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DEMOGRAPHIC-RELATED HEALTH DYNAMICS SHAPING ECONOMIC GROWTH IN MINT COUNTRIES

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Abstract

Health, defined as a state of well-being, is a fundamental component of human capital and plays a crucial role in economic growth. Therefore, it is important to determine its impact on economic growth. In this regard, this study investigates the effect of health, with a specific focus on demographic-related dynamics, on economic growth within the MINT countries (Mexico, Indonesia, Nigeria, and Türkiye). The analysis covers the period 2000 to 2023 and employs a panel cointegration approach. Then, the long-run relationship between the variables is examined using the Augmented Mean Group (AMG) and the Common Correlated Effects Mean Group (CCE-MG) estimators. In the analysis, health is represented by life expectancy, the ratio of the population aged 65 and above (elderly population), and the dependency ratio, while economic growth is proxied by Gross Domestic Product (GDP) per capita. The study concludes that life expectancy, the share of the elderly population, and the dependency ratio exert statistically significant and positive effects on economic growth in the long-run. These findings suggest that policies aimed at improving population health, extending life expectancy, and addressing demographic transitions may contribute to sustainable economic growth. In this context, strengthening health systems and developing policies that support both young and aging populations can play a key role in enhancing long-run economic performance in MINT countries.

Keywords: Health, Economic growth, MINT Countries, Panel cointegration.

JEL Classification: I150, O110, O49

MINT ÜLKELERİNDE SAĞLIKLA İLGİLİ DEMOGRAFİK DİNAMİKLERİN EKONOMİK BÜYÜMEYİ ŞEKİLLENDİRMESİ

Özet

İyi olma hali olarak tanımlanan sağlık, beşeri sermayenin temel unsurlarından biridir ve ekonomik büyümede önemli bir rol oynar. Bu nedenle sağlığın ekonomik büyüme üzerindeki etkisini belirlemek kritik önem taşımaktadır. Çalışmada, bu bağlamda, MINT (Meksika, Hindistan, Nijerya ve Türkiye) ülkelerinde sağlığın (özellikle demografik unsurlar dikkate alınarak) ekonomik büyüme üzerindeki etkisinin belirlenmesi amaçlanmış ve 2000-2023 dönemi panel eşbütünleşme kullanarak analiz edilmiştir. Ardından değişkenler arasındaki uzun dönem ilişkisi, Augmented Mean Group (AMG) ve Common Correlated Effects Mean Group (CCE-MG) tahmincileriyle yorumlanmıştır. Analizde, yaşam beklentisi, 65 yaş ve üstü nüfus oranı (yaşlı nüfus oranı) ve bağımlılık oranı sağlığı temsil ederken, kişi başına GSYH ekonomik büyümeyi temsil etmek için kullanılmıştır. Çalışmada, yaşam beklentisi, yaşlı nüfus oranı ve bağımlılık oranının uzun vadede ekonomik büyüme üzerinde istatistiksel olarak anlamlı ve olumlu etkiler yarattığı sonucuna ulaşılmıştır. Sonuçlar; toplum sağlığını iyileştirmeyi, yaşam süresini uzatmayı ve demografik dönüşümleri ele almayı amaçlayan politikaların sürdürülebilir ekonomik büyümeye katkı sağlayabileceğini göstermektedir. Bu bağlamda, sağlık sistemlerinin güçlendirilmesi ile hem genç hem de yaşlanan nüfusu destekleyen politikaların geliştirilmesi, MINT ülkelerinde uzun vadeli ekonomik performansın artırılmasında kilit bir rol oynayabilir.

Anahtar Kelimeler: Sağlık, Ekonomik büyüme, MINT Ülkeleri, Panel eşbütünleşme.

JEL Sınıflandırması: I150, O110, O49

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1. Introduction

After the Second World War, the concept of human capital gained a central role in economic growth. Human capital refers to the knowledge, health status, and experience individuals possess. Health, as one of its main components, is closely linked to labor productivity and economic performance. Within this framework, health is increasingly recognized as a key component of human capital because it directly affects individuals' ability to work, accumulate skills, and participate productively in the economy.

One of the fundamental papers in this field is Samuel H. Preston's 1975 study, "The Changing Relation Between Mortality and Level of Economic Development." Using life expectancy and income variables, Preston identified a positive relationship between health and economic growth. This relationship was illustrated by what is now known as the Preston Curve (see Appendix 1). Later, different health indicators were included in growth models. Health began to be treated as a production factor in both neoclassical and endogenous growth theories. Consequently, health indicators such as life expectancy, mortality rates, and demographic structures have increasingly been incorporated into empirical growth analyses.

The health-led growth hypothesis has gained attention over time. Based on Selma Mushkin's "Health as an Investment" (1962), this approach emphasizes the role of health expenditures in promoting growth. Empirical studies support this idea, showing that health spending has a positive effect on economic performance (Atilgan et al., 2017; Wu et al., 2021; Boyacıoğlu & Terzioğlu, 2022). Over the years, indicators such as dependency ratios, morbidity and mortality rates, maternal and child health measures, and alcohol or tobacco use have been widely used in this context (Shi, 1993; Ehrlich & Kim, 2005; Osang & Sarkar, 2008; Roe & Smith, 2008; Augier & Yaly, 2013; Erdoğan et al., 2013; Goenka et al., 2014; Cole, 2019; Bischi et al., 2022; Kammerland & Schulze, 2023). Among these indicators, demographic-based health variables such as life expectancy, the elderly population ratio, and the dependency ratio provide important insights into how population structure and health conditions jointly shape economic outcomes.

Research in this field highlights the importance of health for achieving economic growth, and development. This link is especially critical for developing economies, where improvements in health condition can significantly enhance labor productivity and welfare levels. MINT countries (Mexico, Indonesia, Nigeria, and Türkiye) represent a group of emerging economies with considerable demographic and economic potentials. These countries have relatively large and dynamic populations, expanding labor markets, and increasing integration into the global economy, all of which make them important candidates for sustained long-run growth. At the same time, demographic changes such as rising life expectancy and shifts in dependency structures are expected to play a significant role in shaping their future economic trends. For this reason, this study focuses on the impact of health on economic growth in MINT countries.

Panel cointegration analysis was preferred as the method. The long-run coefficients between the variables were interpreted using the Augmented Mean Group (AMG) and Common Correlated Effects Mean Group (CCE-MG). These estimators were preferred to provide robust and consistent results by taking into account cross-sectional dependence and heterogeneity among the variables. The analysis covers the period 2000-2023 due to data accessibility. Life expectancy, ratio of population ages 65 and above (elderly population), and total dependency ratio for representing health indicators and, GDP per capita variables for representing economic growth are used in the analysis.

The study also aims to fill specific gaps in the literature. Although a large body of research has examined the relationship between health and economic growth, relatively few studies focus on demographic-based health indicators such as the elderly population ratio and dependency ratio in explaining growth dynamics. Moreover, empirical evidence focusing specifically on MINT countries remains limited. To our knowledge, no previous research has analyzed this relationship in this country group using panel cointegration together with the AMG and CCE-MG estimators. Therefore, this study contributes to the literature by providing new empirical evidence on how demographic health dynamics influence economic growth in MINT economies.

Following this introduction, the document proceeds in five main sections. The literature is surveyed in Section 2. Section 3 establishes the theoretical background. The data set and research methods are detailed in Section 4. Section 5 then presents the empirical results. The paper is completed in Section 6, which summarizes the main conclusions and their practical implications.

2. Theoretical Background

Health is often conceptualized as a complex state of well-being with various aspects such as physical, mental, and social. One of the fundamental human rights is to achieve the highest possible standard of health without discrimination (WHO, 1948). Being healthy, which is among the fundamental human rights is not only important for individuals to survive their lives, but also economically considerable in terms of workforce.

As mentioned before, health has an important role in economic growth as it is one of the human capital components of the production function. To be more specific, health has shown its impact on economic growth through labor productivity, labor supply, education, investment, and savings. The labor productivity effect/channel expresses the increase in the amount of production per labor hour that occurs with the increase in the health level. This is expected to occur due to the increased physical and mental activity of the labor force that has attained a higher level of health. In terms of labor supply, the effect of the increase in the health level emerges in two different ways. If the productivity-based wages are valid, the more productive labor force might prefer to work less depending on its increased income. This has an impact on the labor supply negatively. On the other side, the decrease in the number of sick days in the workforce with an increased health level will also have a positive effect on the labor supply. Accordingly, the net effect on labor supply will also vary. Education, another channel of influence on health has a net positive effect. Considering this positive effect on labor productivity, it is expected that the probability of healthy individuals being absent from education and dropping out of school will decrease. In addition, if health is associated with life expectancy, it is thought that investment in the education of an individual will be directly proportional to life expectancy. The probable positive impact of health on income, depending on life expectancy and productivity, will have an impact on the savings and investment decisions of individuals positively (Suhrcke et al., 2005).

The influences mentioned above have progressively integrated health into economic growth theories. Consequently, health has been incorporated into both neoclassical and endogenous growth models. For instance, Mankiw, Romer, and Weil expanded the Solow Model that is a prominent neoclassical growth theory by introducing the human capital factor. In their model, human capital encompasses both educational capital and health capital (Mankiw et al., 1992). Knowles and Owen (1995) further applied this model, utilizing the schooling rate as a proxy for educational capital and life expectancy as a proxy for health capital. Their study concluded that there is a significant and robust relationship between per capita income and life expectancy (Knowles & Owen, 1995).

In the Infinite Horizon Model, another neoclassical growth model developed by Ramsey (1928), Cass (1965), and Koopmans (1963), health is integrated into the production function as both an endogenous and an exogenous factor and has been evaluated in various ways. Health is considered an exogenous factor in terms of the health status of the workforce, while health expenditures are treated as an endogenous factor. It has been established that the health status of the workforce positively affects growth. Conversely, health expenditures are evaluated as a factor that enhances the health of the workforce and ensures the maintenance of health status.

The role of health in endogenous growth models can be examined through R&D and Human Capital Models. In the R&D Model, health is incorporated into Schumpeter's creative destruction process and features in the growth model. According to the model, the long-run impact of health on growth manifests through factors such as life expectancy, productive efficiency, creativity, learning capacity, coping skills, and income inequality. Findings suggest that all factors except income inequality demonstrate a positive linkage with health and economic growth, while income inequality is negatively related (Howitt, 2005).

In the context of Human Capital Models, the endogenous growth model developed by Lucas (1988), which includes health, serves as an example. In this model, health services are integrated as a crucial component of human capital. It is emphasized that health services have a direct impact on the workforce since labor supply depends on the average health level of the workforce. Additionally, it is indicated that good health has a direct effect on benefits (Van Zon & Muysken, 2001). Grossman's (1972) assertion that good health positively contributes to the economy further supports the Lucas model.

3. Literature Review

The summary of the literature prepared by taking into account the analysis methods and samples selected that are examining the health-economic growth relation is given in Table 1.

Table 1: Summary of Literature Review

Autor(s)	Sample	Period	Methodology	Result
Rivera and Currias (1999)	24 OECD counties	1960-1990	Regression	Health exerts a positive impact on EG.
Mayer (2001)	18 Latin American counties	1950-1990	Regression	AH and OAH has a permanent increment on income.
Bloom et al. (2004)	104 countries	1960-1990	Panel Regression	Health has a positive effect on EG.
Erdoğan and Bozkurt (2008)	Türkiye	1980-2005	ARDL	There is a positive relation between LE and EG.
Li and Huang (2009)	China	1978-2005	Panel OLS	Both health and education have positive effect on EG.
Bloom et al. (2010)	China and India	1960-2000	OLS, 2SLS	Health has a positive effect on EG.
Çetin and Ecevit (2010)	15 OECD countries	1990-2006	Panel OLS	There is a significant relation between HE and EG.
Hartwig (2010)	OECD countries	1970-2005	Panel Granger Causality	HC does not urge economic growth in long-run.

Table 1: Summary of Literature Review (Continue)

Autor(s)	Sample	Period	Methodology	Result
Peykarjou et al. (2011)	OIC	2001-2009	Panel Regression	LE has a positive and FR has a negative effect on EG.
Wang (2011)	31 countries	1986-2007	Panel-Quantile Regression	HE has an impact on EG in countries having medium and high growth rate positively.
Gong et al. (2012)	28 Chinese provinces	1979-2003	Panel Regression	HC and HL have significant effect on EG.
Akıncı and Tuncer (2016)	Türkiye	2006:1-2016:2	Johansen Cointegration, Granger Causality	There is both cointegration relation and bidirectional causality between EG and health.
Chaabouni et al. (2016)	51 countries	1995-2013	GMM	HE and EG exhibit bidirectional causality.
Tıraş and Ağır (2018)	36 OECD countries	1995-2014	Panel Causality	Causal relationship between income and one kind of HE exists in general.
Zaidi and Saidi (2018)	Sub-Saharan countries	1990-2015	ARDL	Positive relationship between HE and EG exists.
Altunöz (2020)	15 OECD countries	2000-2016	Panel OLS	Significant relationship between HE and EG is exist.
Erdoğan et al. (2019)	36 OECD countries	2000-2017	Panel Cointegration	HE is not among the determinants of EG in long-run.
Kırılmaz et al. (2019)	6 Turkic Republics	1995-2014	Panel OLS	There is no significant effect of health variables on EG.
Yar et al. (2019)	Turkey	1966-2016	Johansen Cointegration, Granger Causality	Increase in the number of HP and HB effect on economic growth negatively and positively, respectively.
Bayraktutan and Alancıoğlu (2020)	17 OECD countries	2000-2017	Konya Causality	Bidirectional causality was determined between HE and EG.
Binay (2020)	23 OECD countries	1975-2012	Panel Cointegration	HE has a positive effect on EG.
Çelik (2020)	G20 countries	2000-2016	Panel Cointegration, Panel Causality	HE has a positive effect on EG. Causality runs from EG to HE.
Çeştepe et al. (2020)	81 Turkish cities	2007-2017	GMM	The positive changes in health variables make a positive contribution to the output.

Table 1: Summary of Literature Review (Continue)

Autor(s)	Sample	Period	Methodology	Result
Keyifli and Re-cepoğlu (2020)	E7 count-ries	2000-2016	Bootstrap Pa-nel Causality	A causal relationship was de-termined between HE and re-newable energy and EG.
Lopreite and Zhu (2020)	China	1978-2016	Bayesian-VAR	HE and LE have positive, aging has negative effect on EG.
Şahin and Yalçın-kaya (2020)	MINT co-untires	2000-2016	Static Panel	GDP growth leads to a dec-line in young and old depen-dency ratios.
Albayrak and Öz-türk (2021)	Türkiye	1988-2017	ARDL	Real HE has positive effect on EG.
Canbay and Kırca (2021)	BRICS+T	2000-2018	Konya Panel Causality	The causality was determined between public and total HE and income.
Cylus and Tayara (2021)	180 count-ries	1990-2017	Panel (Fixed Effect Model)	The decline in EG that occur-red an increasing in the he-althy 55–69-year-old popula-tion is moderated well.
Eryer and Konuk (2021)	E7 count-ries	2005-2018	Panel Regres-sion	Health-related variables exert a positive and significant inf-luence on EG.
Kızılkaya (2021)	21 OECD countries	1975-2019	Panel Fourier Causality	Unidirectional causality runs from EG to HE.
Köse et al. (2021)	G20 count-ries	2000-2017	Panel ARDL	The increase in public HE is positive effect on EG and the opposite is for private HE.
Sağdıç and Yıldız (2021)	81 Turkish cities	2004-2019	Panel, Panel Causality	Public HE positively affects EG; causality runs from HE to growth.
Tunalı Sarı et al. (2021)	16 Euro-zone co-untries	2000-2018	Panel, Panel Causality	A bidirectional causality between HE and EG exists.
Alwago (2022)	Kenya	2000-2020	ARDL, Granger Cau-sality	Health expenditure and longe-vity significantly drive GDP growth in Kenya.
Lai and Yip (2022)	74 develo-ping count-ries	1990-2019	Panel Regression	Aging adversely affects growth; however, labor force participation of the elderly mitigates this effect.

Table 1: Summary of Literature Review (Continue)

Autor(s)	Sample	Period	Methodology	Result
Skirbekk et al. (2022)	188 countries	2017 and 2019	Cross-Sectional, Bivariate Regression	Standard age metrics exaggerate the aging burden in developed nations while overlooking the higher disease impact in younger populations.
Turan (2022)	13 Middle and East European countries	1995-2017	Panel Cointegration, Panel Causality	The increase income leads to a decrease in IMR. A unidirectional causality was determined from income to IMR.
Ibukun and Omisore (2022)	MINT countries	1995-2018	Bound Test, Causality	A bidirectional causality relationship between HE and EG is valid.
Kotschy and Bloom (2023)	145 countries	1950-2015 2020-2050	OLS, Projection	Aging slows growth, yet increased labor supply among the elderly significantly cushions this demographic drag.
Vyas et al. (2023)	India	1975-2018	ARDL	There is a significant relationship between HE and EG.
Trong et al. (2024)	ASEAN Countries	2001-2021	Panel Regression	Old-age dependency hinders growth, while productive young labor remains a key driver of GDP.
Lee and Song (2025)	China, India, Indonesia, Japan, S. Korea, USA	1980-2019 2023-2071	Pooled OLS, Projection	The demographic drag from aging is cushioned by improvements in technology and physical capital investment
Mansouri et al. (2025)	Morocco	1990-2023	ARDL	Aging-induced fiscal risks can be offset by efficient health spending and macroeconomic stability.
Tangpatthamachart and Amornkitvikai (2025)	123 countries	1960-2020	2SLS	Longevity promotes growth in aging nations through innovation, while increasing dependency hinders non-aging economies

Abbreviations: 2SLS; two stage least squares regression, AH; adult health, ARDL; autoregressive distributed lag model, ASR; adult survival rates, EG; economic growth, FE; fertility rate, HB; hospital bed, HC; health capital, HE; health expenditures, HL; health level, HP; health personnel, LE; life expectancy, IMR; infant mortality rate, OAH; old-age health, OLS; ordinary least squares regression.

Table 1 illustrates that the majority of studies report a statistically significant positive association between health and economic growth. (Li & Huang, 2009; Bloom et al., 2010; Çetin & Ecevit, 2010; Wang, 2011; Chaabouni et al., 2016; Altunöz, 2019; Binay, 2020; Çeştepe et al., 2020; Albayrak and Öztürk, 2021; etc.), although there have been studies (Hartwig, 2010; Erdoğan et al., 2019; Kırılmaz et al., 2019) that they cannot reach a significant result in the literature.

Studies in the table on aging and dependency generally show that the effects of demographic change on economic growth are multidimensional. These studies indicate that population aging may slow economic growth, however increased labor force participation among the elderly can mitigate this negative effect. In addition, a young and productive labor force remains a key driver of growth, while technology, capital investment, and effective health policies can help offset the economic pressures created by demographic change (Lai and Yip, 2022; Skirbekk et al., 2022; Kotschy and Bloom, 2023; Trong et al., 2024; Lee and Song, 2025; Mansouri et al., 2025; Tangpatthamachart and Amornkitvikai, 2025).

When the studies are examined with regard to method, it is seen that panel data and causality analyze are frequently used. As a method, it was preferred panel cointegration analyses by Çelik (2020), Çeştepe et al. (2020), Tunalı Sarı et al. (2021), Turan (2022); panel OLS by ; Çetin & Ecevit (2010), Gong et al. (2012) and Kırılmaz (2019); GMM by Chaabouni et al. (2016), Çeştepe et al., (2020) and Panel ARDL by Köse (2021), Zaidi &Saidi (2018) and Vyas et al. (2023). It is also seen that there are studies in which different causality analyses (Granger causality, panel causality, Konya panel causality, and panel Fourier causality) are applied. The papers that belong to Hartwig (2010), Tıraş & Ağır (2018), Bayraktutan & Alancıoğlu (2020), Keyifli & Recepoğlu (2020), Kızılkaya (2021), etc. can be given as an example. These analysis results differed in terms of the direction of causality. For instance; Akıncı & Tuncer (2016), Chaabouni et al. (2016), Bayraktutan & Alancıoğlu (2020), Tunalı Sarı et al. (2021), and Ibukun and Omisori (2022) identified a bidirectional causal relationship between the two variables, whereas Kızılkaya (2021) reported a unidirectional causality running from economic growth to health expenditures, and Sağdıç & Yıldız (2021) observed causality in the reverse direction.

A review of the relevant literature reveals that studies investigating the impact of health on economic growth specifically within the MINT countries are scarce.

4. Data - Methodology

4.1. Data and Sources

In the study, the relationship between health and economic growth for MINT (Indonesia, Mexico, Nigeria, and Türkiye) was analyzed by applying the panel cointegration method. It was used data from 2000 to 2023 annually for the sample. In the analysis are used life expectancy at birth, population ages 65 and above and total dependency ratio for representing health indicators, and GDP variable for representing economic growth. Table 2 consists of the details about these variables.

Table 2: Variables Details

Variables	Abr.	Source
Age dependency ratio (% of working-age population)	ADR	World Bank
Life expectancy at birth, total (years)	LE	
Population ages 65 and above (% of total population)	PA65	
GDP per capita, PPP (constant 2021 international \$)	GDP	

The model to be estimated using the logarithmic values of the variables were generated as follows. And descriptive statistics are represented in Table 3.

$$LGDP_{it} = \alpha_0 + \alpha_1 LLE_{it} + \alpha_2 LPA65_{it} + \alpha_3 LADR_{it} + u_{it} \quad (1)$$

Table 3: Descriptive Statistics

	Variables			
	LGDP	**LLE**	**LPA65**	**LADR**
Obs.	96	96	96	96
Mean	4.020	1.819	0.717	1.781
Median	4.052	1.852	0.763	1.745
Max.	4.535	1.890	1.000	1.956
Min.	3.491	1.673	0.471	1.657
Std. Dev.	0.326	0.068	0.158	0.102
Skewness	-0.088	-0.927	-0.437	0.690
Kurtosis	1.384	2.254	1.954	1.991

According to Table 3, the logarithm of GDP per capita (LGDP) has the highest values in terms of mean (4.020), median (4.052), minimum (3.491), and maximum (4.535), indicating that it is consistently greater than the other variables in the dataset. Notably, the mean value of LGDP is more than twice that of LPA65 (0.717) and significantly higher than LLE (1.819) and LADR (1.781). Regarding dispersion, LGDP also exhibits the highest standard deviation

(0.326), suggesting a relatively wide variation across observations. Skewness and kurtosis values indicate that while LGDP is approximately symmetrically distributed, LLE and LPA65 are negatively skewed, and LADR is positively skewed.

4.2. Method

Unit root tests are the first steps of analysis. The choice of which unit root tests to use for testing the stationarity of the series is determined by the presence of cross-sectional dependence (CD). CD represents the correlation between sections. In this regard, if there is no CD, first-generation unit root tests (Hadri, 2000; Levin, Lin, and Chu, 2002; Im, Pesaran, and Shin, 2003; Breitung &Das, 2005; etc.) are used. However, if there is CD, second-generation unit root tests (Bai & Ng, 2004; Pesaran, 2007; Hadri & Kurozumi, 2012; etc.) are applied. The unit root tests to be used are determined by considering cross-sectional dependency. Therefore, a cross-sectional analysis is first applied to determine the homogeneity of the series. After performing panel cointegration analyses that require a long-run cointegration relationship between variables, estimators are determined by taking into account the cross-section and homogeneity test results.

In this study, the Pesaran (2004) CD test was employed to examine cross-sectional independence among the series, while the Pesaran-Yamagata (2008) bias-adjusted delta tilde test was used to assess slope homogeneity. In addressing cross-sectional dependence during unit root testing, the Pesaran (2007) Cross-sectionally Augmented IPS (CIPS) test was employed.

Subsequently, the cointegration analysis was conducted using the Westerlund and Edgerton (2008) ECM-based test, which offers a robust and comprehensive framework for addressing key challenges in panel data analysis, such as heterogeneity and cross-sectional dependence. Unlike traditional panel cointegration tests that often produce unreliable results under complex data conditions, this method explicitly considers heterogeneity, cross-sectional dependence, and potential structural breaks in both intercept and slope coefficients (Westerlund and Edgerton, 2008). Given the detection of CD and heterogeneity in the panel structure, the Westerlund ECM cointegration test was deemed appropriate for the analysis.

Finally, considering the outcomes of the cross-sectional dependence and slope homogeneity tests, the long-run associations among the variables were estimated through the Augmented Mean Group (AMG) and Common Correlated Effects Mean Group (CCE-MG) estimators (Eberhardt & Bond, 2009; Eberhardt & Teal, 2010).

5. Empirical Results

5.1. Cross Section Dependency (CD)- Homogeneity-Unit Root Tests

As expressed in the data and methodology chapter, prior to conducting the cointegration test, it is necessary to determine whether cross-sectional dependence (CD) exists in the models and to examine the estimated coefficients of each model. Cross-sectional dependence at the variable level was assessed using the LM (Lagrange Multiplier) and LM_adj (Adjusted Cross-sectional Dependence Lagrange Multiplier) tests, whereas model-level dependence was evaluated using the Bias-adjusted LM (LM_adj) and LM CD tests proposed by Breusch and Pagan (1980) and Pesaran et al. (2008). In these CD tests, the null hypothesis assumes the absence of cross-sectional dependence. The results of the model's CD tests, along with the slope heterogeneity statistics, are presented in Table 4. The slope heterogeneity test, proposed by Pesaran and Yamagata (2008), evaluates whether slope coefficients differ across cross-sectional units, assuming homogeneity under the null hypothesis. Both the delta and adjusted delta statistics are significant at the 1% level, rejecting the null and indicating that slope coefficients are heterogeneous across countries. Consequently, models assuming homogeneous coefficients are inappropriate, and approaches that allow for heterogeneous slopes should be applied (Pesaran, 2007; Pesaran and Yamagata, 2008).

Table 4: CD and Heterogeneity Results

Panel-Level CD Test Results				
	stat.		**p-val.**	
LM	28.620		0.000*	
LM adj*	15.030		0.000*	
LM CD*	3.112		0.002*	
Variable-Level CD Test Results				
	LGDP	**LLE**	**LPA65**	**LADR**
Breusch-Pagan LM	88.64 (0.00)*	70.53 (0.00)*	91.77 (0.00)	82.63 (0.00)*
Pesaran Scaled LM	23.85 (0.00)*	18.62 (0.00)*	24.76 (0.00)*	22.12 (0.00)*
Bias-corrected Scaled LM	23.76 (0.00)*	18.54 (0.00)*	24.67 (0.00)*	22.03 (0.00)*
Pesaran CD	9.24 (0.00)*	7.10 (0.00)*	2.57 (0.01)	8.46 (0.00)*
Heterogeneity				
	delta	**p-value**		
	12.321	0.000*		
adj	13.848	0.000*		

Note: *Values in parentheses represent probability values (prob). Prob. values are assumed to possess asymptotic normality. (*) depicts significance at level of 1%*

In according to prob. values of four different cross-section dependency test results depict that the null hypothesis was rejected at the 1% significance level. This indicates that cross-section dependency is exist. The result of the homogeneity test shows that the null hypothesis of "slope coefficients are homogeneous" is rejected, meaning that heterogeneity exists.

Second generation unit root test was employed due to the determine of CD between the series. One of the second-generation unit root tests, CIPS (Cross-sectionally augmented Im-Pesaran-Shin) unit root test developed by Pesaran (2007) was used. These statistics are calculated by taking the sample average of individual CADF (Cross-Sectionally Augmented Dickey Fuller) statistics. The null hypothesis of the CIPS test states that the series is I(1). CIPS unit root test results are given in Table 5.

Table 5: CIPS Test Results

	c		**c+t**	
	Zt-bar	**p-val.**	**Zt-bar**	**p-val.**
LGDP	1.446	0.926	2.048	0.980
LLE	0.590	0.722	0.707	0.760
LPA65	4.572	1.000	-0.776	0.219
LADR	-2.356	0.009*	2.345	0.990
dLGDP	-4.029	0.000*	-5.181	0.000*
dLLE	-4.543	0.000*	-3.947	0.000*
dLPA65	-1.793	0.036*	-2.328	0.010*
dLADR	5.146	1.000	2.400	0.992

Note: *(*) depicts significance at level of 1% and (**) indicates it at level of 5%. The maximum lag length is specified as 2, and the optimal lag length is selected based on the Schwarz Information Criterion (SIC).*

Examining the p-values of the variables in the panel, it is observed that, at the 1% significance level, the null hypothesis cannot be rejected for all variables under both the constant and trend models, except for LADR. LADR is found to be stationary at level under the constant model. The other variables (LGDP, LLE, and LPA65) become stationary at the first difference under both model specifications.

These findings indicate that the variables have different orders of integration. However, this does not pose a problem for the subsequent cointegration analysis, since the panel ARDL approach allows variables integrated at I(0) and I(1) to be used together in the same model, provided that none of the variables is integrated at I(2) (Pesaran et al., 1999; Pesaran et sl, 2001). Therefore, the mixed integration orders of the variables do not invalidate the cointegration analysis in this study.

In addition to the integration properties, the potential for multicollinearity among the independent variables was also examined to ensure that the estimated coefficients are unbiased. Following the unit root tests, multicollinearity was assessed using the Variance Inflation Factor (VIF). According to Gujarati and Porter (2009), a VIF value exceeding 10 indicates a potential multicollinearity problem that could bias the standard errors. As shown in Table 6, the highest VIF is 2.83 with a mean VIF of 2.23. Since all values are substantially below the critical threshold, these results confirm the absence of multicollinearity in the model specification.

Table 6: Multicollinearity Test Results (VIF)

Variables	VIF	1/VIF (Tolerance)
LADR	2.83	0.3533
d_LPA65	2.83	0.3528
d_LLE	1.01	0.9884
Mean VIF	2.23	

5.2. Panel Cointegration and AMG Results

Panel cointegration analysis is conducted to examine whether a long-run association exists among the variables. As previously stated, the Westerlund ECM cointegration test, which accounts for CD and heterogeneity, is employed in this paper.

The application of the Westerlund panel cointegration test established a long-run equilibrium between the indicators LGDP, LLE, LPA65, and LADR. These findings are specifically reported in Table 6. The Westerlund test is designed to determine whether a set of variables share a common stochastic trend, meaning they are cointegrated. In this context, both the group statistic (Gt) and the panel statistic (Pt) provide evidence of cointegration, with robust p-values of 0.028 and 0.092, respectively. These results are statistically significant at the 5% (for Gt) and 10% (for Pt) significance levels, confirming that the variables in the model are not independent in the long-run. This implies that changes in demographic indicators, such as life expectancy or the aging population, correspond to systematic changes in economic growth over time. Consequently, these indicators exhibit a joint movement in the long-run. The presence of cointegration among them highlights the significant and structural role that demographic factors play in long-run economic growth.

Table 7: Westerlund ECM Cointegration Test Results

Statistic	Z-value	P-value	Robust	P-value
Gt	-3.227	-2.107	0.018	0.028**
Ga	-4.569	1.819	0.966	0.808
Pt	-5.578	-1.644	0.050	0.092***
Pa	-5.015	0.746	0.772	0.632

Note: *(*) depicts significance at level of 1%, (**), denotes at level of 5% and (***) indicates it at level of 10%.*

To determine the long-run coefficients, the AMG and CCE-MG estimators were applied following the confirmation of panel cointegration. The estimator was essential for properly addressing the cross-sectional dependence and heterogeneity across the countries. Table 8 summarizes these findings, providing both the panel-level and country-specific AMG and CCE-MG coefficient estimates.

Table 8: Panel AMG and CCE-MG Test Results

		AMG		CCE-MG	
Panel		**Coefficients**	**Prob.**	**Coefficients**	**Prob.**
	LLE	1.421	0.074***	1.866	0.388
	LPA65	1.483	0.021**	-0.689	0.336
	LADR	0.552	0.000*	0.341	0.708
Country		**Coefficients**	**Prob.**	**Coefficients**	**Prob.**
Indonesia	LLE	0.890	0.007*	-2.031	0.059**
	LPA65	0.762	0.000*	1.088	0.000*
	LADR	-0.422	0.408	-1.615	0.457
Mexico	LLE	0.469	0.068***	0.859	0.460
	LPA65	0.605	0.001*	-0.541	0.459
	LADR	2.180	0.000*	2.106	0.026**
Nigeria	LLE	3.790	0.000*	8.055	0.003*
	LPA65	0.427	0.743	-2.404	0.282
	LADR	2.281	0.000*	-0.790	0.668
Türkiye	LLE	0.537	0.619	0.581	0.709
	LPA65	0.414	0.001*	-0.899	0.020**
	LADR	1.892	0.001*	1.663	0.027**

Note: *(*) depicts significance at level of 1%, (**), denotes at level of 5% and (***) indicates it at level of 10%. While the 1% and 5% levels are the most commonly used significance thresholds, the 10% level is also often reported in empirical economic studies and is considered acceptable for interpretation.*

According to the results obtained from the AMG and CCE-MG estimators, demographic variables exhibit important long-run relationships with economic growth. Under the AMG estimator, life expectancy is significant at the 10% level, indicating that a 1% increase in life expectancy is associated with an approximate 1.42% increase in economic growth. However, this effect becomes statistically insignificant in the aggregate panel under the CCE-MG estimator, suggesting that the impact of life expectancy may be sensitive to cross-sectional correlations. Similarly, the proportion of the population aged sixty-five and over is significant at the 5% level in the AMG model, suggesting that a 1% increase in the elderly population contributes to an approximate 1.48% increase in growth. These findings imply that an aging population may positively influence eco growth through channels such as enhanced human capital, accumulated experience, or the expansion of the health sector.

Moreover, the dependency ratio demonstrates a strong and positive relationship with economic growth, significant at the 1% level in the AMG model. A 1% increase in the dependency ratio is associated with an approximate 0.55% increase in growth. While this outcome diverges from some prior findings in the literature, it may be attributable to country-specific structural characteristics, including differences in labor markets, social security systems, and demographic transitions. However, while the aggregate panel results for the dependency ratio lose statistical significance under the CCE-MG estimator, the country-specific analysis reveals persistent effects in certain contexts.

The country-level analysis further underscores the heterogeneous effects of demographic variables. Life expectancy exerts the strongest influence on growth in Nigeria, whereas the elderly population plays a particularly notable role in Indonesia, Mexico, and Türkiye. Additionally, the effect of the dependency ratio is significant in Mexico and Türkiye but not in Indonesia. Additionally, the effect of the dependency ratio is significant in Mexico and Türkiye across both AMG and CCE-MG specifications, confirming the robustness of these findings for these specific countries. For instance, in Türkiye the dependency ratio remains significant at the 5% level in the CCE-MG model (1.663), highlighting its robust contribution to growth.

Overall, the results highlight that demographic structures are not only significant determinants of long-term economic growth but also vary substantially across national contexts. Life expectancy and the share of the elderly population consistently contribute positively to growth, whereas the effect of the dependency ratio depends on country-specific conditions. These findings underscore the importance of incorporating demographic dynamics into the design of development policies and strategies, as they play a critical role in shaping long-run growth patterns even when cross-country interdependencies are taken into account.

6. Conclusion

Health constitutes a fundamental element of human capital and has become increasingly influential in shaping long-run economic growth. This study analyzes the effects of health-related demographic variables on economic outcomes in MINT countries for the period 2000–2023. The empirical analysis, conducted using panel cointegration techniques and both AMG and CCE-MG estimators, reveals that life expectancy, the elderly population rate, and the dependency ratio have long-run relationships with economic growth. However, the magnitude and statistical significance of these effects vary across estimators and countries, reflecting heterogeneous country-level dynamics. The main findings can be summarized as follows:

• Life expectancy has a relatively stronger influence on economic growth compared with the other variables. Longer life expectancy extends individuals' participation in the labor force and increases the effective use of accumulated human capital. It also influences savings and investment decisions by encouraging longer-term economic planning. While this effect is statistically significant in the AMG estimation at the 10% level, it becomes insignificant in the aggregate panel under the CCE-MG estimator, suggesting that the impact of life expectancy may be sensitive to cross-country interdependencies and common factors.

• The elderly population contributes positively to economic growth, especially in Indonesia, Mexico, and Türkiye. This effect may be associated with the accumulated knowledge and experience of older individuals as well as the expansion of health and service sectors that support aging populations. Although the AMG estimator identifies a statistically significant panel-level effect, the CCE-MG results indicate that this relationship becomes less robust once unobserved common factors across countries are taken into account.

• The dependency ratio shows a positive impact on growth at the panel level but exhibits variation across countries. While it significantly contributes to growth in Mexico and Türkiye, no such effect is observed in Indonesia. These differences may reflect structural characteristics of national economies. In some cases, higher dependency may encourage households to increase income-generating efforts, whereas in others it may reduce productivity by lowering the share of the working-age population and limiting savings and investment capacity. Similar to the other variables, the AMG estimator reports a statistically significant panel-level effect, whereas the CCE-MG estimator suggests that this significance weakens once cross-sectional dependence is considered. Nevertheless, country-specific effects remain evident, particularly in Mexico and Türkiye. These results may reflect structural characteristics of MINT economies. In Mexico, strong economic integration with the United States and an export-oriented manufacturing structure may encourage higher labor market participation to sustain household income. In Türkiye, a diversified industrial base and the expansion of service sectors such as tourism and trade may lead households to increase labor supply when dependency pressures rise.

When compared with the existing literature, these findings are largely consistent with studies documenting a positive relationship between health and economic growth (Li & Huang, 2009; Bloom et al., 2010; Çetin & Ecevit, 2010; Wang, 2011; Chaabouni et al., 2016; Altunöz, 2019; Binay, 2020; Çeştepe et al., 2020; Albayrak & Öztürk, 2021). However, some studies have reached different conclusions (Hartwig, 2010; Erdoğan et al., 2019; Kırılmaz et al., 2019), suggesting that methodological differences and country-specific conditions may influence empirical results. The literature also indicates that different econometric approaches such as panel cointegration, OLS, GMM, panel ARDL, and causality analyses often produce varying findings regarding the health–growth nexus, emphasizing its multidimensional nature. In addition, studies focusing on aging and dependency ratios highlight that the economic effects of demographic change are complex. While population aging may slow economic growth, increased labor force participation among the elderly can mitigate this negative effect. Moreover, a young and productive labor force remains a key driver of economic performance, while technological progress, capital investment, and effective health policies can help offset the economic pressures created by demographic change (Lai and Yip, 2022; Skirbekk et al., 2022; Kotschy and Bloom, 2023; Trong et al., 2024; Lee and Song, 2025; Mansouri et al., 2025; Tangpatthamachart and Amornkitvikai, 2025).

Focusing on MINT economies, this study demonstrates that demographic-based health dynamics play an important role in shaping long-term economic performance. The findings suggest that policies aimed at improving healthcare access and quality can support economic growth by increasing life expectancy, enhancing labor productivity, and extending participation in the labor market. Furthermore, the positive contribution of the elderly population observed in some countries indicates that aging should not be viewed solely as a demographic burden. Policies that support active aging and encourage the continued participation of older individuals in economic life may enable economies to benefit from their accumulated knowledge and experience. Finally, the positive relationship between the dependency ratio and economic growth in some MINT countries suggests that demographic pressures may encourage greater labor supply within households. In this context, policies that expand employment opportunities and strengthen labor market participation can help transform demographic challenges into potential economic advantages. Future research could further explore these dynamics by comparing the relationship between health and economic growth across countries with different development levels or by explicitly incorporating health policy frameworks into empirical analyses.

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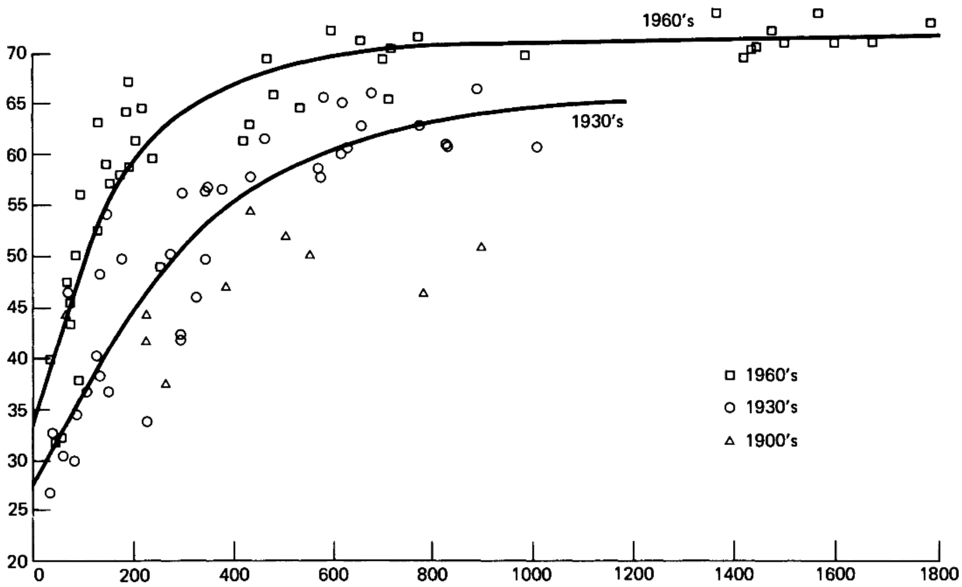
Appendix 1:

Graphic 1. Preston Curves



Note: Preston Curve, with the horizontal axis representing national income per head in 1963 US dollars and the vertical axis representing life expectancy at birth for the 1900s, 1930s, and 1960s.

Source: Preston, Samuel H.; (1975), "The Changing Relation Between Mortality and Level of Economic Development", Population Studies, 29 (2), p 235.