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Abstract

The economic effects and consequences of an aging population on economic growth in terms of productivity and demand have attracted great attention from policy makers, particular in emerging countries. This study examines the effect of an aging population on economic growth in 84 developing countries in the period 1971–2015, using panel fixed effects and quantile regression. The results confirm a negative effect on economic growth in the long run from having a high share of young people (14 years old and younger). However, in the long run, a positive relationship exists between the share of those 65 and older and economic performance. The quantile regression results confirm the importance of an aging population on economic growth at most percentiles. However, from lower to higher percentiles, the estimated magnitudes differ.

Keywords: Aging population; Developing countries; Quantile regression.

1. Introduction

Population plays a key role in economic development in any economy, regardless of the level of economic growth. However, different age groups tend to have different levels of productivity and have different economic demands, so their effects on economic growth attract great attention from policy makers and researchers worldwide.

In general, a population is considered aging if the share of those age 65 and older is increasing (United Nations 2015). Table 1 shows that, after a baby boom in the 1940s–1960s, the combination of declining fertility rates, declining mortality rates, and increasing life expectancy created a rapidly aging population in most developing countries over the next four decades. Over the period 1970–2015, thanks to advances in medicine and health care and the increase in the number of women in the labor force, around the world the average fertility rate declined from 4.77 to 2.54, while life expectancy rose from 58.65 to 71.89. Shetty (2012) indicates that by 2050, 80% of the elderly population over age 60 worldwide will be in developing countries. At the regional level, by 2050 the proportion of people age 60 and over may reach 25% of the population in all Asian countries while in sub-Saharan Africa the number is expected to triple, from 53 million at present to 150 million by 2050.

[TABLE 1]

An aging population is a problem not only for developing countries (Bloom, Canning, and Fink 2010; Cameron and Cobb-Clark 2002) but also for developed countries (Alders and Broer 2004; Fougère et al. 2009). In rich countries, these problems could be solved by implementing timely and appropriate policies, even though these are not perfect. However, many developing countries seem to be unprepared for the next two or three decades, when their proportion of the elderly reaches its peak. Nagarajan, Teixeira, and Silva (2016) point out the urgent need for empirical studies on aging populations and economic growth to address anticipated problems.

Prior studies show that changes in the proportion of the elderly are associated with labor productivity, individual consumption and savings, and government spending, which eventually affect economic growth (Aigner-Walder and Döring 2012; Bloom, Canning, and Fink 2010; Fougère et al. 2009; Sharpe 2011). In addition, the impacts of the aging population on economic growth may change according to the empirical methodology used to analyze them (Nagarajan, Teixeira, and Silva 2016). Although a majority of the prior studies find that age has negative effects on economic performance (Bloom et al. 2011; Lee, Mason, and Park 2011; Thiébaut, Barnay, and Ventelou 2013), others suggest positive or neutral effects (Blake and Mayhew 2006; Cai 2010; Li, Li, and Chan 2012).

At the same time, this impact may differ widely, according to the part of the elderly share distribution, especially in a distribution with great inequality (as shown in the Results section). In other words, different shares of the elderly could create different combined effects of the aforementioned drivers of growth. As such, estimates of the relationship between economic growth and demographic factors that result from an ordinary least squares (OLS) regression, which is based on the conditional mean function, may be ineffective. A quantile regression, proposed by Koenker and Bassett (1978), can address this problem by yielding a complete picture of the relations between the aging population and economic growth. In other words, relations at different sample quantiles are examined, rather than averages. Moreover, quantile regression estimators are not sensitive to outlying observations (Hao and Naiman 2007; Kodila-Tedika and Bolito-Losembe 2014; Wang 2017) and relax some OLS assumptions (e.g., normality, homoskedasticity).

As such, this paper aims to provide empirical evidence on the effect of an aging population on economic growth in developing countries. Applying a quantile regression framework, we can reveal the importance of differences in the distribution of demographic characteristics. The remainder of the paper is structured as follows. In the next section, we review some empirical studies related to the relation between an aging population and economic growth. Section 3 introduces the data sources, measurements, and specification model used. In Section 4, we present our results and some discussion of them, followed by our conclusions.

2. Literature Review

An aging population affects economic growth through government expenditure, the level of consumption, and sources of income; however, the magnitude of their impact varies between developed and developing countries (Alders and Broer 2004; Bakshi and Chen 1994; de Meijer et al. 2013; Elmeskov 2004; Lee and Mason 2007; Nagarajan et al. 2016; Tosun 2003). Several researchers argue that this relationship could be negative; for example, the increase in the share of the young and the elderly tends to decrease labor force participation, savings, and the demand for capital, which slows down economic growth (Bloom et al. 2011, 2015; Narciso 2010). According to Bloom et al. (2011), in developed countries the flexibility of institutions and policies allows them to dampen the negative effects of an aging population. Specifically, having a health-care system for the elderly and a pay-as-you-go pension system would result in the improvement of elderly well-being and reduction of the possibility that pension funds will be depleted. These authors argue that in developing countries, the aging population did not seem to adversely affect economic development because of the low proportion of the elderly in the population and the high proportion of those of working age. However, in the long run, declines in the fertility rate and an increase in migration from developing countries to developed countries would shrink the labor force in the developing countries and have negative effects on economic growth there.

The consequences of an aging population on national finances due to public expenditure on health care and pensions are examined by Tosun (2003), Elmeskov (2004), and Harper (2014). In Europe, the average old-age dependency rate (the ratio of those 65 and older to those age 20-64) is projected to double between 2015 and 2050. This could lead to an average increase in public expenditure of 6–7% of the gross domestic product (GDP) across the member countries of the Organization for Economic Cooperation and Development (OECD) until 2050 (Elmeskov 2004; United Nations 2015). The reasons behind the increase in public spending are pressures on pension systems and demand for health care at the same time. In other words, an aging population creates imbalance in public spending and might also affect the output per person (Tosun 2003; Lisenkova et al. 2013).

Furthermore, the slowdown in population growth leads to a decrease in consumption. In lower- and middle-income countries, the level of consumption among the elderly relative to the group age 30-49 declines; in contrast, in high-income countries, an increase in age leads to a rise in the level of consumption (United Nations, 2015). To explain this problem, Nagarajan et al. (2016) state that the aging population directly affects the level of consumption in households on average because those items no longer provide any utility for their household. For example, in a country whose population skews more toward the elderly, general interest in education will fall as that cohort becomes more likely to pay for medical care instead. As people age, their preferences and demand change, in particular shifting toward demand for health care.

Therefore, countries that supply a higher level of health-care services will maintain a higher level of consumption (United Nations, 2015).

As indicated by Bloom, Canning, and Fink (2010), in reality, policies related to a rise in the retirement age and expansion in migration will help to balance out the contraction in the labor force. Because of differences across countries in terms of the aging process, in which poor countries are aging more slowly than rich ones, the latter can utilize the large working-age population from developing countries. Therefore, the aging population will influence neither the creation nor the flow of development (Elgin and Tumen 2012). Moreover, Elgin and Tumen (2012) contend that modern advanced economies can switch their production from labor-oriented technologies to human capital-oriented ones, to deal with the aging population structure. In this way, a decline in labor power will have no impact on profitability. Bloom et al. (2015) postulate that behavioral changes and policy reactions will follow that countervail the negative impacts of an aging population. For instance, the expansion in the dependent elderly group could be counterbalanced, in whole or in part, by investing in human capital, such as education, training, and health care. The inevitable contraction in the proportion of the population of working age and the decrease in fertility could be alleviated by having workers defer retirement and expanding the proportion in the workforce of women, who will have fewer child-care responsibilities. Moreover, the labor market could be modified by empowering more labor-saving innovations that raise productivity per worker.

However, Lisenkova et al. (2013) state that, although raising the retirement age may in part address the diminishing workforce, the working productivity of various age groups (e.g., working-age group and elderly group) is not perfectly substitutable, thus worker productivity will decrease. When age-specific effects—that is, individual behavior, consumption, and productivity for various age groups—are taken into consideration, the impacts of population aging on macroeconomic variables increase. Different authors likewise focus on the negative effects of an aging population and the related contraction in a country's supply of human capital (Narciso 2010), with the ensuing negative impacts on finance. Under the assumption that the old age group can be correlated with dissaving activities, it is argued that an increase in the elderly population diminishes investment capital, which will then influence financial development.

Cotlear and Tornarolli (2011) rely on the Socioeconomic Database for Latin America and the Caribbean (SEDLAC) in 18 Latin American and Caribbean countries in the period 2005–2007 to study poverty rankings in aging populations. They estimate that 19% of the population over 60 in Latin American and Caribbean countries lives below the poverty line, defined as $2.50 per day. However, this proportion increased among the population over 80 in the region because of a reduction in their sources of income. Moreover, the proportion of pensions in their income sources tends to increase as people age. Specifically, the pension shares account for 30-40% and almost 50% of the income distribution of people over 60 and 80, respectively. Despite the importance of the pension in income distribution, the coverage rate is considered quite low in these countries, at approximately 40%. The authors argue that the pensioners were poorer than non-pensioners because non-pensioners were active in the labor market; moreover, in some cases, among the population age 60 and over, having longer work experience resulted in higher income. However, for those over the age of 80, a decline in average working hours caused a change to lower-income jobs.

3. Methodology and Data

The dataset in this paper covers the post-baby boom period, 1971–2015, and includes developing countries classified by the World Bank as low income and lower-middle income. Countries with insufficient data are excluded from our data, so the final sample consists of 2,229 country-year observations (see Table S1, available online).

Consider the dynamic relation between the actual and steady-state level of income per capita as follows:

$$g_y = lny_t - lny_{t-1} = \delta(lny_t^* - lny_{t-1}) \tag{1}$$

where g_y represents the growth of income per capita, δ denotes the speed of conversion, y_t^* represents the steady state of income per capita. Because y_t^* cannot be observed, it is essential to calculate it using our equations. As suggested by Stone and Lee (1995) and recently applied in the works of Hayakawa, Kimura, and Lee (2013) and Lee et al. (2013), Equation (1) can be written using the partial-adjustment model as follows:

$$lny_t - lny_{t-1} = -\delta lny_{t-1} + \alpha_1 X_{t-1} + \alpha_2(X_t - X_{t-1}) + \mu_t \tag{2}$$

where X is the set of explanatory variables for income per capita, including capital stock, education, trade openness (Bloom, Canning, and Finlay 2010; Lee et al. 2013), and life expectancy (Acemoglu and Johnson 2007; Zhang and Zhang 2005). The adjustment model assumes that lny_t^* can be expressed by determining the level of income per capita in period $t-1$ and their first-difference form. The coefficient α_1 corresponds with each level variable demonstrating the long-run effects, while α_2 demonstrates "the short-run adjustment to contemporaneous changes in the lny determinants" (Lee et al. 2013, p. 406).

In this paper, the following specification model is utilized from Equation (2) to examine the effect of an aging population on economic growth:

$$g_y = \beta_0 + \beta_1 lny_{i,t-1} + \beta_2 Cap_{i,t-1} + \beta_3 Edu_{i,t-1} + \beta_4 Trade_{i,t-1} + \beta_6 Youth_{i,t-1} + \beta_7 Old_{i,t-1} + +\beta_8\left(Cap_{i,t} - Cap_{i,t-1}\right) + \beta_9\left(Edu_{i,t} - Edu_{i,t-1}\right) + \beta_{10}\left(Trade_{i,t} - Trade_{i,t-1}\right) + \beta_{12}\left(Youth_{i,t} - Youth_{i,t-1}\right) + \beta_{13}\left(Old_{i,t} - Old_{i,t-1}\right) + \varepsilon_{i,t} \quad (3)$$

where g_y is the growth rate in GDP per capita, lny is the log real GDP per capita, *Cap* is the capital stock, *Edu* is the proportion of primary school enrollment relative to the total population of the corresponding age group, *Trade* is total exports and imports relative to GDP, *Life* is life expectancy, *Youth* and *Old* are the percentage of the population below 15 years old and over 65 years old, respectively, and *ΔYouth* and *ΔOld* are changes in the percentage of the population below 15 years old and over 65 years old, respectively (see Table S2, available online).

We consider the effects of an aging population on economic growth in the long run through the significance of the *Youth* and *Old* variables and their impacts in the short run via *ΔYouth* and *ΔOld*. Model 3 is estimated using country-fixed effects panel data, including year dummies to account for heterogeneity (i.e. unobserved factors that do not change over time). The existence of cross-sectional dependence will be tested using both Breusch and Pagan (1980) LM statistic and Pesaran (2004) CD statistic. In the case of existing the cross-sectional dependence, each variable will be adjusted by the cross-sectional average and the Driscoll-Kraay (1998) standard errors estimation will be used[1].

Based on the conditional mean function, the fixed-effects estimators as indicated above show the average relation between the dependent and independent variables (Hao and Naiman 2007). In other words, the central location of the distribution is focused. However, the non-central relation should be investigated as well, especially for large dispersion distributions. In addition, Kodila-Tedika and Bolito-Losembe (2014) suggest that the outlying observations,

[1] We thank one of the referees for this suggestion.

which usually occur in the sample, are likely to generate a biased estimate using the least squares approach. Using a quantile regression approach could deal with these problems. Specifically, at τth sample quantile, the quantile regression estimator is expressed by the following minimization function:

$$\beta_{QR} = \arg\min\left[\sum_{Y_i > \beta X_i} \tau|Y_i - \beta X_i| + \sum_{Y_i < \beta X_i}(1-\tau)|Y_i - \beta X_i|\right] \forall \tau \in (0,1) \quad (4)$$

The quantile regression estimators, β_{QR}, obtained by linear programming, examine the marginal effect under each conditional quantile. Accordingly, the relationship between regressors and outcome variables at non-central locations can be investigated at the corresponding sample quantile. Moreover, the minimization function shows that the quantile regression estimators are not sensitive to outliers (Hao and Naiman 2007).

As such, together with the fixed-effects techniques, this study applies a panel data quantile regression to investigate the relation between an aging population and economic growth using Equation (3). Although estimating various quantiles simultaneously can yield a complete picture of the relation of interest, this study presents only the estimation results at some quantiles that are commonly used in recent empirical studies (Reboredo and Naifar 2017) (e.g., 0.05 – 0.1 – 0.25 – 0.5 – 0.75 – 0.9 – 0.95).

4. Results and Discussion

Table 2 presents the summary statistics of variables used in this study. The mean of the GDP annual growth rate for the sample is 1.49%. In terms of demographic measurement, the average shares of the elderly and of the young are 3.83% and 41.63%, respectively.

[TABLE 2]

Next, Table 3 provides some descriptive analysis of the distribution of the shares of the elderly and of the young. It shows that, at the low and middle percentiles of the distribution (i.e., from the 5th to the 70th percentile), the share of the young is likely to be dispersed more than the share of the elderly because the values of the former relative to the average are higher than those of the latter. However, at higher percentiles (i.e., from the 80th percentile upward), the opposite situation is found. In particular, at the highest part of the distribution, such as the 99th percentile, the share of the elderly relative to the average, 3.72, is much higher than that of the share of the young, 1.20. That information suggests a large dispersion in the distribution of the shares of these two groups.

[TABLE 3]

Table 4 presents the fixed-effects regression results. Each variable is adjusted by the cross-sectional average before regression and the Driscoll-Kraay (1998) standard errors are used to deal with the existence of cross-sectional dependence in this panel data since both Breusch-Pagan LM test and Pesaran's test indicate the same results. Column 1 shows the long-run effect of demographic factors on economic growth, and their effects in the short run are presented in Column 2. Columns 3 and 4 present the results with life expectancy taken into account. The estimation results in all four columns suggest that trade openness and education have significantly positive effects on economic growth whereas life expectancy and capital do not affect growth.

[TABLE 4]

The regression results indicate that the share of the young has a significantly negative effect on economic growth in the long run. This could be explained by the fact that women tend to exit the workforce when the proportion of youth-age dependency is high. In contrast to the vast majority of results in prior studies (Bloom et al. 2011; Lee, Mason, and Park 2011; Li, Li, and Chan 2012; Thiébaut, Barnay, and Ventelou 2013), our study is consistent with Mason and Lee (2013) and Kopecky (2011) in which we find that the share of the elderly has a positive effect on economic growth. This could be explained by the accumulation of capital and assets and the consumption behavior of the elderly in developing countries. In particular, the increase in life expectancy and retirement age might extend the employability of the elderly workers, and thus their household’s income and consumption.

In the short run, changes in the share of both the young and the elderly do not have significant impact on economic performance, which is inconsistent with other studies (Bloom, Canning, and Fink 2010; Lee et al. 2013). The results suggest that having a large proportion of young people may hamper economic growth in the long run but not in the short run. Conversely, although the increasing share of the elderly in the population might not increase the economic performance in the short run, it may help stimulate economic growth in the long run. We find similar results when life expectancy is taken into account.

Next, we use a panel data quantile regression to examine the effect of an aging population on economic growth at different quantiles. Table 5 presents the estimation results. Similar magnitudes with OLS are found for trade openness and education at many quantiles, except for the lower tail of trade openness (e.g., the 5th and 10th percentiles). By contrast, while the OLS estimator of life expectancy does not show a significant effect on economic growth, its quantile regression estimators suggest a positive relation at the lower tail (e.g., 5th, 10th, and 25th percentiles) and a negative effect at the upper tail of the distribution (e.g., 75th, 90th, and 95th). Capital is found to have a negative effect on economic growth at most percentiles.

[TABLE 5]

Next, this study focuses on the effect of the share of the young and the elderly on economic performance. Figures 1 and 2 show these relations across quantiles. Figure 1 indicates the quantile regression coefficient of the youth variable increases from the lower tail, at about -0.60 at the 5th quantile to -0.15 at the 50th quantile. For the upper tail, the estimated coefficients tend to remain about -0.15. Although the estimated coefficients from the 30th quantile are higher than the OLS estimator, and they vary significantly across quantiles, the negative effect of the share of the young on economic growth across the distribution is found. This implies that a one-percentage-point decrease in the share of the young leads to growth in both slowly and rapidly growing countries.[2]

Figure 2 reveals some interesting views of the share of the elderly on economic performance across quantiles. At the 0.05 quantile, the estimated coefficient is about -1.7. From the 5th to the 40th quantile, the estimators increase sharply to zero. For the upper-tail quantiles, the estimators are positive and reach 0.3 at the 95th quantile. This implies that a one-percentage-point increase in the share of the elderly would have a negative effect in countries with slow growth and generate positive signals in those growing extremely quickly.[3]

Our estimated results confirm that an aging population has significant effects on economic growth at all most quantiles. However, the estimated magnitudes differ from the lower to the higher quantiles.

[2] We thank one of the referees for this suggestion.
[3] We thank one of the referees for this suggestion.

5. Conclusions

In most developing countries, the combination of declining fertility rates and mortality rates and increasing life expectancy in recent years has led to a rapidly aging population, and the situation is forecast to worsen over the next few decades. Prior theoretical and empirical studies (e.g., Aigner-Walder and Döring 2012; Bloom, Canning, and Fink 2010; Fougère et al. 2009; Sharpe 2011) suggest that overall economic performance in these countries could be affected by growth in the share of the elderly through three main mechanisms: consumption and savings patterns, human capital, and public expenditure.

This paper contributes to the literature by applying a panel data quantile regression to examine the effects of an aging population on economic growth in developing countries during the period 1971–2015. Results from the conditional mean function suggest that the shares of the young and the elderly have significant effects on economic growth in the long run but not in the short run. Although in the long run we find a positive effect of the elderly population on economic performance, the share of the young may lead to negative effects on economic growth. In addition, their effects on economic growth at particular quantiles vary in the quantile regression. Although the negative relation of the share of the young is consistent, the magnitude of the share of the elderly differs from lower (negative) to higher quantiles (positive). Future research may use the semiparametric regression approach such as the partially linear model in Deng and Lin (2013) or the smooth-coefficient quantile regression approach in Deng et al. (2012) to deal with the heterogeneous relation between economic growth and aging population.

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REFERENCES

Acemoglu, Daron, and Simon Johnson. 2007. "Disease and Development: The Effect of Life Expectancy on Economic Growth." *Journal of Political Economy* 115, no. 6: 925-85.

Aigner-Walder, Birgit, and Thomas Döring. 2012. "The Effects of Population Ageing on Private Consumption: A Simulation for Austria Based on Household Data up to 2050." *Eurasian Economic Review* 2, no. 1: 63-80.

Alders, Peter, and D. Peter Broer. 2004. "Ageing, Fertility, and Growth." *Journal of Public Economics* 89, no. 5: 1075-95.

Bakshi, Gurdip S., and Zhiwu Chen. 1994. "Baby Boom, Population Aging, and Capital Markets." *Journal of Business* 67, no. 2: 165-202.

Blake, David, and Les Mayhew. 2006. "On the Sustainability of the UK State Pension System in the Light of Population Ageing and Declining Fertility." *Economic Journal* 116, no. 512: 286-305.

Bloom, David E., Axel Boersch-Supan, Patrick McGee, and Atsushi Seike. 2011. "Population Aging: Facts, Challenges, and Responses." PGDA Working Papers 7111, Program on the Global Demography of Aging.

Bloom, David E., David Canning, and Günther Fink. 2010. "Implications of Population Ageing for Economic Growth." *Oxford Review of Economic Policy* 26, no. 4: 583-612.

Bloom, David E., David Canning, and Jocelyn E. Finlay. 2010. "Population Aging and Economic Growth in Asia." In *The Economic Consequences of Demographic Change in East Asia,* pp. 61-89. Chicago: University of Chicago Press.

Bloom, David E., Somnath Chatterji, Paul Kowal, Peter Lloyd-Sherlock, Martin McKee, Bernd Rechel, Larry Rosenberg, and James P. Smith. 2015. "Macroeconomic Implications of Population Ageing and Selected Policy Responses." *Lancet* 385, no. 9968: 649-57.

Cai, Fang. 2010. "Demographic Transition, Demographic Dividend, and Lewis Turning Point in China." *China Economic Journal* 3, no. 2: 107-19.

Cameron, Lisa A., and Deborah A. Cobb-Clark. 2002. "Old-Age Labour Supply in the Developing World." *Applied Economics Letters* 9, no. 10: 649-52.

Cotlear, Daniel (Ed.), 2010. "Population Aging: Is Latin America Ready?" World Bank, Washington, DC.

de Meijer, Claudine, Bram Wouterse, Johan Polder, and Marc Koopmanschap. 2013. "The Effect of Population Aging on Health Expenditure Growth: A Critical Review." *European Journal of Ageing* 10, no. 4: 353-61.

Deng, Wen-Shuenn, and Yi-Chen Lin. 2013. "Parameter heterogeneity in the foreign direct investment-income inequality relationship: a semiparametric regression analysis." *Empirical Economics* 45, no. 2: 845-872.

Deng, Wen-Shuenn, Yi-Chen Lin, and Jinguo Gong. 2012. "A smooth coefficient quantile regression approach to the social capital–economic growth nexus." *Economic Modelling* 29, no. 2: 185-197.

Elgin, Ceyhun, and Semih Tumen. 2012. "Can Sustained Economic Growth and Declining Population Coexist?" *Economic Modelling* 29, no. 5: 1899-1908.

Elmeskov, Jørgen. 2004. "Aging, Public Budgets, and the Need for Policy Reform." *Review of International Economics* 12, no. 2: 233-42.

Fougère, Maxime, Simon Harvey, Jean Mercenier, and Marcel Mérette. 2009. "Population Ageing, Time Allocation and Human Capital: A General Equilibrium Analysis for Canada." *Economic Modelling* 26, no. 1: 30-39.

Hao, Lingxin, and Daniel Q. Naiman. 2007. *Quantitative Applications in the Social Sciences: Quantile Regression.* Thousand Oaks, CA: Sage.

Harper, Sarah. 2014. "Economic and Social Implications of Aging Societies." *Science* 346, no. 6209: 587-91.

Hayakawa, Kazunobu, Fukunari Kimura, and Hyun-Hoon Lee. 2013. "How Does Country Risk Matter for Foreign Direct Investment?" *Developing Economies* 51, no. 1: 60-78.

Kodila-Tedika, Oasis, and Remy Bolito-Losembe. 2014. "Poverty and Intelligence: Evidence Using Quantile Regression." *Economic Research Guardian* 4, no. 1: 25-32.

Koenker, Roger, and Gilbert Bassett Jr. 1978. "Regression Quantiles." *Econometrica: Journal of the Econometric Society* 46, no. 1: 33-50.

Kopecky, Karen A. 2011. "The trend in retirement." *International Economic Review* 52, no. 2: 287-316.

Lee, Hyun-Hoon, Hyeou-seung Huh, Young-Youn Lee, and Jae-Young Lim. 2013. “Effects of Population Aging on Economic Growth: A Panel Analysis.” *Seoul Journal of Economics* 26, no. 4: 402-432.

Lee, Sang-Hyop, and Andrew Mason. 2007. “Who Gains from the Demographic Dividend? Forecasting Income by Age.” *International Journal of Forecasting* 23, no. 4: 603-19.

Lee, Sang-Hyop, Andrew Mason, and Donghyun Park. 2011. “Why Does Population Aging Matter So Much for Asia? Population Aging, Economic Security and Economic Growth in Asia.” ERIA Discussion Paper Series 4.

Li, Xing, Zeguang Li, and Man-wah Luke Chan. 2012. “Demographic Change, Savings, Investment, and Economic Growth: A Case from China.” *Chinese Economy* 45, no. 2: 5-20.

Lisenkova, Katerina, Marcel Mérette, and Robert Wright. 2013. “Population Ageing and the Labour Market: Modelling Size and Age-Specific Effects.” *Economic Modelling* 35: 981-89.

Mason, Andrew, and Ronald Lee. 2013. "Labor and consumption across the lifecycle." *The Journal of the Economics of Ageing* 1-2: 16-27.

Nagarajan, N. Renuga, Aurora A.C. Teixeira, and Sandra T. Silva. 2016. “The Impact of an Ageing Population on Economic Growth: An Exploratory Review of the Main Mechanisms.” *Análise Social* 51, no. 216: 4-35.

Narciso, Alexandre. 2010. “The Impact of Population Ageing on International Capital Flows.” MPRA Papers, no. 2645.

Reboredo, Juan Carlos, and Nader Naifar. 2017. “Do Islamic Bond (Sukuk) Prices Reflect Financial and Policy Uncertainty? A Quantile Regression Approach.” *Emerging Markets Finance and Trade* 53, no. 7: 1535-46.

Sharpe, Andrew. 2011. “Is Ageing a Drag on Productivity Growth? A Review Article on Ageing, Health and Productivity: The Economics of Increased Life Expectancy.” *International Productivity Monitor* 21: 82-94.

Shetty, Priya. 2012. “Grey Matter: Ageing in Developing Countries.” *Lancet* 379, no. 9823: 1285-87.

Stone, Joe A., and Hyun-Hoon Lee. 1995. “Determinants of Intra-Industry Trade: A Longitudinal, Cross-Country Analysis.” *Weltwirtschaftliches Archiv* 131, no. 1: 67-85.

Thiébaut, S. P., Thomas Barnay, and Bruno Ventelou. 2013. “Ageing, Chronic Conditions and the Evolution of Future Drugs Expenditure: A Five-Year Micro-Simulation from 2004 to 2029.” *Applied Economics* 45, no. 13: 1663-72.

Tosun, Mehmet Serkan. 2003. “Population Aging and Economic Growth: Political Economy and Open Economy Effects.” *Economics Letters* 81, no. 3: 291-96.

United Nations, Department of Economic and Social Affairs, Population Division. 2015. *World Population Ageing 2015* (ST/ESA/SER.A/390).

Wang, Fang. 2017. “Which Part of the Chinese Art Market Is More Worth Investing in? Applying the Quantile Regression to Analyze Chinese Oil Paintings 2000–2014.” *Emerging Markets Finance and Trade* 53, no. 1: 44-53.

Zhang, Jie, and Junsen Zhang. 2005. “The Effect of Life Expectancy on Fertility, Saving, Schooling and Economic Growth: Theory and Evidence.” *Scandinavian Journal of Economics* 107, no. 1: 45-66.

Table 1. Demographic information in some developing countries

	Number of developing countries	GDP per capita		Fertility rate		Life expectancy		Old-age share	
		1970	2015	1970	2015	1970	2015	1970	2015
World		802.46	10130.18	4.77	2.45	58.65	71.89	5.31	8.28
East Asia & Pacific	14	1159.27	2138.68	5.74	3.07	49.30	69.07	3.18	4.72
Europe & Central Asia	8	2381.25	2537.57	4.15	2.21	64.94	71.79	6.59	9.03
Latin America & Caribbean	6	1863.25	2317.01	6.50	2.63	51.09	71.03	3.22	5.51
Middle East & North Africa	8	1022.05	2617.97	7.10	3.20	52.16	70.88	3.32	4.60
South Asia	7	448.13	1631.81	2.74	6.22	47.03	69.26	3.06	5.30
Sub-Saharan Africa	41	842.07	1144.01	6.89	4.85	43.98	60.40	3.02	2.97

Table 2. Descriptive statistic

Variable	Obs.	Mean	Std. dev.	Min	Max
GDP annual growth rate	2229	1.49	5.51	-57.53	25.57
Log GDP per capita	2229	77.91	7.32	57.38	94.05
Capital stock	2229	3.75	14.72	0.01	218.98
Trade Openness	2229	66.89	32.09	0.17	277.14
Life Expectancy	2229	57.57	9.22	28.11	75.70
Education	2229	87.84	26.72	12.15	152.25
Youth-age-share	2229	41.63	6.75	14.10	50.22
Old-age-share	2229	3.83	1.93	1.68	16.05
ΔCapital	2229	0.21	1.23	-0.90	36.89
ΔTrade Openness	2229	0.74	11.79	-99.07	206.83
ΔLife Expectancy	2229	0.42	0.72	-6.23	12.28
ΔEducation	2229	1.08	4.96	-34.51	48.51
ΔYouth-age-share	2229	-0.18	0.31	-1.39	0.72
ΔOld-age-share	2229	0.02	0.07	-0.28	0.61

Table 3. Old age share and Youth age share distribution

		Old age share	Relative to Average	Youth age share	Relative to Average
Percentile	1	2.17	0.57	17.72	0.43
	5	2.47	0.65	27.19	0.65
	10	2.61	0.68	31.84	0.76
	20	2.79	0.73	37.71	0.90
	30	2.96	0.78	41.07	0.99
	40	3.08	0.81	42.67	1.02
	50	3.24	0.85	43.84	1.05
	60	3.49	0.91	44.71	1.07
	70	3.79	0.99	45.54	1.09
	80	4.32	1.13	46.38	1.11
	90	5.22	1.37	47.60	1.14
	95	6.70	1.75	48.67	1.17
	99	14.21	3.72	49.81	1.20
Average		**3.82**		**41.68**	

Table 4. Regression result

Dependent variable: Growth of income per capita	(1)	(3)	(4)	(6)
Ln(GDP)	-0.664***	-0.673***	-0.646***	-0.644***
	(0.146)	(0.146)	(0.139)	(0.134)
Capital	-0.043	-0.037*	-0.035	-0.026
	(0.025)	(0.021)	(0.022)	(0.017)
Trade Openness	0.043***	0.042***	0.042***	0.041***
	(0.010)	(0.010)	(0.010)	(0.010)
Life Expectancy			-0.032	-0.044
			(0.067)	(0.065)
Education	0.043***	0.038***	0.044***	0.038***
	(0.010)	(0.010)	(0.010)	(0.009)
Youth Age Share	-0.215***	-0.231**	-0.211***	-0.220***
	(0.076)	(0.089)	(0.069)	(0.080)
Old Age Share	1.705	1.546*	1.886*	1.748*
	(1.039)	(0.852)	(1.084)	(0.907)
ΔCapital	0.833***	0.819***	0.767***	0.713***
	(0.300)	(0.299)	(0.268)	(0.247)
ΔTrade	-0.005	-0.006	-0.005	-0.007
	(0.024)	(0.024)	(0.023)	(0.023)
ΔLife Expectancy			1.435***	1.624***
			(0.396)	(0.426)
ΔEducation	0.105***	0.095***	0.096***	0.085***
	(0.027)	(0.025)	(0.026)	(0.023)
ΔYouth Age Share		-1.23		-1.991
		(0.988)		(1.209)
ΔOld Age Share		-8.195		-7.798
		(8.339)		(7.693)
Breusch-Pagan LM test	142.145	123.957	143.276	122.053
Pesaran's test	-3.130	-3.126	-3.160	-3.158

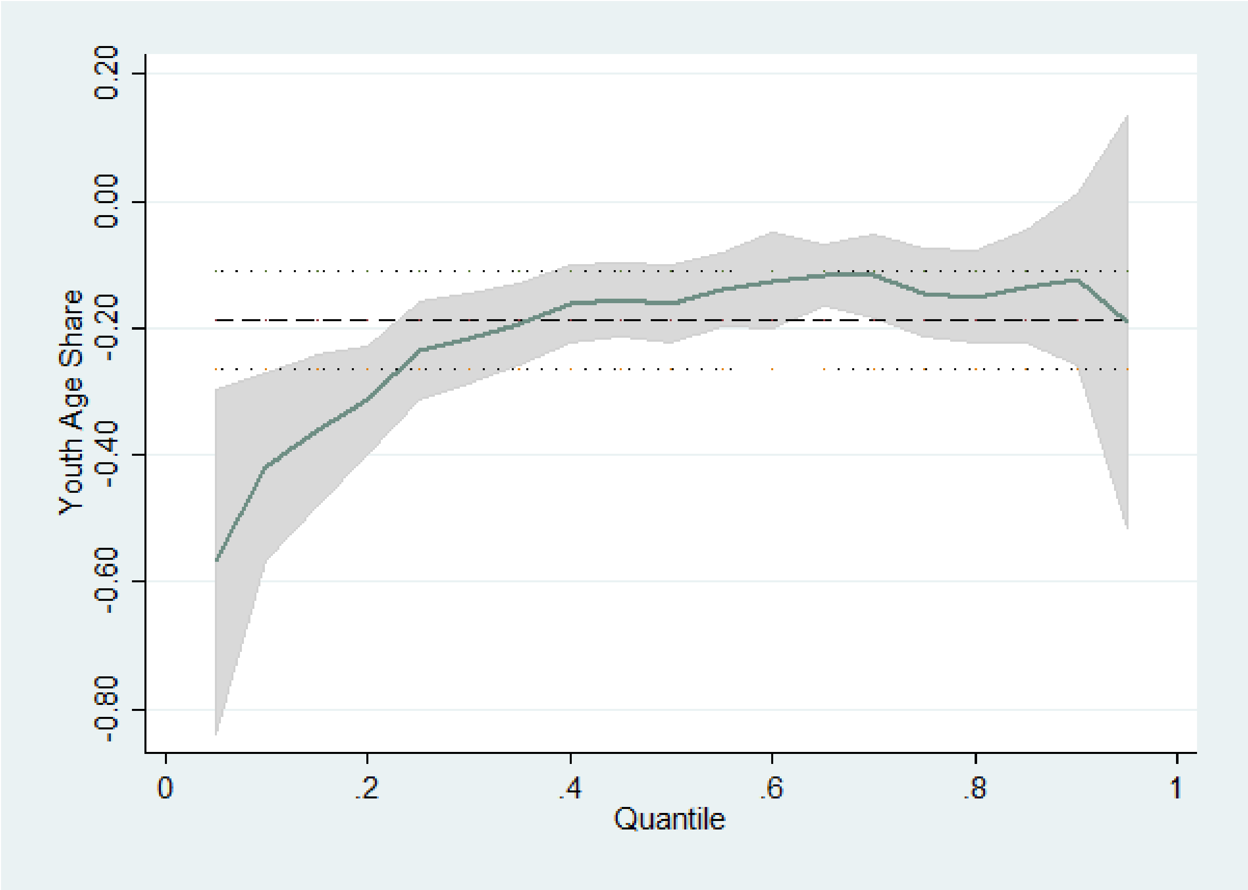
*Note: Standard errors in parentheses. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively. Models are estimated using country-fixed effects with Driscoll-Kraay standard errors. Variables are adjusted by subtracting the cross-sectional average before regression.*

Table 5. Quantile regression estimation results

	τ=0.05	τ=0.10	τ=0.25	τ=0.50	τ=0.75	τ=0.90	τ=0.95
Ln(GDP)	-0.125***	-0.123***	-0.110***	-0.076***	-0.074***	-0.086***	-0.183***
	(0.003)	(0.007)	(0.005)	(0.001)	(0.001)	(0.001)	(0.004)
Capital	-0.013***	-0.023***	0.011***	-0.009***	-0.053***	-0.068***	-0.079***
	(0.003)	(0.004)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)
Trade Openness	-0.017***	-0.014***	0.010***	0.009***	0.012***	0.018***	0.022***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)
Life Expectancy	0.069***	0.104***	0.083***	0.020***	-0.013***	-0.058***	-0.041***
	(0.003)	(0.008)	(0.007)	(0.001)	(0.001)	(0.002)	(0.004)
Education	0.010***	-0.008*	0.011***	0.005***	0.002***	0.008***	0.025***
	(0.001)	(0.003)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Youth Age	-0.595***	-0.443***	-0.251***	-0.154***	-0.142***	-0.152***	-0.199***
	(0.009)	(0.01)	(0.004)	(0.002)	(0.003)	(0.003)	(0.006)
Old Age	-1.654***	-1.032***	-0.333***	0.008	0.185***	0.367***	0.260***
	(0.013)	(0.019)	(0.015)	(0.005)	(0.008)	(0.005)	(0.012)
ΔCapital	0.488***	0.400***	0.023	0.400***	0.892***	0.983***	0.977***
	(0.034)	(0.054)	(0.031)	(0.012)	(0.017)	(0.009)	(0.018)
ΔTrade	-0.048***	-0.007*	-0.004***	0.011***	0.011***	-0.008***	-0.010***
	(0.002)	(0.003)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)
ΔLife Expectancy	3.734***	2.276***	1.835***	1.187***	1.256***	1.574***	1.511***
	(0.067)	(0.175)	(0.021)	(0.007)	(0.019)	(0.006)	(0.03)
ΔEducation	0.111***	0.067***	0.070***	0.039***	0.048***	0.073***	0.097***
	(0.005)	(0.008)	(0.004)	(0.001)	(0.001)	(0.001)	(0.002)
ΔYouth Age	-4.966***	-3.757***	-2.202***	-1.506***	-0.904***	-0.271***	-0.024
	(0.199)	(0.145)	(0.08)	(0.007)	(0.031)	(0.019)	(0.104)
ΔOld Age	-11.049***	-6.929***	-2.723***	0.245***	0.035	0.670***	2.572***
	(0.505)	(0.879)	(0.252)	(0.050)	(0.100)	(0.091)	(0.471)

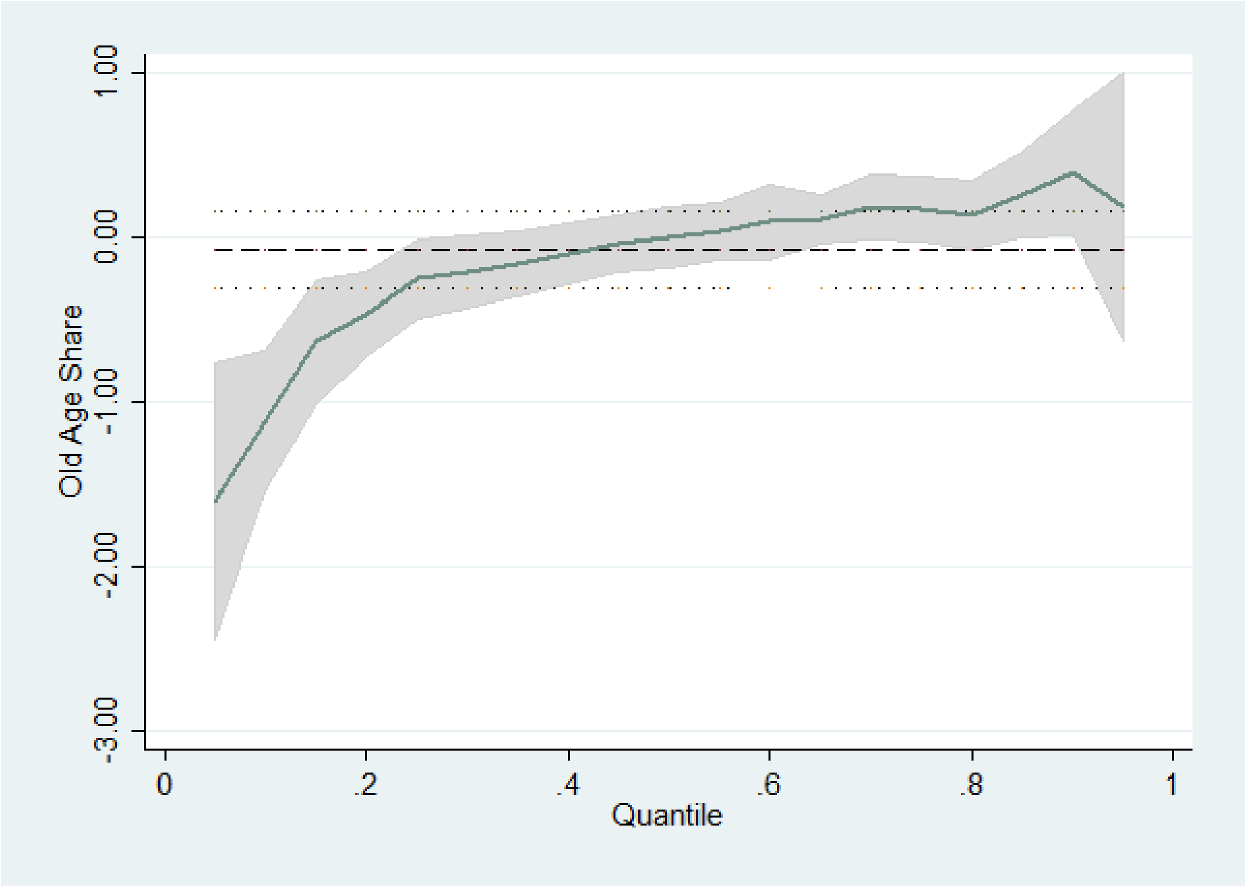
*Note: Standard errors in parentheses. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.*

Figure 1. Estimated coefficient of Youth age share using Quantile regression



Note: The dotted line represents the OLS estimator. The solid line shows the quantile regression estimator. The upper and lower shaded areas indicate the 95% confidence level of the quantile regression coefficient.

Figure 2. Estimated coefficient of Old age share using Quantile regression



Note: The dotted line represents the OLS estimator. The solid line shows the quantile regression estimator. The upper and lower shaded areas indicate the 95% confidence level of the quantile regression coefficient.