selection for t_j, which should be valid for ζ_j, j =1, 2, as well. Azomahou et al. consider the positivity of $(s - \gamma)$. They make this property valid despite some exceptions. For example, $s = \gamma$ is an exception. Also, the age of the worker is an exception when it is 0. They assume that every individual in every generation is employed. The age $s - \gamma$ is also employed. This age is closer to 0.

According to, it is possible to settle this model. Any γ individual is only employed from $\gamma + P_0$. Thus, $P_0 > 0$. This term denotes a positive number. However, the properties of the model of benchmark are preferred by Azomahou et al. (2009), and their model shows similarities to the properties of the model. The planning process beginning age should be understood as age 0 for the individuals.

$h = 0$ is the assumption in Azomahou et al. (2009). They provide Romer's equation for externality as $A = K$. Under this condition, at date s, population magnitude with age $s - \gamma$ becomes $m\, e^{-m(s-\gamma)}$. Then, with aggregation under symmetric property, profit-maximization of firms gives:

$$q(\gamma, s) = X(1-\iota)\, \tilde{L}^{-\iota}(s)\, \Gamma(s-\gamma)\, K(s),$$

with

$$\tilde{L}(s) = \int_{-\infty}^{s} \Gamma(s-\gamma)\; m\, e^{-m(s-\gamma)}\, d\gamma,$$

At date s, the wage $q(\gamma, s)$ is age $(s-\gamma)$ payment. The integral is precisely estimated. Then, the wage per age becomes constant. For instance, they assume $t_1 = -t_2 = t > 0$. Then, they get:

$$\tilde{L}\,(s) = \tilde{L} = t\,m\left[\frac{1}{\zeta_1 + m} - \frac{1}{\zeta_2 + m}\right].$$

They consider that there is a requirement for $\zeta_1 < \zeta_2$. Also, the requirement for $\tilde{L} > 0$ is valid. These are also similar to the properties of the model by Faruqee et al. (1997) and Japelli and Pagano (1989). $t_1 = - t_2$ are combined with these terms. There is positivity for the function of age weight as $\Gamma\,(s - \gamma)$. By following a hump-shaped curve, this function begins increasing with age. The equation of the wage per age $q\,(\gamma, s)$ is:

$$q\,(\gamma, s) = \Gamma\,(s - \gamma)\,\tilde{q}\,(s), \tag{2.2.2.1}$$

with

$$\tilde{q}\,(s) = X\,(1 - \iota)\;\tilde{L}^{-\iota}\,(s)\,K\,(s),$$

There is age-unadjusted wage, and this property provides this wage. For the interest rate, maximization of firms based on capital produces the equation below in Azomahou et al.'s model:

$$z = \iota\,X\,\tilde{L}^{1-\iota},$$

The wage per age, thus, remains constant at equilibrium as before. Azomahou et al. (2009) argue that the consumer problem is the same. There is only one exception regarding this issue. Now, the age-dependent property of life earnings should be involved in the budgetary restriction:

$$\dot{Z}\,(\gamma, s) = (z\,(s) + m)\,Z\,(\gamma, s) + q\,(\gamma, s) - W\,(\gamma, s). \tag{2.2.2.2}$$

Azomahou et al. (2009) get proportionality property which is consistent with the model of benchmark. There is also an exception for the description of human wealth. This equation is:

$W(\gamma, s) = (m + \delta)\,[Z(\gamma, s) + C(\gamma, s)],$

together with

$$C(\gamma, s) = \int_s^{\infty} q(\gamma, \sigma)\, e^{-\int_s^{\sigma}[z(v)+m]dv}\, d\sigma.$$

For aggregate human wealth, Proposition C gives the related LoM.

Proposition C: $C(s) = \int_{-\infty}^{s} C(\gamma, s)\, m\, e^{-m(s-\gamma)}\, d\gamma$, *the aggregate human wealth utilizes LoM:*

$$\dot{C}(s) = (z + m)C(s) + \int_s^{\infty} \frac{\partial \varpi(\sigma, s)}{\partial s}\, \tilde{q}(\sigma)\, e^{-(z+m)(\sigma - s)}\, d\sigma - \tilde{L}\tilde{q}(s),$$

where

$$\varpi(\sigma, s) = \int_{-\infty}^{s} \Gamma(\gamma - \sigma)\; m\, e^{-m(s-\gamma)}\, d\gamma,$$

PROOF: See Azomahou et al. (2009: 218)

Azomahou et al. (2009) significantly change LoM of the aggregate human capital since there is term $\int_s^{\infty} \frac{\partial \varpi(\sigma,\ s)}{\partial s}\, \tilde{q}(\sigma)\, e^{-(z+m)(\sigma - s)}\, d\sigma$, which is newly introduced. Under the conditions of the human wealth dynamics, this integral produces effects of earning which is age-dependent. According to Azomahou et al., this age-dependent earning affects LoM of the aggregate consumption as well. This property is given in Proposition D.

Proposition D: $Z(s) = \int_{-\infty}^{s} Z(\gamma, s)\, m\, e^{-m(s-\gamma)}\, d\gamma$, *the aggregate nonhuman wealth uses LoM:*

$\dot{Z}(s) = z\, Z(s) + \tilde{L}\, \tilde{q}(s) - W(s).$

The aggregate consumption utilizes:

$$\dot{W}(s) = (z - \delta)\, W - m(m + \delta)\, Z(s) + (m + \delta) \int_{z}^{\infty} \frac{\partial \varpi(\sigma, s)}{\partial s}\, \tilde{q}(\sigma)\, e^{-(z + m)(\sigma - s)}\, d\sigma.$$

PROOF: See Azomahou et al. (2009: 219)

LoM for nonhuman wealth is obtained in the former proposition. Then, Azomahou et al. (2009) give properties of the steady-state of the general equilibrium outcome of their model.

Azomahou et al. (2009) assume that the closed economy is valid. They change, $Z(s)$, the aggregate nonhuman wealth by, $K(s)$, the capital stock, based on the former proposition in LoM:

$\dot{K}(s) = r\, K(s) + \tilde{L}\, \tilde{q}(s) - W(s),$

This gives the equation with expressions of the equilibrium for z and $\tilde{q}(s)$:

$\dot{K}(s) = X\, \tilde{L}^{\,1-\iota} - W(s).$

They get similar equation in path of the steady-state.

$g = \tilde{X} - B,$

with $\tilde{X} = X\, \tilde{L}^{1-\iota}$. Then, they get g and B. They change Z (s) and $\tilde{q}$ (s) with expressions of the equilibrium in K (s):

$$\dot{W}(s) = (z - \delta) W - m(m+\delta) K(s) + X(1-\iota)\tilde{L}^{-\iota}(m + \delta) \times \int_s^{\infty} \frac{\partial \varpi(\sigma, s)}{\partial s} K(\sigma)\, e^{-(z+m)(\sigma - s)}\, d\sigma.$$

They change consumption to capital ratio, B, by $B = \tilde{X} - \text{g}$:

$$\text{g} = (z - \delta) - \frac{m(m+\delta)}{\tilde{X} - \text{g}} \times \left[1 - X(1-\iota)\,\tilde{L}^{-\iota}(m + \delta) \int_s^{\infty} \frac{\partial \varpi(\sigma,s)}{\partial s}\, e^{-(z+m-\text{g})(\sigma - s)}\, d\sigma\right], \qquad (2.2.2.3)$$

together with

$$\varpi(\sigma, s) = t\, m \left[\frac{e^{-\zeta_1(\sigma - s)}}{\zeta_1 + m} - \frac{e^{-\zeta_2(\sigma - s)}}{\zeta_2 + m}\right].$$

along

$$\int_s^{\infty} \frac{\partial \varpi(\sigma, s)}{\partial s}\, e^{-(z+m-\text{g})(\sigma - s)}\, d\sigma = \frac{tm\zeta_1}{(\zeta_1 + m)(z + m + \zeta_1 - \text{g})} - \frac{tm\zeta_2}{(\zeta_2 + m)(z + m + \zeta_2 - \text{g})},$$

They assume that, g, economic growth in the path of steady-state, gives the solution for the equation:

$$F(\mathrm{g})$$
$$= \mathrm{g} - (z - \delta)$$
$$+ \frac{m(m+\delta)}{\tilde{X} - \mathrm{g}} \times \left[1 - X(1-\iota)\tilde{L}^{-\iota}(m+\delta)\left(\frac{\Gamma^1}{(z+m+\zeta^1-\mathrm{g})} - \frac{\Gamma^2}{(z+m+\zeta^2-\mathrm{g})}\right)\right]$$
$$= 0, \qquad (2.2.2.4)$$

with $\Gamma_j = \frac{tm\zeta_j}{(\zeta_j + m)}$, j = 1, 2.

Azomahou et al. (2009) consider using numerical imitations. They formulate Proposition E for their numerical inquiry.

Proposition E: *It is assumed that, X, the productivity parameter has sufficiently higher value. At the same time, it is assumed that the gap between* $\zeta_2 - \zeta_1$ *gets an adequately lower positive value. Within these two conditions, g solves equation (2.2.2.4) with positive rate of growth. This positive rate of growth matches with the ratio consumption to capital. Also, this ratio has a positive value.*

PROOF: See Azomahou et al. (2009: 221)

Azomahou et al. (2009) reach a similar finding to Kelley and Schmidt (1995), and Boucekkine et al. (2002). Their numerical imitation result points to the existence of a hump-shaped curve association between economic growth rate and LE due to the age threshold. In this association, income decreases and economic growth rate decreases depending on, $\Gamma\,(s - \gamma)$, the age profile's natural path. Then, they determine that age-dependent survival probabilities can produce a convex, and then, a concave-shaped curve. They aim to obtain such a curve.

2.2.3. Considerations on a Model with Naturalistic Demography

Azomahou et al. (2009) introduce the law of survival for their model. This model is similar to the one given in Boucekkine et al. (2002). They describe the surviving probability up to age t $(t = s - \gamma)$ for, γ, member of the generation as any individual. This is:

$$u(t, \gamma) \ = \frac{e^{-\varrho(\gamma)t} - \zeta(\gamma)}{1 - \zeta(\gamma)} \tag{2.2.3.1}$$

and at age *t* death probability is:

$$F\ (t, \gamma) \ = \ 1 \ - \ \frac{e^{-\varrho(\gamma)t} \ - \zeta(\gamma)}{1 \ - \ \zeta(\gamma)} \ = \ 1 \ - \ u[\ \zeta(\gamma), \varrho\ (\gamma), (s \ - \ \gamma)]$$
$$= \ \frac{1 \ - e^{-\varrho(\gamma)t}}{1 \ - \ \zeta(\gamma)}, \tag{2.2.3.2}$$

There is, $\varrho\ (\gamma)$, the elderly survival measurement. There is also, $\zeta\ (\gamma)$, the youth survival measurement. Azomahou et al. (2009) assume that $\varrho\ (\gamma) < 0$. Also, $\zeta\ (\gamma) > 1$ in this assumption., which is similar to Boucekkine et al.'s (2002) model to obtain a concave law of survival that occurs in daily life.

There is the maximum age for, γ, generation members as individuals. This possibility is produced by this equation as $u\ (t, \gamma) = 0$. Then, there is $A_{maximum} = -\frac{ln(\zeta(\gamma))}{\varrho(\gamma)}$. Thus, there is the equation that describes the instant death probability:

$$V(t) \ = \frac{\partial F\ (t)/\partial s}{u} = \frac{-\partial u/\partial s}{u} = \frac{\varrho(\gamma)\ e^{-\varrho(\gamma)(s-\gamma)}}{e^{-\varrho(\gamma,\ s-\gamma)} \ - \ \zeta(\gamma)}. \tag{2.2.3.3}$$

The equation for LE is:

$$E \ = \int_{\gamma}^{\infty} (s - \gamma) \frac{\varrho(\gamma)\ e^{-\varrho(\gamma)(s-\gamma)}}{1 - \ \zeta(\gamma)} ds \ = \frac{\zeta(\gamma)\ ln\ \zeta(\gamma)}{\varrho(\gamma)(1 - \ \zeta(\gamma))} + \frac{1}{\varrho(\gamma)}\ . \tag{2.2.3.4}$$

For $\zeta\ (\gamma) \rightarrow 0$ with $\varrho\ (\gamma) > 0$. Blanchard's finding is obtained. At time *s,* the population magnitude is:

$$P_s = \int_{s-A_{maximum}}^{s} \tau e^{h\gamma} \frac{e^{\varrho(\gamma)(s-\gamma)} - \zeta(\gamma)}{1 - \zeta(\gamma)} d\gamma\,. \qquad (2.2.3.5)$$

Azomahou et al. (2009) do not change the property of production. However, the growth of population is accepted as 0. They regularize the magnitude of the population total to one. This property is similar to that in Blanchard (1985). They change the property of consumer radically. They want to make the model consistent with the demographics in real life. They neglect the dependence of $\zeta\ (\gamma)$ and $\varrho\ (\gamma)$ as parameters of demographics on γ. By doing this, they want to ease the solution of the equation. There is utility of the instant, which is obtained from consumption. It occurs in log form and it is for an agent born and living respectively in γ and s. Then, the equation of utility of the intertemporality is:

$$\int_{\gamma}^{\gamma + A_{maximum}} ln\, W\ (\gamma, s)\ \frac{e^{-\varrho(s-\gamma)} - \zeta}{1 - \zeta} e^{-\delta(s-\gamma)}\, ds\,. \qquad (2.2.3.6)$$

Azomahou et al. (2009) assume that work disutility does not exist in their model. This property is different from Boucekkine et al.'s (2002) model. Then, they obtain the classical equation of Euler:

$$\frac{\partial W(\gamma,s)/\partial s}{W(\gamma,s)} = \frac{\dot{W}}{W} = z\ (s) - \delta + V\ (\gamma, s) - V\ (\gamma, s)$$
$$= z\ (s) - \delta. \qquad (2.2.3.7)$$

$W(\gamma, s) = W(\gamma, \gamma)\, e^{\int_{\gamma}^{s}(z\ (v) - \delta)dv}$. According to Azomahou et al., Faruqee et al. (2003) denote over-time consumption very well in their model.

Proposition F

$$W\ (\gamma, s)\ = \vartheta\ (\gamma, s)\ [\ Z\ (\gamma, s)\ +\ C\ (\gamma, s)\ ], \tag{2.2.3.8}$$

where

$$\vartheta\ (\gamma, s) = \frac{1}{\int_s^{\infty} e^{-\int_s^{\sigma}[\delta + V\ (\zeta,\ \varrho,\ (b-\gamma))]db} d\sigma}.$$

PROOF: See Azomahou et al. (2009: 237-238)

Corollary A: *Equation (2.2.3.8) is transformed into the approach of Blanchard as* $W(\gamma, s) = (m + \delta)\ [Z\ (\gamma, s) + C\ (\gamma, s)]$, *if* $V\ (\gamma, s) = m$.

Azomahou et al. (2009) denote marginal propensity to consume (MPC) by $\vartheta\ (\gamma, s)$. They utilize MPC according to age and properties of cohort in their model.

$$\vartheta(\gamma, s) = \frac{\delta(\delta\ +\ \varrho)(e^{-\varrho t}\ -\ \zeta)}{\delta\ [e^{-\varrho t}\ -\ e^{(\delta+\varrho)(t-A_{maximum})}]\ +\ \zeta(\delta\ +\ \varrho)\ [e^{\delta(t-A_{maximum})}\ -1]} \tag{2.2.3.9}$$

and

$$\vartheta(\gamma, \gamma) = \frac{\delta(\delta\ +\ \varrho)\ (1-\ \zeta)}{\delta\ [1-\ e^{-A_{maximum}\ (\delta+\varrho)}]\ +\ \zeta(\delta\ +\ \varrho)\ [e^{-\delta A_{maximum}}\ -1]}. \tag{2.2.3.10}$$

According to Azomahou et al. (2009), MPC is age-dependent. The function obtained from demographics and the parameters of preference affects MPC. Then, Azomahou et al. (2009) present the development process of $\vartheta(\gamma, \gamma)$ according to ϱ, ζ, and δ.

$$\frac{\partial\vartheta(\gamma,\gamma)}{\partial\varrho} = \frac{e^{-(\delta+\varrho)A_{maximum}}\left[(1-\zeta)\left(-\delta^2+\frac{\delta^3(\delta+\varrho)}{\varrho}\right)\right]-\frac{e^{-\delta A_{maximum}}\delta^2\zeta(1-\zeta)(\delta+\varrho)^2}{\varrho}+\delta^2(1-\zeta)}{[\delta\,(1-e^{-(\delta+\varrho)A_{maximum}})+\zeta(\delta+\varrho)(e^{-\delta A_{maximum}}-1)]^2}$$

$$\frac{\partial\vartheta(\gamma,\gamma)}{\partial\zeta} = \frac{e^{-(\delta+\varrho)A_{maximum}}\delta^2(\delta+\varrho)\left[\left(\frac{(1-\zeta)(\delta+\varrho)}{\zeta\varrho}\right)\right]-e^{-\delta A_{maximum}}\delta(\delta+\varrho)^2+\left[1+\frac{\delta(1-\zeta)}{\varrho}\right]+\varrho\delta(\delta+\varrho)}{[\delta\,(1-e^{-(\delta+\varrho)A_{maximum}})+\zeta(\delta+\varrho)(e^{-\delta A_{maximum}}-1)]^2}$$

$$\frac{\partial\vartheta(\gamma,\gamma)}{\partial\delta} = \frac{-e^{-(\delta+\varrho)A_{maximum}}\delta^2(1-\zeta)[(\delta+\varrho)A_{maximum}+1]+e^{-\delta A_{max}}\zeta(1-\zeta)(\delta+\varrho)^2+[\delta A_{maximum}+1]}{[\delta\,(1-e^{-(\delta+\varrho)A_{maximum}})+\zeta(\delta+\varrho)(e^{-\delta A_{maximum}}-1)]^2}$$

$$\frac{+(1-\zeta)[-\zeta(\delta+\varrho)^2+\delta^2]}{[\delta\,(1-e^{-(\delta+\varrho)A_{maximum}})+\zeta(\delta+\varrho)(e^{-\delta A_{maximum}}-1)]^2}.$$

Then, they obtain Proposition G:

Proposition G *There are* $\frac{\partial\vartheta(\gamma,\gamma)}{\partial\zeta} < 0, \frac{\partial\vartheta(\gamma,\gamma)}{\partial\varrho} < 0, \frac{\partial\vartheta(\gamma,\gamma)}{\partial\delta} > 0,$ *if* $A_{maximum}$ *(the age maximum) is sufficiently higher (if* ζ *is adequately higher and/or* ϱ *goes to 0).*

PROOF: See Azomahou et al. (2009: 238-240)

Azomahou et al. (2009) describe the saving rate, $\nu\ (\gamma,\ \gamma)$. This rate equals to $1-\vartheta(\gamma,\gamma)$. They simulate the saving behavior according to the parameters, ϱ and δ. If LE and/or ζ and ϱ rise, then saving rate also increases. If δ increases, then consumption tends to increase and saving rate decreases.

In Azomahou et al.'s (2009) model, considering $b_{\gamma,s}$, any vintage, $B\ (s)$, the size of the aggregate is:

$$B(s) = \int_{-\infty}^{s} b(\gamma,s)P(\gamma,s)d\gamma = \int_{s-A_{maximum}}^{s} b(\gamma,s)P(\gamma,s)d\gamma,$$

$P\ (\gamma,\ s)$ is the cohort magnitude of γ. Azomahou et al. (2009) give the aggregate consumption in proposition H.

Proposition H: $W(s) = \int_{s-A_{maximum}}^{s} W(\gamma,s)P(\gamma,s)d\gamma$, *the aggregate consumption is transformed into:*

$$\dot{W}(s) = \tau\vartheta(s,s)\ C(s,s) + (z\ (s) - \delta)W(s) - \int_{s-A_{maximum}}^{s} W(\gamma,s)\ V(\gamma,s)P(\gamma,s)d\gamma \qquad (2.2.3.11)$$

along $P\ (\gamma,\ s) = \tau u\ [\ \varrho,\ \zeta,\ (s - \gamma)]$ *together with*

$$W(\gamma,s) = W(\gamma,\gamma)\ e^{\int_{\gamma}^{s}[z\ (v)-\delta]dv}. \qquad (2.2.3.12)$$

PROOF: See Azomahou et al. (2009: 230)

There is aggregate consumption in Azomahou et al.'s (2009) model. Three terms determine this consumption. These terms are the newborn human wealth, the gap between the interest rate and impatience rate, and the anticipated forgone consumption at s by agents passing away. According to Azomahou et al. (2009), the third term produces different results compared to the classic Blanchard model. Then, $C\ (s)$, human wealth is developed in Proposition I:

Proposition I: $C(s) = \int_{s-A_{maximum}}^{s} C(\gamma,s)P(\gamma,s)d\gamma$, *the total human wealth at* s *is transformed into:*

$$\dot{C}\ (s) = \tau C(s,s) - q(s)L(s) + \int_{s-A_{maximum}}^{s}\int_{s}^{s+A_{maximum}} q(\sigma)[z\ (s) + V(s - \gamma)]e^{-\int_{s}^{\sigma}[z\ (v)+V(s-\gamma)]dv}\ P(\gamma,s)d\sigma\ d\gamma$$

$$-\int_{s-A_{maximum}}^{s} C(\gamma,s)P(\gamma,s)V(s-\gamma)d\gamma. \tag{2.2.3.13}$$

PROOF: See Azomahou et al. (2009: 240)

The *Z(s)*, the non-human wealth, is presented in the following equation:

Proposition J $Z(s) = \int_{s-A_{maximum}}^{s} Z(\gamma,s)P(\gamma,s)d\gamma$, *the aggregate nonhuman wealth is transformed into:*

$$\dot{Z}(s) = Z(s,s)P(s,s) + z(s)Z(s) + q(s)L(s) - W(s).$$

PROOF: See Azomahou et al. (2009: 240)

Azomahou et al. (2009) introduce (2.2.3.7), the Euler equation, together with $Z(\gamma,\gamma) = 0$.

$$W(s) = \int_{-\infty}^{s} \vartheta(\gamma,\gamma)C(\gamma,\gamma)\, e^{\int_{\gamma}^{s}[z-\delta]dv}\, P(\gamma,s)d\gamma,$$
$$= \int_{s-A_{maximum}}^{s} \vartheta(\gamma,\gamma)C(\gamma,\gamma)\, e^{\int_{\gamma}^{s} z-\delta]dv}\, P(\gamma,s)d\gamma,$$

in place of

$$C(\gamma,\gamma) = \int_{\gamma}^{\gamma+A_{maximum}} q(\sigma)\, e^{-\int_{\gamma}^{\sigma}[z(v)+V(v-\gamma)]dv}\, d\sigma$$

together with

$$q(s) = (1-\iota)XKL^{-\iota} = \bar{G}K,$$

along $\bar{G} = (1 - \iota)XL^{-\iota}$. There is a requirement to denote $W(s)$ clearly. Hence, Azomahou et al. (2009) want to define $L(s)$ and $C(\gamma, \gamma)$ plainly as well. They assume the growth of demographic as 0 in their model. Thus, they obtain the constant labor force and the following equation:

$$L = \int_{s-A_{maximum}}^{s} \tau\, e^{h\gamma}\, \frac{e^{\varrho(\gamma,\ s-\gamma)} - \zeta(\gamma)}{1-\zeta(\gamma)}\, d\gamma$$

$$= \frac{\tau}{1-\zeta}\left[\frac{1-e^{-\varrho A_{maximum}}}{\varrho} - \zeta A_{maximum}\right].$$

Azomahou et al. (2009) obtain $C(\gamma, \gamma)$ together with steady state. They seek exponential outcome at rate g for *K*. They introduce $K(s) = \bar{K}e^{gs}$; $\bar{K}$ is a constant. They get:

$$C(\gamma,\gamma) = \bar{G}\bar{K}\int_{\gamma}^{\gamma+A_{maximum}} e^{g\sigma} e^{-\int_{\gamma}^{\sigma}[z + V(v-\gamma)]dv}\, d\sigma$$

$$= \bar{G}\bar{K}\int_{\gamma}^{\gamma+A_{maximum}} e^{g\sigma} e^{-z(\sigma-\gamma)+ln\left(\frac{e^{-\varrho(\sigma-\gamma)} - \zeta}{e^{-\varrho(\gamma-\gamma)} - \zeta}\right)}\, d\sigma$$

$$= \bar{G}\bar{K}\int_{\gamma}^{\gamma+A_{maximum}} e^{g\sigma} e^{-z(\sigma-\gamma)} \frac{e^{-\varrho(\sigma-\gamma)} - \zeta}{e^{-\varrho(\gamma-\gamma)} - \zeta}\, d\sigma$$

$$= \frac{\bar{G}\bar{K}\, e^{g\gamma}}{1-\zeta}\left[\frac{e^{A_{maximum}(g-z-\varrho)} - 1}{(g-z-\varrho)} - \frac{\zeta(e^{A_{maximum}(g-z)} - 1)}{(g-z)}\right]$$

$$= \bar{K}\bar{M}(g)e^{g\gamma},$$

together with $\bar{M}(g) = \frac{\bar{G}}{1-\zeta}\left[\frac{e^{A_{maximum}(g-z-\varrho)}-1}{(g-z-\varrho)} - \frac{\zeta(e^{A_{maximum}(g-z)}-1)}{(g-z)}\right]$.

Azomahou et al. (2009) give aggregate consumption equation as:

$$W(s) = \tau\vartheta(\gamma,\gamma)\bar{K}\bar{M}\,(\mathrm{g}) \int_{s-A_{maximum}}^{s} e^{\mathrm{g}\gamma} e^{(z-\delta)(s-\gamma)} \frac{e^{-\varrho(s-\gamma)} - \zeta}{1-\zeta} d\gamma$$

$$W(s) = \frac{\tau\vartheta(\gamma,\gamma)\bar{K}\bar{M}(\mathrm{g})e^{\mathrm{g}s}}{1-\zeta} \left[\frac{1 - e^{A_{maximum}(z-\varrho-\delta-g)}}{(g-z+\varrho+\delta)} - \frac{\zeta(1-e^{A_{maximum}(z-\delta-g)})}{(g-z+\delta)}\right] \quad (2.2.3.14)$$

Azomahou et al. (2009) introduce $W(s)$ in steady-state.

$W(s) = \bar{W}e^{\mathrm{g}s}; \bar{W}$ is a constant. They characterize $\frac{\bar{W}}{\bar{K}} = B$. They obtain B using Equation (2.2.3.14) as a function of g:

$$B = \frac{\tau\vartheta(\gamma,\gamma)\bar{M}(\mathrm{g})}{1-\zeta} \left[\frac{1 - e^{A_{maximum}(z-\varrho-\delta-\mathrm{g})}}{(\mathrm{g}-z+\varrho+\delta)} - \frac{\zeta(1-e^{A_{maximum}(z-\delta-\mathrm{g})})}{(\mathrm{g}-z+\delta)}\right]. \quad (2.2.3.15)$$

Azomahou et al. (2009) introduce a simple equation that represents the asset restriction of economy. They denote this equation by B and g to identify both. They bring together Equations (2.2.3.15) and (2.2.1.12).

$$F(\mathrm{g},\vartheta) = XL^{1-\iota} - \mathrm{g}$$

$$-\frac{\tau\vartheta(\gamma,\gamma)\bar{M}(\mathrm{g})}{1-\zeta} \left[\frac{1 - e^{A_{maximum}(z-\varrho-\delta-\mathrm{g})}}{(\mathrm{g}-z+\varrho+\delta)} - \frac{\zeta(1-e^{A_{maximum}(z-\delta-\mathrm{g})})}{(\mathrm{g}-z+\delta)}\right] = 0, \quad (2.2.3.16)$$

This equation provides basic Proposition K:

Proposition K: *The solution of the equation is produced by g, if there is* $g > 0$ *:*

$F(g; \vartheta) = 0,$ (2.2.3.17)

where $\vartheta = (\zeta; \varrho; \tau; \delta; \iota; X)$ *as the parameters' set.*

Then, there is a need to get the positive root of the *g*-equation:

Proposition L: *There is* t $g > 0$ *solution to* $F(.)$ *that equals to zero*, *if L or X are sufficiently higher.*

PROOF: See Azomahou et al. (2009: 241)

Azomahou et al. (2009) provide proof that economic growth and LE association should be non-linear and non-monotonic. If LE has low values, the association should be convex. If LE has sufficiently high values, the association should be concave.

Proposition M: *For sufficiently lower in value of* ζ*, g is a raising convex function of* ζ*. In opposition, g is inevitably a concave function of* ζ *when* ζ *gets adequately higher in value.*

Proposition M can be divided into two parts. The proof of the first part for this proposition can be seen in Azomahou et al. (2009:241-243). The proof of the second part is accepted intuitively. They assume that the long-term rate of growth *g* is restricted. If ζ begins to get adequately high values, the increase in g should begin to decrease. Azomahou et al. get by reasoning that $g \leq X$. *X* is a variable of productivity. It is not dependent on ζ in Equation (2.2.1.12). The economic rate of growth, *g,* should go to negative (or 0), if ζ continues to get sufficiently high values. This mechanism blocks convexity for high values of ζ.

Azomahou et al. (2009: 235 and 236) demonstrate in their Figures 16 to 19 that their proposition clearly works. They explain two main results:

Firstly, in their numerical experiments, a rising LE function is the economic rate of growth as g. If ζ or ϱ rises, the rate of growth rises as well. The flow of motion in their model is that the elderly should be less prone to saving. A person who is born at γ and lives at s has a tendency to decrease the saving rate. Younger people save more than the elderly. They assume that there is physical capital accumulation-dependent economic growth. Also, there is an assumption for domestic savings that are the only source of this accumulation. Based on these assumptions, higher LE has a negative effect on economic growth as there are the raising shares of the individuals who have comparatively lower rates of saving. The negative effect of relatively lower rates of savings by higher LE is not tolerated sufficiently by the positive improvement effect of LE on economic growth.

Secondly, the function of economic growth as g has largely a convex-concave-shaped curve. According to Azomahou et al. (2009: 208-209 and 236), this is also similar to their empirical findings as shown in Figures 5 and 6. Especially, the shape of the curve in Figure 19 estimated by their model is very close to the empirical estimations in Figures 5 and 6. Azomahou et al. clarify the logic behind their empirical, and, then, simulated estimation results. Sufficiently low level of LE provides low level of economic growth. The increment in LE increases economic growth through the increase in aggregate savings. This part describes the convex shape for ζ in lower levels. If LE has adequately higher values, economic growth decreases. This explains the concave shape of the curve as there is an increment in elderly shares in population. These increasing shares of the elderly lead to less saving rate because the elderly have higher time preference rates.

2.3. Obtaining Reduced Form Equations from the Theoretical Model of Azomahou et al. (2009) in Terms of Time Preference Rate and Proxy Variables

We follow the explanations of Azomahou et al. (2009) closely, but we use our own notation. A guide for the letters in the notation is presented in Appendix B. According to Azomahou et al. (2009: 243), U determines the sign of $\frac{\partial^2 g(A_{maximum})}{\partial A_{maximum}^2}$

as it is known that $\lim_{\infty \to 1} A_{maximum} = 0$, either g, L *or* z falls to 0. At the end of the process, they obtain:

$$U = (2\varrho + \delta)(\delta^2 + \varrho\delta) > 0. \quad (2.3.1)$$

We would like to expand the terms in $= (2\varrho + \delta)(\delta^2 + \varrho\delta)$. Then, we have:

$$= (2\varrho + \delta)\delta^2 + (2\varrho + \delta)\varrho\delta > 0.$$

So, we obtain:

$$= 2\varrho\delta^2 + \delta^3 + 2\varrho^2\delta + \varrho\delta^2 > 0.$$

We combine and rearrange these terms. Then, we get:

$$= 2\varrho^2\delta + 3\varrho\delta^2 + \delta^3 > 0. \quad (2.3.2)$$

In Proposition G (Azomahou et al., 2009: 225), ϱ is assumed as close to 0. We may multiply this very small value of ϱ with coefficient terms as 2 and 3. Then, we may ignore these very small values (multiplication results of ϱ with these coefficient terms as 2 and 3) to leave δ alone. Hence, we obtain:

$$U \cong \delta + \delta^2 + \delta^3 > 0. \quad (2.3.3)$$

Then, we ignore the other parts of the solution for $\frac{\partial^2 g(A_{maximum})}{\partial A^2_{maximum}}$ due to the dominant effect of U on determining the sign of $\frac{\partial^2 g(A_{maximum})}{\partial A^2_{maximum}}$ in this solution (Azomahou et al., 2009: 243). Therefore, being limited by the determination of the sign of $\frac{\partial^2 g(A_{maximum})}{\partial A^2_{maximum}}$, U equals by this definition to:

$$\frac{\partial^2 g(A_{maximum})}{\partial A_{maximum}^2} \stackrel{\text{def}}{=} U \cong \delta + \delta^2 + \delta^3 > 0. \quad (2.3.4)$$

Hence, (2.3.4) is consistent with the conclusion in Azomahou et al. (2009: 243) as $\frac{\partial^2 g(A_{maximum})}{\partial A_{maximum}^2} \geq 0$.

We assume that time preference rate (rate of impatience), δ, can be represented by any appropriate substitute. For example, δ increases with LE (Azomahou et al., 2009: 225). Thus, LE may be a substitute for δ in (2.3.4). Therefore, LE in cubic specification may determine the sign of $\frac{\partial^2 g(A_{maximum})}{\partial A_{maximum}^2}$. Then, (2.3.4) turns into:

$$\frac{\partial^2 g(A_{maximum})}{\partial A_{maximum}^2} \stackrel{\text{def}}{=} U \cong \text{LE} + \text{LE}^2 + \text{LE}^3 > 0. \quad (2.3.5)$$

Also, we assume that BMI and SBP are embedded in LE. Thus, both BMI and SBP can be substitutes for LE for cubic specifications in (2.3.5). Therefore, BMI and SBP may determine the sign of $\frac{\partial^2 g(A_{maximum})}{\partial A_{maximum}^2}$. Then, (2.3.5) turns into:

$$\frac{\partial^2 g(A_{maximum})}{\partial A_{maximum}^2} \stackrel{\text{def}}{=} U \cong \text{BMI} + \text{BMI}^2 + \text{BMI}^3 > 0. \quad (2.3.6)$$

$$\frac{\partial^2 g(A_{maximum})}{\partial A_{maximum}^2} \stackrel{\text{def}}{=} U \cong \text{SBP} + \text{SBP}^2 + \text{SBP}^3 > 0. \quad (2.3.7)$$

So, we may use LE, BMI and SBP for cubic specification estimations in (2.3.6) and (2.3.7) as the substitutes for time preference rate, δ.

The sign of $\frac{\partial^2 g(A_{maximum})}{\partial A_{maximum}^2}$ is closely related with the indicators of growth, which are GDP per capita, human capital, GDP per person engaged, productivity, and gross domestic savings. Therefore, we can use these engines of growth as a substitute for

$\frac{\partial^2 g(A_{maximum})}{\partial A_{maximum}^2}$ in (2.3.4). Then, we may utilize these indicators of growth for cubic specification estimations from (2.3.5) to (2.3.7) in the place of $\frac{\partial^2 g(A_{maximum})}{\partial A_{maximum}^2}$. Then, (2.3.5), (2.3.6) and (2.3.7) turn into:

$$\text{GDP per capita} \stackrel{\text{def}}{=} U \cong \text{LE} + \text{LE}^2 + \text{LE}^3 > 0. \quad (2.3.8)$$

$$\text{human capital} \stackrel{\text{def}}{=} U \cong \text{LE} + \text{LE}^2 + \text{LE}^3 > 0. \quad (2.3.9)$$

$$\text{GDP per person engaged} \stackrel{\text{def}}{=} U \cong \text{LE} + \text{LE}^2 + \text{LE}^3 > 0. \quad (2.3.10)$$

$$\text{productivity} \stackrel{\text{def}}{=} U \cong \text{LE} + \text{LE}^2 + \text{LE}^3 > 0. \quad (2.3.11)$$

$$\text{gross domestic savings} \stackrel{\text{def}}{=} U \cong \text{LE} + \text{LE}^2 + \text{LE}^3 > 0. \quad (2.3.12)$$

$$\text{GDP per capita} \stackrel{\text{def}}{=} U \cong \text{BMI} + \text{BMI}^2 + \text{BMI}^3 > 0. \quad (2.3.13)$$

$$\text{human capital} \stackrel{\text{def}}{=} U \cong \text{BMI} + \text{BMI}^2 + \text{BMI}^3 > 0. \quad (2.3.14)$$

$$\text{GDP per person engaged} \stackrel{\text{def}}{=} U \cong \text{BMI} + \text{BMI}^2 + \text{BMI}^3 > 0. \quad (2.3.15)$$

$$\text{productivity} \stackrel{\text{def}}{=} U \cong \text{BMI} + \text{BMI}^2 + \text{BMI}^3 > 0. \quad (2.3.16)$$

$$\text{gross domestic savings} \stackrel{\text{def}}{=} U \cong \text{BMI} + \text{BMI}^2 + \text{BMI}^3 > 0. \quad (2.3.17)$$

$$\text{GDP per capita} \stackrel{\text{def}}{=} U \cong S\text{BP} + \text{SBP}^2 + \text{SBP}^3 > 0. \quad (2.3.18)$$

$$\text{human capital} \stackrel{\text{def}}{=} U \cong S\text{BP} + \text{SBP}^2 + \text{SBP}^3 > 0. \quad (2.3.19)$$

$$\text{GDP per person engaged} \stackrel{\text{def}}{=} U \cong \text{SBP} + \text{SBP}^2 + \text{SBP}^3 > 0. \quad (2.3.20)$$

$$\text{productivity} \stackrel{\text{def}}{=} U \cong \text{SBP} + \text{SBP}^2 + \text{SBP}^3 > 0. \quad (2.3.21)$$

$$\text{gross domestic savings} \stackrel{\text{def}}{=} U \cong \text{SBP} + \text{SBP}^2 + \text{SBP}^3 > 0. \quad (2.3.22)$$

Therefore, we may use the engines of growth as GDP per capita, human capital, GDP per person engaged, productivity, and gross domestic savings as the substitutes for $\frac{\partial^2 g(A_{maximum})}{\partial A_{maximum}^2}$ cubic specification estimations from (2.3.8) to (2.3.22).

2.4. Econometric Methodology

For LE, Desbordes (2011) and Hansen (2012) are also followed in the estimation methods used in this paper. Following Desbordes, we use OLS and IV estimation by using predicted mortality as an instrument. In addition, we consider other instruments such as age 1-5, age 5-14, age 65-69, age 80-84, and crude survival probabilities, and measles vaccine coverage percent. Next, following Hansen, we use fixed effect (FE) estimation and the Arellano-Bond estimation of the Generalized Method of Moments (GMM) for the Model from (3.2.1) to (3.2.5).

For BMI and SBP, Desbordes (2011) and Hansen (2012) are followed in the estimation methods used in this paper as well. Following Desbordes, we use OLS and IV estimation by using crude survival and age 75-79 survival probabilities as the instrumental variables. Next, following Hansen, we use fixed effect (FE) estimation and the GMM (Arellano-Bond) estimation for the Model from (3.2.6) to (3.2.15). The GMM (Arellano-Bond) and IV estimations are explained below.

The diagnostic tests are applied to all the models from Model (3.2.1) to (3.2.15). These diagnostic tests include the Arellano–Bond test for autocorrelation, the test of overidentifying restrictions, the regression equation specification error test (RESET) for misspecification of the functional form, the weak identification test of the instrumental variables, and the endogeneity test of explanatory variables. These diagnostic tests are explained after the brief explanations of estimators.

2.4.1. A Brief Explanation for the Arellano-Bond Estimator

We follow the explanations of Arellano and Bond (1991) closely; but we use our own notation. A guide for the letters in the notations is presented in Appendix B. An autoregressive (AR) specification is not a complicated model with imprecisely exogenous variables. The plain model is

$$y_{jp} = \zeta y_{j(p-1)} + \epsilon_j + \omega_{jp}, \quad |\zeta| < 1. \tag{2.4.1.1}$$

Arellano and Bond (1991) assume that the sample of H time series as individual $(y_{j1}, \dots, y_{jP})$ can be utilized haphazardly. There are lower P and higher H levels. It is assumed that ω_{jp} holds moments of finite. These are specifically $E(\omega_{jp}) = E(\omega_{jp}\omega_{jv}) = 0$ for $p \neq v$. They assume that there is no serial correlation. Yet, this property may have an exemption over unit of time. In first differences, valid instruments are found for equations as y values lagged two or more periods with these assumptions. The proceeding $u = (P-2)(P-1)/2$ is the constraint of linear moment

$$E\left[(\bar{y}_{jp} - \zeta\bar{y}_{j(p-1)})y_{j(p-i)}\right] = 0 \qquad (i = 2, \dots, (p-1);\ p = 3, \dots, P) \tag{2.4.1.2}$$

where for purity $\bar{y}_{jp} = y_{jp} - y_{j(p-1)}$ is inferred by the model for $P \geqq 3$. Arellano and Bond (1991) want to get ζ optimal estimator based on these moment constraints via fixed P and $H \to \infty$ without any information related with ω_{jp} and ϵ_j for their initial specifications or the distributions. The assumption for restrictions of the quadratic moment is inferred as $E(\bar{\omega}_{jp}\bar{\omega}_{j(p-2)}) = 0$. However, it will not be used due to the refraining iterative procedures. Hansen (1982) and White (1982) investigate this calculation issue. Also, there is an estimator of instrumental variables as two-stage or GMM as optimal. Arellano and Bond (1991) utilize (2.4.1.2) with equations of the moment as $E(S'_j\bar{\omega}_j) = 0$ in the form of vector that $\bar{\omega}_j = (\bar{\omega}_{j3} \dots \bar{\omega}_{jP})'$. And $(y_{j1} \dots y_{jv})$ provides vth block for S_j which is a $(P-2) \times u$

matrix of block diagonal. $\widehat{\zeta}$ is the estimator of GMM based on $H^{-1}\sum_{j=1}^{H}S'_j\overline{\omega}_j = H^{-1}S'\overline{\omega}$ as the moments of sample. A $H(P-2)\times 1$ vector is given by $\overline{\omega} = \overline{y} - \zeta\overline{y}_{-1} = (\overline{\omega}'_1,\dots,\overline{\omega}'_H)'$. And a $H(P-2)\times u$ matrix is provided by $S = (S'_1,\dots,S'_H)'$. $\widehat{\zeta}$ is obtained by

$$\widehat{\zeta} = \text{argmin}_{\zeta}(\overline{\omega}'\,S)\,A_H\,(S'\overline{\omega}) = \frac{\overline{y}'_{-1}SA_H\,S'\overline{y}}{\overline{y}'_{-1}SA_H\,S'\overline{y}_{-1}}. \tag{2.4.1.3}$$

It is inferred by the theorem of central limit as standard multivariate normal that there is normal as standard in $\overline{\Omega}_H^{-1/2}\,H^{-1/2}\,S'\overline{\omega}$ asymptotically. And there is, $S'_j\overline{\omega}$, the matrix of covariance of average in $\overline{\Omega}_H = H^{-1}\sum_j E(S'_j\,\overline{\omega}_j\overline{\omega}_j{}'S_j)$.

There is an assumption that $\widehat{\Omega}_H = H^{-1}\sum_j(S'_j\widehat{\overline{\omega}}_j\,\widehat{\overline{\omega}}'_jS_j)$ which provides a substitute for $\overline{\Omega}_H$. $\widehat{\zeta}_1$, as a preceding consistent estimator gives residuals as $\overline{\omega}_j$. Adjusting $A_H = (H^{-1}\sum_j S'_jNS_j)^{-1}$ provides $\widehat{\zeta}_1$ as an estimator of one-step. And diagonal as the main gives both ones as minus and zeroes in sub-diagonals as the first and in other diagonals respectively from $(P-2)$ matrix as square, N. "avar" $(\widehat{\zeta})$ for A_H is obtained by

$$av\hat{a}r\,(\widehat{\zeta}) = H\frac{\overline{y}'_{-1}SA_H\,\widehat{\Omega}_HA_H\,S'\overline{y}_{-1}}{(\overline{y}'_{-1}SA_H\,S'\overline{y}_{-1})^2}\;. \tag{2.4.1.4}$$

$\widehat{\Omega}_H^{-1}$ provides $\widehat{\zeta}_2$ as an estimator of two-step that is an optimal alternative for A_H. Both across units and over unit of time in the independency and homoskedasticity of the ω_{jp} has $\widehat{\zeta}_1$ and $\widehat{\zeta}_2$ equivalency asymptotically. By relation, regressing process of "$\overline{y}$" over "$\overline{y}_{-1}$" utilizing each of two "$\overline{y}_{-2}$" or else "y_{-2}" being the instruments is given by Anderson and Hsiao (1981) to calculate ζ. The estimators obtained will not be efficient due to the two "$\overline{y}_{-2}$" or else "y_{-2}" as S's subgroups in linear form. As it is known, by utilizing $S_j^{+} = \text{diag}\,(y_{jp})$ $(p = 1,\dots,P-2)$, the estimator is equivalent asymptotically to the estimator that is based on the arranged vector "y_{-2}" under property of stationarity, while $E(y_{jp}y_{j\,(p-k)}) = w_{jk}$ for all p. $\widehat{\zeta}_1$ and $\widehat{\zeta}_2$, at even under property of stationarity, are not equivalent asymptotically to these estimators. There is a serial correlation in limited amount conceded in the ω_{jp} as the former estimation extension. Assume that ω_{jp} is the moving average model of order c, understood as $E(\omega_{jp}\omega_{j\,(p-k)}) \neq 0$ for k $\leqq$ c and 0 otherwise. Thus, when P = c + 3, ζ is exactly identified. And there are constraints as

$$u_c = (P - c - 2)\,(P - c - 1)\,/\,2.$$

2.4.2. A Brief Explanation for the Instrumental Variable (IV) Estimation

We follow the explanations of Wooldridge (2002) closely; but we use our own notation. A guide for letters in the notations is presented in Appendix B. The linear model of population is provided to hold the instrumental variable (IV) estimation

$$y = \varrho_0 + \varrho_1 b_1 + \varrho_2 b_2 + \ldots + \varrho_\xi b_\xi + \psi \qquad (2.4.2.1)$$

$$E(\psi) = 0, Cov\,(b_i, \psi) = 0, i = 1, 2, \ldots, K - 1 \qquad (2.4.2.2)$$

ψ may be correlated with b_ξ. This means that regressors as $b_1, b_2, \ldots, b_{\xi-1}$ are exogenous; however, b_ξ is likely to be endogenous in the equation (2.4.2.1). For solution, it is considered that ψ includes an omitted variable which correlates with b_ξ but not with other regressors. If there is $Cov\,(b_i, \psi) \neq 0$ in equation (2.4.2.1), ordinary least squares estimation mostly produces inconsistent ϱ_i. The endogenous regressor issue is dealt with the instrumental variables (IV) approach. There is a need for s_1 as an observable variable, not in equation (2.4.2.1), to utilize IV methodology with endogenous variable b_ξ. s_1 should satisfy two requirements. First, s_1 has no correlation with ψ:

$$Cov\,(s_1, \psi) = 0 \qquad (2.4.2.3)$$

Exogeneity of s_1 should exist in equation (2.4.2.1) as in $b_1, b_2, \ldots, b_{\xi-1}$. The second condition includes the link between s_1 and b_ξ as the endogenous regressor. There is a need for linear estimation of exogenous regressors on b_ξ.

$$b_\xi = \beta_0 + \beta_1 b_1 + \beta_2 b_2 + \ldots + \beta_{\xi-1} b_{\xi-1} + \phi_1 s_1 + \alpha_\xi \qquad (2.4.2.4)$$

$E(\alpha_\xi) = 0$ and α_ξ has no correlation with s_1 and $b_1, b_2, \ldots, b_{\xi-1}$. There is a critical assumption with this linear estimation. This is the coefficient on s_1 which becomes nonzero:

$$\phi_1 \neq 0 \qquad (2.4.2.5)$$

The requirement $\phi_1 \neq 0$ means that s_1 has a partial correlation with b_ξ after $b_1, b_2, \ldots, b_{\xi-1}$ is taken away. If there is only b_ξ as regressor in equation (2.4.2.1), the linear equation becomes $b_\xi = \beta_0 + \phi_1 s_1 + \alpha_\xi$. There is $\phi_1 = Cov\,(s_1, b_\xi)/Var\,(s_1)$, and specification in (2.4.2.5) and $Cov\,(s_1, b_\xi) \neq 0$ are similar.

The distribution of b_ξ or s_1 has no constraints. At the same time, b_ξ and s_1 can have binary, continuous and/or discrete specifications. There is a linear projection in Equation (2.4.2.4). When second moments of all variables are finite, this condition is consistently defined. When the conditions for (2.4.2.3) and (2.4.2.5) are satisfied, s_1 is considered as an instrumental variable (IV) for b_ξ since exogenous variables as $b_1, \ldots, b_{\xi-1}$ have no correlation with ψ. Therefore, in equation (2.4.2.1), explanatory variables as exogenous provide their own instrumental variables. This means that the list of the exogenous regressors is the same with that of the instrumental variables. However, instrument is often preferred to indicate explanatory variable as endogenous.

2.4.3. A Brief Explanation for the Arellano-Bond Autocorrelation Test

We follow the explanations of Roodman (2009) closely; but we use our own notation. A guide for the letter used in the notations is presented in Appendix B. The test is improved by Arellano and Bond, who provide some invalid lags as instruments, called as autocorrelation in the error as idiosyncratic term ω_{jp}. Supposed to be autocorrelated, the full error term, η_{jp}, includes fixed effects, and the estimators are arranged to solve this problem. If ω_{jp} is correlated serially in themselves, for example, in differences of the disturbance term, the $\omega_{j,p-1}$ have an endogenous link with $y_{j,p-2}$, $\Delta\,\eta_{jp} = \omega_{jp} - \omega_{j,p-1}$, which provides an invalid instrument in prospect. There is a need for constraining the set of instruments to lags 3 and longer of "y" until the second order autocorrelation is found at even longer lags. The Arellano-Bond test is used for the residues in differences due to the mathematical relation with $\Delta\omega_{jp}$ using the common $\omega_{j,p-1}$ term. It is expected to have the negative autocorrelation in differences for first-order. Hence, to examine autocorrelation in levels for first-order, they examine autocorrelation in differences for second-order. They find the correlation between $\omega_{j,p-1}$ in $\Delta\omega_{jp}$ and $\omega_{j,p-2}$ in $\Delta\omega_{j,p-2}$. In general, by controlling correlation of order $\lambda + 1$ in differences, autocorrelation of order λ in levels is found. In orthogonal deviations, this application is not useful due to the existence of the interrelation between all residues in deviations by depending on many forward "lags" they render. This test is conducted on residuals in differences even following the deviations in estimation. The Arellano-Bond test for autocorrelation is used for OLS, 2SLS and GMM regressions on panel data by having no "postdetermined" regressors regarding further errors. Another assumption should be that disturbances are not correlated across agents. Thus, common GMM estimate, $\hat{\varrho}_{\mathrm{A}}$, is used for pretransformed datasets as B, Y, S; residues **"Ê"** are provided by the estimator. Q should be the matrix of data. By 0 for $p \leq \lambda$, $Q^{-\lambda}$ should be its λ lag. The autocorrelation test of Arellano–Bond depends on the product as inner $\left(\frac{1}{H}\right)\sum_j \hat{\mathrm{E}}_j^{-\lambda}\,\hat{\mathrm{E}}_j$, which is expected to be 0 under H_0

order-λ autocorrelation. Having the assumption that disturbances are uncorrelated across agents, a theorem of central limit guarantees that the statistic

$$\sqrt{H}\frac{1}{H}\sum_{j} \hat{E}_j^{-\lambda}\,\hat{E}_j = \frac{1}{\sqrt{H}}\hat{E}_j^{-\lambda}\,\hat{E}_j \qquad (2.4.3.1)$$

provides normal distribution as asymptotic. To have propensity to normal distribution, only H should be higher, not P. To calculate, under H_0, the statistic as asymptotic variance, Arellano and Bond begin with derivation of Windmeijer above, obtaining the interest amount from the hypothetical value deviation that it comes close. Specifically, since $Y = B\varrho + E = B\hat{\varrho} + \hat{E}, \hat{E} = E - B\,(\hat{\varrho}_A - \varrho)$.

Replacing into (2.4.3.1) provides

$$\frac{1}{\sqrt{H}}\hat{E}_j^{-\lambda}\,\hat{E}_j = \frac{1}{\sqrt{H}}\left\{E^{-\lambda} - B_j^{-\lambda}(\hat{\varrho}_A - \varrho)\right\}'\{E - B\,(\hat{\varrho}_A - \varrho)\}$$

$$= \frac{1}{\sqrt{H}}E^{-\lambda'}E - \frac{E^{-\lambda'}B}{H}\sqrt{H}\,(\hat{\varrho}_A - \varrho)$$
$$-\sqrt{H}\,(\hat{\varrho}_A - \varrho)'\,\frac{B^{-\lambda'}E}{H}$$
$$+\sqrt{H}\,(\hat{\varrho}_A - \varrho)'\,\frac{1}{H}\frac{B^{-\lambda'}B}{H}\sqrt{H}\,(\hat{\varrho}_A - \varrho) \qquad (2.4.3.2)$$

As $H \rightarrow \infty$, the last two terms drop out. According to Ruud (2000: 546), since $\hat{\varrho}_A$ is a $\sqrt{H}$ - estimate as consistent in ϱ, $\sqrt{H}\,(\hat{\varrho}_A - \varrho)$ has no limits or comes close to zero. At the same time, having the assumption that b is not postdetermined, $\frac{B^{-\lambda'}E}{H}$ comes close to zero, which omits the third term. According to Arellano and Bond (1991), providing consistent motives, having the assumption that $\frac{B^{-\lambda'}B}{H}$ has no limits, the fourth term comes close to zero. If we replace (2.4.3.3)

$$\hat{\varrho}_A - \varrho = (B'SAS'B)^{-1}\, B'SAS'\,(B\varrho + E\,)\; -\; \varrho$$

$$= (B'SAS'B)^{-1}\, B'SAS'B\varrho\; + (B'SAS'B)^{-1}\, B'SAS'E\; -\; \varrho$$

$$= (\mathrm{B'SAS'B})^{-1}\, \mathrm{B'SAS'}E \qquad (2.4.3.3)$$

into the term as second, the formula transforms into

$\left(\frac{1}{\sqrt{H}}\right)\left\{E^{-\lambda'}E\; -\; E^{-\lambda'}B\,(B'SAS'B)^{-1}B'SAS'E\right\}$, in which variance is systematically calculated by

$$\left(\frac{1}{\sqrt{H}}\right)\left\{\hat{\mathrm{E}}^{-\lambda'}\,\widehat{Var}\,\left(\hat{\mathrm{E}}\mid S\right)\hat{\mathrm{E}}^{-\lambda}\; - 2\hat{\mathrm{E}}^{-\lambda'}B\,(B'SAS'B)^{-1}\,B'SAS'\,\widehat{Var}\left(\hat{\mathrm{E}}\mid S\right)\hat{\mathrm{E}}^{-\lambda}\right.$$
$$\left. + \hat{\mathrm{E}}^{-\lambda'}B\,\widehat{Avar}\,(\hat{\varrho}_A)\,B'\hat{\mathrm{E}}^{-\lambda}\right\}$$

This provides the autocorrelation z test of Arellano–Bond for order λ by dividing its value into (2.4.3.1) to regularize it.

2.4.4. A Brief Explanation for the Test of Overidentifying Restrictions

We follow the explanations of Roodman (2009) closely; but we use our own notation. A guide for letters used in notations is presented in Appendix B. The exogeneity of the instruments in GMM is a significant assumption that guarantees the estimation validity. The exactly identified model does not give a possibility to determine the instrument as invalid, since, when $E[s\eta] \neq 0$, the estimator prefers $\hat{\varrho}$, $S'\hat{\mathrm{E}} = 0$. The overidentified model provides the test statistic for the joint validity of the identifying constraints, which leaves out the GMM set up. Under H_0 for joint validity, empirical moments vector $\frac{1}{H}S'\hat{\mathrm{E}}$ comes close to zero in random expression. A Wald test can control this theorem. If it is applied, then the statistic

$$\left(\frac{1}{H}S'\hat{E}\right)' Var\,[s\eta]^{-1}\frac{1}{H}S'\hat{E} \;=\frac{1}{H}\left(S'\hat{E}\right)' A_{EGMM}S'\hat{E} \qquad (2.4.4.1)$$

is χ^2 having the same freedom degrees with the overidentification degree, $i - k$. By replacing an estimate as consistent of A_{EGMM}, it is feasible to get Hansen J test statistic formula for overidentifying constraints according to Hansen (1982). The minimized value of the criterion formula in (2.4.4.2) provides an efficient generalized method of moments (EGMM) estimator as feasible.

$$\| E_H(s\eta) \|_A = \| \frac{1}{H}S'\hat{E} \|_A \equiv H\left(\frac{1}{H}S'\hat{E}\right)' A \left(\frac{1}{H}S'\hat{E}\right) = \frac{1}{H}\hat{E}'SAS'\hat{E} \qquad (2.4.4.2)$$

If Γ has just magnitude and no direction, then $A_{EGMM} = (S'S)^{-1}$. According to Sargan (1958), the Hansen test matches the test of Sargan. However, if there is no sphericity in the disturbances, one-step robust GMM estimation occurs and the statistic of Sargan $\frac{1}{H}\left(S'\hat{E}\right)' (S'S)^{-1} S'\hat{E}$ becomes inconsistent.

We can use the statistics of Sargan/Hansen to check the validity of the subsets of instruments through the Sargan/Hansen difference test, which is also known as C statistic. Under H_0 of joint validity of all the instruments, the result of the difference of test statistics of Sargan/Hansen is χ^2, having the same freedom degrees with the quantity of instruments in suspicion. Unrestricted regression provides fewer moment conditions without the suspect instruments. The C test statistic is appropriate for unrestricted regression that has adequate identified instruments. First, we run $\frac{1}{H}S'\hat{E}$ to converge to zero, and then, we apply the test to converge to zero. If we use this test after GMM, the Sargan/Hansen test has weakness due to growing inadequately to satisfy all the conditions of moment that increase more than the test.

2.4.5. A Brief Explanation for the Regression Equation Specification Error Test (RESET)

We follow the explanations of Baum et al. (2007) closely; but we use our own notation. A guide for the letters in the notations is presented in Appendix B. Polynomials of low-order in $\hat{y}$ should have uncorrelated residues, where the predicted values of the dependent variable are $\hat{y}$s. Under H_0, there are no neglected nonlinearities. The expression of the equation $y = B\varrho + Y\alpha + \sigma$ is calculated through instrumental variable estimation. The dependent variable, *y,* has fitted value, $\hat{y}$ which has powers as Y s. Under H_0, if there are no neglected nonlinearities, α should not be significant. Then, there is no misspecification for the equation. As B has correlated with ψ as endogenous regressors, the standard instrumental variable predicted the values as $\hat{y} \equiv B\hat{\varrho}$ in the regression equation specification error test (RESET) for instrumental variable estimation cannot be used according to Pesaran and Taylor (1999) and Pagan and Hall (1983). They suggest that RESET test should use the functional products of exogenous variables only as "forecast values" of *y.*

The reduced form predicted estimates of y are the forecast estimates $\hat{y}$ as the predicted estimates from a regression of y on the instruments S in the test of Pagan-Hall. The "optimal forecast" estimates are the forecast estimates $\hat{y}$ in the test of Pesaran-Taylor. $\hat{B}\hat{\varrho}$ is the description of the optimal forecast $\hat{y}$. The coefficient of the instrumental variable estimation and $\hat{B} \equiv [S\hat{\Theta}S_2]$ is $\hat{\varrho}$. That is the reduced form predicted estimates of the endogenous regressors plus the exogenous regressors. At the exactly identified equation, the Pesaran-Taylor and Pagan-Hall tests have similar estimates. The third order polynomial has good power to test the functional form misspecification according to Godfrey (1991). In addition, Pesaran and Taylor suggest that C statistic RESET test has reasonable small sample properties with the Pesaran and Smith (1994) optimal forecast estimates.

2.4.6. A Brief Explanation for the Weak Identification Test

We follow the explanations of Mikusheva (2007) closely; but we use our own notation. A guide for the letters used in the notations is presented in Appendix B. We need to make comparison with the first-stage F statistic along the cut-off tables in Stock and Yogo (2005). We have the assumption that there is homoscedastic instrumental variable model with one endogenous variable b_p and several exogenous variables Q_p

$$y_p = \varrho b_p + \alpha Q_p + \psi_p$$

Being one-dimensional as y_p and b_p, there is $EQ_p\psi_p = 0$. The provided data is i.i.d. We assume that S_p is $t\ k \times 1$ as an instrument. Then, specifically, $E\psi_p S_p = 0$. There is the first-stage regression as

$$b_p = S_P\varsigma + \beta Q_p + \omega_p,$$

$\varsigma \neq 0$ is the relevance condition. There can be a weak instrument issue when $\varsigma \approx 0$. The distribution of the first-stage F-statistic as χ^2, as non-central, together with the parameter of non-centrality, is demonstrated by Stock and Yogo (2005). And this distribution is exactly associated with the concentration parameter γ. Consequently, F-statistic of the first-stage can provide the scale of the estimate of γ. In the first stage regression, the statistic for testing $\varsigma = 0$ is the the first stage F-statistic.

$$b_p = S_p\varsigma + \beta Q_p + \omega_p.$$

We get $EF = 1 + \gamma^2/k,$ and thus, we can calculate γ^2/k as $F - 1$. We can compare the calculated γ^2/k with the estimates of Stock, Wright and Yogo (2002). For F-test, the critical values can be lower than the estimates of Stock, Wright and Yogo (2002). Pre-test as $\varsigma = 0$ cannot detect exactly the weak instruments that are more common. However, the rule for determining weak identification is $F < 10$. The mechanism as it is provided above is for one endogenous variable b_p. Cragg and Donald (1993) suggest that if there are more than one endogenous regressor, the estimated F-tests will be the matrix of first-stage. Then, this matrix rank should be tested.

2.4.7. A Brief Explanation for the Endogeneity Test

We follow the explanations of Wooldridge (2012) closely; but we use our own notation. A guide for the letters used in the notations is presented in Appendix B. If the explanatory variables are endogenous, the 2SLS is more efficient than OLS. However, the standard errors of the 2SLS estimates can be higher. For this reason, we have to check endogeneity of the variables to start 2SLS estimates. We have one expected endogenous variable,

$$y_1 = \varrho_0 + \varrho_1 y_2 + \varrho_2 s_1 + \varrho_3 s_2 + \psi_1, \qquad (2.4.7.1)$$

s_1 and s_2 are exogenous. We also have two exogenous variables as s_3 and s_4. However, these are not in the equation (2.4.7.1). To estimate (2.4.7.1) by OLS, y_2 should not have a correlation with ψ_1. Thus, we have a test problem on this correlation. According to Hausman (1978), the exact comparison of the OLS and 2SLS estimates and the identification of the statistical significance of the differences help us decide.

There are consistent estimates for variables if all are exogenous in both OLS and 2SLS estimators. By keeping exogeneity of s_i, if OLS and 2SLS estimates are significantly different from zero, we can accept that there is endogeneity of y_2. Observing the empirical difference between OLS and 2SLS can be useful. Regression test can be useful to decide whether differences are significantly different from zero or not. The reduced form for y_2 is provided as a basis for this case

$$y_2 = \varsigma_0 + \varsigma_1 s_1 + \varsigma_2 s_2 + \varsigma_3 s_3 + \varsigma_4 s_4 + \omega_2. \qquad (2.4.7.2)$$

As s_i has no correlation with ψ_1, y_2 has no correlation with ψ_1, which is only possible when ω_2 is uncorrelated with ψ_1. This is the test framework we consider using. Let $\psi_1 = \beta_1 \omega_2 + e_1$, and e_1 has no correlation with ω_2. e_1 also has zero mean. Thus, ψ_1 and ω_2 have no correlation. This is only possible when $\beta_1 = 0$. Using t test by adding ω_2 in (2.4.7.1) could be a simple way to test what we want. As ω_2 is the disturbance term in (2.4.7.2), we have no observation for it . This is an obstacle to deal with for the implementation of the test. The reduced form for y_2 can be calculated using OLS. Then, we can get the residues of reduced form, $\widehat{\omega_2}$. Hence, we get

$$y_1 = \varrho_0 + \varrho_1 y_2 + \varrho_2 s_1 + \varrho_3 s_2 + \beta_1 \widehat{\omega_2} + disturbance, \qquad (2.4.7.3)$$

by using OLS and test result H_0: $\beta_1 = 0$ to obtain a t statistic. If H_0 is rejected significantly, we determine that y_2 has an endogeneity issue due to the observed correlation between ω_2 and ψ_1.

CHAPTER 3

DATA AND EMPIRICAL SPECIFICATIONS

3.1. Data

We follow the base sample data structure explained and provided in Acemoglu and Johnson (2007: 939, 979-980) for 47 countries from the beginning of the 1940-1980 period due to reliable historical data consideration. Thus, there are 47 countries in our panel data and three periods to investigate the association between economic development and health. These periods are 1940-1980, 1940-2009 and 1980-2009.

We arrange balanced panel data to estimate models. Descriptive statistics for variables are given in Table 3.1. The information regarding each variable is provided below. Each age-specific death rate represents the mean of these age-based death rates for male and female individuals. We utilize exact transformation of Brady et al. (2007: 10) for one-to-five years survival probability estimation.

Log life expectancy at birth is the mean anticipated life for the newborn calculated assuming that the reasons for death which a person encountered first at his/her birth are fixed and these fixed reasons will continue in this fixedness (WHO; The World Bank). Data for 1940 are utilized from Acemoglu and Johnson (2007: 979-980). Data for 1950 are used from United Nations (UN) (2017: 65-70) Table A1, 1950-1955 Column for both genders. Data from 1960 to 2009 are utilized from the World Bank. The panel data cover the period 1940-2009 with 376 observations covering 10-year periods.

Log years of schooling is the average years of total schooling, aged 25-64. This variable is exactly used from Lee and Lee (2016). The panel data include the period 1940-2009 with 376 observations covering 10-year periods.

Log gross domestic product (GDP) per capita is exactly utilized from the Maddison-Project (2013). There are only two exceptions for Bangladesh and Pakistan in the 1940 data. The data for these countries are used from Acemoglu and Johnson (2007). The panel data cover the period 1940-2009 with 376 observations covering a 10-year period. In the Maddison-Project (2013), the values for 2008 are utilized for countries El Salvador, Honduras, Nicaragua, Panama, and Paraguay due to the missing values for 2009 for these countries.

Predicted mortality is exactly utilized from Acemoglu and Johnson (2007). For the 1940 and 1980 data are used from Acemoglu and Johnson (2007). For the 2009 data are determined according to data for the 1980. The panel data cover the period 1940-2009 with 94 observations covering only these two years.

Log age 5-14 survival probability is estimated by using the following formulas: There is age 5-9 survival probability = (1 – (age 5-9 death rate / 1000)); then, age 10-14 survival probability = (1 – (age 10-14 death rate / 1000)); and, the mean log age 5-14 survival probability = (ln (age 5-9 survival probability) + ln (age 10-14 survival probability)) / 2. Data for 1940 and 1980 are utilized from UN Demographic Yearbooks. The data for 2009 are used from the WHO. The panel data cover the period 1940-2009 with 94 observations covering only these two years.

Log mean body mass index (BMI) 18+ years is calculated by utilizing the following formulation: Log mean body mass index (BMI) 18+ years = ln ((male mean body mass index + female mean body mass index) / 2). The unit is kg/m^2 and values are age-standardized estimate. The data from 1980 to 2009 are utilized from the WHO. The panel data cover the period 1980-2009 with 329 observations covering 5-year periods.

Log mean systolic blood pressure (SBP) 25+ years is estimated using the following formula: Log mean systolic blood pressure (SBP) 25+ years = ln ((male mean systolic blood pressure (SBP) + female mean systolic blood pressure (SBP)) / 2). The unit is in mm Hg and data values are age-standardized estimate. The data from 1980 to 2009 are used from the WHO. The panel data cover the period 1980-2009 with 329 observations covering 5-year periods.

Log GDP per person engaged is calculated using the following formulation: Log GDP per person engaged = ln (real GDP at constant national prices (in millions 2011 US $)) / (number of persons engaged (in millions)). The data for the period from 1980 to 2009 are utilized from Feenstra et al. (2015). The panel data cover the period 1980-2009 with 329 observations covering 5-year periods.

Log productivity is estimated by utilizing the following formulation: log productivity = ln ((manufacturing, value added (percent of GDP) × real GDP at constant national prices (in millions 2011 US $)) / (number of persons engaged (in millions)). The data for the period from 1980 to 2009 are used from the World Bank, World Development Reports, Feenstra et al. (2015) and Knoema data (2018). The panel data cover the period 1980-2009 with 329 observations covering 5-year periods.

Gross domestic savings (percent of GDP) are estimated as GDP minus total consumption by the World Bank. The data for the period from 1980 to 2009 are utilized from the World Bank, World Development Reports and Asian Development Bank Reports. The panel data cover the period 1980-2009 with 329 observations covering 5-year periods.

Log crude survival probability is estimated using the following formulation: log crude survival probability = ln (1 – (crude death rate / 1000)). The data for 1980 and 2009 are used from the World Bank. The panel data cover the period 1980-2009 with 94 observations for these two years.

Log one-to-five years survival probability is calculated by utilizing the following formulas: Firstly, infant survival probability = (1 – (infant mortality / 1000)); then, under five survival probability = (1 – (under five mortality / 1000)); finally, log one-to-five years survival probability = ln (infant survival probability – under five survival probability). This transformation is exactly utilized from Brady et al. (2007: 10). The panel data cover the period 1980-2009 with 94 observations for these two years.

Log age 65-69 survival probability is estimated by using the following formulation: log age 65-69 survival probability = ln (1 – (age 65-69 death rate / 1000)). The data for 1940 and 1980 are utilized from UN Demographic Yearbooks. The data for the year 2009 are used from the WHO. The panel data cover the period 1940-1980-2009 with 141 observations for these three years. The data include 94 observations for two years.

Log age 75-79 survival probability is estimated by utilizing the following formula: log age 75-79 survival probability = ln (1 – (age 75-79 death rate / 1000)). The data for 1980 are utilized from the UN Demographic Yearbooks. The data for 2009 are used from the WHO. The panel data cover the period 1980-2009 with 94 observations for these two years.

Log age 80-84 survival probability is calculated by using the following formula: log age 80-84 survival probability = ln (1 – (age 80-84 death rate / 1000)). The data for 1980 are utilized from the UN Demographic Yearbooks. The data for 2009 are used from the WHO. The panel data cover the period 1980-2009 with 94 observations for these two years.

Log measles vaccine coverage percent is measles-containing-vaccine-first-dose (MCV1) immunization coverage among one-year-olds (percent) data which is exactly utilized from the WHO. The panel data cover the period 1980-2009 with 94 observations for these two years.

Table 3.1

Variables, Data and Descriptive Statistics

Variable	Description / Formula	Data Source	Period	N	Mean	Std. Dev.	Minimum	Maximum
log life expectancy at birth	Log life expectancy at birth is mean anticipated life for the newborn calculated assuming that the reasons for death which a person encountered first at his/her birth are fixed and these fixed reasons will continue in this fixedness (WHO, and The World Bank).	Data for 1940 are utilized from Acemoglu and Johnson (2007: 979-980). Data for 1950 are used from United Nations (UN) (2017: 65-70) Table A1 in both sexes 1950-1955 Column. Data from 1960 to 2009 are utilized from the World Bank.	1940-2009	376	4.153809	0.2126264	3.397858	4.407255
log years of schooling	The average years of total schooling, aged 25-64, is exactly utilized from Lee and Lee (2016).	Data from 1940 to 2010 are utilized from Lee and Lee (2016).	1940-2010	376	1.667591	0.6605405	–0.2876821	2.583242
log gross domestic product (GDP) per capita	This variable is exactly used from the Maddison-Project (2013) with only two exceptions for Bangladesh and Pakistan for their 1940 data. These countries' GDP per capita the year 1940 data are utilized from Acemoglu and Johnson (2007).	Data from 1940 to 2009 are used from the Maddison-Project (2013) with only two exceptions for Bangladesh and Pakistan for their 1940 data. These countries' GDP per capita the year 1940 data are utilized from Acemoglu and Johnson (2007).	1940-2009	376	8.432874	1.030355	5.980621	10.30557
predicted mortality	This variable is exactly utilized from Acemoglu and Johnson (2007).	Data for 1940 and 1980 are utilized from Acemoglu and Johnson (2007). Data for 2009 are determined according to 1980 data.	1940-2009	94	0.2362979	0.3083373	0	1.126
log age 5-14 survival probability	* age 5-9 survival probability = (1 – (age 5-9 death rate / 1000)) * age 10-14 survival probability = (1 – (age 10-14 death rate / 1000)) * (mean) log age 5-14 survival probability = (ln (age 5-9 survival probability) + ln (age 10-14 survival probability)) / 2	Data for 1940 and 1980 are used from UN Demographic Yearbooks. Data for 2009 are taken from WHO data.	1940-2009	94	–0.0016647	0.0019134	–0.0075297	–0.0001
log mean body mass index (BMI) 18+ years	= ln ((male mean body mass index + female mean body mass index) / 2) **(The unit is kg/m^2 and age-standardized estimate)	Data from 1980 to 2009 are utilized from WHO.	1980-2009	329	3.188368	0.0825268	2.917771	3.348148
log mean systolic blood pressure pressure (SBP) 25+ years	= ln ((male mean systolic blood pressure + female mean systolic blood pressure) / 2) **(The unit is in mm Hg and age-standardized estimate)	Data from 1980 to 2009 are used from WHO.	1980-2009	329	4.848745	.0304552	4.786241	4.946985
log GDP per person engaged	= ln (real GDP at constant national prices (in millions 2011 US $)) / (number of persons engaged (in millions))	Data from 1980 to 2009 are utilized from Feenstra et al. (2015).	1980-2009	329	10.33784	0.9133531	7.320517	11.98606
log productivity	= ln ((manufacturing, value added (percent of GDP) × real GDP at constant national prices (in millions 2011 US $)) / (number of persons engaged (in millions))	Data from 1980 to 2009 are used from the World Bank, World Development Reports, Feenstra et al. (2015) and https://knoema.com.	1980-2009	329	8.655354	0.9570671	4.794788	10.155

Table 3.1

Variables, Data and Descriptive Statistics (Continued)

Variable	Description / Formula	Data Source	Period	N	Mean	Std. Dev.	Minimum	Maximum
gross domestic savings (percent of GDP)	Gross domestic savings are estimated as GDP minus total consumption by the World Bank.	Data from 1980 to 2009 are utilized from the World Bank, World Development Reports and Asian Development Bank Reports.	1980-2009	329	22.44033	8.743491	−2.439481	50.65072
log crude survival probability	* = ln (1 − (crude death rate / 1000))	Data for 1980 and 2009 are used from the World Bank.	1980-2009	94	−0.0082234	0.0022935	−0.0143282	−0.0045332
log one-to-five years survival probability	* infant survival probability = (1 − (infant mortality / 1000)) * under five survival probability = (1 − (under five mortality / 1000)) * log one-to-five years survival probability = ln (infant survival probability − under five survival probability) This transformation is exactly utilized from Brady et al. (2007: 10).	Data for 1980 and 2009 are utilized from the World Bank.	1980-2009	94	−5.65037	1.308793	−7.600975	−2.733368
log age 65-69 survival probability	* log age 65-69 survival probability = ln (1 − (age 65-69 death rate / 1000))	Data for 1940 and 1980 are used from UN Demographic Yearbooks. Data for 2009 are used from WHO.	1940-2009	94	−0.0313982	0.0177761	−0.1041391	−0.0110609
log age 75-79 survival probability	* log age 75-79 survival probability = ln (1 − (age 75-79 death rate / 1000))	Data for 1980 are utilized from UN Demographic Yearbooks. Data for 2009 are utilized from WHO.	1980-2009	94	−0.0625243	0.0248765	−0.1687146	−0.0314907
log age 80-84 survival probability	* log age 80-84 survival probability = ln (1 − (age 80-84 death rate / 1000))	Data for 1980 are used from UN Demographic Yearbooks. Data for 2009 are used from WHO.	1980-2009	94	−0.1066114	0.0475629	−0.380675	−0.034695
log measles vaccine coverage percent	Measles-containing-vaccine-first-dose (MCV1) immunization coverage among one-year-olds (percent) is exactly utilized from the WHO data.	Data for 1980 and 2009 are utilized from WHO.	1980-2009	94	3.858404	1.112616	0	4.59512

3.2. Empirical Specifications

For LE, by obtaining Equation (2.3.8) and following quadratic and cubic empirical specifications in Desbordes (2011), Hansen (2012) and Husain et al. (2014) respectively, we specify the following reduced form association between GDP per capita and LE:

$$\log \text{GDP}_{it} = \alpha_0 + \alpha_1 \log \text{LE}_{it} + \alpha_2 (\log \text{LE}_{it})^2 + \alpha_3 (\log \text{LE}_{it})^3 + \lambda_i + \eta_t + \omega_{it}, \quad (3.2.1)$$

where log indicates the natural logarithm, GDP is GDP per capita, and LE is life expectancy, λ and η are country and time specific effects, and ω is the disturbance term. Following Hansen (2012), the Model (3.2.1) is estimated by including a one-period lagged value of "log GDP" on the right-hand side as an additional regressor. This formulation allows for dynamic effects as well as endogeneity issues. We estimate this association by GMM as it is proposed by Arellano and Bond (1991) and performed by Hansen (2012).

According to the Equations obtained from (2.3.9) to (2.3.12) and the suggestion made by Hansen (2012), a shape of nonlinearity should be added in the health-related empirical model. Reduced form associations between the years of schooling and LE, GDP per person engaged and LE, productivity and LE, and gross domestic savings and LE are specified in the Model (3.2.2), the Model (3.2.3), the Model (3.2.4), and the Model (3.2.5) respectively:

$$\log \text{years of schooling}_{it} = \alpha_0 + \alpha_1 \log \text{LE}_{it} + \alpha_2 (\log \text{LE}_{it})^2 + \alpha_3 (\log \text{LE}_{it})^3 + \lambda_i + \eta_t + \omega_{it}, \quad (3.2.2)$$

$$\log \text{GDP per person engaged}_{it} = \alpha_0 + \alpha_1 \log \text{LE}_{it} + \alpha_2 (\log \text{LE}_{it})^2 + \alpha_3 (\log \text{LE}_{it})^3 + \lambda_i + \eta_t + \omega_{it}, \quad (3.2.3)$$

log manufacturing value added per person engaged $_{it}$ = α_0 + α_1 log LE_{it} + α_2 (log LE_{it})^2 + α_3 (log LE_{it})^3 + λ_i + η_t + ω_{it} , (3.2.4)

gross domestic savings $_{it}$ = α_0 + α_1 log LE_{it} + α_2 (log LE_{it})^2 + α_3 (log LE_{it})^3 + λ_i + η_t + ω_{it} , (3.2.5)

where Model (3.2.1) notation and estimation methods are followed in Model (3.2.2), Model (3.2.3), Model (3.2.4), and Model (3.2.5) closely.

Finally, three periods are used for the estimations of the relations between GDP per capita and LE, and years of schooling (human capital) and LE. These periods are 1940-1980, 1940-2009 and 1980-2009. In the estimation of the associations between GDP per person engaged, manufacturing value added per person engaged (productivity), gross domestic savings and LE, only the 1980-2009 period is used due to data limitations. For the estimations in Model (3.2.1), (3.2.2), (3.2.3), (3.2.4), and (3.2.5) and all FE estimations, time and country dummies are included to account for the relevant effects. In Model (3.2.1), we use the period 1940-1980 to replicate the results obtained by Desbordes (2011) and Hansen (2012).

The results obtained by Desbordes (2011) are replicated precisely by applying long-difference estimation using two-time points for the years 1940 and 1980. In addition, in Model (3.2.1), the results by Hansen (2012) are replicated qualitatively using the 47 countries (rather than the 119 countries) for the panel data for the 1940-1980 period. Next, we update the period beyond 1980 and use the period 1940-2009. Finally, the entire analysis is repeated for the 1980-2009 period. Long-difference analysis used by Desbordes (2011) is applied in the Model (3.2.2).

For BMI, by obtaining Equation (2.3.13) and following the quadratic and cubic empirical specifications in Desbordes (2011), Hansen (2012) and Husain et al. (2014) respectively, we specify the following reduced form association between GDP per capita and BMI:

$$\log \text{GDP}_{it} = \alpha_0 + \alpha_1 \log \text{BMI}_{it} + \alpha_2 (\log \text{BMI}_{it})^2 + \alpha_3 (\log \text{LE}_{it})^3 + \lambda_i + \eta_t + \omega_{it} , \quad (3.2.6)$$

where log indicates the natural logarithm, GDP is GDP per capita, and BMI is body mass index that has unit of kilogram/square meter (kg/m^2), λ and η are country and time specific effects, and ω is the disturbance term. Following Hansen (2012), Model (3.2.6) is estimated by including one or two periods lagged value of "log GDP" on the right-hand side as an additional regressor. This formulation allows for dynamic effects as well as endogeneity issues. We estimate this association by GMM as it is proposed by Arellano and Bond (1991) and performed by Hansen (2012).

According to the Equations obtained from (2.3.14) to (2.3.17) and the suggestion made by Hansen (2012), a shape of nonlinearity should be added in the health-related empirical model. Reduced form associations between human capital and BMI, GDP per person engaged and BMI, productivity and BMI, and gross domestic savings and BMI are specified in Model (3.2.7), Model (3.2.8), Model (3.2.9), and Model (3.2.10) respectively:

$$\log \text{years of schooling}_{it} = \alpha_0 + \alpha_1 \log \text{BMI}_{it} + \alpha_2 (\log \text{BMI}_{it})^2 + \alpha_3 (\log \text{BMI}_{it})^3 + \lambda_i + \eta_t + \omega_{it} , \quad (3.2.7)$$

$$\log \text{GDP per person engaged}_{it} = \alpha_0 + \alpha_1 \log \text{BMI}_{it} + \alpha_2 (\log \text{BMI}_{it})^2 + \alpha_3 (\log \text{BMI}_{it})^3 + \lambda_i + \eta_t + \omega_{it} , \quad (3.2.8)$$

$$\log \text{manufacturing value added per person engaged}_{it} = \alpha_0 + \alpha_1 \log \text{BMI}_{it} + \alpha_2 (\log \text{BMI}_{it})^2 + \alpha_3 (\log \text{BMI}_{it})^3 + \lambda_i + \eta_t + \omega_{it} , \quad (3.2.9)$$

$$\text{gross domestic savings}_{it} = \alpha_0 + \alpha_1 \log \text{BMI}_{it} + \alpha_2 (\log \text{BMI}_{it})^2 + \alpha_3 (\log \text{BMI}_{it})^3 + \lambda_i + \eta_t + \omega_{it} , \quad (3.2.10)$$

where Model (3.2.6) notation and estimation methods are followed in Model (3.2.7), Model (3.2.8), Model (3.2.9), and Model (3.2.10) closely.

Lastly, in the estimation of the associations between GDP per capita, human capital, GDP per person engaged, productivity, gross domestic savings, and BMI, only the 1980-2009 period is used due to data limitations. For the estimations in Model (3.2.6), (3.2.7), (3.2.8), (3.2.9), and (3.2.10) and all FE estimations, time and country dummies are included to account for the relevant effects.

For SBP, by obtaining Equation (2.3.18) and following the quadratic and cubic empirical specifications in Desbordes (2011), Hansen (2012) and Husain et al. (2014) respectively, we specify the following reduced form association between GDP per capita and SBP:

$$\log \text{GDP}_{it} = \alpha_0 + \alpha_1 \log \text{SBP}_{it} + \alpha_2 (\log \text{SBP}_{it})^2 + \alpha_3 (\log \text{LE}_{it})^3 + \lambda_i + \eta_t + \omega_{it} , \tag{3.2.11}$$

where log indicates the natural logarithm, GDP is GDP per capita, and SBP is body mass index that has the unit of the millimeter of mercury (mm Hg), λ and η are the country and time specific effects, and ω is the disturbance term. Following Hansen (2012), Model (3.2.11) is estimated by including one or two periods lagged value of "log GDP" on the right-hand side as an additional regressor. This formulation allows for dynamic effects as well as endogeneity issues. We estimate this association by GMM as it is proposed by Arellano and Bond (1991) and performed by Hansen (2012).

According to the Equations obtained from (2.3.19) to (2.3.22) and the suggestion made by Hansen (2012), a shape of nonlinearity should be added in the health-related empirical model. Reduced form associations between human capital and SBP, GDP per person engaged and SBP, productivity and SBP, and gross domestic savings and

SBP are specified in Model (3.2.12), Model (3.2.13), Model (3.2.14), and Model (3.2.15) respectively:

log years of schooling $_{it} = \alpha_0 + \alpha_1 \log \text{SBP}_{it} + \alpha_2 (\log \text{SBP}_{it})^2 + \alpha_3 (\log \text{SBP}_{it})^3 + \lambda_i + \eta_t + \omega_{it}$, (3.2.12)

log GDP per person engaged $_{it} = \alpha_0 + \alpha_1 \log \text{SBP}_{it} + \alpha_2 (\log \text{SBP}_{it})^2 + \alpha_3 (\log \text{SBP}_{it})^3 + \lambda_i + \eta_t + \omega_{it}$, (3.2.13)

log manufacturing value added per person engaged $_{it} = \alpha_0 + \alpha_1 \log \text{SBP}_{it} + \alpha_2 (\log \text{SBP}_{it})^2 + \alpha_3 (\log \text{SBP}_{it})^3 + \lambda_i + \eta_t + \omega_{it}$, (3.2.14)

gross domestic savings $_{it} = \alpha_0 + \alpha_1 \log \text{SBP}_{it} + \alpha_2 (\log \text{SBP}_{it})^2 + \alpha_3 (\log \text{SBP}_{it})^3 + \lambda_i + \eta_t + \omega_{it}$, (3.2.15)

where Model (3.2.11) notation and estimation methods are followed in Model (3.2.12), Model (3.2.13), Model (3.2.14), and Model (3.2.15) closely.

In sum, in the estimation of the associations between GDP per capita, human capital, GDP per person engaged, productivity, gross domestic savings and SBP, only the 1980-2009 period is used due to data limitations. For the estimations in Models (3.2.11), (3.2.12), (3.2.13), (3.2.14), and (3.2.15) and all FE estimations, time and country dummies are included to account for the relevant effects.

CHAPTER 4

THE IMPACT OF LIFE EXPECTANCY ON ECONOMIC DEVELOPMENT, HUMAN CAPITAL, GROSS DOMESTIC PRODUCT (GDP) PER PERSON ENGAGED, PRODUCTIVITY AND GROSS DOMESTIC SAVINGS

4.1. Introduction

The association between GDP per capita and life expectancy (LE) has been investigated widely. Also, we examine the effects of LE on GDP per capita by utilizing our identified empirical specifications in Chapter 3 derived from Azomahou et al.'s (2009) study. We use balanced panel data for three periods from 47 countries. In quadratic specification, our findings support the non-linear and non-monotonic association between GDP per capita and LE. Put differently, we find a U-shaped association for the 1940-1980 and 1940-2009 periods and an inverted U-shaped association for the 1980-2009 period. These results confirm the findings of Desbordes (2011) and Hansen (2012) in that the link between GDP per capita and LE may vary during the process of development. At this point, Hansen suggests that a shape of non-linearity for health should be added to the empirical investigations for a specified period.

From this perspective, depending on our empirical specifications in Chapter 3, the effect of life expectancy on years of schooling is also investigated for 1940-1980, 1940-2009, and 1980-2009 periods. We find that years of schooling (human capital) and LE linkage has an inverse U-shape during all these periods. In addition, we study the connection between GDP per person engaged, manufacturing value added per person engaged (productivity), gross domestic savings, and LE only for the 1980-2009 period due to data limitations by utilizing our empirical specifications given in

Chapter 3. For the 1980-2009 period, it is found that association between all these dependent variables and LE has an inverse U-shape.

In cubic specification, we find that the association between GDP per capita and LE follows first concave-, and then, convex-shape for the 1940-1980 period. For human capital, this association is first convex-, and then, concave-shaped for the same period. And this result is valid for the period 1940-2009, between GDP per capita and LE, and human capital and LE associations. For the 1980-2009 period, the association between GDP per capita and LE is first convex-, and then concave-shaped. This result is also valid for the association between human capital and LE, GDP per person engaged and LE, productivity and LE for the same period. For the association between gross domestic savings and LE, we find that the coefficients of the linear, quadratic, and cubic terms are insignificant. As a conclusion, our empirical results yield significant proof that securing human physiological health functions perpetuates economic development through enough savings.

4.2. Literature Review

Bloom et al. (2004) find that vigor and LE have a remarkable and positive effect on economic development. One-year improvement in LE leads to a four-percent increase in GDP per capita outcome. According to Bloom et al., (2004) this effect is quite large, which demonstrates the positive direct effects of health on labor productivity. Acemoglu and Johnson (2007) suggest that LE has a negative causal linear impact on economic growth rate because of its positive effect on population growth rate. For this reason, there is no proof that increasing life expectancy provides rapid economic growth. Also, Acemoglu and Johnson point to the significant negative effect of poor well-being status on economic growth rate due to the decreased labor productivity of individuals.

Cervellati and Sunde (2009) indicate that the effect of life expectancy on GDP per capita is roughly linear. This effect could be negative or positive depending on whether the countries in the sample are experiencing demographic transition or not. According to Cervellati and Sunde, the effect is strongly positive if the countries complete their demographic transition process, and negative if not. As put forward by Kelley and Schmidt (1995), population growth rate holds both some advantages and disadvantages for economic growth rate, and population growth has different effects in the short and the long terms on economic growth. Faruqee and Mühleisen (1997) explain that the age structure of the population has an important impact on aggregate savings by varying age-earnings and consumption/saving propensities. They demonstrate that there is a hump-shaped association between relative earnings and longevity.

Using human capital as the single driving force of growth, Kalemli-Ozcan et al. (2000) found that there is a non-monotonic and non-linear association between economic development and LE. Boucekkine et al. (2002; 2003; 2004) reveal the same result together with Boucekkine et al. (2007). Kalemli-Ozcan et al. (2000) also showed that low mortality rates affect schooling and consumption significantly.

Boucekkine et al. (2002) find that a positive change in survival probabilities leads to longer schooling and later retirement. Low levels of LE have a positive effect on GDP per capita. However, it turns negative after some thresholds. There is growth enhancing population growth that has an adequate mass of human capital. The main finding of Boucekkine et al. (2003) indicates that the observed shift in adult mortality rate is the fundamental effect on modern economic development. Boucekkine et al. (2004) follow an analytical approach to explore the linear and quasi-linear models for studying the association between demographic and economic variables. For instance, they examined the non-linear and non-monotonic link between growth and LE in 2002. Boucekkine et al. (2007) explain that population density affects economic growth by increasing literacy through opening more schools.

Azomahou et al. (2009) explain that economic growth increases with LE. However, this association is convex at lower LE levels, and concave at adequately higher LE levels according to their empirical results and theoretical model. They demonstrate that age-dependent survival laws yield this empirical result for the period 1820-2005. There is a simple mechanism behind this finding. When LE decreases greatly, economic growth rate also decreases. LE has either a positive or negative impact on economic growth rate as it increases or decreases the saving rates depending on the health status of individuals. If LE is sufficiently higher, economic growth is softened due to the significantly lower saving rates of the elderly.

In other empirical studies, Desbordes (2011) provides empirical evidence and theoretical reasoning that the association between GDP per capita and life expectancy is, in fact, non-linear and non-monotonic during the 1940-1980 period. He argues that this link is conditional on the initial level of life expectancy in each country. This U-shaped non-linearity is very significant because there is evidence that the increase in LE beyond the estimated threshold improves economic growth. The subsequent study by Hansen (2012) reinforces that the association under consideration is, in fact, non-linear and U-shaped during the 1940-1980 period. A 1% increment in LE is related with −0.2% decrease in economic growth before the estimated threshold. After the threshold value, it is associated with 0.4% rise in wealth.

Kunze (2014) explains that economic growth and LE association is determined by the balanced effects of various channels. LE increases physical capital accumulation by increasing the saving rates. When old-age consumption gets more significant, it decreases the investments in the schooling of children. It lowers physical capital accumulation by decreasing the amount of the bequests that parents give to their children. Public schooling expenditures are affected by LE through politically determined income tax rate. Tax rates increase with increasing LE; but they are always below their growth-enhancing levels. Thus, with operative bequests, LE lowers economic growth by decreasing private savings. With inoperative bequests, LE increases economic growth if public education spending amount reduces the private schooling investments.

Husain et al. (2014) analyze the effect of LE on GDP per capita in the model that is specified by the cubic transformation for the 1980-2009 period. They find an N-shaped, non-linear and non-monotonic association between GDP per capita and LE. However, when they introduce reverse causality into their cubic specification model, their results suggest that the shape of the association may be inverse U-shaped. Husain et al. emphasizes the Neo-liberal model by saying that the endogenous growth model cannot sustain investment on health in a way to provide ongoing marginal benefits. The Neo-liberal model is valid as returns to investment in LE will be lower as economic growth occurs. However, there is a need to examine other health dimensions before reaching a decision that investment in health cannot maintain economic growth.

4.3. Estimation Results for Economic Growth

4.3.1. Diagnostics for the 1940-1980 Period

For GMM estimations in Columns (5) and (6) of Table 4.1a, and in Column (3) of Table 4.1b, Arellano-Bond AR (1) test rejects H_0 at 10% or higher significance level, but AR (2) test does not. These results satisfy the Arellano-Bond estimation assumptions in Chapter 2. Furthermore, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, which means that the instrument set is valid.

Table 4.1a

The Association between per Capita GDP and Life Expectancy for the 1940-1980 Period by Linear and Quadratic Estimations

	log GDP					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log GDP	-	-	-	-	0.69***	0.12
					(0.24)	(0.10)
log life expectancy at birth	3.34***	−42.65***	−0.56**	−14.67***	0.13	−18.70**
	(0.22)	(5.40)	(0.25)	(2.85)	(0.44)	(7.40)
(log life expectancy at birth)²	-	5.83***	-	1.90***	-	2.37**
		(0.68)		(0.39)		(0.96)
Number of observations	235	235	235	235	141	141
Number of countries	47	47	47	47	47	47
R-squared	0.62	0.74	0.81	0.84	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.07	0.04
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.77	0.51
Hansen test *p*-value	-	-	-	-	0.23	0.19
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	38.90	-	47.88	-	51.49

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per ten years and per country. GDP is GDP per capita. The dependent variable is the log GDP per capita. Columns (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), (4), and (6) columns is 46.09.

In Table 4.2a, 4.2b, 4.2c, and 4.2d, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level, which indicates that in Table 4.2a, 4.2b, 4.2c, and 4.2d, there is no functional form misspecification.

Table 4.1b

The Association between per Capita GDP and Life Expectancy for the 1940-1980 Period by Cubic Estimations

	log GDP		
	(1)	(2)	(3)
	OLS	FE (within)	GMM (Arellano-Bond)
lagged log GDP	-	-	0.03
			(0.10)
log life expectancy at birth	267.15**	157.33***	394.13***
	(108.76)	(55.35)	(128.46)
(log life expectancy at birth)²	−73.79***	−42.88***	−102.77***
	(27.82)	(14.40)	(32.84)
(log life expectancy at birth)³	6.80***	3.88***	8.93***
	(2.37)	(1.25)	(2.80)
Number of observations	235	235	141
Number of countries	47	47	47
R-squared	0.75	0.85	-
F test *p*-value	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	0.06
Arellano-Bond test for AR (2) *p*-value	-	-	0.41
Hansen test *p*-value	-	-	0.28
Country dummies	-	yes	-
Time dummies	-	yes	yes
Turning points (1)	d.l.z.	32.61	41.47
(2)	-	48.15	52.04

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per ten years and per country. GDP is GDP per capita. The dependent variable is the log GDP per capita. Columns (3) is difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. "d.l.z." means that "the discriminant is less than zero."

The instrumental variables are predicted mortality, age 5-14, and age 65-69 survival probabilities. All these instruments and their squared values are valid instruments according to the weak identification test statistic by excluding Columns (2), (3), (4), and (7) in Table 4.2b and 4.2d, and Column (6) in Table 4.2d which satisfy the rule of thumb that F statistics of the first stage should be over ten (Staiger and

Stock,1997). Although Stock and Yogo (2005) critical values are not available for Columns (2) and (3) in Table 4.2b and 4.2d, this problem is solved by applying this rule of thumb.

Table 4.2a

Exact Replication of Desbordes (2011) Long-Difference Estimations for the Association between per Capita GDP and Life Expectancy for the 1940-1980 Period by Linear and Quadratic Estimations

	log GDP							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (age 5-14 survival probability)	IV (age 5-14 survival probability)	IV (both instruments)	IV (both instruments)
log life expectancy at birth	−0.81***	−21.13***	−1.32***	−18.10**	−0.47	−23.15***	−0.94***	−21.84***
	(0.26)	(3.43)	(0.35)	(7.30)	(0.40)	(5.17)	(0.27)	(4.30)
(log life expectancy at birth)^2	-	2.76***	-	2.31**	-	3.02***	-	2.83***
		(0.47)		(0.99)		(0.71)		(0.58)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.14	0.51	0.08	0.49	0.11	0.50	0.13	0.50
F test *p*-value	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00
Weak identification test statistic	-	-	47.32	11.92	38.85	22.62	84.41	24.97
Endogeneity test *p*-value	-	-	0.11	0.33	0.34	0.84	0.57	0.41
Hansen J statistic	-	-	e.e.i.	e.e.i.	e.e.i.	e.e.i.	0.09	0.76
C (2nd polynomial) RESET test *p*-value	0.34	0.60	0.09	0.89	0.88	0.51	0.09	0.98
C (3rd polynomial) RESET test *p*-value	0.33	0.52	0.20	0.74	0.51	0.37	0.22	0.97
Turning points	-	46.29	-	49.91	-	46.25	-	47.38

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940 and 1980. GDP is GDP per capita. The dependent variable is the log GDP per capita. In Column (3) predicted mortality, and in Column (4) predicted mortality and its squared value are used as the instrumental variables in Desbordes (2011). In Column (5) log age 5-14 survival probability, and in Column (6) log age 5-14 survival probability, and its squared value are used as instrumental variables which are not used in Desbordes (2011). In Column (7) predicted mortality, and log age 5-14 survival probability, and in Column (8) predicted mortality, and log age 5-14 survival probability, and their squared values are used as instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), and (5), Stock-Yogo weak ID test critical value is 16.38. In (4), and (6), Stock-Yogo weak ID test critical value is 7.03. In (7), Stock-Yogo weak ID test critical value is 19.93. In (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), (4), (6), and (8) columns is 47.46.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level with the exception of Column (7) in Table 4.2a which fails to be rejected at 5% or higher significance level. This means that the instruments are appropriate at given significance level. The endogeneity test of LE fails to be rejected in Table 4.2a, 4.2b, 4.2c, and 4.2d at 10% or higher significance level. Thus, the OLS gives the consistent and relatively more efficient estimates.

Table 4.2b

Long-Difference Estimations for the Association between per Capita GDP and Life Expectancy for the 1940-1980 Period Using GDP per Capita, Life Expectancy at Birth and Predicted Mortality Data in Acemoglu and Johnson (2007) by Linear, Quadratic and Cubic Estimations

	log GDP						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	IV (predicted mortality)	IV (age 5-14 survival probability)	IV (both instruments)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)
log life expectancy at birth	151.04*	14.34	(omitted)	− 166.73	−0.94***	−20.04***	202.03
	(76.13)	(597.17)		(710.06)	(0.27)	(4.40)	(242.69)
(log life expectancy at birth)²	−41.94**	−6.11	− 2.87***	40.44	-	2.59***	−54.87
	(19.67)	(155.25)	(0.51)	(183.92)		(0.59)	(63.03)
(log life expectancy at birth)³	3.87**	0.73	0.50***	−3.26	-	-	4.95
	(1.69)	(13.46)	(0.10)	(15.88)			(5.46)
Number of observations	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47
R-squared	0.55	0.51	0.52	0.38	0.13	0.50	0.54
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	0.09	0.00	0.05	55.92	20.14	0.39
Endogeneity test *p*-value	-	0.63	0.93	0.75	0.64	0.40	0.63
Hansen J statistic	-	e.e.i.	e.e.i.	0.93	0.18	0.41	0.25
C (2nd polynomial) RESET test *p*-value	-	-	-	-	0.11	0.46	-
C (3rd polynomial) RESET test *p*-value	0.15	0.33	n.r.	n.r.	0.28	0.73	n.r.
C (4rd polynomial) RESET test *p*-value	0.21	0.40	n.r.	n.r.	-	-	n.r.
Turning points (1)	29.60	-	-	-	-	-	-
(2)	46.69	-	45.93	-	-	47.91	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940 and 1980. GDP is GDP per capita. The dependent variable is the log GDP per capita. In Column (2) predicted mortality, its squared, and cubed values are used as the instrumental variables. In Column (3) log age 5-14 survival probability, its squared, and cubed values are used as the instrumental variables. In Column (4) predicted mortality, and log age 5-14 survival probability, and their squared, and cubed values are used as instrumental variables in estimations. In Column (5) predicted mortality, log age 5-14, and log age 65-69 survival probabilities are used as the instrumental variables in estimations. In Column (6) predicted mortality, log age 5-14, and log age 65-69 survival probabilities, and their squared values are used as the instrumental variables in estimations. In Column (7) predicted mortality, log age 5-14, and log age 65-69 survival probabilities, and their squared, and cubed values are used as the instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means that "not reported" by the test. In (2), and (3), Stock-Yogo weak ID test critical values are not available. In (4), Stock-Yogo weak ID test critical value is 12.20. In (5), Stock-Yogo weak ID test critical value is 13.91. In (6), Stock-Yogo weak ID test critical value is 15.72. In (7), Stock-Yogo weak ID test critical value is 16.10. Turning point is estimated for coefficients at 10% or better significance level in a Column.

4.3.2. Estimation Results for the 1940-1980 Period

In linear specification for the 1940-1980 period, Columns (1), (3) and (5) in Table 1b, Columns (1), (3), (5), and (7) in Table 4.2a and Table 4.2c, and Column (5) in Table 4.2b and Table 4.2d report the estimation results of the Model (3.2.1). In linear specification, in the Model (3.2.1), α_2 and α_3 are restricted to be zero. We find that the coefficient of ln LE is negative at 5% or higher significance level in Columns (3) in Table 4.1a, Columns (1), (3), and (7) in Table 4.2a and Table 4.2c, and Column (5) in Table 4.2b and 4.2d. In addition, we find that the coefficient of ln LE is positive at 1% significance level in Column (1) in Table 4.1a. Also, the coefficient of ln LE is found insignificant in Column (5) in Table 4.1a, Table 4.2a, and Table 4.2c.

For comparison, in Desbordes (2011), this coefficient is negative at 1% level of significance. In Hansen (2012), this coefficient is not significantly different from "0". Hence, our linear functional specification estimation results are consistent with the same specification results of Desbordes and Hansen for the 1940-1980 period.

Table 4.2c

Long-Difference Estimations for the Association between per Capita GDP and Life Expectancy for the 1940-1980 Period by Linear and Quadratic Estimations

	log GDP							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (age 5-14 survival probability)	IV (age 5-14 survival probability)	IV (both instruments)	IV (both instruments)
log life expectancy at birth	−0.84***	−21.00***	−1.12***	−15.17**	−0.36	−23.75***	−0.81***	−20.98***
	(0.27)	(3.75)	(0.38)	(7.69)	(0.39)	(6.24)	(0.29)	(4.76)
(log life expectancy at birth)²	-	2.74***	-	1.93*	-	3.11***	-	2.72***
		(0.51)		(1.04)		(0.85)		(0.65)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.14	0.44	0.13	0.42	0.10	0.44	0.14	0.44
F test *p*-value	0.00	0.00	0.01	0.01	0.37	0.00	0.01	0.00
Weak identification test statistic	-	-	48.41	11.49	38.91	21.70	84.51	22.82
Endogeneity test *p*-value	-	-	0.39	0.46	0.19	0.84	0.81	0.74
Hansen J statistic	-	-	e.e.i.	e.e.i	e.e.i.	e.e.i.	0.13	0.63
C (2nd polynomial) RESET test *p*-value	0.07	0.67	0.19	0.83	0.69	0.47	0.15	0.86
C (3rd polynomial) RESET test *p*-value	0.12	0.47	0.41	0.97	0.61	0.66	0.33	0.93
Turning points	-	46.34	-	50.87	-	45.47	-	47.04

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940 and 1980. GDP is GDP per capita. The dependent variable is the log GDP per capita. In Column (3) predicted mortality, and in Column (4) predicted mortality and its squared value are used as the instrumental variables Desbordes (2011). In Column (5) log age 5-14 survival probability, and in Column (6) log age 5-14 survival probability, and its squared value are used as instrumental variables which are not used in Desbordes (2011). In Column (7) predicted mortality, and log age 5-14 survival probability, and in Column (8) predicted mortality, and log age 5-14 survival probability, and their squared values are used as instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), and (5), Stock-Yogo weak ID test critical value is 16.38. In (4), and (6), Stock-Yogo weak ID test critical value is 7.03. In (7), Stock-Yogo weak ID test critical value is 19.93. In (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), (4), (6), and (8) Columns is 47.43.

In quadratic specification for the 1940-1980 period, Columns (2), (4), and (6) in Table 4.1a, Columns (2), (4), (6), and (8) in Table 4.2a and in Table 4.2c, Column (6) in Table 4.2b and Table 4.2d report the estimation results of the Model (3.2.1). In quadratic specification, in the Model (3.2.1), α_3 is restricted to zero. We find that the coefficients of the linear and the quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are negative and positive, respectively. These results are similar to the findings of Desbordes (2011) and Hansen (2012) in quadratic functional specification estimations for the 1940-1980 period. Both coefficients of the linear and quadratic terms are found negative and positive at 5% or higher significance level, respectively.

Our estimated turning points are within the range of 38.90-51.49 years in Columns (2), (4), and (6) in Table 4.1a, Columns (2), (4), (6), and (8) in Table 4.2a and Table 4.2c, Column (6) in Table 4.2b and Table 4.2d. Turning points of Desbordes and Hansen results are within the range of 43.23-49.91 years for the 1940-1980 period. Thus, our quadratic functional specification estimation results suggest that there is non-monotonic and a U-shaped association between per capita GDP and LE for the

1940-1980 period. This suggestion is consistent with the findings of Desbordes and Hansen.

Table 4.2d

Long-Difference Estimations for the Association between per Capita GDP and Life Expectancy for the 1940-1980 Period by Linear, Quadratic and Cubic Estimations

	log GDP						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	IV (predicted mortality)	IV (age 5-14 survival probability)	IV (both instruments)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)
log life expectancy at birth	116.90	−173.30	(omitted)	−246.60	−0.79***	−18.17***	156.07
	(94.63)	(786.54)		(807.30)	(0.28)	(5.03)	(324.01)
(log life expectancy at birth)^2	−33.10	43.04	− 2.85***	61.35	-	2.35***	−42.76
	(24.50)	(204.74)	(0.63)	(209.39)		(0.68)	(84.34)
(log life expectancy at birth)^3	3.10	−3.56	0.50***	−5.08	-	-	3.89
	(2.11)	(17.77)	(0.12)	(18.10)			(7.32)
Number of observations	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47
R-squared	0.47	0.31	0.45	0.29	0.14	0.44	0.46
F test *p*-value	0.00	0.01	0.00	0.00	0.01	0.00	0.00
Weak identification test statistic	-	0.10	0.00	0.05	55.38	15.66	0.41
Endogeneity test *p*-value	-	0.75	0.83	0.97	0.56	0.91	0.67
Hansen J statistic	-	e.e.i.	e.e.i.	0.86	0.23	0.39	0.25
C (2nd polynomial) RESET test *p*-value	-	-	-	-	0.18	0.23	-
C (3rd polynomial) RESET test *p*-value	0.12	0.75	n.r.	n.r.	0.40	0.39	n.r.
C (4rd polynomial) RESET test *p*-value	0.21	0.73	n.r.	n.r.	-	-	n.r.
Turning points (1)	-	-	-	-	-	-	-
(2)	-	-	44.88	-	-	47.65	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940 and 1980. GDP is GDP per capita. The dependent variable is the log GDP per capita. In Column (2) predicted mortality, its squared, and cubed values are used as the instrumental variables. In Column (3) log age 5-14 survival probability, its squared, and cubed values are used as the instrumental variables. In Column (4) predicted mortality, and log age 5-14 survival probability, and their squared, and cubed values are used as the instrumental variables in estimations. In Column (5) predicted mortality, log age 5-14, and log age 65-69 survival probabilities are used as the instrumental variables in estimations. In Column (6) predicted mortality, log age 5-14, and log age 65-69 survival probabilities, and their squared values are used as the instrumental variables in estimations. In Column (7) predicted mortality, log age 5-14, and log age 65-69 survival probabilities, and their squared, and cubed values are used as the instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means that "not reported" by the test. In (2), and (3), Stock-Yogo weak ID test critical values are not available. In (4), Stock-Yogo weak ID test critical value is 12.20. In (5), Stock-Yogo weak ID test critical value is 13.91. In (6), Stock-Yogo weak ID test critical value is 15.72. In (7), Stock-Yogo weak ID test critical value is 16.10. Turning point is estimated for coefficients at 10% or better significance level in a Column.

In cubic specification for the 1940-1980 period, Columns (1), (2), and (3) in Table 4.1b, and Columns (1), (2), (3), (4), and (7) in Table 4.2b and Table 4.2d report the estimation results of the Model (3.2.1). We find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 10% or higher significance level, and they are positive, negative, and positive respectively in Columns (1), (2), and (3) in Table 4.1b, and Columns (1) in Table 4.2b. In addition, we find that the coefficient of the linear term is omitted, but the coefficients of the quadratic and cubic terms are significantly different from "0" at 1% significance level, and they are negative and positive respectively in Column (3) in Table 4.2b and Table 4.2d. Also, we find that the coefficients of the linear, quadratic, and cubic terms are insignificant in Columns (2), (4), and (7) in Table 4.2b, and in Columns (1), (2), (4), and (7) in Table 4.2d.

Estimated turning point-1s[3] are within the range of 29.60-41.47 years; and turning point-2s are within the range of 46.69-52.04 years in Columns (1), (2), and (3) in Table 4.1b, and Columns (1) in Table 4.2b. Hence, our cubic functional specification estimation results suggest that there is first a concave-, and then a convex-shaped association between per capita GDP and LE for the 1940-1980 period.

4.3.3. Diagnostics for the 1940-2009 Period

For GMM estimations in Columns (5) and (6) of Table 4.3a, and in Column (3) of Table 4.3b, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, but AR (2) test does not. These results satisfy the Arellano-Bond estimation assumptions in Chapter 2, which increases the efficiency of estimation. In addition, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, which indicates that the set of instruments is valid.

In Table 4.4a, 4.4b, and 4.4c, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level with the exception of Column (1) in Table 4.4a and Table 4.4b. This indicates that there is no functional form misspecification in Table 4.4a, 4.4b, and 4.4c.

The instrumental variables are predicted mortality, age 5-14, and age 65-69 survival probabilities. All these instruments and their squared values are valid instruments according to the weak identification test statistics by exempting Columns (3), (4), (5), (6), (7), and (8) in Table 4.4b, and Columns (2), (3), and (4) in Table 4.4c that satisfy the rule of thumb that F statistics of the first stage should be over ten according to Staiger and Stock (1997). Although Stock and Yogo (2005) critical values are not available for Columns (3), (4), (5), and (6) in Table 4.4b, this problem is solved by applying this rule of thumb. Hansen J tests indicate that over-

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[3] Cubic specification turning points (*TPs*) are estimated by using general mathematical formula: $\frac{d}{dx}\left(\hat{\beta}_3 x^3 + \hat{\beta}_2 x^2 + \hat{\beta}_1 x + \text{constant}\right)$, *then*, $TPs\,(1,2) = \exp\left((-(2\hat{\beta}_2) \pm \sqrt{(2\hat{\beta}_2)^2 - 4(3\hat{\beta}_3\hat{\beta}_1)})\ /\ (2(3\hat{\beta}_3))\right)$.

identification restrictions fail to be rejected at 10% or higher significance level, which indicates out that the set of instruments is appropriate.

Table 4.3a

The Association between per Capita GDP and Life Expectancy for the Period 1940-2009 by Linear and Quadratic Estimations

	log GDP					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log GDP	-	-	-	-	1.27***	1.28***
					(0.11)	(0.13)
log life expectancy at birth	3.83***	−47.78***	−0.54	−17.47***	1.33***	−21.11*
	(0.21)	(4.51)	(0.36)	(5.65)	(0.39)	(11.03)
(log life expectancy at birth)²	-	6.45***	-	2.23***	-	2.90**
		(0.56)		(0.77)		(1.40)
Number of observations	376	376	376	376	282	282
Number of countries	47	47	47	47	47	47
R-squared	0.63	0.75	0.80	0.82	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.00	0.01
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.23	0.39
Hansen test *p*-value	-	-	-	-	0.34	0.67
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	40.64	-	49.84	-	38.20

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per ten years and per country. GDP is GDP per capita. The dependent variable is the log GDP per capita. Columns (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), (4), and (6) is 42.89.

The endogeneity test of LE fails to be rejected in Table 4.4a, 4.4b, and 4.4c at 10% or higher significance level with the exemptions for Column (6) in Table 4.4a, and Column (4) in Table 4.4c that fails to be rejected at 5% or higher significance level. Thus, the OLS gives the consistent and relatively more efficient estimates.

Table 4.3b

The Association between per Capita GDP and Life Expectancy for the Period 1940-2009 by Cubic Estimations

	log GDP				
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano- Bond)
lagged log GDP	-	0.93***	-	0.85***	0.94***
		(0.02)		(0.05)	(0.12)
log life expectancy at birth	293.96***	57.34	155.04*	23.21	−563.34**
	(75.32)	(72.74)	(80.80)	(79.33)	(263.83)
(log life expectancy at birth)²	−80.20***	−13.38	−42.25*	−5.02	139.40**
	(18.99)	(17.91)	(21.18)	(19.78)	(65.90)
(log life expectancy at birth)³	7.30***	1.05	3.82**	0.36	−11.48**
	(1.59)	(1.47)	(1.85)	(1.64)	(5.49)
Number of observations	376	329	376	329	282
Number of countries	47	47	47	47	47
R-squared	0.77	0.97	0.82	0.91	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.02
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.22
Hansen test *p*-value	-	-	-	-	0.31
Country dummies	-	-	yes	yes	-
Time dummies	-	-	yes	yes	yes
Turning points (1)	d.l.z.	-	31.48	-	49.87
(2)	-	-	50.41	-	65.52

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per ten years and per country. GDP is GDP per capita. The dependent variable is the log GDP per capita. Columns (5) is difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column. "d.l.z." means that "the discriminant is less than zero.

4.3.4. Estimation Results for the 1940-2009 Period

In linear specification for the period 1940-2009, Columns (1), (3) and (5) in Table 4.3a, Columns (1), (3), (5), and (7) in Table 4.4a, and Column (1) in Table 4.4c report the estimation results of the Model (3.2.1). In linear specification, in the Model (3.2.1), α_2 and α_3 are restricted to zero. We find that the coefficient of ln LE is negative at 10% or higher significance level in Columns (1), (3), and (7) in Table 4.4a. Moreover, we find that the coefficient of ln LE is positive at 1% significance level in Columns (1) and (3) in Table 4.3a. Also, the coefficient of ln LE is found insignificant in Column (3) in Table 4.3a, Column (5) in Table 4.4a, and Column (1) in Table 4.4c.

For comparison, in Desbordes (2011), this coefficient is negative at 1% level of significance. In Hansen (2012), this coefficient is not significantly different from "0". Hence, our linear functional specification estimation results for the period 1940-2009 are similar to the linear specification results of Desbordes and Hansen for the 1940-1980 period.

Table 4.4a

Long-Difference Estimations for the Association between per Capita GDP and Life Expectancy for the Period 1940-2009 by Linear and Quadratic Estimations

	log GDP							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (age 5-14 survival probability)	IV (age 5-14 survival probability)	IV (both instruments)	IV (both instruments)
log life expectancy at birth	−0.70**	−24.01***	−0.99**	−11.63	−0.18	−34.15**	−0.60*	−24.65**
	(0.30)	(8.21)	(0.45)	(17.44)	(0.50)	(13.80)	(0.34)	(11.38)
(log life expectancy at birth)²	-	3.13***	-	1.43	-	4.55**	-	3.23**
		(1.10)		(2.32)		(1.84)		(1.51)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.08	0.26	0.06	0.20	0.03	0.20	0.07	0.26
F test *p*-value	0.02	0.01	0.04	0.08	0.72	0.07	0.10	0.08
Weak identification test statistic	-	-	50.44	9.72	41.27	19.10	90.97	18.57
Endogeneity test *p*-value	-	-	0.52	0.50	0.13	0.06	0.40	0.45
Hansen J statistic	-	-	e.e.i.	e.e.i.	e.e.i.	e.e.i.	0.17	0.10
C (2nd polynomial) RESET test *p*-value	0.00	0.03	0.48	0.22	0.69	0.76	0.17	0.77
C (3rd polynomial) RESET test *p*-value	0.01	0.08	0.31	0.43	n.r.	0.94	0.39	0.85
Turning points	-	46.34	-	-	-	42.71	-	45.68

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940 and 2009. GDP is GDP per capita. The dependent variable is the log GDP per capita. In (3) predicted mortality, and in (4) predicted mortality and its squared value are used as the instrumental variables Desbordes (2011). In Column (5) log age 5-14 survival probability, and in Column (6) log age 5-14 survival probability, and its squared value are used as instrumental variables which are not used in Desbordes (2011). In Column (7) predicted mortality, and log age 5-14 survival probability, and in Column (8) predicted mortality, and log age 5-14 survival probability, and their squared values are used as instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means "not reported by the test." In (3), and (5), Stock-Yogo weak ID test critical value is 16.38. In (4), and (6), Stock-Yogo weak ID test critical value is 7.03. In (7), Stock-Yogo weak ID test critical value is 19.93. In (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), (6), and (8) columns is 44.91.

In quadratic specification for the period 1940-2009, Columns (2), (4), and (6) in Table 4.3a, Columns (2), (4), (6), and (8) in Table 4.4a, Column (2) in Table 4.4c report the estimation results of the Model (3.2.1). In quadratic specification, in the Model (3.2.1), α_3 is restricted to zero. We find that the coefficients of the linear and quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are negative and positive, respectively.

Our estimated turning points are within the range of 38.20-49.84 years in Columns (2), (4), and (6) in Table 4.3a, Columns (2), (6), and (8) in Table 4.4a, and Column (2) in Table 4.4c. These results are similar to the findings of Desbordes (2011) and Hansen (2012) in quadratic functional specification estimations for the 1940-1980 period. Both coefficients of the linear and quadratic terms are found negative and positive at 5% or higher significance level, respectively.

For comparison, turning points of Desbordes and Hansen are within the range of 43.23-49.91 years for the 1940-1980 period. In addition, the coefficients of the linear and the quadratic terms are found insignificant in Column (4) in Table 4.4a. Thus, our quadratic functional specification estimation results suggest that there is a non-monotonic and U-shaped association between per capita GDP and LE for the period 1940-2009. This suggestion is consistent with the quadratic specification estimation results of Desbordes and Hansen for the 1940-1980 period, and our results for the period 1940-2009.

In cubic specification for the period 1940-2009, Columns (1), (2), (3), (4), and (5) in Table 4.3b, Columns (1), (2), (3), (4), (5), (6), (7), and (8) in Table 4.4b, and Columns (3), and (4) in Table 4.4c report the estimation results of the Model (3.2.1). We find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 5% or higher significance level, and they are negative, positive, and negative respectively. The association is first convex-, and then concave-shaped in Column (5) in Table 4.3b, Column (2) in Table 4.4b, and Column (4) in Table 4.4c.

For convex-concave-shaped association, the estimated turning point-1s are within the range of 37.55 - 49.87 years; and turning point-2s are within the range of 53.48-65.52 years. At the same time, we find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 10% or higher significance level, and they are positive, negative, and positive respectively. The association is first concave-, and then convex-shaped in Columns (1), and (3) in Table 4.3b.

Table 4.4b

Long-Difference Estimations for the Association between per Capita GDP and Life Expectancy for the Period 1940-2009 by Cubic Estimations

	log GDP							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (age 5-14 survival probability)	IV (age 5-14 survival probability)	IV (both instruments)	IV (both instruments)
lagged log GDP	-	1.08***	-	1.54	-	1.10***	-	1.11***
		(0.05)		(2.07)		(0.17)		(0.09)
log life expectancy at birth	84.97	−133.61**	(omitted)	−1473.43	−846.69	−701.49	850.96	−322.85
	(145.65)	(63.35)		(5696.22)	(2015.68)	(1208.10)	(1084.45)	(353.00)
(log life expectancy at birth)^2	−24.97	35.07**	−1.68	382.66	212.00	180.67	−221.72	83.87
	(37.52)	(16.49)	(2.16)	(1477.70)	(514.96)	(309.48)	(279.16)	(90.57)
(log life expectancy at birth)^3	2.41	−3.06**	0.28	−33.11	−17.64	−15.50	19.26	−7.26
	(3.22)	(1.43)	(0.38)	(127.77)	(43.82)	(26.41)	(23.95)	(7.74)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.28	0.93	0.21	−0.82	−0.80	0.58	−0.36	0.89
F test p-value	0.01	0.00	0.21	0.01	0.09	0.00	0.15	0.00
Weak identification test statistic	-	-	0.00	0.02	0.04	0.04	0.21	0.14
Endogeneity test p-value	-	-	0.61	0.65	0.10	0.67	0.54	0.75
Hansen J statistic	-	-	e.e.i.	e.e.i.	e.e.i.	e.e.i.	0.41	0.72
C (3rd polynomial) RESET test p-value	0.03	0.32	0.39	0.47	n.r.	0.40	n.r.	0.37
C (4rd polynomial) RESET test p-value	n.r.	0.39	n.r.	0.58	n.r.	0.48	n.r.	0.53
Turning points (1)	-	37.55	-	-	-	-	-	-
(2)	-	55.38	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940, and 2009. GDP is GDP per capita. The dependent variable is the log GDP per capita. Lagged log GDP per capita includes two observations by country for the years 1940 and 2000. In Column (3), and (4), predicted mortality, its squared value, and its cubed value are used as the instrumental variables. In Column (5), and (6), log age 5-14 survival probability, its squared, and cubed values are used as the instrumental variables. In Column (7), and (8), predicted mortality, and log age 5-14 survival probability, and their squared, and cubed values are used as the instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means that "not reported" by the test. In (3), (4), (5), and (6), Stock-Yogo weak ID test critical values are not available. In (7), and (8), Stock-Yogo weak ID test critical value is 12.20. Turning point is estimated for coefficients at 10% or better significance level in a Column.

For concave-convex-shaped association, we find that the estimated turning point-1 and turning point-2 are 31.48 and 50.41 years in Column (3) in Table 4.3b. Also, we find that the coefficients of the linear, quadratic, and cubic terms are insignificant in Columns (2), and (4) in Table 4.3b, Columns (1), (3), (4), (5), (6), (7), and (8) in Table 4.4b, and Column (3) in Table 4.4c. Since the discriminant is less than zero in Column (1) in Table 4.3b, the quadratic function, the derivative of cubic function, has no real roots.

This concave-convex-shaped association results for the period 1940-2009 is similar to the findings of cubic reduced form model in Husain et al. (2014) which gives turning points as 36.81 and 51.09 years for the 1980-2009 period. Also, Husain et al. suggest that the shape of the association may be inverse U-shaped by considering reverse causality. However, our estimations (turning points) of convex-concave-shaped association for the period 1940-2009 are consistent with empirical findings and the theoretical foundation in Azomahou et al. (2009) for the period 1820-2005. Hence, we suggest that there is first a convex-, and then a concave-shaped association between per capita GDP and LE for the period 1940-2009.

Table 4.4c

Long-Difference Estimations for the Association between per Capita GDP and Life Expectancy for the Period 1940-2009 by Linear, Quadratic and Cubic Estimations

	log GDP			
	(1)	(2)	(3)	(4)
	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)
lagged log GDP	-	-	-	1.09***
				(0.07)
log life expectancy at birth	−0.54	−19.28**	100.81	−251.30***
	(0.35)	(9.46)	(225.75)	(88.86)
(log life expectancy at birth)^2	-	2.53**	−29.24	65.42***
		(1.26)	(57.75)	(22.86)
(log life expectancy at birth)^3	-	-	2.80	−5.67***
			(4.92)	(1.96)
Number of observations	47	47	47	47
Number of countries	47	47	47	47
R-squared	0.07	0.25	0.27	0.92
F test *p*-value	0.14	0.11	0.02	0.00
Weak identification test statistic	63.50	12.19	6.37	9.23
Endogeneity test *p*-value	0.35	0.37	0.45	0.08
Hansen J statistic	0.36	0.35	0.31	0.54
C (2nd polynomial) RESET test *p*-value	0.07	0.55	-	-
C (3rd polynomial) RESET test *p*-value	0.12	0.82	n.r.	0.60
C (4rd polynomial) RESET test *p*-value	-	-	n.r.	0.70
Turning points (1)	-	-	-	40.96
(2)	-	45.41	-	53.48

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940, and 2009. GDP is GDP per capita. The dependent variable is the log GDP per capita. Lagged log GDP per capita includes two observations by country for the years 1940, and 2000. In Column (1) predicted mortality, log age 5-14 survival probability, and log age 65-69 survival probability are used as the instrumental variables in estimations. In Column (2) predicted mortality, log age 5-14 survival probability, and log age 65-69 survival probability, and their squared values are used as the instrumental variables in estimations. In Column (3), and (4), predicted mortality, log age 5-14 survival probability, and log age 65-69 survival probability, and their squared, and cubed values are used as the instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means that "not reported" by the test. In (1), Stock-Yogo weak ID test critical value is 13.91. In (2), Stock-Yogo weak ID test critical value is 15.72. In (3), and (4), Stock-Yogo weak ID test critical value is 16.10. Turning point is estimated for coefficients at 10% or better significance level in a Column.

4.3.5. Diagnostics for the 1980-2009 Period

For GMM estimations in Columns (5) and (6) of Table 4.5b, and in Column (3) of Table 4.6c, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, but AR (2) test does not. These results satisfy Arellano-Bond estimation assumptions in Chapter 2, which increases the efficiency of estimation. Furthermore, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, meaning that the instrument set is valid.

Table 4.5a

The Association between per Capita GDP and Life Expectancy for the 1980-2009 Period by Linear and Quadratic Estimations

	log GDP			
	(1)	(2)	(3)	(4)
	OLS	OLS	FE (within)	FE (within)
log life expectancy at birth	9.16***	−116.82***	0.01	5.70
	(0.30)	(21.31)	(1.17)	(41.10)
(log life expectancy at birth)²	-	14.89***	-	−0.70
		(2.51)		(5.06)
Number of observations	329	329	329	329
Number of countries	47	47	47	47
R-squared	0.75	0.78	0.61	0.61
F test *p*-value	0.00	0.00	0.00	0.00
Country dummies	-	-	yes	yes
Time dummies	-	-	yes	yes
Turning point	-	50.57	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. GDP is GDP per capita. The dependent variable is the log GDP per capita. Turning point is estimated for coefficients at 10% or better significance level in a Column.

In Table 4.6a, 4.6b, 4.6c, and 4.6d, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level, with the exemptions for Column (4) in Table 4.6a and Column (3) in Table 4.6c. This indicates that in Table 4.6a, 4.6b, 4.6c, and 4.6d, there is no functional form misspecification.

Table 4.5b

The Association Between per Capita GDP and Life Expectancy for the 1980-2009 Period with Lagged Value of Dependent Variable in All Linear and Quadratic Estimations

	log GDP					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log GDP	0.93***	0.93***	0.74***	0.75***	0.88***	0.82***
	(0.01)	(0.02)	(0.05)	(0.05)	(0.08)	(0.12)
log life expectancy at birth	0.74***	2.87	1.13***	32.39*	1.81***	59.34**
	(0.18)	(6.51)	(0.35)	(16.7)	(0.53)	(27.81)
(log life expectancy at birth)²	-	−0.25	-	−3.80*	-	−7.17**
		(0.77)		(2.02)		(3.40)
Number of observations	282	282	282	282	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.99	0.99	0.89	0.89	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.00	0.00
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.59	0.46
Hansen test *p*-value	-	-	-	-	0.12	0.21
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	-	-	70.75	-	62.53

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. GDP is GDP per capita. The dependent variable is the log GDP per capita. Column (5) is difference GMM estimation. Column (6) is two-step difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (4), and (6) is 66.64.

The instrumental variables are age 1-5, age 80-84, age 65-69, and crude survival probabilities, and measles vaccine coverage percent. All these instruments and their squared and cubed values are valid instruments according to the weak identification test statistics by excluding Column (8) in Table 4.6a, Column (6) in Table 4.6b, Columns (3), (4), (5), (6), (7), and (8) in Table 4.6c, and Column (3) in Table 4.6d, which satisfies the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock,1997). Although Stock and Yogo (2005) critical values are not available for Columns (3) and (4) in Table 4.6c, this problem is solved by applying this rule of thumb.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, by excluding Columns (5), (6), (7) in Table 4.6a, Column (5) in Table 4.6c, and Column (4) in Table 4.6d. In addition, Column (1) in Table 4.6d fails to be rejected at 5% or higher significance level, which means that the set of instruments is valid at given significance level.

Table 4.5c

The Association between per Capita GDP and Life Expectancy for the 1980-2009 Period by Cubic Estimations

	log GDP				
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)
lagged log GDP	-	0.93***	-	0.77***	0.84***
		(0.02)		(0.05)	(0.07)
log life expectancy at birth	−225.16	−888.29**	846.84	−840.09**	−967.60***
	(1171.45)	(411.01)	(941.83)	(328.47)	(300.06)
(log life expectancy at birth)^2	40.59	210.39**	−200.83	202.88**	233.87***
	(277.52)	(97.11)	(224.15)	(77.12)	(70.59)
(log life expectancy at birth)^3	−2.03	−16.59**	15.87	−16.31**	−18.83***
	(21.91)	(7.64)	(17.78)	(6.04)	(5.54)
Number of observations	329	282	329	282	235
Number of countries	47	47	47	47	47
R-squared	0.78	0.99	0.61	0.90	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.00
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.49
Hansen test *p*-value	-	-	-	-	0.21
Country dummies	-	-	yes	yes	-
Time dummies	-	-	yes	yes	yes
Turning points (1)	-	59.23	-	55.46	56.59
(2)	-	79.28	-	71.81	69.68

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. GDP is GDP per capita. The dependent variable is the log GDP per capita. Column (5) is difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column.

The endogeneity test of LE fails to be rejected in Table 4.4a, 4.4b, and 4.4c at 10% or higher significance level, with the exemption for Column (8) in Table 4.6a. Furthermore, test for Column (5) in Table 4.6a, and Column (4) in Table 4.6b, and Columns (4) and (6) in Table 4.6c fails to be rejected at 5% or higher significance level. Thus, the OLS gives consistent and relatively more efficient estimates.

Table 4.6a

Long-Difference Estimations for the Association between per Capita GDP and Life Expectancy for the 1980-2009 Period by Linear and Quadratic Estimations

	log GDP							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
log life expectancy at birth	0.60	8.89	0.41	−33.09	2.07	−1.63	−1.41	153.14**
	(1.36)	(50.05)	(2.11)	(69.65)	(1.85)	(63.50)	(1.69)	(75.37)
(log life expectancy at birth)²	-	−1.02	-	4.07	-	0.31	-	−19.17**
		(6.19)		(8.63)		(7.93)		(9.41)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.01	0.01	0.01	−0.03	−0.03	0.003	−0.06	−0.60
F test *p*-value	0.66	0.87	0.85	0.88	0.28	0.81	0.42	0.15
Weak identification test statistic	-	-	48.00	17.54	24.52	12.36	60.99	9.83
Endogeneity test *p*-value	-	-	0.90	0.12	0.09	0.86	0.22	0.003
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.04	0.02	0.04	0.91
C (2nd polynomial) RESET test *p*-value	0.09	0.81	0.88	0.04	0.66	0.65	0.60	0.02
C (3rd polynomial) RESET test *p*-value	0.18	n.r.	0.93	0.01	0.62	0.88	0.73	0.07
Turning point	-	-	-	-	-	-	-	54.33

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. GDP is GDP per capita. The dependent variable is the log GDP per capita. In Column (3) log one-to-five years survival probability, and in Column (4) log one-to-five years survival probability, and its squared value are used as the instrumental variables. In Column (5) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and in Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and their squared values are used as instrumental variables. In Column (7) log crude survival probability, and log age 80-84 survival probability, and in Column (8) log crude survival probability, and log age 80-84 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means "not reported by the test." In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), and (7), Stock-Yogo weak ID test critical value is 19.93. In (6), and (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

4.3.6. Estimation Results for the 1980-2009 Period

In linear specification for the 1980-2009 period, Columns (1) and (3) in Table 4.5a, Columns (1), (3), and (5) in Table 4.5b, Columns (1), (3), (5), and (7) in Table 4.6a and Table 4.6b, and Columns (1) and (2) in Table 4.6d report the estimation results of the Model (3.2.1). In linear specification, in the Model (3.2.1), α_2 and α_3 are restricted to be zero. We find that the coefficient of ln LE is positive at 5% or higher significance level in Column (1) in Table 4.5a, Columns (1), (3), and (5) in Table 4.5b, Columns (1), (3), (5), and (7) in Table 4.6a, and Column (2) in Table 4.6d. Also, the coefficient of ln LE is found insignificant in Column (3) in Table 4.5a, Columns (1), (3), (5), and (7) in Table 4.6a, and Column (1) in Table 4.6d.

Table 4.6b

Long-Difference Estimations for the Association between per Capita GDP and Life Expectancy for the 1980-2009 Period with Lagged Value of Dependent Variable in All Linear and Quadratic Estimations

	log GDP							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
lagged log GDP	1.05***	1.06***	1.05***	1.06***	1.05***	1.06***	1.05**	1.06***
	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)	(0.04)	(0.03)
log life expectancy at birth	0.70***	24.83***	0.68**	25.18***	0.85***	23.29***	0.59**	21.89***
	(0.21)	(6.15)	(0.32)	(8.00)	(0.27)	(7.94)	(0.27)	(7.32)
(log life expectancy at birth)²	-	−2.96***	-	−2.97***	-	−2.75***	-	−2.63***
		(0.75)		(0.99)		(0.99)		(0.91)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.96	0.97	0.96	0.97	0.96	0.97	0.96	0.97
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	47.22	18.23	27.76	10.65	68.23	14.78
Endogeneity test *p*-value	-	-	0.95	0.09	0.31	0.19	0.41	0.17
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.27	0.39	0.10	0.11
C (2nd polynomial) RESET test *p*-value	0.14	0.03	0.14	0.07	0.07	0.19	0.07	0.22
C (3rd polynomial) RESET test *p*-value	0.23	0.08	0.31	0.19	0.06	0.37	0.20	0.19
Turning points	-	66.10	-	68.92	-	69.16	-	63.87

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. GDP is GDP per capita. The dependent variable is the log GDP per capita. Lagged log GDP per capita includes two observations by country for the years 1980 and 2005. In Column (3) log one-to-five years survival probability, and in Column (4) log one-to-five years survival probability, and its squared value are used as the instrumental variables. In Column (5) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and in Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and their squared values are used as instrumental variables. In Column (7) log crude survival probability, and log age 80-84 survival probability, and in Column (8) log crude survival probability, and log age 80-84 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), and (7), Stock-Yogo weak ID test critical value is 19.93. In (6), and (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), (4), (6), and (8) columns is 67.01.

For comparison, in Desbordes (2011), this coefficient is negative at 1% level of significance. In Hansen (2012), this coefficient is not significantly different from "0". Hence, our linear functional specification estimation results for the 1980-2009 period are not similar to the linear specification results of Desbordes and Hansen for the 1940-1980 period.

In quadratic specification for the 1980-2009 period, Columns (2) and (4) in Table 4.5a, Columns (2), (4), and (6) in Table 4.5b, Columns (2), (4), (6), and (8) in Table 4.6a and in Table 4.6b, and Columns (3) and (4) in Table 4.6d report the estimation results of the Model (3.2.1). In quadratic specification, in the Model (3.2.1), α_3 is restricted to be zero. We find that the coefficients of the linear and quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are positive and negative respectively in Columns (4) and (6) in Table 4.5b, Column (8) in Table 4.6a, Columns (2), (4), (6), and (8) in Table 4.6b, and Column (4) in Table 4.6d.

Our estimated turning points are within the range of 54.33-70.75 years in these Columns. Also, we find that the coefficients of the linear and the quadratic terms are both significantly different from "0" at 1% significance level, and they are negative and positive respectively in Column (2) in Table 4.5a. In addition, the coefficients of the linear and the quadratic terms are found insignificant in Column (4) in Table 4.5a, Column (2) in Table 4.5b, Columns (2), (4), (6) in Table 4.6a, and Column (3) in Table 4.6d. Thus, our quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between per capita GDP and LE for the 1980-2009 period.

Table 4.6c

Long-Difference Estimations for the Association between per Capita GDP and Life Expectancy for the 1980-2009 Period by Cubic Estimations

	log GDP							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
lagged log GDP	-	1.08***	-	1.09***	-	1.09***	-	1.08***
		(0.03)		(0.03)		(0.03)		(0.03)
log life expectancy at birth	2240.62	−451.32**	1637.19	−746.35***	1883.93	−720.06***	166.6	−487.24*
	(1463.49)	(210.64)	(1830.51)	(235.48)	(1639.60)	(216.79)	(1808.63)	(267.63)
(log life expectancy at birth)^2	−531.64	110.28**	−394.20	181.17***	−446.47	174.72***	21.93	119.07*
	(347.46)	(49.88)	(434.24)	(56.01)	(390.98)	(51.60)	(431.96)	(63.51)
(log life expectancy at birth)^3	42.04	−8.98**	31.66	−14.66***	35.26	−14.13***	0.20	−9.70*
	(27.50)	(3.94)	(34.33)	(4.44)	(31.09)	(4.10)	(34.41)	(5.02)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.06	0.98	0.01	0.97	0.06	0.97	−0.55	0.98
F test *p*-value	0.46	0.00	0.65	0.00	0.65	0.00	0.19	0.00
Weak identification test statistic	-	-	16.62	15.84	8.45	9.39	3.55	7.06
Endogeneity test *p*-value	-	-	0.20	0.07	0.45	0.09	0.30	0.60
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.03	0.78	0.57	0.14
C (3rd polynomial) RESET test *p*-value	n.r.	0.10	0.02	0.12	0.60	0.12	0.32	0.08
C (4rd polynomial) RESET test *p*-value	n.r.	0.08	n.r.	0.16	n.r.	0.09	0.45	0.11
Turning points (1)	-	53.49	-	58.94	-	58.20	-	55.66
(2)	-	67.52	-	64.31	-	65.37	-	64.56

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980, and 2009. GDP is GDP per capita. The dependent variable is the log GDP per capita. Lagged log GDP per capita includes two observations by country for the years 1980, and 2005. In Column (3), and Column (4) log one-to-five years survival probability, its squared, and cubed values are used as the instrumental variables. In Column (5), and Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), their squared, and cubed values are used as the instrumental variables. In Column (7), and Column (8) log crude survival probability, and log age 80-84 survival probability, their squared, and cubed values are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means that "not reported" by the test. In (3), and (4), Stock-Yogo weak ID test critical values are not available. In (5), (6), (7), and (8), Stock-Yogo weak ID test critical value is 12.20. Turning point is estimated for coefficients at 10% or better significance level in a Column.

This finding is consistent with the results of Husain et al. (2014). Husain et al. suggest that the shape of the association may be inverse U-shaped by considering reverse causality for the 1980-2009 period. These results are not similar to the findings of Desbordes (2011) and Hansen (2012) in quadratic functional specification estimations for the 1940-1980 period in that according to their findings, both coefficients of the linear and quadratic terms are found negative and positive at 5% or higher significance level, respectively.

In cubic specification for the 1980-2009 period, Columns (1), (2), (3), (4), and (5) in Table 4.5c, Columns (1), (2), (3), (4), (5), (6), (7), and (8) in Table 4.6c, and Columns (5) and (6) in Table 4.6d report the estimation results of the Model (3.2.1). We find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 10% or higher significance level, and they are negative, positive, and negative respectively. The association is first convex-, and then concave-shaped in Columns (2), (4), and (5) in Table 4.5c, Columns (2), (4), (6), and (8) in Table 4.6c, and Column (6) in Table 4.6d.

For the convex-concave-shaped association, estimated turning point-1s are within the range of 53.49-59.23 years; and turning point-2s are within the range of 62.75-79.28 years. At the same time, we find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 10% or higher significance level, and they are positive, negative, and positive respectively. The association is first concave-, and then convex-shaped in Column (6) in Table 6d.

For the concave-convex-shaped association, we find that the estimated turning point-1 and turning point-2 are 59.47 and 88.54 years in Column (5) in Table 4.6d. Also, we find that the coefficients of the linear, quadratic, and cubic terms are insignificant in Columns (1), and (3) in Table 4.5c, and Columns (1), (3), (5), and (7) in Table 4.6c.

This concave-convex-shaped association results for the 1980-2009 period are similar to the findings of cubic reduced form model in Husain et al. (2014) which gives turning points as 36.81 and 51.09 years for the 1980-2009 period. Also, Husain et al. suggest that the shape of the association may be inverse U-shaped by considering reverse causality. However, our results of convex-concave-shaped association for the 1980-2009 period are consistent with the empirical findings and the theoretical foundation in Azomahou et al. (2009) for the period 1820-2005. Hence, we suggest that there is first a convex-, and then, a concave-shaped association between per capita GDP and LE for the 1980-2009 period.

Table 4.6d

Long-Difference Estimations for the Association between per Capita GDP and Life Expectancy for the 1980-2009 Period by Linear, Quadratic and Cubic Estimations

	log GDP					
	(1)	(2)	(3)	(4)	(5)	(6)
	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)
lagged log GDP	-	1.05***	-	1.06***	-	1.09***
		(0.04)		(0.03)		(0.03)
log life expectancy at birth	−1.29	0.58**	73.79	30.27***	2260.89*	−628.71**
	(1.71)	(0.26)	(80.98)	(8.46)	(1202.08)	(256.45)
(log life expectancy at birth)²	-	-	−9.31	−3.66***	−528.83*	153.42**
			(10.09)	(1.05)	(287.92)	(60.81)
(log life expectancy at birth)³	-	-	-	-	41.14*	−12.48**
					(23.02)	(4.80)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	−0.05	0.96	−0.18	0.97	−0.07	0.97
F test *p*-value	0.46	0.00	0.57	0.00	0.15	0.00
Weak identification test statistic	39.44	44.47	14.72	16.64	20.48	16.16
Endogeneity test *p*-value	0.19	0.52	0.23	0.70	0.69	0.69
Hansen J statistic	0.07	0.21	0.10	0.04	0.30	0.13
C (2nd polynomial) RESET test *p*-value	0.28	0.09	0.71	0.50	-	-
C (3rd polynomial) RESET test *p*-value	0.41	0.22	0.25	0.61	0.44	0.35
C (4rd polynomial) RESET test *p*-value	-	-	-	-	0.40	0.54
Turning points (1)	-	-	-	-	59.47	57.83
(2)	-	-	-	62.46	88.54	62.75

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980, and 2009. GDP is GDP per capita. The dependent variable is the log GDP per capita. Lagged log GDP per capita includes two observations by country for the years 1980, and 2005. In (1), and (2), log crude survival probability, log age 80-84 survival probability, and log age 65-69 survival probability are used as the instrumental variables. In (3), and (4), log crude survival, log age 80-84 survival, and log age 65-69 survival probabilities, their squared values are used as the instrumental variables. In (5), and (6), log crude survival, log age 80-84 survival, and log age 65-69 survival probabilities, and their squared, and cubed values are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (1), and (2), Stock-Yogo weak ID test critical value is 13.91. In (3), and (4), Stock-Yogo weak ID test critical value is 15.72. In (5), and (6), Stock-Yogo weak ID test critical value is 16.10. Turning point is estimated for coefficients at 10% or better significance level in a Column.

4.4. Estimation Results for Human Capital

4.4.1. Diagnostics for the 1940-1980 Period

For GMM estimations in Columns (5) and (6) of Table 4.7b, and in Column (3) of Table 4.7c, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, but AR (2) test does not. These results satisfy Arellano-Bond estimation assumptions in Chapter 2 that increase the efficiency of estimation. In addition, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level. This hints that instrument set is valid.

In Table 4.8a, 4.8b, 4.8c, 4.8d, 4.8e, 4.8f, 4.8g, and 4.8h, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level, with the exception of Column (2) in Table 4.8a, and Column (1) in Table 4.8b. This indicates that in Table 4.8a, 4.8b, 4.8c, 4.8d, 4.8e, 4.8f, 4.8g, and 4.8h, there is no functional form misspecification.

Table 4.7a

The Association between Years of Schooling and Life Expectancy for the 1940-1980 Period by Linear and Quadratic Estimations

	log years of schooling			
	(1)	(2)	(3)	(4)
	OLS	OLS	FE (within)	FE (within)
log life expectancy at birth	2.63***	−12.92***	0.99***	−2.76
	(0.11)	(2.63)	(0.16)	(2.35)
(log life expectancy at birth)²	-	1.97***	-	0.50
		(0.33)		(0.32)
Number of observations	235	235	235	235
Number of countries	47	47	47	47
R-squared	0.78	0.80	0.85	0.85
F test *p*-value	0.00	0.00	0.00	0.00
Country dummies	-	-	yes	yes
Time dummies	-	-	yes	yes
Turning point	-	26.59	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per ten years and per country. The dependent variable is the log years of schooling. Turning point is estimated for coefficients at 10% or better significance level in a Column.

The instrumental variables are predicted mortality, age 5-14, and age 65-69 survival probabilities. All these instruments and their squared values are valid instruments according to the weak identification test statistic by excluding Columns (3), (4), (5), (6), (7), and (8) in Table 4.8c, Columns (4), (5), and (6) in Table 4.8d, Columns (3), (4), (5), (6), (7), and (8) in Table 4.8g, and Columns (3), (4), (5), and (6) in Table 4.8h that satisfy the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock, 1997).

Table 4.7b

The Association between Years of Schooling and Life Expectancy for the 1940-1980 Period with Lagged Dependent Variable in All Linear and Quadratic Estimations

	log years of schooling					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log years of schooling	0.78***	0.81***	0.51***	0.51***	0.84***	0.90***
	(0.03)	(0.03)	(0.09)	(0.09)	(0.23)	(0.26)
log life expectancy at birth	0.61***	6.71***	1.01***	0.93	1.02***	10.46*
	(0.13)	(1.79)	(0.17)	(2.82)	(0.26)	(5.29)
(log life expectancy at birth)²	-	−0.77***	-	0.01	-	−1.25*
		(0.23)		(0.37)		(0.71)
Number of observations	188	188	188	188	141	141
Number of countries	47	47	47	47	47	47
R-squared	0.97	0.97	0.90	0.90	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.04	0.04
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.82	0.75
Hansen test *p*-value	-	-	-	-	0.51	0.27
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	78.78	-	-	-	66.11

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per ten years and per country. The dependent variable is the log years of schooling. Columns (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), and (6) Columns is 72.45.

Although the Stock and Yogo (2005) critical values are not available for Columns (3), (4), (5), and (6) in Table 4.8c, and Columns (3), (4), (5), and (6) in Table 4.8g, this problem is solved by applying this rule of thumb.

Table 4.7c

The Association between Years of Schooling and Life Expectancy for the 1940-1980 Period by Cubic Estimations

	log years of schooling				
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)
lagged log years of schooling	-	0.81***	-	0.47***	0.32**
		(0.03)		(0.10)	(0.13)
log life expectancy at birth	81.65	42.46	−130.86**	−136.37	−153.02*
	(68.71)	(53.12)	(48.43)	(85.67)	(89.44)
(log life expectancy at birth)²	−22.33	−9.73	33.85**	34.81	38.87*
	(17.62)	(13.38)	(12.62)	(21.86)	(22.78)
(log life expectancy at birth)³	2.08	0.75	−2.89**	−2.94	−3.26*
	(1.50)	1.12	(1.10)	(1.86)	(1.93)
Number of observations	235	188	235	188	141
Number of countries	47	47	47	47	47
R-squared	0.80	0.97	0.86	0.90	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.01
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.64
Hansen test *p*-value	-	-	-	-	0.18
Country dummies	-	-	yes	yes	-
Time dummies	-	-	yes	yes	yes
Turning points (1)	-	-	34.24	-	37.02
(2)	-	-	71.30	-	75.62

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per ten years and per country. The dependent variable is the log years of schooling. Columns (3) is difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, with the exception of Column (7) in Table 4.8g that fail to be rejected at 5% or higher significance level. This indicates that instruments are appropriate at given significance level.

Table 4.8a

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the 1940-1980 Period Using Life Expectancy at Birth, and Predicted Mortality Data in Acemoglu And Johnson (2007) by Linear and Quadratic Estimations

	log years of schooling							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (age5-14 survival probability)	IV (age5-14 survival probability)	IV (both instruments)	IV (both instruments)
log life expectancy at birth	1.21***	1.82	1.46***	8.08	1.49***	−2.13	1.47***	0.60
	(0.19)	(3.19)	(0.34)	(7.98)	(0.33)	(5.53)	(0.26)	(5.06)
(log life expectancy at birth)²	-	−0.08	-	−0.91	-	0.48	-	0.11
		(0.43)		(1.07)		(0.73)		(0.67)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.41	0.41	0.39	0.36	0.39	0.38	0.39	0.40
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	47.32	11.92	38.85	22.62	84.41	24.97
Endogeneity test *p*-value	-	-	0.42	0.61	0.23	0.13	0.11	0.30
Hansen J statistic	-	-	e.e.i.	e.e.i.	e.e.i.	e.e.i.	0.94	0.21
C (2nd polynomial) RESET test *p*-value	0.06	0.04	0.34	0.42	0.32	0.33	0.29	0.11
C (3rd polynomial) RESET test *p*-value	0.05	0.04	0.42	0.43	0.60	0.61	0.15	0.09

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940 and 1980. The dependent variable is the log years of schooling. In Column (3) predicted mortality, and in Column (4) predicted mortality and its squared value are used as the instrumental variables. In Column (5) log age 5-14 survival probability, and in Column (6) log age 5-14 survival probability, and its squared value are used as the instrumental variables. In Column (7) predicted mortality, and log age 5-14 survival probability, and in Column (8) predicted mortality, and log age 5-14 survival probability, and their squared values are used as instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), and (5), Stock-Yogo weak ID test critical value is 16.38. In (4), and (6), Stock-Yogo weak ID test critical value is 7.03. In (7), Stock-Yogo weak ID test critical value is 19.93. In (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is not estimated for coefficients at less than 10% significance level in a Column.

The endogeneity test of LE fails to be rejected in Table 4.8a, 4.8b, 4.8c, 4.8d, 4.8e, 4.8f, 4.8g, and 4.8h at 10% or higher significance level with the exception of Columns (4) and (6) in Table 4.8d. Moreover, test fails to be rejected in Column (4) in Table 4.8d at 5% or higher significance level. Thus, the OLS gives the consistent and relatively more efficient estimates with one exception for Column (6) in Table 4.8d.

Table 4.8b

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the 1940-1980 Period with Lagged Dependent Variable in All Linear and Quadratic Estimations Using Life Expectancy at Birth, and Predicted Mortality Data in Acemoglu and Johnson (2007)

	log years of schooling							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (age5-14 survival probability)	IV (age5-14 survival probability)	IV (both instruments)	IV (both instruments)
lagged log years of schooling	0.23***	0.32***	0.26***	0.36***	0.24***	0.33***	0.25***	0.34***
	(0.07)	(0.07)	(0.08)	(0.09)	(0.07)	(0.10)	(0.07)	(0.09)
log life expectancy at birth	1.40***	9.81**	1.76***	11.34*	1.50***	8.92	1.63***	9.96**
	(0.16)	(3.84)	(0.30)	(5.84)	(0.24)	(6.74)	(0.22)	(5.26)
(log life expectancy at birth)²	-	−1.13**	-	−1.31*	-	−0.99	-	−1.12
		(0.51)		(0.78)		(0.89)		(0.70)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.55	0.61	0.52	0.60	0.55	0.60	0.54	0.60
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	35.17	12.45	39.65	10.60	69.61	14.04
Endogeneity test *p*-value	-	-	0.15	0.36	0.64	0.54	0.15	0.16
Hansen J statistic	-	-	e.e.i.	e.e.i.	e.e.i.	e.e.i.	0.45	0.95
C (2nd polynomial) RESET test *p*-value	0.04	0.29	0.47	0.88	0.74	0.57	0.59	0.52
C (3rd polynomial) RESET test *p*-value	0.04	0.43	0.39	0.67	0.94	0.84	0.83	0.78
Turning points	-	76.72	-	76.74	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940 and 1980. Lagged log years of schooling includes two observations by country for the years 1940 and 1970. The dependent variable is the log years of schooling. In Column (3) predicted mortality, and in Column (4) predicted mortality and its squared value are used as the instrumental variables. In Column (5) log age 5-14 survival probability, and in Column (6) log age 5-14 survival probability, and its squared value are used as the instrumental variables. In Column (7) predicted mortality, and log age 5-14 survival probability, and in Column (8) predicted mortality, and log age 5-14 survival probability, and their squared values are used as instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), and (5), Stock-Yogo weak ID test critical value is 16.38. In (4), and (6), Stock-Yogo weak ID test critical value is 7.03. In (7), Stock-Yogo weak ID test critical value is 19.93. In (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), and (4) Columns is 76.73.

4.4.2. Estimation Results for the 1940-1980 Period

In linear specification for the 1940-1980 period, Columns (1) and (3) in Table 4.7a, Columns (1), (3), and (5) in Table 4.7b, Columns (1), (3), (5), and (7) in Table 4.8a and Table 4.8b, Columns (1) and (2) in Table 4.8d, Columns (1), (3), (5), and (7) in Table 4.8e and Table 4.8f, and Columns (1) and (2) in Table 4.8h report the estimation results of the Model (3.2.2). In linear specification, in the Model (3.2.2), α_2 and α_3 are restricted to zero.

We find that the coefficient of ln LE is positive at 1% significance level in Columns (1) and (3) in Table 4.7a, Columns (1), (3), and (5) in Table 4.7b, Columns (1), (3), (5), and (7) in Table 4.8a and Table 4.8b, Columns (1) and (2) in Table 4.8d, Columns (1), (3), (5), and (7) in Table 4.8e and Table 4.8f, and Columns (1) and (2) in Table 4.8h. These linear functional specification estimation results are not similar to the linear specification results of per capita GDP - LE association estimation in that the coefficient of ln LE is found negative at 5% or higher significance level for the 1940-1980 period

Table 4.8c

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the 1940-1980 Period Using Life Expectancy at Birth, and Predicted Mortality Data in Acemoglu and Johnson (2007) by Cubic Estimations

	log years of schooling							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (age 5-14 survival probability)	IV (age 5-14 survival probability)	IV (both instruments)	IV (both instruments)
lagged log years of schooling	-	0.30***	-	0.38**	-	0.47	-	0.40**
		(0.07)		(0.17)		(0.41)		(0.17)
log life expectancy at birth	−155.22*	−38.23	434.92	95.22	(omitted)	265.05	−213.56	127.56
	(80.84)	(65.85)	(1545.36)	(419.76)		(797.38)	(460.00)	(308.19)
(log life expectancy at birth)^2	40.68*	11.28	−111.82	−23.06	0.37	−66.72	55.83	−31.36
	(21.00)	(17.00)	(400.94)	(109.06)	(0.68)	(205.51)	(119.40)	(79.68)
(log life expectancy at birth)^3	−3.53*	−1.07	9.61	1.88	−0.02	5.62	−4.83	2.59
	(1.82)	(1.46)	(34.68)	(9.45)	(0.12)	(17.65)	(10.33)	(6.87)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.46	0.62	−0.34	0.57	0.35	0.42	0.45	0.55
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	0.09	0.28	0.00	0.12	0.05	0.29
Endogeneity test *p*-value	-	-	0.48	0.29	0.11	0.46	0.64	0.18
Hansen J statistic	-	-	e.e.i.	e.e.i.	e.e.i.	e.e.i.	0.22	0.99
C (3rd polynomial) RESET test *p*-value	0.14	0.38	0.47	0.72	n.r.	n.r.	n.r.	n.r.
C (4rd polynomial) RESET test *p*-value	n.r.	0.58	0.48	0.57	n.r.	n.r.	n.r.	n.r.
Turning points (1)	33.26	-	-	-	-	-	-	-
(2)	65.80	-	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940, and 1980. The dependent variable is the log years of schooling. Lagged log years of schooling includes two observations by country for the years 1940, and 1970. In Column (3), and (4), predicted mortality, its squared value, and its cubed value are used as the instrumental variables. In Column (5), and (6), log age 5-14 survival probability, its squared, and cubed values are used as the instrumental variables. In Column (7), and (8), predicted mortality, and log age 5-14 survival probability, and their squared, and cubed values are used as the instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means that "not reported" by the test. In (3), (4), (5), and (6), Stock-Yogo weak ID test critical values are not available. In (7), and (8), Stock-Yogo weak ID test critical value is 12.20. Turning point is estimated for coefficients at 10% or better significance level in a Column.

In quadratic specification for the 1940-1980 period, Columns (2) and (4) in Table 4.7a, Columns (2), (4), and (6) in Table 4.7b, Columns (2), (4), (6), and (8) in Table 4.8a and Table 4.8b, Columns (3) and (4) in Table 4.8d, Columns (2), (4), (6), and (8) in Table 4.8e and Table 4.8f, and Columns (3) and (4) in Table 4.8h report the estimation results of the Model (3.2.2). In quadratic specification, in the Model (3.2.2), α_3 is restricted to zero. We find that the coefficients of the linear and quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are positive and negative respectively in Columns (2) and (6) in Table 4.7b, Columns (2) and (4) in Table 4.8b, Column (4) in Table 4.8d, and Column (4) in Table 4.8f and Table 4.8h.

Estimated turning points are within the range of 66.11-90.25 years in Columns (2) and (6) in Table 4.7b, Columns (2) and (4) in Table 4.8b, Column (4) in Table 4.8d, and Column (4) in Table 4.8f and Table 4.8h.

Table 4.8d.

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the 1940-1980 Period Using Life Expectancy at Birth, and Predicted Mortality Data in Acemoglu and Johnson (2007) by Linear, Quadratic and Cubic Estimations

	log years of schooling					
	(1)	(2)	(3)	(4)	(5)	(6)
	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)
lagged log years of schooling	-	0.25***	-	0.34***	-	0.24**
		(0.07)		(0.08)		(0.11)
log life expectancy at birth	1.48***	1.63***	2.11	9.83**	−297.86	−245.94
	(0.26)	(0.22)	(4.80)	(4.44)	(257.49)	(154.26)
(log life expectancy at birth)^2	-	-	−0.09	−1.11*	77.76	65.08
			(0.64)	(0.59)	(66.72)	(39.83)
(log life expectancy at birth)^3	-	-	-	-	−6.74	−5.71*
					(5.76)	(3.43)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.39	0.54	0.40	0.60	0.41	0.53
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	55.92	45.37	20.15	10.78	0.39	1.79
Endogeneity test *p*-value	0.11	0.10	0.35	0.09	0.28	0.04
Hansen J statistic	0.38	0.15	0.17	0.69	0.36	0.88
C (2nd polynomial) RESET test *p*-value	0.35	0.54	0.26	0.41	-	-
C (3rd polynomial) RESET test *p*-value	0.22	0.79	0.33	0.45	n.r.	n.r.
C (4rd polynomial) RESET test *p*-value	-	-	-	-	n.r.	n.r.
Turning points (1)	-	-	-	84.33	-	-
(2)	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940, and 1980. The dependent variable is the log years of schooling. Lagged log years of schooling includes two observations by country for the years 1940, and 1970. In Column (1), and (2), predicted mortality, log age 5-14 survival probability, and log age 65-69 survival probability are used as the instrumental variables in estimations. In Column (3), and (4), predicted mortality, log age 5-14 survival probability, and log age 65-69 survival probability, and their squared values are used as the instrumental variables in estimations. In Column (5), and (6), predicted mortality, log age 5-14 survival probability, and log age 65-69 survival probability, and their squared, and cubed values are used as the instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means that "not reported" by the test. In (1), and (2), Stock-Yogo weak ID test critical value is 13.91. In (3), and (4), Stock-Yogo weak ID test critical value is 15.72. In (5), and (6), Stock-Yogo weak ID test critical value is 16.10. Turning point is estimated for coefficients at 10% or better significance level in a Column.

Also, we find that the coefficients of the linear and the quadratic terms are both significantly different from "0" at 1% significance level, and they are negative and positive respectively in Column (2) in Table 4.7a. We further find that the coefficients of the linear and quadratic terms are insignificant in Column (4) in Table 4.7a and Table 4.7b, Columns (2), (4), (6), and (8) in Table 4.8a, Column (6) and with the exception of the linear term in Column (8) in Table 4.8b, Column (3) in Table 4.8d, Columns (2), (4), (6), and (8) in Table 4.8e, Column (6) with the exception of the linear terms in Columns (2) and (8) in Table 4.8f, and Columns (3) in Table 4.8h.

These results are not similar to the findings regarding the association between per capita GDP and LE in quadratic functional specification estimations for the 1940-1980 period. Both coefficients of the linear and quadratic terms are found negative and positive at 10% or higher significance level, respectively. Thus, our quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between years of schooling and LE for the 1940-1980 period.

Table 4.8e

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the 1940-1980 Period by Linear and Quadratic Estimations

	log years of schooling							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (age5-14 survival probability)	IV (age5-14 survival probability)	IV (both instruments)	IV (both instruments)
log life expectancy at birth	1.25***	−1.23	1.41***	8.19	1.50***	−4.30	1.44***	−0.33
	(0.19)	(3.02)	(0.30)	(7.84)	(0.32)	(5.43)	(0.24)	(4.96)
(log life expectancy at birth)^2	-	0.34	-	−0.93	-	0.77	-	0.23
		(0.41)		(1.05)		(0.72)		(0.66)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.46	0.46	0.45	0.37	0.44	0.45	0.45	0.46
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	48.41	11.49	38.91	21.70	84.51	22.82
Endogeneity test *p*-value	-	-	0.57	0.18	0.30	0.41	0.19	0.99
Hansen J statistic	-	-	e.e.i.	e.e.i.	e.e.i.	e.e.i.	0.82	0.10
C (2nd polynomial) RESET test *p*-value	0.17	0.26	0.31	0.35	0.34	0.37	0.37	0.13
C (3rd polynomial) RESET test *p*-value	0.19	0.34	0.28	0.40	0.63	0.66	0.17	0.12

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940 and 1980. The dependent variable is the log years of schooling. In Column (3) predicted mortality, and in Column (4) predicted mortality and its squared value are used as the instrumental variables. In Column (5) log age 5-14 survival probability, and in Column (6) log age 5-14 survival probability, and its squared value are used as the instrumental variables. In Column (7) predicted mortality, and log age 5-14 survival probability, and in Column (8) predicted mortality, and log age 5-14 survival probability, and their squared values are used as instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), and (5), Stock-Yogo weak ID test critical value is 16.38. In (4), and (6), Stock-Yogo weak ID test critical value is 7.03. In (7), Stock-Yogo weak ID test critical value is 19.93. In (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is not estimated for coefficients less than at 10% or better significance level in a Column.

In cubic specification for the 1940-1980 period, Columns (1), (2), (3), (4), and (5) in Table 4.7c, Columns (1), (2), (3), (4), (5), (6), (7), and (8) in Table 4.8c, Columns (5) and (6) in Table 4.8d, Columns (1), (2), (3), (4), (5), (6), (7), and (8) in Table 4.8g, and Columns (5) and (6) in Table 4.8h report the estimation results of the Model (3.2.2).

Table 4.8f

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the 1940-1980 Period with Lagged Dependent Variable in All Linear and Quadratic Estimations

	log years of schooling							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (age5-14 survival probability)	IV (age5-14 survival probability)	IV (both instruments)	IV (both instruments)
lagged log years of schooling	0.25***	0.31***	0.27***	0.37***	0.26***	0.32***	0.27***	0.35***
	(0.06)	(0.07)	(0.07)	(0.09)	(0.06)	(0.10)	(0.06)	(0.08)
log life expectancy at birth	1.47***	6.85*	1.71***	11.63**	1.50***	7.57	1.61***	9.51*
	(0.16)	(3.49)	(0.26)	(5.54)	(0.23)	(6.83)	(0.20)	(5.23)
(log life expectancy at birth)²	-	−0.72	-	−1.35*	-	−0.81	-	−1.07
		(0.47)		(0.74)		(0.90)		(0.70)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.62	0.65	0.61	0.62	0.62	0.64	0.62	0.64
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	37.60	16.65	38.40	8.79	67.35	14.02
Endogeneity test *p*-value	-	-	0.25	0.59	0.90	0.91	0.32	0.60
Hansen J statistic	-	-	e.e.i.	e.e.i.	e.e.i.	e.e.i.	0.50	0.82
C (2nd polynomial) RESET test *p*-value	0.12	0.30	0.48	0.83	0.65	0.56	0.61	0.59
C (3rd polynomial) RESET test *p*-value	0.18	0.37	0.40	0.73	0.89	0.84	0.78	0.80
Turning points	-	-	-	74.60	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940 and 1980. Lagged log years of schooling includes two observations by country for the years 1940 and 1970. The dependent variable is the log years of schooling. In Column (3) predicted mortality, and in Column (4) predicted mortality and its squared value are used as the instrumental variables. In Column (5) log age 5-14 survival probability, and in Column (6) log age 5-14 survival probability, and its squared value are used as the instrumental variables. In Column (7) predicted mortality, and log age 5-14 survival probability, and in Column (8) predicted mortality, and log age 5-14 survival probability, and their squared values are used as instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), and (5), Stock-Yogo weak ID test critical value is 16.38. In (4), and (6), Stock-Yogo weak ID test critical value is 7.03. In (7), Stock-Yogo weak ID test critical value is 19.93. In (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

We find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 10% or higher significance level, and they are negative, positive, and negative respectively in Columns (3) and (5) in Table 4.7c, and Column (1) in Table 4.8c. Estimated turning point-1s are within the range of 33.26-37.02 years; and turning point-2s are within the range of 65.80-75.62 years in Columns (3) and (5) in Table 4.7c, and Column (1) in Table 4.8c.

Table 4.8g

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the 1940-1980 Period by Cubic Estimations

	log years of schooling							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (age 5-14 survival probability)	IV (age 5-14 survival probability)	IV (both instruments)	IV (both instruments)
lagged log years of schooling	-	0.30***	-	0.42**	-	0.47	-	0.43***
		(0.07)		(0.17)		(0.42)		(0.16)
log life expectancy at birth	−119.62	−9.98	543.27	174.45	(omitted)	285.15	−21.51	187.00
	(76.32)	(62.40)	(1666.84)	(444.17)		(891.70)	(489.55)	(317.94)
(log life expectancy at birth)^2	31.10	3.63	−140.05	−43.61	0.08	−72.12	5.91	−46.73
	(19.80)	(16.09)	(432.78)	(115.48)	(0.67)	(230.00)	(127.23)	(82.32)
(log life expectancy at birth)^3	−2.67	−0.37	12.06	3.65	0.03	6.11	−0.50	3.93
	(1.71)	(1.38)	(37.46)	(10.01)	(0.12)	(19.77)	(11.03)	(7.11)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.49	0.65	−0.48	0.57	0.42	0.47	0.46	0.56
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	0.10	0.27	0.00	0.09	0.05	0.27
Endogeneity test *p*-value	-	-	0.24	0.55	0.13	0.63	0.82	0.33
Hansen J statistic	-	-	e.e.i.	e.e.i.	e.e.i.	e.e.i.	0.08	0.999
C (3rd polynomial) RESET test *p*-value	0.32	0.32	0.40	0.76	n.r.	n.r.	n.r.	n.r.
C (4rd polynomial) RESET test *p*-value	n.r.	0.51	0.39	0.55	n.r.	n.r.	n.r.	n.r.
Turning points (1)	-	-	-	-	-	-	-	-
(2)	-	-	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940, and 1980. The dependent variable is the log years of schooling. Lagged log years of schooling includes two observations by country for the years 1940, and 1970. In Column (3), and (4), predicted mortality, its squared value, and its cubed value are used as the instrumental variables. In Column (5), and (6), log age 5-14 survival probability, its squared, and cubed values are used as the instrumental variables. In Column (7), and (8), predicted mortality, and log age 5-14 survival probability, and their squared, and cubed values are used as the instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means that "not reported" by the test. In (3), (4), (5), and (6), Stock-Yogo weak ID test critical values are not available. In (7), and (8), Stock-Yogo weak ID test critical value is 12.20. Turning point is estimated for coefficients at 10% or better significance level in a Column.

Also, we find that the coefficients of the linear, quadratic, and cubic terms are insignificant in Columns (1), (2), and (4) in Table 4.7c, Columns (2), (3), (4), (5), (6), (7), and (8) in Table 4.8c, Columns (5) and (6) in Table 4.8d, Columns (1), (2), (3), (4), (5), (6), (7), and (8) in Table 4.8g, and Columns (5) and (6) in Table 4.8h. These findings are not similar to cubic functional specification estimation results of per capita GDP and LE association that suggests first a concave-, and then a convex-shaped association for the 1940-1980 period.

Hence, our cubic functional specification estimation results suggest that there is first a convex-, and then, a concave-shaped association between years of schooling and LE for the 1940-1980 period.

Table 4.8h

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the 1940-1980 Period by Linear, Quadratic and Cubic Estimations

	log years of schooling					
	(1)	(2)	(3)	(4)	(5)	(6)
	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)
lagged log years of schooling	-	0.27***	-	0.34***	-	0.26**
		(0.06)		(0.08)		(0.11)
log life expectancy at birth	1.46***	1.63***	1.16	9.01**	−262.77	−233.09
	(0.24)	(0.19)	(4.71)	(4.35)	(275.15)	(170.36)
(log life expectancy at birth)^2	-	-	0.03	−1.00*	68.58	61.74
			(0.63)	(0.58)	(71.37)	(44.07)
(log life expectancy at birth)^3	-	-	-	-	−5.94	−5.42
					(6.17)	(3.80)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.45	0.62	0.45	0.64	0.44	0.55
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	55.38	43.55	15.66	10.45	0.41	1.73
Endogeneity test *p*-value	0.14	0.13	0.61	0.35	0.30	0.14
Hansen J statistic	0.54	0.19	0.13	0.71	0.35	0.86
C (2nd polynomial) RESET test *p*-value	0.44	0.49	0.23	0.42	-	-
C (3rd polynomial) RESET test *p*-value	0.19	0.78	0.29	0.42	n.r.	n.r.
C (4rd polynomial) RESET test *p*-value	-	-	-	-	n.r.	n.r.
Turning points (1)	-	-	-	90.25	-	-
(2)	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940, and 1980. The dependent variable is the log years of schooling. Lagged log years of schooling includes two observations by country for the years 1940, and 1970. In Column (1), and (2), predicted mortality, log age 5-14 survival probability, and log age 65-69 survival probability are used as the instrumental variables in estimations. In Column (3), and (4), predicted mortality, log age 5-14 survival probability, and log age 65-69 survival probability, and their squared values are used as the instrumental variables in estimations. In Column (5), and (6), predicted mortality, log age 5-14 survival probability, and log age 65-69 survival probability, and their squared, and cubed values are used as the instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means that "not reported" by the test. In (1), and (2), Stock-Yogo weak ID test critical value is 13.91. In (3), and (4), Stock-Yogo weak ID test critical value is 15.72. In (5), and (6), Stock-Yogo weak ID test critical value is 16.10. Turning point is estimated for coefficients at 10% or better significance level in a Column.

4.4.3. Diagnostics for the 1940-2009 Period

For GMM estimations in Columns (5) and (6) of Table 4.9b, and in Column (3) of Table 4.9c, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, but AR (2) test does not. These results satisfy Arellano-Bond estimation assumptions in Chapter 2 which increase the efficiency of estimation. In addition, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level. This indicates that the instrument set is valid.

In Table 4.10a, 4.10b, 4.10c, and 4.10d, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level, with the exception of Column (2) in Table 4.10a. This indicates that there is no functional form misspecification in Table 4.10a, 4.10b, 4.10c, and 4.10d.

Table 4.9a

The Association between Years of Schooling and Life Expectancy for the Period 1940-2009 by Linear and Quadratic Estimations

	log years of schooling			
	(1)	(2)	(3)	(4)
	OLS	OLS	FE (within)	FE (within)
log life expectancy at birth	2.83***	−12.33***	1.65***	−1.12
	(0.09)	(1.86)	(0.16)	(2.86)
(log life expectancy at birth)²	-	1.89***	-	0.37
		(0.23)		(0.38)
Number of observations	376	376	376	376
Number of countries	47	47	47	47
R-squared	0.83	0.86	0.90	0.90
F test *p*-value	0.00	0.00	0.00	0.00
Country dummies	-	-	yes	yes
Time dummies	-	-	yes	yes
Turning point	-	25.92	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per ten years and per country. The dependent variable is the log years of schooling. Turning point is estimated for coefficients at 10% or better significance level in a Column.

The instrumental variables are predicted mortality, age 5-14, and age 65-69 survival probabilities. All these instruments and their squared values are valid instruments according to the weak identification test statistics excluding Columns (3), (4), (5), (6), (7), and (8) in Table 4.10b and Table 4.10c, and Columns (2), (3), (4), (5), and (6) in Table 4.10d that satisfy the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock,1997).

Table 4.9b

The Association between Years of Schooling and Life Expectancy for the Period 1940-2009 with Lagged Dependent Variable in All Linear and Quadratic Estimations

	log years of schooling					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log years of schooling	0.76***	0.80***	0.68***	0.69***	0.85***	0.85***
	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)	(0.05)
log life expectancy at birth	0.64***	6.38***	0.85***	6.69***	0.62***	8.39***
	(0.11)	(1.16)	(0.16)	(1.74)	(0.17)	(2.52)
(log life expectancy at birth)²	-	−0.72***	-	−0.75***	-	−1.01***
		(0.14)		(0.23)		(0.34)
Number of observations	329	329	329	329	282	282
Number of countries	47	47	47	47	47	47
R-squared	0.97	0.97	0.96	0.96	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.00	0.00
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.91	0.998
Hansen test *p*-value	-	-	-	-	0.26	0.23
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	84.98	-	86.12	-	65.15

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per ten years and per country. The dependent variable is the log years of schooling. Columns (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), (4), and (6) is 78.75.

Although the Stock and Yogo (2005) critical values are not available for Columns (3), (4), (5), and (6) in Table 4.10c, this problem is solved by applying this rule of thumb. Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level. This points out that the instrument set is valid.

Table 4.9c

The Association between Years of Schooling and Life Expectancy for the Period 1940-2009 by Cubic Estimations

	log years of schooling				
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano- Bond)
lagged log years of schooling	-	0.80***	-	0.64***	0.56***
		(0.03)		(0.05)	(0.07)
log life expectancy at birth	9.27	17.59	−210.33***	−103.09**	−147.96***
	(46.52)	(30.60)	(38.55)	(48.97)	(46.31)
(log life expectancy at birth)²	−3.58	−3.49	54.31***	26.76**	38.10***
	(11.75)	(7.59)	(10.00)	(12.38)	(11.72)
(log life expectancy at birth)³	0.46	0.23	−4.64***	−2.30**	−3.25***
	(0.99)	(0.63)	(0.87)	(1.04)	(0.99)
Number of observations	376	329	376	329	282
Number of countries	47	47	47	47	47
R-squared	0.86	0.97	0.92	0.96	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.00
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.85
Hansen test *p*-value	-	-	-	-	0.23
Country dummies	-	-	yes	yes	-
Time dummies	-	-	yes	yes	yes
Turning points (1)	-	-	34.63	34.03	36.24
(2)	-	-	71.34	69.75	68.72

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per ten years and per country. The dependent variable is the log years of schooling. Columns (5) is difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column.

The endogeneity test of LE fails to be rejected in Table 4.10a, 4.10b, 4.10c, and 4.10d at 10% or higher significance level with the exception of Columns (6) and (8) in Table 4.10a, Columns (5) and (7) in Table 4.10c, and Columns (1) and (5) in Table 4.10d. In Column (8) in Table 4.10a, and Column (1) in Table 4.10d, the test fails to be rejected at 5% or higher significance level. Thus, the OLS gives consistent and relatively more efficient estimates.

Table 4.10a

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the Period 1940-2009 by Linear and Quadratic Estimations

	log years of schooling							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (age5-14 survival probability)	IV (age5-14 survival probability)	IV (both instruments)	IV (both instruments)
log life expectancy at birth	1.89***	5.14	2.05***	8.32	2.15***	−7.00	2.10***	−0.75
	(0.20)	(4.60)	(0.30)	(8.20)	(0.33)	(9.95)	(0.26)	(7.65)
(log life expectancy at birth)²	-	−0.44	-	−0.85	-	1.23	-	0.38
		(0.62)		(1.09)		(1.32)		(1.01)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.66	0.66	0.65	0.66	0.65	0.59	0.65	0.64
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	50.44	9.72	41.27	19.10	90.97	18.57
Endogeneity test *p*-value	-	-	0.49	0.79	0.20	0.01	0.10	0.08
Hansen J statistic	-	-	e.e.i.	e.e.i.	e.e.i.	e.e.i.	0.77	0.09
C (2nd polynomial) RESET test *p*-value	0.13	0.01	0.49	0.09	0.90	0.37	0.35	0.36
C (3rd polynomial) RESET test *p*-value	0.22	0.02	0.22	0.23	0.91	0.47	0.53	0.55

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940 and 2009. The dependent variable is the log years of schooling. In Column (3) predicted mortality, and in Column (4) predicted mortality and its squared value are used as the instrumental variables. In Column (5) log age 5-14 survival probability, and in Column (6) log age 5-14 survival probability, and its squared value are used as the instrumental variables. In Column (7) predicted mortality, and log age 5-14 survival probability, and in Column (8) predicted mortality, and log age 5-14 survival probability, and their squared values are used as instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), and (5), Stock-Yogo weak ID test critical value is 16.38. In (4), and (6), Stock-Yogo weak ID test critical value is 7.03. In (7), Stock-Yogo weak ID test critical value is 19.93. In (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is not estimated for coefficients less than at 10% or better significance level in a Column.

4.4.4. Estimation Results for the 1940-2009 Period

In linear specification for the period 1940-2009, Columns (1) and (3) in Table 4.9a, Columns (1), (3), and (5) in Table 4.9b, Columns (1), (3), (5), and (7) in Table 4.10a and Table 4.10b, and Columns (1) and (2) in Table 4.10d report the estimation results of the Model (3.2.2). In linear specification, in the Model (3.2.2), α_2 and α_3 are restricted to be zero.

Table 4.10b

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the Period 1940-2009 with Lagged Dependent Variable in All Linear and Quadratic Estimations

	log years of schooling							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (age5-14 survival probability)	IV (age5-14 survival probability)	IV (both instruments)	IV (both instruments)
lagged log years of schooling	1.02***	1.01***	1.05***	1.06***	0.93***	0.92***	0.99***	1.00***
	(0.05)	(0.05)	(0.07)	(0.07)	(0.09)	(0.09)	(0.06)	(0.06)
log life expectancy at birth	0.21**	2.48**	0.10	−1.01	0.45*	1.05	0.27**	0.87
	(0.08)	(0.93)	(0.14)	(2.48)	(0.23)	(2.16)	(0.12)	(1.44)
(log life expectancy at birth)²	-	−0.31**	-	0.15	-	−0.08	-	−0.08
		(0.12)		(0.33)		(0.28)		(0.19)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.97	0.98	0.97	0.97	0.97	0.97	0.97	0.97
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	8.85	3.68	7.66	3.67	13.91	6.80
Endogeneity test *p*-value	-	-	0.33	0.20	0.21	0.16	0.94	0.25
Hansen J statistic	-	-	e.e.i.	e.e.i.	e.e.i.	e.e.i.	0.16	0.31
C (2nd polynomial) RESET test *p*-value	0.10	0.21	0.15	0.03	0.05	0.09	0.08	0.08
C (3rd polynomial) RESET test *p*-value	0.21	0.39	0.32	0.07	0.11	0.12	0.13	0.12
Turning points	-	58.86	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940, and 2009. Lagged log years of schooling includes two observations by country for the years 1940, and 2000. The dependent variable is the log years of schooling. In Column (3) predicted mortality, and in Column (4) predicted mortality and its squared value are used as the instrumental variables. In Column (5) log age 5-14 survival probability, and in Column (6) log age 5-14 survival probability, and its squared value are used as the instrumental variables. In Column (7) predicted mortality, and log age 5-14 survival probability, and in Column (8) predicted mortality, and log age 5-14 survival probability, and their squared values are used as instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), and (5), Stock-Yogo weak ID test critical value is 16.38. In (4), and (6), Stock-Yogo weak ID test critical value is 7.03. In (7), Stock-Yogo weak ID test critical value is 19.93. In (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

We find that the coefficient of ln LE is positive at 10% or higher significance level in Columns (1) and (3) in Table 4.9a, Columns (1), (3), and (5) in Table 4.9b, Columns (1), (3), (5), and (7) in Table 4.10a, and Columns (1), (5), and (7) Table 4.10b, and Columns (1) and (2) in Table 4.10d. These linear functional specification estimation results are not similar to the linear specification results of per capita GDP - LE association estimation for the period 1940-2009. However, these linear functional specification estimation results are consistent with the findings of the same specification estimations for the years of schooling and LE association for the 1940-1980 period. The coefficient of ln LE is found positive at 5% or higher significance level.

Table 4.10c

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the Period 1940-2009 by Cubic Estimations

	log years of schooling							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (predicted mortality)	IV (predicted mortality)	IV (age 5-14 survival probability)	IV (age 5-14 survival probability)	IV (both instruments)	IV (both instruments)
lagged log years of schooling	-	1.01***	-	1.12***	-	0.93***	-	0.99***
		(0.05)		(0.29)		(0.10)		(0.06)
log life expectancy at birth	−174.09**	−8.24	(omitted)	198.58	744.31	−122.01	484.62	−44.39
	(83.86)	(21.37)		(810.69)	(2808.63)	(212.24)	(780.96)	(83.12)
(log life expectancy at birth)²	45.78**	2.47	1.24	−51.60	−190.59	31.34	−123.88	11.54
	(21.61)	(5.51)	(1.06)	(210.30)	(719.58)	(54.14)	(200.65)	(21.30)
(log life expectancy at birth)³	−3.97**	−0.24	−0.17	4.47	16.31	−2.67	10.60	−0.99
	(1.86)	(0.47)	(0.19)	(18.18)	(61.41)	(4.60)	(17.18)	(1.82)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.70	0.98	0.66	0.91	−0.44	0.95	0.12	0.97
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	0.00	0.02	0.04	0.09	0.21	0.28
Endogeneity test *p*-value	-	-	0.38	0.38	0.01	0.27	0.02	0.36
Hansen J statistic	-	-	e.e.i.	e.e.i.	e.e.i.	e.e.i.	0.83	0.52
C (3rd polynomial) RESET test *p*-value	0.07	0.30	0.35	0.30	n.r.	0.68	n.r.	0.29
C (4rd polynomial) RESET test *p*-value	n.r.	0.44	0.40	0.54	n.r.	0.71	n.r.	0.40
Turning points (1)	31.43	-	-	-	-	-	-	-
(2)	69.36	-	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940, and 2009. The dependent variable is the log years of schooling. Lagged log years of schooling includes two observations by country for the years 1940, and 2000. In Column (3), and (4), predicted mortality, its squared value, and its cubed value are used as the instrumental variables. In Column (5), and (6), log age 5-14 survival probability, its squared, and cubed values are used as the instrumental variables. In Column (7), and (8), predicted mortality, and log age 5-14 survival probability, and their squared, and cubed values are used as the instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. “n.r.” means that “not reported” by the test. In (3), (4), (5), and (6), Stock-Yogo weak ID test critical values are not available. In (7), and (8), Stock-Yogo weak ID test critical value is 12.20. Turning point is estimated for coefficients at 10% or better significance level in a Column.

In quadratic specification for the period 1940-2009, Columns (2) and (4) in Table 4.9a, Columns (2), (4), and (6) in Table 4.9b, Columns (2), (4), (6), and (8) in Table 4.10a and Table 4.10b, and Columns (3) and (4) in Table 4.10d report the estimation results of the Model (3.2.2). In quadratic specification, in the Model (3.2.2), α_3 is restricted to be zero. We find that the coefficients of the linear and the quadratic terms are both significantly different from “0” at 5% or higher significance level, and they are positive and negative respectively in Columns (2), (4), and (6) in Table 4.9b, and Column (2) in Table 4.10b.

Estimated turning points are within the range of 58.86-86.12 years in Columns (2), (4), and (6) in Table 4.9b, and Column (2) in Table 4.10b. Also, we find that the coefficients of the linear and quadratic terms are both significantly different from “0” at 1% significance level, and they are negative and positive respectively in Column (2) in Table 4.9a. In addition, we find that the coefficients of the linear and quadratic terms are insignificant in Column (4) in Table 4.9a, Columns (4), (6), and (8) in Table 4.10b, and Columns (3) and (4) in Table 4.10d.

These results are not similar to the findings regarding the non-monotonic and U-shaped association between per capita GDP and LE in quadratic specification estimations for the period 1940-2009. Both coefficients of the linear and quadratic terms are found negative and positive at 10% or higher significance level, respectively. However, these quadratic specification estimation results are consistent with the findings of the same specification estimations for the non-monotonic and inverse U-shaped association between years of schooling and LE for the 1940-1980 period. Thus, our quadratic specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between years of schooling and LE for the period 1940-2009.

Table 4.10d

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the Period 1940-2009 by Linear, Quadratic and Cubic Estimations

	log years of schooling					
	(1)	(2)	(3)	(4)	(5)	(6)
	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)	IV (both instruments, and age 65-69 survival probability)
lagged log years of schooling	-	0.99***	-	0.99***	-	0.97***
		(0.06)		(0.06)		(0.05)
log life expectancy at birth	2.14***	0.29**	2.39	1.05	−135.09	−11.18
	(0.25)	(0.12)	(7.04)	(1.41)	(101.50)	(34.98)
(log life expectancy at birth)^2	-	-	−0.03	−0.11	35.34	3.12
			(0.94)	(0.18)	(25.88)	(8.94)
(log life expectancy at birth)^3	-	-	-	-	−3.03	−0.28
					(2.20)	(0.76)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.65	0.97	0.64	0.97	0.68	0.97
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	63.50	9.77	12.19	5.44	6.37	3.82
Endogeneity test *p*-value	0.08	0.90	0.12	0.24	0.03	0.23
Hansen J statistic	0.52	0.29	0.22	0.61	0.30	0.54
C (2nd polynomial) RESET test *p*-value	0.42	0.10	0.22	0.08	-	-
C (3rd polynomial) RESET test *p*-value	0.52	0.16	0.46	0.13	n.r.	0.14
C (4rd polynomial) RESET test *p*-value	-	-	-	-	n.r.	0.09
Turning points (1)	-	-	-	-	-	-
(2)	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1940, and 2009. The dependent variable is the log years of schooling. Lagged log years of schooling includes two observations by country for the years 1940, and 2000. In Column (1), and (2), predicted mortality, log age 5-14 survival probability, and log age 65-69 survival probability are used as the instrumental variables in estimations. In Column (3), and (4), predicted mortality, log age 5-14 survival probability, and log age 65-69 survival probability, and their squared values are used as the instrumental variables in estimations. In Column (5), and (6), predicted mortality, log age 5-14 survival probability, and log age 65-69 survival probability, and their squared, and cubed values are used as the instrumental variables in estimations. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means that "not reported" by the test. In (1), and (2), Stock-Yogo weak ID test critical value is 13.91. In (3), and (4), Stock-Yogo weak ID test critical value is 15.72. In (5), and (6), Stock-Yogo weak ID test critical value is 16.10. Turning point is not estimated for coefficients less than 10% significance level in a Column.

In cubic specification for the period 1940-2009, Columns (1), (2), (3), (4), and (5) in Table 4.9c, Columns (1), (2), (3), (4), (5), (6), (7), and (8) in Table 4.10c, and Columns (5) and (6) in Table 4.10d report the estimation results of the Model (3.2.2). We find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 5% or higher significance level, and they are negative, positive, and negative respectively in Columns (3), (4), and (5) in Table 4.9c, and Column (1) in Table 4.10c.

Estimated turning point-1s are within the range of 31.43-36.24 years; and turning point-2s are within the range of 68.72-71.34 years in Columns (3), (4), and (5) in

Table 4.9c, and Column (1) in Table 4.10c. Also, we find that the coefficients of the linear, quadratic, and cubic terms are insignificant in Columns (1) and (2) in Table 4.9c, Columns (2), (3), (4), (5), (6), (7), and (8) in Table 4.10c, and Columns (5) and (6) in Table 4.10d.

These findings are similar to cubic functional specification estimation results of per capita GDP and LE association, which suggests first a convex-, and then a concave-shaped association for the period 1940-2009. At the same time, these cubic functional specification estimation results are consistent with the findings of the same specification estimations for the years of schooling and LE association for the 1940-1980 period. Hence, cubic functional specification estimation results suggest that there is first a convex-, and then a concave-shaped association between years of schooling and LE for the period 1940-2009.

4.4.5. Diagnostics for the 1980-2009 Period

For GMM estimations, in Columns (5) and (6) of Table 4.11b, and in Column (3) of Table 4.11c, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, but AR (2) test does not reject. These results satisfy Arellano-Bond estimation assumptions in Chapter 2 which increase the efficiency of estimation. In addition, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level. This indicates that the instrument set is valid.

Table 4.11a

The Association between Years of Schooling and Life Expectancy for the 1980-2009 Period by Linear and Quadratic Estimations

	log years of schooling			
	(1)	(2)	(3)	(4)
	OLS	OLS	FE (within)	FE (within)
log life expectancy at birth	3.82***	20.48***	2.56***	58.49***
	(0.10)	(6.57)	(0.45)	(10.40)
(log life expectancy at birth)²	-	−1.97**	-	−6.84***
		(0.78)		(1.27)
Number of observations	329	329	329	329
Number of countries	47	47	47	47
R-squared	0.82	0.82	0.81	0.86
F test *p*-value	0.00	0.00	0.00	0.00
Country dummies	-	-	yes	yes
Time dummies	-	-	yes	yes
Turning point	-	-	-	71.98

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log years of schooling. The turning point is given for coefficients at 10% or better significance level in a Column. The turning point which is more than three standard deviations of the sample mean is not given.

In Table 4.12a, 4.12b, 4.12c, and 4.12d, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level by excluding Column (3) in Table 4.12c, which indicates that in Table 4.12a, 4.12b, 4.12c, and 4.12d, there is no functional form misspecification.

Table 4.11b

The Association between Years of Schooling and Life Expectancy for the 1980-2009 Period with Lagged Dependent variable in All Linear and Quadratic Estimations

	log years of schooling					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log years of schooling	0.88***	0.88***	0.79***	0.71***	0.11	0.51**
	(0.02)	(0.02)	(0.05)	(0.04)	(0.12)	(0.19)
log life expectancy at birth	0.10	1.64	0.21	20.62***	5.43***	136.34***
	(0.07)	(3.00)	(0.22)	(4.65)	(1.59)	(46.73)
(log life expectancy at birth)²	-	−0.18	-	−2.45***	-	−16.81***
		(0.35)		(0.57)		(5.82)
Number of observations	282	282	282	282	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.98	0.98	0.93	0.94	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.01	0.03
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.44	0.70
Hansen test *p*-value	-	-	-	-	0.42	0.55
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	-	-	66.53	-	57.73

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log years of schooling. Column (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (4), and (6) is 62.13.

The instrumental variables are age 1-5, age 80-84, age 65-69, crude survival probabilities, and measles vaccine coverage percent. All these instruments and their squared and cubed values are valid instruments according to the weak identification test statistics excluding Column (8) in Table 4.12a, Column (5), (6), and (8) in Table

4.12b, Columns (3), (4), (5), (6), (7), and (8) in Table 4.12c, and Column (3) and (6) in Table 4.12d, which satisfy the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock,1997). Although Stock and Yogo (2005) critical values are not available for Columns (3) and (4) in Table 4.12c, this problem is solved by applying this rule of thumb.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, by excluding Columns (5), (6), and (7) in Table 4.12a, Column (5) in Table 4.12b, and Column (5) and (7) in Table 4.12c. Furthermore, in Column (7) of Table 4.12a, Column (5) of 4.12b, and Column (7) of Table 4.12c, over-identification restrictions fail to be rejected at 5% or higher significance level, which means that the set of instruments is valid at the given significance level.

Table 4.11c

The Association between Years of Schooling and Life Expectancy for the 1980-2009 Period by Cubic Estimations

	log years of schooling				
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)
lagged log years of schooling	-	0.88***	-	0.71***	0.06
		(0.02)		(0.04)	(0.52)
log life expectancy at birth	−169.34	97.90	−472.22	27.49	−2541.43***
	(364.12)	(176.27)	(418.89)	(222.80)	(604.52)
(log life expectancy at birth)²	43.07	−22.94	119.43	−4.09	607.51***
	(86.45)	(41.66)	(99.92)	(53.09)	(150.79)
(log life expectancy at birth)³	−3.56	1.79	−10.01	0.13	−48.33***
	(6.84)	(3.28)	(7.94)	(4.22)	(12.63)
Number of observations	329	282	329	282	235
Number of countries	47	47	47	47	47
R-squared	0.82	0.98	0.86	0.94	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.03
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.11
Hansen test *p*-value	-	-	-	-	0.35
Country dummies	-	-	yes	yes	-
Time dummies	-	-	yes	yes	yes
Turning points (1)	-	-	-	-	55.87
(2)	-	-	-	-	78.02

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log years of schooling. Column (5) is difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column.

The endogeneity test of LE fails to be rejected in Table 4.12a, 4.12b, and 4.12c at 10% or higher significance level, excluding Column (4), (5), (6), and (8) in Table 4.12a, and Column (3) in Table 4.12c and 4.12d. In excluded Columns like Column (6) and (8) in Table 4.12a, and Column (3) in Table 4.12c and 4.12d, the endogeneity test of LE fails to be rejected at 5% or higher significance level. Thus, the OLS gives consistent and relatively more efficient estimates.

Table 4.12a

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the 1980-2009 Period by Linear and Quadratic Estimations

	log years of schooling							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
log life expectancy at birth	2.98***	61.66***	3.21***	30.42	4.10***	40.41**	3.05***	78.27***
	(0.50)	(10.65)	(0.95)	(20.17)	(0.86)	(18.46)	(0.57)	(18.53)
(log life expectancy at birth)²	-	−7.21***	-	−3.30	-	−4.52*	-	−9.33***
		(1.31)		(2.52)		(2.30)		(2.31)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.39	0.57	0.38	0.51	0.33	0.53	0.39	0.54
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	48.00	17.54	24.52	12.36	60.99	9.83
Endogeneity test *p*-value	-	-	0.75	0.04	0.01	0.06	0.60	0.08
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.03	0.04	0.05	0.68
C (2nd polynomial) RESET test *p*-value	0.30	0.48	0.36	0.03	0.07	0.22	0.54	0.16
C (3rd polynomial) RESET test *p*-value	0.12	0.48	0.32	0.08	0.19	0.46	0.72	0.33
Turning points	-	72.20	-	-	-	87.39	-	66.39

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log years of schooling. In Column (3) log one-to-five years survival probability, and in Column (4) log one-to-five years survival probability, and its squared value are used as the instrumental variables. In Column (5) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and in Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and their squared values are used as instrumental variables. In Column (7) log crude survival probability, and log age 80-84 survival probability, and in Column (8) log crude survival probability, and log age 80-84 survival probability, and their squared values are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), and (7), Stock-Yogo weak ID test critical value is 19.93. In (6), and (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), (6), and (8) Columns is 75.33.

4.4.6. Estimation Results for the 1980-2009 Period

In linear specification for the 1980-2009 period, Columns (1) and (3) in Table 4.11a, Columns (1), (3), and (5) in Table 4.11b, Columns (1), (3), (5), and (7) in Table 4.12a and Table 4.12b, and Columns (1) and (2) in Table 4.12d report the estimation results of the Model (3.2.2). In linear specification, in the Model (3.2.2), α_2 and α_3 are restricted to be zero.

Table 4.12b

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the 1980-2009 Period with Lagged Dependent Variable in All Linear and Quadratic Estimations

	log years of schooling							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
lagged log years of schooling	1.05***	1.01***	1.06***	1.03***	1.04***	1.03***	1.05***	1.00***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)
log life expectancy at birth	0.18	9.21**	0.10	4.89	0.23	5.92	0.21	11.77
	(0.23)	(3.78)	(0.34)	(4.72)	(0.32)	(4.75)	(0.29)	(7.51)
(log life expectancy at birth)²	-	−1.09**	-	−0.57	-	−0.70	-	−1.41
		(0.45)		(0.57)		(0.58)		(0.92)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	23.43	17.64	12.60	12.82	32.22	7.33
Endogeneity test *p*-value	-	-	0.74	0.49	0.97	0.11	0.72	0.95
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.07	0.10	0.12	0.37
C (2nd polynomial) RESET test *p*-value	0.93	0.66	0.96	0.83	0.82	0.22	0.58	0.70
C (3rd polynomial) RESET test *p*-value	0.24	0.15	0.20	0.15	0.38	0.39	0.39	0.13
Turning points	-	67.49	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log years of schooling. Lagged log years of schooling includes two observations by country for the years 1980 and 2005. In Column (3) log one-to-five years survival probability, and in Column (4) log one-to-five years survival probability, and its squared value are used as the instrumental variables. In Column (5) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and in Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and their squared values are used as the instrumental variables. In Column (7) log crude survival probability, and log age 80-84 survival probability, and in Column (8) log crude survival probability, and log age 80-84 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), and (7), Stock-Yogo weak ID test critical value is 19.93. In (6), and (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

We find that the coefficient of ln LE is positive at 1% significance level in Columns (1) and (3) in Table 4.11a, Column (5) in Table 4.11b, Columns (1), (3), (5), and (7) in Table 4.12a, and Columns (1) in Table 4.12d. Furthermore, we find that the coefficients of the linear terms are insignificant in Columns (1) and (3) in Table 4.11b, Columns (1), (3), (5), and (7) in Table 4.12b, and Column (2) in Table 4.12d.

These linear functional specification estimation results are similar to the linear specification results of per capita GDP-LE association estimation for the 1980-2009 period. At the same time, these linear functional specification estimation results are consistent with the findings of the same specification estimations for the years of schooling and LE association. The coefficient of ln LE is found positive at 10% or higher significance level for the 1940-1980 period and 1940-2009.

Table 4.12c

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the 1980-2009 Period by Cubic Estimations

	log years of schooling							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
lagged log years of schooling	-	1.00***	-	1.02***	-	1.02***	-	0.99***
		(0.06)		(0.07)		(0.06)		(0.07)
log life expectancy at birth	−296.46	−3.23	−444.74	67.10	−202.38	−3.01	−305.72	−104.96
	(593.66)	(196.37)	(599.77)	(198.69)	(571.33)	(204.37)	(669.75)	(227.36)
(log life expectancy at birth)^2	77.95	1.87	109.99	−15.38	53.84	1.49	82.73	26.54
	(141.37)	(46.77)	(142.24)	(47.35)	(135.46)	(48.78)	(159.64)	(54.55)
(log life expectancy at birth)^3	−6.75	−0.24	−9.01	1.18	−4.69	−0.18	−7.35	−2.23
	(11.22)	(3.71)	(11.24)	(3.76)	(10.70)	(3.88)	(12.68)	(4.36)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.58	0.95	0.53	0.95	0.56	0.95	0.54	0.95
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	16.62	17.51	8.45	7.92	3.55	3.04
Endogeneity test *p*-value	-	-	0.08	0.33	0.41	0.29	0.38	0.97
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.01	0.12	0.07	0.47
C (3rd polynomial) RESET test *p*-value	0.16	0.04	0.01	0.16	0.92	0.41	0.65	0.02
C (4rd polynomial) RESET test *p*-value	0.26	0.07	0.03	0.24	0.91	0.63	n.r.	0.05
Turning points (1)	-	-	-	-	-	-	-	-
(2)	-	-	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980, and 2009. The dependent variable is the log years of schooling. Lagged log years of schooling includes two observations by country for the years 1980, and 2005. In Column (3), and Column (4) log one-to-five years survival probability, its squared, and cubed values are used as the instrumental variables. In Column (5), and Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), their squared, and cubed values are used as the instrumental variables. In Column (7), and Column (8) log crude survival probability, and log age 80-84 survival probability, their squared, and cubed values are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means that "not reported" by the test. In (3), and (4), Stock-Yogo weak ID test critical values are not available. In (5), (6), (7), and (8), Stock-Yogo weak ID test critical value is 12.20. Turning point is not estimated for coefficients less than 10% significance level in a Column.

In quadratic specification for the 1980-2009 period, Columns (2) and (4) in Table 4.11a, Columns (2), (4), and (6) in Table 4.11b, Columns (2), (4), (6), and (8) in Table 4.12a and Table 4.12b, and Columns (3) and (4) in Table 4.12d report the estimation results of the Model (3.2.2). In quadratic specification, in the Model (3.2.2), α_3 is restricted to be zero. We find that the coefficients of the linear and quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are positive and negative respectively in Columns (2) and (4) in Table 4.11a, Columns (4) and (6) in Table 4.11b, Columns (4), (6), and (8) in Table 4.12a, Column (2) in Table 4.12b, and Column (3) in Table 4.12d.

Estimated turning points are within the range of 57.73-87.39 years in Columns (2) and (4) in Table 4.11a, Columns (4) and (6) in Table 4.11b, Columns (4), (6), and (8) in Table 4.12a, Column (2) in Table 4.12b, and Column (3) in Table 4.12d. Furthermore, we find that the coefficients of the linear and quadratic terms are insignificant in Columns (2) in Table 4.11b, Column (4) in Table 4.12a, Columns (4), (6), and (8) in Table 4.12b, and Column (4) in Table 4.12d.

These results are similar to the findings of the non-monotonic and inverse U-shaped association between per capita GDP and LE in quadratic specification estimations for the 1980-2009 period. Both coefficients of the linear and quadratic terms are found positive and negative at 10% or higher significance level, respectively.

At the same time, these quadratic specification estimation results are consistent with the findings of the same specification estimations for the non-monotonic and inverse U- shaped association between years of schooling and LE for the periods 1940-1980 and 1940-2009. Thus, our quadratic specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between years of schooling and LE for the 1980-2009 period.

In cubic specification for the 1980-2009 period, Columns (1), (2), (3), (4), and (5) in Table 4.11c, Columns (1), (2), (3), (4), (5), (6), (7), and (8) in Table 4.12c, and Columns (5) and (6) in Table 4.12d report the estimation results of the Model (3.2.2). We find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 1% significance level, and they are negative, positive, and negative respectively in Column (5) in Table 4.11c.

Table 4.12d

Long-Difference Estimations for the Association between Years of Schooling and Life Expectancy for the 1980-2009 Period by Linear, Quadratic and Cubic Estimations

	log years of schooling					
	(1)	(2)	(3)	(4)	(5)	(6)
	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)
lagged log years of schooling	-	1.04***	-	1.02***	-	1.01***
		(0.06)		(0.06)		(0.06)
log life expectancy at birth	3.04***	0.24	69.97***	4.93	20.05	72.98
	(0.56)	(0.29)	(15.41)	(4.32)	(555.65)	(243.48)
(log life expectancy at birth)^2	-	-	−8.30***	−0.57	3.81	−16.64
			(1.92)	(0.52)	(132.24)	(58.19)
(log life expectancy at birth)^3	-	-	-	-	−0.97	1.27
					(10.49)	(4.64)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.39	0.95	0.55	0.95	0.57	0.95
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	39.44	20.13	14.72	24.00	20.48	12.27
Endogeneity test *p*-value	0.61	0.75	0.08	0.73	0.96	0.86
Hansen J statistic	0.14	0.24	0.78	0.41	0.10	0.38
C (2nd polynomial) RESET test *p*-value	0.50	0.58	0.72	0.79	-	-
C (3rd polynomial) RESET test *p*-value	0.72	0.33	0.47	0.15	0.94	0.10
C (4rd polynomial) RESET test *p*-value	-	-	-	-	n.r.	n.r.
Turning points (1)	-	-	67.71	-	-	-
(2)	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980, and 2009. The dependent variable is the log years of schooling. Lagged log years of schooling includes two observations by country for the years 1980, and 2005. In (1), and (2), log crude survival probability, log age 80-84 survival probability, and log age 65-69 survival probability are used as the instrumental variables. In (3), and (4), log crude survival, log age 80-84 survival, and log age 65-69 survival probabilities, their squared values are used as the instrumental variables. In (5), and (6), log crude survival, log age 80-84 survival, and log age 65-69 survival probabilities, and their squared, and cubed values are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (1), and (2), Stock-Yogo weak ID test critical value is 13.91. In (3), and (4), Stock-Yogo weak ID test critical value is 15.72. In (5), and (6), Stock-Yogo weak ID test critical value is 16.10. Turning point is estimated for coefficients at 10% or better significance level in a Column.

Estimated turning point-1 is 55.87 years; and turning point-2 is 78.02 years in Column (5) in Table 4.11c. Also, we find that the coefficients of the linear, quadratic, and cubic terms are insignificant in Columns (1), (2), (3), and (4) in Table 4.11c, Columns (1), (2), (3), (4), (5), (6), (7), and (8) in Table 4.12c, and Columns (5) and (6) in Table 4.12d. This finding is similar to the cubic functional specification estimation results for the association between per capita GDP and LE for the 1980-2009 period, and between years of schooling and LE for the 1940-1980 period, and 1940-2009. Hence, cubic functional specification estimation results suggest that there is first a convex-, and then a concave-shaped association between years of schooling and LE for the 1980-2009 period.

4.5. Estimation Results for GDP per Person Engaged

4.5.1. Diagnostics for the 1980-2009 Period

For GMM estimations in Columns (5) and (6) of Table 4.13b, and in Column (3) of Table 4.13c, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, but AR (2) test does not. These results satisfy Arellano-Bond estimation assumptions in Chapter 2 that increase the efficiency of estimation. In addition, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, which indicates that the set of instruments is appropriate.

Table 4.13a

The Association between GDP per Person Engaged and Life Expectancy for the 1980-2009 Period by Linear and Quadratic Estimations

	log GDP per person engaged			
	(1)	(2)	(3)	(4)
	OLS	OLS	FE (within)	FE (within)
log life expectancy at birth	8.29***	−102.25***	−0.90	7.41
	(0.39)	(26.89)	(1.19)	(43.10)
(log life expectancy at birth)²	-	13.06***	-	−1.02
	-	(3.16)	-	(5.32)
Number of observations	329	329	329	329
Number of countries	47	47	47	47
R-squared	0.67	0.69	0.44	0.44
F test *p*-value	0.00	0.00	0.00	0.00
Country dummies	-	-	yes	yes
Time dummies	-	-	yes	yes
Turning point	-	50.09	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log GDP per person engaged. Turning point is estimated for coefficients at 10% or better significance level in a Column.

In Table 4.14a, 4.14b, 4.14c, and 4.14d, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level by excluding Column (6) in Table 4.14c, which indicates that in Table 4.14a, 4.14b, 4.14c, and 4.14d, there is no functional form misspecification.

Table 4.13b

The Association between GDP per Person Engaged and Life Expectancy for the 1980-2009 Period with Lagged Value of Dependent Variable in All Linear and Quadratic Estimations

	log GDP per person engaged					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log GDP per person engaged	0.91***	0.91***	0.76***	0.76***	0.95***	0.91***
	(0.02)	(0.02)	(0.06)	(0.06)	(0.10)	(0.10)
log life expectancy at birth	0.88***	−1.70	0.82*	33.48*	1.65**	125.71***
	(0.15)	(6.20)	(0.41)	(18.28)	(0.66)	(27.45)
(log life expectancy at birth)²	-	0.31	-	−3.97*	-	−15.12***
	-	(0.73)	-	(2.20)	-	(3.33)
Number of observations	282	282	282	282	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.99	0.99	0.84	0.85	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.00	0.01
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.46	0.20
Hansen test *p*-value	-	-	-	-	0.12	0.24
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	-	-	67.61	-	63.81

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log GDP per person engaged. Column (5) is difference GMM estimation. Column (6) is two-step difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (4) and (6) Columns is 65.71.

The instrumental variables are age 1-5, age 80-84, age 65-69, crude survival probabilities, and measles vaccine coverage percent. All these instruments and their squared and cubed values are valid instruments according to the weak identification test statistics by excluding Column (8) in Table 4.14a, Column (6) in Table 4.14b, Columns (3), (4), (5), (6), (7), and (8) in Table 4.14c, and Column (3), (4), and (6) in Table 4.14d which satisfy the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock,1997). Although Stock and Yogo (2005) critical values are not available for Columns (3) and (4) in Table 4.14c, this problem is solved by applying this rule of thumb.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, by excluding Columns (5), (6), and (7) in Table 4.14a, Column (7) in Table 4.14b, Column (5) in Table 4.14c, and Columns (1), (3), and (4) in Table 4.14d. In excluded Columns like Column (7) in Table 4.14b, and Column (1) and (4) in Table 4.14d, over-identification restrictions fail to be rejected at 5% or higher significance level, which indicates that the set of instruments is appropriate at the given significance level.

Table 4.13c

The Association between GDP per Person Engaged and Life Expectancy for the 1980-2009 Period by Cubic Estimations

	log GDP per person engaged				
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)
lagged log GDP per person engaged	-	0.91***	-	0.79***	0.96***
		(0.02)		(0.06)	(0.12)
log life expectancy at birth	228.41	−907.38**	1358.75	−955.87**	−1172.49***
	(1317.50)	(388.41)	(937.69)	(363.94)	(320.28)
(log life expectancy at birth)^2	−65.39	214.39**	−322.53	230.41**	282.65***
	(312.06)	(91.76)	(223.27)	(85.70)	(75.80)
(log life expectancy at birth)^3	6.20	−16.86**	25.49	−18.50***	−22.70***
	(24.63)	(7.22)	(17.72)	(6.73)	(5.98)
Number of observations	329	282	329	282	235
Number of countries	47	47	47	47	47
R-squared	0.69	0.99	0.45	0.85	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.00
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.44
Hansen test *p*-value	-	-	-	-	0.42
Country dummies	-	-	yes	yes	-
Time dummies	-	-	yes	yes	Yes
Turning points (1)	-	59.35	-	57.64	58.21
(2)	-	80.86	-	69.93	69.14

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log GDP per person engaged. Column (5) is difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column.

The endogeneity test of LE fails to be rejected in Table 4.14a, 4.14b, 4.14c, and 4.14d at 10% or higher significance level by excluding Column (4) and (8) in Table 4.14a, Column (8) in Table 4.14b, Column (4) and (6) in Table 4.14c, and Column (2) in Table 4.14d. In excluded Columns (Column (4) in Table 4.14a, Column (8) in Table 4.14b, Column (4) in Table 4.14c, and Column (2) in Table 4.14d), the endogeneity test of LE fails to be rejected at 5% or higher significance level. Thus, the OLS gives consistent and relatively more efficient estimates.

Table 4.14a

Long-Difference Estimations for the Association between GDP per Person Engaged and Life Expectancy for the 1980-2009 Period by Linear and Quadratic Estimations

	log GDP per person engaged							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
log life expectancy at birth	−0.35	10.52	−1.05	−30.67	0.75	2.46	−1.93	162.92**
	(1.38)	(53.64)	(2.18)	(76.76)	(1.93)	(69.39)	(1.62)	(75.60)
(log life expectancy at birth)²	-	−1.34	-	3.60	-	−0.36	-	−20.46**
		(6.64)		(9.51)		(8.65)		(9.43)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.002	0.004	−0.01	−0.04	−0.02	0.003	−0.04	−0.60
F test *p*-value	0.80	0.96	0.64	0.48	0.71	0.94	0.25	0.09
Weak identification test statistic	-	-	48.00	17.54	24.52	12.36	60.99	9.83
Endogeneity test *p*-value	-	-	0.67	0.07	0.13	0.70	0.27	0.001
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.02	0.02	0.03	0.59
C (2nd polynomial) RESET test *p*-value	0.10	0.43	0.46	0.23	0.41	0.90	0.76	0.02
C (3rd polynomial) RESET test *p*-value	0.20	0.03	0.51	0.49	0.70	0.46	0.78	0.06
Turning point	-	-	-	-	-	-	-	53.64

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log GDP per person engaged. In Column (3) log one-to-five years survival probability, and in Column (4) log one-to-five years survival probability, and its squared value are used as the instrumental variables. In Column (5) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and in Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and their squared values are used as instrumental variables. In Column (7) log crude survival probability, and log age 80-84 survival probability, and in Column (8) log crude survival probability, and log age 80-84 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), and (7), Stock-Yogo weak ID test critical value is 19.93. In (6), and (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

4.5.2. Estimation Results for the 1980-2009 Period

In linear specification for the 1980-2009 period, Columns (1) and (3) in Table 4.13a, Columns (1), (3), and (5) in Table 4.13b, Columns (1), (3), (5), and (7) in Table 4.14a and Table 4.14b, and Columns (1) and (2) in Table 4.14d report the estimation results of the Model (3.2.3). In linear specification, in the Model (3.2.3), α_2 and α_3 are restricted to be zero.

We find that the coefficient of ln LE is positive at 10% or higher significance level in Column (1) in Table 4.13a, Columns (1), (3), and (5) in Table 4.13b, Columns (1), (3), (5), and (7) in Table 4.14b, and Columns (2) in Table 4.14d. In addition, we find that the coefficients of the linear terms are insignificant in Columns (3) in Table 4.13a, Columns (1), (3), (5), and (7) in Table 4.14a, and Column (1) in Table 4.14d. These linear functional specification estimation results are similar to the linear specification results of the estimations for association between per capita GDP and LE, and between years of schooling and LE for the 1980-2009 period.

Table 4.14b

Long-Difference Estimations for the Association between GDP per Person Engaged and Life Expectancy for the 1980-2009 Period with Lagged Value of Dependent Variable in All Linear and Quadratic Estimations

	log GDP per person engaged							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
lagged log GDP per person engaged	1.08***	1.08***	1.08***	1.09***	1.08***	1.09***	1.07***	1.08***
	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
log life expectancy at birth	0.72***	22.81***	0.83**	20.50*	1.01***	20.20*	0.53*	20.13**
	(0.26)	(7.93)	(0.38)	(11.08)	(0.32)	(11.41)	(0.32)	(9.78)
(log life expectancy at birth)²	-	−2.71***	-	−2.39*	-	−2.36*	-	−2.42**
		(0.96)		(1.37)		(1.41)		(1.19)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.96	0.97	0.96	0.97	0.96	0.97	0.96	0.97
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	49.91	15.88	26.92	9.98	64.08	12.32
Endogeneity test *p*-value	-	-	0.77	0.21	0.16	0.14	0.12	0.06
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.41	0.33	0.07	0.22
C (2nd polynomial) RESET test *p*-value	0.11	0.03	0.15	0.08	0.13	0.10	0.07	0.07
C (3rd polynomial) RESET test *p*-value	0.21	0.07	0.35	0.17	0.29	0.03	0.18	0.19
Turning points	-	67.18	-	73.29	-	71.79	-	63.97

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log GDP per person engaged. Lagged log GDP per person engaged includes two observations by country for the years 1980 and 2005. In Column (3) log one-to-five years survival probability, and in Column (4) log one-to-five years survival probability, and its squared value are used as the instrumental variables. In Column (5) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and in Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and their squared values are used as instrumental variables. In Column (7) log crude survival probability, and log age 80-84 survival probability, and in Column (8) log crude survival probability, and log age 80-84 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), and (7), Stock-Yogo weak ID test critical value is 19.93. In (6), and (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), (4), (6), and (8) columns is 69.06.

In quadratic specification for the 1980-2009 period, Columns (2) and (4) in Table 4.13a, Columns (2), (4), and (6) in Table 4.13b, Columns (2), (4), (6), and (8) in Table 4.14a and Table 4.14b, and Columns (3) and (4) in Table 4.14d report the estimation results of the Model (3.2.3). In quadratic specification, in the Model (3.2.3), α_3 is restricted to be zero. We find that the coefficients of the linear and the quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are positive and negative respectively in Columns (4) and (6) in Table 4.13b, Column (8) in Table 4.14a, Columns (2), (4), (6), and (8) in Table 4.14b, and Column (4) in Table 4.14d.

Estimated turning points are within the range of 53.64-73.29 years in these Columns. Also, we find that the coefficients of the linear and the quadratic terms are both significantly different from "0" at 1% significance level, and they are negative and positive respectively in Column (2) in Table 4.13a. In addition, we find that the coefficients of the linear and quadratic terms are insignificant in Column (4) in Table 4.13a, Column (2) in Table 4.13b, Columns (2), (4), and (6) in Table 4.14a, and Column (3) in Table 4.14d.

Table 4.14c

Long-Difference Estimations for the Association between GDP per Person Engaged and Life Expectancy for the 1980-2009 Period by Cubic Estimations

	log GDP per person engaged							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
lagged log GDP per person engaged	-	1.10***	-	1.11***	-	1.11***	-	1.11***
		(0.04)		(0.04)		(0.04)		(0.04)
log life expectancy at birth	2914.89*	−374.66	2660.35	−735.56**	2727.89*	−773.82**	1263.47	−649.60*
	(1484.00)	(297.81)	(1806.28)	(322.06)	(1629.21)	(327.36)	(1728.42)	(344.93)
(log life expectancy at birth)^2	−691.89*	91.82	−638.06	178.03**	−647.71*	187.09**	−283.11	157.49*
	(352.28)	(70.55)	(428.56)	(76.44)	(388.85)	(77.51)	(412.39)	(82.19)
(log life expectancy at birth)^3	54.72*	−7.49	51.02	−14.36**	51.23*	−15.07**	20.90	−12.72*
	(27.87)	(5.57)	(33.89)	(6.05)	(30.95)	(6.12)	(32.82)	(6.53)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.10	0.97	0.03	0.97	0.09	0.97	−0.44	0.97
F test *p*-value	0.28	0.00	0.39	0.00	0.39	0.00	0.18	0.00
Weak identification test statistic	-	-	16.62	15.47	8.45	8.52	3.55	6.55
Endogeneity test *p*-value	-	-	0.23	0.08	0.51	0.04	0.16	0.28
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.03	0.92	0.83	0.25
C (3rd polynomial) RESET test *p*-value	n.r.	0.06	0.11	0.11	0.74	0.01	0.17	0.11
C (4rd polynomial) RESET test *p*-value	n.r	0.04	0.19	0.10	0.67	0.02	0.23	0.12
Turning points (1)	61.47	-	-	57.39	60.91	57.80	-	57.78
(2)	74.57	-	-	67.82	75.11	67.92	-	66.35

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980, and 2009. The dependent variable is the log GDP per person engaged. Lagged log log GDP per person engaged includes two observations by country for the years 1980, and 2005. In Column (3), and Column (4) log one-to-five years survival probability, its squared, and cubed values are used as the instrumental variables. In Column (5), and Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), their squared, and cubed values are used as the instrumental variables. In Column (7), and Column (8) log crude survival probability, and log age 80-84 survival probability, their squared, and cubed values are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means that "not reported" by the test. In (3), and (4), Stock-Yogo weak ID test critical values are not available. In (5), (6), (7), and (8), Stock-Yogo weak ID test critical value is 12.20. Turning point is estimated for coefficients at 10% or better significance level in a Column.

These results are similar to the findings of non-monotonic and inverse U-shaped association between per capita GDP and LE, and years of schooling and LE in quadratic specification estimations for the 1980-2009 period. Thus, our quadratic specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between GDP per person engaged and LE for the 1980-2009 period.

Table 4.14d

Long-Difference Estimations for the Association between GDP per Person Engaged and Life Expectancy for the 1980-2009 Period by Linear, Quadratic and Cubic Estimations

	log GDP per person engaged					
	(1)	(2)	(3)	(4)	(5)	(6)
	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)
lagged log GDP per person engaged	-	1.07***	-	1.08***	-	1.11***
		(0.04)		(0.04)		(0.04)
log life expectancy at birth	−1.80	0.53*	73.92	28.87***	3133.95**	−576.50*
	(1.65)	(0.31)	(82.12)	(10.29)	(1241.06)	(307.10)
(log life expectancy at birth)^2	-	-	−9.40	−3.50***	−736.56**	140.57*
			(10.22)	(1.26)	(296.75)	(72.76)
(log life expectancy at birth)^3	-	-	-	-	57.60**	−11.42**
					(23.69)	(5.75)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	−0.03	0.96	−0.15	0.97	−0.02	0.97
F test *p*-value	0.29	0.00	0.40	0.00	0.03	0.00
Weak identification test statistic	39.44	41.74	14.72	12.46	20.48	13.08
Endogeneity test *p*-value	0.25	0.09	0.12	0.40	0.13	0.37
Hansen J statistic	0.07	0.19	0.04	0.09	0.27	0.16
C (2nd polynomial) RESET test *p*-value	0.43	0.07	0.53	0.58	-	-
C (3rd polynomial) RESET test *p*-value	0.52	0.17	0.20	0.72	0.66	0.10
C (4rd polynomial) RESET test *p*-value	-	-	-	-	0.49	0.21
Turning points (1)	-	-	-	62.24	59.09	56.08
(2)	-	-	-	-	85.33	65.25

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980, and 2009. The dependent variable is the log GDP per person engaged. Lagged log GDP per person engaged includes two observations by country for the years 1980, and 2005. In (1), and (2), log crude survival probability, log age 80-84 survival probability, and log age 65-69 survival probability are used as the instrumental variables. In (3), and (4), log crude survival, log age 80-84 survival, and log age 65-69 survival probabilities, their squared values are used as the instrumental variables. In (5), and (6), log crude survival, log age 80-84 survival, and log age 65-69 survival probabilities, and their squared, and cubed values are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (1), and (2), Stock-Yogo weak ID test critical value is 13.91. In (3), and (4), Stock-Yogo weak ID test critical value is 15.72. In (5), and (6), Stock-Yogo weak ID test critical value is 16.10. Turning point is estimated for coefficients at 10% or better significance level in a Column.

In cubic specification for the 1980-2009 period, Columns (1), (2), (3), (4), and (5) in Table 4.13c, Columns (1), (2), (3), (4), (5), (6), (7), and (8) in Table 4.14c, and Columns (5) and (6) in Table 4.14d report the estimation results of the Model (3.2.3). We find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 10% or higher significance level, and they are negative, positive, and negative respectively in Columns (1), (2), (3), (4), and (5) in Table 4.13c, Columns (4), (6), and (8) in Table 4.14c, and Column (6) in Table 4.14d.

Estimated turning point-1s are within the range of 56.08-59.35 years; and turning point-2s are within the range of 65.25-80.86 years in these columns. Also, we find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 10% or higher significance level, and they are positive, negative, and positive respectively in Columns (1), and (5) in Table 4.14c, and Column (5) in Table 4.14d. Also, we find that the coefficients of the linear, quadratic, and cubic terms are insignificant in Columns (1) and (3) in Table 4.13c, and Columns (1), (2), (3), and (7) in Table 4.14c.

These findings are similar to cubic functional specification estimation results of the per capita GDP and LE association, and years of schooling and LE association which both suggest first a convex- , and then a concave-shaped association for the 1980-2009 period. Hence, cubic functional specification estimation results suggest that there is first a convex-, and then a concave-shaped association between GDP per person engaged and LE for the 1980-2009 period.

4.6. Estimation Results for Productivity

4.6.1. Diagnostics for the 1980-2009 Period

For GMM estimations in Columns (5) and (6) of Table 4.15b, and in Column (3) of Table 4.15c, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, but AR (2) test does not. These results satisfy Arellano-Bond estimation assumptions in Chapter 2 that increase the efficiency of estimation. Furthermore, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, which shows that the instrument set is valid.

Table 4.15a

The Association between Productivity and Life Expectancy for the 1980-2009 Period by Linear and Quadratic Estimations

	log productivity			
	(1)	(2)	(3)	(4)
	OLS	OLS	FE (within)	FE (within)
log life expectancy at birth	8.09***	−5.07	1.82	71.69
	(0.50)	(32.19)	(1.77)	(58.91)
(log life expectancy at birth)²	-	1.56	-	−8.54
		(3.78)		(7.29)
Number of observations	329	329	329	329
Number of countries	47	47	47	47
R-squared	0.58	0.58	0.05	0.08
F test *p*-value	0.00	0.00	0.00	0.00
Country dummies	-	-	yes	yes
Time dummies	-	-	yes	yes
Turning points	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log productivity. Turning point is not estimated for coefficients less than 10% significance level in a Column.

In Table 4.16a, 4.16b, 4.16c, and 4.16d, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level by excluding Column (8) in Table 4.16b. This indicates that in Table 4.16a, 4.16b, 4.16c, and 4.16d, there is no functional form misspecification.

Table 4.15b

The Association between Productivity and Life Expectancy for the 1980-2009 Period with Lagged Value of Dependent Variable in All Linear and Quadratic Estimations

	log productivity					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log productivity	0.91***	0.91***	0.76***	0.75***	0.57***	0.85***
	(0.03)	(0.03)	(0.07)	(0.06)	(0.10)	(0.17)
log life expectancy at birth	0.46*	20.73**	1.77***	60.12*	1.86**	210.66**
	(0.27)	(10.35)	(0.57)	(34.01)	(0.88)	(102.48)
(log life expectancy at birth)²	-	−2.39*	-	−7.10*	-	−25.46**
		(1.22)		(4.10)		(12.58)
Number of observations	282	282	282	282	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.96	0.96	0.60	0.62	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.00	0.01
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.17	0.16
Hansen test *p*-value	-	-	-	-	0.55	0.50
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	76.78	-	69.07	-	62.64

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log productivity. Column (5) is difference GMM estimation. Column (6) is difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), (4) and (6) Columns is 69.49.

The instrumental variables are age 1-5, age 80-84, age 65-69, crude survival probabilities, and measles vaccine coverage percent. All these instruments and their squared and cubed values are valid instruments according to the weak identification test statistics by excluding Column (8) in Table 4.16a and 4.16b, Columns (3), (4), (5), (6), (7), and (8) in Table 4.16c, and Column (3), (4), and (6) in Table 4.16d which satisfy the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock, 1997). Although Stock and Yogo (2005) critical values are not available for Columns (3) and (4) in Table 4.16c, this problem is solved by applying this rule of thumb.

Table 4.15c

The Association between Productivity and Life Expectancy for the 1980-2009 Period by Cubic Estimations

	log productivity				
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)
lagged log productivity	-	0.91***	-	0.75***	0.85***
		(0.03)		(0.06)	(0.21)
log life expectancy at birth	−1681.90	−778.54	−50.22	−973.78	−3237.39**
	(1711.61)	(730.91)	(1426.29)	(646.28)	(1280.62)
(log life expectancy at birth)²	399.42	186.53	20.46	237.75	771.35**
	(405.73)	(172.87)	(340.85)	(151.24)	(298.18)
(log life expectancy at birth)³	−31.45	−14.88	−2.30	−19.32	−61.24**
	(32.05)	(13.62)	(27.15)	(11.80)	(23.10)
Number of observations	329	282	329	282	235
Number of countries	47	47	47	47	47
R-squared	0.58	0.96	0.08	0.62	-
F test *p*-value	0.61	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.01
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.20
Hansen test *p*-value	-	-	-	-	0.11
Country dummies	-	-	yes	yes	-
Time dummies	-	-	yes	yes	yes
Turning points (1)	-	-	-	-	61.68
(2)	-	-	-	-	71.87

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log productivity. Column (5) is difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, by excluding Columns (5), (6), and (7) in Table 4.16a, Column (5) in Table 4.16c, and Columns (1) and (3) in Table 4.16d. In excluded Columns (Column (6) in Table 4.16a, Column (5) in Table 4.16c, Columns (1) and (3) in Table 4.16d), over-identification restrictions fail to be rejected at 5% or higher significance level, which indicates that the set of instruments is appropriate at given significance level.

The endogeneity test of LE fails to be rejected in Table 4.16a, 4.16b, 4.16c, and 4.16d at 10% or higher significance level by excluding Column (5) and (8) in Table 4.16a, and Column (6) in Table 4.16c. In excluded Columns (Column (5) in Table 4.16a, and Column (6) in Table 4.16c), the endogeneity test of LE fails to be rejected at 5% or higher significance level. Thus, the OLS gives consistent and relatively more efficient estimates.

Table 4.16a

Long-Difference Estimations for the Association between Productivity and Life Expectancy for the 1980-2009 Period by Linear and Quadratic Estimations

	log productivity							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
log life expectancy at birth	3.06	93.02	2.93	12.62	6.03**	61.58	2.11	259.05**
	(1.90)	(77.76)	(3.18)	(104.90)	(2.91)	(96.97)	(2.26)	(103.31)
(log life expectancy at birth)²	-	−11.04	-	−1.17	-	−7.11	-	−31.84**
		(9.65)		(13.02)		(12.12)		(12.87)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.06	0.12	0.06	0.07	0.00	0.11	0.05	−0.17
F test *p*-value	0.11	0.04	0.37	0.37	0.05	0.05	0.37	0.01
Weak identification test statistic	-	-	48.00	17.54	24.52	12.36	60.99	9.83
Endogeneity test *p*-value	-	-	0.96	0.17	0.07	0.96	0.58	0.01
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.01	0.05	0.03	0.94
C (2nd polynomial) RESET test *p*-value	0.23	0.15	0.86	0.16	0.44	0.95	0.79	0.54
C (3rd polynomial) RESET test *p*-value	0.46	0.35	0.86	0.28	0.73	0.53	0.66	0.10
Turning point	-	-	-	-	-	-	-	58.43

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log productivity. In Column (3) log one-to-five years survival probability, and in Column (4) log one-to-five years survival probability, and its squared value are used as the instrumental variables. In Column (5) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and in Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and their squared values are used as instrumental variables. In Column (7) log crude survival probability, and log age 80-84 survival probability, and in Column (8) log crude survival probability, and log age 80-84 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), and (7), Stock-Yogo weak ID test critical value is 19.93. In (6), and (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

4.6.2. Estimation Results for the 1980-2009 Period

In linear specification for the 1980-2009 period, Columns (1) and (3) in Table 4.15a, Columns (1), (3), and (5) in Table 4.15b, Columns (1), (3), (5), and (7) in Table 4.16a and Table 4.16b, and Columns (1) and (2) in Table 4.16d report the estimation results of the Model (3.2.4). In linear specification, in the Model (3.2.4), α_2 and α_3 are restricted to be zero.

Table 4.16b

Long-Difference Estimations for the Association between Productivity and Life Expectancy for the 1980-2009 Period with Lagged Value of Dependent Variable in All Linear and Quadratic Estimations

	log productivity							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
lagged log productivity	1.09***	1.08***	1.09***	1.07***	1.09***	1.08***	1.09***	1.08***
	(0.05)	(0.04)	(0.06)	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)
log life expectancy at birth	1.25***	33.54*	1.42*	23.91	1.73***	25.84	1.06*	28.51
	(0.38)	(19.24)	(0.75)	(26.83)	(0.52)	(27.80)	(0.54)	(23.55)
(log life expectancy at birth)²	-	−3.96*	-	−2.71	-	−2.99	-	−3.39
		(2.35)		(3.33)		(3.45)		(2.89)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.95	0.95	0.94	0.95	0.94	0.95	0.94	0.95
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	43.08	16.38	24.76	11.58	52.61	7.07
Endogeneity test *p*-value	-	-	0.82	0.62	0.19	0.23	0.34	0.26
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.44	0.19	0.16	0.54
C (2nd polynomial) RESET test *p*-value	0.02	0.02	0.05	0.05	0.08	0.25	0.07	0.01
C (3rd polynomial) RESET test *p*-value	0.06	0.05	0.13	0.13	0.22	0.50	0.17	0.04
Turning points	-	69.01	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log productivity. Lagged log productivity includes two observations by country for the years 1980 and 2005. In Column (3) log one-to-five years survival probability, and in Column (4) log one-to-five years survival probability, and its squared value are used as the instrumental variables. In Column (5) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and in Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and their squared values are used as instrumental variables. In Column (7) log crude survival probability, and log age 80-84 survival probability, and in Column (8) log crude survival probability, and log age 80-84 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), and (7), Stock-Yogo weak ID test critical value is 19.93. In (6), and (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

We find that the coefficient of ln LE is positive at 10% or higher significance level in Column (1) in Table 4.15a, Columns (1), (3), and (5) in Table 4.15b, Column (5) in Table 4.16a, Columns (1), (3), (5), and (7) in Table 4.16b, and Column (2) in Table 4.16d. Furthermore, we find that the coefficients of the linear terms are insignificant in Column (3) in Table 4.15a, Columns (1), (3), and (7) in Table 4.16a, and Column (1) in Table 4.16d. These linear functional specification estimation results are consistent with the linear specification results for the per capita GDP and LE association, years of schooling and LE association, and GDP per person engaged and LE association estimations for the 1980-2009 period.

In quadratic specification for the 1980-2009 period, Columns (2) and (4) in Table 4.15a, Columns (2), (4), and (6) in Table 4.15b, Columns (2), (4), (6), and (8) in Table 4.16a and Table 4.16b, and Columns (3) and (4) in Table 4.16d report the estimation results of the Model (3.2.4). In quadratic specification, in the Model (3.2.4), α_3 is restricted to be zero. We find that the coefficients of the linear and quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are positive and negative respectively in Columns (2), (4), and (6) in Table 4.15b, Column (8) in Table 4.16a, and Column (2) in Table 4.16b.

Table 4.16c

Long-Difference Estimations for the Association between Productivity and Life Expectancy for the 1980-2009 Period by Cubic Estimations

	log productivity							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
lagged log productivity	-	1.08***	-	1.08***	-	1.09***	-	1.08***
		(0.04)		(0.04)		(0.04)		(0.04)
log life expectancy at birth	1799.97	−110.56	2189.17	−544.70	1643.48	−766.87	−448.66	−69.11
	(2145.44)	(484.67)	(2503.13)	(479.61)	(2238.73)	(510.79)	(2683.77)	(682.91)
(log life expectancy at birth)²	−416.90	30.29	−520.16	132.85	−380.55	185.91	137.22	20.16
	(509.58)	(114.08)	(593.78)	(112.83)	(535.55)	(120.18)	(639.59)	(161.90)
(log life expectancy at birth)³	32.16	−2.71	41.27	−10.78	29.35	−15.01	−13.46	−1.89
	(40.34)	(8.94)	(46.95)	(8.84)	(42.73)	(9.42)	(50.82)	(12.79)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.13	0.95	0.05	0.95	0.13	0.95	−0.19	0.95
F test *p*-value	0.06	0.00	0.18	0.00	0.03	0.00	0.00	0.00
Weak identification test statistic	-	-	16.62	13.79	8.45	7.93	3.55	2.74
Endogeneity test *p*-value	-	-	0.38	0.42	0.90	0.08	0.14	0.66
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.05	0.37	0.98	0.31
C (3rd polynomial) RESET test *p*-value	0.10	0.13	0.43	0.26	0.65	0.44	0.08	0.09
C (4rd polynomial) RESET test *p*-value	0.19	0.02	0.48	0.00	0.80	0.01	0.15	0.00
Turning points (1)	-	-	-	-	-	-	-	-
(2)	-	-	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980, and 2009. The dependent variable is the log productivity. Lagged log productivity includes two observations by country for the years 1980, and 2005. In Column (3), and Column (4) log one-to-five years survival probability, its squared, and cubed values are used as the instrumental variables. In Column (5), and Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), their squared, and cubed values are used as the instrumental variables. In Column (7), and Column (8) log crude survival probability, and log age 80-84 survival probability, their squared, and cubed values are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), and (4), Stock-Yogo weak ID test critical values are not available. In (5), (6), (7), and (8), Stock-Yogo weak ID test critical value is 12.20. Turning point is not estimated for coefficients less than 10% significance level in a Column.

Estimated turning points are within the range of 58.43-76.78 years in these Columns. In addition, we find that the coefficients of the linear and quadratic terms are insignificant in Columns (2) and (4) in Table 4.15a, Columns (2), (4), and (6) in Table 4.16a, Columns (4), (6), and (8) in Table 4.16b, and Column (3) and (4) in Table 4.16d. These results are similar to the findings regarding the non-monotonic and inverse U-shaped association between per capita GDP and LE, years of schooling and LE, and GDP per person engaged and LE in quadratic specification estimations for the 1980-2009 period. Thus, our quadratic specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between productivity and LE for the 1980-2009 period.

Table 4.16d

Long-Difference Estimations for the Association between Productivity and Life Expectancy for the 1980-2009 Period by Linear, Quadratic and Cubic Estimations

	log productivity					
	(1)	(2)	(3)	(4)	(5)	(6)
	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)
lagged log productivity	-	1.39***	-	1.07***	-	1.07***
		(0.15)		(0.04)		(0.04)
log life expectancy at birth	2.29	5.26***	152.99	45.38*	1593.32	−156.83
	(2.32)	(1.13)	(110.70)	(27.15)	(2034.83)	(555.44)
(log life expectancy at birth)^2	-	-	−18.65	−5.47	−359.51	42.73
			(13.79)	(3.33)	(484.90)	(130.41)
(log life expectancy at birth)^3	-	-	-	-	26.88	−3.82
					(38.55)	(10.20)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.05	0.70	0.07	0.95	0.08	0.95
F test *p*-value	0.34	0.00	0.13	0.00	0.03	0.00
Weak identification test statistic	39.44	41.74	14.72	13.42	20.48	13.06
Endogeneity test *p*-value	0.54	0.28	0.33	0.83	0.35	0.27
Hansen J statistic	0.08	0.41	0.09	0.20	0.13	0.39
C (2nd polynomial) RESET test *p*-value	0.63	0.24	0.35	0.07	-	-
C (3rd polynomial) RESET test *p*-value	0.53	0.27	0.49	0.16	0.86	0.28
C (4rd polynomial) RESET test *p*-value	-	-	-	-	0.77	0.05
Turning points (1)	-	-	-	-	-	-
(2)	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980, and 2009. The dependent variable is the log productivity. Lagged log productivity includes two observations by country for the years 1980, and 2005. In (1), and (2), log crude survival probability, log age 80-84 survival probability, and log age 65-69 survival probability are used as the instrumental variables. In (3), and (4), log crude survival, log age 80-84 survival, and log age 65-69 survival probabilities, their squared values are used as the instrumental variables. In (5), and (6), log crude survival, log age 80-84 survival, and log age 65-69 survival probabilities, and their squared, and cubed values are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (1), and (2), Stock-Yogo weak ID test critical value is 13.91. In (3), and (4), Stock-Yogo weak ID test critical value is 15.72. In (5), and (6), Stock-Yogo weak ID test critical value is 16.10. Turning point is not estimated for coefficients less than 10% significance level in a Column.

In cubic specification for the 1980-2009 period, Columns (1), (2), (3), (4), and (5) in Table 4.15c, Columns (1), (2), (3), (4), (5), (6), (7), and (8) in Table 4.16c, and Columns (5) and (6) in Table 4.16d report the estimation results of the Model (3.2.4). We find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 5% or higher significance level, and they are negative, positive, and negative respectively in Column (5) in Table 4.15c.

Estimated turning point-1 is 61.68 years; and turning point-2 is 71.87 years in this Column. Also, we find that the coefficients of the linear, quadratic, and cubic terms are insignificant in Columns (1), (2), (3), and (4) in Table 4.15c, Columns (1), (2), (3), (4), (5), (6), (7), and (8) in Table 4.16c, and Columns (5) and (6) in Table 4.16d.

This result is consistent with cubic functional specification estimation results regarding the association between per capita GDP and LE, years of schooling and LE, and GDP per person engaged and LE associations, which first suggest a convex-, and then a concave-shaped association for the 1980-2009 period. Hence, cubic functional specification estimation result suggests that there is first a convex-, and then a concave-shaped association between productivity and LE for the 1980-2009 period.

4.7. Estimation Results for Gross Domestic Savings

4.7.1. Diagnostics for the 1980-2009 Period

For GMM estimations in Columns (5) and (6) of Table 4.17b, and in Column (3) of Table 4.17c, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, but AR (2) test does not. These results satisfy Arellano-Bond estimation assumptions in Chapter 2, which increases the efficiency of estimation. In addition, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, which shows that the set of instruments is valid.

Table 4.17a

The Association between Gross Domestic Savings and Life Expectancy for the 1980-2009 Period by Linear and Quadratic Estimations

	Gross domestic savings			
	(1)	(2)	(3)	(4)
	OLS	OLS	FE (within)	FE (within)
log life expectancy at birth	33.06***	375.27	−1.40	608.71
	(4.74)	(369.44)	(27.74)	(622.65)
(log life expectancy at birth)²	-	−40.44	-	−74.60
		(43.65)		(74.79)
Number of observations	329	329	329	329
Number of countries	47	47	47	47
R-squared	0.12	0.12	0.04	0.05
F test *p*-value	0.00	0.00	0.37	0.34
Country dummies	-	-	yes	yes
Time dummies	-	-	yes	yes
Turning points	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the gross domestic savings (percent of GDP). Turning point is not estimated for coefficients less than 10% significance level in a Column.

In Table 4.18a, 4.18b, 4.18c, and 4.18d, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level by excluding Column (3) in Table 4.18c, which indicates that in Table 4.18a, 4.18b, 4.18c, and 4.18d, there is no functional form misspecification.

The instrumental variables are age 1-5, age 80-84, age 65-69, crude survival probabilities, and measles vaccine coverage percent. All these instruments and their squared and cubed values are valid instruments according to the weak identification test statistics by excluding Column (8) in Table 4.18a, and Column (6) and Column (8) in 4.18b, Columns (3), (4), (5), (6), (7), and (8) in Table 4.18c, and Column (3), (4), and (6) in Table 4.18d which satisfy the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock, 1997). Although Stock and Yogo (2005) critical values are not available for Columns (3) and (4) in Table 4.18c, this problem is solved by applying this rule of thumb.

Table 4.17b

The Association between Gross Domestic Savings and Life Expectancy for the 1980-2009 Period with Lagged Value of Dependent Variable in All Linear and Quadratic Estimations

	Gross domestic savings					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged gross domestic savings	0.90***	0.90***	0.32***	0.32***	0.46***	0.28
	(0.04)	(0.04)	(0.09)	(0.10)	(0.18)	(0.18)
log life expectancy at birth	0.82	124.47	0.02	682.57*	3.57	702.15*
	(3.61)	(271.03)	(19.59)	(341.11)	(17.09)	(396.89)
(log life expectancy at birth)²	-	−14.56	-	−83.04**	-	−85.56*
		(31.84)		(41.14)		(48.28)
Number of observations	282	282	282	282	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.75	0.75	0.16	0.17	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.01	0.04
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.01	0.03
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.43	0.27
Hansen test *p*-value	-	-	-	-	0.36	0.50
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	-	-	60.92	-	60.53

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the gross domestic savings (percent of GDP). Column (5) is difference GMM estimation. Column (6) is difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (4) and (6) Columns is 60.73.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, by excluding Columns (5), (6), and (7) in Table 4.18a, and Column (7) in Table 4.18b, Column (5) in Table 4.18c, and Columns (3) in Table 4.18d. In excluded Columns (Column (7) in Table 4.18b, Column (5) in Table 4.18c, Columns (3) in Table 4.18d), over-identification restrictions fail to be rejected at 5% or higher significance level, which indicates that the set of instruments is appropriate at given significance level.

Table 4.17c

The Association between Gross Domestic Savings and Life Expectancy for the 1980-2009 Period by Cubic Estimations

	Gross domestic savings				
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)
lagged gross domestic savings	-	0.89***	-	0.31***	0.47***
		(0.04)		(0.10)	(0.17)
log life expectancy at birth	800.43	−23993.82	18366.36	10163.38	−1424.04
	(20371.43)	(15699.32)	(18698.67)	(13852.38)	(9683.12)
(log life expectancy at birth)²	−141.32	5686.24	−4299.62	−2328.30	375.28
	(4834.44)	(3712.07)	(4429.47)	(3284.73)	(2314.49)
(log life expectancy at birth)³	7.98	−449.00	335.01	177.19	−32.62
	(382.28)	(292.46)	(349.81)	(259.56)	(184.62)
Number of observations	329	282	329	282	235
Number of countries	47	47	47	47	47
R-squared	0.12	0.75	0.05	0.17	-
F test p-value	0.65	0.00	0.39	0.00	0.02
Arellano-Bond test for AR (1) p-value	-	-	-	-	0.01
Arellano-Bond test for AR (2) p-value	-	-	-	-	0.45
Hansen test p-value	-	-	-	-	0.83
Country dummies	-	-	yes	yes	-
Time dummies	-	-	yes	yes	yes
Turning points (1)	-	-	-	-	-
(2)	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the gross domestic savings (percent of GDP). Column (5) is difference GMM estimation. Turning point is not estimated for coefficients less than 10% significance level in a Column.

The endogeneity test of LE fails to be rejected in Table 4.18a, 4.18b, 4.18c, and 4.18d at 10% or higher significance level by excluding Column (8) in Table 4.18a, and Column (4) and (6) in Table 4.18c. In excluded Columns (Columns (4) and (6) in Table 4.18c), the endogeneity test of LE fails to be rejected at 5% or higher significance level. Thus, the OLS gives consistent and relatively more efficient estimates.

Table 4.18a

Long-Difference Estimations for the Association between Gross Domestic Savings and Life Expectancy for the 1980-2009 Period by Linear and Quadratic Estimations

	Gross domestic savings							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
log life expectancy at birth	16.17	219.20	−6.86	395.89	32.49	948.88	9.87	2014.80*
	(32.41)	(704.36)	(35.52)	(951.59)	(32.25)	(952.55)	(41.49)	(1068.83)
(log life expectancy at birth)²	-	−24.93	-	−48.90	-	−115.06	-	−248.40*
		(85.32)		(117.29)		(118.28)		(132.83)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.01	0.01	−0.01	−0.00	−0.00	−0.01	0.01	−0.17
F test p-value	0.62	0.87	0.85	0.92	0.33	0.52	0.82	0.19
Weak identification test statistic	-	-	48.00	17.54	24.52	12.36	60.99	9.83
Endogeneity test p-value	-	-	0.36	0.52	0.28	0.55	0.81	0.03
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.02	0.02	0.04	0.47
C (2nd polynomial) RESET test p-value	0.94	0.36	014	0.17	0.91	0.02	0.70	0.34
C (3rd polynomial) RESET test p-value	0.35	0.13	0.32	0.34	0.56	0.07	0.67	0.56
Turning point	-	-	-	-	-	-	-	57.72

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the gross domestic savings (percent of GDP). In Column (3) log one-to-five years survival probability, and in Column (4) log one-to-five years survival probability, and its squared value are used as the instrumental variables. In Column (5) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and in Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and their squared values are used as instrumental variables. In Column (7) log crude survival probability, and log age 80-84 survival probability, and in Column (8) log crude survival probability, and log age 80-84 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." C (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), and (7), Stock-Yogo weak ID test critical value is 19.93. In (6), and (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

4.7.2. Estimation Results for the 1980-2009 Period

In linear specification for the 1980-2009 period, Columns (1) and (3) in Table 4.17a, Columns (1), (3), and (5) in Table 4.17b, Columns (1), (3), (5), and (7) in Table 4.18a and Table 4.18b, and Columns (1) and (2) in Table 4.18d report the estimation results of the Model (3.2.5). In linear specification, in the Model (3.2.5), α_2 and α_3 are restricted to be zero.

Table 4.18b

Long-Difference Estimations for the Association between Gross Domestic Savings and Life Expectancy for the 1980-2009 Period with Lagged Value of Dependent Variable in All Linear and Quadratic Estimations

	Gross domestic savings							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
lagged gross domestic savings	0.86***	0.86***	0.86***	0.85***	0.86***	0.85***	0.85***	0.85***
	(0.07)	(0.07)	(0.06)	(0.06)	(0.06)	(0.07)	(0.06)	(0.07)
log life expectancy at birth	20.61**	2.53	17.45	237.04	22.71**	284.43	10.62	640.09
	(9.30)	(263.00)	(12.14)	(308.76)	(11.22)	(311.35)	(13.01)	(445.18)
(log life expectancy at birth)²	-	2.22	-	−26.67	-	−32.47	-	−77.86
		(32.45)		(38.40)		(38.78)		(54.70)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.75
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	42.76	16.15	25.20	9.79	59.20	6.53
Endogeneity test *p*-value	-	-	0.75	0.40	0.61	0.16	0.34	0.40
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.40	0.87	0.06	0.26
C (2nd polynomial) RESET test *p*-value	0.21	0.22	0.24	0.13	0.12	0.07	0.25	0.36
C (3rd polynomial) RESET test *p*-value	0.21	0.23	0.21	0.09	0.21	0.07	0.46	0.52
Turning points	-	-	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the gross domestic savings (percent of GDP). Lagged gross domestic savings (percent of GDP) includes two observations by country for the years 1980 and 2005. In Column (3) log one-to-five years survival probability, and in Column (4) log one-to-five years survival probability, and its squared value are used as the instrumental variables. In Column (5) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and in Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), and their squared values are used as instrumental variables. In Column (7) log crude survival probability, and log age 80-84 survival probability, and in Column (8) log crude survival probability, and log age 80-84 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), and (7), Stock-Yogo weak ID test critical value is 19.93. In (6), and (8), Stock-Yogo weak ID test critical value is 11.04. Turning point is not estimated for coefficients less than 10% significance level in a Column.

We find that the coefficient of ln LE is positive at 5% or higher significance level in Column (1) in Table 4.17a, and Columns (1) and (5) in Table 4.18b. In addition, we find that the coefficients of the linear terms are insignificant in Column (3) in Table 4.17a, Columns (1), (3), and (5) in Table 4.17b, Columns (1), (3), (5), and (7) in Table 4.18a, Columns (3) and (7) in Table 4.18b, and Columns (1) and (2) in Table 4.18d. These linear functional specification estimation results are similar to the linear specification results of the estimations for the association between per capita GDP and LE, years of schooling and LE, GDP per person engaged and LE, and productivity and LE for the 1980-2009 period.

In quadratic specification for the 1980-2009 period, Columns (2) and (4) in Table 4.17a, Columns (2), (4), and (6) in Table 4.17b, Columns (2), (4), (6), and (8) in Table 4.18a and Table 4.18b, and Columns (3) and (4) in Table 4.18d report the estimation results of the Model (3.2.5). In quadratic specification, in the Model (3.2.5), α_3 is restricted to be zero. We find that the coefficients of the linear and quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are positive and negative respectively in Columns (4) and (6) in Table 4.17b, Column (8) in Table 4.18a, and Column (4) in Table 4.18d.

Table 4.18c

Long-Difference Estimations for the Association between Gross Domestic Savings and Life Expectancy for the 1980-2009 Period by Cubic Estimations

	Gross domestic savings							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV (one-to-five years survival probability)	IV (one-to-five years survival probability)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (one-to-five years survival probability, and measles vaccine coverage percent)	IV (crude survival probability, and age 80-84 survival probability)	IV (crude survival probability, and age 80-84 survival probability)
lagged gross domestic savings	-	0.85***	-	0.86***	-	0.86***	-	0.84***
		(0.07)		(0.07)		(0.07)		(0.07)
log life expectancy at birth	40415.51	9344.47	21805.89	−864.72	32110.52	−3611.41	16948.45	7277.94
	(27450.45)	(14518.9)	(33085.7)	(18714.19)	(30822.45)	(17704.28)	(38412.5)	(13864.47)
(log life expectancy at birth)²	−9582.18	−2218.70	−5153.96	236.02	−7509.72	905.76	−3813.09	−1666.23
	(6518.29)	(3461.13)	(7854.68)	(4470.66)	(7329.52)	(4222.48)	(9165.87)	(3310.66)
(log life expectancy at birth)³	757.25	175.95	405.95	−20.89	584.52	−75.43	283.93	126.72
	(515.87)	(275.06)	(621.57)	(356.17)	(581.03)	(335.78)	(729.38)	(263.62)
Number of observations	47	47	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47	47	47
R-squared	0.06	0.78	0.05	0.78	0.01	0.77	−0.10	0.76
F test *p*-value	0.51	0.00	0.92	0.00	0.45	0.00	0.16	0.00
Weak identification test statistic	-	-	16.62	16.25	8.45	9.68	3.55	3.82
Endogeneity test *p*-value	-	-	0.67	0.08	0.72	0.05	0.18	0.26
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.01	0.29	0.24	0.24
C (3rd polynomial) RESET test *p*-value	0.03	0.23	0.01	0.18	0.16	0.26	0.70	0.30
C (4rd polynomial) RESET test *p*-value	0.07	0.22	0.03	0.22	0.22	0.32	0.55	0.47
Turning points (1)	-	-	-	-	-	-	-	-
(2)	-	-	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980, and 2009. The dependent variable is the gross domestic savings (percent of GDP). Lagged gross domestic savings (percent of GDP) includes two observations by country for the years 1980, and 2005. In Column (3), and Column (4) log one-to-five years survival probability, its squared, and cubed values are used as the instrumental variables. In Column (5), and Column (6) log one-to-five years survival probability, and log measles-containing-vaccine first-dose (MCV1) immunization coverage among 1-year-olds (%), their squared, and cubed values are used as the instrumental variables. In Column (7), and Column (8) log crude survival probability, and log age 80-84 survival probability, their squared, and cubed values are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), and (4), Stock-Yogo weak ID test critical values are not available. In (5), (6), (7), and (8), Stock-Yogo weak ID test critical value is 12.20. Turning point is not estimated for coefficients less than 10% significance level in a Column.

Estimated turning points are within the range of 57.72-61.71 years in these columns. Moreover, we find that the coefficients of the linear and quadratic terms are insignificant in Columns (2) and (4) in Table 4.17a, Column (2) in Table 4.17b, Columns (2), (4), and (6) in Table 4.18a, Columns (2), (4), (6), and (8) in Table 4.18b, and Column (3) in Table 4.18d.

These results are similar to the findings of non-monotonic and inverse U-shaped association between per capita GDP and LE, years of schooling and LE, GDP per person engaged and LE, and productivity and LE in quadratic specification estimations for the 1980-2009 period. Thus, our quadratic specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between gross domestic savings and LE for the 1980-2009 period.

Table 4.18d

Long-Difference Estimations for the Association between Gross Domestic Savings and Life Expectancy for the 1980-2009 Period by Linear, Quadratic and Cubic Estimations

	Gross domestic savings					
	(1)	(2)	(3)	(4)	(5)	(6)
	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)	IV (crude survival, ages 80-84, and 65-69 survival probabilities)
lagged gross domestic savings	-	0.86***	-	0.85***	-	0.84***
		(0.06)		(0.06)		(0.07)
log life expectancy at birth	10.21	10.95	784.36	595.05*	38255.62	4891.24
	(41.30)	(13.07)	(948.45)	(344.66)	(26006.18)	(13628.79)
(log life expectancy at birth)^2	-	-	−95.96	−72.17*	−8998.03	−1092.49
			(117.94)	(42.58)	(6196.59)	(3242.92)
(log life expectancy at birth)^3	-	-	-	-	705.04	80.73
					(492.34)	(257.23)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.01	0.78	−0.01	0.75	0.04	0.76
F test *p*-value	0.81	0.00	0.69	0.00	0.27	0.00
Weak identification test statistic	39.44	37.78	14.72	13.48	20.48	12.54
Endogeneity test *p*-value	0.85	0.31	0.60	0.25	0.56	0.35
Hansen J statistic	0.09	0.18	0.08	0.35	0.10	0.38
C (2nd polynomial) RESET test *p*-value	0.67	0.25	0.99	0.39	-	-
C (3rd polynomial) RESET test *p*-value	0.84	0.44	0.58	0.44	0.44	0.42
C (4rd polynomial) RESET test *p*-value	-	-	-	-	0.56	0.51
Turning points (1)	-	-	-	61.71	-	-
(2)	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980, and 2009. The dependent variable is the gross domestic savings (percent of GDP). Lagged gross domestic savings (percent of GDP) includes two observations by country for the years 1980, and 2005. In (1), and (2), log crude survival probability, log age 80-84 survival probability, and log age 65-69 survival probability are used as the instrumental variables. In (3), and (4), log crude survival, log age 80-84 survival, and log age 65-69 survival probabilities, their squared values are used as the instrumental variables. In (5), and (6), log crude survival, log age 80-84 survival, and log age 65-69 survival probabilities, and their squared, and cubed values are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (1), and (2), Stock-Yogo weak ID test critical value is 13.91. In (3), and (4), Stock-Yogo weak ID test critical value is 15.72. In (5), and (6), Stock-Yogo weak ID test critical value is 16.10. Turning point is estimated for coefficients at 10% or better significance level in a Column.

In cubic specification for the 1980-2009 period, Columns (1), (2), (3), (4), and (5) in Table 4.17c, Columns (1), (2), (3), (4), (5), (6), (7), and (8) in Table 4.18c, and Columns (5) and (6) in Table 4.18d report the estimation results of the Model (3.2.5). We find that the coefficients of the linear, quadratic, and cubic terms are insignificant in these Columns.

This result is not consistent with cubic functional specification estimation results regarding the association between per capita GDP and LE, years of schooling and LE, GDP per person engaged and LE, and productivity and LE which suggest first a convex-, and then a concave-shaped association for the 1980-2009 period. Thus, turning points are not estimated for cubic specification model.

4.8. Conclusions

This Chapter investigates the effects of LE on per capita GDP, years of schooling (human capital), GDP per person engaged, manufacturing value added per person engaged (productivity), and gross domestic savings. Based on this empirical balanced panel data results, there are four significant findings.

First, we verify the results[4] of Cervellati and Sunde (2009), and Desbordes (2011). Also, this study has consistent results with the findings of Hansen (2012) in quadratic specification Model for the 1940-1980 period for the same association. Also, we verify the similar nonparametric estimation findings[5] in Azomahou et al. (2009).

The second significant finding is that our cubic functional specification estimation results suggest that there is first a convex-, and then a concave-shaped association between per capita GDP and LE for all periods with the exception of the period 1940-1980. For short duration, there is an increase in the number of countries that have less than 30/1000 birth rate as seen in Figure 1 for the period 1940-1950. Thus, this increment reduces the negative dependency rate of birth rate on savings. Hence, this positive effect on economic growth generates first a concave-, and then a convex-shaped curve for the 1940-1980 period. However, in the long run, we cannot

[4] These results are in linear specification estimations in Columns (1), (7) of Table 2, and Table 4 in Cervellati and Sunde (2009: 31 and 33) for the link between per capita GDP and LE for the 1940-1980 period with our estimations in Columns (1), and (4) in Table 2.1, and in linear specification estimation in Column (1) in Table 1, and in quadratic specification estimations in Columns (2), and (3) in the same Table in Desbordes (2011:117) for the same association for the 1940-1980 period with our estimations in Columns (1), (2), (3), and (4) in Table 4.2a. Besides, there is methodologically verified results in quadratic specification estimations in Columns (2) and (4) in Table 1 in Hansen (2012: 176) for the same association for the 1940-1980 period with our estimations in Columns (4), and (6) in Table 4.1a.

[5] These findings provide first convex-, and then concave-shaped-curves in Figures 5 and 6 that have very close thresholds (turning point-1s are around 49.03-51.07 years; turning point-2s are around 63.46-65.70 years based on graph in Figure 5) of these curves according to x-axis values in Azomahou et al. (2009: 208-209) for association between GDP per capita growth and LE for the period 1820-2005 with our convex-, first, and, then, concave-shaped-curve in Figure 2.2 and in cubic specification estimation turning points (convex turning point is 49.87; and concave turning point is 65.52) in Column (5) in Table 4.3b for the period 1940-2009. In addition, all our estimation results in a convex-concave-shaped association between per capita GDP and LE for the 1940-2009 period have estimated turning point-1s within the range of 37.55-49.87 years, and turning point-2s within the range of 53.48-65.52 years in Column (5) in Table 4.3b, in Column (2) in Table 4.4b and in Column (4) in Table 4.4c. These ranges of turning points are close to the mentioned thresholds of these curves according to x-axis values in Azomahou et al (2009: 208-209).

observe this effect on economic growth for the 1940-2009 period. This short period or the small effect of population shock on economic growth is also mentioned in Azomahou et al. (2009: 208).

Third, we find a first convex-, and then a concave-shaped association between human capital and LE for all the periods (1940-1980, 1940-2009, and 1980-2009), and between GDP per person engaged and LE, and productivity and LE only for the 1980-2009 period due to data limitations.

The fourth significant finding is that for gross domestic savings, only in quadratic specification estimation, results are similar to the association between per capita GDP and LE. In cubic specification, we find that linear, quadratic, and cubic terms are insignificant for this dependent variable. These findings suggest that there is a non-monotonic and inverse U-shaped association between gross domestic savings and LE for the 1980-2009 period.

To conclude, these empirical findings yield significant evidence that preserving human physiological health functions promotes economic development through enough savings. Now, we provide detailed concluding remarks on the associations between all dependent variables and LE below.

4.8.1. Economic Growth

For the 1940-1980 period, in linear specification, we find that the coefficient of LE is negative at 5% or higher significance level. In addition, in quadratic specification, we find that the coefficients of the linear and quadratic terms are both significantly different from “0” at 10% or higher significance level, and they are negative and positive, respectively. For quadratic specification, our estimated turning points are within the range of 38.90-51.49 years. Also, in cubic specification, we find that the coefficients of the linear, quadratic, and cubic terms are significantly different from “0” at 10% or higher significance level, and they are positive, negative, and positive respectively. Estimated turning point-1s are within the range of 29.60-41.47 years; and turning point-2s are within the range of 46.69-52.04 years.

Our linear and quadratic specification results are consistent with Desbordes, and cubic specification results are not exactly similar to Azamadou et al.'s (2009) findings. Yet, the turning point-2s for the 1940-1980 period are close to the turning point-1s in Azamadou et al.'s (2009) study for the period 1820-2005.

For the period 1940-2009, in linear specification, we find that the coefficient of LE is negative at 10% or higher significance level. Also, in quadratic specification, we find that the coefficients of the linear and quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are negative and positive respectively. Our estimated turning points are within the range of 38.20-49.84 years. Also, in cubic specification, we find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 5% or higher significance level, and they are negative, positive, and negative respectively. The association is first convex-, and then, concave-shaped. For the convex-concave-shaped association, estimated turning point-1s are within the range of 37.55-49.87 years; and turning point-2s are within the range of 53.48-65.52 years.

Our linear and quadratic specification results for the period 1940-2009 are consistent with Desbordes's (2011) and Hansen's (2012) results for the 1940-1980 period. Our cubic specification results for the period 1940-2009 are similar to Azamadou et al.'s (2009) results for the period 1820-2005. Our cubic functional specification estimation results suggest that there is first a convex-, and then a concave-shaped association between per capita GDP and LE for the period 1940-2009.

For the 1980-2009 period, in linear specification, we find that the coefficient of LE is positive at 5% or higher significance level. In addition, in quadratic specification, we find that the coefficients of the linear and quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are positive and negative respectively. For quadratic specification, our estimated turning points are within the range of 54.33-70.75 years. Also, in cubic specification, we find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 10% or higher significance level, and they are negative, positive, and negative respectively. The association is first convex-, and then concave-shaped. For the convex-concave-shaped association, the estimated turning point-1s are within the range of 53.49-59.23 years; and turning point-2s are within the range of 62.75-79.28 years.

Our linear and quadratic specification results for the 1980-2009 period are not similar to Desbordes's (2011) and Hansen's (2012) results for the 1940-1980 period. Our cubic specification results for the 1980-2009 period are consistent with Azamadou et al.'s (2009) results for the period 1820-2005. Our cubic functional specification estimation results suggest that there is first a convex-, and then a concave-shaped association between per capita GDP and LE for the 1980-2009 period.

4.8.2. Human Capital

For the 1940-1980 period, in linear specification, we find that the coefficient of LE is positive at 1% significance level. Furthermore, in quadratic specification, we find that the coefficients of the linear and quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are positive and negative respectively. For quadratic specification, our estimated turning points are within the range of 66.11-90.25 years. Also, in cubic specification, we find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 10% or higher significance level, and they are negative, positive, and negative respectively. Our estimated turning point-1s are within the range of 33.26-37.02 years; and turning point-2s are within the range of 65.80-75.62 years.

Thus, the linear, quadratic, cubic specification results are not consistent with the per capita GDP and LE association estimations for the 1940-1980 period. Hence, our cubic functional specification estimation results suggest that there is first a convex-, and then a concave-shaped association between years of schooling and LE for the 1940-1980 period.

For the period 1940-2009, in linear specification, we find that the coefficient of LE is positive at 10% or higher significance level. In addition, in quadratic specification, we find that the coefficients of the linear and quadratic terms are both significantly different from “0” at 5% or higher significance level, and they are positive and negative respectively. Estimated turning points are within the range of 58.86-86.12 years. Also, in cubic specification, we find that the coefficients of the linear, quadratic, and cubic terms are significantly different from “0” at 5% or higher significance level, and they are negative, positive, and negative respectively. Estimated turning point-1s are within the range of 31.43-36.24 years; and turning point-2s are within the range of 68.72-71.34 years.

These findings are consistent with cubic specification results for the per capita GDP and LE association for the period 1940-2009, and years of schooling and LE association for the 1940-1980 period. Hence, our cubic functional specification estimation results suggest that there is first a convex-, and then a concave-shaped association between years of schooling and LE for the period 1940-2009.

For the 1980-2009 period, in linear specification, we find that the coefficient of LE is positive at 1% significance level. In addition, in quadratic specification, we find that the coefficients of the linear and quadratic terms are both significantly different from “0” at 10% or higher significance level, and they are positive and negative respectively. For quadratic specification, the estimated turning points are within the range of 57.73-87.39 years. Also, in cubic specification, we find that the coefficients of the linear, quadratic, and cubic terms are significantly different from “0” at 1%

significance level, and they are negative, positive, and negative respectively. The estimated turning point-1 is 55.87 years; and turning point-2 is 78.02 years.

These cubic specification findings are consistent with cubic specification results regarding per capita GDP and LE association for the 1980-2009 period, and years of schooling and LE association for the periods 1940-1980, and 1940-2009. Hence, our cubic functional specification estimation results suggest that there is first a convex-, and then a concave-shaped association between years of schooling and LE for the 1980-2009 period.

4.8.3. GDP per Person Engaged

For the 1980-2009 period, in linear specification, we find that the coefficient of LE is positive at 10% or higher significance level. Also, in quadratic specification, we find that the coefficients of the linear and quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are positive and negative respectively. For quadratic specification, the estimated turning points are within the range of 53.64-73.29 years. Also, in cubic specification, we find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 10% or higher significance level, and they are negative, positive, and negative respectively. The estimated turning point-1s are within the range of 56.08-59.35 years; and the turning point-2s are within the range of 65.25-80.86 years.

These cubic specification findings are similar to cubic specification estimation results regarding the per capita GDP and LE association for the 1980-2009 period, and years of schooling and LE association for the periods 1940-1980, 1940-2009, and 1980-2009. Hence, cubic functional specification estimation results suggest that there is first a convex-, and then a concave-shaped association between GDP per person engaged and LE for the 1980-2009 period.

4.8.4. Productivity

For the 1980-2009 period, in linear specification, we find that the coefficient of LE is positive at 10% or higher significance level. In addition, in quadratic specification, we find that the coefficients of the linear and quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are positive and negative respectively. For quadratic specification, the estimated turning points are within the range of 58.43-76.78 years. Also, in cubic specification, we find that the coefficients of the linear, quadratic, and cubic terms are significantly different from "0" at 5% or higher significance level, and they are negative, positive, and negative respectively. The estimated turning point-1 is 61.68 years; and turning point-2 is 71.87 years.

These cubic specification findings are similar to cubic specification estimation results pertaining to the per capita GDP and LE association for the 1980-2009 period, the years of schooling and LE association for the periods 1940-1980, 1940-2009, and 1980-2009, and the GDP per person engaged and LE association for the 1980-2009 period. Hence, cubic functional specification estimation result suggests that there is first a convex-, and then a concave-shaped association between productivity and LE for the 1980-2009 period.

4.8.5. Gross Domestic Savings

For the 1980-2009 period, in linear specification, we find that the coefficient of LE is positive at 5% or higher significance level. In addition, in quadratic specification, we find that the coefficients of the linear and quadratic terms are both significantly different from "0" at 10% or higher significance level, and they are positive and negative respectively. For quadratic specification, the estimated turning points are within the range of 57.72-61.71 years. Also, in cubic specification, we find that the coefficients of the linear, quadratic, and cubic terms are insignificant. In quadratic specification, these results are similar to the estimation findings regarding the associations between per capita GDP and LE for the 1980-2009 period, years of schooling and LE for the periods 1940-1980, 1940-2009, and 1980-2009, GDP per person engaged and LE, and productivity and LE associations for the 1980-2009 period. Thus, our quadratic specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between gross domestic savings and LE for the 1980-2009 period.

In cubic specification, these results are not consistent with cubic specification estimation results pertaining to the associations between per capita GDP and LE for the 1980-2009 period, years of schooling and LE for the periods 1940-1980, 1940-2009, and 1980-2009, GDP per person engaged and LE, and productivity and LE for the 1980-2009 period, which suggests first a convex-, and then a concave-shaped association for the 1980-2009 period.

CHAPTER 5

THE IMPACT OF BODY MASS INDEX (BMI) ON ECONOMIC GROWTH, HUMAN CAPITAL, GROSS DOMESTIC PRODUCT (GDP) PER PERSON ENGAGED, PRODUCTIVITY, AND GROSS DOMESTIC SAVINGS

5.1. Introduction

The effect of BMI has not yet been investigated in the literature. In this study, we aim to examine the association between GDP per capita and BMI based on the empirical specifications in Chapter 3 obtained from Azomahou et al.'s (2009). This association has been investigated in other studies with different proxy variables in micro and macro studies, and the impacts of nutritional health on economic growth have been observed. Due to data limitations, the present study utilizes balanced panel data for the 1980-2009 period from 47 countries. In quadratic specification, the findings support the non-linear and non-monotonic association between GDP per capita and BMI. That is, an inverted U-shaped association between GDP per capita and BMI has been found.

The study has also analyzed the connection between years of schooling (human capital), GDP per person engaged, manufacturing value added per person engaged (productivity), gross domestic savings and BMI. The quadratic functional specification estimation results point to a non-monotonic, and inverse U-shaped association between all dependent variables and BMI for the 1980-2009 period.

The cubic specification revealed that this association is first convex-, and, then, concave-shaped. This result is also valid between GDP per person engaged and BMI, and productivity and BMI for the 1980-2009 period. As regards the association between human capital and BMI, and gross domestic savings and BMI, the coefficients of the linear, the quadratic, and the cubic terms were found insignificant. That is, the empirical findings significantly confirm that healthy mean population BMI level supports economic development via promoting savings.

5.2. Literature Review

Leibenstein (1957) provides evidence that the nutrition status has a significant effect on economic growth. The efficiency wage theory (Mazumdar, 1959; Mirrlees, 1976; Stiglitz, 1976; Bliss and Stern, 1978; Pitt et al., 1990) analyzes the association between labor productivity, positive labor wage rate, nutrition status, food distribution, and involuntary unemployment especially in under-developed countries.

The wage determination theory (Shapiro and Stiglitz, 1984; Weiss, 1991), on the other hand, explains involuntary unemployment in developed economies regarding the nutrition-productivity nexus. Deolalikar (1988) measures nutritional status by both weight-for-height and the daily energy intake and proves that it has positive effects on agricultural labor productivity and market wages. He finds that the elasticity of farm output and market wages regarding weight-for-height is higher whereas it is not so regarding the daily energy intake. He suggests that weight-for-height might be better proxy for nutrition status than daily energy intake.

Schultz (1997) examines the association between the productivity/wages of the individuals and BMI, determined as one of the forms of the human capital. He considers the diminishing scale of BMI in this association. In addition, he suggests that public and private sectors should collaborate to enable individuals to effectively use recent technologies so that health and nutrition can be secured, individual productivity can be raised, and economic growth can accelerate. Strauss and Thomas (1998) stress the non-linear association between health and labor productivity. For them, mortality risk is higher in decreased or highly increased values of BMI, and consistent results can be seen in the linkage between BMI and other health proxies. They believe there is little, if any, positive effect of health on labor productivity.

Indeed, thresholds in health variables suggested by biomedical research may shed light onto these associations.

Croppenstedt and Muller (2000) offer empirical evidence that nutrition status affects agricultural productivity, and BMI influences market wage rate. Strikingly, they find that nutrition and BMI strongly affect wage equation and labor productivity; and thus, wage equation and labor productivity elasticity is found to be high. They believe that the investment in nutrition dramatically improves productivity. Arcand (2001) investigates the association between GDP per capita growth and dietary energy supply (DES) per capita. He finds that both the linear and quadratic terms are significantly different from "0", suggesting that there is an inverse U-shaped association between economic growth and nutrition status as DES.

Arcand (2001) asserts that the turning point of this non-linear association is 3066 kcal/day. Wang and Taniguchi (2003) claim that an increment in DES can improve the economic growth in different magnitudes depending on the duration of the periods. The impact of the short-period is larger than that of the long period. They observed a negative short-run effect of nutrition status on economic growth, which stems from the increasing population. Thus, if population growth can be controlled, nutrition status can make a positive contribution to economic growth both in the short- or long-term. Ayalew (2003) finds that nutrition intake has a positive impact on labor earnings and productivity. In addition, he suggests that the positive effect of the nutrition status is larger than the positive impact of chemical fertilizers on farm productivity.

Kedir (2009) provides proof that BMI has a significantly positive effect on wage levels. The researcher shows a possible inverse U-shaped association between wage and BMI (Figure 2). Similar to Kedir's study, the present first reveals a roughly convex-, and then concave-shaped non-parametric regression curve, which produces a graph between wage and BMI for the period 1994-2000. According to Kedir, providing priority for the food-related regulations, such as food price subsidies, in policy implications will benefit wage distribution in the market.

Erdil and Kalyoncu (2010) used per capita dietary energy supply (DES) to estimate the labor effort level. They defined human capital with years of schooling to calculate the labor effort level in their model. Thus, they demonstrated that the ratio of physical to human capital (K/H) and economic growth interaction tend to be positive. This is the one of the factors of saving in the Augmented Solow model, which explains the differences between countries in per-capita income levels.

5.3. Estimation Results for Economic Growth

5.3.1. Diagnostics for the 1980-2009 Period

For GMM estimations in Columns (5) and (6) of Table 5.1a, and in Column (3) of Table 5.1b, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, whereas AR (2) test does not. These results satisfy Arellano-Bond estimation assumptions in Chapter 2, which increase the efficiency of estimation. In addition, Hansen tests indicate that over-identification fails to be rejected at 10% or higher significance level. This hints that instrument set is valid.

In Table 5.2a, and 5.2b, the RESET test indicates that H0 fails to be rejected at 5% or higher significance level. This indicates that there is no functional form of misspecification.

Table 5.1a

The Association between GDP per Capita and Mean Body Mass Index for the 1980-2009 Period

	log GDP per capita					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log GDP per capita	1.01***	1.01***	0.73***	0.68***	0.55***	0.43***
	(0.01)	(0.01)	(0.05)	(0.05)	(0.07)	(0.07)
log mean body mass index 18+ years	−0.44***	−6.07	1.91***	30.73**	2.33***	49.71***
	(0.11)	(5.76)	(0.65)	(11.41)	(0.84)	(16.27)
(log mean body mass index 18+ years)²	-	0.89	-	−4.58**	-	−7.56***
		(0.91)		(1.75)	-	(2.55)
Number of observations	282	282	282	282	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.99	0.99	0.89	0.90	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.01	0.02
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.82	0.81
Hansen test *p*-value	-	-	-	-	0.22	0.29
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	-	-	28.61	-	26.82

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log GDP per capita. Column (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (4), and (6) Columns is 27.71.

The instrumental variables are crude survival, and age 75-79 survival probabilities. All these instruments and their squared and cubed values are valid instruments according to the weak identification test statistic when Columns (3), (5) in Table 5.2a and Columns (2), (3) in Table 5.2b are exempted. Columns (3) in Table 5.2a and in Table 5.2b satisfy the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock, 1997).

Table 5.1b.

The Association between GDP per Capita and Mean Body Mass Index for the 1980-2009 Period

	log GDP		
	(1)	(2)	(3)
	OLS	FE (within)	GMM (Arellano-Bond)
first lagged log GDP	1.01***	0.67***	-
	(0.01)	(0.05)	
second lagged log GDP	-	-	0.19
			(0.13)
log mean body mass index 18+ years	839.15***	264.91	−4175.95**
	(268.17)	(310.13)	(1595.02)
(log mean body mass index 18+ years)²	−267.30***	−78.99	1339.79**
	(85.30)	(98.20)	(507.66)
(log mean body mass index 18+ years)³	28.35***	7.87	−143.02**
	(9.04)	(10.36)	(53.93)
Number of observations	282	282	188
Number of countries	47	47	47
R-squared	0.99	0.90	-
F test *p*-value	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	0.02
Arellano-Bond test for AR (2) *p*-value	-	-	0.27
Hansen test *p*-value	-	-	0.16
Country dummies	-	yes	-
Time dummies	-	yes	yes
Turning points (1)	20.82	-	19.88
(2)	25.79	-	25.93

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. GDP is GDP per capita. The dependent variable is the log GDP per capita. Column (3) is difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column.

Hansen J tests indicate that over-identification restrictions cannot be rejected at 10% or higher significance level. This shows that instruments are appropriate at the given significance level.

Table 5.2a

Long-Difference Estimations for the Association Between GDP per Capita and Mean Body Mass Index for the 1980-2009 Period

	log GDP per capita					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV (crude survival probability)	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)	IV (crude survival probability, and age 75-79 survival probability)
lagged log GDP per capita	1.05***	0.99***	1.05***	0.99***	1.05***	0.96***
	(0.04)	(0.04)	(0.05)	(0.04)	(0.05)	(0.05)
log mean body mass index 18+ years	0.90***	22.65***	2.04**	22.53**	2.31**	29.99***
	(0.32)	(5.06)	(1.00)	(9.02)	(1.01)	(7.38)
(log mean body mass index 18+ years)²	-	−3.49***	-	−3.52**	-	−4.68***
		(0.80)		(1.44)		(1.20)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.96	0.97	0.95	0.97	0.95	0.97
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	14.15	9.90	8.09	12.36
Endogeneity test *p*-value	-	-	0.19	0.71	0.14	0.13
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.40	0.47
C (2nd polynomial) RESET test *p*-value	0.07	0.06	0.27	0.07	0.38	0.16
C (3rd polynomial) RESET test *p*-value	0.10	0.16	0.52	0.15	0.65	0.35
Turning points	-	25.66	-	24.53	-	24.51

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. GDP is GDP per capita. The dependent variable is the log GDP per capita. Lagged log GDP per capita includes two observations by country for the years 1980 and 2005. In Column (3) log crude survival probability, and in Column (4) log crude survival probability, and its squared value are used as the instrumental variables. In Column (5) log crude survival probability, and log age 75-79 survival probability, and in Column (6) log crude survival probability, and log age 75-79 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), Stock-Yogo weak ID test critical value is 19.93. In (6), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), (4) and (6) Columns is 24.90.

The null hypotheses of the endogeneity test of LE fail to be rejected in Table 5.2a, and Table 5.2b at 10% or higher significance level. Thus, the OLS gives the consistent and relatively more efficient estimates.

Table 5.2b

Long-Difference Estimations for the Association between GDP per Capita and Mean Body Mass Index for the 1980-2009 Period

	log GDP		
	(1)	(2)	(3)
	OLS	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)
lagged log GDP	0.99***	0.98***	0.94***
	(0.04)	(0.08)	(0.06)
log mean body mass index 18+ years	56.20	−94.79	−822.23
	(165.92)	(1102.98)	(620.11)
(log mean body mass index 18+ years)²	−14.19	34.27	268.75
	(52.57)	(355.89)	(199.50)
(log mean body mass index 18+ years)³	1.14	−4.06	−29.23
	(5.55)	(38.26)	(21.39)
Number of observations	47	47	47
Number of countries	47	47	47
R-squared	0.97	0.97	0.95
F test *p*-value	0.00	0.00	0.00
Weak identification test statistic	-	0.10	0.75
Endogeneity test *p*-value	-	0.82	0.46
Hansen J statistic	-	e.e.i.	0.51
C (3rd polynomial) RESET test *p*-value	0.12	0.84	0.42
C (4rd polynomial) RESET test *p*-value	0.05	0.93	0.61
Turning points (1)	-	-	-
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. GDP is GDP per capita. The dependent variable is the log GDP per capita. Lagged log GDP includes two observations by country for the years 1980 and 2005. In in Column (2) log crude survival probability, its squared, and cubed values are used as the instrumental variables. In Column (3) log crude survival probability, and log age 75-79 survival probability, and their squared, and cubed values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (2), Stock-Yogo weak ID test critical value is not available. In (3), Stock-Yogo weak ID test critical value is 12.20. Turning point is not estimated for coefficients less than 10% significance level in a Column.

5.3.2. Estimation Results for the 1980-2009 Period

In linear specification for the 1980-2009 period, Columns (1), (3), and (5) in Table 5.1a, and Columns (1), (3), and (5) in Table 5.2a report the estimation results of Model (3.2.6). In linear specification of Model (3.2.6), the α_2 and α_3 are restricted to be zero. The coefficient of ln LE was found positive at 5% or higher significance level in Columns (3) and (5) in Table 5.1a, Columns (1), (3), and (5) in Table 5.2a. In addition, the coefficient of ln LE was found negative at 1% significance level in Column (1) in Table 5.1a.

In quadratic specification for the 1980-2009 period, Columns (2), (4), and (6) in Table 5.1a, and Columns (2), (4), and (6) in Table 5.2a report the estimation results of Model (3.2.6). In the quadratic specification of Model (3.2.6), the α_3 is restricted to be zero. The coefficients of the linear and the quadratic terms were both found significantly different from “0” at 5% or higher significance level, and they are positive and negative respectively.

The estimated turning points[6] are within the range of 24.51-28.61 kilogram/square meter (kg/m^2) as can be seen in Columns (4) and (6) of Table 5.1a, and Columns (2), (4), and (6) of Table 5.2a. Thus, the quadratic functional specification estimation results of the present study suggest that there is a non-monotonic and inverse U-shaped association between GDP per capita and BMI for the 1980-2009 period.

As regards, cubic specification for the 1980-2009 period, Columns (1), (2), and (3) of Table 5.1b, and Columns (1), (2), and (3) of Table 5.2b report the estimation results of Model (3.2.6). Accordingly, the coefficients of the linear, the quadratic, and the cubic terms are significantly different from "0" at 5% significance level, and as can be seen in Column (3) of Table 5.1b, they are negative, positive, and negative, respectively.

In addition, the coefficients of the linear, the quadratic, and the cubic terms are significantly different from "0" at 1% significance level, and as can be seen in Column (1) of Table 5.1b, they are positive, negative, and positive, respectively. Also, Column (2) in Table 5.1b, and Columns (1), (2), and (3) in Table 5.2b demonstrate that the coefficients of the linear, the quadratic, and the cubic terms are insignificant.

Estimated turning point-1[7] is 19.88 kg/m^2 and turning point-2 is 25.93 kg/m^2 in this Column. Hence, the cubic functional specification estimation results suggest that first there is convex-, and, then, concave-shaped association between GDP per capita and BMI for the 1980-2009 period.

[6] Quadratic specification turning point (*TP*) is estimated by following formula: $TP = \exp\left(\left|\frac{\hat{\beta}_1}{2\hat{\beta}_2}\right|\right)$.

[7] Cubic specification turning points (*TPs*) are estimated by using general mathematical formula: $\frac{d}{dx}(\hat{\beta}_3 x^3 + \hat{\beta}_2 x^2 + \hat{\beta}_1 x + \text{constant})$, then, $TPs\,(1,2) = \exp\left((-(2\hat{\beta}_2) \pm \sqrt{(2\hat{\beta}_2)^2 - 4(3\hat{\beta}_3\hat{\beta}_1)})\,/\,(2(3\hat{\beta}_3))\right)$

5.4. Estimation Results for Human Capital

5.4.1. Diagnostics for the 1980-2009 period

As for GMM estimations shown in Columns (5) and (6) of Table 5.3a, and in Column (3) of Table 5.3b, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, whereas AR (2) test does not. These results satisfy the Arellano-Bond estimation assumptions summarized in Chapter 2. Moreover, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level. It hints that instrument set is valid.

In Table 5.4a, and Table 5.4b, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level. That is, there is no functional form misspecification.

Table 5.3a

The Association between Years of Schooling and Mean Body Mass Index for the 1980-2009 Period

	log years of schooling					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
first lagged log years of schooling	0.91*** (0.01)	0.91*** (0.01)	0.81*** (0.04)	0.75*** (0.04)	-	-
second lagged log years of schooling	-	-	-	-	0.59*** (0.13)	0.06 (0.17)
log mean body mass index 18+ years	−0.04 (0.05)	0.54 (2.29)	−0.12 (0.33)	12.66* (6.30)	2.82** (1.29)	76.78** (37.05)
(log mean body mass index 18+ years)²	-	−0.09 (0.36)	-	−2.02** (0.98)	-	−11.31* (5.98)
Number of observations	282	282	282	282	188	188
Number of countries	47	47	47	47	47	47
R-squared	0.98	0.98	0.93	0.93	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.04	0.01
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.16	0.31
Hansen test *p*-value	-	-	-	-	0.11	0.36
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	-	-	23.13	-	29.77

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log years of schooling. Column (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (4), and (6) Columns is 26.45.

The instrumental variables are crude survival probabilities and age 75-79 survival probabilities. In weak identification tests, all these instruments and their squared and cubed values are not over 5% maximal IV relative bias critical values (Stock and Yogo, 2005). These test results decrease the validity of the instruments by exempting

Column (4) in Table 5.4a, which satisfies the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock, 1997).

Table 5.3b

The Association between Years of Schooling and Mean Body Mass Index for the 1980-2009 Period

	log years of schooling		
	(1)	(2)	(3)
	OLS	FE (within)	GMM (Arellano-Bond)
first lagged log years of schooling	0.90***	0.75***	-
	(0.01)	(0.04)	
second lagged log years of schooling	-	-	0.03
			(0.21)
log mean body mass index 18+ years	63.52	172.47	509.76
	(89.56)	(105.20)	(1792.38)
(log mean body mass index 18+ years)²	−20.07	−52.81	−148.49
	(28.33)	(33.71)	(572.17)
(log mean body mass index 18+ years)³	2.11	5.38	14.47
	(2.99)	(3.60)	(60.91)
Number of observations	282	282	188
Number of countries	47	47	47
R-squared	0.98	0.94	-
F test *p*-value	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	0.03
Arellano-Bond test for AR (2) *p*-value	-	-	0.35
Hansen test *p*-value	-	-	0.32
Country dummies	-	yes	-
Time dummies	-	yes	yes
Turning points (1)	-	-	-
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log years of schooling. Column (3) is difference GMM estimation. Turning point is not estimated for coefficients less than 10% significance level in a Column.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level. This shows that set of instruments is valid at the given significance level.

Table 5.4a

Long-Difference Estimations for the Association between Years of Schooling and Mean Body Mass Index for the 1980-2009 Period

	log years of schooling					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV (crude survival probability)	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)	IV (crude survival probability, and age 75-79 survival probability)
lagged log years of schooling	1.08***	1.03***	1.04***	0.97***	1.03***	1.02***
	(0.04)	(0.05)	(0.07)	(0.13)	(0.07)	(0.05)
log mean body mass index 18+ years	0.04	7.79*	0.91	13.20	0.99	5.93*
	(0.23)	(4.13)	(0.92)	(13.02)	(0.81)	(3.38)
(log mean body mass index 18+ years)²	-	−1.23*	-	−1.98	-	−0.86
		(0.65)		(1.95)		(0.55)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.95	0.95	0.94	0.94	0.93	0.95
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	5.99	1.40	4.16	6.72
Endogeneity test *p*-value	-	-	0.34	0.48	0.20	0.65
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.81	0.56
C (2nd polynomial) RESET test *p*-value	0.995	0.90	0.98	0.82	0.92	0.65
C (3rd polynomial) RESET test *p*-value	0.23	0.27	0.64	0.50	0.64	0.19
Turning points	-	23.78	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log years of schooling. Lagged log years of schooling includes two observations by country for the years 1980 and 2005. In Column (3) log crude survival probability, and in Column (4) log crude survival probability, and its squared value are used as the instrumental variables. In Column (5) log crude survival probability, and log age 75-79 survival probability, and in Column (6) log crude survival probability, and log age 75-79 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), Stock-Yogo weak ID test critical value is 19.93. In (6), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

As can be seen in Table 5.4a and Table 5.4b, the endogeneity test of LE fails to be rejected at 10% or higher significance level. Thus, the OLS gives consistent and relatively more efficient estimates.

Table 5.4b

Long-Difference Estimations for the Association between Years of Schooling and Mean Body Mass Index for the 1980-2009 Period

	log years of schooling		
	(1)	(2)	(3)
	OLS	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)
lagged log years of schooling	1.03***	0.98***	1.04***
	(0.05)	(0.08)	(0.05)
log mean body mass index 18+ years	−36.86	(omitted)	174.90
	(106.27)		(263.79)
(log mean body mass index 18+ years)²	13.01	1.93	−55.11
	(33.82)	(1.22)	(84.94)
(log mean body mass index 18+ years)³	−1.51	−0.39	5.80
	(3.59)	(0.25)	(9.11)
Number of observations	47	47	47
Number of countries	47	47	47
R-squared	0.95	0.95	0.95
F test *p*-value	0.00	0.00	0.00
Weak identification test statistic	-	0.00	1.59
Endogeneity test *p*-value	-	0.63	0.37
Hansen J statistic	-	e.e.i.	0.57
C (3rd polynomial) RESET test *p*-value	0.29	0.80	0.03
C (4rd polynomial) RESET test *p*-value	0.46	0.68	0.05
Turning points (1)	-	-	-
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log years of schooling. Lagged log years of schooling includes two observations by country for the years 1980 and 2005. In in Column (2) log crude survival probability, its squared, and cubed values are used as the instrumental variables. In Column (3) log crude survival probability, and log age 75-79 survival probability, and their squared, and cubed values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (2), Stock-Yogo weak ID test critical value is not available. In (3), Stock-Yogo weak ID test critical value is 12.20. Turning point is not estimated for coefficients less than 10% significance level in a Column.

5.4.2. Estimation Results for the 1980-2009 Period

As for linear specification pertaining to the period of 1980-2009, Columns (1), (3), and (5) in Table 5.3a, and Columns (1), (3), and (5) in Table 5.4a report the estimation results of the Model (3.2.7). Here, the α_2 and α_3 are restricted to be zero. The coefficient of ln LE was found positive at 5% significance level (Column 5 Table 5.3a). In addition, the coefficient of ln LE was found insignificant as can be seen in Columns (1) and (3) in Table 5.3a, and in Columns (1), (3), and (5) in Table 5.4a.

Estimation of quadratic specification according to Model (3.2.7) for the 1980-2009 period are shown in Columns (2), (4), and (6) in Table 5.3a, and Columns (2), (4), and (6) in Table 5.4a, where the α_3 is restricted to be zero. The coefficients of the linear and the quadratic terms were both found significantly different from "0" at 10% or higher significance level, and they are positive and negative in Columns (4) and (6) in Table 5.3a, and Column (2) in Table 5.4a, respectively. The estimated turning points are within the range of 23.13-29.77 kg/m^2 in these Columns.

The coefficients of the linear and the quadratic terms, however, are insignificant as shown in Columns (2) in Table 5.3a, Column (4) and (with exception for the linear term) Column (6) in Table 5.4a. Thus, our quadratic functional specification estimation suggests that there is a non-monotonic and inverse U-shaped association between years of schooling and BMI for the 1980-2009 period.

The estimation of cubic specification by Model (3.2.7) for the 1980-2009 period are presented in Columns (1), (2), and (3) in Table 5.3b, and Columns (1), (2), and (3) in Table 5.4b. They all show that the coefficients of the linear, quadratic, and cubic terms are insignificant.

5.5. Estimation Results for GDP per Person Engaged

5.5.1. Diagnostics for the 1980-2009 Period

As for GMM estimations, Columns (5) and (6) of Table 5.5a, and Column (3) of Table 5.5b show that Arellano-Bond AR (1) test rejects H_0 at 10% significance level, whereas AR (2) test does not. These results satisfy Arellano-Bond estimation assumptions, discussed in Chapter 2, which increase the efficiency of estimation. Furthermore, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, which points out that the set of instruments is appropriate.

In Table 5.6a and Table 5.6b, the RESET test indicates that H_0 fails to be rejected at 5% significance level, pointing to that there is no functional form misspecification.

Table 5.5a

The Association between GDP per Person Engaged and Mean Body Mass Index for the 1980-2009 Period

	log GDP per person engaged					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log GDP per person engaged	1.00***	1.00***	0.75***	0.69***	0.58***	0.43***
	(0.01)	(0.01)	(0.06)	(0.05)	(0.07)	(0.07)
log mean body mass index 18+ years	−0.31***	−1.82	1.80**	32.35***	2.00**	50.68***
	(0.11)	(5.83)	(0.72)	(11.87)	(0.88)	(14.83)
(log mean body mass index 18+ years)²	-	0.24	-	−4.87**	-	−7.76***
	-	(0.92)	-	(1.82)	-	(2.31)
Number of observations	282	282	282	282	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.99	0.99	0.84	0.86	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.00	0.00
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.27	0.32
Hansen test *p*-value	-	-	-	-	0.19	0.21
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	-	-	27.69	-	26.17

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log GDP per person engaged. Column (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (4), and (6) Columns is 26.93.

The instrumental variables are crude survival and age 75-79 survival probabilities. All these instruments, and their squared and cubed values are valid instruments according to the weak identification test statistics. It exempts Column (3) in Table 5.6a and in Table 5.6b, which satisfy the rule of thumb that F statistics of the first stage should be over ten according to Staiger and Stock (1997). However, weak identification test results in Column (5) in Table 5.6a and Column (2) in Table 5.6b are not over 5% maximal IV relative bias according to the Stock and Yogo (2005) critical values. These test results decrease the validity of the instruments in these Columns.

Table 5.5b

The Association between GDP per Person Engaged and Mean Body Mass Index for the 1980-2009 Period

	log GDP per person engaged		
	(1)	(2)	(3)
	OLS	FE (within)	GMM (Arellano-Bond)
lagged log GDP per person engaged	1.00***	0.69***	0.84***
	(0.01)	(0.05)	(0.25)
log mean body mass index 18+ years	940.26***	305.88	−2256.71*
	(230.25)	(361.01)	(1138.20)
(log mean body mass index 18+ years)²	−298.77***	−91.79	727.98*
	(73.12)	(114.02)	(365.25)
(log mean body mass index 18+ years)³	31.61***	9.20	−78.19*
	(7.73)	(12.00)	(39.11)
Number of observations	282	282	235
Number of countries	47	47	47
R-squared	0.99	0.86	-
F test p-value	0.00	0.00	0.00
Arellano-Bond test for AR (1) p-value	-	-	0.06
Arellano-Bond test for AR (2) p-value	-	-	0.13
Hansen test p-value	-	-	0.30
Country dummies	-	yes	-
Time dummies	-	yes	yes
Turning points (1)	21.15	-	20.03
(2)	25.76	-	24.78

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log GDP per person engaged. Column (3) is difference GMM estimation. Turning point is not estimated for coefficients less than 10% significance level in a Column.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10%significance level, showing that the set of instruments is appropriate at the given significance level.

Table 5.6a

Long-Difference Estimations for the Association between GDP per Person Engaged and Mean Body Mass Index for the 1980-2009 Period

	log GDP per person engaged					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV (crude survival probability)	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)	IV (crude survival probability, and age 75-79 survival probability)
lagged log GDP per person engaged	1.07***	1.01***	1.07***	1.01***	1.07***	1.00***
	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)
log mean body mass index 18+ years	0.91**	20.67***	1.90	19.47	2.16	25.94***
	(0.34)	(5.51)	(1.18)	(12.81)	(1.31)	(8.61)
(log mean body mass index 18+ years)²	-	−3.18***	-	−3.04	-	−4.05***
	-	(0.86)		(2.06)		(1.40)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.96	0.97	0.95	0.97	0.95	0.97
F test p-value	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	14.45	7.51	8.50	11.43
Endogeneity test p-value	-	-	0.33	0.54	0.38	0.33
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.47	0.60
C (2nd polynomial) RESET test p-value	0.06	0.08	0.29	0.08	0.32	0.14
C (3rd polynomial) RESET test p-value	0.14	0.21	0.58	0.21	0.59	0.31
Turning points	-	25.79	-	-	-	24.62

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log GDP per person engaged. Lagged log GDP per person engaged includes two observations by country for the years 1980 and 2005. In Column (3) log crude survival probability, and in Column (4) log crude survival probability, and its squared value are used as the instrumental variables. In Column (5) log crude survival probability, and log age 75-79 survival probability, and in Column (6) log crude survival probability, and log age 75-79 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." C (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), Stock-Yogo weak ID test critical value is 19.93. In (6), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), and (6) Columns is 25.20.

The endogeneity test of LE fails to be rejected in Table 5.6a and in Table 5.6b at 10% significance level. Thus, the OLS gives consistent and relatively more efficient estimates.

Table 5.6b

Long-Difference Estimations for the Association between GDP per Person Engaged and Mean Body Mass Index for the 1980-2009 Period

	log GDP per person engaged		
	(1)	(2)	(3)
	OLS	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)
lagged log GDP per person engaged	1.01***	1.01***	0.96***
	(0.04)	(0.13)	(0.06)
log mean body mass index 18+ years	200.30	−81.43	−844.10
	(222.96)	(1583.19)	(593.86)
(log mean body mass index 18+ years)^2	−60.47	29.48	275.22
	(70.54)	(511.48)	(190.78)
(log mean body mass index 18+ years)^3	6.09	−3.49	−29.87
	(7.43)	(55.07)	(20.43)
Number of observations	47	47	47
Number of countries	47	47	47
R-squared	0.97	0.97	0.94
F test *p*-value	0.00	0.00	0.00
Weak identification test statistic	-	0.06	0.73
Endogeneity test *p*-value	-	0.61	0.52
Hansen J statistic	-	e.e.i.	0.39
C (3rd polynomial) RESET test *p*-value	0.10	0.94	0.66
C (4rd polynomial) RESET test *p*-value	0.03	0.96	0.84
Turning points (1)	-	-	-
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log GDP per person engaged. Lagged log GDP per person engaged includes two observations by country for the years 1980 and 2005. In in Column (2) log crude survival probability, its squared, and cubed values are used as the instrumental variables. In Column (3) log crude survival probability, and log age 75-79 survival probability, and their squared, and cubed values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (2), Stock-Yogo weak ID test critical value is not available. In (3), Stock-Yogo weak ID test critical value is 12.20. Turning point is not estimated for coefficients less than 10% significance level in a Column.

5.5.2. Estimation Results for the 1980-2009 Period

Estimation of linear specification based on Model (3.2.8) for the 1980-2009 period are presented in Columns (1), (3), and (5) in Table 5.5a and Columns (1), (3), and (5) in Table 5.6a. Here, the α_2 and α_3 are restricted to be zero. The coefficient of ln LE was found positive at 5% significance level in Columns (3) and (5) in Table 5.5a and Column (1) in Table 5.6a. In addition, the coefficient of ln LE was found negative at 1% significance level as can be seen in Column (1) in Table 5.5a. Also, the coefficient of ln LE turned out to be insignificant as shown in Columns (3) and (5) in Table 5.6a.

The estimation results of the Model (3.2.8) pertaining to the quadratic specification for 1980-2009 are presented in Columns (2), (4), and (6) in Table 5.5a, and Columns (2), (4), and (6) in Table 5.6a. It should be noted that the α_3 is restricted to be zero.

The coefficients of the linear and the quadratic terms were both found significantly different from “0” at 5% significance level, and they are positive and negative in Columns (4), (6) in Table 5.5a, and in Columns (2), and (6) in Table 5.6a, respectively.

The estimated turning points are within the range of 24.62-27.69 kg/m^2. In addition, the coefficients of the linear and the quadratic terms were found insignificant as can be seen in Column (2) in Table 5.5a, and in Column (4) in Table 5.6a. Thus, the quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between GDP per person engaged and BMI for the 1980-2009 period.

The estimation of cubic specification by Model (3.2.8) for the 1980-2009 period are shown in Columns (1), (2), and (3) in Table 5.5b, and Columns (1), (2), and (3) in Table 5.6b. The coefficients of the linear, the quadratic, and the cubic terms were found significantly different from “0” at 10% significance level, and they are negative, positive, and negative, respectively, as can be seen in Column (3) in Table 5.5b.

The estimated turning point-1 is 20.03 kg/m^2 and turning point-2 is 24.78 kg/m^2 in this Column. In addition, the coefficients of the linear, the quadratic, and the cubic terms are significantly different from “0” at 1% significance level, and they are positive, negative, and positive, respectively, as can be seen in Column (1) in Table 5.5b. Also, the coefficients of the linear, the quadratic, and the cubic terms were found insignificant in Column (2) in Table 5.5b, and in Columns (1), (2), and (3) in Table 5.6b.

Hence, the cubic functional specification estimation results suggest that there is first convex-, and then, concave-shaped association between GDP per person engaged and BMI for the 1980-2009 period.

5.6. Estimation Results for Productivity

5.6.1. Diagnostics for the 1980-2009 Period

For GMM estimations presented in Columns (5) and (6) of Table 5.7a, and in Column (3) of Table 5.7b, Arellano-Bond AR (1) test rejects H_0 at 5% significance level, whereas AR (2) test does not. These results satisfy Arellano-Bond estimation assumptions stated in Chapter 2, which increase the efficiency of estimation. In addition, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% significance level. That is, the instrument set is valid.

Table 5.7a

The Association between Productivity and Mean Body Mass Index for the 1980-2009 Period

	log productivity					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log productivity	0.98***	0.97***	0.74***	0.60***	0.52***	0.66***
	(0.02)	(0.02)	(0.06)	(0.05)	(0.08)	(0.14)
log mean body mass index 18+ years	−0.71***	17.50*	2.64*	97.28***	4.26**	90.90**
	(0.19)	(10.50)	(1.37)	(23.81)	(1.97)	(41.06)
(log mean body mass index 18+ years)²	-	−2.87*	-	−14.94***	-	−13.51**
		(1.65)		(3.66)		(6.12)
Number of observations	282	282	282	282	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.96	0.96	0.60	0.66	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.00	0.02
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.11	0.17
Hansen test *p*-value	-	-	-	-	0.20	0.28
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	21.07	-	25.96	-	28.90

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log productivity. Column (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), (4), and (6) Columns is 25.31.

In Table 5.8a and Table 5.8b, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level, so, there is no functional form misspecification.

The instrumental variables are crude survival and age 75-79 survival probabilities. All these instruments, their squared, and cubed values are valid instruments according to the weak identification test statistic by exempting Columns (3), (4) in Table 5.8a, and Columns (2), (3) in Table 5.8b which satisfy the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock,1997). However, weak identification test results in Column (5) in Table 5.8a is not over 5% maximal

IV relative bias according to the Stock and Yogo (2005) critical values. This test result decreases the validity of the instruments in this Column.

Table 5.7b

The Association between Productivity and Mean Body Mass Index for the 1980-2009 Period

	log productivity		
	(1)	(2)	(3)
	OLS	FE (within)	GMM (Arellano-Bond)
lagged log productivity	0.97***	0.60***	−0.45
	(0.02)	(0.05)	(0.39)
log mean body mass index 18+ years	1423.06***	561.15	−13772.01**
	(352.27)	(611.99)	(6629.30)
(log mean body mass index 18+ years)²	−449.07***	−162.48	4463.42**
	(111.54)	(193.31)	(2124.92)
(log mean body mass index 18+ years)³	47.19***	15.63	−482.04**
	(11.77)	(20.35)	(226.91)
Number of observations	282	282	235
Number of countries	47	47	47
R-squared	0.96	0.66	-
F test *p*-value	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	0.04
Arellano-Bond test for AR (2) *p*-value	-	-	0.10
Hansen test *p*-value	-	-	0.49
Country dummies	-	yes	-
Time dummies	-	yes	yes
Turning points (1)	21.50	-	20.75
(2)	26.49	-	23.11

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log productivity. Column (3) is difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% significance level. This indicates that set of instruments is appropriate at the given significance level.

Table 5.8a

Long-Difference Estimations for the Association between Productivity and Mean Body Mass Index for the 1980-2009 Period

	log productivity					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV (crude survival probability)	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)	IV (crude survival probability, and age 75-79 survival probability)
lagged log productivity	1.09***	0.98***	1.05***	0.96***	1.06***	0.96***
	(0.05)	(0.04)	(0.05)	(0.07)	(0.05)	(0.05)
log mean body mass index 18+ years	1.14*	40.99***	3.94	49.02*	3.29	50.90***
	(0.66)	(12.43)	(2.46)	(29.25)	(2.30)	(14.38)
(log mean body mass index 18+ years)²	-	−6.31***	-	−7.56	-	−7.89***
		(1.94)		(4.65)		(2.33)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.94	0.95	0.92	0.95	0.93	0.95
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	14.22	4.48	8.86	14.14
Endogeneity test *p*-value	-	-	0.16	0.86	0.25	0.16
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.35	0.61
C (2nd polynomial) RESET test *p*-value	0.02	0.03	0.22	0.10	0.16	0.06
C (3rd polynomial) RESET test *p*-value	0.05	0.07	0.44	0.20	0.36	0.18
Turning points	-	25.70	-	-	-	25.19

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log productivity. Lagged log productivity includes two observations by country for the years 1980 and 2005. In Column (3) log crude survival probability, and in Column (4) log crude survival probability, and its squared value are used as the instrumental variables. In Column (5) log crude survival probability, and log age 75-79 survival probability, and in Column (6) log crude survival probability, and log age 75-79 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), Stock-Yogo weak ID test critical value is 19.93. In (6), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), and (6) Columns is 25.45.

The endogeneity test of LE fails to be rejected (Table 5.8a; Table 5.8b) at 10% significance level. Thus, the OLS gives consistent and relatively more efficient estimates.

Table 5.8b

Long-difference estimations for the association between productivity and mean body mass index for the 1980-2009 Period

	log productivity		
	(1)	(2)	(3)
	OLS	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)
lagged log productivity	0.99***	0.96***	0.90***
	(0.04)	(0.06)	(0.09)
log mean body mass index 18+ years	466.03	(omitted)	−949.87
	(347.79)		(1137.84)
(log mean body mass index 18+ years)^2	−142.02	8.17**	314.32
	(110.60)	(3.21)	(365.85)
(log mean body mass index 18+ years)^3	14.43	−1.68**	−34.55
	(11.72)	(0.69)	(39.21)
Number of observations	47	47	47
Number of countries	47	47	47
R-squared	0.95	0.95	0.93
F test *p*-value	0.00	0.00	0.00
Weak identification test statistic	-	0.00	0.61
Endogeneity test *p*-value	-	0.96	0.28
Hansen J statistic	-	e.e.i.	0.42
C (3rd polynomial) RESET test *p*-value	0.05	0.50	0.57
C (4rd polynomial) RESET test *p*-value	0.05	0.39	0.27
Turning points (1)	-	25.46	-
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log productivity. Lagged log productivity includes two observations by country for the years 1980 and 2005. In in Column (2) log crude survival probability, its squared, and cubed values are used as the instrumental variables. In Column (3) log crude survival probability, and log age 75-79 survival probability, and their squared, and cubed values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (2), Stock-Yogo weak ID test critical value is not available. In (3), Stock-Yogo weak ID test critical value is 12.20. Turning point is estimated for coefficients at 10% or better significance level in a Column.

5.6.2. Estimation Results for the 1980-2009 Period

Model (3.2.9) estimation results of linear specification for 1980-2009 are demonstrated in Columns (1), (3), and (5) in Table 5.7a, and Columns (1), (3), and (5) in Table 5.8a. It should be noted that the α_2 and α_3 are restricted to be zero. The coefficient of ln LE is positive at 10% or higher significance level as can be seen in Columns (3) and (5) in Table 5.7a, Column (1) in Table 5.8a. In addition, the coefficient of ln LE is negative at 1% significance level in Column (1) in Table 5.7a. Also, the coefficient of ln LE is insignificant in Columns (3), and (5) in Table 5.8a.

Columns (2), (4), and (6) in Table 5.7a, and Columns (2), (4), and (6) in Table 5.8a report the estimation results of the Model (3.2.9) that belong to quadratic specification for the 1980-2009 period. Here, the α_3 is restricted to be zero. The coefficients of the linear and the quadratic terms were both found significantly different from “0” at 5% or higher significance level, and they are positive and negative, respectively as can be seen in Columns (2), (4), and (6) in Table 5.7a, and Columns (2), and (6) in Table 5.8a.

The estimated turning points are within the range of 21.07-28.90 kg/m^2. In addition, Column (4) in Table 5.8a shows that the coefficient of the quadratic term was found insignificant in. Thus, the quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between productivity and BMI for the 1980-2009 period.

The estimation results of cubic specification by the Model (3.2.9) for the 1980-2009 period are reported in Columns (1), (2), and (3) in Table 5.7b, and Columns (1), (2), and (3) in Table 5.8b. The coefficients of the linear, the quadratic, and the cubic terms were found significantly different from "0" at 5% or higher significance level, and they are negative, positive, and negative, respectively as shown in Column (3) in Table 5.7b.

The estimated turning point-1 is 20.75 kg/m^2 and turning point-2 is 23.11 kg/m^2 in this Column. At the same time, it was found that the coefficient of the linear term is omitted, and the coefficients of the quadratic and the cubic terms are significantly different from "0" at 5% or higher significance level, and they are positive and negative, respectively as in Column (2) in Table 5.8b.

In addition, it was found that the coefficients of the linear, the quadratic, and the cubic terms are significantly different from "0" at 1% significance level, and they are positive, negative, and positive respectively as shown in Column (1) in Table 5.7b. Also, the coefficients of the linear, the quadratic, and the cubic terms are insignificant can be seen in Column (2) in Table 5.7b, and in Columns (1), and (3) in Table 5.8b.

Hence, our cubic functional specification estimation results suggest that there is first convex-, and then a concave-shaped association between productivity and BMI for the 1980-2009 period.

5.7. Estimation Results for Gross Domestic Savings

5.7.1. Diagnostics for the 1980-2009 Period

As regards GMM estimations presented in Columns (5) and (6) of Table 5.9a, and in Column (3) of Table 5.9b, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, whereas AR (2) test does not. These results satisfy the Arellano-Bond estimation assumptions stated in Chapter 2, which increases the efficiency of estimation. In addition, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level. That is, set of instruments is valid.

Table 5.9a

The Association between Gross Domestic Savings and Mean Body Mass Index for the 1980-2009 Period

	Gross domestic savings					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged gross domestic savings	0.90***	0.90***	0.32***	0.29***	0.51*	0.45***
	(0.04)	(0.04)	(0.09)	(0.10)	(0.26)	(0.16)
log mean body mass index 18+ years	−7.94***	98.41	26.14	790.88**	23.92	623.62**
	(3.01)	(228.10)	(29.00)	(315.34)	(54.19)	(233.61)
(log mean body mass index 18+ years)²	-	−16.85	-	−121.53**	-	−95.52**
		(36.20)		(51.48)		(37.97)
Number of observations	282	282	282	282	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.75	0.75	0.17	0.19	-	-
F test *p*-value	0.00	0.00	0.01	0.00	0.01	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.02	0.01
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.48	0.41
Hansen test *p*-value	-	-	-	-	0.43	0.48
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	-	-	25.89	-	26.16

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the gross domestic savings (percent of GDP). Column (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (4), and (6) Columns is 26.02.

As can be seen in Table 5.10a and Table 5.10b, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level. This indicates that there is no functional form misspecification.

The instrumental variables are crude survival and age 75-79 survival probabilities. All these instruments, their squared, and cubed values are valid instruments according to the weak identification test statistic when Column (3) in Table 5.10a is exempted as it satisfies the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock, 1997). However, weak identification test results in Columns (5) and (6) in Table 5.10a, and in Columns (2) and (3) in Table 5.10b are not over 5% maximal IV relative bias according to the Stock and Yogo (2005) critical values. These test results decrease the validity of the instruments.

Table 5.9b

The Association between Gross Domestic Savings and Mean Body Mass Index for the 1980-2009 Period

	Gross domestic savings		
	(1)	(2)	(3)
	OLS	FE (within)	GMM (Arellano-Bond)
first lagged gross domestic savings	0.90***	0.28***	-
	(0.04)	(0.10)	
second lagged gross domestic savings	-	-	−0.19**
			(0.09)
log mean body mass index 18+ years	690.24	10704.21	27026.11
	(7182.74)	(11881.24)	(24659.41)
(log mean body mass index 18+ years)^2	−204.56	−3271.67	−8397.85
	(2275.24)	(3783.89)	(7796.13)
(log mean body mass index 18+ years)^3	19.83	333.41	870.01
	(240.14)	(401.00)	(820.64)
Number of observations	282	282	188
Number of countries	47	47	47
R-squared	0.75	0.19	-
F test *p*-value	0.00	0.00	0.03
Arellano-Bond test for AR (1) *p*-value	-	-	0.04
Arellano-Bond test for AR (2) *p*-value	-	-	0.71
Hansen test *p*-value	-	-	0.32
Country dummies	-	yes	-
Time dummies	-	yes	yes
Turning points (1)	-	-	-
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the gross domestic savings (percent of GDP). Column (3) is difference GMM estimation. Turning point is not estimated for coefficients less than10% significance level in a Column.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, providing evidence that set of instruments is appropriate at the given significance level.

Table 5.10a

Long-Difference Estimations for the Association between Gross Domestic Savings and Mean Body Mass Index for the 1980-2009 Period

	Gross domestic savings					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV (crude survival probability)	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)	IV (crude survival probability, and age 75-79 survival probability)
lagged gross domestic savings	0.85***	0.80***	0.85***	0.81***	0.85***	0.82***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)
log mean body mass index 18+ years	15.70	546.00***	41.97	532.60	37.79	386.45*
	(16.77)	(191.00)	(44.94)	(337.63)	(37.73)	(199.68)
(log mean body mass index 18+ years)²	-	−85.12***	-	−82.88	-	−60.49*
		(30.40)		(52.70)		(33.44)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.77	0.79	0.76	0.79	0.76	0.79
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	14.11	8.13	8.29	7.63
Endogeneity test *p*-value	-	-	0.48	0.997	0.48	0.58
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.81	0.91
C (2nd polynomial) RESET test *p*-value	0.23	0.43	0.18	0.50	0.18	0.53
C (3rd polynomial) RESET test *p*-value	0.31	0.26	0.31	0.35	0.30	0.29
Turning points	-	24.71	-	-	-	24.39

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the gross domestic savings (percent of GDP). Lagged gross domestic savings (percent of GDP) includes two observations by country for the years 1980 and 2005. In Column (3) log crude survival probability, and in Column (4) log crude survival probability, and its squared value are used as the instrumental variables. In Column (5) log crude survival probability, and log age 75-79 survival probability, and in Column (6) log crude survival probability, and log age 75-79 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), Stock-Yogo weak ID test critical value is 19.93. In (6), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (2), and (6) Columns is 24.55.

The endogeneity test of LE fails to be rejected (Table 5.10a; Table 5.10b) at 10% or higher significance level. Thus, the OLS gives consistent and relatively more efficient estimates.

5.7.2. Estimation Results for the 1980-2009 Period

Results pertaining the estimation of linear specification (Model 3.2.10) for the 1980-2009 period are given in Columns (1), (3), and (5) in Table 5.9a, and Columns (1), (3), and (5) in Table 5.10a. In linear specification in this model, the α_2 and α_3 are restricted to be zero. Column (1) in Table 5.9a shows the coefficient of ln LE, which was found negative at 1% or higher significance level. In addition, in Columns (3), (5) in Table 5.9a and in Columns (1), (3), and (5) in Table 5.10a, the coefficient of ln LE was found insignificant.

Table 5.10b

Long-Difference Estimations for the Association between Gross Domestic Savings and Mean Body Mass Index for the 1980-2009 Period

	Gross domestic savings		
	(1)	(2)	(3)
	OLS	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)
lagged gross domestic savings	0.80***	0.82***	0.82***
	(0.07)	(0.10)	(0.07)
log mean body mass index 18+ years	4565.95	15092.52	18704.16
	(6763.42)	(72565.06)	(21350.49)
(log mean body mass index 18+ years)^2	−1366.73	−4770.99	−5929.12
	(2167.33)	(23403.75)	(6851.12)
(log mean body mass index 18+ years)^3	136.09	502.84	626.40
	(231.09)	(2513.91)	(732.64)
Number of observations	47	47	47
Number of countries	47	47	47
R-squared	0.79	0.78	0.77
F test *p*-value	0.00	0.00	0.00
Weak identification test statistic	-	0.07	0.98
Endogeneity test *p*-value	-	0.97	0.58
Hansen J statistic	-	e.e.i.	0.84
C (3rd polynomial) RESET test *p*-value	0.21	0.20	0.34
C (4rd polynomial) RESET test *p*-value	0.37	0.36	0.53
Turning points (1)	-	-	-
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the gross domestic savings (percent of GDP). Lagged gross domestic savings (percent of GDP) includes two observations by country for the years 1980 and 2005. In in Column (2) log crude survival probability, its squared, and cubed values are used as the instrumental variables. In Column (3) log crude survival probability, and log age 75-79 survival probability, and their squared, and cubed values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (2), Stock-Yogo weak ID test critical value is not available. In (3), Stock-Yogo weak ID test critical value is 12.20. Turning point is not estimated for coefficients less than 10% significance level in a Column.

Estimation of quadratic specification by the Model (3.2.10) for the 1980-2009 period are presented in Columns (2), (4), and (6) in Table 5.9a, and Columns (2), (4), and (6) in Table 5.10a. Here the α_3 is restricted to be zero. The coefficients of the linear and the quadratic terms were found to be both significantly different from "0" at 10% or higher significance level, and they are positive and negative, respectively, as shown in Columns (4), (6) in Table 5.9a, and Columns (2) and (6) in Table 5.10a. The estimated turning points are within the range of 24.39-26.16 kg/m^2 in these Columns. In addition, the coefficients of the linear and the quadratic terms were found insignificant (Column 2 in Table 5.9a; Column 4 in Table 5.10a.) Thus, the quadratic functional specification estimation results suggest a non-monotonic and inverse U-shaped association between gross domestic savings and BMI for the 1980-2009 period.

In cubic specification for the 1980-2009 period, Columns (1), (2), and (3) in Table 5.9b, Columns (1), (2), and (3) in Table 5.10b report the estimation results of the Model (3.2.10). The coefficients of the linear, the quadratic, and the cubic terms are insignificant in these Columns.

5.8. Conclusions

This study examines the effects of BMI on GDP per capita, years of schooling (human capital), GDP per person engaged, manufacturing value added per person engaged (productivity), and gross domestic savings for the 1980-2009 period. The empirical results are generally in agreement with findings related to GDP per capita-LE association. There are non-linear and non-monotonic associations between all dependent variables and BMI. These findings support our assumption concerning the impact of BMI as a human physiological function on LE via aging. This can also be observed in these empirical results. To conclude, the empirical findings of the present study yield significant evidence that healthy mean population BMI level secures economic development by promoting savings. The following section presents detailed concluding remarks about the effects of BMI on all dependent variables.

5.8.1. Economic Growth

In linear specification, the coefficient of BMI is positive at 5% or higher significance level. In addition, in quadratic specification, the coefficients of the linear and the quadratic terms are both significantly different from “0” at 5% or higher significance level, and they are positive and negative, respectively. The estimated turning points in quadratic specification are within the range of 24.51-28.61 kilogram/square meter (kg/m^2). Also, in cubic specification, the coefficients of the linear, the quadratic, and the cubic terms are significantly different from “0” at 5% or higher significance level, and they are negative, positive, and negative, respectively. This association is first convex-, and, then concave-shaped. In the latter, the estimated turning point-1 is 19.88 kg/m^2; and the turning point-2 is 25.93 kg/m^2. Hence, our cubic functional specification estimation results suggest that first there is a convex-, and, then concave-shaped association between GDP per capita and BMI for the 1980-2009 period.

5.8.2. Human Capital

In linear specification, the coefficient of BMI was found positive at 5% significance level. In quadratic specification, on the other hand, the coefficients of the linear and the quadratic terms were both found significantly different from "0" at 10% or higher significance level, and they are positive and negative, respectively. The estimated turning points in quadratic specification are within the range of 23.13-29.77 kg/m^2. Hence, the quadratic functional specification estimation results in the present study suggest that there is a non-monotonic and inverse U-shaped association between years of schooling and BMI for the 1980-2009 period. Also, cubic specification produced insignificant coefficients of the linear, quadratic, and cubic terms for the association between years of schooling and BMI for the 1980-2009 period.

5.8.3. GDP per Person Engaged

The coefficient of BMI for the linear specification was observed to be positive at 5% or higher significance level. For the quadratic specification, the coefficients of both the linear and the quadratic terms were found significantly different from "0" at 5% or higher significance level, and they are positive and negative, respectively. For the quadratic specification, the estimated turning points are within the range of 24.62-27.69 kg/m^2. Also, in cubic specification, the coefficients of the linear, the quadratic, and the cubic terms are significantly different from "0" at 10% or higher significance level, and they are negative, positive, and negative, respectively. The association is first convex-, and, then concave-shaped. In the convex-concave-shaped association, the estimated turning point-1 is 20.03 kg/m^2; and turning point-2 is 24.78 kg/m^2. Hence, the cubic functional specification estimation results suggest that there is first a convex-, and, then concave-shaped association between GDP per person engaged and BMI for the 1980-2009 period.

5.8.4. Productivity

The BMI coefficient in the linear specification was found positive at 10% or higher significance level. For quadratic specification, the coefficients of both the linear and the quadratic terms are significantly different from "0" at 5% or higher significance level, and they are positive and negative, respectively. For the quadratic specification, the estimated turning points are within the range of 21.07-28.90 kg/m^2. Also, in cubic specification, the coefficients of the linear, the quadratic, and the cubic terms are significantly different from "0" at 5% or higher significance level, and they are negative, positive, and negative, respectively. The association is first convex-, and then concave- shaped. In the latter, the estimated turning point-1 is 20.75 kg/m^2; and turning point-2 is 23.11 kg/m^2. Hence, the cubic functional specification estimation results suggest that first there is a convex-, and then concave-shaped association between productivity and BMI for the 1980-2009 period.

5.8.5. Gross Domestic Savings

The coefficient of BMI in the linear specification was found negative at 1% significance level. In addition, in quadratic specification, the coefficients of both the linear and the quadratic terms are significantly different from "0" at 10% or higher significance level, and they are positive and negative, respectively. For the quadratic specification, the estimated turning points are within the range of 24.39-26.16 kg/m^2. Hence, the quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between gross domestic savings and BMI for the 1980-2009 period. Also, the cubic specification produced insignificant coefficients of the linear, the quadratic, and the cubic terms as regards association between gross domestic savings and BMI for the 1980-2009 period.

CHAPTER 6

THE IMPACT OF SYSTOLIC BLOOD PRESSURE (SBP) ON ECONOMIC GROWTH, HUMAN CAPITAL, GROSS DOMESTIC PRODUCT (GDP) PER PERSON ENGAGED, PRODUCTIVITY AND GROSS DOMESTIC SAVINGS

6.1. Introduction

The effect of SBP has not yet been investigated in the literature. The association between wealth and health has been analyzed within different dimensions of proxy variables for wealth and health. However, the previous studies have not utilized SBP as a proxy variable for health. This study intended to investigate the effect of SBP on GDP per capita depending on the empirical specifications in Chapter 3 derived from Azomahou et al. (2009). We use balanced panel of 47 countries for the 1980-2009 period only due to data limitations. The quadratic specification confirms the non-linear and non-monotonic association between GDP per capita and SBP. It clearly revealed an inverse U-shaped association between GDP per capita and SBP.

The study also focuses on the connection between years of schooling (human capital), GDP per person engaged, manufacturing value added per person engaged (productivity), gross domestic savings, and SBP by using the empirical specifications in Chapter 3. Thus, other quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between all other dependent variables and SBP for the 1980-2009 period.

In cubic specification, the linear term was observed to be omitted. The coefficients of the quadratic, and the cubic terms are significantly different from "0", and they are positive, and negative respectively for the association between GDP per capita and SBP. Hence, it was asserted that cubic specification estimation results share the same findings with quadratic specification estimations of the association between GDP per capita and SBP for the 1980-2009 period. This is also valid between human capital and SBP in cubic specification.

The other cubic functional specification estimation results suggest that there is first a convex-, and, then concave-shaped association between GDP per person engaged and SBP, and productivity and SBP for the 1980-2009 period. For the association between gross domestic savings and SBP, the coefficients of the linear, the quadratic, and the cubic terms turned out to be insignificant. As a conclusion, the empirical findings offer remarkable evidence that healthy mean population SBP level sustains economic development by means of fostering savings.

6.2. Literature Review

Fogel (1994) suggests that there is a thermodynamic and physiological basis of economic development. There are long lags between socioeconomic, biomedical, and environmental investments and their returns to economic growth. For example, Britain and other OECD countries made investments in 1910 to receive benefits in 1980. Because of these long lags, making judgements based on the association between socioeconomic, biomedical, and environmental investments and economic growth within these short periods becomes paradoxical.

According to Fogel (1994), the crisis and challenges of globalization should be handled by long-term approaches, strategies, and implications. Even today, humanity has not yet got rid of three hundred years old problems, such as hunger and premature death. Without long-term approaches and true dedication of policymakers, humanity cannot effectively handle physiological challenges to reduce chronic diseases and increase longevity for long-run economic growth.

Kim et al. (1997) claim that Onchocercal Skin Disease (OSD) has significant effects on productivity of plantation labors. Indeed, perpetual labors lose their daily earnings by about 10-15 percent due to OSD. It affects productivity of terrestrial workers, driving them towards other employment options and daily plantation works.

Schultz and Tansel (1997) investigate the impact of disease on labor productivity. Based on self-reports of participants, they find that disability days of wage earners and self-employed people decrease earnings by 10 percent or more and hours by at least 3 percent. Rivera and Currais (1999) claim that health provides a significantly positive increment in economic growth. They observe that health and economic growth interact closely.

McCarthy et al (2000) investigate the malaria morbidity effect on economic growth. They find that there is an important climate effect on malaria increment. Another important finding is that malaria negatively affects economic development, decreasing per capita growth by 0.25 percent.

Parker (2000, 71-110), Cortez (2000, 189-218), Savedoff and Schultz (2000,1-34), Ribero and Nunez (2000,111-150), Murrugarra and Valdivia (2000,151-188), and Ferrando et al. (2000,219-245) examine the effect of well-being on labor productivity and earnings. The main finding of these studies is that well-being has a remarkable impact on labor productivity and earnings depending on its status. Morbidity reduces both labor productivity and wages. Poor health status averts people from contributing to employment and having earnings. From this perspective, it also increases poverty in society especially among the elderly.

Arora (2001), whose focus dates back to about 100 to 125 years from today, examines the association between well-being and economic growth rate for industrialized countries, and suggests that improvement in health status elevates long-term economic growth by 30 to 40 percent. Mainly, the infrastructural investments in public health, manufacturing improvements in nutrients, and medical advances in the theory of infectious diseases lead to these positive results for economic growth.

Some models that investigate the impact of well-being on economic growth are provided by Van Zon and Muysken (2001). They find different results depending on whether LE is an internality or externality. The impact of health status on economic growth rate changes between being against economic growth and complementing economic growth.

Weil (2005) develops methodologies with improved efficiency of estimates to investigate the association between health status inputs and individual income. He manages to decrease log GDP per worker variance by nearly 10 percent. He finds that health is a significant variable influencing individual income.

Erdil and Yetkiner (2009) investigate the Granger-causality association between per capita spending of health and per capita output by using macro panel of 75 countries for the period 1990-2000. They find that there is common bidirectional Granger-causality between spending of health and output. There are also two different one-way causality association between spending of health and output depending on income levels. For high-income countries, one-way causality is running from health to output. For other countries, the causal direction follows a reverse path.

Bleakley, (2010) finds that health in childhood leads to other human capital structures in economics. Also, health issues in adulthood reduce labor productivity. According to Bleakley, health intervention is not a panacea for all problems in any economy. However, it provides cost/benefit testable morbidity control options and thus enhance economic growth.

Wang and Zou (2011) demonstrate that different balance growth can occur in economy with a minimum consumption specification in the health generation equation. This explains the existence of poverty trap in real economies i.e., high-income countries have higher capital, better health and higher consumption than low-income countries. Improving the technology level in low-income economies and enhancing health of citizens may play a pivotal role in eliminating the poverty trap in low-income countries. Zang (2018) indicates that deceleration in economic growth may stem from health status. Economic growth may vanish for economies with decreased health status, productivity in health-sector, or output.

6.3. Estimation Results for Economic Growth

6.3.1. Diagnostics for the 1980-2009 Period

For GMM estimations, seen in Columns (5) and (6) of Table 6.1a, and in Column (3) of Table 6.1b, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, but AR (2) test does not. These results satisfy the Arellano-Bond estimation assumptions stated in Chapter 2, increasing the efficiency of estimation. In addition, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level. It hints that the instrument set is valid.

As shown in Table 6.2a and Table 6.2b, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level. It indicates that, in Table 6.2a and Table 6.2b, there is no functional form misspecification.

Table 6.1a

The Association between GDP per Capita and Mean Systolic Blood Pressure for the 1980-2009 Period

	log GDP per capita					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log GDP per capita	-	-	-	-	0.65*** (0.09)	−1.90 (1.29)
log mean systolic blood pressure 25+ years	13.71*** (1.54)	181.65 (458.05)	5.11*** (1.15)	289.58* (156.34)	3.03*** (0.63)	4429.73** (1838.08)
(log mean systolic blood pressure 25+ years)²	-	−17.29 (47.06)	-	−29.30* (16.13)	-	−455.77** (189.64)
Number of observations	329	329	329	329	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.19	0.19	0.67	0.68	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.02
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.00	0.02
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.36	0.10
Hansen test *p*-value	-	-	-	-	0.16	0.36
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	-	-	140.11	-	128.98

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log GDP per capita. Column (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (4), and (6) Columns is 134.55.

The instrumental variables are crude survival, and age 75-79 survival probabilities. All these instruments and their squared and cubed values are valid instruments according to the weak identification test statistic. Columns (5), (6) in Table 6.2a and Column (3) in Table 6.2b are exempt as they satisfy the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock (1997). At the same time, weak identification test in Column (2) in Table 6.2b is not over 10% maximal IV size according to Stock and Yogo (2005) critical values. This test result decreases the validity of the instruments in this Column.

Table 6.1b

The Association between GDP per Capita and Mean Systolic Blood Pressure for the 1980-2009 Period

	log GDP		
	(1)	(2)	(3)
	OLS	FE (within)	GMM (Arellano-Bond)
lagged log GDP	-	-	0.42***
			(0.08)
log mean systolic blood pressure 25+ years	(omitted)	−29403.74	(omitted)
		(22855.82)	
(log mean systolic blood pressure 25+ years)^2	21.16	6078.44	14.32
	(46.99)	(4693.76)	(9.39)
(log mean systolic blood pressure 25+ years)^3	−2.71	−418.76	−1.91
	(6.44)	(321.29)	(1.29)
Number of observations	329	329	235
Number of countries	47	47	47
R-squared	0.19	0.69	-
F test *p*-value	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	0.02
Arellano-Bond test for AR (2) *p*-value	-	-	0.53
Hansen test *p*-value	-	-	0.39
Country dummies	-	yes	-
Time dummies	-	yes	yes
Turning points (1)	-	-	-
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. GDP is GDP per capita. The dependent variable is the log GDP per capita. Column (3) is difference GMM estimation. Turning point is not estimated for coefficients less than 10% significance level in a Column.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 5% or higher significance level. That is, instruments are appropriate at the given significance level.

Table 6.2a

Long-Difference Estimations for the Association between GDP per Capita and Mean Systolic Blood Pressure for the 1980-2009 Period

	log GDP per capita					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV (crude survival probability)	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)	IV (crude survival probability, and age 75-79 survival probability)
log mean systolic blood pressure 25+ years	4.71***	220.84	−2.79	1772.98*	−3.31	1095.46
	(1.35)	(207.67)	(4.86)	(928.47)	(4.61)	(861.13)
(log mean systolic blood pressure 25+ years)²	-	−22.23	-	−182.65*	-	−112.14
		(21.38)		(95.64)		(88.66)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.15	0.17	−0.23	−0.96	−0.29	−0.08
F test *p*-value	0.00	0.00	0.58	0.19	0.49	0.00
Weak identification test statistic	-	-	18.17	8.77	11.89	7.42
Endogeneity test *p*-value	-	-	0.06	0.06	0.03	0.11
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.85	0.12
C (2nd polynomial) RESET test *p*-value	0.06	0.06	0.34	0.90	0.11	0.18
C (3rd polynomial) RESET test *p*-value	0.11	0.16	0.60	0.11	0.24	0.35
Turning points	-	-	-	128.19	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. GDP is GDP per capita. The dependent variable is the log GDP per capita. In Column (3) log crude survival probability, and in Column (4) log crude survival probability, and its squared value are used as the instrumental variables. In Column (5) log crude survival probability, and log age 75-79 survival probability, and in Column (6) log crude survival probability, and log age 75-79 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), Stock-Yogo weak ID test critical value is 19.93. In (6), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

The endogeneity test of LE fails to be rejected in Table 6.2a and Table 6.2b at 5% significance level by excluding Column (5) in Table 6.2a. Thus, the OLS gives consistent and relatively more efficient estimates.

Table 6.2b

Long-Difference Estimations for the Association between GDP per Capita and Mean Systolic Blood Pressure for the 1980-2009 Period

	log GDP		
	(1)	(2)	(3)
	OLS	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)
log mean systolic blood pressure 25+ years	−43727.99	(omitted)	(omitted)
	(44201.67)		
(log mean systolic blood pressure 25+ years)²	9016.15	201.35**	77.54
	(9077.22)	(94.31)	(92.21)
(log mean systolic blood pressure 25+ years)³	−619.58	−27.66**	−10.57
	(621.34)	(12.96)	(12.66)
Number of observations	47	47	47
Number of countries	47	47	47
R-squared	0.19	−1.18	0.08
F test *p*-value	0.09	0.13	0.02
Weak identification test statistic	-	6.55	8.91
Endogeneity test *p*-value	-	0.05	0.17
Hansen J statistic	-	e.e.i.	0.09
C (3rd polynomial) RESET test *p*-value	0.17	0.14	0.58
C (4rd polynomial) RESET test *p*-value	0.14	0.19	n.r.
Turning points (1)	-	128.25	-
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. GDP is GDP per capita. The dependent variable is the log GDP per capita. In Column (2) squared, and cubed values of log crude survival probability are used as the instrumental variables. In Column (3) squared, and cubed values of log crude survival probability and log age 75-79 survival probability are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. "n.r." means that "not reported" by the test. In (2), Stock-Yogo weak ID test critical value is 7.03. In (3), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

6.3.2. Estimation Results for the 1980-2009 Period

Estimation results of linear specification obtained by Model (3.2.11) for the 1980-2009 period are reported in Columns (1), (3) and (5) in Table 6.1a and Columns (1), (3), and (5) in Table 6.2a. In linear specification model (3.2.11), the α_2 and α_3 are restricted to be zero. The coefficient of ln LE is positive at 1% significance level as can be seen in Columns (1), (3) and (5) in Table 6.1a and Column (1) in Table 6.2a. In addition, the coefficient of ln LE is insignificant in Column (3), and (5) in Table 6.2a.

The estimation results of quadratic specification by Model (3.2.11) for the 1980-2009 period are in Columns (2), (4), and (6) in Table 6.1a, Columns (2), (4), and (6) in Table 6.2a In this model, the α_3 is restricted to be zero. The coefficients of both the linear and the quadratic terms are significantly different from "0" at 10% or higher significance level, and they are positive and negative, respectively in Columns (4), and (6) in Table 6.1a, Column (4) in Table 6.2a.

As can be seen in these columns, the estimated turning points[8] are within the range of 128.19-140.11 mm Hg. Also, the coefficients of the linear and the quadratic terms were found insignificant in Columns (2) in Table 6.1a, in Columns (2), and (6) in Table 6.2a. Thus, our quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between GDP per capita and SBP for the 1980-2009 period.

The estimation results cubic specification by Model (3.2.11) for the 1980-2009 period are presented in Columns (1), (2), and (3) in Table 6.1b and Columns (1), (2), and (3) in Table 6.2b of the. The linear term is observed to be omitted. The coefficients of the quadratic, and the cubic terms are significantly different from "0"

[8] Quadratic specification turning point (TP) is estimated by following formula: $TP = \exp\left(\left|\frac{\hat{\beta}_1}{2\hat{\beta}_2}\right|\right)$.

at 1% significance level, and they are positive and negative, respectively, in Column (2) in Table 6.1b.

The turning point[9] is 128.25 mm Hg. In addition, the coefficients of the linear, the quadratic, and the cubic terms were insignificant in Columns (1), (2) in Table 6.1b, in Columns (1), and (3) in Table 6.2b. Hence, cubic specification estimation results reveal the same findings with quadratic specification estimations of the association between GDP per capita and SBP for the 1980-2009 period.

6.4. Estimation Results for Human Capital

6.4.1. Diagnostics for the 1980-2009 Period

For GMM estimations shown in Columns (5) and (6) of Table 6.3a and in Column (3) of Table 6.3b, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, but AR (2) test does not. These results satisfy Arellano-Bond estimation assumptions stated in Chapter 2, increasing the efficiency of estimation. In addition, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level. It hints that instrument set is valid.

As can be seen in Table 6.4a and Table 6.4b, the RESET test indicates that H_0 fails to be rejected at 10% or higher significance level. This indicates that in Table 6.4a, and Table 6.4b, there is no functional form misspecification.

The instrumental variables are crude survival, and age 75-79 survival probabilities. All these instruments, their squared, and cubed values are valid instruments according to the weak identification test statistic, yet this exempts Columns (5), (6) in Table 6.2a and Columns (2), (3) in Table 6.2b as only Columns (5), (6) in Table 6.2a, and Column (3) in Table 6.2b satisfy the rule of thumb that F statistics of the

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[9] Cubic specification turning points (*TPs*) are estimated by using general mathematical formula: $\frac{d}{dx}\left(\hat{\beta}_3 x^3 + \hat{\beta}_2 x^2 + \hat{\beta}_1 x + \text{constant}\right)$, then, $TPs\,(1,2) = \exp\left((-(2\hat{\beta}_2) \pm \sqrt{(2\hat{\beta}_2)^2 - 4(3\hat{\beta}_3\hat{\beta}_1)})\,/\,(2(3\hat{\beta}_3))\right)$

first stage should be over ten (Staiger and Stock, 1997). On the other hand, weak identification test value shown in Column (2) in Table 6.2b is not over 10% maximal IV size according to Stock and Yogo (2005) critical values. This test result decreases the validity of the instruments in this Column.

Table 6.3a

The Association between Years of Schooling and Mean Systolic Blood Pressure for the 1980-2009 Period

	log years of schooling					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log years of schooling	-	-	-	-	0.27**	0.29***
					(0.11)	(0.09)
log mean systolic blood pressure 25+ years	2.76***	425.72**	3.82***	160.52*	5.36***	468.54***
	(0.73)	(194.41)	(0.76)	(82.53)	(0.98)	(144.70)
(log mean systolic blood pressure 25+ years)²	-	−43.54**	-	−16.14*	-	−47.90***
		(19.97)		(8.51)		(14.91)
Number of observations	329	329	329	329	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.05	0.07	0.81	0.81	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.01	0.02
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.74	0.36
Hansen test *p*-value	-	-	-	-	0.38	0.24
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	132.74	-	144.54	-	133.07

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log years of schooling. Column (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (4), and (6) Columns is 136.78.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% significance level, so the set of instruments is valid at the given significance level.

Table 6.3b

The Association between Years of Schooling and Mean Systolic Blood Pressure for the 1980-2009 Period

	log years of schooling		
	(1)	(2)	(3)
	OLS	FE (within)	GMM (Arellano-Bond)
first lagged log years of schooling	-	-	-
second lagged log years of schooling	-	-	0.21
			(0.13)
log mean systolic blood pressure 25+ years	(omitted)	2993.53	(omitted)
		(9649.6)	
(log mean systolic blood pressure 25+ years)²	44.23**	−598.87	46.42***
	(19.95)	(1981.45)	(16.79)
(log mean systolic blood pressure 25+ years)³	−6.03**	39.95	−6.32***
	(2.73)	(135.62)	(2.30)
Number of observations	329	329	188
Number of countries	47	47	47
R-squared	0.07	0.81	-
F test *p*-value	0.00	0.12	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	0.01
Arellano-Bond test for AR (2) *p*-value	-	-	0.44
Hansen test *p*-value	-	-	0.29
Country dummies	-	yes	-
Time dummies	-	yes	yes
Turning points (1)	132.72	-	133.65
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log years of schooling. Column (3) is difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column.

Table 6.4a

Long-Difference Estimations for the Association between Years of Schooling and Mean Systolic Blood Pressure for the 1980-2009 Period

	log year of schooling					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV (crude survival probability)	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)	IV (crude survival probability, and age 75-79 survival probability)
log mean systolic blood pressure 25+ years	4.72***	280.22***	8.34***	339.53	7.47***	444.91
	(0.80)	(93.16)	(1.54)	(342.51)	(1.36)	(280.53)
(log mean systolic blood pressure 25+ years)²	-	−28.34***	-	−34.07	-	−45.10
		(9.59)		(35.24)		(28.82)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.43	0.50	0.18	0.24	0.28	0.42
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Weak identification test statistic	-	-	18.17	8.77	11.89	7.42
Endogeneity test *p*-value	-	-	0.02	0.04	0.03	0.13
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.18	0.24
C (2nd polynomial) RESET test *p*-value	0.65	0.57	0.995	0.71	0.61	0.32
C (3rd polynomial) RESET test *p*-value	0.85	0.85	0.91	0.89	0.58	0.45
Turning points	-	140.28	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log years of schooling. In Column (3) log crude survival probability, and in Column (4) log crude survival probability, and its squared value are used as the instrumental variables. In Column (5) log crude survival probability, and log age 75-79 survival probability, and in Column (6) log crude survival probability, and log age 75-79 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), Stock-Yogo weak ID test critical value is 19.93. In (6), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

The endogeneity test of LE fails to be rejected at 5% or higher significance level as shown in Columns (6) in Table 6.4a and Column (3) in Table 6.4b. Thus, the OLS gives consistent and relatively more efficient estimates. The endogeneity test of LE rejects at 5% or higher significance level in Columns (3), (4), (5) in Table 6.4a, and in Column (2) in Table 6.4b.

Table 6.4b

Long-Difference Estimations for the Association between Years of Schooling and Mean Systolic Blood Pressure for the 1980-2009 Period

	log years of schooling		
	(1)	(2)	(3)
	OLS	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)
log mean systolic blood pressure 25+ years	20919.92*	(omitted)	(omitted)
	(12035.18)		
(log mean systolic blood pressure 25+ years)²	−4273.04*	35.67	49.26*
	(2473.26)	(35.79)	(27.09)
(log mean systolic blood pressure 25+ years)³	290.97*	−4.77	−6.66*
	(169.41)	(4.91)	(3.71)
Number of observations	47	47	47
Number of countries	47	47	47
R-squared	0.51	0.23	0.37
F test *p*-value	0.00	0.00	0.00
Weak identification test statistic	-	6.55	8.91
Endogeneity test *p*-value	-	0.04	0.09
Hansen J statistic	-	e.e.i.	0.41
C (3rd polynomial) RESET test *p*-value	0.33	0.85	0.28
C (4rd polynomial) RESET test *p*-value	0.53	0.80	0.21
Turning points (1)	d.l.z.	-	138.62
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log years of schooling. In Column (2) squared, and cubed values of log crude survival probability are used as the instrumental variables. In Column (3) squared, and cubed values of log crude survival probability and log age 75-79 survival probability are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (2), Stock-Yogo weak ID test critical value is 7.03. In (3), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column. "d.l.z." means that "the discriminant is less than zero."

6.4.2. Estimation Results for the 1980-2009 Period

Estimation results of linear specification by Model (3.2.12) for the 1980-2009 period are displayed in Columns (1), (3), and (5) in Table 6.3a and in Columns (1), (3), and (5) in Table 6.4a. In this linear specification model, the α_2 and α_3 are restricted to be zero. The coefficient of ln LE was found positive at 1% significance level as can be seen in all these Columns in Table 6.3a and Table 6.4a.

The estimation results of quadratic specification by Model (3.2.12) for the 1980-2009 period are presented in Columns (2), (4), and (6) in Table 6.3a and Columns (2), (4), and (6) in Table 6.4a. Note that the α_3 is restricted to be zero. The coefficients of both the linear and the quadratic terms were significantly different from "0" at 10% significance level, and they are positive and negative respectively as shown in Columns (2), (4), and (6) in Table 6.3a and in Column (2) in Table 6.4a.

The estimated turning points are within the range of 132.74-144.54 mm Hg in these Columns. In addition, Columns (4) and (6) in Table 6.4a show that the coefficients of the linear and quadratic terms are insignificant. Thus, the quadratic functional specification estimation results point to a non-monotonic and inverse U-shaped association between years of schooling and SBP for the 1980-2009 period.

The estimation results of cubic specification (Model 3.2.12) for the 1980-2009 period are presented in Columns (1), (2), and (3) in Table 6.3b and in Columns (1), (2), and (3) in Table 6.4b. It was found that the linear terms are omitted, and the coefficients of the quadratic, and the cubic terms are significantly different from "0" at 10% or higher significance level, and they are positive, and negative, respectively, as shown in Column (1), (3) in Table 6.3b and in Column (3) in Table 6.4b.

The estimated turning points are within the range of 132.72-138.62 mm Hg. Also, as can be seen in Column (1) in Table 6.4b, the coefficients of the linear, the quadratic, and the cubic terms are significantly different from "0" at 10% significance level, and they are positive, negative, and positive, respectively. However, the discriminant is less than zero in this Column. In addition, it was found that the linear terms are omitted, and the coefficients of the quadratic, and the cubic terms are insignificant as shown in Column (2) in Table 6.3b and in Table 6.4b. Hence, the cubic specification estimation results share the same findings with quadratic specification estimations of the association between years of schooling and SBP for the 1980-2009 period.

6.5. Estimation Results for GDP per Person Engaged

6.5.1. Diagnostics for the 1980-2009 Period

For GMM estimations in Columns (5) and (6) of Table 6.5a and in Column (3) of Table 6.5b, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, but AR (2) test does not. These results satisfy Arellano-Bond estimation assumptions laid out in Chapter 2, increasing the efficiency of estimation. In addition, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, pointing out that set of instruments is appropriate.

Table 6.5a

The Association between GDP per Person Engaged and Mean Systolic Blood Pressure for the 1980-2009 Period

	log GDP per person engaged					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log GDP per person engaged	-	-	-	-	0.35***	0.45***
					(0.08)	(0.09)
log mean systolic blood pressure 25+ years	14.29***	579.38	4.27***	467.70**	3.99***	323.02*
	(1.50)	(442.90)	(1.37)	(182.38)	(0.96)	(188.12)
(log mean systolic blood pressure 25+ years)²	-	−58.18	-	−47.73**	-	−32.83*
		(45.50)		(18.78)		(19.35)
Number of observations	329	329	329	329	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.23	0.23	0.49	0.53	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.02	0.01
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.17	0.30
Hansen test *p*-value	-	-	-	-	0.15	0.91
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	-	-	134.28	-	136.95

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log GDP per person engaged. Column (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (4), and (6) Columns is 135.62.

As can be seen in Table 6.6a and Table 6.6b, the RESET test indicates that H_0 fails to be rejected at 5% significance level. It demonstrates that there is no functional form misspecification.

Table 6.5b

The Association between GDP per Person Engaged and Mean Systolic Blood Pressure for the 1980-2009 Period

	log GDP per person engaged		
	(1)	(2)	(3)
	OLS	FE (within)	GMM (Arellano-Bond)
lagged log GDP per person engaged	-	-	0.44***
			(0.08)
log mean systolic blood pressure 25+ years	(omitted)	−42019.48*	(omitted)
		(24347.95)	
(log mean systolic blood pressure 25+ years)²	61.87	8691.63*	38.13**
	(45.43)	(4998.84)	(14.69)
(log mean systolic blood pressure 25+ years)³	−8.29	−599.18*	−5.18**
	(6.22)	(342.08)	(2.02)
Number of observations	329	329	
Number of countries	47	47	
R-squared	0.23	0.55	-
F test *p*-value	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	0.04
Arellano-Bond test for AR (2) *p*-value	-	-	0.29
Hansen test *p*-value	-	-	0.26
Country dummies	-	yes	-
Time dummies	-	yes	yes
Turning points (1)	-	118.38	134.85
(2)	-	133.83	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log GDP per person engaged. Column (3) is difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column.

The instrumental variables are crude survival and age 75-79 survival probabilities. All these instruments, their squared, and cubed values are valid instruments according to the weak identification test statistic though Columns (5), (6) in Table 6.6a and Columns (2), (3) in Table 6.6b are exempted as only Columns (5), (6) in Table 6.6a and Column (3) in Table 6.6b satisfy the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock, 1997). On the other hand, weak identification test result shown in Column (2) in Table 6.6b is not over 10% maximal IV size according to the Stock and Yogo (2005) critical values. This test result decreases the validity of the instruments in this Column.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 5% or higher significance level. That is, the set of instruments is appropriate at the given significance level.

Table 6.6a

Long-Difference Estimations for the Association between GDP per Person Engaged and Mean Systolic Blood Pressure for the 1980-2009 Period

	log GDP per person engaged					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV (crude survival probability)	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)	IV (crude survival probability, and age 75-79 survival probability)
log mean systolic blood pressure 25+ years	3.62**	350.50	−4.10	2145.84**	−4.31	1479.03
	(1.61)	(236.14)	(4.96)	(973.40)	(4.78)	(942.48)
(log mean systolic blood pressure 25+ years)²	-	−35.68	-	−221.14**	-	−151.72
	-	(24.28)		(100.27)		(97.03)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.08	0.12	−0.30	−1.22	−0.32	−0.27
F test *p*-value	0.03	0.03	0.42	0.11	0.38	0.02
Weak identification test statistic	-	-	18.17	8.77	11.89	7.42
Endogeneity test *p*-value	-	-	0.06	0.04	0.04	0.12
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.94	0.13
C (2nd polynomial) RESET test *p*-value	0.03	0.03	0.58	0.74	0.20	0.39
C (3rd polynomial) RESET test *p*-value	0.03	0.06	0.82	0.14	0.42	0.69
Turning points	-	-	-	127.98	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log GDP per person engaged. In Column (3) log crude survival probability, and in Column (4) log crude survival probability, and its squared value are used as the instrumental variables. In Column (5) log crude survival probability, and log age 75-79 survival probability, and in Column (6) log crude survival probability, and log age 75-79 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), Stock-Yogo weak ID test critical value is 19.93. In (6), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

The endogeneity test of LE fails to be rejected at 5% or higher significance level in Columns (3), (6) in Table 6.6a and in Column (3) in Table 6.6b. Thus, the OLS gives consistent and relatively more efficient estimates. The endogeneity test of LE rejects at 5% or higher significance level in Columns (4), (5) in Table 6.6a and in Column (2) in Table 6.6b.

Table 6.6b

Long-Difference Estimations for the Association between GDP per Person Engaged and Mean Systolic Blood Pressure for the 1980-2009 Period

	log GDP per person engaged		
	(1)	(2)	(3)
	OLS	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)
log mean systolic blood pressure 25+ years	−60125.03	(omitted)	(omitted)
	(45429.58)		
(log mean systolic blood pressure 25+ years)²	12401.54	233.45**	109.16
	(9329.92)	(96.96)	(100.08)
(log mean systolic blood pressure 25+ years)³	−852.56	−32.08**	−14.92
	(638.67)	(13.32)	(13.74)
Number of observations	47	47	47
Number of countries	47	47	47
R-squared	0.16	−1.37	−0.03
F test *p*-value	0.02	0.08	0.05
Weak identification test statistic	-	6.55	8.91
Endogeneity test *p*-value	-	0.04	0.23
Hansen J statistic	-	e.e.i.	0.08
C (3rd polynomial) RESET test *p*-value	0.12	0.18	0.69
C (4rd polynomial) RESET test *p*-value	0.08	0.24	0.55
Turning points (1)	-	128.04	-
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log GDP per person engaged. In Column (2) squared, and cubed values of log crude survival probability are used as the instrumental variables. In Column (3) squared, and cubed values of log crude survival probability and log age 75-79 survival probability are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (2), Stock-Yogo weak ID test critical value is 7.03. In (3), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

6.5.2. Estimation Results for the 1980-2009 Period

Columns (1), (3), and (5) in Table 6.5a and Columns (1), (3), and (5) in Table 6.6a display the estimation results of linear specification by Model (3.2.13) for the 1980-2009 period. In this model of linear specification, the α_2 and α_3 are restricted to be zero. The coefficient of ln LE was found positive at 5% significance level as shown in Columns (1), (3), and (5) in Table 6.5a and Column (1) in Table 6.6a. Also, Columns (3) and (5) in Table 6.6a show that the coefficient of ln LE is insignificant.

The estimation results of quadratic specification by Model (3.2.13) for the 1980-2009 period are reported in Columns (2), (4), and (6) in Table 6.5a and Columns (2), (4), and (6) in Table 6.6a. In this model, the α_3 is restricted to be zero. It was found that the coefficients of both the linear and the quadratic terms are significantly different from "0" at 10% or higher significance level, and they are positive and negative, respectively as shown in Columns (4), (6) in Table 6.5a and in Column (4) in Table 6.6a.

The estimated turning points are within the range of 127.98-136.95 mm Hg in these Columns. In addition, Columns (2) in Table 6.5a and Columns (2) and (6) in Table 6.6a show that the coefficients of the linear and quadratic terms are insignificant. Thus, the quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between GDP per person engaged and SBP for the 1980-2009 period.

Columns (1), (2), and (3) in Table 6.5b and Columns (1), (2), and (3) in Table 6.6b report the estimation results of cubic specification for the 1980-2009 period by Model (3.2.13). The coefficients of the linear, the quadratic, and the cubic terms were found significantly different from "0" at 10% significance level, and they are negative, positive, and negative, respectively as shown in Column (2) in Table 6.5b.

The estimated turning point-1 is 118.38 mm Hg and turning point-2 is 133.83 mm Hg in this Column. Also, it was found that the linear terms are omitted, and the coefficients of the quadratic, and the cubic terms are significantly different from "0" at 5% significance level, and they are positive, and negative, respectively, as shown in Column (3) in Table 6.5b and in Column (2) in Table 6.6b. In addition, the coefficients of the linear, the quadratic, and the cubic terms were found insignificant in Column (1) (with omitted linear term) in Table 6.5b and in Columns (3) (with omitted linear term) and (1) in Table 6.6b. Hence, the cubic functional specification estimation results suggest that there is first a convex-, and then a concave-shaped association between GDP per person engaged and SBP for the 1980-2009 period.

6.6. Estimation Results for Productivity

6.6.1. Diagnostics for the 1980-2009 Period

As for GMM estimations shown in Columns (5) and (6) of Table 6.7a and in Column (3) of Table 6.7b, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, but AR (2) test does not. These results satisfy Arellano-Bond estimation assumptions stated in Chapter 2, increasing the efficiency of estimation. In addition, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, which points out that the instrument set is valid.

Table 6.7a

The Association between Productivity and Mean Systolic Blood Pressure for the 1980-2009 Period

	log productivity					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged log productivity	-	-	-	-	0.76***	0.36***
					(0.11)	(0.10)
log mean systolic blood pressure 25+ years	16.19***	210.70	11.49***	530.35*	6.22***	639.21**
	(1.52)	(448.31)	(1.88)	(275.83)	(2.10)	(297.90)
(log mean systolic blood pressure 25+ years)²	-	−20.03	-	−53.43*	-	−64.90**
		(46.06)		(28.42)		(30.55)
Number of observations	329	329	329	329	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.27	0.27	0.32	0.35	-	-
F test *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.01	0.02
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.24	0.25
Hansen test *p*-value	-	-	-	-	0.34	0.29
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	-	-	142.98	-	137.62

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log productivity. Column (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column. Mean turning point of the estimations in (4), and (6) Columns is 140.30.

As can be seen in Table 6.8a and Table 6.8b, according to the RESET test, H_0 fails to be rejected at 5% or higher significance level except for Column (1) in Table 6.8a and in Table 6.8b. This indicates that, in Table 6.8a and Table 6.8b, there is no functional form misspecification.

Table 6.7b

The Association between Productivity and Mean Systolic Blood Pressure for the 1980-2009 Period

	log productivity		
	(1)	(2)	(3)
	OLS	FE (within)	GMM (Arellano-Bond)
lagged log productivity	-	-	0.67***
			(0.17)
log mean systolic blood pressure 25+ years	(omitted)	−75954.93**	(omitted)
		(35972.46)	
(log mean systolic blood pressure 25+ years)²	24.22	15679.12**	49.84*
	(46.01)	(7388.63)	(26.34)
(log mean systolic blood pressure 25+ years)³	−3.10	−1078.65**	−6.74*
	(6.30)	(505.84)	(3.59)
Number of observations	329	329	235
Number of countries	47	47	47
R-squared	0.27	0.38	-
F test *p*-value	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	0.02
Arellano-Bond test for AR (2) *p*-value	-	-	0.24
Hansen test *p*-value	-	-	0.22
Country dummies	-	yes	-
Time dummies	-	yes	yes
Turning points (1)	-	118.76	138.42
(2)	-	136.11	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the log productivity. Column (3) is difference GMM estimation. Turning point is estimated for coefficients at 10% or better significance level in a Column.

The instrumental variables are crude survival and age 75-79 survival probabilities. All these instruments, their squared, and cubed values are valid instruments according to the weak identification test statistic, which exempts Columns (5), (6) in Table 6.8a and Columns (2), (3) in Table 6.8b as only Columns (5), (6) in Table 6.8a, and Column (3) in Table 6.8b satisfy the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock (1997). On the other hand, weak identification test result shown in Column (2) in Table 6.8b is not over 10% maximal IV size according to the Stock and Yogo (2005) critical values. This test result decreases the validity of the instruments in this Column.

Table 6.8a

Long-Difference Estimations for the Association between Productivity and Mean Systolic Blood Pressure for the 1980-2009 Period

	log productivity					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV (crude survival probability)	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)	IV (crude survival probability, and age 75-79 survival probability)
log mean systolic blood pressure 25+ years	11.37***	441.08	6.97	1960.50*	6.06	1356.35
	(2.11)	(320.01)	(5.05)	(1100.97)	(5.12)	(1177.61)
(log mean systolic blood pressure 25+ years)²	-	−44.21	-	−200.93*	-	− 138.10
		(32.93)		(113.47)		(121.23)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.34	0.37	0.29	0.03	0.27	0.25
F test *p*-value	0.00	0.00	0.18	0.02	0.25	0.00
Weak identification test statistic	-	-	18.17	8.77	11.89	7.42
Endogeneity test *p*-value	-	-	0.35	0.22	0.26	0.21
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.79	0.33
C (2nd polynomial) RESET test *p*-value	0.02	0.03	0.87	0.71	0.66	0.30
C (3rd polynomial) RESET test *p*-value	0.02	0.07	0.96	0.66	0.90	0.52
Turning points	-	-	-	131.43	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log productivity. In Column (3) log crude survival probability, and in Column (4) log crude survival probability, and its squared value are used as the instrumental variables. In Column (5) log crude survival probability, and log age 75-79 survival probability, and in Column (6) log crude survival probability, and log age 75-79 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), Stock-Yogo weak ID test critical value is 19.93. In (6), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% significance level, showing that the set of instruments is appropriate at the given significance level.

Table 6.8b

Long-Difference Estimations for the Association Between Productivity and Mean Systolic Blood Pressure for the 1980-2009 Period

	log productivity		
	(1)	(2)	(3)
	OLS	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)
log mean systolic blood pressure 25+ years	−93585.19	(omitted)	(omitted)
	(61314.72)		
(log mean systolic blood pressure 25+ years)²	19292.97	198.52*	78.63
	(12593.65)	(109.23)	(123.13)
(log mean systolic blood pressure 25+ years)³	−1325.55	−27.13*	−10.58
	(862.18)	(15.02)	(16.90)
Number of observations	47	47	47
Number of countries	47	47	47
R-squared	0.41	0.05	0.33
F test *p*-value	0.01	0.01	0.00
Weak identification test statistic	-	6.55	8.91
Endogeneity test *p*-value	-	0.27	0.34
Hansen J statistic	-	e.e.i.	0.25
C (3rd polynomial) RESET test *p*-value	0.02	0.76	0.17
C (4rd polynomial) RESET test *p*-value	0.04	0.82	0.11
Turning points (1)	-	131.52	-
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the log productivity. In Column (2) squared, and cubed values of log crude survival probability are used as the instrumental variables. In Column (3) squared, and cubed values of log crude survival probability and log age 75-79 survival probability are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (2), Stock-Yogo weak ID test critical value is 7.03. In (3), Stock-Yogo weak ID test critical value is 11.04. Turning point is estimated for coefficients at 10% or better significance level in a Column.

The endogeneity test of LE fails to be rejected in Table 6.8a and in Table 6.8b at 10% significance level. Thus, the OLS gives consistent and relatively more efficient estimates.

6.6.2. Estimation Results for the 1980-2009 Period

Columns (1), (3), and (5) in Table 6.7a and Columns (1), (3), and (5) in Table 6.8a report the estimation results of linear specification by Model (3.2.14) for the 1980-2009 period. In this model, the α_2 and α_3 are restricted to be zero. It was found that the coefficient of ln LE is positive at 1% significance level in Columns (1), (3), and (5) in Table 6.7a and Column (1) in Table 6.8a. Also, Columns (3) and (5) in Table 6.8a show that the coefficient of ln LE is insignificant.

Columns (2), (4), and (6) in Table 6.7a and Columns (2), (4), and (6) in Table 6.8a present the estimation results of quadratic specification for the 1980-2009 period by Model (3.2.14). In the model, the α_3 is restricted to be zero. The coefficients of both the linear and the quadratic terms were found significantly different from "0" at 10% significance level, and they are positive and negative, respectively in Columns (4) and (6) in Table 6.7a, and Column (4) in Table 6.8a.

The estimated turning points are within the range of 131.43-142.98 mm Hg in these Columns. In addition, the coefficient of the quadratic term is insignificant as can be seen in Column (2) in Table 6.7a and in Columns (2), and (6) in Table 6.8a. Thus, the quadratic specification estimation results point to a non-monotonic and inverse U-shaped association between productivity and SBP for the 1980-2009 period.

Columns (1), (2), and (3) in Table 6.7b and Columns (1), (2), and (3) in Table 6.8b demonstrate the estimation results of cubic specification for the 1980-2009 period by Model (3.2.14). It was found that the coefficients of the linear, the quadratic, and the cubic terms are significantly different from "0" at 5% significance level, and they are negative, positive, and negative, respectively, as shown in Column (2) in Table 6.7b.

The estimated turning point-1 is 118.76 mm Hg and turning point-2 is 136.11 mm Hg in this Column. Also, note that the linear terms are omitted, and the coefficients of the quadratic, and the cubic terms are significantly different from "0" at 10%

significance level, and they are positive, and negative, respectively as shown in Column (3) in Table 6.7b and in Column (2) in Table 6.8b.

Furthermore, the coefficients of the linear, the quadratic, and the cubic terms were found insignificant as shown in Column (1) (with omitted linear term) in Table 6.7b, and in Columns (3) (with omitted linear term), and (1) in Table 6.8b. Hence, our cubic functional specification estimation results suggest that there is first a convex-, and then a concave-shaped association between productivity and SBP for the 1980-2009 period.

6.7. Estimation Results for Gross Domestic Savings

6.7.1. Diagnostics for the 1980-2009 Period

As for GMM estimations in Columns (5) and (6) of Table 6.9a and in Column (3) of Table 6.9b, Arellano-Bond AR (1) test rejects H_0 at 5% or higher significance level, but AR (2) test does not. These results satisfy Arellano-Bond estimation assumptions laid out in Chapter 2, increasing the efficiency of estimation. In addition, Hansen tests indicate that over-identification restrictions fail to be rejected at 10% or higher significance level, which points out that the set of instruments is valid.

Table 6.9a

The Association between Gross Domestic Savings and Mean Systolic Blood Pressure for the 1980-2009 Period

	Gross domestic savings					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	FE (within)	FE (within)	GMM (Arellano-Bond)	GMM (Arellano-Bond)
lagged gross domestic savings	-	-	-	-	0.23	0.26
					(0.15)	(0.16)
log mean systolic blood pressure 25+ years	56.06***	403.72	69.64**	4861.43*	47.11*	156.42
	(14.13)	(3548.75)	(26.58)	(2795.28)	(23.77)	(3560.11)
(log mean systolic blood pressure 25+ years)²	-	−35.79	-	−493.47*	-	−11.45
		(364.72)		(287.72)		(366.89)
Number of observations	329	329	329	329	235	235
Number of countries	47	47	47	47	47	47
R-squared	0.04	0.04	0.08	0.09	-	-
F test *p*-value	0.00	0.00	0.04	0.03	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	-	-	0.04	0.03
Arellano-Bond test for AR (2) *p*-value	-	-	-	-	0.26	0.28
Hansen test *p*-value	-	-	-	-	0.35	0.53
Country dummies	-	-	yes	yes	-	-
Time dummies	-	-	yes	yes	yes	yes
Turning points	-	-	-	137.79	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the gross domestic savings (percent of GDP). Column (5) and (6) are difference GMM estimations. Turning point is estimated for coefficients at 10% or better significance level in a Column.

As can be seen in Table 6.10a and Table 6.10b, the RESET test indicates that H_0 fails to be rejected at 5% or higher significance level, indicating that, in Table 6.10a and Table 6.10b, there is no functional form misspecification.

The instrumental variables are crude survival and age 75-79 survival probabilities. All these instruments, their squared, and cubed values are valid instruments according to the weak identification test statistic, except for Columns (5), (6) in Table 6.10a and Columns (2), (3) in Table 6.10b as only Columns (5), (6) in Table 6.10a and Column (3) in Table 6.10b satisfy the rule of thumb that F statistics of the first stage should be over ten (Staiger and Stock, 1997). On the other hand, weak identification test result in Column (2) in Table 6.10b is not over 10% maximal IV size according to the Stock and Yogo (2005) critical values. This test result decreases the validity of the instruments in this Column.

Table 6.9b

The Association between Gross Domestic Savings and Mean Systolic Blood Pressure for the 1980-2009 Period

	Gross domestic savings		
	(1)	(2)	(3)
	OLS	FE (within)	GMM (Arellano-Bond)
lagged gross domestic savings	-	-	0.26*
			(0.14)
log mean systolic blood pressure 25+ years	(omitted)	473118.1	(omitted)
		(308628.2)	
(log mean systolic blood pressure 25+ years)²	48.62	−96810.98	90.83
	(364.66)	(63384.01)	(349.40)
(log mean systolic blood pressure 25+ years)³	−5.88	6603.68	−11.84
	(49.96)	(4338.92)	(48.00)
Number of observations	329	329	235
Number of countries	47	47	47
R-squared	0.04	0.10	-
F test *p*-value	0.00	0.00	0.00
Arellano-Bond test for AR (1) *p*-value	-	-	0.02
Arellano-Bond test for AR (2) *p*-value	-	-	0.27
Hansen test *p*-value	-	-	0.43
Country dummies	-	yes	-
Time dummies	-	yes	yes
Turning points (1)	-	-	-
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All panels are balanced panels with one observation per five years and per country. The dependent variable is the gross domestic savings (percent of GDP). Column (3) is difference GMM estimation. Turning point is not estimated for coefficients less than 10% significance level in a Column.

Hansen J tests indicate that over-identification restrictions fail to be rejected at 10% significance level, indicating that the set of instruments is appropriate at the given significance level.

Table 6.10a

Long-Difference Estimations for the Association between Gross Domestic Savings and Mean Systolic Blood Pressure for the 1980-2009 Period

	Gross domestic savings					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV (crude survival probability)	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)	IV (crude survival probability, and age 75-79 survival probability)
log mean systolic blood pressure 25+ years	69.95**	4245.75	45.06	19548.65	−6.37	14161.29
	(31.14)	(3735.72)	(101.68)	(14389.3)	(88.17)	(13151.57)
(log mean systolic blood pressure 25+ years)²	-	−429.58	-	−2006.06	-	−1449.12
		(384.31)		(1481.27)		(1351.47)
Number of observations	47	47	47	47	47	47
Number of countries	47	47	47	47	47	47
R-squared	0.08	0.10	0.07	−0.10	−0.02	0.02
F test *p*-value	0.03	0.06	0.67	0.35	0.94	0.34
Weak identification test statistic	-	-	18.17	8.77	11.89	7.42
Endogeneity test *p*-value	-	-	0.76	0.52	0.17	0.84
Hansen J statistic	-	-	e.e.i.	e.e.i.	0.31	0.20
C (2nd polynomial) RESET test *p*-value	0.57	0.72	0.48	0.15	0.25	0.03
C (3rd polynomial) RESET test *p*-value	0.28	0.32	0.46	0.16	0.39	0.10
Turning points	-	-	-	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the gross domestic savings (percent of GDP). In Column (3) log crude survival probability, and in Column (4) log crude survival probability, and its squared value are used as the instrumental variables. In Column (5) log crude survival probability, and log age 75-79 survival probability, and in Column (6) log crude survival probability, and log age 75-79 survival probability, and their squared values are used as instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (3), Stock-Yogo weak ID test critical value is 16.38. In (4), Stock-Yogo weak ID test critical value is 7.03. In (5), Stock-Yogo weak ID test critical value is 19.93. In (6), Stock-Yogo weak ID test critical value is 11.04. Turning point is not estimated for coefficients less than 10% significance level in a Column.

As can be seen in Table 6.10a and in Table 6.10b, the endogeneity test of LE fails to be rejected, at 10% significance level. Thus, the OLS gives consistent and relatively more efficient estimates.

Table 6.10b

Long-Difference Estimations for the Association between Gross Domestic Savings and Mean Systolic Blood Pressure for the 1980-2009 Period

	Gross domestic savings		
	(1)	(2)	(3)
	OLS	IV (crude survival probability)	IV (crude survival probability, and age 75-79 survival probability)
log mean systolic blood pressure 25+ years	851748.1	(omitted)	(omitted)
	(705077.3)		
(log mean systolic blood pressure 25+ years)²	−174724.5	2482.78	1427.39
	(144870.7)	(1622.65)	(1337.20)
(log mean systolic blood pressure 25+ years)³	11947.79	−339.91	−194.80
	(9921.59)	(222.83)	(183.18)
Number of observations	47	47	47
Number of countries	47	47	47
R-squared	0.12	−0.24	0.02
F test *p*-value	0.33	0.26	0.43
Weak identification test statistic	-	6.55	8.91
Endogeneity test *p*-value	-	0.43	0.74
Hansen J statistic	-	e.e.i.	0.21
C (3rd polynomial) RESET test *p*-value	0.83	0.13	0.12
C (4rd polynomial) RESET test *p*-value	0.08	0.24	0.24
Turning points (1)	-	-	-
(2)	-	-	-

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All Columns are long-difference estimations with two observations by country for the years 1980 and 2009. The dependent variable is the gross domestic savings (percent of GDP). In Column (2) squared, and cubed values of log crude survival probability are used as the instrumental variables. In Column (3) squared, and cubed values of log crude survival probability and log age 75-79 survival probability are used as the instrumental variables. In Hansen J statistic, "equation exactly identified" term is represented by the term as "e.e.i." *C* (GMM-distance) RESET test uses Pesaran-Smith optimal forecast values. In (2), Stock-Yogo weak ID test critical value is 7.03. In (3), Stock-Yogo weak ID test critical value is 11.04. Turning point is not estimated for coefficients less than 10% significance level in a Column.

6.7.2. Estimation Results for the 1980-2009 Period

Columns (1), (3), and (5) in Table 6.9a and Columns (1), (3), and (5) in Table 6.10a report the estimation results of linear specification for the 1980-2009 period by Model (3.2.15). In the model, the α_2 and α_3 are restricted to be zero. The coefficient of ln LE is was found negative at 10% significance level as shown in Columns (1), (3), and (5) in Table 6.9a and Column (1) in Table 6.10a. In addition, as Columns (3), (5) in Table 6.10a show, the coefficient of ln LE is insignificant.

Columns (2), (4), and (6) in Table 6.9a and Columns (2), (4), and (6) in Table 6.10a present the estimation results of quadratic specification for the 1980-2009 period by Model (3.2.15). In the model, the α_3 is restricted to be zero. The coefficients of both the linear and the quadratic terms were found significantly different from "0" at 10% significance level, and they are positive and negative, respectively as shown in Column (4) in Table 6.9a.

The estimated turning point is 137.79 mm Hg in this column. In addition, as Columns (2) and (6) in Table 6.9a and Columns (2), (4), and (6) in Table 6.10a show, the coefficients of the linear and the quadratic terms are insignificant. Thus, the quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between gross domestic savings and SBP for the 1980-2009 period.

Columns (1), (2), and (3) in Table 6.9b and Columns (1), (2), and (3) in Table 6.10b present the estimation results of cubic specification for the 1980-2009 period by Model (3.2.15). It was found that the coefficients of the linear, the quadratic, and the cubic terms are insignificant as for the association between gross domestic savings and SBP for the 1980-2009 period in these Columns (with omitted linear term in Columns (1), (3) in Table 6.9b and in Columns (2) and (3) in Table 6.10b.)

6.8. Conclusions

The study investigates the association between GDP per capita, years of schooling (human capital), GDP per person engaged, manufacturing value added per person engaged (productivity), and gross domestic savings, which are the dependent variables and SBP, the the explanatory variable, for the 1980-2009 period due to the data limitations. The empirical results in this study are in agreement with GDP per capita-LE association findings in general. There are non-linear and non-monotonic associations between all dependent variables and SBP. The assumption that the effect of SBP as a human physiological function is embedded in LE via aging finds evidence. The empirical findings reveal the strength of such effect. To conclude, our empirical findings confer significant evidence that healthy mean population SBP level expands economic growth by fostering savings. What follows in the next section is the concluding remarks for the associations between all dependent variables and SBP below.

6.8.1. Economic Growth

In linear specification, the coefficient of SBP was found to be positive at 1% significance level. In addition, in quadratic specification, the coefficients of both the linear and the quadratic terms were found significantly different from “0” at 10% significance level, and they are positive and negative, respectively. For quadratic specification, the estimated turning points are within the range of 128.19-140.11 mm Hg**.** Thus, quadratic functional specification estimation results in this study suggest that there is a non-monotonic and inverse U-shaped association between GDP per capita and SBP for the 1980-2009 period. Also, in cubic specification, it was found that the linear term is omitted, and the coefficients of the quadratic, and the cubic terms are significantly different from “0” at 1% significance level, with them being positive, and negative respectively. The estimated turning point is 128.25 mm Hg. Hence, cubic specification estimation results share the same findings with quadratic specification estimations of the association between GDP per capita and SBP for the 1980-2009 period.

6.8.2. Human Capital

The linear specification revealed that the coefficient of SBP is positive at 1% significance level. In addition, quadratic specification produced coefficients of the linear and the quadratic terms that are significantly different from "0" at 10% significance level. They are positive and negative, respectively. For quadratic specification, the estimated turning points are within the range of 132.74-144.54 mm Hg. Hence, the quadratic functional specification estimation results in the study suggest that there is a non-monotonic and inverse U-shaped association between years of schooling and SBP for the 1980-2009 period. Also, in cubic specification, it was found that the linear terms are omitted, and the coefficients of the quadratic, and the cubic terms are significantly different from "0" at 10% significance level, with them being positive and negative, respectively. The estimated turning points are within the range of 132.72-138.62 mm Hg. Hence, the cubic specification estimation results share the same findings with quadratic specification estimations of the association between years of schooling and SBP for the 1980-2009 period.

6.8.3. GDP per Person Engaged

In linear specification, the coefficient of SBP was found positive at 5% significance level. In addition, in quadratic specification, the coefficients of both the linear and the quadratic terms were found significantly different from "0" at 10% or higher significance level, and they are positive and negative, respectively. For quadratic specification, the estimated turning points are within the range of 127.98-136.95 mm Hg. Also, in cubic specification, the coefficients of the linear, the quadratic, and the cubic terms were found significantly different from "0" at 10% significance level, and they are negative, positive, and negative, respectively. They first follow a convex-, and then a concave-shaped pattern. In the latter, the estimated turning point-

1 is 118.38 mm Hg and turning point-2 is 133.83 mm Hg. Hence, the cubic functional specification estimation results suggest that there is first a convex-, and then a concave-shaped association between GDP per person engaged and SBP for the 1980-2009 period.

6.8.4. Productivity

In linear specification, it was found that the coefficient of SBP is positive at 1% significance level. In addition, in quadratic specification, it was found that the coefficients of both the linear and the quadratic terms are significantly different from "0" at 10% significance level, and they are positive and negative, respectively. For quadratic specification, the estimated turning points are within the range of 131.43-142.98 mm Hg. Also, in cubic specification, the coefficients of the linear, the quadratic, and the cubic terms were found significantly different from "0" at 5% significance level, and they are negative, positive, and negative, respectively. Their association is first convex-, and then concave-shaped. In convex-concave-shaped association, the estimated turning point-1 is 118.76 mm Hg and turning point-2 is 136.11 mm Hg. Hence, our cubic functional specification estimation results suggest that there is first a convex-, and, then a concave-shaped association between productivity and SBP for the 1980-2009 period.

6.8.5. Gross Domestic Savings

In linear specification, the coefficient of SBP is negative at 10% significance level. In addition, in quadratic specification, the coefficients of both the linear and the quadratic terms are significantly different from "0" at 10% or higher significance level, and they are positive and negative, respectively. For quadratic specification, the estimated turning point is 137.79 mm Hg. Thus, the quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between gross domestic savings and SBP for the 1980-2009 period. Also, in cubic specification, the coefficients of the linear, the quadratic, and the cubic terms were found insignificant as for the association between gross domestic savings and SBP for the 1980-2009 period.

CHAPTER 7

CONCLUSIONS AND POLICY RECOMMENDATIONS

7.1. Conclusions

The empirical results presented in three chapters, each of which has a different health proxy variable (namely LE, BMI and SBP), are generally consistent with each other. Indeed, there are non-linear and non-monotonic associations between all dependent wealth proxy and health proxy variables, namely GDP per capita, GDP per person engaged, years of schooling (human capital), manufacturing value added per person engaged (productivity), and gross domestic savings.

The non-linearity issue regarding health has been studies in many empirical studies. However, this study has theoretical significance in that it has confirmed the results of different articles in the literature. By comparing these vindicated linear, quadratic, and cubic specification estimation results with the empirical findings of the present study, this study proposes a basic empirical methodology to thoroughly investigate the association between economic development and health. Another theoretical significance is it offers a basic approach to obtain the reduced form equations from the evidence of Azamohou et al. (2009) in terms of time preference rates for cubic specifications.

It is also noteworthy that the study provides empirical evidence to keep the assumption that the effects of BMI and SBP as human physiological functions are embedded in LE as they are closely related with aging: it obtained appropriate weak identification test results between the instrumental variables, particularly age-specific survival probabilities and all these health proxy variables. This embeddedness assumption of BMI and SBP enabled the study to focus on other dimensions of health, such as mean fasting blood glucose and mean total cholesterol levels, by using similar specifications with our Models. It can be inferred from the related literature that SBP is a candidate health proxy variable to be accepted as “firstly utilized health proxy” that can be used to explain the sign of economic growth in the economic development literature. The mean fasting blood glucose and mean total cholesterol levels are expected to provide these potentials, too.

These empirical results hint at the possibility of a neutral health-related policy intervention for LE that is related with human physiological functions for sustainable economic growth. Consequently, this significant evidence supports the notion that healthy mean population BMI and SBP levels perpetuate economic growth by means of fostering savings. Hence, it is possible to manipulate saving propensities and time preference rates of individuals by keeping individuals between healthy BMI and SBP levels, and maybe mean fasting blood glucose and mean total cholesterol levels.

These factors are profoundly important for economic growth (Azomahou et al., 2009) as they are related with age-dependent survival probabilities and saving propensities. A possible neutral health-related policy intervention can bring closer the individual interests, national interests, and humanitarian interests. Thus, a conflict of interest that has occurred occasionally within these terms can be eliminated. The following sections explain the issue of intervention, the effects of health proxy variables on all dependent variables are elaborated below.

In GDP per capita-LE nexus, the cubic functional specification estimation results reveal a concave-convex-shaped association between GDP per capita and LE for the 1940-1980 period. However, for the periods 1940-2009 and 1980-2009, the cubic functional specification estimation results reveal a convex-concave-shaped association between GDP per capita and LE. These results are in concordance with those of Azomahou et al. (2009) for the period 1820-2005. In GDP per capita-BMI linkage, the cubic functional specification estimation results point to a convex-concave-shaped association between GDP per capita and BMI for the 1980-2009 period. In GDP per capita-SBP association, the quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between GDP per capita and SBP for the 1980-2009 period. Cubic specification estimation results are the same for the 1980-2009 period due to the excluded linear term.

In human capital-LE association, for the periods 1940-1980, 1940-2009, and 1980-2009, our cubic functional specification estimation results suggest that there is convex-concave-shaped 1980-2009, in cubic specification, we find that the coefficients of the linear, the quadratic, and the cubic terms association between years of schooling and LE. In human capital-BMI nexus, for the period are insignificant. Thus, the quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between years of schooling and BMI. In human capital-SBP association, the quadratic functional specification estimation results suggest that, for the 1980-2009 period, there is a non-monotonic and inverse U-shaped association between years of schooling and SBP. The cubic specification estimation yields the same findings with quadratic specification estimations of the association between the two for this period due to the excluded linear term.

In GDP per person engaged-LE association, our cubic functional specification estimation results suggest that, for the 1980-2009 period, there is convex-concave-shaped association between GDP per person engaged and LE. In GDP per person engaged-BMI association, the cubic functional specification estimation results suggest that, for the 1980-2009 period, there is a convex-concave-shaped association between GDP per person engaged and BMI. In GDP per person engaged-SBP association, for the 1980-2009 period, the cubic functional specification estimation results show that there is a convex-concave-shaped association between GDP per person engaged and SBP.

In productivity-LE association, for the 1980-2009 period, cubic functional specification estimation results show that there is a convex-concave-shaped association between productivity and LE. In the productivity and BMI association, the cubic functional specification estimation results suggest that there is a convex-concave-shaped association between productivity and BMI for the 1980-2009 period. In productivity-SBP association, for the 1980-2009 period, our cubic functional specification estimation results suggest that there is a convex-concave-shaped association between productivity and SBP.

In gross domestic savings-LE association, the cubic specification revealed insignificant coefficients of the linear, the quadratic, and the cubic terms for the 1980-2009 period. Thus, the quadratic specification estimation results point to a non-monotonic and inverse U-shaped association between gross domestic savings and LE for the 1980-2009 period. In cubic specification of gross domestic savings-BMI association, the coefficients of the linear, the quadratic, and the cubic terms are insignificant for the 1980-2009 period. Hence, the quadratic functional specification estimation results show that there is a non-monotonic and inverse U-shaped association between gross domestic savings and BMI. In cubic specification of gross domestic savings-SBP link, in the coefficients of the linear, the quadratic, and the cubic terms are insignificant for the 1980-2009 period. Thus, the quadratic functional specification estimation results suggest that there is a non-monotonic and inverse U-shaped association between gross domestic savings and SBP.

According to Husain et al. (2014), if economic growth takes place, returns to investment in LE will decrease as in Neo-liberal models. From this perspective, investment in health cannot support economic growth. However, according to endogenous growth models, there are marginal benefits of investing in health on an ongoing basis. Nevertheless, the results presented in Chapter 4, Chapter 5, and Chapter 6 suggest that Neo-liberal models and endogenous growth models have conflicting claims about return on investment in health. This study provides evidence that LE involves several physiological function characteristics such as BMI and SBP, each of which can affect the shape of the association between other dependent variables and LE.

We can also observe these connections in Chapter 5 and Chapter 6. In fact, the close associations between age-specific survival probabilities, BMI, and SBP became evident as a result of the weak identification test results carried out in this study. These strong associations, between age-specific survival probabilities and BMI and SBP, display similarities between all dependent variables and LE, BMI and SBP. Hence, it can be concluded that characteristics related to these human physiological functions are embedded in LE and have significant effects on its behaviors, and between almost all dependent variables. The embeddedness of these physiological functions is represented by BMI and SBP in the empirical results in this study.

From this point of view, it can be inferred that LE, aging, involves several factors that contribute to the aging of human body. Thus, these contributory factors can also affect saving propensities of individuals through influencing their time preference rate. BMI and SBP are only two of these several factors that make a person older physiologically and physically, increasing time preference rate. These changes affect behaviors and choices in relation with consumptions and savings.

Public health studies propose intervention strategies for some of these contributory factors. BMI and SBP, in particular, have this chance. Furthermore, if we can minimize these several factors and/or lower their adverse effects on human physiology, behavior, and time preference rate, we can improve economic growth by shifting age-dependent survival probabilities and saving propensities of target age groups and individuals who are affected. Such an effort can extend the duration between thresholds in economic growth-longevity association. Indeed, it can lower and raise the turning points to such an extent that the path of economic growth-longevity association can follow a longer linear positive trend. At this point, we consider that the term *longevity* refers to exact *healthiness*, for it does not occur all the time in practice.

If health status improvement strategies are combined with saving enhancement policies appropriately for ages, e.g. for early work entry age 15 groups or age over 65 groups, taking into consideration age-specific conditional requirements, the Neo-liberal models and the endogenous growth models can get closer to each other because sufficient returns to health investment can be achieved at appropriate ages. Thus, this study provides evidence for the existence of conflict between the Neo-liberal models' and endogenous growth models' approaches to health investment in achieving sustainable economic growth. This finding about the issue of complex wealth-health association is the main contribution of this empirical study. Hence, if this mechanism works, its end-products will cause national interests and humanitarian interests overlap each other because there is a need for protecting of human physiology. At the same time, this has a similar meaning with 'the behavior of saving propensity'. Thus, the protection of human physiology prolongs the time duration before an individual reaches high time preference rate. This effort that elaborates on this mechanism eliminates the conflict between individuals, thus nations, for any economic reason.

7.2. Policy Recommendations

The empirical results of this study provide clear evidence that, if we can combine good health with savings or savings with good health, the association between health and economic growth will be positive. This positive association has a potential to be longer than the recent period provided that it ensures appropriate policy supports. For this reason, based on the empirical findings in this study, findings of Azomahou et al. (2009), and the related literature, the association between good health and saving propensities lies in the core of our policy recommendations. If an appropriate economic structure is designed, providing equal opportunities for all individuals to maintain their saving propensities and preserve their human physiological functions at appropriate ages (e.g. early work entry age 15, age over 65), sustainable economic growth can be achieved. The following section introduces the details of the proposed policy recommendations, as well as a summary of them in Table 7.1.

Figure 7.1 presents the association between real GDP and gross domestic savings. The graph clearly shows that the changes in real GDP follow the changes in gross domestic savings. Notably, the trends in China and the United States of America (USA) provide evidence for this association in that their real GDP levels are higher than other countries for the 1980-2009 period. According to the graph, while China benefits from its raising gross domestic savings, USA has a problem from its decreasing gross domestic savings, which is also pointed out as a problem in the USA economy (Stiglitz, 2018). Actually, there is one practical way of regaining increase in domestic savings for countries whose savings are decreasing. Countries whose saving are increasing can as well employ this to maintain the increment in gross domestic savings. This practical way is to protect human physiological functions of people at proper ages (from early work entry age 15 to age over 65 years). It has the potential for achieving sustainable economic growth all around the world. An improvement in health status of citizens of a country having debts leads to an increment in its debt payment capability as it gains gross domestic savings following the improvement in the health status of people.

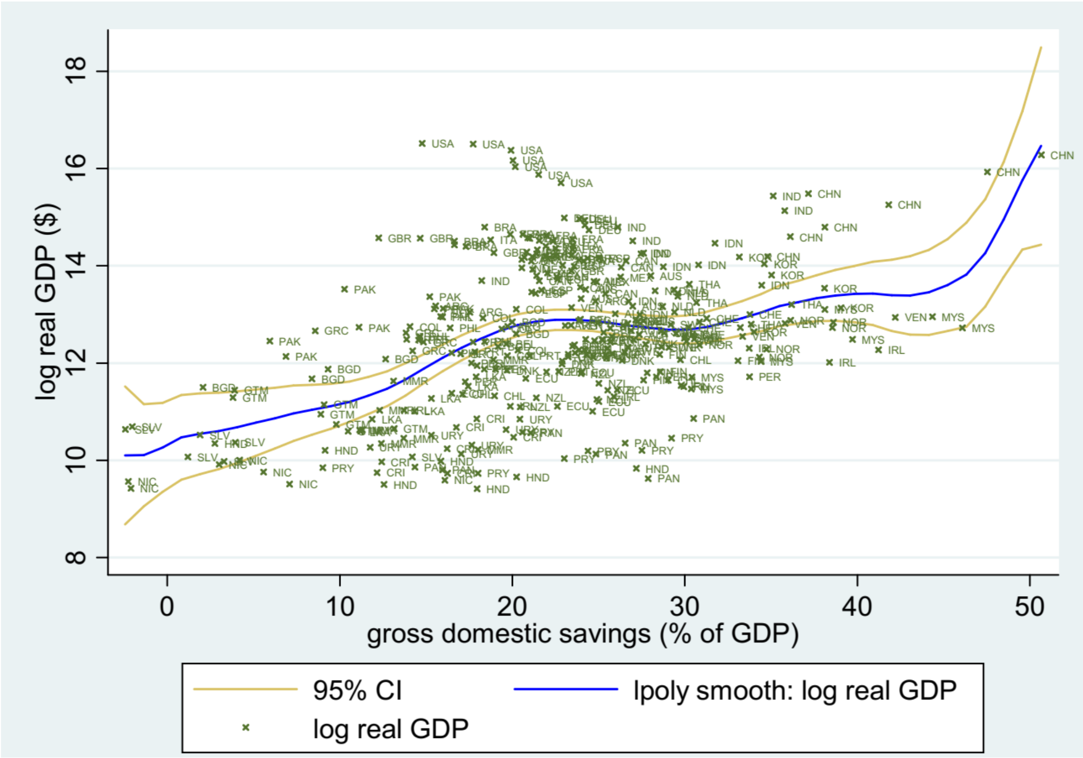

Figure 7.1. Local Cubic Polynomial Smooth Plots with Confidence Intervals (CIs) of Real GDP and Gross Domestic Savings of 47 Countries for the 1980-2009 Period.

Source: Prepared by the Author.

At this point, we want to introduce our policy recommendations based on our empirical results. To make policy recommendations, there is a need for applying microdata studies and examining their validity through evidence-based findings.

Our first policy issue is *low age-dependent saving propensity between certain thresholds*. The estimation performed in this study results in a convex-concave-shaped association between GDP per capita and LE for the 1940-2009 period (estimated turning point-1s are within the range of 37.55-49.87 years and turning point-2s are within the range of 53.48-65.52 years) and Azomahou et al. (2009) demonstrate that economic growth increases by the increment in savings. However, older people tend to spend rather than save. The saving rate of a person decreases in time duration. Especially, after the turning point-2s, a decrease in saving rate has a negative effect on GDP per capita. Younger people prefer to save more than the elderly. Paradoxically, their savings are not high enough until the turning point-1s.

Having physical capital accumulation triggering economic growth and domestic savings-dependent source for this accumulation create a concavity in the curve as LE increases due to expanded proportion of less prone that can save. The positive effect of LE cannot effectively tolerate the negative effect of having a higher proportion of older people, who are less prone, that save. Younger and older people's saving rates' being determined by their conditions produce this convex-concave-shaped curve.

The mechanism works like this: low economic growth occurs with low enough values of LE. Thus, by the positive effects of LE, aggregate savings increase, and economic growth takes place. This time duration aspect characterizes the convex-shaped curve in the economic growth-LE linkage. Moreover, the concave-shaped curve in this association occurs with high enough values of LE as a result of the negative effect of high time preference rates of increasing elderly in the society, who are less prone to save.

At this point, Kunze (2014) explains why old people are less prone to save. One reason is the significantly increasing old-age consumption for health. Another is old people's tendency to spend some part of their savings on their children's education. These decrease saving rates of the old and lower physical capital accumulation-dependent economic growth.

These explanations simply form the theoretical base for most government funded lifetime health care and education for all people. 'All people' preferably refer to all youth, older people in health care, and population of age 3 to age 50 years in education. These funding applications depend on economic resources and priorities of any country; taxation includes negative taxes for target age groups. Policy implications are discussed below based on empirical findings and theoretical propositions.

At the macro level, a major policy implication is regulations aiming at age-dependent saving propensity in the country. The purpose of this policy is to increase age-dependent saving propensity. First policy instrument is to initiate age-dependent income tax rates/negative age-dependent income tax rates for targeted age groups. This is expected to augment economic growth. To clarify, the first target age group may consist of those from early work entry age 15 to age 50 years. The second target age group may start from age 65 years depending on the turning points of a country. According to Linke (2018), contrary to regular income tax implementation, an individual who has low income can obtain payment from the government in negative income tax application. Another strategy is to activate economic growth augmenting age-dependent healthcare spending tax rates/negative age-dependent healthcare spending tax rates. Finally, economic growth can be achieved by increasing age-dependent education spending tax rates/negative age-dependent education spending tax rates between determined thresholds for targeted age groups.

The first policy entails increasing age-dependent saving propensity by at least 1 percent by the end of the first year in pilot applications. The second policy raises age-dependent saving propensity by at least 1 percent by the end of second year in local applications and elevates age-dependent saving propensity by at least 1 percent by the end of the third year in country level applications. The final strategy is to enhance age-dependent saving propensity as planned by the end of the fourth year in country level applications.

The second policy issue to be discussed is *low BMI-dependent saving propensity between certain thresholds.* The quadratic specification yielded that the coefficients of the linear and the quadratic terms are both significantly different from "0" at 10% significance level, and they are positive and negative, respectively. The estimated turning points are within the range of 24.39-26.16 kg/m^2 for quadratic specification. Thus, the quadratic functional specification estimation results suggest that there is a non-monotonic inverse U-shaped association between gross domestic savings and BMI for the 1980-2009 period. Based on the empirical findings obtained in this study, the following policy implications emerged.

At the macro level, that policy implication is that regulations and applications will aim at BMI-dependent saving propensity. Its purpose is to increase BMI-dependent saving propensity. The policy instrument is to introduce economic growth augmenting public health strategies to reach targeted mean population BMI level. The policy first aims to raise BMI-dependent saving propensity by at least 1 percent in the first year of pilot applications. Secondly, it intends to increase BMI-dependent saving propensity by at least 1 percent in the second year of local applications. The third goal is to enhance BMI-dependent saving propensity by at least 1 percent in the third year in country level applications. Finally, it aims to elevate BMI-dependent saving propensity by at least the targeted percent in the fourth year in country level applications.

At meso level, the policy implication is a strategy application plan for BMI-dependent saving propensity in organizational level. The purpose of this policy is to raise BMI-dependent saving propensity. The policy instrument is to organize round-table activities involving economic, public health, education, and other related public/private institutions to design an economic *growth augmenting public health strategy application plan* to reach the targeted mean population BMI level. The round-table activities can be characterized in "soft instrument" according to Borras and Edquist (2013: 1516). Soft instruments are non-mandatory and non-compulsory. They are divergent and act on the ability to convince. These policy instruments are based on information sharing among solution partners. There are low-ranking and less bureaucratic associations between private and public representatives. The policy goal is to increase BMI-dependent saving propensity by at least 1 percent by one-year applications.

At the micro level, the policy implication is executive orders for BMI-dependent saving propensity in micro level. Executive orders can be referred to as "soft instruments" according to Borras and Edquist (2013: 1516). They can activate media information activities, such as tv series and fact-based films. They can issue guidelines and principles for, say, the admission of researchers, as well as advising national or international investors and citizens. They can also determine discretionary technical standards in the country or at multi-country level. They can establish a non-mandatory protocol and legitimate alliance with public research and procurement activities. Besides, they can contract public and private collaborations by sharing costs, risks, and benefits. The Policy purpose is to promote BMI-dependent saving propensity.

The main policy instrument is the effective management of the interaction of economic growth augmenting public health strategy application plan and households to reach the targeted mean population BMI level. This type of management can be categorized as "soft instruments" according to Borras and Edquist (2013: 1516). Here, the government acts like a facilitator and coordinator rather than a regulator and supplier. There is no direct or indirect enforced action, penalty, or reward by the government or sub-organizations. Alternatively, there are policy advice and requests, as well as providing non-compulsory protocols. The government and its public agencies accept private sectors and entrepreneurs as their solution partners. Moreover, they find and execute solutions together. Policy goal is to enhance BMI-dependent saving propensity by at least 1 percent by one-year applications.

At this point, we want to give examples of soft instruments related with nutrition and healthy BMI levels. We identify some examples of soft instruments based on suggestions and comments of B. Çobaner, C. Akça, and N. Korkmaz (personal communication, September 18, 2018). Solution partners (for example, public and private sectors) might issue a very simple description of nutrition as the main principle for leading other soft instrument activities. According to B. Çobaner (personal communication, September 18, 2018), "Nutrition is to satisfy the dietary need of the human body by using accurate foods with proper portions on time."

Another principle as soft instrument may be identifying the target locations such as school, workplaces, and home to follow and activate nutrition elements as also suggested by Rayner and Lang (2012: 320-321). Individuality might be accepted as another significant principle by solution partners to realize nutrition elements at these suggested locations. Another soft instrument may be the determination of critical body fat thresholds as medical standard to provide medical support for individuals who suffer from overweight at hospital clinics.

Another principle might be selecting some significant foods to support the nutrition of society, informing people about these foods, and determining tax rates and incentives to achieve affordable prices for these selected foods. Another recommendation may be to increase the employment opportunities of nutrition experts at the suggested locations, namely schools, workplaces, and family medicine services. Having nutrition scenes in movies and TV series may be another recommendation of solution partners. These activities may contain stories and fables in children literature.

Increasing school nutrition by serving foods for students under the supervision of their responsible teachers is another recommendation. Solution partners may start media campaigns to support social solidarity organizations for providing regular nutrition to individuals who suffer from mental health problems. Another principle may be to provide dietary services for all public or private social facilities. Moreover, municipalities may increase walking areas near workplaces.

Nutrition education at schools, workplaces and for households may be initiated by solution partners as another soft instrument application. Paid leave may be recommended to employers so that they can support their employees' diet to overcome obesity. Entrepreneurs may create new technological applications for nutrition and diet. These applications may be educational healthy diet food portions and meal simulation toys, equipment and software for children, medical body composition and regional weight-loss devices, fat measuring mobile phones, watches, shoes or some other complicated systems.

The third policy issue is *low SBP-dependent saving propensity between certain thresholds.* As reported in the previous sections, the quadratic specification yielded that the coefficients of the linear and the quadratic terms are both significantly different from "0" at 10% significance level, and they are positive and negative, respectively. For the quadratic specification, the estimated turning point is 137.79 mm Hg. Therefore, the quadratic functional specification estimation results obtained in this study suggest that a non-monotonic inverse U-shaped association exists between gross domestic savings and SBP for the 1980-2009 period. Related policy implications are introduced below.

The macro level policy implication is regulations and applications in the country level aiming at SBP-dependent saving propensity. The purpose of the policy is to raise SBP-dependent saving propensity. The policy instrument is economic growth augmenting public health strategies to reach the targeted mean population SBP level. The first policy goal is to increase SBP-dependent saving propensity by at least 1 percent by end of the first year in pilot applications. The second goal is to foster SBP-dependent saving propensity by at least 1 percent in the second year in local applications. Thirdly, it aims is to raise SBP-dependent saving propensity by at least 1 percent in the third year in country level applications. Its final goal is to enhance SBP-dependent saving propensity by at least the targeted percent by the end of the fourth year in country level applications.

The meso level policy implication is to design a strategy application plan for SBP-dependent saving propensity in organizational level. The policy purpose is to improve SBP-dependent saving propensity. The policy instrument is to organize round-table activities involving economic, public health, education, and other related public/private institutions to design an economic growth augmenting public health strategy application plan to reach the targeted mean population SBP level. The main goal is to increase SBP-dependent saving propensity by at least 1 percent by one-year applications.

At micro level, the policy implication is about executive orders for SBP-dependent saving propensity in micro level. The purpose is to increase SBP-dependent saving propensity. The policy instrument is to ensure effective interaction of economic growth augmenting public health strategy application plan and households to reach the targeted mean population SBP level. The policy goal is to enhance SBP-dependent saving propensity by at least 1 percent by one-year applications.

The fourth policy issue is *low BMI- and SBP-dependent saving propensity between certain thresholds.* According to Wang and Zou (2011), low-income countries should keep technology levels constant. They should enhance welfare of citizens. These priorities may help them eliminate the poverty trap. In our opinion, low-income economies are not restricted by only these two options: only increasing the technology level and the improving the health level of a country. Indeed, there is the third option which involves the innovation methodology.

This third option entails improving health by health enhancing technologies. Technology and health levels do not necessarily mean to conflict. Technology is an output of two ingredients: scientific principle and aim of use (Agarwal and Lang, 2005: 3). This aim can well be public health enhancement. This enhancement can be different from medical technologies dealing with the emerging physiological health crises. They can actually decrease the magnitude of these health crises events before they break out. Besides, they are cheaper to produce and diffuse than medical technologies (Rose et al., 2008:130-133 and 139-140). The following section contemplates the above-mentioned issues and discusses relevant policy implications.

At macro level, the policy implication is that a roadmap should be drawn to innovate and diffuse technologies in country level for BMI- and SBP-dependent saving propensity. The purpose of the policy is to increase BMP- and SBP-dependent saving propensity. The policy instrument is to develop strategies towards economic growth augmenting technology innovation and diffusion such as initiating tax incentives/negative tax incentives to reach targeted mean population BMI and SBP levels. The first policy goal is to raise BMI- and SBP-dependent saving propensity by at least 1 percent in the first year in pilot applications. The second goal is to increase BMI- and SBP-dependent saving propensity by at least 1 percent in the second year in local applications. The third goal is to foster BMI- and SBP-dependent saving propensity by at least 1 percent by the end of the third year in country level applications. The last goal is to enhance BMI- and SBP-dependent saving propensity by at least the targeted percent by end of the fourth year in country level applications.

According to this study, at meso level, the policy implication is that a strategy application plan should be developed technology innovation and diffusion in the organizational level aiming at BMI- and SBP-dependent saving propensity. The policy purpose is to raise BMP- and SBP-dependent saving propensity. The policy instrument is to put in practice an application plan of economic growth augmenting technology innovation and diffusion strategies to reach the targeted mean population BMI and SBP levels. The policy goal is to increase BMI- and SBP-dependent saving propensity by at least 1 percent by one-year applications.

At micro level, the policy implication is executive orders for BMI- and SBP-dependent saving propensity aimed technology innovation and diffusion in micro level. The policy purpose is to enhance BMP- and SBP-dependent saving propensity. The policy instrument is to effectively manage the interaction of diffusion of economic growth augmenting innovative products and households to reach the targeted mean population BMI and SBP levels. These innovative products should support BMI and SBP-friendly schools, workplaces, and other local environments (Rayner and Lang, 2012: 320-321). They should do so by, for example, providing healthy (Cornwell et al., 2014; Wu et al., 2015), small portion and affordable food (Rayner and Lang, 2012). They should reduce noise (Babisch, 2005) and air pollution (Pittman, 2013; Chan et al., 2015; Zhao et al., 2015) as well as enhancing physical activity (Nicolopoulou-Stamati et al., 2005). Also, they should promote higher public health standards (Rayner and Lang, 2012: 315-321). Some recent examples of these technologies are healthy diet foods, noise barriers in cities, ecologically-safe automobiles, chemical and gas scrubbers, safe pavements, and bike paths (Rayner and Lang, 2012: 320-321) for all generations. The policy goal is to increase BMI- and SBP-dependent saving propensity by at least 1 percent through one-year applications.

Table 7.1

Policy Recommendations

Policy Issue: *Low age-dependent saving propensity between certain thresholds.*				
At	**Policy Implications**	**Policy Purposes:**	**Policy Instruments:**	**Policy Targets:**
Macro Level	Age-dependent saving propensity aimed regulations in country level.	To increase age-dependent saving propensity.	To initiate economic growth augmenting age-dependent income tax rates/negative age-dependent income tax rates between determined thresholds for targeted age groups.	To increase age-dependent saving propensity at least 1 % by first year pilot applications. To raise age-dependent saving propensity at least 1 % by second year regional applications. To elevate age-dependent saving propensity at least 1 % by third year country level applications. To enhance age-dependent saving propensity at least targeted % by fourth year country level applications.
			To activate economic growth augmenting age-dependent health care spending tax rates/negative age-dependent health care spending tax rates between determined thresholds for targeted age groups.	To increase age-dependent saving propensity at least 1 % by first year pilot applications. To raise age-dependent saving propensity at least 1 % by second year regional applications. To elevate age-dependent saving propensity at least 1 % by third year country level applications. To enhance age-dependent saving propensity at least targeted % by fourth year country level applications.
			To start economic growth augmenting age-dependent education spending tax rates/negative age-dependent education spending tax rates between determined thresholds for targeted age groups.	To increase age-dependent saving propensity at least 1 % by first year pilot applications. To raise age-dependent saving propensity at least 1 % by second year regional applications. To elevate age-dependent saving propensity at least 1 % by third year country level applications. To enhance age-dependent saving propensity at least targeted % by fourth year country level applications.

Table 7.1

Policy Recommendations (Continued)

Policy Issue: *Low BMI-dependent saving propensity between certain thresholds.*				
At	**Policy Implications**	**Policy Purposes:**	**Policy Instruments:**	**Policy Goals:**
Macro Level	BMI-dependent saving propensity aimed regulations and applications in country level.	To increase BMI-dependent saving propensity.	To initiate economic growth augmenting public health strategies for reaching targeted mean population BMI level.	To raise BMI-dependent saving propensity at least 1 % by first year pilot applications. To increase BMI-dependent saving propensity at least 1 % by second year regional applications. To enhance BMI-dependent saving propensity at least 1 % by third year country level applications. To elevate BMI-dependent saving propensity at least targeted % by fourth year country level applications.
Meso Level	Strategy application plan for BMI-dependent saving propensity in organizational level.	To raise BMI-dependent saving propensity.	To establish round-table between economic, public health, education, and other related public/private organizations to determine economic growth augmenting public health strategy application plan for reaching targeted mean population BMI level.	To elevate BMI-dependent saving propensity at least 1 % by one-year applications.
Micro Level	Executive orders for BMI-dependent saving propensity in micro level.	To elevate BMI-dependent saving propensity.	To provide appropriate interaction governance between economic growth augmenting public health strategy application plan action items and households for reaching targeted mean population BMI level.	To enhance BMI-dependent saving propensity at least 1 % by one-year applications.

Table 7.1

Policy Recommendations (Continued)

Policy Issue: *Low SBP-dependent saving propensity between certain thresholds.*				
At	**Policy Implications**	**Policy Purposes:**	**Policy Instruments:**	**Policy Goals:**
Macro Level	SBP-dependent saving propensity aimed regulations and applications in country level.	To raise SBP-dependent saving propensity.	To initiate economic growth augmenting public health strategies for reaching targeted mean population SBP level.	To increase SBP-dependent saving propensity at least 1 % by first year pilot applications. To elevate SBP-dependent saving propensity at least 1 % by second year regional applications. To raise SBP-dependent saving propensity at least 1 % by third year country level applications. To enhance SBP-dependent saving propensity at least targeted % by fourth year country level applications.
Meso Level	Strategy application plan for SBP-dependent saving propensity in organizational level.	To elevate SBP-dependent saving propensity.	To establish round-table between economic, public health, education, and other related public/private organizations to determine economic growth augmenting public health strategy application plan for reaching targeted mean population SBP level.	To increase SBP-dependent saving propensity at least 1 % by one-year applications.
Micro Level	Executive orders for SBP-dependent saving propensity in micro level.	To increase SBP-dependent saving propensity.	To provide appropriate interaction governance between economic growth augmenting public health strategy application plan action items and households for reaching targeted mean population SBP level.	To enhance SBP-dependent saving propensity at least 1 % by one-year applications.

Table 7.1

Policy Recommendations (Continued)

Policy Issue: *Low BMI- and SBP-dependent saving propensity between certain thresholds.*				
At	**Policy Implications**	**Policy Purposes:**	**Policy Instruments:**	**Policy Goals:**
Macro Level	Roadmap for BMI- and SBP-dependent saving propensity aimed technology innovation and diffusion in country level.	To increase BMP- and SBP-dependent saving propensity.	To initiate economic growth augmenting technology innovation and diffusion strategies by appropriate tax incentives/negative tax incentives for reaching targeted mean population BMI and SBP levels.	To raise BMI- and SBP-dependent saving propensity at least 1 % by first year pilot applications. To increase BMI- and SBP-dependent saving propensity at least 1 % by second year regional applications. To elevate BMI- and SBP-dependent saving propensity at least 1 % by third year country level applications. To enhance BMI- and SBP-dependent saving propensity at least targeted % by fourth year country level applications.
Meso Level	Strategy application plan for BMI- and SBP-dependent saving propensity aimed technology innovation and diffusion in organizational level.	To raise BMP- and SBP-dependent saving propensity.	To establish round-table between economic, industry, public health, education, and other related public/private organizations to determine economic growth augmenting technology innovation and diffusion strategy application plan for reaching targeted mean population BMI and SBP levels.	To elevate BMI- and SBP-dependent saving propensity at least 1 % by one-year applications.
Micro Level	Executive orders for BMI- and SBP-dependent saving propensity aimed technology innovation and diffusion in micro level.	To enhance BMP- and SBP-dependent saving propensity.	To provide appropriate interaction governance between economic growth augmenting innovative products diffusion and households for reaching targeted mean population BMI and SBP levels.	To increase BMI- and SBP-dependent saving propensity at least 1 % by one-year applications.

7.3. Science and Technology Policy Issues

Three issues in the policy recommendations that this study makes are directly related to science and technology policy (STP) and its applications. First, the policy recommendations aforementioned underline human capital and education conditions. Specific turning points determine risky health status limits. These limits have an impact on human capital and education duration. The policy recommendation instruments provide incentives for target health status that positively affects human capital and education pinpoints, which are within the scope of STP. Indeed, according to Ruttan (2001), regardless of whether it is mission-oriented as in USA or diffusion-oriented as in Germany, STP of any nation distributes its research resources by principle. This approach includes human capital, education, and training listed in the research activities for funded technologies.

Second, the policy recommendations made in this study provide a strong motive for health aimed STP activities. The empirical findings demonstrate the importance of the health status and savings link for raising economic growth. If individuals have good health status and enough savings, economic growth gains increment. At this point, human health-oriented STP activities gains importance for sustainability search in STP and economic activities. Put differently, increase or decrease in the cost of labor compared to capital has a robust impact, influencing STP and economic activities in the long run. Thus, the sustainability of STP and economic activities depend on strategies towards decreasing the cost of labor. The cost of labor is primarily affected by labor productivity, and labor productivity is influenced by the health status of individuals (Ruttan, 2001; Acemoglu and Johnson, 2007: 975-976) in STP and economic activities.

Third, the policy recommendations concerning the health (BMI and SBP)-dependent saving propensity aimed technology innovation and diffusion includes roadmaps, strategy applications, and executive orders. These policy items provide a basic framework for transition to human health-oriented STP activities. These initiator items include relatively less costly preventive strategies than medical treatment technologies (Rose et al., 2008:130-133 and 139-140). According to Ruttan (2001: 614-615), substantial resources allocated for scientific health researches do not guarantee successful results in their applications. Sometimes, minimal allocation of resources can have successful outcomes in science-based health researches. Thus, alternative options should be sought to fulfill health needs of individuals, promote savings, and decrease cost of labor requirements of economic growth to achieve sustainability in both STP and economic activities. In the policy recommendation in this study, these primary framework starters for STP activities meet these needs and requirements.

7.4. Synopsis of the Contributions

Numerous studies have examined the effects of health on economic development by utilizing different proxy variables. Among many researchers who focused on this complex association, Azomahou et al. (2009) have significantly contributed to the related literature empirically and theoretically.

Azomahou et al. (2009) present the empirical and theoretical results of the examination of the nonlinear association between GDP per capita growth rate and LE by using historical data for eighteen countries for the 1820-2005 period. There is no justification for the selection of this period. However, this period includes liberal, Keynesian, and Neo-liberal economic policies in different durations. Based on the assumptions of Azomahou et al. (2009), individuals at different ages will implement different plans and make different saving decisions. For instance, younger individuals tend to save more than the elderly because of their low time preference rate (rate of impatience) in their decisions.

These saving tendencies influence the form of the association between GDP per capita growth rate and LE. Azomahou et al. (2009) clarify the empirical findings related to this non-linear and non-monotonic association between economic growth and health in their theoretical model. They assert that the GDP per capita growth rate increases with LE. However, the link between GDP per capita growth rate and LE shifts depend on the level of LE. This association is convex-shaped for low-level LE and concave-shaped for higher level LE.

This study has theoretical significance in that it employs a reduced form of cubic specification from the model of Azomahou et al. (2009: 243). This reduced form of cubic specification was obtained with particular focus on the time preference rate by remaining limited to determining the sign of economic growth.

It is assumed that any appropriate substitute can represent this time preference rate. According to Azomahou et al. (2009: 225), time preference rate increases with LE. Thus, LE can be a substitute for this impatience rate. Another assumption is that BMI and SBP are embedded in LE. This assumption is based on the findings in weak identification test in IV estimations. Hence, both BMI and SBP can be substitutes for LE in this cubic specification estimation.

Following that, the present study expands this association with growth indicators according to the extent to which they are linked with economic growth. These growth indicators are GDP per capita, human capital, GDP per person engaged, productivity, and gross domestic savings. Therefore, these growth indicators can be used as a substitute for GDP per capita growth in Azomahou et al. (2009). This has enabled the present study to investigate the association between economic development and health with different growth indicators and to test the robustness of this association.

The findings of Cervellati and Sunde (2009), Desbordes (2011), and Hansen (2012) were confirmed by the estimations performed in the present study, which utilizes their specification variables and estimation methodologies. The reduced form in the cubic specification was estimated in this study by using methodologies of these confirmed results. The base sample data structure used by Acemoglu and Johnson (2007: 939, 979-980) was employed.

A total of 47 countries comprises the panel data. The study focuses on three periods, 1940-1980, 1980-2009, and 1940-2009 due to reliable historical data consideration. It investigates the association between economic development and health. These periods include Keynesian and Neo-liberal economics that have different and combined economic policies, which helps test the robustness of our findings. Table 7.2 presents the vindicated results, besides those of Azomahou et al. (2009), to demonstrate the consistency between findings.

Having obtained the reduced form in the cubic specification with all these variables, we find robust non-linear and non-monotonic association between economic growth and health in estimations for all periods. Also, health status (BMI and SBP) thresholds for economic development for the 1980-2009 period are estimated based on variable data availability. It seems that no study so far has provided these thresholds for BMI and SBP in the related literature by utilizing macro-level economic growth indicators as the response variables.

Understanding the reason behind these significant results will help handle the adverse effects of bad health status on economic growth. These negative effects of the bad health status can be solved by utilizing a neutral health intervention approach between certain thresholds. These thresholds may follow the range of 24.39-26.16 kg/m^2 for BMI and 137.79 mm Hg for SBP based on the quadratic specification estimation findings for the associations between the gross domestic savings and BMI and SBP, respectively. This neutral health intervention approach provides the policymakers with a practical method.

The varying effects of bad or good health status in this cubic specification can provide a new perspective entailing sharing of information reciprocally between different disciplines in science and technology. Thus, multidisciplinary approaches can be developed to achieve health-induced innovations, to promote individual savings (from early work entry age 15 to age over 65), and to secure sustainable economic growth.

Based on these consistent findings, a general conclusion was derived about realizing sustainable economic development: the saving ability of young and older generations should be increased, and time preference rate (improved health status level) of all health-at-risk individuals and elderly groups should be decreased through effective and appropriate economic policies.

Table 7.2

Vindicated Results

Item	Study	Period	Number of Countries	Number of Observations	Data Source	Dependent Variable	Explanatory Variable	Estimation	Linear Coefficient	Quadratic Coefficient	Vindication
1	Cervellati and Sunde (2009)	1940-1980	47	-	Acemoglu and Johnson (2007)	GDP per capita	Life expectancy at birth	OLS long difference	−0.81*** (0.26)	-	-
	Our Study			47					−0.81*** (0.26)		* The linear specification estimation is exactly replicated.
2	Cervellati and Sunde (2009)			-				IV long difference	−1.32*** (0.36)		-
	Our Study			47					−1.32*** (0.35)		* The linear specification estimation is exactly replicated.
3	Cervellati and Sunde (2009)		16	-				OLS long difference	1.73*** (0.46)		-
	Our Study			16					1.73*** (0.46)		* The linear specification estimation is exactly replicated.
4	Cervellati and Sunde (2009)			-				IV long difference	1.79* (0.94)		-
	Our Study			16					1.79** (0.88)		* The linear specification estimation is exactly replicated.

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7.2

Vindicated Results (Continued)

Item	Study	Period	Number of Countries	Number of Observations	Data Source	Dependent Variable	Explanatory Variable	Estimation	Linear Coefficient	Quadratic Coefficient	Vindication
5	Desbordes (2011)	1940-1980	-	47	Acemoglu and Johnson (2007)	GDP per capita	Life expectancy at birth	IV long difference	−1.32*** (0.36)	-	-
	Our Study		47						−1.32*** (0.35)		* The linear specification estimation is exactly replicated.
6	Desbordes (2011)		-						−18.10** (7.54)	2.31** (1.02)	-
	Our Study		47						−18.10** (7.30)	2.31** (0.99)	* The quadratic specification estimation is exactly replicated.
7	Desbordes (2011)		-					OLS long difference	−21.13*** (3.43)	2.75*** (0.47)	-
	Our Study		47						−21.13*** (3.43)	2.76*** (0.47)	* The quadratic specification estimation is exactly replicated.

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7.2

Vindicated Results (Continued)

Item	Study	Period	Number of Countries	Number of Observations	Data Source	Dependent Variable	Explanatory Variable	Estimation	Linear Coefficient	Quadratic Coefficient	Vindication
8	Hansen (2012)	1940-1980	119	-	Acemoglu and Johnson (2007)	GDP per capita	Life expectancy at birth	FE (within)	−19.60*** (2.62)	2.58*** (0.35)	-
	Our Study		47	235	Acemoglu and Johnson (2007), the Maddison-Project (2013), UN World Mortality Report 2015, World Bank				−14.67*** (2.85)	1.90*** (0.39)	*The quadratic specification estimation is vindicated.
9	Hansen (2012)		119	-	Acemoglu and Johnson (2007)			GMM (Arellano-Bond)	−9.46*** (3.53)	1.26*** (0.47)	-
	Our Study		47	141	Acemoglu and Johnson (2007), the Maddison-Project (2013), UN World Mortality Report 2015, World Bank				−18.70** (7.40)	2.37** (0.96)	* The quadratic specification estimation is vindicated.

Notes: Robust standard errors (SE)s in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7.2

Vindicated Results (Continued)

Item	Study	Period	Number of Countries	Number of Observations	Data Source	Dependent Variable	Explanatory Variable	Estimation	Convex Turning Point	Concave Turning Point	Vindication
10	Azomahou et al. (2009)	1820-2005	18	-	The World Economy: Historical Statistics OECD Development Centre, The Human Mortality Database (University of California, Berkeley and the Max Planck Institute for Demographic Research)	the growth rate of GDP per capita	Life expectancy at birth	Generalized Additive Model (GAM)	49.03-51.07 years	63.46-65.70 years	* The thresholds are measured in range from graph in Figure 5 in Azomahou et al. (2009: 208) by the author.
10	Our Study	1940-2009	47	282	Acemoglu and Johnson (2007), the Maddison-Project (2013), UN World Mortality Report 2015, World Bank	GDP per capita	Life expectancy at birth	GMM (Arellano-Bond)	49.87 years	65.52 years	* The cubic specification estimation is vindicated.
11	Our Study	1940-2009	47	47	Acemoglu and Johnson (2007), the Maddison-Project (2013), World Bank	GDP per capita	Life expectancy at birth	OLS long difference	37.55 years	55.38 years	* The cubic specification estimation is vindicated.
11	Our Study	1940-2009	47	47	Acemoglu and Johnson (2007), the Maddison-Project (2013), World Bank	GDP per capita	Life expectancy at birth	IV long difference	40.96 years	53.48 years	* The cubic specification estimation is vindicated.

7.5. Further Research

Further research can enlarge the association between GDP per capita and human physiological functions. These health functions closely related with aging can be mean fasting blood glucose and mean total cholesterol levels. By using the same specifications of this study, these health proxies are expected to provide similar results for the association between economic growth and health.

Moreover, further research can focus on the saving propensity differences depending on risk levels of physiological health functions for certain age groups. For example, the difference between young age individuals who are at the high-risk level in physiological health function and those who are at no risk level in these physiological functions should be explored. The same framework can be enlarged for the elderly at the same risk levels. Saving propensities of the lowest risk level young and old age individuals could be analyzed comparatively. Furthermore, causes of high time preference behaviours of elderly at certain ages can be investigated. For example, whether there are differences between elderly age groups over 65 and their risk status of physiological health functions on the issue of time preference can be studied.

The effect of incentive/taxation policy of individual income, and education and health expenditures on age-dependent saving propensities can be the subject of future studies. Maintaining healthy human physiological function with technology innovation and diffusion strategies and how they influence age-dependent saving propensities of individuals could also be handled. Last but not least, Granger-causality test analysis can be conducted to study the association between health and economic development; all variables belonging to data available periods used in this study can be used to compare the bidirectional associations between them.

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APPENDICES

A. THE DATA SOURCES AND CONSTRUCTION OF FIGURE 2.1

In Figure 2.1, data for birth rate per 1000 people for the years 1940 and 1950 are taken from UN *Demographic Yearbook* for 1948, 1949-1950, 1951, 1952, 1954, 1955, 1958 and 1960. Birth rate per 1000 people values for the year 1960 to 2009 are utilized from data of The World Bank. India birth rate per 1000 people values in 1940 as 32 is used for Bangladesh birth rate per 1000 people value in 1940 due to the missing value of Bangladesh data in 1940 in UN *Demographic Yearbooks*. Brazil birth rate per 1000 people values in 1946 as 33.7 is used for its the year 1940 value due to its missing value in 1940 in UN *Demographic Yearbooks*. Myanmar birth rate per 1000 people values in 1939 as 32.4 is used for its the year 1940 value due to its missing value in 1940 in UN *Demographic Yearbook*. Pakistan birth rate per 1000 people values in 1946 as 24.9 is used for its the year 1940 value due to its missing value in 1940 in UN *Demographic Yearbooks*. Panama birth rate per 1000 people values in 1941 as 37.4 is used for its the year 1940 value due to its missing value in 1940 in UN *Demographic Yearbooks.* Indonesia birth rate per 1000 people values in 1952 as 26.5 is used for its the year 1950 value due to its missing value in 1950 in UN *Demographic Yearbooks.*

B. A GUIDANCE OF THE LETTERS

Reference Letter	***A***	*B*	*C*	*D*	***E***	***F***	***G***	*H*	***K***	***L***	*M*	*N*	*P*	*R*	*S*	*T*	*V*	*W*	*X*	***Y***	*Z*
The Letter Used in This Study	***A***	*X*	*W*	*C*	***E***	***F***	***G***	*N*	***K***	***L***	*U*	*H*	*M*	*Z*	*V*	*P*	*Ω*	*Q*	*B*	***Y***	*S*

Reference Letter	*a*	*c*	***d***	***e***	***f***	**g**	*h*	*i*	*j*	***k***	*l*	*m*	*n*	*p*	*q*	*r*	*s*	*t*	*u*	*v*	*w*	*x*	***y***	*z*
The Letter Used in This Study	*t*	*w*	***d***	***e***	***f***	**g**	*n*	*j*	*i*	***k***	*λ*	*u*	*h*	*m*	*c*	*z*	*v*	*p*	*ψ*	*ω*	*q*	*b*	***y***	*s*

Reference Letter	***Δ***	*Θ*	*Π*	*Ω*
The Letter Used in This Study	***Δ***	*ϕ*	*Θ*	*Γ*

Reference Letter	α	β	γ	δ	ε	ϵ	ζ	η	ι	κ	λ	μ	ξ	π	ρ	σ	τ	υ	ϕ	ψ
The Letter Used in This Study	ζ	ϱ	α	β	η	ι	ε	ϵ	μ	ξ	κ	γ	τ	ς	δ	π	ρ	σ	ϑ	ϖ

C. CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Öztürk, Ceyhan
Nationality: Turkish
Year and Province of Birth: 1970, Kırklareli

EDUCATION

Degree	Institution	Year of Graduation
PhD	Middle East Technical University (METU), Social Sciences Institute, Science and Technology Policy Studies, Ankara	2018
MBA	Yeditepe University, Social Sciences Institute, Business Administration, Istanbul	2000
BA	Turkish Military Academy, Management, Ankara	1992
High School	Kuleli Military High School, Istanbul	1988

FOREIGN LANGUAGE

English (advanced)

COMPUTER SKILLS

STATA (advanced), CGE Models (intermediate)

HOBBIES

Classical Music, Tennis

D. TURKISH SUMMARY/ TÜRKÇE ÖZET

ÖZ

SAĞLIK VE İKTİSADİ GELİŞİM İLİŞKİSİ ÜZERİNE MAKALELER:
ÜLKE PANEL VERİSİ İLE YENİ BULGULAR

Bu ampirik çalışmada, 1940-1980, 1940-2009 ve 1980-2009 dönemleri için birinci, ikinci ve üçüncü dereceden denklemler içeren modeller kullanılarak sağlığın iktisadi gelişmeye olan etkileri incelenmektedir. Bu çalışma, iktisadi büyüme ve sağlık ilişkisinin farklı boyutlarını ortaya çıkarmaya çalışmaktadır. Bu nedenle, sağlığın, iktisadi gelişmeye olan etkilerinin araştırılması için sağlık değişkenleri olarak beklenen yaşam süresi (BYS), beden kitle indeksi (BKİ) ve sistolik kan basıncı (SKB) kullanılmıştır. Ayrıca ilişkinin incelenmesinde kısa ve uzun dönem zaman süreleri esas alınmıştır.

Bu temsili sağlık değişkenlerinin en önemli ortak özelliği yaşlanmayla güçlü bağlarının bulunmasıdır. Temsili sağlık değişkenlerinin bu ortak özelliği, gelir ve sağlık ilişkisinin farklı boyutlarını incelememize imkân vermektedir. Bahse konu ilişkinin, eğitim süresi (beşerî sermaye), katılan kişi başına düşen gayri safi yurtiçi hasıla, katılan kişi başına üretim katma değeri (verimlilik) ve gayri safi yurtiçi tasarruflar olarak genişletilmesi suretiyle de gelir ve sağlık arasındaki bağa ilişkin temel bir ortak görüşe ulaşılmıştır.

Regresyon, sabit-etki ve genelleştirilmiş moment metodu (Arellano-Bond) tahmin araçları kullanılarak 47 ülke için 1940-1980 ve 1940-2009 dönemi için 10’ar yıllık ve 1980-2009 dönemi için 5’er yıllık dengeli panel verileri kullanılarak hesaplamalar yapılmıştır. Ayrıca, tüm bu dönemler için, regresyon ve araç değişken hesaplayıcısı

ile uzun dönem-fark tahmini yöntemi kullanılmıştır. Farklı temsili sağlık değişkenlerini ihtiva eden bu çalışmanın ampirik sonuçları genellikle birbirleriyle tutarlı bulunmuştur. Daha açık olarak, tüm bağımlı temsili iktisadi gelişme değişkenleri ve temsili sağlık değişkenleri arasında doğrusal ve tekdüze olmayan bir ilişki bulunmuştur. Sonuç olarak, ampirik sonuçlarımız insan fizyolojik sağlık fonksiyonlarının korunmasının iktisadi büyümeyi güçlendirdiğine dair önemli kanıtlar sunmaktadır.

Bu çalışmada, birinci bölümde Giriş, ikinci bölümde Yöntem, üçüncü bölümde Veri ve Ampirik Özellikler, dördüncü, beşinci ve altıncı bölümlerde temsili sağlık değişkenlerinin temsili iktisadi gelişme değişkenlerine olan etkilerini inceleyen üç ayrı makale sunulmaktadır. Yedinci bölümde Sonuçlar ve Politika Önerileri verilmektedir. Ayrıca, yedinci bölümde Politika Önerilerinde yer alan Bilim ve Teknoloji Politikası ile İlgili Hususlar paylaşılmaktadır. Yedinci bölümde ilave olarak, bu çalışma ile ilgili Katkıların Özeti sunulmaktadır.

Tez kapsamında, kişi başına gayri safi yurtiçi hasıla ve beklenen yaşam süresi arasındaki ilişki araştırılmıştır. Ancak, bu değişkenler arasındaki nedensellik araştırılmamış olup bu inceleme gelecekteki çalışmalara bırakılmıştır.

1940-1980 döneminin başından itibaren 47 ülke için tarihsel güvenilir veriler göz önünde bulundurularak Acemoğlu ve Johnson'daki (2007: 939, 979-980) temel örnek veri yapısı takip edilmiştir. Bu nedenle, panel verilerimizde 47 ülke ve ekonomik kalkınma ve sağlık arasındaki bağlantıyı incelemek için üç dönem bulunmaktadır. Bu dönemler 1940-1980, 1940-2009 ve 1980-2009. 1940-1980 dönemi Hansen (2012), Desbordes (2011), Cervellati ve Sunde (2009) ve Acemoğlu ve Johnson' da (2007) kullanılmıştır. 1980-2009 dönemi Husain v.d.'de (2014) kullanılmıştır. Bu iki dönem nispeten kısa vade özelliklerine sahiptir. Bu iki dönemin birleşimi olarak nispeten uzun bir vade özelliklerine sahip olan 1940-2009 dönemi bizim tarafımızdan yeni kullanılmıştır. Kısa ve uzun vade, iktisatta aynı olaylar için farklı sonuçlar doğurabilmektedir.

Bu 47 ülkenin tarihsel güvenilir verileri dikkate alındığında, 1940-1980 ve 1980-2009 dönemleri, iki farklı iktisat politikası uygulamasına, sırasıyla Keynesyen ve Neo-liberal iktisat politikalarına denk gelmektedir.

Jahan v.d.' e (2014) göre, Keynesyen iktisat anlayışında, toplam talep ekonomide ana itici unsur olarak kabul edilmektedir. Toplam talep, ticari faaliyetler, hane halkı ve hükümetler tarafından yapılan harcamaların bütününü içermektedir. Kamu politikalarının, tam istihdam sağlayan serbest piyasalarda kendi kendini dengeleme işlevi bulunmadığından, tam istihdam ve fiyat sürdürülebilirliğini gerçekleştirmesi gerekmektedir. Buna göre toplam talepteki eksiklik, işsizliğin artmasına neden olabilmektedir. Keynesyen iktisada göre, iktisadi hareketleri üç prensip yönlendirmektedir.

İlk prensip, kamu ve özel sektör kararlarının toplam talebi etkilemesidir. İkinci prensip, arz ve talep değişimlerinin yavaş da olsa fiyatlar genel düzeyini ve ücretleri etkilemesi, bunun da iş gücü daralması veya iş gücü fazlalıklarına periyodik olarak neden olmasıdır. Üçüncü prensibe göre, toplam talep değişiklikleri reel üretim ve istihdam üzerinde güçlü bir kısa vadeli etki yaratmakta olup fiyatlar üzerinde bir etkisi olmamaktadır. Keynesyen iktisadi görüşe göre fiyatlar belirli bir derecede inelastiktir. Herhangi bir harcama kalemindeki değişim üretimi etkilemektedir. Örneğin, kamu harcamalarındaki artış fiyat artışından ziyade üretim artışına neden olmaktadır. Keynesyen iktisatta, ekonomik dalgalanmalara karşı kullanılmak üzere mali politikalara yer verilmektedir. Para politikaları da ekonomiyi motive etmek için Keynesyen iktisatta kullanılmaktadır. Keynesyen iktisada göre, ekonomideki kısa vadeli sorunlar bile kamu müdahalesi ile çözülmelidir. Kamu, piyasa mekanizmasının daha uzun sürede sorunu çözmesini beklememelidir.

Thorsen ve Lie'ye (2010) göre, iktisadi mekanizmanın temel unsuru kaynak tahsislerinin verimliliğidir. Bu tespit ile ilişkin olarak Neo-liberal iktisada göre, piyasa sistemi kaynakları dağıtmak için en etkili eylem olarak kabul edilmektedir. Kamu müdahalesi, piyasanın bu mükemmel dengelenmiş sistemini zayıflatmakta ve ekonomik kaynak tahsisinin etkinliğini azaltmaktadır. Neo-liberal doktrin, kurumsal anlamda serbest ticaret, serbest piyasalar ve mülkiyet haklarını güvence altına alarak bireysel girişimcilik aklını ve yeteneklerini geliştirmenin insan refahını destekleyeceğini ileri sürmektedir. Kamu sektörünün sorumluluğu, bu temelleri, doğru bir şekilde çalışacak işleyiş içinde kurmak ve bu işleyişi de güvence altına almak olmalıdır. Neo-liberal iktisada göre, para birimi hükümetler tarafından kalite ve dürüstlük içinde korunmalıdır. Özel mülkiyet haklarını ve yeterince işleyen bir pazar mekanizmasını garanti etmek için savunma ile asayiş hizmetleri ve yasal düzenlemeler yerine getirilmelidir.

Su ve kanalizasyon, eğitim, sağlık hizmetleri, sosyal güvenlik veya ekolojik sorunlar için piyasa mekanizması oluşmamış ise kamu bu hizmetleri sağlamalıdır. Ancak, piyasa mekanizmasındaki kamu müdahalesi piyasadaki bozulmayı ve fiyat spekülasyonunu önlemek için en düşük düzeyde gerçekleştirilmelidir. Bununla birlikte bu doktrine göre, bireyler serbest olarak aldıkları kararlarının ve piyasa mekanizması içinde gerçekleştirdikleri eylemlerinin sorumluluğunu da taşımaktadırlar. Bu nedenden ötürü, sosyal ayrımcılık ve eşitlik sorunsalı, bireyin özgür seçimlerinin bir sonucu olarak ortaya çıkıyor ise ahlaki olarak kabul edilebilmektedir. Bu yaklaşımın doğal sonucu olarak Neo-liberal doktrin; reformların, bireysel ve girişimci özgürlüklerin, bu sürecin uzmanlar ya da yasal araçlar kuralıyla değiştirilerek demokratik işleyişin baskısına karşı kurumlar tarafından güvence altına alınmasını gerektirmektedir.

Sonuç olarak, 1940-2009 dönemi, bu süre içerisinde uygulanan bu iki farklı iktisat politikasının benzersiz ve bütünleşik bir özelliğini sunmaktadır. Ayrıca 1940-1980 ve 1980-2009 dönemleri için farklı doğum oranı hareketleri olduğu da görülmektedir. Doğum oranı 1940-1950 dönemi için önce azalmakta, daha sonra 1950-1970 dönemi için artmakta ve sonrasında 1970-1980 dönemi için tekrar azalmaya başlamaktadır. 1980-2009 döneminde ise, doğum oranı doğrusal bir eğilimle azalmaktadır.

1940-1980 ve 1940-2009 dönemleri için, tarihsel güvenilir veri değerlendirmesine bağlı olarak, bağımlı değişkenler kişi başına GSYİH ve eğitim yılı olarak kullanılmaktadır. Açıklayıcı değişken olarak sağlık temsili değişkeni BYS kullanılmaktadır. 1980-2009 döneminde ise, güvenilir tarihsel veri mevcudiyetine bağlı olarak, bağımlı değişkenler olarak kişi başına GSYİH, ortalama eğitim süresi (beşeri sermaye), katılan kişi başına düşen GSYİH, katılan kişi başına üretim katma değeri (verimlilik) ve gayri safi yurtiçi tasarruf kullanılmaktadır. Sağlık temsili değişkenleri olarak açıklayıcı değişkenler BYS, BKİ ve SKB kullanılmaktadır. Ekonomik gelişim değişkenleri, kararlılık testi yapılabilmesi maksadıyla ekonomik büyüme ile güçlü ilişkilerine göre büyüme göstergelerinden seçilmişlerdir. Sağlık temsili değişkenleri, yaşa bağlı olarak değişimlerine ve BYS içinde gömülü bir etkiye sahip olmalarından dolayı tercih edilmişlerdir.

Sağlığın ekonomik kalkınma üzerindeki etkisi nedir? Bu soru, bu çalışmayı yürütmek için temel sorumuz olmaktadır. Genel anlamda, Azomahou v.d. (2009) çalışması, bu soruyu araştırmak için bir rehber olarak kullanılmaktadır. Azomahou v.d. (2009) çalışmasının varsayımlarına göre, farklı yaşlardaki insanlar farklı "etkili planlama öngörüsüne" sahip olacaklar ve farklı "tasarruf kararları" alacaklardır. Bu tasarruf tercihleri, BYS ve GSYİH arasındaki ilişkinin şeklini belirlemektedir. Bu ilişkinin, bu bağlantıların boyutlarını anlamak için farklı sağlık temsili değişkenleri ile test edilmesi gerekmektedir. Daha sonra, tıbbi literatürde yer alan, yaşlanma ile BKİ ve ayrıca yaşlanma ile SKB arasında güçlü bir bağı olduğu varsayımı çalışmamızda kullanılmak üzere kabul edilmektedir. Böylece, aynı yaşlardaki insanların çok yakın BKİ ölçümlerine ve SKB sonuçlarına sahip oldukları kabul edilmektedir.

Bu yakın bağlantılar sağlık durumu temsili değişkenleri olarak iki yeni BYS değişkeninin kullanımını mümkün kılmaktadır. Bunlar SKB ve BKİ. Daha sonra, iki temel terim, sağlık durumu ve ekonomik gelişme, ekonomik büyüme göstergeleri olarak beş temsili değişken ve üç alt sağlık temsili değişkeni olarak genişletilmektedir. Böylece, açıklayıcı değişkenler olan sağlık konularına bağlı olarak ana üç bölümde guruplandırılmış on beş soru elde edilmektedir. Bunlar, uzun ömür ve ekonomik kalkınma ile ilgili sorular, beslenme ve ekonomik kalkınma ile ilgili sorular ve damar sağlığı ve ekonomik gelişme ile ilgili sorular olarak sınıflandırılmaktadır.

Beklenen Yaşam Süresinin, Ekonomik Büyümeye, Beşeri Sermayeye, Katılan Kişi Başına GSYİH'ye, Verimlilik ve Gayri Safi Yurtiçi Tasarruflara Etkisi

Bölüm 4'te, kişi başına düşen GSYİH, beşeri sermaye, katılan kişi başına düşen GSYİH, verimlilik ve gayri safi yurtiçi tasarruflar ile BYS arasındaki ilişki 1940-1980, 1940-2009 ve 1980-2009 dönemlerini kapsayacak şekilde, birinci, ikinci ve üçüncü dereceden denklemler içeren modellerde araştırılmaktadır. Araç değişken tahminlerinde, araç değişkeni olarak; tahmin edilen ölüm oranı, 1-5 arası yaşa, 5-14 arası yaşa, 65-69 arası yaşa, 80-84 arası yaşa ilişkin hayatta kalma olasılıkları ve kızamık aşısı kapsama oranı şeklinde kullanılmaktadır. Sonuç olarak, bu bölümdeki ampirik sonuçlar, insan fizyolojik sağlık fonksiyonlarının korunmasının ekonomik kalkınmayı, bireylerin yeterli tasarruf yapabilme imkanına sahip olmaları ile güçlendirdiğine dair önemli kanıtlar sunmaktadır.

Beden Kitle İndeksinin (BKİ), Ekonomik Büyümeye, Beşeri Sermayeye, Katılan Kişi Başına GSYİH'ye, Verimlilik ve Gayri Safi Yurtiçi Tasarruflara Etkisi

Bölüm 5'de 1980-2009 döneminde kişi başına düşen GSYİH, beşeri sermaye, katılan kişi başına düşen GSYİH, verimlilik ve gayri safi yurtiçi tasarruflar ile BKİ arasındaki ilişki incelenmektedir. Veri sınırı nedeniyle sadece bu süre kullanılmaktadır. Araç değişken tahminlerinde araç değişkenler olarak; ham hayatta kalma ve 75-79 arası yaş hayatta kalma olasılıkları şeklinde kullanılmaktadır. Bu bölümde, sağlık için temsili değişkeni olarak BYS'nin bireylerin "*hastalıklılık*", "*engellilik*", "*rahatsızlık*" durumlarına ilişkin sınırlılığını (Husain v.d., 2014: 128) bir derereceye kadar aşabilmek maksadıyla BYS yerine BKİ kullanılmaktadır.

Yaşlanma ile yakın bağlantısının bulunması nedeniyle, BKİ'nin fizyolojik bir sağlık fonksiyonu olarak etkisinin BYS'ne gömülü olduğu varsayılmaktadır. Bu nedenle, zayıf araç değişken tanımlama testi sonuçları, BKİ ile bu çalışmada araçsal değişkenler olarak kullanılan yaşa özgü hayatta kalma olasılıkları arasında güçlü bir ilişki olduğunu kanıtlamaktadır. Bu bölümdeki ampirik sonuçlarımız genellikle kişi başına düşen GSYİH-BYS ilişkisi bulguları ile tutarlıdır. Bu bulgular, BKİ'nin insan fizyolojik fonksiyonu olarak etkisinin, BYS'ne yaşlanma yoluyla gömülü olduğuna dair dayanak sağlamaktadır. Sonuç olarak, ampirik bulgularımız, ortalama toplumsal BKİ seviyesinin, bireylerin yeterli tasarruf yapabilme imkanına sahip olmaları ile ekonomik kalkınmayı arttırdığına dair önemli kanıtlar sunmaktadır.

Sistolik Kan Basıncı (SKB)'nin, Ekonomik Büyümeye, Beşeri Sermayeye, Kişi Başına GSYİH'ye, Verimlilik ve Gayri Safi Yurtiçi Tasarruflara Etkisi

Bölüm 6'da 1980-2009 döneminde kişi başına düşen GSYİH, beşeri sermaye, katılan kişi başına düşen GSYİH, verimlilik ve gayri safi yurtiçi tasarruflar ile SKB arasındaki ilişki incelenilmektedir. Veri sınırı nedeniyle sadece bu süre kullanılmaktadır. Araç değişken tahminlerinde araç değişkenler olarak ham hayatta kalma ve 75-79 arası yaş hayatta kalma olasılıklarını kullanılmaktadır. Bu bölümde, sağlık için temsili değişken olarak olarak bireylerin "hastalıklılık", "engellilik", "rahatsızlık" durumlarına ilişkin kısıtlılığını (Husain v.d., 2014: 128) bir ölçüde kadar aşabilmek maksadıyla BYS yerine SKB kullanılmaktadır.

Yaşlanma ile yakın bağlantısının bulunması nedeniyle, SKB'nin fizyolojik bir sağlık fonksiyonu olarak etkisinin BYS'ne gömülü olduğu varsayılmaktadır. Bu nedenle, araç değişken zayıflık tanımlama testi sonuçları, SKB ile bu çalışmada araçsal değişkenler olarak kullanılan yaşa özgü hayatta kalma olasılıkları arasında güçlü bir ilişki olduğunu kanıtlamaktadır. Bu bölümdeki ampirik sonuçlarımız genellikle kişi başına düşen GSYİH-BYS ilişkisi bulguları ile tutarlı bulunmuştur. Bu bulgular, SKB'nin insan fizyolojik fonksiyonu olarak etkisinin, BYS'ne yaşlanma yoluyla gömülü olduğuna dair kanıtlar sağlamaktadır. Sonuç olarak, ampirik sonuçlarımız, sağlıklı toplum ortalama SKB seviyesinin, bireylerin yeterli tasarruf yapabilme imkanına sahip olmaları ile ekonomik kalkınmayı desteklediğine dair önemli bulgular sunmaktadır.

SONUÇLAR

Nihai olarak, bu çalışmada farklı sağlık temsili değişkenlerine (BYS, BKİ ve SKB) sahip üç farklı bölümdeki ampirik sonuçlarımız genellikle birbiriyle tutarlı bulunmuştur. Daha açık bir şekilde, tüm bağımlı ekonomik gelişme temsili değişkenleri (kişi başına düşen GSYİH, beşeri sermaye, katılan kişi başına düşen GSYİH, verimlilik ve gayri safi yurt içi tasarruflar) ve sağlık temsili değişkenleri arasında doğrusal ve tekdüze olmayan ilişki olduğu görülmektedir. Sağlık temsili değişkenlerinin tüm bağımlı değişkenlere etkilerine ilişkin açıklamalar aşağıda sunulmaktadır.

Kişi başına GSYİH'de, 1940-1980 dönemi için, üçüncü dereceden denklem içeren model sonuçlarımız, kişi başına GSYİH ve BYS arasında önce içbükey sonra dışbükey şeklinde bir ilişki olduğunu göstermektedir. Ancak 1940-2009 ve 1980-2009 dönemleri için, üçüncü dereceden denklem içeren model sonuçlarımız, kişi başına GSYİH ve BYS arasında önce dışbükey sonra içbükey şeklinde bir ilişki olduğunu ortaya koymaktadır. Bu sonuçlar, Azomahou v.d. (2009) 1820-2005 dönemi çalışması sonuçları ile benzer bulunmuştur. Kişi başına GSYİH-BKİ bağlantısında, 1980-2009 dönemi için üçüncü dereceden denklem içeren model sonuçlarımız, kişi başına GSYİH ile BKİ arasında dışbükey-içbükey şeklinde bir ilişki olduğunu göstermektedir. Kişi başına düşen GSYİH-SKB ilişkisinde, 1980-2009 döneminde, ikinci dereceden denklem içeren model sonuçlarımız, kişi başına düşen GSYİH ile SKB arasında monotonik olmayan ve ters U-şekilli bir ilişki olduğu görülmektedir. Ayrıca, üçüncü dereceden denklem içeren model sonuçları, 1980-2009 döneminde kişi başına GSYİH ile SKB arasındaki ilişkinin ikinci dereceden denklem içeren model sonuçları ile doğrusal terim modelden düştüğü için aynı bulguları paylaşmaktadır.

Beşeri sermaye-BYS ilişkisinde, 1940-1980, 1940-2009 ve 1980-2009 dönemlerinde üçüncü dereceden denklem içeren model sonuçları, ortalama eğitim süresi ve BYS arasında dışbükey-içbükey şekilli bir bağlantı olduğunu ortaya koymaktadır. Beşeri sermaye-BKİ bağlantısında, 1980-2009 dönemi için, üçüncü dereceden denklem içeren model sonuçlarında, doğrusal, karesel ve kübik terimlerin katsayılarının önemsiz olduğu görülmektedir. Böylece, ikinci dereceden denklem içeren model tahmin sonuçlarımız, ortalama eğitim yılları ile BKİ arasında monotonik olmayan ve ters U-şekilli bir ilişki olduğuna işaret etmektedir. Beşeri sermaye-SKB ilişkisinde, 1980-2009 döneminde, ikinci dereceden fonksiyonel model tahmin sonuçlarımız, ortalama eğitim süresi ve SKB arasında monotonik olmayan ve ters U-şekilli bir ilişki olduğunu göstermektedir. Ayrıca, üçüncü dereceden denklem özelliği olan model sonuçlarımız, bu dönem için beşeri sermaye ile SKB arasındaki ilişkinin doğrusal terimin hesaplamadan düşmesi nedeniyle ikinci dereceden denklem içeren model sonuçlarıyla benzer bulguları paylaşmaktadır.

Katılan kişi başına düşen GSYİH ile BYS arasındaki ilişkide, 1980-2009 dönemi için, üçüncü dereceden denklem içeren model tahmin sonuçlarımız, katılan kişi başına GSYİH ile BYS arasında dışbükey içbükey şeklinde bir ilişki olduğunu ortaya koymaktadır. Katılan kişi başına düşen GSYİH ile BKİ arasındaki bağ ile ilgili olarak 1980-2009 dönemi için, üçüncü dereceden denklem içeren model tahmin sonuçlarımız, katılan kişi başına GSYİH ile BKİ arasında dışbükey içbükey şeklinde bir ilişki olduğunu göstermektedir. Katılan kişi başına düşen GSYİH ile SKB arasındaki bağ ile ilgili olarak 1980-2009 dönemi için, üçüncü dereceden denklem içeren model sonuçlarımız, katılan kişi başına GSYİH ile SKB arasında dışbükey içbükey şeklinde bir ilişki olduğuna işaret etmektedir.

Üretkenlik-BYS ilişkisinde, 1980-2009 dönemi için, üçüncü dereceden denklem içeren model sonuçları, katılan kişi başına imalat katma değeri ile BYS arasında dışbükey içbükey şeklinde bir ilişki olduğunu göstermektedir. Üretkenlik-BKİ bağına ilişkin olarak 1980-2009 dönemi için, üçüncü dereceden denklem içeren model sonuçları, katılan kişi başına imalat katma değeri ile BKİ arasında dışbükey içbükey şeklinde bir ilişki olduğunu ortaya koymaktadır. Katılan kişi başına imalat katma değeri-SKB bağına yönelik olarak 1980-2009 dönemi için, üçüncü dereceden denklem içeren model sonuçları, Üretkenlik ile BKİ arasında dışbükey içbükey şeklinde bir ilişki olduğuna işaret etmektedir.

Gayri safi yurtiçi tasarruflar-BYS ilişkisinde, 1980-2009 dönemi için, üçüncü dereceden denklemler içeren model sonuçlarında, doğrusal, karesel ve kübik terimlerin katsayılarının önemsiz olduğunu görülmektedir. Bu nedenle, ikinci dereceden denklemler içeren model tahmin sonuçlarımız, 1980-2009 dönemi için gayri safi yurtiçi tasarruflarla BYS arasında monotonik olmayan ve ters U-şekilli bir ilişki olduğunu ortaya koymaktadır. Gayri safi yurtiçi tasarruflar-BKİ ilişkisinde, 1980-2009 dönemi için, üçüncü dereceden denklemler içeren model sonuçlarında, doğrusal, karesel ve kübik terimlerin katsayılarının önemsiz olduğunu görülmektedir. Bu nedenden ötürü, ikinci dereceden denklemler içeren model tahmin sonuçlarımız, 1980-2009 dönemi için gayri safi yurtiçi tasarruflarla BKİ arasında monotonik olmayan ve ters U-şekilli bir ilişki olduğunu ortaya koymaktadır. Gayri safi yurtiçi tasarruflar-SKB ilişkisinde, 1980-2009 dönemi için, üçüncü dereceden denklemler içeren model sonuçlarında, doğrusal, karesel ve kübik terimlerin katsayılarının önemsiz olduğunu görülmektedir. Bu nedenle, ikinci dereceden denklemler içeren model tahmin sonuçlarımız, 1980-2009 dönemi için gayri safi yurtiçi tasarruflarla SKB arasında monotonik olmayan ve ters U-şekilli bir ilişki olduğunu ortaya koymaktadır.

Eğer sağlık durumu iyileştirme stratejileri, yaşa özgü koşullara bağlı olarak, uygun yaşlar için tasarruf artırıcı politikalar ile birleştirilirse, örneğin, erken çalışmaya giriş yaşı olan 15'ten başlatılıp 65 yaş üstüne kadar, bu yaklaşım Neo-liberal modellerle içsel büyüme modellerini, sağlık yatırımlarına yeterli getiri sağlayarak birbirine yaklaştırabilir. Bu şekilde, sürdürülebilir ekonomik büyümeyi sağlamak için sağlık yatırımlarında Neo-liberal modeller ve içsel büyüme modelleri arasında çelişen bir hususun nedenine ilişkin bir kanıt da elde edilmiş olmaktadır. Bu husus, karmaşık ekonomik gelişme-sağlık ilişkisi konusunda bu ampirik çalışmanın ana katkısı olmaktadır. Dolayısıyla, eğer bu mekanizma işletilebilir ise, bu sürecin sonuçları ulusal ve insani çıkarları birbiriyle örtüştürebilecek bir nitelik gösterebilir. Çünkü "insan fizyolojisini" koruma durumu ortaya çıkmaktadır.

Aynı zamanda, bu durum "tasarruf eğilim davranışı"nın korunması anlamını da ihtiva etmektedir. Bu şekilde, insan fizyolojisinin korunması hususu, herhangi bir bireyin yüksek zaman tercih oranına ulaşmadan önce daha uzun bir zaman süresince tasarruf yapabilmesine imkan sağlamış olmaktadır. Bu mekanizmayı güçlendirecek olan bu çabalar, ekonomik nedenlerle bireyler arasında ve dolayısıyla da milletler arasında çatışma nedenini ortadan kaldırmış olacaktır.

Ampirik sonuçlarımız, iyi sağlık durumunu tasarruf veya tasarrufu iyi sağlık durumu ile bir araya getirebilirsek, sağlık ve ekonomik büyüme arasındaki ilişkinin olumlu olacağına dair açık kanıtlar sunmaktadır. Ve bu olumlu ilişki, uygun politika destekleri ile günümüzde olduğundan daha uzun bir süre devam edebilme potansiyeline sahiptir. Bu nedenle, ampirik bulgularımızdan, Azomahou v.d. (2009) sonuçlarından ve ayrıca literatürde yapılan önerilerden esinlenen politika önerilerimizin özü, iyi sağlık durumu ve tasarruf eğilimleri arasındaki ilişkinin kurulmasına dayanmaktadır. Özet olarak iktisadi yapılanmalarımızda, tüm bireylerin fizyolojik işlevlerini uygun yaşlarda itibaren koruyarak (örneğin, erken çalışma giriş yaşı olan 15 yaşından başlayarak 65 yaş üstüne kadar), bu bireylerin tasarruf eğilimlerini yeterince yüksek tutabilmeleri için bir fırsat da yaratabilirsek, herkes için sürdürülebilir bir ekonomik büyüme elde edebileceğimiz hususu ortaya konulmaya çalışılmaktadır.

Çalışmamızda kullandığımız verilere dayanarak sunduğumuz Şekil 7.1, reel GSYİH ile gayri safi yurt içi tasarruf arasındaki ilişkiyi ortaya koymaktadır. Bu grafikte, reel gayri safi milli hasıladaki değişimlerin gayri safi yurt içi tasarruflardaki değişiklikleri takip ettiği açıkça görülmektedir. Özellikle, Çin ve Amerika Birleşik Devletleri (ABD)'nin ekonomik büyüme hareketi, 1980-2009 dönemi için ülkelerin geri kalanından daha yüksek reel GSYİH seviyelerine sahip olmaları itibariyle, bu ilişkiyi ortaya çıkaran çok açık bir kanıt sağlamaktadır. Bu grafikte gözlemlenen husus, ABD'nin yurtiçi tasarruflarının azalma eğilimi göstermesine karşılık ki bu durum Stiglitz (2018) tarafından da ABD ekonomisinde bir sorun olarak işaret edilmektedir, Çin'in büyüme eğiliminin yükselen gayri safi yurtiçi tasarruflarından faydalanıyor olduğu hususudur.

Bizim düşüncemize göre, ülkelerin (azalan tasarruf konumdaki) gayri safi yurt içi tasarruflarda bir artış elde etmek için makul ve kolay bir yöntem bulunmaktadır. Kanaatimiz odur ki bu yöntem, diğer ülkelerde (artan tasarrufa sahip) de gayri safi yurtiçi tasarruflarda artışa devam edilebilmesine faydalı olacaktır. Bu makul ve kolay yöntem, tüm insanların fizyolojik işlevlerini uygun yaşlarda (örneğin, erken işe giriş yaşı olan 15 yaşından başlayıp 65 yaş üstüne kadar) korunmasıdır. Bu makul ve kolay yöntem, tüm dünyada sürdürülebilir ekonomik büyümenin elde edilmesi için bir potansiyele sahiptir. Sonuçlarımıza göre, bu yönde ilerleme kaydedebilen ülkeler vatandaşlarının sağlık durumlarındaki iyileşme seviyesine bağlı olarak gayri safi yurtiçi tasarruflarında artış sağlamaları nedeniyle ekonomik gelişmede de ilerleme sağlayabilecektir. Aşağıda politika önerilerinizin bir özeti sunulmaktadır.

İlk politika sorunumuz, *belirli eşikler arasında yaşa bağlı düşük tasarruf eğilimi* olarak ortaya çıkmaktadır. 1940-2009 döneminde, ampirik sonuçlarımız, kişi başına GSYH ile BYS arasında dışbükey içbükey şekilli bir ilişki olduğunu (1 nci dönme noktası 37.55-49.87 yılları aralığında ve 2 nci dönme noktası 53,48-65,52 yılları aralığında olmak üzere) Azomahou v.d.' nin (2009) bulgularına benzer olarak ekonomik büyümenin tasarruflardaki yükselme ile arttığını göstermektedir. Ancak yeterince yaşlanan insanlar, tasarruf etmek yerine harcama eğilimine sahip olmaktadırlar. Bir insanın tasarruf oranı, zaman süreci içinde azalmaktadır. Özellikle, 2 nci dönme noktasından sonra, tasarruf oranındaki düşüş eğilimi kişi başına düşen GSYİH üzerinde olumsuz etki yaratmaktadır.

Genç insanlar yeterince yaşlanan insanlardan daha fazla tasarruf etmeyi tercih etmektedirler. Ne yazık ki, onların tasarrufları da gelir düzeyleriyle ilişkili olarak

1 nci dönme noktası aralığına kadar yeterince yüksek olamamaktadır. Fiziksel sermaye birikiminin itici güç olduğu ekonomik büyümede ve gayri safi yurtiçi tasarruflara bağlı olan bu birikim yoluyla, bu zaman tercihleri, toplumda tasarrufa daha az eğilimli olma oranını artan yaşlı nüfus üzerinden arttırarak, eğride bir içbükey bir şekil yaratmaktadır. BYS'nin pozitif etkisi, tasarruf için daha az eğilimli olan yeterince yaşlı insanların artan oranının ortaya çıkardığı bu olumsuz etkiyi yeterince karşılayamamaktadır. Bu nedenle, genç ve yeterince yaşlı insanların kendi koşullarına bağlı olarak ortaya çıkan tasarruf oranları bu dışbükey-içbükey şekilli bağlantı eğrisini oluşturmaktadır. Bu sorunun çözümünün de genç ve yeterince yaşlı insanların koşullarının düzenlenmesinde bulunduğu değerlendirilmektedir.

Mekanizma şöyle çalışmaktadır: Yeterince düşük BYS değerleri ile düşük oranlı iktisadi büyüme gerçekleşmektedir. Daha sonra, BYS'nin olumlu etkisiyle toplam tasarruflar yükselmekte ve iktisadi büyüme artmaktadır. Bu süreç, ekonomik büyüme-BYS bağlantısındaki dışbükey biçimli eğriyi karakterize etmektedir. Daha sonra, bu ilişkideki içbükey şekilli eğri, toplumda sayıları artmış olan yüksek zaman tercih oranlarıyla tasarruf etmeye daha az eğilimli olan yeterince yaşlı nüfusun iktisadi büyüme üzerinde büyüyen olumsuz etkisiyle yeterince yüksek BYS değerlerinde ortaya çıkmaktadır.

Bu noktada, Kunze (2014) yeterince yaşlı insanların neden daha az tasarruf yapmaya eğilimli olduklarını şöyle açıklamaktadır. Bu nedenlerden birisi sağlık için yaşlılıkta harcama yapılmasının önemli ölçüde artmak durumunda olmasıdır. Diğeri ise yaşlı insanların birikimlerinin bir kısmını çocuklarının eğitimi için verme eğilimleridir. Yaşlı insanların bu iki eğilimi, yaşlıların tasarruf ve fiziksel sermaye birikimine bağlı olarak iktisadi büyüme oranlarını olumsuz yönde etkilediği görülmektedir.

Bu açıklamalar, özünde kamu tarafından finanse edilen tüm yaşam boyu sağlık hizmetinin sunulmasına ve tüm insanlar için eğitimin desteklenmesine yönelik basit bir teorik dayanak da içermektedir. Bu destekten yararlanması gereken insanlar, tercihen tüm gençler, sağlık hizmetlerinden yararlanmakta olan yaşlı insanlar, eğitimde olan 3 ile 50 yaş arasındaki nüfus olarak değerlendirilebilir. Bu kaynak tahsisi uygulamaları, uygun vergilendirme yoluyla (hedef yaş grupları için negatif vergiler dahil) herhangi bir ülkenin iktisadi kaynaklarına ve önceliklerine bağlı olarak şekillenebilir. Bahse konu ampirik bulgular ve teorik önermelere bağlı olarak oluşturduğumuz politika çıkarımlarımız aşağıda şu şekilde sunulmaktadır.

Makro düzeyde politika çıkarımımız, ülke seviyesinde yaş odaklı tasarruf eğilimi hedefleyen düzenlemelerdir. Politika amacı yaşa bağlı tasarruf eğilimini arttırmaktır. İlk politika aracı, hedeflenen yaş grupları için belirlenen eşikler arasındaki iktisadi büyümeyi destekleyici nitelikte yaşa bağlı gelir vergisi oranlarının / yaşla bağlantılı negatif gelir vergisi oranlarının düzenlenmesidir. Örneğin, ilk hedef yaş grubu, erken çalışma giriş yaşı olan 15 yaş ile 50 yaş arasında başlayabilir. Ayrıca, ikinci hedef yaş grubu, herhangi bir ülkenin dönüm noktalarına bağlı olarak 65 yaşından sonra başlayabilecektir. Linke'ye (2018) göre, normal gelir vergisi ödemesi uygulamasının aksine, düşük gelirli bireyler, negatif gelir vergisi uygulamasında hükümetten ödeme almaktadırlar.

Diğer bir araç ise, hedeflenen yaş grupları için belirlenen bu eşikler arasındaki yaşa bağlı sağlık hizmeti harcaması vergi oranlarının/ yaşa bağlı negatif sağlık hizmet harcaması vergi oranlarının düzenlenmesidir. Son politika aracı ise, hedeflenen yaş grupları için belirlenen eşikler arasında yaşa bağlı eğitim harcamalarının vergi oranlarının / yaşa bağlı negatif eğitim harcamalarının vergi oranlarının düzenlenmesi olmaktadır.

İlk politika hedefi, pilot uygulamalarda yaşa bağlı tasarruf eğiliminin ilk yıl itibariyle en az yüzde 1 oranında arttırılmasıdır. İkinci hedef ise, yerel uygulamalarda ikinci yıla göre yaşa bağımlı tasarruf eğiliminin en az yüzde 1 oranında artırılmasıdır. Üçüncü hedef, ülke düzeyinde uygulamalarda üçüncü yıla göre yaşa bağımlı tasarruf eğiliminin en az yüzde 1'e yükseltilmesidir. Son hedef, ülke düzeyinde uygulamalarda dördüncü yıla göre en az hedeflenen yüzdeye göre yaşa bağlı tasarruf eğiliminin artırılması olmaktadır.

İkinci politika sorunsalımız, *belirli eşikler arasındaki düşük BKİ bağlı tasarruf eğilimidir.* Çünkü ikinci dereceden denklem içeren model sonuçlarında, doğrusal ve karesel terimlerin katsayılarını her ikisinin de sıfırdan % 10 veya daha yüksek önem seviyesinde anlamlı ölçüde farklı olduğu görülmektedir. Sırasıyla pozitif ve negative katsayı değerleri elde edilmiştir. Tahmin edilen eşik noktalarımız, ikinci dereceden denklem içeren model için 24.39-26.16 kg / m2 aralığında yer almaktadır. Bu nedenle, ikinci dereceden denklem içeren model tahmin sonuçlarımız, 1980-2009 dönemi için gayri safi yurtiçi tasarruflar ile BKİ arasında monotonik olmayan ters U-şekilli ilişki olduğunu göstermektedir. Bu ampirik bulgularımız dikkate alınarak, ilgili politika çıkarımlarımız aşağıda şu şekilde sunulmaktadır.

Makro düzeyde politika çıkarımımız BKİ'ne bağlı tasarruf eğilimi hedefleyen düzenlemeler ve ülke seviyesindeki uygulamalardır. Politika amacı, BKİ'ye bağlı tasarruf eğilimini arttırmaktır. Politika aracı, hedeflenen ortalama nüfus BMI seviyesine ulaşmak için ekonomik büyümeyi arttıran halk sağlığı stratejilerini etkinleştirmektir. İlk politika hedefi, pilot uygulamalarda BKİ'ye bağlı tasarruf eğiliminin ilk yıl itibariyle en az yüzde 1 oranında artırılmasıdır. İkinci amaç, yerel uygulamalarda BMI'ya bağlı tasarruf eğiliminin ikinci yıl itibariyle en az yüzde 1 oranında arttırılmasıdır. Üçüncü hedef, ülke düzeyinde uygulamalarda BKİ'ye bağlı tasarruf eğiliminin üçüncü yıl itibariyle en az yüzde 1 oranında arttırılmasıdır. Son hedef ülke düzeyinde uygulamalarda dördüncü yılda en az hedeflenen yüzde seviyesinde BKİ bağlı tasarruf eğilimini yükseltmektir.

Mezo seviyesinde politika çıkarımımız, kurum/kuruluşlar seviyesinde BKİ'ye bağlı tasarruf eğilimi için strateji uygulama planıdır. Politika amacı, BKİ'ye bağlı tasarruf eğilimini yükseltmektir. Politika aracı, iktisatla, halk sağlığıyla, eğitimle ve diğer ilgili kamu/özel kurum/ kuruluşları arasında, hedeflenen ortalama nüfus BKİ seviyesine ulaşarak iktisadi büyümeyi arttırabilmak maksadıyla halk sağlığı stratejisi uygulama planına yönelik bir yuvarlak masa oluşturulmasıdır. Yuvarlak masa aktiviteleri Borras ve Edquist'in (2013: 1516) tanımlamasına göre "esnek politika aracı" olarak karakterize edilebilir. Çünkü "esnek politika araçları" zorunlu olmayan hususlar olarak tasvir edilmektedir.

Bu politika araçları çeşitli unsurlar içerebilmektedir. İkna etmeye dayanmaktadırlar. Çözüm ortakları arasında bilgi paylaşımı üzerine kurulmaktadırlar. Özel ve kamu temsilcileri arasında hiyerarşik olmayan ve daha az bürokratik ilişkilerin mevcudiyeti söz konusu olmaktadır. Politika hedefi, BKİ'ye bağlı tasarruf eğilimini bir yıllık uygulamalar ile en az yüzde 1 oranında yükseltmektir.

Mikro düzeyde politika çıkarımımız ise BKİ'ne bağlı tasarruf eğilimi için yönetici kararları veya uygulama talimatlarıdır. Yönetici kararları, Borras ve Edquist'in (2013: 1516) tanımına göre "esnek politik araçlar" olarak kabul edilebilirler. Bu kararlar vasıtasıyla, televizyon dizileri ve gerçeğe dayalı filmler gibi medya bilgilendirme aktiviteleri harekete geçirebilir. Araştırmacıların kabulü gibi hususlarda kurallar ve ilkeler yayınlanabilir. Ulusal veya uluslararası yatırımcılara ve vatandaşlara tavsiyelerde bulunulabilir. Ülke seviyesinde veya uluslararası düzeyde ihtiyari teknik standartlar belirlenebilir. Kamu araştırmaları ve satın alma faaliyetleri ile zorunluluk taşımayan isteğe bağlı protokoller ve hukuki ortaklıklar yapılabilir. Ayrıca, masrafları, riskleri ve faydaları paylaşarak kamu ve özel sektörün işbirliği halinde hizmet vermesi sağlanabilir.

Politika amacı, BKİ'ye bağlı tasarruf eğilimini yükseltmektir. Politika aracı, ekonomik büyümeyi arttıran halk sağlığı stratejisi uygulama planı ve hane halkının hedeflenen ortalama nüfus BKİ seviyesine ulaşması için eylem öğeleri arasında etkileşimin uygun olarak yönetilmesidir. Bu tür bir yönetişim Borras ve Edquist'e (2013: 1516) tanımlamasına göre "esnek politik araçlar" olarak sınıflandırılabilir. Bu yönetişimde, hükümet düzenleyici ve tedarikçi olmaktan ziyade kolaylaştırıcı veya koordinatör olarak davranmaktadır.

Bu araçlarda, kamu kuruluşları tarafından doğrudan veya dolaylı olarak uygulanmakta olan herhangi bir icraat, ceza veya ödül mekanizması bulunmamaktadır. Aksine, bu tür bir yönetim anlayışı tavsiyelerde bulunmakta ve isteğe bağlı protokollerin hayata geçirilmesine olanak vermektedirler. Hükümet ve bağlı kamu kurum/kuruluşları, özel sektörü ve girişimcileri çözüm ortakları olarak kabul etmektedirler. Dahası, çözümleri birlikte geliştirmekte ve uygulamaya geçirmektedirler. Politika hedefi, BKİ'ye bağlı tasarruf eğilimini bir yıllık uygulamalar ile en az yüzde 1 oranında artırmaktır.

Borras ve Edquist'de (2013: 1516) karakterize edilen "esnek politik araçları" daha anlaşılabilir kılmak üzere, bu politika oluşturucu araçların sağlıklı beslenme ve BKİ konusuyla ilgili hususlara ilişkin olarak B. Çobaner, C. Akça, ve N. Korkmaz (kişisel görüşme, 18 Eylül, 2018) ile yapılan görüşme neticesinde şu şekilde örneklendirilebileceği değerlendirilmektedir. Bir ülkedeki paydaşlar bir araya gelerek (kamu ve özel sektör temsilcileri örneğin) uygulamalarda esas alınmak üzere sağlıklı beslenmenin basit ve işlevsel bir tanımı üzerinde ana prensip olarak mutabakat sağlayabilirler. Örnek sağlıklı beslenme tanımı B. Çobaner'e (kişisel görüşme, 18 Eylül, 2018) göre şu şekilde düzenlenebilir. "Sağlıklı beslenme; doğru besinlerle, doğru porsiyonlarda ve vaktinde vücudun beslenme ihtiyacının karşılanmasıdır."

Bu tanım esas alınarak bazı uygulama prensiplerinde de paydaşlarca mutabık kalınabilir. Örneğin, bu tanımın unsurlarının, Rayner and Lang (2012: 320-321) tarafından tavsiye edildiği gibi "okulda", "iş yerlerinde" ve "ev ortamında" uygulamaya geçirilmesine yönelik prensip ve tavsiyesi kararı alabilirler.

Başka bir esnek politika örneği olarak çözüm ortakları bu tanımın unsurlarının belirtilen ortamlarda hayat geçirilmesinde bireyselliğin gözetilmesi prensibini kabul edebilirler. Paydaşlar, bir esnek politika uygulama prensibi olarak kritik vücut yağ oranı üzerinde uzlaşı sağlayarak bu oranın üzerindeki bireylerin hastanelerde bu amaca uygun olarak düzenlenebilecek tıbbi kliniklerde sağlık hizmeti alabilmeleri hususunda mutabık kalabilirler.

Paydaşlarca, sağlıklı beslenmeyi desteklemek maksadıyla belirli ürün gruplarında uygun fiyatlama yapılması yönünde yine prensip olarak mutabık kalınabilir. Çözüm ortakları, okul, iş yerleri ve aile hekimliği kurumunlarında beslenme uzmanı personel istihdam edilmesi üzerinde anlaşabilirler. Paydaşlar, güncel film ve dizilerde sağlıklı beslenmeyi öne çıkaran sahnelere, ayrıca çocuk yazınında, masallarda, çizgi filmlerde yer verilmesi üzerinde prensip olarak tavsiye kararı alabilirler.

Çözüm ortaklarınca, okullarda sağlıklı beslenmeye ilişkin yemek hizmetinin yaygınlaşması ve çocukların beslenme alışkanlıklarının sorumluluk verilecek sınıf öğretmenleri gözetiminde yürütülmesi veya bulundurulması tavsiye edilebilir. Akıl sağlığı yeterli olmayan bireylerin sağlıklı beslenmelerinin sosyal yardımlaşma kurumları tarafından takip edilmesi ve yerine getirilmesine ilişkin prensip kararı alınabilir.

Tüm sosyal tesislerde (özel ve kamu olmak üzere) diyet kısımlarının açılması tavsiye edilebilir. Bu konuda pilot uygulamaların hayata geçirilmesi özendirilebilir. İş yerlerinin yoğun olduğu yerlerde yürüyüş alanlarının yaygınlaştırılması hususu belediye hizmetlerinde dikkate alınmak üzere tavsiye edilebilir.

Sağlıklı beslenmeye yönelik olarak geliştirilecek eğitim programlarının okul, iş yeri ve hane halkına yönelik olarak geliştirilmesi ve uygulanması tavsiye edilebilir. Çalışanların diyet programlarına katılmalarını teşvik etmek üzere belirlenecek süre kadar ve koşul içerisinde ücretli izin verilebilmesine imkan sağlanabilir.

Sağlıklı beslenme diyet ile ilgili olarak yağ yakımı esaslı medikal vücut tanılama sistemleri ve bölgesel incelme cihazları, yağ oranını ölçebilen saat, cep telefonu, künye, ayakkabılar veya bunları birbirleri ile irtibatlandırabilecek daha komplike sistemler, çocukların veya bireylerin eğitimi için sağlıklı beslenmeyi veya diyet porsiyon büyüklüklerini örneklendirebilen veya gösterebilen oyuncaklar, yazılımlar, ve simülasyonlar ülkelerin sahip oldukları kültür, yöresel gelenek ve görenekleri de dikkate alınarak geliştirilmesi prensibi kabul edilebilir, tavsiye edilebilir veya teşvik edilebilirler.

Üçüncü politika sorunumuz, *belirli eşikler arasındaki düşük SBP'ye bağlı tasarruf eğilimidir.* Çünkü ikinci dereceden denklem içeren model sonuçlarımızda, doğrusal ve karesel terimlerin katsayılarının sıfırdan % 10 veya daha yüksek anlamlılık düzeyinde farklı olduğu ve katsayıların sırasıyla pozitif ve negatif olduğu görülmektedir. İkinci dereceden denklem içeren model için tahmini eşik noktası 137,79 mm Hg'dir. Bu nedenle, ikinci dereceden denklem içeren model tahmin sonuçlarımız, 1980-2009 dönemi için gayri safi yurtiçi tasarruflar ile SKB arasında monotonik olmayan ve ters U-şekilli ilişki olduğunu göstermektedir. Bu ampirik sonuçlara bağlı olarak tespit edilen politik çıkarımlarımız aşağıda sunulmaktadır.

Makro düzeyde, politika çıkarımımız ülke düzeyinde SKB'ye bağlı tasarruf eğilimine yönelik düzenlemeler ve uygulamalardır. Politika amacı, SBP'ye bağlı tasarruf eğilimini arttırmaktır. Politika aracı, ekonomik büyümeyi arttırmak üzere hedeflenen ortalama nüfus SKB seviyesine ulaşmak için halk sağlığı stratejilerini geliştirmektir. İlk politika hedefi, pilot uygulamalarda SKB'ye bağlı tasarruf eğiliminin ilk yıl itibariyle en az yüzde 1 oranında arttırılmasıdır. İkinci amaç, yerel uygulamalarda SBP'ye bağlı tasarruf eğiliminin ikinci yıl itibariyle en az yüzde 1 oranında yükseltilmesidir. Üçüncü hedef ülke düzeyinde uygulamalarda SKB'ye bağlı tasarruf eğiliminin üçüncü yıl itibariyle en az yüzde 1 oranında artmasıdır. Son hedef, ülke düzeyinde uygulamalarda SKB'ye bağlı tasarruf eğiliminin en az hedeflenen yüzde oranında artırılmasıdır.

Mezo düzeyinde politika uygulaması, kurumsal/kuruluşlar düzeyinde SKB'ye bağlı tasarruf eğilimi için strateji uygulama planıdır. Politika amacı, SKB'ye bağlı tasarruf eğilimini yükseltmektir. Politika aracı, ekonomik büyümeyi destekleyici hedeflenen ortalama nüfus SKB seviyesine ulaşmak için halk sağlığı stratejisi uygulama planını belirlemek üzere ekonomiyle, halk sağlığıyla, eğitimle ve diğer ilgili kamu / özel kurum/kuruluşları arasında yuvarlak masa kurulmasıdır. Politika hedefi, SKB'ye bağlı tasarruf eğilimini bir yıllık uygulamalar ile en az yüzde 1 oranında artırmaktır.

Mikro düzeyde politikamız, mikro düzeyde SKB'ye bağlı tasarruf eğilimi için icra kararlarıdır. Politika amacı, SKB'ye bağlı tasarruf eğilimini arttırmaktır. Politika aracı, ekonomik büyümeyi geliştirici halk sağlığı stratejisi uygulama planı ve hane halkının hedeflenen ortalama nüfus SKB seviyesine ulaşması için eylem öğeleri arasında uygun etkileşim yönetimini sağlamaktır. Politika hedefi, SKB'ye bağlı tasarruf eğilimini bir yıllık uygulamalar ile en az yüzde 1 oranında artırmaktır.

Dördüncü politika sorunumuz, *belirli eşikler arasında düşük BKİ ve SKB'ye bağlı tasarruf eğilimidir.* Wang ve Zou'ya (2011) göre, düşük gelirli ülkelerin yeni teknolojileri takip etme seviyelerini korumaları gerekmektedir. Bu ülkelerin vatandaşlarının sağlık durumunu geliştirmeyi tercih etmeleri gerekmektedir. Bu politika önceliklendirme tercihi, yoksulluk tuzağını ortadan kaldırmak için düşük gelirli ülkelere yardımcı olabilir. Bizim yaklaşımımıza göre, düşük gelirli ekonomilerin önünde sadece teknoloji seviyesinin yükseltilmesi veya sağlık seviyesinin ilerletilmesi şeklinde iki seçenek bulunmamaktadır. Bizim bakış açımızdan, inovasyon metodolojisinin desteğiyle oluşturulabilecek ve bu iki seçeneğin de gerçekleşmesine imkan sağlayabilecek üçüncü bir seçenek daha bulunmaktadır.

Bu üçüncü seçenek, herhangi bir ülkenin sağlık düzeyini geliştirici teknolojiler üzerinden halk sağlığı seviyesini ilerletmesi olabilir. Teknoloji ve sağlık seviyeleri arasında bir tercih çatışmasının bulunmasına ihtiyaç bulunmamaktadır. Zira teknoloji iki bileşenin bir sonucu olmaktadır: bilimsel prensip ve kullanım amacı (Agarwal ve Lang, 2005: 3). Bu amaç, halk sağlığını geliştirmek olarak kolayca belirlenebilecektir. Bu gelişme, herhangi bir insan için ortaya çıkan fizyolojik sağlık krizini tedavi etmeye çalışan tıp teknolojilerinden farklı olabilir. Bu halk sağlığı seviyesini ilerletme teknolojileri, yaşamsal sağlık krizi olaylarının büyüklüğünü daha ortaya çıkmadan önce azaltabilecek bir nitelik taşıyabileceklerdir. Ayrıca, bu teknolojiler, medikal teknolojilerin üretilmesi ve yaygınlaşması sürecinden daha uygun maliyetlere sahip olabileceklerdir (Rose v.d., 2008: 130-133 ve 139-140). Yukarıda bahsedilen hususlar dikkate alınarak aşağıdaki politika uygulamaları önerilmektedir.

Makro düzeyde politika çıkarımımız BKİ ve SKB'ye bağlı tasarruf eğilimi için ülke düzeyinde teknoloji inovasyonu ve yayılmasını hedefleyen bir yol haritası oluşturulmasıdır. Politika amacı, BKİ ve SKB'ye bağlı tasarruf eğilimini arttırmaktır. Politika aracı, iktisadi büyümeyi arttırmak üzere hedeflenen ortalama nüfus BKİ ve SKB seviyelerine ulaşmak için uygun vergi teşvikleri / negatif vergi teşvikleri ile teknoloji yeniliğinin ve yayılımı stratejilerinin desteklenmesidir. İlk politika hedefi, pilot uygulamalarda BKİ ve SKB'ye bağlı tasarruf eğiliminin ilk yıl itibariyle en az yüzde 1 oranında artmasıdır. İkinci amaç, yerel uygulamalarda BKİ ve SKB'ye bağlı tasarruf eğiliminin ikinci yıl itibariyle en az yüzde 1 oranında artmasıdır. Üçüncü hedef, ülke düzeyinde uygulamalarda BKİ ve SKB'ye bağlı tasarruf eğiliminin üçüncü yıl itibariyle en az yüzde 1 oranında yükseltilmesidir. Son hedef, ülke düzeyinde uygulamalarda BKİ ve SKB'ye bağlı tasarruf eğiliminin dördüncü yıl itibariyle en az hedeflenen yüzde kadar arttırılmasıdır.

Mezo seviyesinde politika uygulamalarımız, kurum/kuruluşlar düzeyinde teknoloji inovasyonu ve yayılımını hedefleyen BKİ ve SKB'ye bağlı tasarruf eğilimi için strateji uygulama planıdır. Politika amacı, BKİ ve SKB'ye bağlı tasarruf eğilimini yükseltmektir. Politika aracı, iktisadi büyümeyi desteklemek üzere hedeflenen ortalama nüfus BKİ ve SKB seviyelerine ulaşmak için teknoloji yeniliği ve yayılımı stratejisi uygulama planının işletilmesidir. Politika hedefi, BKİ ve SKB'ye bağlı tasarruf eğiliminin bir yıllık uygulamalar ile en az yüzde 1 oranında yükseltilmesidir.

Mikro düzeyde politika çıkarımımız, BKİ ve SBP'ye bağlı tasarruf eğilimini arttırma odaklı teknoloji yeniliği ve yayılımına ilişkin icra kararlarıdır. Politika amacı, BKİ ve SKB'ye bağlı tasarruf eğilimini arttırmaktır. Politika aracı, iktisadi büyümeyi arttırıcı hedeflenen ortalama nüfus BKİ ve SKB seviyelerine ulaşmak için yenilikçi ürünler ve bunların yaygınlaşması ile hanehalkı arasında uygun bir etkileşimin yönetiminin sağlanmasıdır. Anılan yenilikçi ürünlerin BKİ ve SKB dostu “okul”, “iş yerleri” ve “yaşam alanlarını” (Rayner and Lang, 2012: 320-321) desteklemesi gerekmektedir.

Bu yenilikçi ürünler bahse konu BKİ ve SKB dostu ortamları; sağlıklı (Cornwell et al., 2014; Wu et al., 2015), küçük porsiyonlu ve uygun fiyatlı yiyecekler (Rayner and Lang, 2012: 320-321) sağlayarak gerçekleştirebilirler. Ayrıca gürültüyü (Babisch, 2005) azaltabilirler. İlave olarak, hava kirliliği (Pittman, 2013; Chan v.d., 2015; Zhao v.d., 2015) yaratmayabilirler. Dahası fiziksel aktiviteyi (Nicolopoulou-Stamati v.d., 2005) arttırabilirler. Yine, daha yüksek halk sağlığı standartlarını (Rayner and Lang, 2012: 315-321) hayata geçirebilirler.

Bahse konu yetenekleri gerçekleştirme potansiyeline sahip teknolojiler: Sağlıklı beslenmeye yönelik gıda ürünleri, şehirler için gürültü engelleyici bariyerler, ekolojik olarak güvenli otomobiller, kimyasal ve gaz atıklar için filtreler, tüm yaş grupları için güvenli kaldırımlar ve bisiklet yolları (Rayner and Lang, 2012: 320-321) olarak örneklendirilebilirler. Politika hedefi, BKİ ve SKB'ye bağlı tasarruf eğiliminin bir yıllık uygulamalar ile en az yüzde 1 oranında arttırılmasıdır.

Genel olarak, bahse konu *belirli eşikler arasında yaşa bağlı düşük tasarruf eğilimi* ve *belirli eşikler arasında düşük BKİ ve SKB'ye bağlı tasarruf eğilimi* politika sorunsallarına yönelik olarak geliştirmiş olduğumuz makro, mezo ve mikro düzey politika çıkarımlarımızla ilgili daha alt seviyelerde ve mikro veri setleri kullanılarak araştırma çalışmalarının başlatılmasına ihtiyaç bulunduğu ve bu şekilde anılan uygulamalardan daha verimli ve faydalı sonuçlar elde edilebileceği değerlendirilmektedir.

Politika çıkarımlarımızda doğrudan bilim ve teknoloji politikası (BTP) ve uygulamaları ile ilgili üç konu yer almaktadır. İlk olarak, politika tavsiyemiz beşeri sermaye ve eğitim koşullarına dikkat çekmektedir. Riskli sağlık durumlarının sınırlarını belirleyen belirli eşik değerleri tespit edilmiştir. Bu sınırların beşeri sermaye ve eğitim süresi üzerinde bir etkiye sahip olduğu görülmektedir. Politika önerilerimiz, insan sermayesi ve eğitimin bulunduğu seviyeyi olumlu yönde ileri taşıyacak olan sağlık durumunu geliştirici teşvikler ileri sürmektedir. Zira beşeri sermaye ve eğitim BTP içeriğinde yer almaktadır. Çünkü Ruttan'a (2001) göre, ABD'de olduğu gibi görev odaklı olunması ya da Almanya'da olduğu gibi yayılma odaklı olunması olsun, herhangi bir ulusun BTP'si yaygın olarak araştırma kaynaklarının dağıtım methodolojisi olarak ortaya çıkmaktadır. Bu yaklaşım, finanse edilen teknolojiler için araştırma faaliyetlerinin içeriğinde yer alan beşeri sermaye, öğretim ve eğitimi içermektedir.

İkincisi, politika çıkarımlarımız sağlık odaklı BTP faaliyetleri için güçlü bir motivasyon sağlamaktadır. Ampirik bulgularımız, iktisadi büyümeyi arttırmak için sağlık durumu ve tasarruf arasındaki bağlantıyı göstermektedir. Bireylerin iyi bir sağlık durumu ve yeterli tasarrufları olur ise, iktisadi büyüme olumlu yönde bir artış göstermektedir. Aynı zamanda, insan sağlığı odaklı BTP faaliyetleri, BTP ve iktisadi faaliyetlerde sürdürülebilirlik yönünden inceleme yapılabilmesi için makul cevaplara da ev sahipliği yapmaktadır. Daha açık belirtmek gerekir ise, sermaye ile karşılaştırıldığında emek maliyetindeki artış veya azalma, uzun vadede BTP ve iktisadi faaliyetlere yön verecek önemli bir mekanizmaya işaret etmektedir. Bu açıdan bakıldığında, BTP'nin ve iktisadi faaliyetlerin sürdürülebilirliğe geçişinin, işgücü maliyeti üzerinde azalma etkisi sağlayan yaklaşımlarla olacağı kabul edilebilecektir. Emek maliyeti öncelikle işgücü verimliliğinden etkilenmektedir. BTP ve iktisadi faaliyetlerdeki emek verimliliği de doğrudan bireylerin sağlık durumundan etkilenmektedir (Ruttan, 2001; Acemoglu and Johnson, 2007: 975-976).

Üçüncü olarak, politika çıkarımımızda; sağlık (BKİ ve SKB) odaklı teknoloji yeniliği ve yaygınlaştırma politikasına ilişkin yol haritasına, strateji uygulamalarına ve yönetici kararlarına yer verilmektedir. Bu politika öğeleri, insan sağlığı odaklı BTP faaliyetlerine başlangıç olarak geçiş için temel bir çerçeve sağlamaktadır. Bu başlatıcı öğeler, hastalara uygulanan tıbbi tedavi teknolojilerine kıyasla nispeten daha ucuz olan önleyici sağlık stratejisi yaklaşımlarını da içermektedir (Rose v.d., 2008:

130-133 and 139-140). Zira Ruttan'a (2001: 614-615) göre, bilimsel sağlık araştırmalarında tahsis edilen kaynak büyüklüğü uygulamalarda başarılı sonuçları garanti etmemektedir. Bazen, daha düşük kaynak ayrılan sağlık araştırmalarında başarılı sonuçlar alındığı görülmektedir. Bu nedenle, BTP ve ekonomik faaliyetlerde sürdürülebilirliğin sağlanması için, bireylerin iyi sağlık ihtiyacını karşılayan, ekonomik büyüme için de bireylerde yeterli birikimin oluşmasına imkan verebilen, aynı zamanda işgücü maliyetlerini de azaltabilen seçeneklere ihtiyaç duyulmaktadır. Politika çıkarımımızda yer alan, BTP faaliyetlerine ilişkin temel başlatıcı çerçeve öneriler bahse konu ihtiyaç ve gereksinimleri karşılayacak bir içerik sunmaktadır.

Farklı temsili değişkenleri kullanarak sağlığın iktisadi kalkınma üzerindeki etkilerini incelemek için birçok çalışma yapılmıştır. Bu ilişkinin karmaşıklığı şu ana kadar gerçekleştirilen birçok çalışmanın başlatılma nedeni olabilir. Bizim açımızdan, Azomahou v.d. (2009) bu konuya ampirik ve teorik yönden önemli ölçüde katkıda bulunmuştur.

Azomahou v.d. (2009) onsekiz ülke ve 1820'den 2005 (dahil) yılına kadarlık bir dönemde tarihsel veriler kullanılarak kişi başına GSYH büyüme oranı ile BYS arasındaki doğrusal olmayan ilişkinin ampirik ve teorik sonuçlarını ortaya koymaktadır. 1820-2005 dönemi, farklı süreler için, liberal, Keynesyen ve Neo-liberal ekonomi politika yaklaşımlarını içermektedir. Azomahou v.d. (2009) dayandığı varsayıma göre farklı yaştaki bireyler farklı tasarruf planları yapmakta ve tasarruf kararları almaktadırlar. Genç bireyler, kararlarında düşük zaman tercih oranı (sabırsızlık oranı) nedeniyle nispeten daha yaşlı insanlardan daha fazla tasarruf etme eğilimindedirler. Bu tasarruf eğilimleri kişi başına düşen GSYİH büyüme oranı ile BYS arasındaki ilişkinin şeklini yönlendirmektedir.

Azomahou v.d. (2009) ekonomik büyüme ve sağlık arasında buldukları doğrusal ve monotonik olmayan bu ilişkinin sonuçlarını kuramsal modellerinde de açıklığa kavuşturmuşlardır. Kişi başına GSYİH büyüme oranının BYS ile birlikte arttığını açıklamışlardır. Bununla birlikte, kişi başına GSYİH büyüme oranı ve BYS arasındaki bağlantının, BYS düzeyine bağlı olarak değişmekte olduğunu da ortaya koymuşlardır. Bu ilişkinin, düşük BYS seviyeleri için dışbükey, yüksek BYS seviyeleri için de içbükey şekle sahip olduğunu göstermişlerdir.

Bu konudaki katkılarımız Azomahou v.d. (2009: 243) modelindeki üçüncü dereceden denklemler içeren indirgenmiş formun, literatürde de yeni olmak üzere, türetilmesiyle başlamıştır. Üçüncü dereceden denklemler içeren bu indirgenmiş form, ekonomik büyümenin işaretini belirlemekle sınırlı olmak üzere zaman tercih oranı ile elde edilmiştir. Uygun bir vekil değişkenin zaman tercih oranını temsil edebileceği varsayılmıştır. Azomahou v.d.'ne (2009: 225) göre BYS yükseldikçe zaman tercih oranı da artmaktadır. BYS'nin bu nedenle zaman tercih oranını vekil değişken olarak temsil edebileceği kabul edilmektedir.

Daha sonra, araç değişken hesaplamalarımızda yer alan zayıf araç değişken tanımlama testindeki bulgularımıza da dayanarak BKİ ve SKB'nin BYS'ye gömülü olduğu varsayımı kabul edilmiştir. Bu nedenle, BKİ ve SKB, bu üçüncü dereceden denklemler içeren model tahminimiz için BYS'nin ikamesi olarak kullanılabilmiştir. Bunu takiben, literatürde açıklanan ekonomik büyüme ile güçlü ilişkiye sahip olan büyüme göstergeleri ile bu ilişki büyüme göstergeleri boyutunda da genişletilmiştir. Bu büyüme göstergeleri kişi başına GSYİH, beşeri sermaye, katılan kişi başına GSYİH, verimlilik ve gayri safi yurtiçi tasarruflardan oluşmaktadır. Bu nedenle, bu büyüme göstergeleri, Azomahou v.d. (2009) kullanılan kişi başına düşen GSYH büyüme oranının vekil değişkeni olarak kullanabilmiştir. Böylece, ekonomik büyüme ve sağlık arasındaki ilişkinin kararlılığını test etmek için farklı büyüme göstergeleriyle inceleme fırsatına sahip olunmuştur.

Ayrıca Cervellati ve Sunde (2009), Desbordes (2011) ve Hansen'in (2012) bulguları, onların çalışmalarında kullandıkları veri yapısı, ülkeleri ve zaman periyodu, model özellikleri, hesaplama metodolojileri ve değişkenleri kullanılarak teyit edilmiştir. Bu nedenle, üçüncü dereceden denklem içeren bahse konu indirgenmiş formun, çalışmamızda bu teyit edilmiş sonuçların metodolojisinden yararlanarak hesaplanması tercih edilmiştir. Acemoğlu ve Johnson'nın (2007: 939, 979-980) çalışmalarnda, 47 ülke için kullandıkları tarihi güvenilir bir veri seti bulunması nedeniyle, bu veri seti 1940-1980 döneminin başından itibaren temel örneklem veri yapısı olarak kabul edilmiştir.

Dolayısıyla, ekonomik veriler ve sağlık arasındaki ilişkiyi araştırmak için panel verilerimizde 1940-1980, 1980-2009 ve 1940-2009 dönemlerini içermek üzere toplam 47 ülkeye yer verilebilmiştir. 1940-2009 dönemini literatürde yeni olarak kullanılmaktadır. Bu dönem, Keynesyen ve Neo-liberal iktisat politikalarının uygulama sonuçlarını içermektedir. Bulgularımızın kararlılığının sınanabilmesi için farklı ve her iki iktisadi politika yaklaşımını da içeren bahse konu üç dönemden de yararlanılmıştır. Bu kapsamda literatürde yer alan çalışmaların teyit edilmiş sonuçları Tablo 7.2'de sunulmaktadır. Ayrıca, Azomahou v.d. (2009) ampirik sonucuna da bu tabloda yer verilerek bu tezin sonuçları ile anılan çalışmanın sonuçları arasındaki tutarlılığın ortaya konulması hedeflenmiştir.

Üçüncü dereceden denklem içeren indirgenmiş formun elde edilmesiyle ve anılan tüm değişkenlerin bu formun hesaplanmasında kullanılmasıyla, tüm dönemler için ekonomik büyüme ve sağlık arasında güçlü doğrusal ve monotonik olmayan bir ilişki bulunmuştur. Ayrıca, değişkenlere ilişkin verinin bulunabilirliğine bağlı olarak 1980-2009 dönemi için ekonomik büyümeye ilişkin sağlık durumu (BKİ ve SKB) eşikleri tahmin edilmiştir. Araştırmamıza göre, makro seviyede ekonomik büyüme göstergeleri kullanılarak ve açıklayıcı değişken olarak da BKİ ve SKB'ye yer verilerek yapılmış ve bu eşikleri gösteren bir çalışmaya rast gelinmemiştir.

Bu önemli sonuçların arkasındaki nedenleri irdeleyerek ve anlayarak, kötü sağlık durumunun ekonomik büyüme üzerindeki olumsuz etkilerini ele alma şansı yaratılabileceği değerlendirilmektedir. Bizim yaklaşımımıza göre, belirli eşikler arasında nötr sağlık müdahalesi yaklaşımı kullanarak bireylerin kötü sağlık durumunun olumsuz etkilerininin bir çözüme kavuşturulabileceği düşünülmektedir. Bu eşikler, BKİ için 24.39-26.16 kg/m2 ve SKB için 137.79 mm Hg aralığını takip etmektedir. Bahse konu eşikler gayri safi yurtiçi tasarruflar ile ayrı ayrı BKİ ve SKB arasındaki bağlantının ikinci dereceden denklem içeren model sonuçlarına dayanmaktadır. Bu nötr sağlık müdahalesi yaklaşımı, politika yapıcılar tarafından hayata geçirilebilecek makul ve kolay nitelikte uygulama araçlarını içermektedir.

Bu üçüncü dereceden denklem içeren model hesaplamalarının, kötü ya da iyi sağlık durumunun değişen etkileri üzerinden, bilim ve teknolojideki farklı disiplinler arasında karşılıklı olarak bilgi paylaşımı için bize yeni bir bakış açısı sağlayabileceği değerlendirilmektedir. Bu bakış açısıyla, sağlık odaklı yenilikler yapabilmek için çok disiplinli ve disiplinlerarası yeni yaklaşımlar geliştirebileceği düşünülmektedir. Ayrıca bu anlayışla, sürdürülebilir ekonomik büyümeyi güvence altına almak üzere bireylere (çalışma hayatına en erken başlama yaşı olan 15 yaşından itibaren 65 yaş üstüne kadar) yeterli tasarruf yapabilme imkanı sağlanabileceği düşünülmektedir.

Sonuç olarak bahse konu tutarlı bulguların dikkate alınmasıyla sürdürülebilir ekonomik kalkınmanın gerçekleştirilmesine ilişkin genel bir sonuca varılmıştır. Genç ve yeterince yaşlı nesillerin tasarruf imkanlarının arttırılması, sağlık riski altındaki bireyler ile yaşlılara ilişkin sağlık politikalarının geliştirilmesi ve genel anlamda bireylerin zaman tercih oranlarının düşürülmesi (sağlık durumlarının iyileştirilmesi) için mevcut ekonomik politika uygulamalarında uygun ve makul iyileştirmeler yapılmasının sürdürülebilir ekonomik kalkınmanın gerçekleştirilmesinde ülkeler için büyük bir katkı sağlayacağı değerlendirilmektedir.

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