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Abstract

This paper aims to examine the effects of demographic dynamics on economic growth with a focus on working-age population and saving rate in 17 Asian economies for the past period from 1970 to 2018 and for the future period from 2018 to 2050. For the analytical methodology, this study applies a panel vector autoregressive model considering endogenous interactions among concerned variables. The main findings are summarized as follows: first, the estimation identified both the direct channel from working-age population share to economic growth and the indirect channel through saving rate; second, the estimated result also found the feedback effect from economic growth to saving rate; third, the contribution ratio of the demographic effect to economic growth for the past period, around 30 percent on average, is consistent with those in previous studies; and fourth, in the projection for 2018-2050, the degrees of the negative demographic effects in sample economies are getting larger than those of previous studies, due to the earlier-coming population onus with aging.

Key words: demographic dynamics, economic growth, Asia, saving rate, working-age population, panel vector-autoregressive model
JEL Classification: J11, O11, O53

1. Introduction

Demographic dynamics are, in general, supposed to be one of the important determinants of economic growth. In the literature, the relationship between demographic changes and economic growth has been intensively discussed from theoretical and empirical perspectives. East Asian countries experienced the most dramatic transition in demographic structure in the world during the twentieth century (e.g. Feeney and Mason 2001), and at the same time, they attained high economic growth in the latter half of the century, which was often referred to as the East Asian Miracle (e.g. World Bank 1993). In this context, East Asia benefited from demographic and economic processes more than any other region in the world as Mason (2001) emphasized, and as a result of these two simultaneous processes, studies that seek to explain economic impacts of demography have attracted considerable attentions.

The seminal work, Bloom and Williamson (1998), found that population dynamics, in terms of working-age and dependent populations, mattered in the determinant of economic growth, and that its dynamics accounted for as much as one-third to a half of East Asia's annual growth in GDP per capita during its miracle period of 1965-1990. A large number of subsequent studies as will be mentioned in Section 2 have also reaffirmed a vital role of demographic factors, in particular, working-age population, in explaining economic growth.

The Demographic dynamics in Asian region in terms of working-age population share has started to face a critical phase due to the progress in aging in the early twenty-first century as will be explained in Section 3.1 by Figure 1. The high and middle incomers such as Japan, Korea, Singapore, China and Thailand have already entered a declining phase in their working-age population shares together with an increase in their aging rates, and some of the latecomers in Asian region will also follow the same trend soon. In this context, the early twenty-first century would be a turning point from the "population bonus" (Mason 1997) to the "population onus", thereby being worth reexamining the contributions of population dynamics to economic growth.

There are considered to be two kinds of channels in which changes in working-age population share would affect economic growth. The first channel is the one through labor market: faster growth of working-age population relative to total population would directly contributes to economic growth through an increase in labor supply. The second channel is the indirect one through national saving: an increase in working-age population share means an increase in the share of working-age "savers" in the context of the life-cycle hypothesis, thereby leading to an expansion of aggregate saving; and the saving would be one of the crucial determinants of economic growth according to the post-neoclassical endogenous growth model. Whereas the first channel has been studied empirically in intensive ways, the second channel and the combination of the first and second channels have been relatively less-studied, due to the difficulty to manage endogeneity problems among variables in simple growth regression models.

This paper revisits the issue on economic impacts of population dynamics focusing on working-age population by examining two kinds of channels jointly: a direct channel through labor supply and an indirect channel through saving. This study, targeting 17 Asian economies, shows the quantitative roles of population dynamics on economic growth in the future trend for 2018-2050 as well as in the past trend for 1970-2018. For the estimation methodology, the study applies a panel vector-autoregressive (PVAR) model with a panel sample of 17 Asian economies for 1970-2018, considering endogenous interactions among economic growth, saving and working-age population.

The remainder of the paper is structured as follows. Section 2 reviews the literature related to this study and clarifies this study's contribution to the literature. Section 3 conducts an empirical analysis of economic impacts of population dynamics. Section 4 summarizes and concludes.

2. Literature Review and Contributions

This section reviews the literature related to this study and clarifies this study's contributions to the literature. As was mentioned in the introduction, there are two kinds of channels that link demographic dynamics to economic growth as follows: a direct channel through labor supply and an indirect channel through saving. Thus the reviewed literature can be classified into the following three categories: the direct linkage between demographic dynamics and economic growth, the linkage between demographic dynamics and saving, and the linkage between saving and economic growth.

2.1 Linkage between Demographic Dynamics and Economic Growth

The relationship between population change and economic growth remains an issue of debate for a long time among economists, demographers and social scientists. They continue to disagree on whether population growth restricts economic growth (e.g. Solow 1956; Barro 1991), promotes economic growth (e.g. Kuznets 1960; Kremer 1993), or is independent of economic growth (e.g. Ehrlich and Lui 1997; Feyrery 2002). While the debate on economic impacts of population-size growth has continued, a critical variable, i.e. the age structure of population, represented by working-age and dependent populations, has attracted more attentions in recent studies, since the age structure is considered to capture the overall impact of demographic changes in a more appropriate way (e.g. Kelley and Schmidt 2005; Macunovich 2012). It has also been contended that the "convergence" model as one of empirical frameworks is better in helping identify the channel through which demographic structure affects economic growth (e.g. Kelley and Schmidt 2005).

Using the convergence model with demographic-structure variables, Bloom and Williamson (1998), dividing growth in working-age population from that in total population, found that the rapid growth in working-age population relative to total population had significantly positive impacts on economic growth in East Asia for 1965-1990 (the positive effect of working-age population growth was referred to as the "demographic dividend" by Bloom et al., 2003b). Bloom et al. (2000), considering the feedback effect from economic growth to demographic change, found that the effect of demographic structure on economic growth was much larger than one-way effect between them in Asia. Bloom and Finlay (2009), updating the similar demographic model toward 2005, reaffirmed the role of demographic-structure transition in contributing to cross-country differences in economic growth with a focus on Asian economies, and emphasized the need for policy to offset potential negative effects of aging populations in the future. Wei and Hao (2010) confirmed the effect of the decline in youth dependency rate on economic growth and the feedback effect from economic growth on demographic behavior in the Chinese context using provincial-level data.

2.2 Linkage between Demographic Dynamics and Saving

There have been two main streams of theoretical foundations to explain the impacts of demographic structure on national saving. The first one is the "dependency hypothesis" proposed by Coale and Hoover (1958): the dependents aged below 15 years old (children) and above 65 (aged persons) contributes to consumption but not to production, and their consumptions should be financed out of saving; thus a high rate of dependents to the working-age population impose a constraint on an economy's potential for saving. This hypothesis obtained empirical supports in a seminal paper by Leff (1969) and subsequent studies (e.g. Higgins and Williamson, 1997), whereas studies by several scholars found that demographic dependency had little and no impacts on national saving (e.g. Goldberger 1973; Ram 1982).

The alternative hypothesis is the one based on the life-cycle model of consumption and saving argued by Modigliani and Brumberg (1954): Households, faced with an income that varies over a lifetime, attempt to smooth their consumption; this results in an age-specific pattern of dissaving to finance consumption during early ages and retirement and saving during working ages; and thus the economy-wide saving is accounted for by the weighting of age-specific household saving by the relative share of household by age. Mason (1981) showed a life-cycle micro-theoretic model of household consumption and derived its macroeconomic-implications under steady-state growth in both per capita income and population. Kelley and Schmidt (1996), using the Mason's life-cycle framework, found that demographic factors accounted for a major portion of changes in saving across countries and over time, whereas they identified their weak relationship in the Leff-type dependency model. For developing Asian economies, Horioka and Terada-Hagiwara (2012) found that their domestic saving rates had been high and rising for 1966-2007, and that the main determinants of this trend were the age structure of population as well as income levels and the level of financial sector development. Kwack and Lee (2005), using the life-cycle hypothesis, also showed that the age structure of the population had an impact on aggregate saving rates in Korea.

Another discussion on the linkage demographic factors and saving is how the effect of longevity (i.e., life expectancy) on saving is related to the effect of old-age dependency rate on saving. The longevity effect on saving contains two aspects of the life-cycle hypothesis. On the one hand, when they expect to live longer, individuals save more, thereby leading to an increase in aggregate savings. This positive effect has been proven empirically by such studies as Bloom et al. (2003a) and Lee and Mason (2006). On the other hand, increasing life expectancy also implies more old individuals who dissave and reduce aggregate savings. Thus, the pure longevity effect can be obtained only with age structure held constant. Li et al. (2007), examining the independent roles of longevity and age structure, identified a positive effect of longevity and a negative effect of old-age dependency on aggregate savings.

2.3 Linkage between Saving and Economic Growth

The literature has experienced theoretical developments on the relationship between saving and economic growth in the following growth theories. Traditional growth theories presumed that domestic savings are the principal determinant of economic growth (e.g., Lewis 1955; Kaldor 1956; Samuelson and Modigliani 1966). The Harrod-Domar model (Harrod 1939; Domar 1946) proposed that economic growth depends on marginal propensity to save and capital-output ratio. The neoclassical growth model (Solow 1956;

Swan 1956) postulated that the exogenously increased saving leads to the higher "level" of capital stock and output per capita in the steady-state, and to the higher "growth" rate temporarily in the transition to the steady-state. The post-neoclassical endogenous growth theory predicted that an increase in saving generates a permanently higher rate of growth through its positive effects on investment and capital accumulation (e.g., Romer 1986, 1990; Lucas 1988; Barro 1990; Barro and Sala-i-Martin 1995). Another strand of the argument on saving-growth linkage is that it is economic growth that encourages saving endogenously. Carroll and Weil (1994) and Carroll et al. (2000) argued that the positive effect of economic growth on saving could be justified by a model of consumption with habit formation rather than standard permanent income models of consumption.

As for the empirical studies for examining endogeneity and causality of saving, there have been enormous volume of works, but their results have been mixed and inconclusive depending on their samples and methodologies. The positive effect of saving on economic growth was identified by such studies as Bacha (1990) for a group of developing countries, De Gregorio (1992) for Latin American countries, Jappelli and Pagano (1994) and Misztal (2011) for a group of countries in the world, Alguacil et al. (2004) for Mexico, and Zhang et al. (2017) for China. The reverse causality from economic growth to saving was verified by the studies of e.g., Edward (1995), Loayza, et al. (2000) and Rodrik (2000) for a group of countries in the world, Sinha and Sinha (1998) for Latin American countries, Salz (1999) for developing countries, Anuro and Ahmad (2001) for African countries, Sahoo et al. (2001) for India, and Shahbaz and Khan (2010) for Pakistan. Their bidirectional causality was found in the studies of e.g., Romm (2005) for South Africa and Singh (2010) for India, and no causality in e.g., Ijeoma et al. (2011) for Lesotho, Sothan (2014) for Cambodia, and Yadav et al. (2018) for India.

2.4 This study's contributions

As reviewed above, each individual linkage among demography, saving and economic growth has been intensively studied from theoretical and empirical perspectives. There have been few works, however, to deal with these interacted three variables in a comprehensive way. Uddin et al. (2016), for instance, examined the relationship among dependency ratio, saving rates and real GDP for Australia by dynamic and fully modified ordinary least squares and vector error correction model. They did not necessarily take into account explicitly, however, an indirect effect of dependency ratio on real GDP through saving rates and a reverse causality from real GDP to saving. Considering the endogeneity of the variables, Sanchez-Romero (2013) implemented a computable general equilibrium model, and confirmed the role of demography on per capita output growth and saving rates in Taiwan's economy.

This paper revisits the issue on impact of population dynamics (represented by working-age population share) on economic growth by the following contributions to the literature. First, this study constructs an empirical model to deal jointly with a direct channel through labor market and an indirect channel through saving. The study also takes into account the feedback effects from economic growth to saving and working-age population share.

Second, to address endogeneity problem of the interactions among economic growth, saving and working-age population, this study applies a PVAR model with a panel sample of 17 Asian economies for 1970-2018 for an analytical methodology. Using growth regression models as in the literature would lead to the existence of biased and inconsistent estimators under the endogeneity. The PVAR instead allows for potential and highly-likely endogeneity among estimation variables by its data-driven approach, and also for tracing out the dynamic responses of an explained variable to the shock of a set of explaining variables (see e.g., Abrigo and Love 2016).

Third, this study updates a quantitative estimation of demographic role on economic growth for the past trend of 1970-2018 and the future trend of 2018-2050, targeting 17 Asian economics. Bloom and Finlay (2009), using a growth regression model, showed demographic impacts on economic growth by estimating them for 1965-2005 and projecting them for 2005-2050 for 13 Asian economies. This study, using the alternative approach, i.e., a PVAR including a saving channel, revises the estimation period into 1970-2018 and the projection one into 2018-2050, and also widens the sample into 17 Asian economies adding Cambodia, Lao PDR, Myanmar and Vietnam.

3. Empirical Analysis

This section conducts an empirical analysis of the impacts of population dynamics on economic growth. This section first observes the trend in population dynamics with a focus on the age structure in 17 Asian countries, and then presents a PVAR estimation describing methodologies, data and results with discussions.

3.1 Trend in Population Dynamics

Figure 1 shows the trend in the age structure, i.e., the share of young (1-14 years old), working-age (15-64), aged (65 and over) population for the past (1950-2020) and the future (2020-2050) on 17 Asian countries. The data including the projection is retrieved from the 2019 Revision of World Population Prospects by the United Nations[1]. The sample countries are Japan, South Korea and China in East Asia; Singapore, Malaysia, Thailand, Indonesia, the Philippines, Lao PDR, Vietnam, Myanmar and Cambodia in Southeast Asia; and Sri Lanka, India, Bangladesh, Pakistan and Nepal in South Asia (the country order in each region is based on the level of real per capita GDP in 2018[2]).

The process of demographic transition is characterized by the following three phases as fertility falls in sequence of a mortality decline: from a high dependency ratio of young population, through a high proportion of working-age population, to finally a high dependency ratio of aged population. As aforementioned in Section 2, a higher proportion of working-age population is considered to produce a positive effect on economic growth through a direct channel through labor market and an indirect channel through saving, while a higher dependency ratio of the young and the aged having a negative economic effect. The period when a proportion of working-age population is growing was referred to as the "demographic dividend" by Bloom et al. (2003b) and the "population bonus" by Mason (1997). This study uses the term of the "population bonus" for the period of growing proportion of working-age population, and the one of the "population onus" for the period of declining proportion of working-age population with a rise in youth and/or elderly dependency ratio.

In East Asia, Japan already passed the turning point from the population bonus to the onus in the early 1990s, and is and will be under the deep onus. South Korea and China, followed by Japan, have entered the phase of the population onus by passing through the turning point during the 2010s. It should be noted that South Korea will face a sharp decline in her working-age population share with a rapid increase in aging, since her total fertility rate is extremely low by 1.11 on the average for 2015-2020. In Southeast Asia, Singapore, Malaysia, Thailand and Vietnam passed the turning point just in the 2010s and have entered the onus phase due to their relatively low fertility rates, while the other countries with their higher fertility rates have still enjoyed the bonus. As for South Asian region, Sri Lanka, passing through the turning point in the 2000s, have entered the onus phase, but the other countries have still been and will be in the bonus phase.

In sum, the higher-income countries with the lower fertility rates, passing already through the turning point, have entered the phase of the population onus in East Asia and some of Southeast and South Asia, while the lower-income countries with the higher

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[1] See the website: https://population.un.org/wpp/.

[2] The real GDP per capita is the GDP per capita at constant prices (2015) by US dollars, retrieved from UNCTADSTAT: https://unctadstat.unctad.org/EN/.

fertility rates have still enjoyed the population bonus in some of Southeast Asia and a majority of South Asia. Thus, the disparity in GDP per capita might have a momentum of convergence in Asia from the perspective of demographic dynamics.

3.2 PVAR Analysis

This subsection presents a PVAR estimation for examining economic impacts of population dynamics. It starts with a model specification, followed by data description, a block exogeneity test, an impulse response test and impact analyses of population dynamics with discussions.

3.2.1 Model Specification

This subsection shows first a standard convergence model in growth regressions as shown in Bloom et al. (2000) and Bloom and Finlay (2009), as a yardstick to consider the variable selection for a PVAR model estimation. The model is specified as follows.

$$g_{pcy} = g_{pwy} + g_{was},$$
$$g_{pwy} = \lambda\ (pwy^* - pwy_0) \qquad (1)$$

where the first equation is a growth identity assuming that the number of workers is equal to that of working-age population: g denotes growth rate, pcy is income per capita, pwy is income per worker, and was is the ratio of working-age population to total population; the second equation represents a convergence model: λ is the speed of convergence, pwy^* is the steady-state of income per worker, and pwy_0 is initial value of income per worker.

According to the neoclassical Solow-Swan growth model (Solow 1956; Swan 1956), the steady-state of income per worker (pwy^*) is determined by population growth and saving rate. The "population growth" also has a debate of its effect on economic growth as aforementioned in Section 2.1. The "saving" is not only a determinant of the steady-state in growth process, but also a dependent variable affected by age structure and life expectancy based on the life-cycle and dependency hypotheses as reviewed in Section 2.2. In addition, the "saving" and age structure might be feedbacked by growth of income per capita as shown in Section 2.3.

The candidates of variables involved in Equation (1) can, therefore, be growth of income per capita (g_{pcy}), growth of working-age population share (g_{was}), saving rate to income (sav), population growth (g_{pop}), life expectancy (lfe), and initial value of income per worker (pwy_0). It should also be noted that all these variables except initial value of income per worker (pwy_0) might be endogenously interacted among them. Here comes the necessity to apply a PVAR model instead of growth regressions, because a PVAR model allows for potential and highly-likely endogeneity among estimated variables by its data-driven approach. The PVAR model can be specified for the estimation as follows.

$$y_{it} = \alpha + \beta\, y_{it-1} + \gamma\, pwy_0 + \varepsilon_{it} \tag{2}$$

where y_{it} is a column vector of the endogenous variables with economy i and year t: $y = (g_{pcy}, g_{was}, sav, g_{pop}, lfe)'$; y_{it-1} is a vector of the lagged endogenous variables; α, β and γ are coefficient matrixes; and ε_{it} is a vector of the random error terms in the system. The lag length (-1) is selected by the Schwarz Information Criterion with the maximum lags being three lags under the limited number of time-series data. The next step is to examine Granger causalities among the endogenous variables above by a block exogeneity test based on the PVAR model estimation (2).

3.2.2 Data

For the estimation, this study constructs a panel data of 17 Asian countries (as shown in Section 3.1) with every five year for 1970-2015 and 2018, based on the data availability of targeted variables. The reason for setting a five-year time span, not a yearly one, is to avoid short-term disturbances, business cycle fluctuations and serial correlations, as in such previous studies as Bloom and Finlay (2009).

The data of the five variables selected in Section 3.2.1 is described as follows. The data of income per capita (*pcy*) and saving rate to income (*sav*) are retrieved from the UNCTADSTAT: the income per capita (*pcy*) is from the series of "Gross domestic product per capita, US dollars at constant (2015) prices", and the saving rate to income (*sav*) is computed by subtracting "Final consumption expenditure" from "Gross domestic product (GDP)", dividing it by GDP and taking the average for five years in the sample period. The working-age population share (*was*), the total population (*pop*) and the life expectancy (*lfe*) are retrieved from the 2019 Revision of World Population Prospects by the United Nations. The growth term (g_{pcy}, g_{was}, g_{pop}) is represented by an annual growth rate on the average for every five year starting from 1975. The initial value of income per worker (pwy_0) in terms of thousand US dollars is computed by dividing the income per capita in 1970 by the working-age population in 1970.

For the subsequent PVAR estimation, this study investigates the stationary property of the constructed panel data by employing panel unit root tests: Levin, Lin and Chu test (Levin et al. 2002) as a common unit root test; and Fisher - ADF and PP tests (Maddala and Wu 1999; Choi 2001) and Im, Pesaran and Shin test (Im et al. 2003) as an individual unit root test. The common unit root test assumes that there is a common unit root process across cross-sections, and the individual unit root test allows for individual unit root processes that vary across cross-sections. These tests are conducted on the null hypothesis that a level of panel data has a unit root, by including "intercept" and "trend and intercept" in the test equations. Table 1 reports the test results as follows: the common unit root test, i.e., Levin, Lin and Chu test, identifies the rejection of the null hypothesis of a unit root at 99 percent significant level in all the variables in the both test equations; and the individual unit root tests do not necessarily reject the null hypothesis of a unit root in all cases, but the Fisher-PP test rejects it at more than 95 percent level in all the variables in the test equation including the trend and intercept. Thus, it is speculated that the problem of low power in the unit root tests does not arise seriously, although the data might have cross-sectional dependence. The study, therefore, uses the level of panel data for the estimation.

3.2.3 Block Exogeneity Test

The block exogeneity test provides a data-driven toolkit to judge whether a variable should be included or excluded in an estimation model. The test justifies the inclusion of a variable depending on the existence of its Granger causality in a VAR framework. The Granger causality is identified by the rejection of the null hypothesis that the variable is excluded in a VAR model.

Table 2 reports the test result of Equation (2). The Granger causalities are confirmed: from growth of working-age population share (g_{was}) to growth of income per capita (g_{pcy}), from population growth (g_{pop}) to g_{was}, and from g_{pcy} and g_{was} to saving rate to income (*sav*). It should be noted that life expectancy (*lfe*) does not Granger-cause any other variables against the hypothesis that it would affect saving as presented in Section 2.2, and that population growth (g_{pop}) Granger-causes only growth of working-age population share (g_{was}) against the hypothesis that it would have direct impacts on economic growth as discussed in Section 2.1. Thus, the life expectancy can be excluded from the PVAR estimation, and the demographic factors can be represented only by growth of working-age population share.

The study then conducts an alternative PVAR estimation by focusing only on the three endogenous variables, namely, $y = (g_{pcy}, g_{was}, sav)'$ in Equation (2). Table 3 shows the alternative test result: g_{was} and *sav* Granger-cause g_{pcy}; and g_{pcy} and g_{was} Granger cause *sav*. Thus, the PVAR estimation with three endogenous variables identifies the causal effect of working-age population share on growth of income per capita through a direct channel through labor market and an indirect channel through saving. The three-variable estimation also confirms the feedback effect from growth of income per capita to saving, but not to working-age population share. The subsequent estimation will, therefore, be based on this three-variable estimation.

3.2.4 Impulse Response Test

Based on the three-variable PVAR mode estimation shown in Table 4, this section conducts an impulse responses test to trace out the dynamic responses of an variable to the one-unit shock of a set of variables. Table 5 and Figure 2 reveal the test results as follows. First, growth of income per capita (g_{pcy}) with a 95 percent error band responds positively to the one-unit shock of growth of working-age population share (g_{was}) in a continuous way after the shock. This positive response corresponds to a direct channel through labor market. Second, the shock of g_{was} is transmitted positively to saving rate to income (*sav*), and the shock of *sav* is further transmitted positively to g_{pcy}. These positive responses correspond to an indirect channel through saving. Third, the positive response of *sav* to the shock of g_{pcy} represents the feedback effect from growth of income per capita to saving.

Another angle to see variables' interactions is a variance decomposition test. The main findings from Table 6 are: in the variance of g_{pcy}, the contribution of g_{was} is greater than that of *sav*; and in the variance of *sav*, the contribution of g_{pcy} is larger than g_{was}.

3.2.5 Impact Analyses of Population Dynamics

This section, targeting 17 Asian economies, demonstrates the quantitative roles of population dynamics on economic growth for the past period of 1970-2018 and the future period of 2018-2050, and compares them with those of Bloom and Finlay (2009).

This analysis uses the elasticity values obtained by the impulse response test in Table 5. Since the impulse response of g_{pcy} to the shock of g_{was} peaks out at the fourth period, the estimation applies the response values to one unit (percent-point) shock at that period: 1.799 and 0.071 as the responses of g_{pcy} to the shocks of g_{was} and *sav*, respectively; and 4.694 and 1.069 as the responses of *sav* to the shocks of g_{pcy} and g_{was}, respectively. Thus, the variables' interactions are described as follows.

$$g_{pcy} = 1.799\ g_{was} + 0.071\ sav \quad (3)$$

$$sav = 4.692\ g_{was} + 1.069\ g_{pcy} \quad (4)$$

The sav in Equation (3) is substituted by Equation (4), and then Equation (3) is reorganized as follows.

$$g_{pcy} = \{1.799/(1–0.071*1.069)\}\ g_{was} + \{0.071*4.692/(1–0.071*1.069)\}\ g_{was} \qquad (5)$$

The first term in the right side of Equation (5) can be interpreted as a direct effect of growth of working-age population share on growth of income per capita, and the second term can be interpreted as an indirect effect through saving rate to income.

Table 7 shows the impact analyses of population dynamics in 17 Asian economies for 1970-2018 and for 2018-2050. In the upper table for the past period of 1970-2018, the column (a) denotes annual growth of income per capita; the column (b) indicates annual growth of working-age population share; the column (c) and (d) show the direct and indirect effects of population dynamics computed by the first and second terms of Equation (5), respectively; the column (e) is the sum of the direct and indirect effects in the column (c) and (d); the column (f) shows the contribution ratios of population dynamics, obtained by dividing the values in the column (e) by those in the column (a); and the last column refers to the contribution ratios in 13 Asian economies for 1965-2005 shown in Bloom and Finlay (2009). Focusing on the contribution ratios in the column (f), they are in a reasonable range from China (15.42 percent) to the Philippines (58.87 percent) with the average of 32.10 percent among 16 economies except Japan who has a negative contribution. The ratios in the column (f) are also comparable to those in Bloom and Finlay (2009) with the average of 27.08 percent among 10 economies except Japan, Pakistan and Nepal, and to the estimated results in Bloom and Williamson with around one-third demographic contributions in East Asia.

The lower part of Table 7 displays the projection of 2018-2025: the column (g) presents annual growth of working-age population share; the column (j) shows the sum of the direct effect in the column (h) and the indirect effect in the column (i); and the last column refers to the projected demographic effect in 13 Asian economies for 2005-2050 in Bloom and Finlay (2009). Looking at the column (j), a negative demographic effect on economic growth is identified in Japan, South Korea and China in East Asia; Singapore, Malaysia, Thailand, Indonesia, Vietnam and Myanmar in Southeast Asia; and Sri Lanka in South Asia. On the other hand, a positive effect is kept in the Philippines, Lao PDR and Cambodia in Southeast Asia; and India, Bangladesh, Pakistan and Nepal in South Asia. These projections on demographic effect reflects the difference in the transitionary processes from the population bonus to the onus among Asian economies as shown in Section 3.1. It should be noted that in comparison with the estimated results of Bloom and Finlay (2009) for 2005-2050, the degrees of the negative demographic effects are getting larger and those of the positive effects are getting smaller except in Nepal, in this study for 2018-2050. It is because the transitions from the population bonus to the onus have been moved forward in most of the economies under their lowering fertility rates and rising aging rates, based on the revisions of the World Population Prospects by the United Nations.

4. Concluding Remarks

This paper examined the effects of demographic dynamics on economic growth with a focus on working-age population and saving rate in 17 Asian economies for the past period from 1970 to 2018 and for the future period from 2018 to 2050. For the analytical methodology, this study applied a PVAR model considering endogenous interactions among concerned variables. The main findings are summarized as follows: first, the PVAR estimation identified both the direct channel from working-age population share to economic growth and the indirect channel through saving rate; second, the estimated result also found the feedback effect from economic growth to saving rate; third, the contribution ratio of the demographic factor to economic growth for the past period, around 30 percent on average in this study, is consistent with those in previous studies in the literature; and fourth, in the projection for 2018-2050, the degrees of the negative demographic effects are getting larger in sample economies than those of previous studies, because their transitions from the population bonus to the onus have been moved forward under their lowering fertility rates and rising aging rates.

The policy implications extracted from the findings above are twofold. For the economies that have already entered the phase of the population onus, they need to mitigate the negative effect of the decline in working-age population share. As Bloom and Finlay (2009) argued, the maintenance of effective labor forces requires such policies as encouraging women to enter job markets, extending retirement age or relaxing incentives to retire, and deregulating immigration. More fundamentally, the economies should focus more on productivity-driven growth strategies such as enhancing innovation and institutional qualities, restructuring industrial structures and developing human resources. For the economies that have still enjoyed the population bonus, they need to utilize this blessing for their structural reforms to maximum extent, to prepare well for the upcoming population onus.

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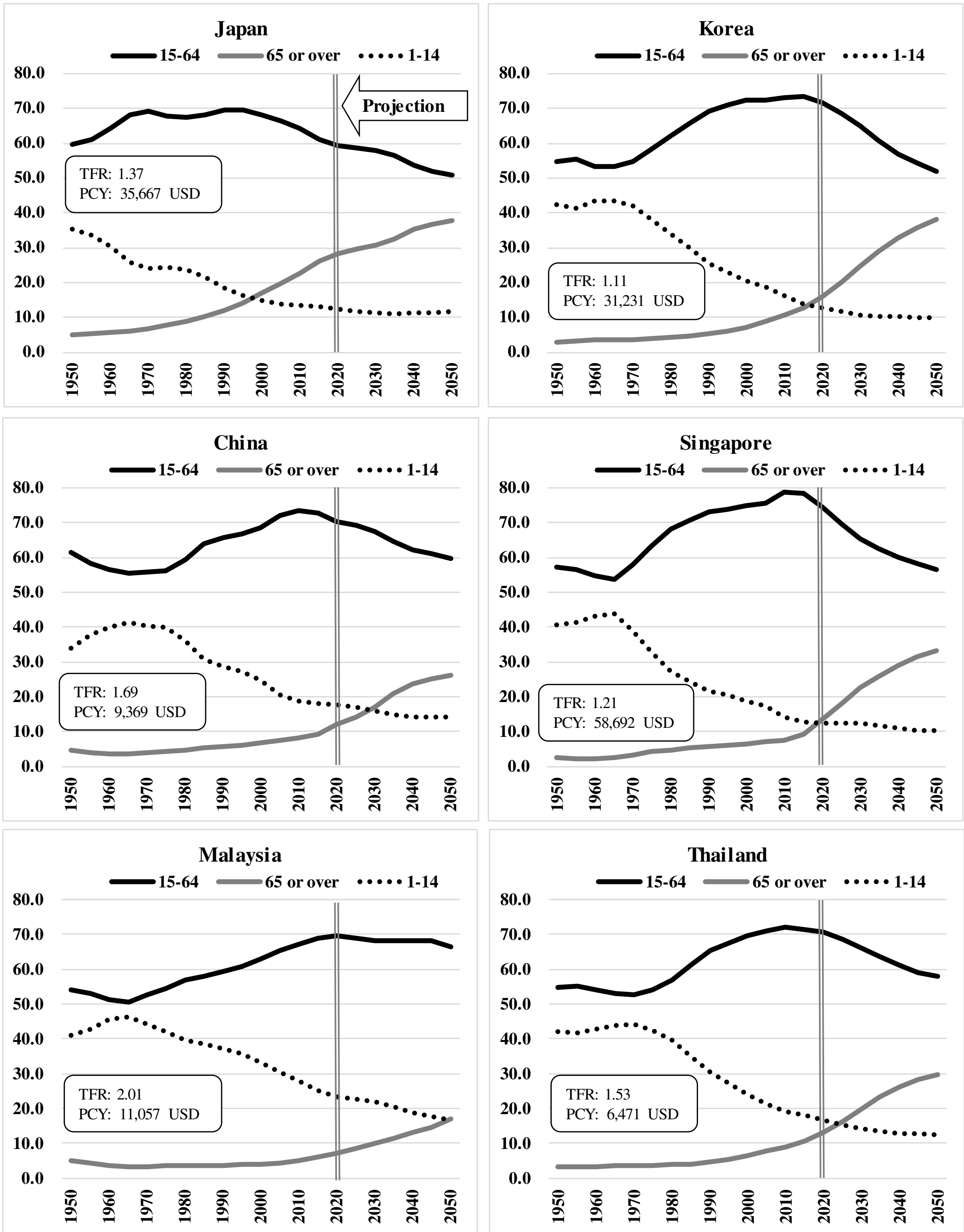
Figure 1 Demographic Dynamics in Asia for 1950-2050



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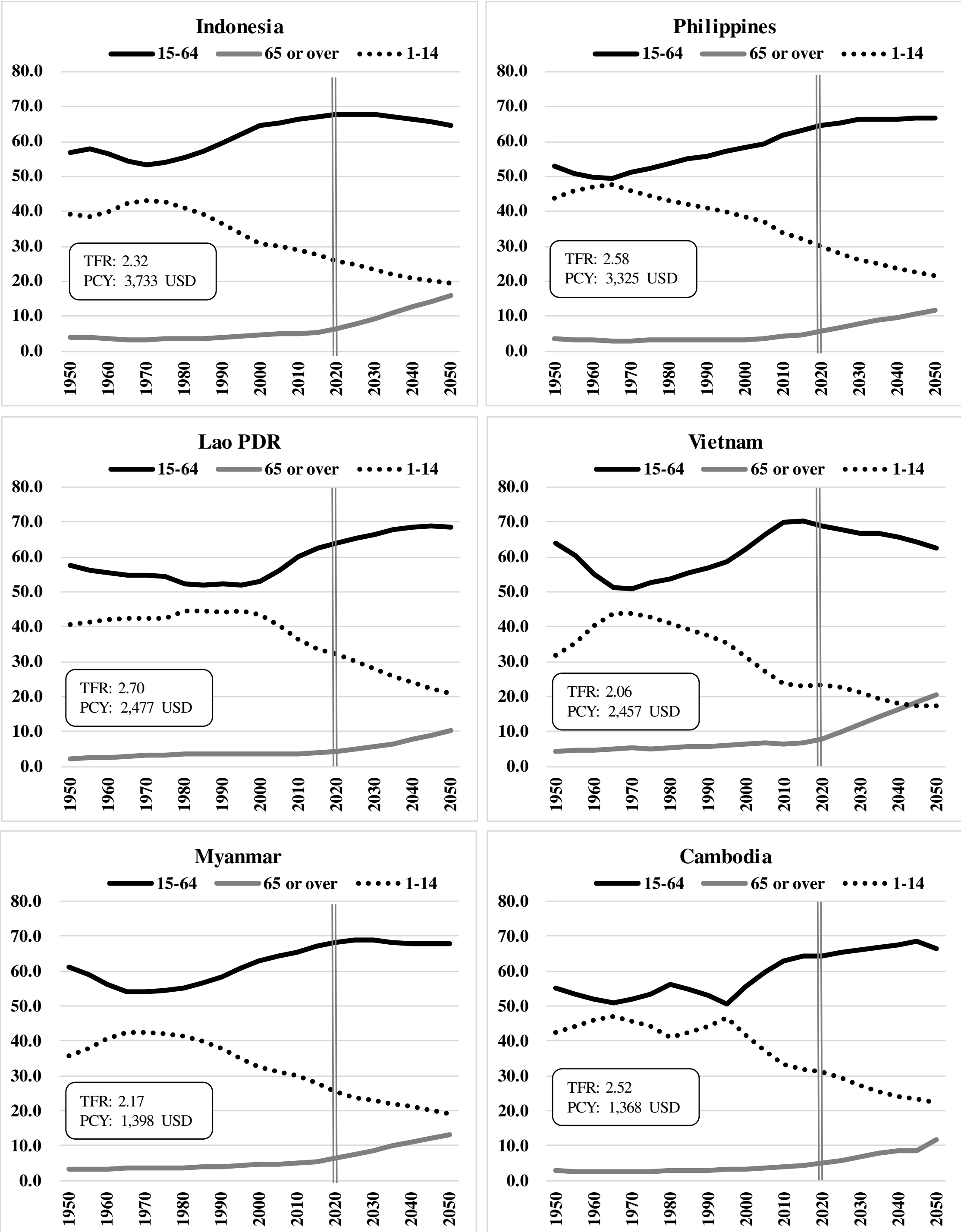
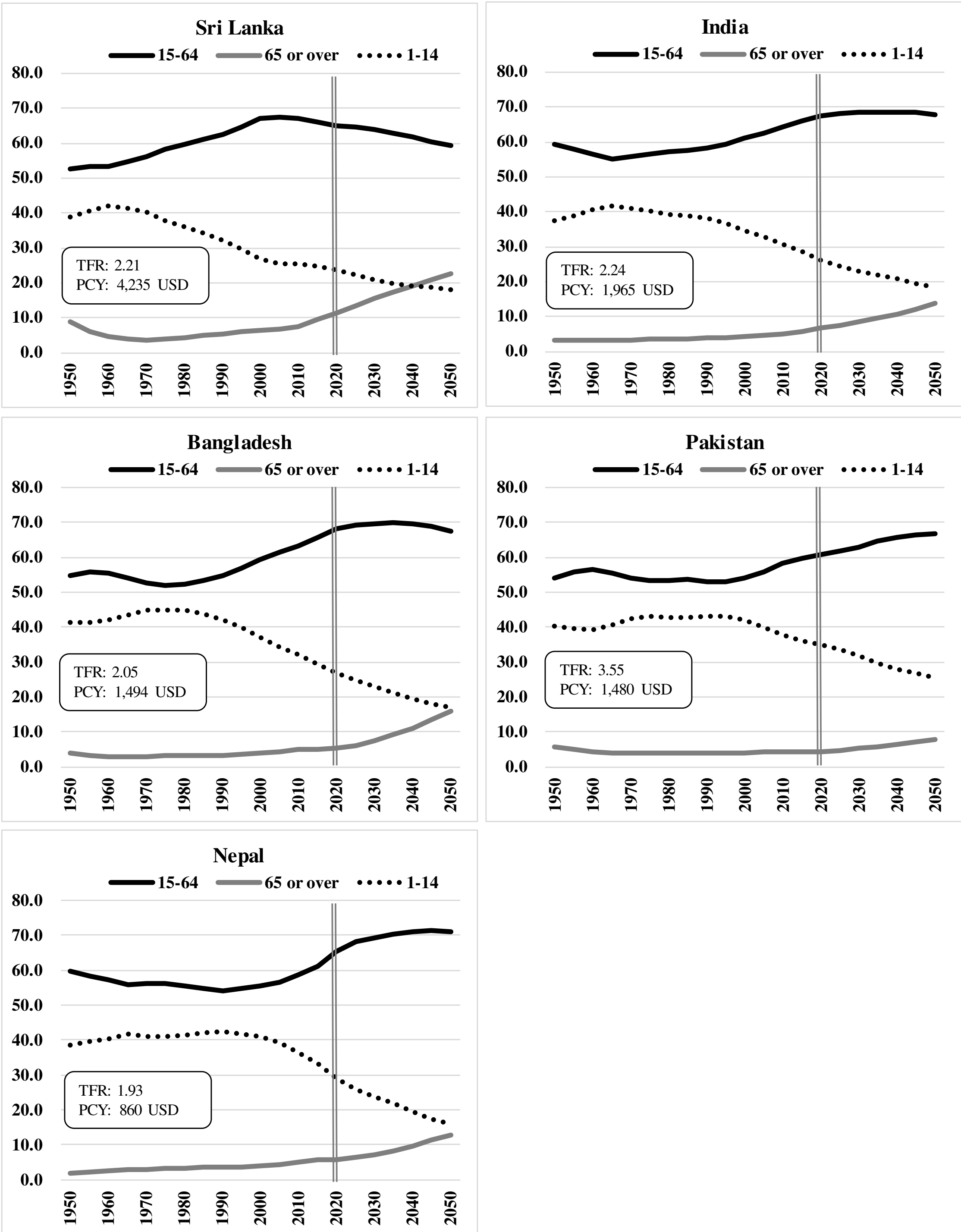


Indonesia
15-64
65 or over
1-14
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
TFR: 2.32
PCY: 3,733 USD
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
Philippines
15-64
65 or over
1-14
TFR: 2.58
PCY: 3,325 USD
Lao PDR
15-64
65 or over
1-14
TFR: 2.70
PCY: 2,477 USD
Vietnam
15-64
65 or over
1-14
TFR: 2.06
PCY: 2,457 USD
Myanmar
15-64
65 or over
1-14
TFR: 2.17
PCY: 1,398 USD
Cambodia
15-64
65 or over
1-14
TFR: 2.52
PCY: 1,368 USD

(continued)



Notes: TFR: Total fertility rate on the average for 2015-2020
PCY: GDP per capita at constant prices (2015) by US dollars in 2018

Sources: The author's description based on the 2019 Revision of World Population Prospects by the United Nations: https://population.un.org/wpp/Download/Standard/Population/.
UNCTADstat: https://unctadstat.unctad.org/EN/

Table 1 Panel Unit Root Tests

	g_{pcy}	g_{was}	*sav*	g_{pop}	*lfe*
[Intercept]					
Levin, Lin & Chu Test	-2.017 **	-2.782 ***	-2.501 ***	-2.929 ***	-10.152 ***
Fisher ADF Chi-square	41.569	38.546	30.756	30.497	59.713 ***
Fisher PP Chi-square	82.109 ***	34.496	35.430	64.160 ***	166.033 ***
Im, Pesaran and Shin W-stat	-0.802	-0.451	0.665	0.564	-2.250 **
[Intercept & Trend]					
Levin, Lin & Chu Test	-15.804 ***	-7.200 ***	-4.750 ***	-10.267 ***	-5.845 ***
Fisher ADF Chi-square	79.539 ***	47.005 *	47.452 *	50.725 **	38.014
Fisher PP Chi-square	114.782 ***	59.557 ***	53.058 **	88.779 ***	57.683 ***
Im, Pesaran and Shin W-stat	-2.626 ***	-0.676	0.060	-0.692	0.365

Note: *, **, and *** denote the rejection of the null hypothesis at the 90%, 95%, and 99% levels of significance.
Sources: Author's estimation

Table 2 Block Exogeneity Test on Five Endogenous Variables

Dependent Variable: g_{pcy}			
Excluded	Chi-sq	df	Probability
g_{was}	6.015	1	0.014
sav	0.115	1	0.734
g_{pop}	1.509	1	0.219
lfe	0.257	1	0.612
Dependent Variable: g_{was}			
Excluded	Chi-sq	df	Probability
g_{pcy}	0.717	1	0.397
sav	1.527	1	0.217
g_{pop}	13.635	1	0.000
lfe	0.541	1	0.462
Dependent Variable: *sav*			
Excluded	Chi-sq	df	Probability
g_{pcy}	23.049	1	0.000
g_{was}	4.088	1	0.043
g_{pop}	0.796	1	0.372
lfe	0.471	1	0.493

Sources: Author's estimation

Table 3 Block Exogeneity Test on Three Endogenous Variables

Dependent Variable: g_{pcy}			
Excluded	Chi-sq	df	Probability
g_{was}	12.830	1	0.000
sav	7.786	1	0.005
Dependent Variable: g_{was}			
Excluded	Chi-sq	df	Probability
g_{pcy}	2.312	1	0.128
sav	0.160	1	0.690
Dependent Variable: *sav*			
Excluded	Chi-sq	df	Probability
g_{pcy}	28.121	1	0.000
g_{was}	6.100	1	0.014

Sources: Author's estimation

Table 4 PVAR Model Estimation

	g_{pcy}	g_{was}	sav
g_{pcy} (-1)	0.573 ***	0.019	0.589 ***
	[8.512]	[1.520]	[5.303]
g_{was} (-1)	1.340 ***	0.687 ***	1.526 **
	[3.582]	[10.902]	[2.470]
sav (-1)	0.040 ***	0.001	0.902 ***
	[2.790]	[0.400]	[38.053]
pwy_0	-0.030	-0.010	0.097
	[-0.720]	[-1.327]	[1.399]
adj. R^2	0.285	0.408	0.926

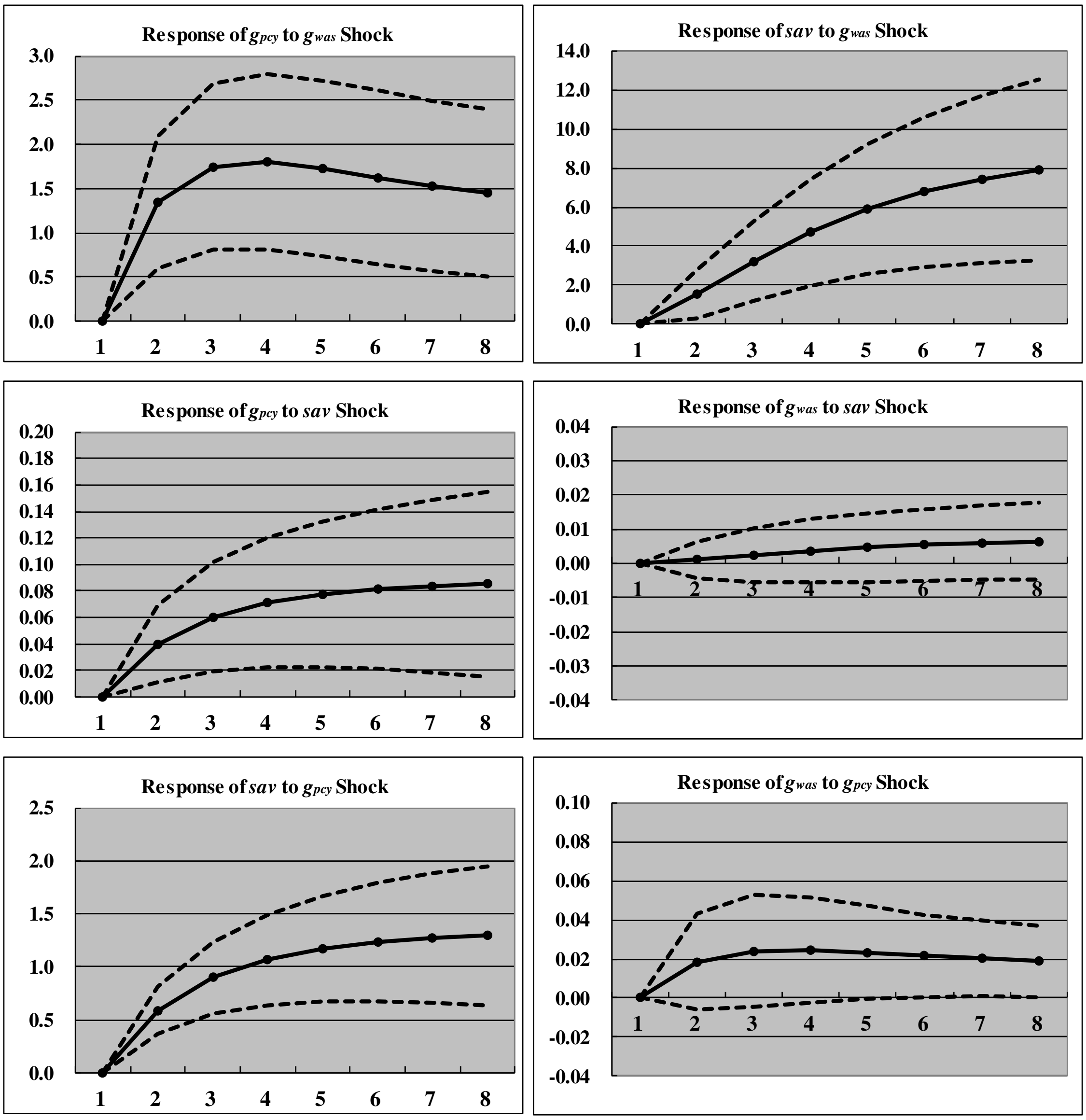
Note: **, and *** denote the rejection of the null hypothesis at the 95% and 99% levels of significance. T-statistics are in the parentheses.
Sources: Author's estimation

Table 5 Impulse Response Test

	Effect of g_{was} Innovation		Effect of sav Innovation		Effect of g_{pcy} Innovation	
	g_{pcy}	sav	g_{pcy}	g_{was}	sav	g_{was}
1st	0.000	0.000	0.000	0.000	0.000	0.000
2nd	1.340 **	1.526 **	0.040 **	0.001	0.589 **	0.019
3rd	1.750 **	3.216 **	0.060 **	0.002	0.898 **	0.024
4th	1.799 **	4.694 **	0.071 **	0.004	1.069 **	0.024
5th	1.726 **	5.873 **	0.078 **	0.005	1.169 **	0.023
6th	1.624 **	6.772 **	0.081 **	0.005	1.231 **	0.022 **
7th	1.528 **	7.439 **	0.084 **	0.006	1.270 **	0.020 **
8th	1.447 **	7.924 **	0.085 **	0.006	1.295 **	0.019 **

Note: ** denotes the rejection of the null hypothesis at the 95% level of significance.
Sources: Author's estimation

Figure 2 Impulse Response Test



Note: The dotted lines denote a 95 percent error band over 8 periods.
Sources: Author's estimation

Table 6 Variance Decomposition

	Variance Decomposition of g_{pcy}		
	g_{pcy}	g_{was}	sav
1st	100.000	0.000	0.000
2nd	95.505	3.870	0.625
3rd	89.845	8.575	1.580
4th	84.958	12.461	2.581
5th	81.113	15.359	3.528
6th	78.119	17.482	4.399
7th	75.747	19.059	5.194
8th	73.820	20.260	5.920
	Variance Decomposition of g_{was}		
	g_{pcy}	g_{was}	sav
1st	3.173	95.200	1.627
2nd	5.506	92.795	1.699
3rd	7.433	90.747	1.820
4th	8.934	89.089	1.976
5th	10.103	87.741	2.156
6th	11.033	86.617	2.350
7th	11.795	85.650	2.554
8th	12.441	84.796	2.764
	Variance Decomposition of sav		
	g_{pcy}	g_{was}	sav
1st	4.758	0.000	95.242
2nd	17.799	1.235	80.967
3rd	27.564	3.990	68.446
4th	33.735	7.333	58.932
5th	37.484	10.609	51.907
6th	39.774	13.534	46.692
7th	41.203	16.035	42.762
8th	42.123	18.133	39.744

Sources: Author's estimation

Table 7 Impact Analyses of Population Dynamics

[1970-2018]

Country	Growth of *pcy* [annual, %] 1970-2018 (a)	Growth of *was* [annual, %] 1970-2018 (b)	Direct effect of g_{was} on g_{pcy} (c)	Indirect effect of g_{was} on g_{pcy} through *sav* (d)	(c)+(d) (e)	(e)/(a) [%] (f)	Bloom & Finlay (2009) 1965-2005
Japan	2.024	-0.301	-0.608	-0.227	-0.835	-34.26	9.53
Korea	5.844	0.592	1.197	0.448	1.646	23.39	36.40
China	7.591	0.507	1.026	0.384	1.410	15.42	16.46
Singapore	4.598	0.576	1.164	0.436	1.599	28.88	51.13
Malaysia	4.138	0.583	1.179	0.442	1.621	32.54	26.71
Thailand	4.099	0.631	1.275	0.477	1.753	35.51	20.81
Indonesia	3.987	0.490	0.990	0.371	1.361	28.35	41.01
Philippines	1.844	0.471	0.951	0.356	1.307	58.87	36.18
Lao PDR	3.928	0.305	0.616	0.231	0.846	17.90	-
Viet Nam	4.249	0.655	1.324	0.496	1.820	35.58	-
Myanmar	4.703	0.478	0.966	0.362	1.327	23.44	-
Cambodia	1.956	0.445	0.900	0.337	1.237	52.54	-
Sri Lanka	3.674	0.320	0.647	0.242	0.890	20.11	32.30
India	3.537	0.375	0.758	0.284	1.042	24.47	0.27
Bangladesh	2.271	0.516	1.043	0.390	1.433	52.41	9.53
Pakistan	1.953	0.240	0.485	0.182	0.667	28.35	-3.90
Nepal	2.243	0.272	0.549	0.206	0.754	27.94	-50.32

[2018-2050]

Country	Growth of *was* [annual, %] 2018-2050 (g)	Direct effect of g_{was} on g_{pcy} (h)	Indirect effect of g_{was} on g_{pcy} through *sav* (i)	(g)+(h) (j)	Bloom & Finlay (2009) 2005-2050
Japan	-0.510	-1.030	-0.386	-1.18	-0.91
Korea	-1.035	-2.093	-0.784	-2.39	-0.87
China	-0.545	-1.101	-0.412	-1.26	-0.36
Singapore	-0.930	-1.879	-0.704	-2.15	-0.78
Malaysia	-0.139	-0.280	-0.105	-0.32	0.13
Thailand	-0.629	-1.271	-0.476	-1.45	-0.45
Indonesia	-0.136	-0.275	-0.103	-0.31	-0.05
Philippines	0.137	0.277	0.104	0.32	0.46
Lao PDR	0.251	0.508	0.190	0.58	-
Viet Nam	-0.340	-0.687	-0.257	-0.78	-
Myanmar	-0.009	-0.017	-0.006	-0.02	-
Cambodia	0.096	0.193	0.072	0.22	-
Sri Lanka	-0.297	-0.600	-0.225	-0.69	-0.26
India	0.048	0.096	0.036	0.11	0.36
Bangladesh	0.011	0.022	0.008	0.03	0.42
Pakistan	0.304	0.614	0.230	0.70	0.73
Nepal	0.336	0.679	0.254	0.77	0.66

Sources: Author's estimation