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Contents

Abstract

The demographic dividend that contributed substantially to economic growth in developing Asia in the past is dissipating. Population aging affects growth through savings, capital accumulation, labor force participation, and total factor productivity. We examined the impact of aging on those four channels in 12 developing Asian economies that collectively make up the bulk of the region's population and output. We then made projections about the effects of demographic change on the economic growth of the 12 from 2011 to 2020 and from 2021 to 2030. Our results indicate that there will be a sizable adverse economic impact where population aging is more advanced.

I. Introduction

Logically, demographic structure—the age structure of a country's population—should affect that country's economic performance. A country with a youthful population will be more productive than a country with an older one as it will have a larger labor force relative to population size. More workers produce more goods and services, so younger countries tend to grow faster economically than older countries. A general loss of economic dynamism explains why advanced economies with maturing populations are concerned about population aging and also helps to explain why such economies have become more open to immigration in recent years. The ongoing shift of global economic power from advanced economies to developing economies to some extent reflects the demographic differences between the two.

Due to a wide range of economic and social factors, developing Asia has begun to follow in the demographic footsteps of the advanced economies; the demographic transition now under way in the region shares many of the same features. Rising living standards have led to mortality declines that in turn have resulted in a fall in birth rates and a rise in life expectancy. Better health care has been a key factor in both, and improvements in female education and the greater participation of women in the labor force along with reduced reliance on children for old-age support have also contributed to lower birth rates. In short, developing Asia's population aging follows the general historical pattern of countries growing older as they get richer.

Developing Asia's seemingly inexhaustible supply of workers for export-oriented industrialization catapulted the region from the periphery to the center of the world economy, but the working-age population in the region is aging and is expected to do so at accelerated rates in the coming decades though this will vary from economy to economy. Some economies still have youthful populations while in others aging is a much more immediate issue. Regardless of these differences, the region as a whole will have to address the economic consequences of the demographic transition to sustain growth in the medium and long term.

Our objective was to project the impact of the demographic transition on the economic growth of 12 developing Asian economies from 2011 to 2020 and from 2021 to 2030 using projections of age structures readily available from the United Nations (UN) population database. To make our projections, we first used past data to estimate the impact of the old-age dependency ratio and the youth dependency ratio on three primary determinants of economic growth: labor force participation, capital accumulation, and the growth of total factor productivity (TFP). On the basis of those estimates, we projected how the two dependency ratios would affect the three determinants in the next 2 decades. We made separate projections for each of the two channels through which demographic change can influence capital accumulation, i.e., directly and indirectly via savings. Summing the projected impact of the two demographic variables gave us the projected impact on growth.

Our analysis is based on well grounded theoretical rationales for why demographic change can have a significant influence on economic growth. The economic needs and contributions of individuals vary over the course of their economic lifecycles. It is well known that working-age adults tend to work and save more than youth or those aged 60 and older. That is, the ratio of consumption to production is generally high for youth and low for working-age adults. Children rely on parents for material needs during the early years of life. After retirement, adults rely on income from savings, transfers from children, and pension benefits. Between youth and retirement, adults work to provide for their families and to save for retirement. A larger labor force therefore contributes directly to economic growth, and higher savings rates contribute to growth by boosting the investment rate.

The theoretical basis for the relationship between demographic change on one hand and labor supply and savings on the other is well established. It is also intuitively plausible that population aging may directly affect investment. To the extent that physical capital can substitute for labor, an economy can accumulate more capital in order to compensate for the slowdown in the growth of the labor force. Capital and labor can, however, also be complements; this would dilute the positive effect of aging on investment. Changes in the age structure of the labor force can also influence the investment rate. For example, older workers may need more capital than younger workers to compensate for their diminished physical strength. In addition, demographic change will have a sizable effect on the structure of demand for services and goods for the elderly and may bring about structural changes in production, e.g., the capital intensity of production that can in turn influence the investment rate.

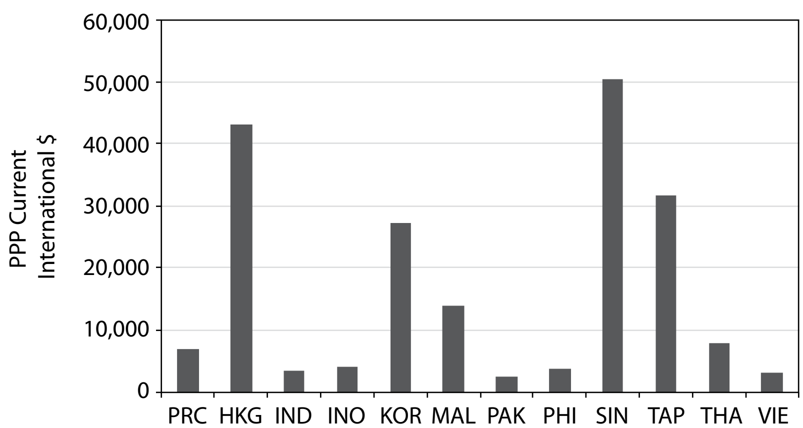
Finally, economic intuition suggests that demographic changes will affect labor productivity. Older workers tend to have more experience and knowledge, but younger workers tend to be physically stronger and have stronger incentives to invest in human capital. Alesina, Spolaore, and Wacziarg (2003) point out that declining fertility affects not only the size of the working-age population but also its age structure. Due to age-specific differences in labor productivity, the aggregate productivity of a country with larger numbers of older, experienced workers will be higher than that of a younger country. Since labor productivity grows fastest and peaks between the ages of 35 and 54, the productive capacity of a country with a large proportion of workers in the prime age group should be markedly higher than that of a country with more younger or older workers. An analysis of a balanced panel of 84 countries by Gomez and Hernandez de Cos (2008) found evidence that an increase in the share of workers in the prime age group had a positive but curvilinear effect on per capita gross domestic product (GDP). While labor productivity and TFP are separate concepts, the former will have a significant effect on the latter under certain conditions. In fact, the two appear to be equivalent if we assume a Cobb-Douglas production function. In this connection, in a study of 10 Canadian provinces from 1981 to 2001 with projections up to 2046, Tang and MacLeod (2006) found that older workers were, on average, less productive than younger workers and that an aging labor force had a negative effect on productivity.

Our quantitative projections will give developing Asia's policy makers some insights into the impact of demographic change on economic growth that will help them design and implement appropriate policies for sustaining growth as the demographic dividend dissipates. The exact impact of aging and hence the appropriate policy response will necessarily differ from economy to economy given the wide diversity of demographic profiles in the region.

II. Population Aging in Developing Asia: Trends and Prospects

The 12 economies in our sample are the People's Republic of China (PRC); Hong Kong, China; India; Indonesia; the Republic of Korea; Malaysia; Pakistan; the Philippines; Singapore; Taipei,China; Thailand; and Viet Nam. They encompass a very wide range of income and development levels. In terms of purchasing power parity, GDP per capita in 2009 ranged from $2,596 in Pakistan and $2,939 in Viet Nam to $43,134 in Hong Kong, China and $50,650 in Singapore (Figure 1).

Figure 1: Gross Domestic Product Per Capita, Purchasing Power Parity in 2009 for 11 Asian Economies



HKG = Hong Kong, China; IND = India; INO = Indonesia; KOR = Korea, Rep. of; MAL = Malaysia; PAK = Pakistan; PHI = Philippines; PPP = purchasing power parity; PRC = China, People's Rep. of; SIN = Singapore; TAP = Taipei,China; THA = Thailand; VIE = Viet Nam.

Source: World Bank (2010) accessed 19 September 2011.

In general, all the economies in our sample are clearly experiencing a demographic transition toward older populations. Table 1 shows the old-age ratio—the ratio of those aged 65 or older to the working-age population (people aged 15–64)—and the youth-dependency ratio—the ratio of those aged 0–14 to the working-age population. Figures 2 and 3 show slightly different definitions of the old-age and youth-dependency ratios with total population replacing the working-age population as the denominator.[1] For both definitions, the share of the elderly has grown visibly throughout the region and is projected to growth further in the next 2 decades. Conversely, the share of youth has shrunk and will continue to shrink in the coming years.

Table 1: Actual and Projected Demographic Changes in 12 Asian Economies, 1981–2030

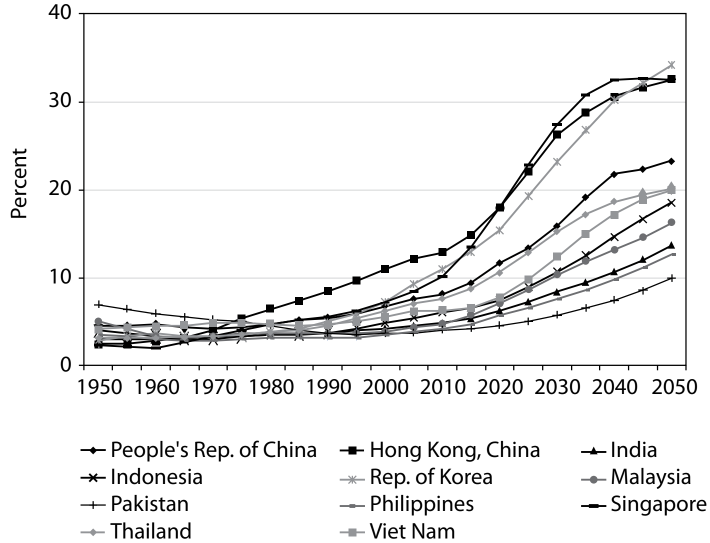
	Actual			Projections	
	1981–1990	1991–2000	2001–2007	2011–2020	2021–2030
China, People's Rep. of					
Youth dependency	0.481	0.409	0.328	0.273	0.260
Old-age dependency	0.081	0.092	0.106	0.137	0.200
Hong Kong, China					
Youth dependency	0.336	0.268	0.203	0.150	0.173
Old-age dependency	0.109	0.139	0.163	0.210	0.340
India					
Youth dependency	0.668	0.613	0.540	0.440	0.363
Old-age dependency	0.064	0.068	0.073	0.083	0.107
Indonesia					
Youth dependency	0.654	0.522	0.437	0.363	0.307
Old-age dependency	0.062	0.069	0.082	0.100	0.130
Korea, Rep. of					
Youth dependency	0.448	0.321	0.270	0.200	0.193
Old-age dependency	0.067	0.086	0.124	0.183	0.287
Malaysia					
Youth dependency	0.664	0.588	0.496	0.407	0.347
Old-age dependency	0.064	0.062	0.066	0.090	0.130
Pakistan					
Youth dependency	0.827	0.800	0.686	0.580	0.497
Old-age dependency	0.076	0.068	0.066	0.073	0.083
Philippines					
Youth dependency	0.758	0.683	0.599	0.500	0.430
Old-age dependency	0.058	0.058	0.063	0.080	0.103
Singapore					
Youth dependency	0.337	0.307	0.279	0.183	0.193
Old-age dependency	0.074	0.089	0.115	0.193	0.357
Taipei,China					
Youth dependency	0.449	0.343	0.270	0.183	0.163
Old-age dependency	0.080	0.111	0.133	0.180	0.299
Thailand					
Youth dependency	0.554	0.403	0.336	0.293	0.287
Old-age dependency	0.068	0.082	0.100	0.127	0.190
Viet Nam					
Youth dependency	0.747	0.632	0.471	0.337	0.300
Old-age dependency	0.085	0.088	0.095	0.097	0.143

Note: Youth and old-age dependency rates, obtained from World Bank (2010) are defined as the percentage of the population below age 15 and over age 64 divided by the working-age population (age between 15 and 65) , respectively. Projections of aging were obtained from UN (2009).

Sources: World Bank (2010) accessed 5 April 2011; UN (2009) accessed 1 May 2011.

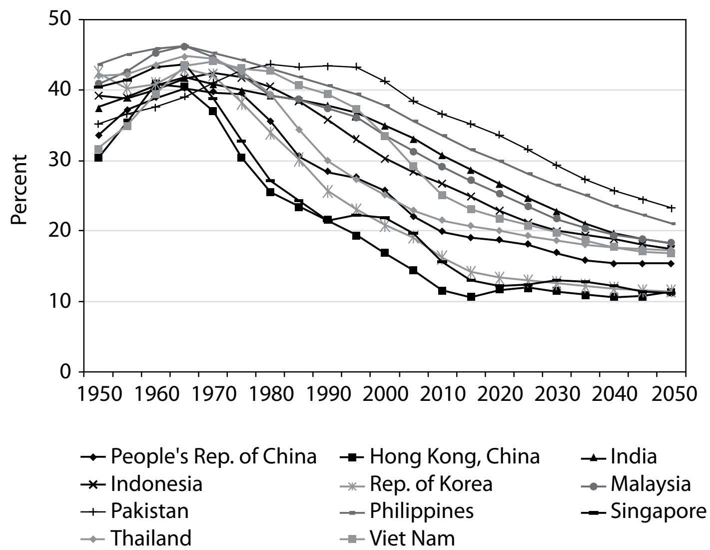
[1] Taipei,China is not included in Figures 2 and 3 due to a lack of United Nations data.

Figure 2: Population Aged 65 and Older as a Share of Total Population in 11 Asian Economies, 1950–2050



Source: UN (2009) accessed 1 May 2011.

Figure 3: Population Aged 0–14 as a Share of Total Population in 1 Asian Economies, 1950–2050



Source: UN (2009) accessed 1 May 2011.

Although the trend toward older populations is regionwide, there is nevertheless a great deal of diversity in the demographic profiles of the 12. By 2021–2030, the ratio of elderly to the working-age population will exceed 33% in Hong Kong, China and Singapore. In striking contrast, the corresponding figures for Pakistan and the Philippines will be only 8.3% and 10.3% respectively (Table 1).

Due to its very rapid growth, developing Asia is compressing industrialization and economic transformation into a much shorter time period than the advanced economies did, and the region is replicating the demographic transition of the advanced economies within a much shorter time frame as well. In fact, the sheer speed and scale of the region's population aging are unprecedented and are largely driven by the region's exceptional economic growth.

III. Sources of Growth

Because demographic change affects growth through a number of different channels, in order to estimate the impact of population aging on economic growth we first have to estimate growth and identify its sources. In order to get the broader picture in developing Asia, we estimated growth rates of aggregate GDP, per capita GDP, per capita labor input, TFP, per capita physical capital, and education or human capital from 1981 to 2007. We also estimated the relative contribution of the different determinants of per capita GDP, i.e., per capita labor input, TFP, per capita physical capital, and education.

We used a standard Cobb-Douglas aggregate production function in which output is produced by combining productive inputs and TFP. In order to capture the impact of demographic change we distinguished between population, P and labor force, L. Per capita GDP $\frac{Y}{P}$ is the product of per capita labor force—the ratio of workers to total population—and the ratio of output to labor force.

$$\frac{Y}{P} = \frac{L}{P}\frac{Y}{L} = \frac{L}{P}\frac{AK^{\alpha}(hL)^{1-\alpha}}{L} = \frac{L}{P}A\left(\frac{K}{L}\right)^{\alpha}h^{1-\alpha} \quad (1)$$

where Y = aggregate GDP, P = population, L = labor force, A = total factor productivity, K = aggregate physical capital, h = human capital, and α = share of capital in income.

The growth rate of per capita GDP (= $\frac{Y}{P}$) is equal to the growth rate of per capita labor force plus the growth rate of per labor GDP.

$$\Delta\ln\left(\frac{Y}{P}\right) = \Delta\ln\left(\frac{L}{P}\right) + \Delta\ln\left(\frac{Y}{L}\right) \quad (2)$$

As population aging progresses, if the labor participation rate of the elderly does not change, the growth rate of per capita labor force will decrease. This should be a very important channel through which aging influences economic growth; we explore it in the next section. Note, however, that this is only a temporary effect because the growth rate of per capita labor force cannot increase or decrease forever.

We can disaggregate the growth rate of per labor GDP (= $\frac{Y}{L}$) further as follows.

$$\Delta\ln\left(\frac{Y}{L}\right) = \Delta\ln(A) + \propto \Delta\ln\left(\frac{K}{L}\right) + (1-\propto)\Delta\ln(h) \quad (3)$$

Combining (2) and (3) gives us:

$$\Delta\ln\left(\frac{Y}{P}\right) = \Delta\ln\left(\frac{L}{P}\right) + \Delta\ln(A) + \propto \Delta\ln\left(\frac{K}{L}\right) + (1-\propto)\Delta\ln(h) \quad (2)'$$

Equation (2)' shows that the growth rate of per capita GDP is made up of four components: the growth rates of (i) per capita labor, (ii) TFP, (iii) per labor physical capital, and (iv) human capital.

Our data source for aggregate and per capita GDP and for investment and population was Penn World Table 6.3 (Heston et al. 2009), for labor force was the International Labour Organization's Office of Statistics LABORSTA database (ILO 2010) accessed 15 March 2011, and for human capital was Barro and Lee (2010). We calculated the physical capital stock by using the standard approach of Harberger (1978) which assumes that the economy is initially in a steady state. Then the remaining capital stock is constructed by the perpetual inventory method:

$$K_t = (1-\delta)K_{t-1} + I_t \quad (4)$$

where δ is the depreciation rate set at 6%.

Following Barro and Lee (2010), we assumed that human capital per unit of labor has a relation to the number of years of schooling as follows:

$$\mathrm{h} = e^{\theta s} \quad (5)$$

where θ measures the average marginal return on an additional year of schooling, and hence θs is the efficiency of a unit of labor with *s* years of education relative to one without any schooling. Following Barro and Lee (2010), we set θ = 8%.

Table 2 reports the results of our basic growth accounting exercise for per capita GDP. We assumed that share of labor income was 0.6. The table reports the growth rates of aggregate GDP, per capita GDP, per capita labor input, TFP, per capita physical capital, and human capital output for the two most recent decades—1981–1990 and 1991–2000—and for 2001–2007 as well as the entire sample period 1981–2007.[2]

Table 2: Growth Accounts for 12 Asian Economies, 1981–2007 (%)

	1981–1990	1991–2000	2001–2007	1981–2007
China, People's Rep. of				
Aggregate GDP	8.34	9.10	11.10	9.34
Per capita GDP	6.80	8.10	10.52	8.25
Per capita labor input	1.01	0.14	0.25	0.49
Total factor productivity	2.98	3.76	6.11	4.08
Per labor physical capital	5.97	8.73	9.14	7.82
Education/human capital	0.70	1.19	0.84	0.92
Hong Kong, China				
Aggregate GDP	6.24	3.85	4.69	4.95
Per capita GDP	5.07	2.28	4.02	3.76
Per capita labor input	0.41	0.13	0.75	0.39
Total factor productivity	1.77	0.32	1.99	1.29
Per labor physical capital	5.58	4.70	1.80	4.27
Education/human capital	1.11	–0.08	0.93	0.62
India				
Aggregate GDP	5.39	4.75	6.74	5.50
Per capita GDP	3.37	2.94	5.05	3.65
Per capita labor input	0.16	0.16	0.45	0.23
Total factor productivity	1.61	1.05	1.84	1.46
Per labor physical capital	2.66	3.44	5.76	3.76
Education/human capital	0.88	0.60	0.75	0.75
Indonesia				
Aggregate GDP	5.67	4.17	4.51	4.81
Per capita GDP	3.78	2.55	3.18	3.17
Per capita labor input	1.14	1.12	0.64	1.00
Total factor productivity	0.17	–0.31	2.05	0.48
Per labor physical capital	5.87	3.15	0.01	3.34
Education/human capital	0.21	0.79	0.80	0.58
Korea, Republic of				
Aggregate GDP	8.96	5.34	3.98	6.33
Per capita GDP	7.78	4.46	3.55	5.46
Per capita labor input	1.25	0.76	0.59	0.90
Total factor productivity	3.04	–0.04	1.12	1.40
Per labor physical capital	7.46	7.31	3.62	6.41
Education/human capital	0.84	1.37	0.65	0.99
Malaysia				
Aggregate GDP	5.86	7.41	5.18	6.26
Per capita GDP	3.45	5.21	3.32	4.07
Per capita labor input	0.68	0.77	0.48	0.66
Total factor productivity	0.29	1.10	1.84	0.99
Per labor physical capital	4.68	5.81	1.18	4.19
Education/human capital	1.02	1.70	0.89	1.24
Pakistan				
Aggregate GDP	5.99	3.50	6.16	5.11

continued.

[2] The last time period is 2001–2007 rather than 2001–2010 due to data limitations.

Table 2: *continued.*

	1981–1990	1991–2000	2001–2007	1981–2007
Per capita GDP	3.03	1.06	4.08	2.57
Per capita labor input	–0.12	0.49	1.50	0.53
Total factor productivity	1.84	–0.35	1.63	0.97
Per labor physical capital	2.37	1.12	0.12	1.33
Education/human capital	0.61	0.77	1.50	0.90
Philippines				
Aggregate GDP	2.02	3.77	4.85	3.40
Per capita GDP	–0.43	1.55	2.74	1.12
Per capita labor input	0.42	0.48	0.35	0.42
Total factor productivity	–1.26	0.42	1.98	0.20
Per labor physical capital	0.02	0.68	0.18	0.31
Education/human capital	0.67	0.65	0.56	0.63
Singapore				
Aggregate GDP	7.03	7.84	5.02	6.81
Per capita GDP	4.70	5.03	3.30	4.46
Per capita labor input	0.98	0.04	0.58	0.53
Total factor productivity	1.49	2.64	1.90	2.02
Per labor physical capital	3.91	4.12	0.90	3.21
Education/human capital	1.11	1.16	0.76	1.04
Taipei,China				
Aggregate GDP	7.61	6.38	3.70	6.14
Per capita GDP	6.25	5.48	3.25	5.19
Per capita labor input	1.02	0.60	0.85	0.82
Total factor productivity	2.47	1.28	0.49	1.52
Per labor physical capital	5.52	7.40	2.99	5.56
Education/human capital	0.91	1.06	1.18	1.03
Thailand				
Aggregate GDP	7.53	3.81	4.82	5.45
Per capita GDP	5.93	2.67	4.10	4.25
Per capita labor input	1.43	–0.30	0.49	0.54
Total factor productivity	2.40	0.04	2.61	1.58
Per labor Ppysical capital	4.04	6.47	0.81	4.10
Education/human capital	0.81	0.56	1.12	0.80
Viet Nam				
Aggregate GDP	5.69	6.45	7.38	6.41
Per capita GDP	3.44	4.84	6.30	4.70
Per capita labor input	0.50	0.38	1.00	0.58
Total factor productivity	2.95	0.38	1.39	1.60
Per labor physical capital	1.35	9.04	8.23	5.98
Education/human capital	–0.92	0.77	1.04	0.22

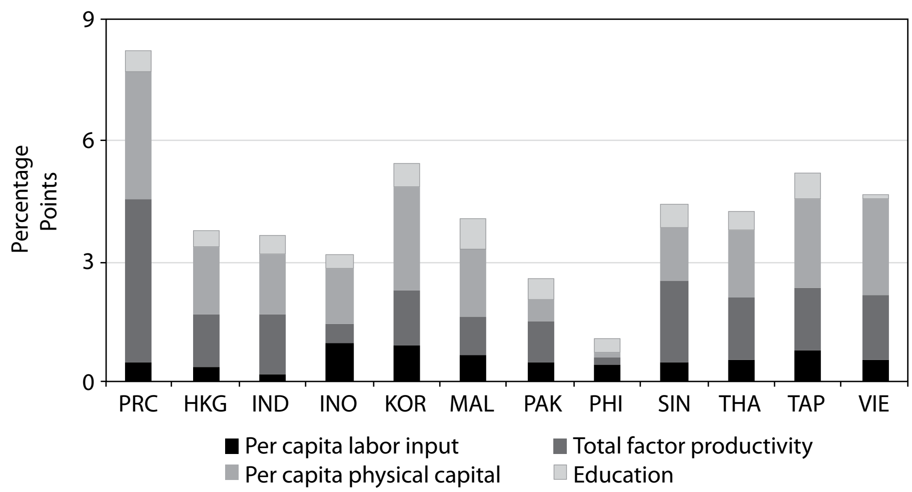
GDP = gross domestic product.
Note: We report annual average growth rates. The labor share is set at .6 for all economies.
Source: Authors' calculations.

Again, it is worth repeating that our variable of interest is per capita GDP, not per labor GDP. The growth rate of per capita GDP steadily decreased in the Republic of Korea and Taipei,China, both of which are maturing, high-income economies, while the growth rates in the PRC and Viet Nam—two fast-growing economies at much lower income levels—accelerated from 1981 to 2007. The growth rate of per capita GDP from 2001 to 2007 was lower than that for the entire sample period in the Republic of Korea; Malaysia;

Singapore; Taipei,China; and Thailand. The average growth rate of per capita labor input was higher than 0.5% from 1981 to 2007 in Indonesia; the Republic of Korea; Malaysia; Pakistan; Singapore; Taipei,China; Thailand; and Viet Nam, but it is likely that this trend will be reversed as the populations age.

Figure 4 shows the relative contributions of per capita labor input, TFP, per capita physical capital, and education to the growth rate of per capita GDP. Our results indicated that in most countries, per capita physical capital has played a major role in economic growth which is consistent with the results of most existing studies and with the widespread perception that high investment rates contributed substantially to developing Asia's growth by rapidly augmenting the physical capital stock and hence productive capacity. At the same time, TFP growth also played a key role. This suggests that changes in technical efficiency along with technical progress made a substantial contribution to the region's economic growth. In the case of the PRC, in fact, growth in TFP contributed more to economic growth than capital accumulation. For the region as a whole, labor inputs and education accounted for only a relatively small share of growth.

Figure 4: Contribution to Per Capita GDP Growth in 12 Asian Economies, 1981–2007



HKG = Hong Kong, China; IND = India; INO = Indonesia; KOR = Rep. of Korea; MAL = Malaysia; PAK = Pakistan; PHI = Philippines; PRC = People's Rep. of China; SIN = Singapore; THA = Thailand; TAP = Taipei,China; VIE = Viet Nam.

Source: Authors' calculations.

IV. The Impact of Demographic Change on Developing Asia's Economic Growth

We estimated the effects of the old-age dependency and youth ratios on four sources of growth in the 12 economies: labor force participation, TFP, the capital to labor ratio, and the savings rate. More precisely, we measured the impact of aging on the growth rate of per capita GDP (=Y/P) based on equation (2)':

$$\Delta\ln\left(\frac{Y}{P}\right) = \Delta\ln\left(\frac{L}{P}\right) + \Delta\ln(A) + \propto \Delta\ln\left(\frac{K}{L}\right) + (1-\propto)\Delta\ln(h) \quad (2)'$$

Suppose the growth rate of per capita GDP changed. According to equation (2)', this means that there were changes in any of the four components on the right-hand side. It is reasonable to expect that the four components are simultaneously determined, so although it would be best to form a system of four equations, it would be too complicated. To simplify the analysis, we assumed that the first and the last terms—labor force participation and education—were independently determined. We assumed that the labor participation rate was determined primarily by the level of per capita GDP and by demographic factors. The results of the regression analysis are reported in Table 3.

Table 3: Impact on Aging of the Growth Rate of Labor Force Participation

	[1] Random Effects	[2] Fixed Effects
Old-age dependency	–0.056***	–0.068**
	[0.008]	[0.028]
Youth dependency	–0.003	–0.016**
	[0.003]	[0.007]
Per capita GDP	0.010***	0.003
	[0.004]	[0.011]
Per capita GDP^2	–0.000**	0
	[0.000]	[0.001]
Observations	514	514
R-squared	0.32	0.125

** significant at 0.05, and *** significant at 0.01 using a two-tailed test.
GDP = gross domestic product.
Note: Both dependent and explanatory variables are 10-year averages.
Source: Authors' calculations.

The dependent variable is the growth rate of the per capita labor force, i.e., the labor force divided by the total population. The independent variables are old-age dependency, youth dependency, per capita GDP, and per capita GDP squared. We included the squared term to capture possible nonlinear effects. Both dependent and explanatory variables are 10-year average values.

Table 3 includes results for both random effects and fixed effects. The old-age dependency ratio is highly significant in both results while the youth dependency ratio is significant only in the fixed-effects regression. As expected, both coefficients are negative. The coefficient indicates that if the old-age dependency ratio increased by 10%, the growth rate of per capita labor would decrease either by 0.56% (random effects) or by 0.68% (fixed effects). This effect is expected to persist for 10 years. Thus as expected, our results indicate that demographic change has a significant impact on labor force participation.

In addition to labor force participation—the first term—we also assumed education and human capital—the last term—was independently determined. To calculate it, we used the projections made by Lee and Francisco (2010) (Table 4). Intuitively, the first and the last terms cannot increase or decrease forever because there are limits to their values. For example, the labor force participation rate cannot decrease to zero. Hence the impact, if any, should be temporary. For the second and third terms—TFP and physical capital per labor—we followed the growth projection framework of Lee and Hong (2010) but considered the impact of demographic change and quantified its importance.

The system of three equations is

TFP: $\Delta \ln(A_t) = f_A(Z_{At})$ (6)

Physical capital per labor: $\Delta \ln(k_t) = f_k(S_t,\ Z_{kt})$ (7)

Savings rate: $S_t = f_s(\Delta \ln\left(\frac{Y_t}{P_t}\right), Z_{st})$ (8)

where k_t is physical capital per labor ($= \frac{K_t}{L_t}$) and S_t is the savings rate at time t. Furthermore, $Z_{At}, Z_{kt},$ and Z_{st} are exogenous variables affecting $\Delta \ln(A_t)$, $\Delta \ln(k_t)$ and S_t., respectively. We added equation (8) for the savings rate because it influences physical capital per labor. Originally equations (6), (7), and (8) were derived from Park (2010), Shioji and Vu (2010), and Horioka and Terada-Hagiwara (2010), respectively. Lee and Hong (2010) combine these three to form a system of equations.

When you plug equation (3) into (8), it becomes:

$S_t = f_s(\ln(A_t) + \propto \Delta\ln(k_t) + (1-\propto)\Delta\ln(h_t), Z_{st})$ (8)’

where we explicitly included the time subscript and utilized the fact that $k_t = \frac{K_t}{L_t}$.

Now equations (6), (7), and (8)’ form a three-equation system with three endogenous variables: $\ln(A_t)$, $\Delta \ln(k_t)$ and S_t.

All other variables including $\Delta \ln(h_t)$ were considered as exogenous.

Lee and Hong (2010) included the following exogenous variables:

$Z_{At} = (\ln(A_{t-1}), \ln(Life_{t-1}), h_t, \ln(pop_{t-1}), \Delta RND_t)$ (9)

$Z_{kt} = (k_{t-1}, \Delta \ln(A_{t-1}), \ln(A_{t-1}), \ln(pop_{t-1}), open_t, propright_t)$ (10)

$Z_{st} = (life_t, Old_t, Young_t, ln(y_t), \Delta\, ln(y_t), labor\_p65_t)$ (11)

where $Life_t$ = life expectancy at $t-1$, pop_{t-1} = population at , $t-1$, ΔRND_t = growth rate of research and development, $open_t$ = a measure of openness, (exports+imports)/GDP, $propright_t$ = the Heritage Foundation's Property Rights Index, Old_t = the old-age dependency ratio defined as the population aged 65 and older divided the by population aged 15–64, $Young_t$ = youth dependency ratio defined as the population aged 14 and younger divided by the population aged 15–64, $labor\_p65_t$ = the labor force participation rate of elderly people.

A major departure from Lee and Hong (2010) is that we included the demographic variables old-age and youth dependency ratios in either Z_{At} or Z_{kt} and reported the results when the demographic variables were included in both Z_{At} and Z_{kt}. The data sources for our variables were as follows: (i) The World Bank's World Development Indicators (WDI) (World Bank 2010, accessed 5 April 2011) for old-age and youth dependency ratios except for Taipei,China for which we relied on the Council for Economic Planning and Development (CEPD 2010; accessed 5 April 2011); (ii) Penn World Table 6.3 for the savings rate (S/Y=(Y-C-G)/Y); (iii) WDI for life expectancy; (iv) Lee and Hong (2010) for research and development; (v) Penn World Table 3.1 for openness; (vi) The Heritage Foundation for property rights (accessed 5 April 2011); and the International Labour Organization's LABORSTA database (accessed 15 March 2011) for labor force participation and the labor force participation rate of the elderly.

Column 1 in Table 4 replicates the analysis of Lee and Hong (2010), and the results are reasonably similar. Column 2 is the result of the regression when we included the demographic factors (the old-age and youth dependency ratios). We excluded population growth from the explanatory variables in Column 2 when the dependent variable was per capita physical capital since other demographic factors were already included.
Our variables of interest are the old-age and youth dependency ratios since we are interested in the impact of demographic change on the different sources of economic growth. Both demographic variables have a negative effect on TFP growth. This implies that the age structure of the labor forces affects labor productivity and the productivity of all productive inputs. On the other hand, neither the old-age nor the youth dependency ratio was significant for capital accumulation. Therefore, demographic change does not seem to have a direct effect on investment. At the same time, the savings rate had a positive and highly significant effect on capital accumulation, and both the old-age and youth dependency ratios had a negative effect on the savings rate. Therefore, although demographic change does not exert a direct effect on capital accumulation, it does so indirectly through its negative effect on the savings rate.

Table 4: Estimation Results

	[1]	[2]
TFP Growth		
Initial TFP	–0.020***	–0.018***
	[0.003]	[0.003]
Initial life expectancy	0.050***	–0.006
	[0.012]	[0.015]
Years of schooling	0	0
	[0.001]	[0.001]
Initial population	0.001**	0
	[0.001]	[0.001]
Research and development stock growth	0.064***	0.031
	[0.020]	[0.021]
Old-age dependency		–0.068***
		[0.024]
Youth dependency		–0.061***
		[0.011]
K/L Growth		
Initial per labor physical capital	–0.023***	–0.027***
	[0.003]	[0.003]
Initial TFP	0.022***	0.01
	[0.006]	[0.009]
Growth rate of TFP	0.680***	–0.046
	[0.240]	[0.570]
Growth rate of population	–0.447*	
	[0.254]	
Savings rate	0.122***	0.141***
	[0.025]	[0.030]
Openness	0	0
	[0.003]	[0.003]
Property rights	0.000***	0.000***
	[0.000]	[0.000]
Old-age dependency		0.062
		[0.059]
Youth dependency		–0.044
		[0.049]
Savings Rate		
Life expectancy	0.001	0.003*
	[0.002]	[0.002]
Elderly participation	0.268***	0.261***
	[0.060]	[0.060]
GDP growth	2.479***	2.619***
	[0.786]	[0.838]
Initial per capita GDP	0.109***	0.109***
	[0.018]	[0.018]
Old-age dependency	–0.638***	–0.597***
	[0.154]	[0.160]
Youth dependency	–0.294***	–0.199*
	[0.107]	[0.113]
Observations	170	170

K/L = aggregate physical capital/labor force, TFP = total factor productivity.

Note: Column 1 is a replication of the estimation made by Lee and Hong (2010). Column 2 includes demographic variables (old-age dependency and youth dependency ratios) as explanatory variables in all three equations.

Source: Authors' calculations.

V. Projections of the Impact of Demographic Change

We used the regression estimates in Section IV to make projections about the impact of demographic change on the future economic growth of the sample. More precisely, we projected the impact of the old-age and youth dependency ratios on the change in the future growth rate of per capita GDP. There are three channels through which demographic change affects growth: (i) per capita labor force, (ii) TFP, and (iii) capital accumulation. The third channel is further divided into direct impact and indirect impact through the savings rate. To simplify the analysis, we assumed that the 2001–2010 averages were the same as those for 2001–2007. Table 5 reports the projections for 2011–2020 and for 2021–2030.

The following example will help to illustrate how we can interpret the projections in Table 5. According to Table 1, the youth and old-age dependency ratios in the PRC are expected to change from 0.328 to 0.273 and from 0.106 to 0.137, respectively, from 2001 to 2020. The fixed-effects regression estimates in Table 3 imply that the change in the youth dependency ratio will increase the growth rate of the per capita labor force by 0.087% while the change in the old-age dependency ratio will reduce it by 0.209%. The estimates in the first panel of Table 4 imply that the impact of changes in the youth and old-age dependency ratios on the TFP growth rate would be 0.334% and –0.208%, respectively. In order to understand how the changes affect the growth rate of physical capital per labor, we relied on the reduced form equations converted from the estimates in the second and third panels in Table 5. According to those equations, the youth dependency ratio directly increases the growth rate of physical capital per labor by 0.112% and increases it indirectly through the savings rate by 0.072%. The old-age dependency ratio directly increases the growth rate of physical capital per labor by 0.089% but indirectly reduces it through the savings rate by 0.121%.

Combining the three channels, the collective impact of the change in the youth dependency ratio is to increase the PRC's growth rate of per capita GDP by 0.605% while the total impact of the change in the old-age dependency ratio is to decrease it by 0.449%. Overall, demographic change raises the growth rate of per capita GDP by 0.156%. In the decade 2021–2030, the PRC's youth dependency ratio is expected to further decrease to 0.260 and the old-age dependency ratio is expected to further increase to 0.200 (Table 1). The three channels indicate that the change in the youth ratio will increase the growth rate of per capita GDP by 0.148% and the change in the old-age ratio will decrease it by 0.933%. Overall the demographic changes are expected to decrease the growth rate of per capita GDP by 0.785%. We repeated the exercise for the rest of the sample. As in the PRC, the youth dependency ratio exerted a positive effect on economic growth while the old-age dependency ratio exerted a negative effect.

Table 5 reveals a great deal of diversity among the 12 economies with respect to the size and timing of demographic effects on economic growth. In Hong Kong, China; the Republic of Korea; and Singapore where population aging is well under way, demography will already have a negative impact on growth in 2011–2020, i.e., they will pay a demographic tax rather than earn a demographic dividend in the immediate future. In the PRC; Taipei,China; Thailand; and Viet Nam where aging began at a later

Table 5: Impact of Aging on Economic Growth Projections for 12 Asian Economies

		2011–2020 (%)				
				Aggregate Physical Capital/Labor Force		
	Variable (Dependency Ratio)	Labor Force/ Population	Total Factor Productivity	Indirect (through saving)	Direct	Total
China, People's Rep. of						
	Youth	0.087	0.334	0.072	0.112	0.605
	Old-age	–0.209	-0.208	–0.121	0.089	–0.449
Hong Kong, China						
	Youth	0.085	0.327	0.070	0.110	0.592
	Old-age	–0.319	–0.318	–0.185	0.136	–0.686
India						
	Youth	0.159	0.615	0.132	0.206	1.113
	Old-age	–0.072	–0.071	–0.041	0.030	–0.154
Indonesia						
	Youth	0.117	0.453	0.098	0.152	0.819
	Old-age	–0.125	–0.124	–0.072	0.053	–0.268
Korea, Rep. of						
	Youth	0.112	0.431	0.093	0.145	0.780
	Old-age	–0.407	–0.405	–0.235	0.173	–0.874
Malaysia						
	Youth	0.142	0.549	0.118	0.184	0.994
	Old-age	–0.162	–0.161	–0.094	0.069	–0.349
Pakistan						
	Youth	0.169	0.651	0.140	0.218	1.178
	Old-age	–0.048	–0.048	–0.028	0.021	–0.104
Philippines						
	Youth	0.157	0.606	0.131	0.203	1.097
	Old-age	–0.117	–0.117	–0.068	0.050	–0.252
Singapore						
	Youth	0.152	0.586	0.126	0.197	1.061
	Old-age	–0.540	–0.537	–0.312	0.229	–1.160
Taipei,China						
	Youth	0.140	0.539	0.116	0.181	0.976
	Old-age	–0.323	–0.321	–0.187	0.137	–0.694
Thailand						
	Youth	0.068	0.262	0.057	0.088	0.475
	Old-age	–0.184	–0.183	–0.107	0.078	–0.396
Viet Nam						
	Youth	0.214	0.826	0.178	0.277	1.494
	Old-age	–0.014	–0.014	–0.008	0.006	–0.030

K/L = aggregate physical capital/labor force.
Source: Authors' calculations.

stage, demographic impacts will still be positive from 2011 to 2020 but will turn negative in 2021–2030. India, Indonesia, Malaysia, Pakistan, and the Philippines will continue to reap a demographic dividend in 2021–2030; however, even in those youthful economies the dividend will be visibly smaller in 2021–2030 relative to 2011–2020. All in all, our projections resoundingly supported the popular belief that the contribution of demography to developing Asia's growth is set to decline substantially as the region ages.

2021–2030 (%)				
		Aggregate Physical Capital/Labor Force		
Labor Force/ Population	Total Factor Productivity	Indirect (through saving)	Direct	Total
0.021	0.082	0.018	0.027	0.148
−0.434	−0.432	−0.251	0.184	−0.933
−0.037	−0.143	−0.031	−0.048	−0.260
−0.891	−0.887	−0.516	0.378	−1.915
0.122	0.471	0.102	0.158	0.853
−0.160	−0.159	−0.093	0.068	−0.344
0.090	0.348	0.075	0.117	0.630
−0.206	−0.205	−0.119	0.087	−0.442
0.011	0.041	0.009	0.014	0.074
−0.708	−0.705	−0.410	0.301	−1.522
0.095	0.369	0.079	0.124	0.667
−0.274	−0.273	−0.159	0.116	−0.589
0.133	0.512	0.110	0.172	0.927
−0.069	−0.068	−0.040	0.029	−0.147
0.111	0.430	0.093	0.144	0.779
−0.160	−0.159	−0.093	0.068	−0.344
−0.016	−0.061	−0.013	−0.021	−0.111
−1.119	−1.114	−0.648	0.475	−2.406
0.032	0.123	0.026	0.041	0.222
−0.815	−0.812	−0.472	0.346	−1.753
0.011	0.041	0.009	0.014	0.074
−0.434	−0.432	−0.251	0.184	−0.933
0.058	0.225	0.049	0.076	0.408
−0.320	−0.318	−0.185	0.136	−0.687

VI. Quantitative Estimates of Past Demographic Dividends

We used the same regression estimates in Section IV but combined them with actual changes in the old-age and youth dependency ratios to quantitatively estimate the size of the demographic dividend in the sample in the decades 1981–1990, 1991–2000, and 2001–2010. Quantitative estimates of past demographic dividends are useful for comparative purposes and provide a better perspective on estimates of future dividends.

Table 6: Impact of Aging on Growth: Historical Estimations for 12 Asian Economies, 1981–1990, 1991–2000, and 2001–2010

	1981–1990 (%)				
			Aggregate Physical Capital/Labor Force		
	Labor Force/ Population	Total Factor Productivity	Indirect (through savings)	Direct	Total
China, People's Rep. of					
Youth dependency	0.312	1.204	0.259	0.404	2.180
Old-age dependency	–0.017	–0.017	–0.010	0.007	–0.036
Hong Kong, China					
Youth dependency	0.215	0.830	0.179	0.278	1.502
Old-age dependency	–0.170	–0.169	–0.098	0.072	–0.366
India					
Youth dependency	0.061	0.235	0.051	0.079	0.426
Old-age dependency	–0.024	–0.024	–0.014	0.010	–0.051
Indonesia					
Youth dependency	0.159	0.614	0.132	0.206	1.111
Old-age dependency	–0.016	–0.016	–0.009	0.007	–0.034
Korea, Rep. of					
Youth dependency	0.314	1.213	0.261	0.407	2.196
Old-age dependency	–0.044	–0.044	–0.025	0.019	–0.094
Malaysia					
Youth dependency	0.163	0.629	0.136	0.211	1.138
Old-age dependency	0.022	0.021	0.012	–0.009	0.046
Pakistan					
Youth dependency	–0.015	–0.056	–0.012	–0.019	–0.102
Old-age dependency	0.121	0.121	0.070	–0.052	0.261
Philippines					
Youth dependency	0.124	0.477	0.103	0.160	0.864
Old-age dependency	0.002	0.002	0.001	–0.001	0.004
Singapore					
Youth dependency	0.276	1.064	0.229	0.357	1.926
Old-age dependency	–0.063	–0.062	–0.036	0.027	–0.135
Taipei,China					
Youth dependency	0.204	0.789	0.170	0.265	1.428
Old-age dependency	–0.142	–0.142	–0.082	0.060	–0.306
Thailand					
Youth dependency	0.357	1.377	0.297	0.462	2.493
Old-age dependency	–0.003	–0.003	–0.002	0.001	–0.007
Viet Nam					
Youth dependency	0.136	0.524	0.113	0.176	0.949
Old-age dependency	0.055	0.054	0.032	–0.023	0.117

Source: Authors' calculations.

In contrast to the projections in Table 5, Table 6 shows that all developing economies in Asia earned a demographic dividend in the past. This was true even for those that according to Table 5 will begin to pay a demographic tax in the immediate future. For example, in 1981–1990 in the Republic of Korea, the collective impact of the change in the youth ratio was to raise the annual growth rate of per capita GDP by 2.196% while the collective impact of the change in the old-age dependency ratio was to reduce the growth rate by 0.094%. Overall, therefore, demographic change raised the Republic of Korea's annual growth rate of per capita GDP in 1981–1990 by 2.102%. The Republic of Korea reaped a reduced but still sizable demographic dividend of 1.133% in 1991–2000, but the dividend disappeared in 2001–2010. These estimates resoundingly confirm the notion that economic growth in developing Asia benefited substantially from favorable demographic trends in the past.

1991–2000 (%					2001–2010 (%)				
		Aggregate Physical Capital/Labor Force					K/L		
Labor Force/ Population	Total Factor Productivity	Indirect (through savings)	Direct	Total	Labor Force/ Population	Total Factor Productivity	Indirect (through savings)	Direct	Total
0.115	0.443	0.095	0.149	0.801	0.130	0.502	0.108	0.168	0.908
–0.077	–0.076	–0.044	0.033	–0.165	–0.097	–0.096	–0.056	0.041	–0.208
0.107	0.414	0.089	0.139	0.749	0.104	0.400	0.086	0.134	0.724
–0.204	–0.204	–0.118	0.087	–0.439	–0.169	–0.168	–0.098	0.072	–0.363
0.087	0.337	0.073	0.113	0.610	0.116	0.449	0.097	0.151	0.813
–0.021	–0.021	–0.012	0.009	–0.046	–0.036	–0.036	–0.021	0.015	–0.078
0.211	0.816	0.176	0.274	1.476	0.135	0.521	0.112	0.175	0.942
–0.050	–0.049	–0.029	0.021	–0.107	–0.087	–0.087	–0.050	0.037	–0.187
0.202	0.781	0.168	0.262	1.413	0.081	0.311	0.067	0.104	0.563
–0.130	–0.130	–0.075	0.055	–0.280	–0.262	–0.261	–0.152	0.111	–0.564
0.120	0.462	0.100	0.155	0.837	0.147	0.567	0.122	0.190	1.026
0.014	0.014	0.008	–0.006	0.030	–0.031	–0.031	–0.018	0.013	–0.067
0.042	0.164	0.035	0.055	0.296	0.182	0.702	0.151	0.235	1.270
0.057	0.056	0.033	–0.024	0.122	0.012	0.012	0.007	–0.005	0.026
0.119	0.459	0.099	0.154	0.830	0.134	0.518	0.112	0.174	0.938
0.004	0.004	0.003	–0.002	0.010	–0.037	–0.036	–0.021	0.016	–0.079
0.048	0.186	0.040	0.062	0.336	0.045	0.173	0.037	0.058	0.314
–0.103	–0.103	–0.060	0.044	–0.222	–0.173	–0.173	–0.100	0.074	–0.373
0.168	0.649	0.140	0.218	1.175	0.116	0.448	0.097	0.150	0.811
–0.216	–0.216	–0.125	0.092	–0.465	–0.149	–0.149	–0.087	0.064	–0.321
0.239	0.924	0.199	0.310	1.673	0.107	0.414	0.089	0.139	0.750
–0.096	–0.096	–0.056	0.041	–0.207	–0.121	–0.121	–0.070	0.051	–0.260
0.182	0.705	0.152	0.236	1.275	0.256	0.990	0.213	0.332	1.791
–0.018	–0.018	–0.011	0.008	–0.039	–0.046	–0.046	–0.027	0.020	–0.099

VII. Conclusions

While developing Asia is following in the demographic footsteps of the advanced economies, the sheer speed and scale of the transition make preparing for a grayer future all the more challenging and complex as the transition to an older population will deprive the region of one of the main drivers of its past economic success. According to Bloom, Canning, and Fink (2011), favorable demographics can explain much of East Asia's spectacular economic growth in the second half of the 20th century. The rapid declines in infant and child mortality that began in the late 1940s triggered a fall in birth rates from 40 births per 1,000 in 1950 to 20 per 1,000 by 1980. The lag between mortality and fertility declines gave rise to a baby boom generation that was larger than the cohorts that preceded and followed it. When the baby boomers reached working age, both the savings rate and the size of the labor force shot up. Bloom, Canning, and Malaney (2000) found that this demographic dividend accounted for up to 33% of East Asia's economic miracle between 1965 and 1990.

Our central objective was to project the impact of demographic change on economic growth from 2011 to 2030 in the 12 developing Asian economies that collectively make up the bulk of the region's population and output. Our projections indicate that the region's demographic transition will have a substantial effect on its economic growth in the next 2 decades; in fact, the demographic dividend that drove economic growth in the past will turn into a demographic tax that will subtract from it. The magnitude and timing of the transition from dividend to tax will differ from economy to economy, but the positive impact of demography on economic growth will weaken across the region even in youthful economies where the demographic dividend will persist in 2021–2030. Our projections support the notion that a primary means of sustaining economic growth in the sample in the future will be successful adaptations to rapidly changing population structures.

Aging populations pose a number of difficult policy challenges for developing Asian nations; the unprecedented nature of their transition means that the earlier experiences of the advanced economies can provide at best only limited guidance. Although the need to prepare for older populations is greatest where aging is most advanced, youthful economies should take advantage of their larger window of opportunity to prepare also. Just as reaping the demographic dividend requires appropriate institutions and policies, so does managing the impending demographic transition. Working longer and encouraging more women to participate in the labor force can mitigate the negative impact of aging on growth. Therefore, to the extent that governments implement policy reforms that bring about those responses—more and better child care and raising the legal retirement age—our projections overestimate the demographic effects. In this context, a particularly challenging issue for policy makers will be to provide adequate income support and health care for the elderly without jeopardizing growth by imposing excessive burdens on the working-age population.

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About the Paper

Donghyun Park and Kwanho Shin examine the quantitative impact of population aging on economic growth in 12 developing Asian economies that make up the bulk of the region's population and output. They find that the demographic dividend that contributed to growth is set to decline visibly in 2011–2030. In fact, the dividend will turn into a tax that reduces growth in the region's older countries.

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