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Demographic Transitions and Economic Miracles in Emerging Asia

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The demographic transition—a change from high to low rates of mortality and fertility—has been more dramatic in East Asia during the twentieth century than in any other region or historical period. By introducing demographic variables into an empirical model of economic growth, this article shows that this transition has contributed substantially to East Asia's so-called economic miracle. The miracle occurred in part because East Asia's demographic transition resulted in its working-age population growing at a much faster rate than its dependent population during 1965-90, thereby expanding the per capita productive capacity of East Asian economies. This effect was not inevitable; rather, it occurred because East Asian countries had social, economic, and political institutions and policies that allowed them to realize the growth potential created by the transition. The empirical analyses indicate that population growth has a purely transitional effect on economic growth; this effect operates only when the dependent and working-age populations are growing at different rates. These results imply that future demographic change will tend to depress growth rates in East Asia, while it will promote more rapid economic growth in Southeast and South Asia.

This article has two objectives. The first is to estimate an empirical model that isolates the impact of demographic variables on economic growth. The second is to use these results to infer how much of the East Asian miracle can be explained by the region's spectacular demographic transition.[1]

1. We define East Asia to include China, Hong Kong (China), Japan, the Republic of Korea, Singapore, and Taiwan (China); Southeast Asia to include Cambodia, Indonesia, Laos, Malaysia, Myanmar (Burma), the Philippines, Thailand, and Vietnam; and South Asia to include Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka.

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The article begins by revisiting the debate on the impact of population growth on economic growth. "Population pessimists" believe that rapid population growth is immiserizing, because it tends to overwhelm any induced response by technological progress and capital accumulation (Coale and Hoover 1958 and Ehrlich 1968). "Population optimists" believe that rapid population growth allows countries to capture economies of scale and promotes technological and institutional innovation (Boserup 1981, Kuznets 1967, and Simon 1981). Research culminating in the 1980s cast doubt on both views: investigators showed that population growth has neither a significant positive nor a significant negative impact on economic growth (Bloom and Freeman 1986 and Kelley 1988). These studies were typically based on cross-country regressions of per capita income growth on population growth, controlling for a variety of other influences. As Kelley and Schmidt (1995: 543) put it recently,

> Possibly the most influential statistical finding that has shaped the "population debates" in recent decades is the failure, in more than a dozen studies using cross-country data, to unearth a statistically significant association between the growth rates of population and of per capita output.

This "population neutralist" finding is surprising, but whether it arose because population has no positive or negative effects on economic growth, because it has no net effect on economic growth, or because both the pessimists and the optimists have misspecified the test remains unclear.

More recent work has decomposed population growth into its fertility and mortality components and examined their independent effects on economic growth (Barlow 1994, Bloom and Freeman 1988, Brander and Dowrick 1994, Coale 1986, and Kelley and Schmidt 1995). These studies find that measures of fertility, specifically past birth rates, are negatively and significantly associated with economic growth, whereas the effect of mortality is insignificant. This more recent work is the direct precursor of this article, insofar as it justifies the decomposition on the grounds that changes in fertility and mortality imply very different changes in the age distribution and points toward our hypothesis that population growth affects economic growth insofar as it affects the ratio of working-age population to dependent population. Population growth attributable to improvements in longevity among the elderly should have an immediate negative effect on economic growth, because this implies a greater number of elderly to support. Population growth attributable to a general decline in mortality has no effect, because the ratio of the economically active population to dependents stays the same. Population growth attributable to a rise in fertility should have an immediate negative effect on economic growth, given the presence of more mouths to feed, and so should population growth stemming from a fall in infant mortality. These latter demographic effects will, however, have a delayed positive impact on economic growth, because the economically active population will boom two decades later.

This article contributes to the population debate in four ways. First, like Kelley and Schmidt (1995), it uses the new empirical models of economic growth to isolate the effects of demography. It does this by incorporating demographic variables into a growth model similar to the one used in Asian Development Bank (1997) and Barro and Sala-i-Martin (1995). Second, it explores the possibility of reverse causality between economic growth and demographic change by using a two-stage specification in which instruments for the growth rate of the population are used to correct for possible endogeneity. Third, it introduces demography into the growth equations in a theoretically more appealing way—by adding the growth rates of the total population and the economically active population rather than by simply including birth and death rates. This allows population growth to affect economic growth both by its overall rate of increase *and* by its effect on the age structure. The distinction matters. Finally, the article highlights how changes in the growth of labor force per capita, changes in the savings rate, and changes in the investment rate are three plausible channels through which a changing age structure might affect the rate of economic growth (Bloom and Williamson 1997 and Higgins and Williamson 1997).

The article uses the econometric results to assess the extent to which population dynamics may account for a significant portion of East Asia's economic miracle. East Asia is an excellent context in which to examine this effect for several reasons. It has experienced a more rapid demographic transition than any other region at any time in history. We argue that the initial fall in infant mortality, which set the demographic transition in motion, was likely to have been exogenous in late twentieth century East Asia. East Asia has also experienced higher sustained rates of economic growth over the past 30 years than any other region at any other time in history. East Asia is often compared with Southeast and South Asia, whose demographic transitions either began later or proceeded more slowly and whose recent economic progress has not rivaled that of East Asia. And analysts have badly neglected the potential role of population change in economic performance in the region, a neglect illustrated best by the World Bank's oft-quoted work *The East Asian Miracle* (1993). In redressing this imbalance, the article compares Asia with the rest of the world and Asia's subregions with one another.

Section I describes the demographic transition in more detail, focusing on the difference between the experiences of Western Europe and Asia to show that demographic effects have been much more pronounced in Asia. Section II describes the model and the recent literature on economic growth on which it is based. Section III presents the econometric results, and section IV uses those results to estimate just how much of the East Asian miracle may be accounted for by demographic dynamics. Section V discusses labor supply and capital accumulation, the most likely channels through which population dynamics affect economic growth. Section VI concludes with an agenda for future research.

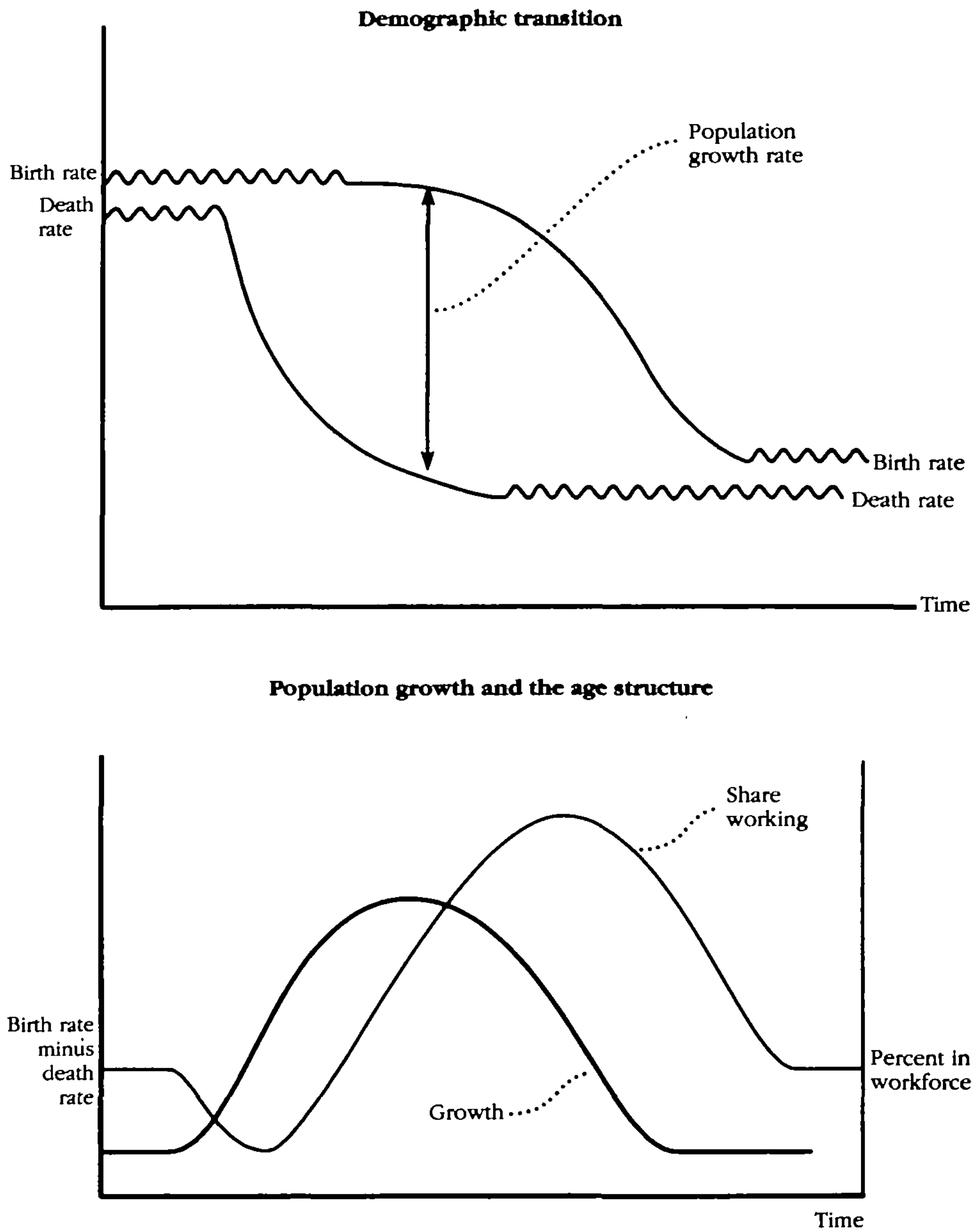
I. THE DEMOGRAPHIC TRANSITION AND ECONOMIC GROWTH

The demographic transition describes the change from preindustrial high fertility and mortality to postindustrial low fertility and mortality. Figure 1 offers a stylized view of the transition. Declines in mortality mark the beginning of almost all demographic transitions, and changes in the age structure are exacerbated because infants and children enjoy most of these early declines in mortality. True, the improved survivor rates for children induce parents to reduce their fertility. If parents adjusted completely and immediately, there would be no youth glut and no acceleration in population growth. But they do not: they adjust slowly, and the youth glut is large and persistent. After a lag, however, fertility begins to decline, which marks the next stage of the transition. The population growth rate is implicit in the first panel of figure 1 as the difference between fertility and mortality. The second panel makes the population dynamics explicit: the demographic transition must be accompanied by a cycle in population growth *and* the age structure. Figure 1 and the rest of this article treat the demographic system as if it were closed and thus ignore external migration. If it were quantitatively important and responded to cohort gluts and scarcities, external migration might very well mute the impact of demographic transitions. In the late twentieth century, international migrations are simply not great enough to matter except, perhaps, for the United States and some oil-producing countries in the Middle East (Bloom and Noor 1997). They mattered a great deal, however, in the age of relatively unrestricted mass migration prior to World War I (Williamson 1998).

These components of the demographic transition might have separate influences on economic growth. The population growth rate could influence economic growth for the reasons cited by population pessimists or optimists. The demographic transition could also affect economic growth through the age distribution, as we emphasize. Coale and Hoover (1958) made the dependency rate the centerpiece of their analysis of the impact of large youth cohorts on savings, investment, and educational capital deepening. Because they were, by virtue of the decade in which they conducted their analysis, constrained to study only the first—"burden"—phase of the Asian demographic transition, they could not devote attention to the "gift" phase from the mid-1960s to the present that drives this analysis. Overall, the age distribution effect will operate first to lower, then to raise, then to lower again the ratio of the economically active population to the total population and thus will have a transitional impact on growth of the labor force per capita. Note that the demographic "gift" in the middle phase of the transition may or may not be realized. It represents a growth potential whose realization depends on other features of the social, economic, and political environment.

Like industrial revolutions, demographic transitions take many decades to complete, but in the case of postwar East Asia it has been much faster than it was in nineteenth century Europe. Over a century and a half, Europe slowly

Figure 1. *Demographic Transition and Population Growth*



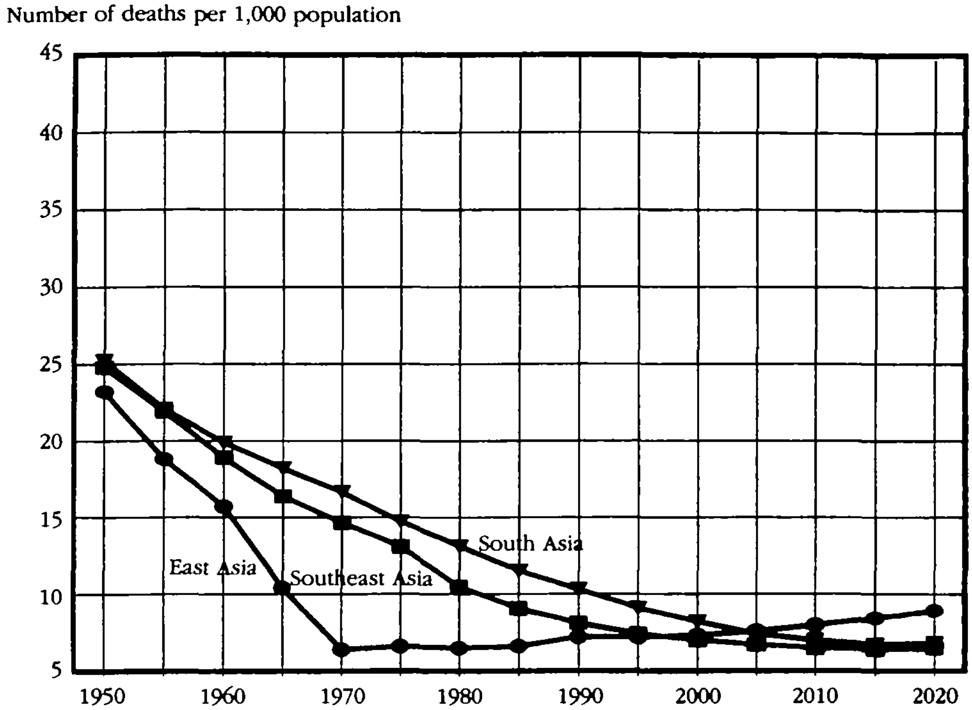
improved its understanding of and practices with respect to basic sanitation, management of solid waste, provision of clean drinking water, and the elements of sound nutrition. It invested in these measures to reduce mortality and chronic malnutrition and eventually eliminated famines (Fogel 1994). It cleaned up what Victorian reformers called "killer cities" (Williamson 1990). These factors, together with the advent of antibiotics and vaccines and recognition of the importance of preventive medicine, led to a gradual decline in mortality in Europe. Infant and child mortality led the decline because the very young, like the elderly, are most vulnerable to infectious disease, and because children are far more numerous than the elderly at early development stages, the decline in infant and child mortality matters most. The fertility rate also declined, but more slowly, and the European demographic transition stretched out for more than 100 years (Coale and Watkins 1986).

The health investments and medical technologies that had been developed and put into practice in Europe did not exist in Asia until relatively recently. There was a large gap between the best health practices prevailing in industrialized Europe and local health practices prevailing in Asia, and by 1940 the scope for the transmission of health technologies was enormous, having been pent up by deglobalization, two world wars, the Great Depression, and wars of colonial liberation. When the postwar transfer of this pent-up health technology finally took place, it happened in a rush. The process was sped up even further by investment in health-improving social overhead, which was heavily financed by world funding agencies that did not exist prior to the 1940s. In short, the possibilities for Asia to catch up with the West in terms of health and demography were enormous in the late 1940s, and they were driven by factors external to Asia itself. In the half century since then, Asia has exploited the catch-up potential with such enthusiasm that it has produced one of the fastest and most dramatic demographic transitions ever. The language we use in this section is purposely similar to that used in the debate about economic catch-up and convergence (Abramovitz 1986, Barro 1991, Baumol 1986, and Sachs and Warner 1995), because we think that exactly the same reasoning applies to the demographic transition in Asia.

Asia's demographic transition followed the stylized model by starting with a decline in mortality rates. By the late 1940s, the crude death rate had begun to decline very rapidly throughout much of Asia. The decline proceeded most rapidly in East Asia (figure 2) and was accompanied by an increase in life expectancy from 61.2 to 74.6 years from 1960 to 1992. Similar declines occurred in Southeast and South Asia, where life expectancy improved from 51.6 to 67.2 years and from 46.9 to 60.6 years, respectively. In the 1950s and 1960s, most of the aggregate decline in mortality was driven by declines in mortality among the youngest cohorts (Bloom and Williamson 1997).

There are a number of possible explanations for the rapid decline in child mortality in Asia in the middle of this century. One possibility has already been suggested: that is, in the 1940s Asia escaped from some four or five decades of relative isolation, ushering in an era of transfer and diffusion of new public health programs, technologies, and techniques. For example, the medical advances that were implemented in postwar Asia had been accumulating on the technological shelf for at least two decades: penicillin was discovered in 1927, sulfa drugs in 1932, and bacitracin in 1943; streptomycin was isolated in 1943

Figure 2. *Crude Death Rate, by Subregion in Asia, 1950–2020*

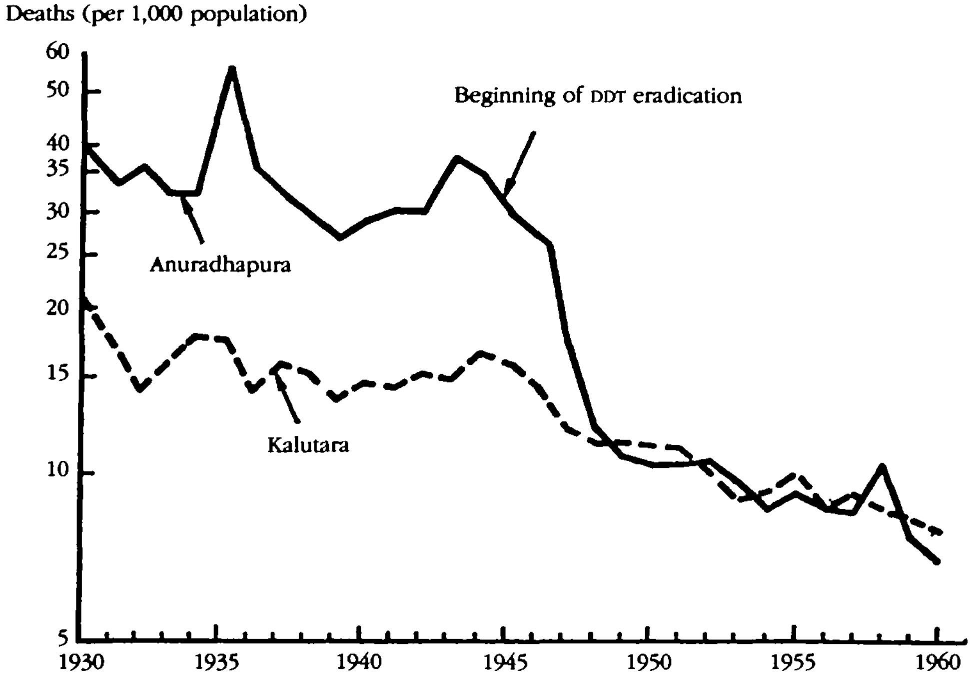


Source: United Nations (1994).

and its curative value against tuberculosis demonstrated; the efficacy of chloroquine in treating malaria was demonstrated in 1943; and 1945 saw the nonmilitary use of penicillin and 1948 the introduction of tetracycline. With the advent of these and other drugs, diseases that had once killed hundreds of thousands, and even millions, became treatable at low cost. In addition, the pesticide DDT became available in 1943. To cite just one example, DDT spraying in the late 1940s dramatically reduced the incidence of malaria in Sri Lanka: the crude death rate declined from 21.5 to 12.6 between 1945 and 1950, with the most precipitous drops in the most malarial areas (Livi-Bacci 1992). Figure 3 illustrates the effect by plotting changes in mortality in the most and least malarial zones of Sri Lanka between 1930 and 1960. While the least malarial areas show a gradual decline during the period, the decline is dramatic and steep between 1943 and 1949 in the most malarial zone.

Another possibility is that increased agricultural productivity and trade in food both improved nutrition sufficiently to lower infant mortality dramatically in less than a decade and did so everywhere in Asia. This may be true, but it seems unlikely given that the magnitude and timing of the decline in mortality were so similar everywhere in Asia, regardless of level of development and agricultural productivity.

Figure 3. *The Effect of* DDT *Usage on Mortality in Sri Lanka, 1930–60*



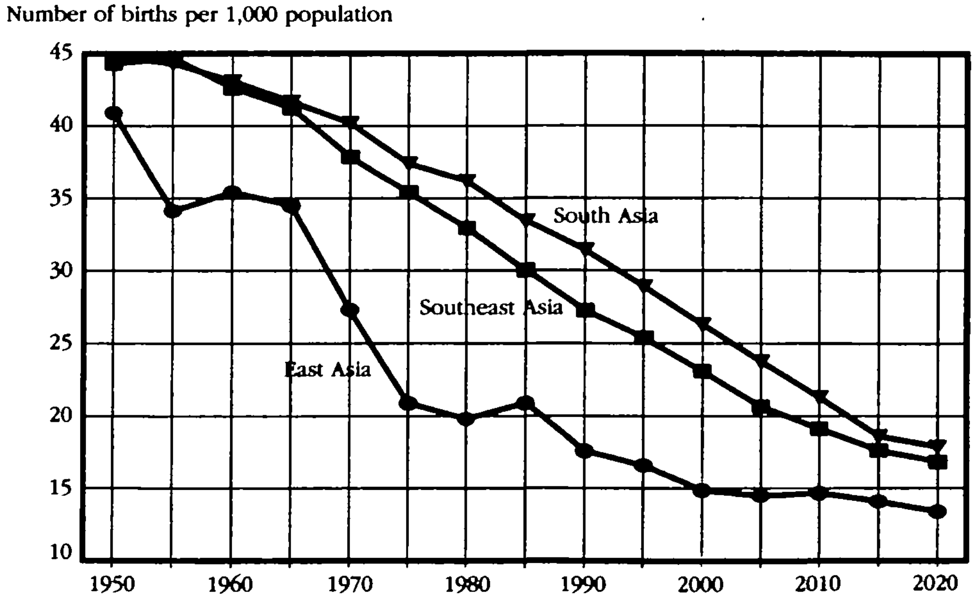
Source: Livi-Bacci (1992).

Resolving the debate between the view that favors an *exogenous* supply-side-driven fall in infant mortality in the 1940s and 1950s and one that favors an *endogenous* demand-side-driven fall matters because it influences the extent to which the demographic transition in East Asia was mostly exogenous to the economic miracle itself. Future research must resolve this issue.

It must be stressed that whether and how fertility responds to economic events (and to rising child survivor rates) is irrelevant to the discussion of whether these demographic shocks were exogenous to the economic miracle in the first place. The decline in fertility is, of course, largely endogenous, but that response simply serves to mute the impact on population growth of the exogenous decline in child mortality that sets the whole demographic transition in motion. Although the timing of the decline in mortality was remarkably similar across rich and poor Asia—suggesting that exogenous forces were at work—the lag between the drop in mortality and fertility, as well as the size of the ensuing fall in fertility, varied—suggesting that endogenous forces were at work (Bloom and Williamson 1997 and Feeney and Mason 1997). Figure 4 plots the decline in the crude birth rate for East, Southeast, and South Asia. Although the crude birth rate fell much more rapidly in East Asia than in Southeast or South Asia, the timing was not so different. In most countries, like Korea, Malaysia, and Singapore, fertility began to decline about 15 years after the drop in child mortality. In other countries, like Thailand, the delay was closer to 25 years. What is remarkable about the onset of the decline in Asian fertility is that it occurred in such a short period and that it was so dramatic everywhere, even where the pace of economic development was slow (Caldwell and Caldwell 1996).

There are, of course, a number of possible explanations for the decline in fertility. Contraceptive use rates vary across Asia (Bloom and Williamson 1997: table 5); government intervention accounts for some of this variance, while family demand, responding in part to economic events, accounts for the remainder. The big debate is over which factor matters most. Two well-known demographers argue that government intervention matters a great deal and that the intervention is distinctly Asian (Caldwell and Caldwell 1996). Another even offers an estimate: examining the decline in the total fertility rate from 1965 to 1975 for 68 developing countries, Boulier (1986) concludes that 27 percent was due to economic change and 40 percent to government-supported family planning, with the remainder representing a continuation of long-term trends. By contrast, Gertler and Molyneaux (1994) and Pritchett (1994) both find that socioeconomic variables such as income and education play a much more significant role in fertility decline than family planning does. The general view, however, seems to be that family planning programs helped to trigger the decline in Asian fertility, beginning with India in 1951. But, as Sanderson and Tan (1995) point out, diminishing marginal returns may imply a reduced ben-

Figure 4. *Crude Birth Rate, by Subregion in Asia, 1950–2020.*



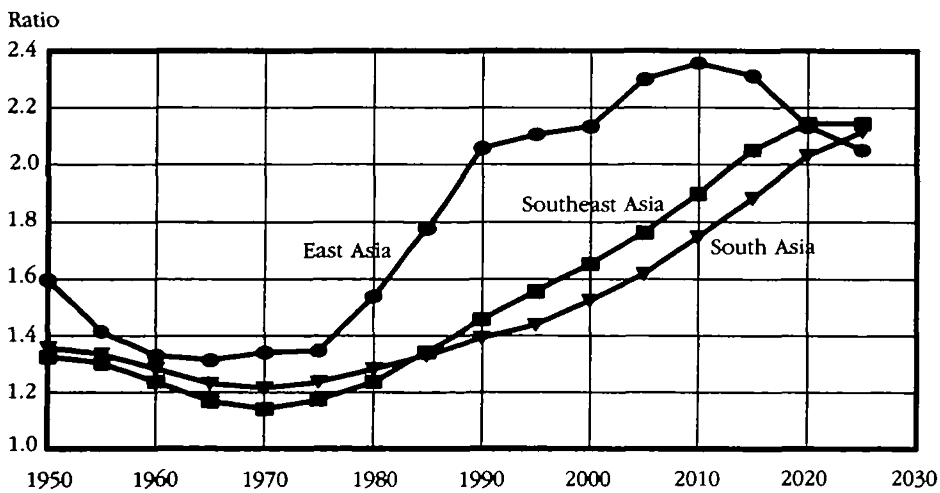
Source: United Nations (1994).

efit to incremental government investments in family planning in countries with well-established programs.

The pace and timing of the demographic transition have led to enormously divergent trends in population growth and age structure across Asia. Figure 5 plots the ratio of the working-age population to the nonworking-age population for the three subregions in Asia. With only two precocious exceptions, Japan and Sri Lanka, Asia's surge to peak youth dependency rates occurred in the 1960s and 1970s, reflected in figure 5 by the low ratio of working-age population to nonworking-age population in those decades.

As figure 5 demonstrates, the ratio of working-age population to nonworking-age population has been rising in Asia since 1970, but this increase was especially dramatic in East Asia between 1975 and 1990. According to the United Nations (1991) projections, the ratio of working-age population to nonworking-age population will peak in East Asia in 2010, ending the second phase of its demographic transition. With the exception of Japan, the elderly dependency rate has been mostly irrelevant to Asia in this century, even to the more economically mature East Asia. It will, of course, become very relevant to these older tigers as they enter the next century. Indeed, figure 5 projects a decline in the ratio of the working-age to the nonworking-age population after 2010 (the third phase of the demographic transition). This reflects the increase in the elderly dependency rate as the bulge in the age distribution works its way through East Asia's population pyramid. However, the elderly dependency rate is not expected to become a dominant demographic force anywhere else in Asia even as late as 2030.

Figure 5. *Ratio of Working-age to Nonworking-age Population in Asia, 1950–2030*



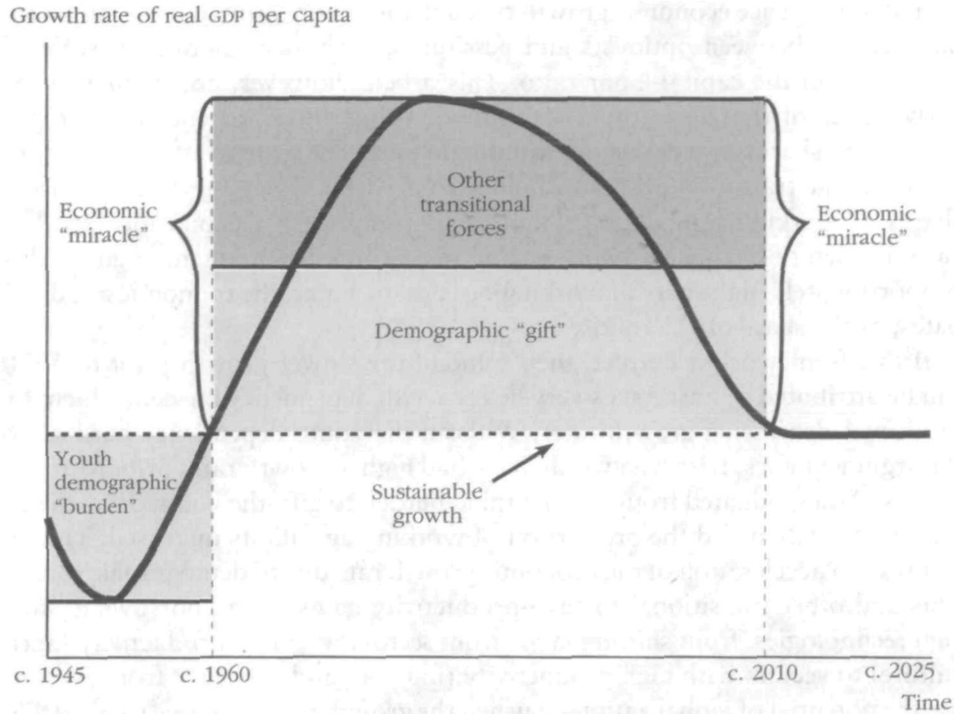
Source: United Nations (1994).

In this article, we seek to measure the effects on economic performance of population growth and of changes in age structure. Population growth is expected to influence economic growth through the channels discussed in the standard debate between optimists and pessimists, such as economies of scale or reductions in the capital-labor ratio. This article, however, argues that in the early stages of the demographic transition, rising youth dependency burdens and falling shares of working-age adults diminish the growth of per capita income. As the transition proceeds, falling youth dependency burdens and rising shares of working-age adults promote the growth of per capita income. The early burden of having few workers and savers becomes a potential gift: a disproportionately high share of working-age adults. Later, the economic gift dissipates, as the share of elderly rises.

If this framework is correct, then some of the slower growth prior to 1970 can be attributed to East Asia's very heavy youth dependency burden, which, by itself, was depressing growth rates. Without the youth dependency burden, so the argument goes, East Asia would have had higher growth rates prior to 1970. As East Asia graduated from demographic burden to gift, the youth dependency burden decreased and the proportion of working-age adults increased. The result was an acceleration of the economic growth rate due to demographic forces. This and other transitional forces—productivity gains from "borrowing" foreign technologies, from shifting labor from sectors with low productivity (agriculture) to sectors with high productivity (industry and services), from exploiting the potential of globalization—pushed the growth rate far above its pre-1970 level to the "miraculous" rates of the past quarter century. The demographic transition accounts for a decrease in the growth rate associated with high youth dependency burdens and a subsequent rise in the growth rate stemming from the emergence of the demographic gift. Some time in the near future, however, East Asia's demographic gift will dissipate, and, consequently, economic growth will tend to slow as the share of elderly in the population increases. Once the demographic transition is complete and the population age structure stabilizes, population growth will affect economic growth only insofar as it operates through level effects. Hence, any economic effect due to the changing age distribution will be temporary.

Figure 6 offers a stylized version of the economic hypothesis in which the sustainable growth rate is taken to be about 2 percent a year. Note, however, that the contribution of the demographic transition to the East Asian miracle will also depend on how the miracle is defined. If it is defined as a share of per capita GDP growth between 1960 and 2010 (as in figure 6), then the demographic transition accounts for about one-third of the miracle. If it is defined as the surplus over the sustainable rate, then the transition accounts for almost half, while if it is defined as the increase in growth rates from 1945–60 to 1960–2010, then the transition accounts for almost three-quarters. What follows is a test of the hypothesis and a defense of the magnitudes suggested by figure 6.

Figure 6. *Stylized Model of Economic Growth and the Demographic Transition in East Asia, 1945–2025*



II. The Theoretical Framework

The cross-country growth equations estimated in the next section are derived from a conventional Solow-Swan model of economic growth (Barro and Sala-i-Martin 1995). The Solow-Swan model is a special case of the Ramsey model with fixed savings rates. However, the empirical estimation equation derived by the log-linear approximation around the steady state is identical in both models. Competitive firms take wages and the interest rate as given and produce the same good. The savings rate is fixed and exogenously determined. Workers are identical. If we assume that production per worker (y) takes the form $y = Ak^{\alpha}$, where A is an index of total factor productivity, α is the output elasticity of capital, and k represents capital stock per worker, then we can derive equation 1 for the growth rate of y. Equation 1 will be familiar to anyone who has read a current advanced macroeconomics textbook (for example, Barro and Sala-i-Martin 1995). It is also consistent with the empirical growth literature, especially that which focuses on conditional convergence (Barro 1991, Barro and Lee 1994, Mankiw, Romer, and Weil 1992, and Sachs and Warner 1995).[2] In

2. For an alternative framework within which to model the demographic transition, see Ehrlich and Lui (1991). Using an overlapping generations model, they show that utility-maximizing individuals will

the Solow-Swan model, the average growth rate (g_y) of output per worker between any time T_1 and T_2 is proportional to the natural logarithm of the ratio of income per worker in the steady state (y^*) and income per worker at time T_1 as follows:

$$g_y = \frac{1}{T_2 - T_1} \ln\left[\frac{y(T_2)}{y(T_1)}\right] = \alpha \ln\left[\frac{y^*}{y(T_1)}\right]. \tag{1}$$

We add two modifications to this model. The first involves the formulation of steady-state output. As in Asian Development Bank (1997), we assume that y^* is formed as

$$y^* = X\beta \tag{2}$$

where X is a matrix with k determinants of the steady state. We also follow Asian Development Bank (1997) in our selection of the variables to include in X. These variables are average years of secondary schooling in the initial period (in natural logs), life expectancy in the initial period, a measure of natural resource abundance, a measure of openness, an index of institutional quality, average government savings, and geographic variables indicating the ratio of coastline to land area, whether there is access to major ports, and whether the country is located in the tropics.

The second modification involves changing the model from output per worker (y) to output per capita ($\tilde{y}$). We note that

$$\tilde{y} = \frac{Y}{N} = \frac{Y}{L}\frac{L}{N} = y\frac{L}{N} \tag{3}$$

where N is the total population, L is the number of workers, and $\tilde{y}$ is output per capita. This expression can easily be converted to growth rates,

$$g_{\tilde{y}} = g_y + g_{\text{workers}} - g_{\text{population}}. \tag{4}$$

When equations 1 and 2 are substituted into 4 and a stochastic term is added, the estimation equation 5 emerges:

$$g_{\tilde{y}} = X\Pi_1 + y(T_1)\Pi_2 + g_{\text{workers}}\Pi_3 + g_{\text{population}}\Pi_4 + \varepsilon. \tag{5}$$

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choose to have fewer children in response to an exogenous decline in mortality rates. The resultant investment in the quality, instead of in the quantity, of children can push a country onto an endogenous growth path, leading to higher growth rates. Meltzer (1995) includes health along with education as a factor of production in a standard Ramsey growth model. When fertility rates are endogenous, an exogenous decline in mortality can be shown once again to set the economy on a path of sustained economic growth with a parallel decline in population growth.

Table 1. *Variable Definitions and Selected Descriptive Statistics*

Variable	*Source*	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
Population growth rate, 1965–90	World Bank data	1.88	1.00	0.17	3.49
Growth rate of economically active population, 1965–90	World Bank data	2.17	1.03	0.25	3.63
Growth rate of population under age 15	World Bank data	1.11	1.53	–1.43	3.69
Growth rate of population over age 64	World Bank data	2.62	0.98	0.79	5.73
Growth rate of the dependent population	World Bank data	1.46	1.17	–0.40	3.55
Average birth rate, 1967–87	World Bank data	30.89	12.56	13.7	53.9
Average death rate, 1967–87	World Bank data	11.68	5.04	5.15	28.85
Average infant death rate, 1967–87	World Bank data	2.54	2.52	0.12	9.70
Average noninfant death rate, 1967–87	World Bank data	9.03	3.21	3.87	19.55
Log GDP per capita as a ratio of U.S. GDP per capita, 1965	World Bank data	–1.65	0.91	–3.34	0.00
Log years of secondary schooling, 1965 (average years of secondary school for population age 25 or older)	Barro and Lee (1994)	–0.70	1.15	–4.83	1.26
Log life expectancy, 1960	World Bank data	4.02	0.22	3.47	4.30
Natural resource abundance (share of primary product exports in GDP in 1971)	World Bank data	0.10	0.09	0.00	0.51
Access to ports dummy (indicating if the country is landlocked)		0.13	0.34	0.0	1.0
Openness	Sachs and Warner (1995)	0.45	0.45	0.0	1.0
Tropics dummy (indicating if country is located between the tropics)	World Bank data	0.51	0.48	0.0	1.0
Ratio of coastline to land area	World Bank data	0.30	0.96	0.0	7.33
Government savings as a share of GDP, 1970–90	World Bank data	1.44	3.43	–5.24	12.57
Quality of institutions (index of quality of governmental institutions)	Keefer and Knack (1995)	6.11	2.42	2.27	9.98

Note: The database is available from the authors upon request.

Theoretically, one would expect that $\Pi_3 = -\Pi_4 = 1$, which implies that for a stable population, where the growth rate of the work force equals the growth rate of the population, net demographic effects should vanish. If the population is unstable, as it is during a dynamic transition, then demography might matter. This formulation takes age structure into account by focusing on both the total population and the working-age population. Bloom, Canning, and Malaney (forthcoming) extend this approach to account for the age structure of the working-age population, which may be important insofar as productivity varies over the working life cycle. Their model can be generalized to take account of other productivity-related characteristics as well.

It is possible as well that both population growth and growth in the labor force might affect the steady-state rate of income growth. The Solow-Swan model posits an exogenous rate of growth of workers n. This is presumed to have a negative effect on the steady-state level of income per worker through reductions in the capital-labor ratio and hence on the rate of growth of income per worker. However, once demographic factors are incorporated, an increase in n relative to population growth will also reduce the dependency ratio. According to Coale and Hoover's (1958) hypothesis, this leads to increases in the per capita rate of savings, which will offset, and possibly even reverse, the negative effect of labor growth on the capital-labor ratio. If the increase in savings is more than proportional to the growth in labor, then increases in n will lead to a rise in the steady-state rate of growth. Alternatively, if it is less than proportional, the capital-labor ratio will decline and the steady state will fall. These effects on growth rates are not identified separately in our model and will be absorbed into the coefficient on g_{workers}, potentially causing it to deviate from 1 in magnitude. The coefficient on $g_{\text{population}}$ will also absorb any influences of population growth on the steady-state rate of economic growth, as discussed in the debate between population optimists and pessimists. To the extent that these influences are important, the coefficient on $g_{\text{population}}$ may deviate from -1.

III. Econometric Results

The econometric analysis is based on 78 Asian and non-Asian countries covering the quarter century from 1965 to 1990. It includes every country for which all the data exist. Table 1 provides a complete description of the data with sources, and the appendix provides a list of the countries.

We start by asking whether the level of population growth affects economic growth, because the population debate has always been couched—erroneously we believe—in those terms. The results appear in table 2. Most of the recent research on economic convergence has focused on the sign of the coefficient on logged initial income. If the coefficient is negative, the model predicts conditional convergence, that is, after controlling for factors that determine the steady-state level of income, poor countries tend to grow faster and approach their steady-state level more quickly than rich countries. Consistent with recent re-

Table 2. *The Impact of Population Growth and Other Factors on Economic Growth, 1965–90*

Variable	*a*	*b*
Population growth rate, 1965–90	0.16	0.56
	(0.20)	(0.16)
GDP per capita as ratio of U.S. GDP per capita, 1965 (logged)	-1.50	-2.30
	(0.25)	(0.22)
Log life expectancy, 1960		5.81
		(0.98)
Log years of secondary schooling, 1965	0.82	0.37
	(0.18)	(0.15)
Natural resource abundance	-4.68	-2.40
	(1.35)	(1.17)
Openness	2.23	1.88
	(0.47)	(0.36)
Quality of institutions	0.21	0.22
	(0.10)	(0.07)
Access to ports dummy	-0.68	-0.87
	(0.39)	(0.29)
Average government savings rate, 1970–90	0.18	0.15
	(0.04)	(0.03)
Tropics dummy		-1.09
		(0.33)
Ratio of coastline to land area		0.29
		(0.12)
Constant	-2.11	-27.38
	(0.92)	(4.3)
Adjusted R^2	0.69	0.83

Note: The dependent variable is the growth rate of real GDP per capita in 1965–90 in purchasing power parity terms. Estimates are from ordinary least squares. The sample size is 78 economies (see the appendix). Standard errors are in parentheses.

Source: Authors' calculations.

search on economic convergence, we also find conditional convergence in our sample. Our focus, however, is on the rate of population growth. In the first specification in table 2 (column a), there is no significant relationship between population growth and growth of gross domestic product (GDP) per capita, thereby supporting the neutralist position. However, this result is sensitive to the specification. As soon as log life expectancy in 1960 and two variables controlling for economic geography are added, population is shown to have a positive and significant impact on growth of GDP per capita (table 2, column b), thereby supporting the optimists' position. Throughout this section, and specifically in tables 2, 3, 4, 5 and 6, we report both specifications. Specification a always refers to a model that excludes initial life expectancy and two geographical variables—a tropics dummy and a ratio of coastline to land area. Specification b always includes these three variables.

Table 2 illustrates the kind of analyses that economic demographers have undertaken to examine the connection between demography and economic growth. It seems plausible, however, that both the sources of population growth and the stage of the demographic transition do matter: both a decline in child mortality and a baby boom raise the share of young dependents in the population; a decline in mortality among the elderly increases the share of the retired dependent age cohort; immigration raises the working-age population (because it self-selects young adults); and improved mortality among the population at large has no impact on age structure at all. Because an economy's productive capacity is linked directly to the size of its working-age population relative to its total population, distinguishing between the two components when exploring the impact of demographic change on economic performance seems natural and worthwhile.

Table 3 conforms to these notions: the growth rate in the economically active population joins population growth in the regression. The growth rate of the working-age population measures the change in the size of the population ages 15 to 64 between 1965 and 1990. Table 3 confirms that the growth of the working-age population has a powerful, positive impact on growth of GDP per capita, while growth of the total population has a powerful negative impact after controlling for other expected influences. Consider the results reported in column 1b of table 3. The coefficient on the growth rate of the working-age population is positive, statistically significant, and large in magnitude: an increase of 1 percent in the growth rate of the working-age population is associated with an increase of 1.46 percent in the growth rate of GDP per capita. The coefficient on the growth rate of the total population is negative, statistically significant, and almost as large: an increase of 1 percent in the growth rate of the overall population (effectively, the dependent population, since the empirical specification holds fixed the growth rate of the working-age population) is associated with a decrease of 1.03 percent in the growth rate of GDP per capita. The coefficients of the other variables are similar to those found in Asian Development Bank (1997) and Radelet, Sachs, and Lee (1997). Columns 2a and 2b of table 3 show what happens when the impact of the growth rate of the working-age population and that of the entire population are constrained to be equal, but of opposite sign. In steady state, when the age distribution is stable, population growth will not matter in either of these two specifications. In transition, when the age distribution changes, population growth does matter. The coefficient here is large, positive, and significant. Thus, in our sample, where the growth rate of the economically active population exceeds that of the overall population, higher growth rates of GDP per capita have appeared (ceteris paribus). The opposite is true if the growth rate of the total population exceeds that of the economically active population. If the dependent population is growing more rapidly than the work force, the estimates provide evidence of slower growth.

Previous contributions to the population debate typically failed to explore the possibility of reverse causality between population growth and economic growth, despite a literature suggesting that economic events can induce demographic responses. While table 3 uses ordinary least squares (OLS), table 4 reports the

Table 3. *The Effects of Growth in the Population and the Economically Active Population on Economic Growth, 1965–90*

Variable	*1a*	*1b*	*2a*	*2b*
Growth rate of economically active population, 1965–90	1.95	1.46		
	(0.38)	(0.34)		
Population growth rate, 1965–90	-1.87	-1.03		
	(0.43)	(0.40)		
Difference in growth rates[a]			1.97	1.68
			(0.38)	(0.35)
GDP per capita as a ratio of U.S. GDP per capita, 1965 (logged)	-1.36	-2.00	-1.39	-1.97
	(0.21)	(0.21)	(0.21)	(0.22)
Log life expectancy, 1960		3.96		2.94
		(0.97)		(0.97)
Log years of secondary schooling, 1965	0.50	0.22	0.50	0.28
	(0.16)	(0.14)	(0.16)	(0.14)
Natural resource abundance	-4.86	-2.35	-4.86	-2.57
	(1.2)	(1.0)	(1.1)	(1.1)
Openness	2.06	1.92	2.00	1.72
	(0.40)	(0.32)	(0.38)	(0.33)
Quality of institutions	0.23	0.20	0.22	0.15
	(0.08)	(0.07)	(0.08)	(0.07)
Access to ports dummy	-0.35	-0.64	-0.31	-0.40
	(0.34)	(0.27)	(0.32)	(0.27)
Average government savings rate, 1970–90	0.14	0.12	0.14	0.13
	(0.03)	(0.03)	(0.03)	(0.03)
Tropics dummy		-1.31		-1.20
		(0.30)		(0.31)
Ratio of coastline to land area		0.24		0.23
		(0.11)		(0.12)
Constant	-2.46	-19.5	-2.28	-14.3
	(0.79)	(4.3)	(0.69)	(4.1)
Adjusted R^2	0.76	0.86	0.78	0.85
$F(1, 68)$[b]	0.22; Prob > F = 0.64			
$F(1, 64)$[b]		9.03; Prob > F = 0.003		

Note: The dependent variable is the growth rate of real GDP per capita in 1965–90 in purchasing power parity terms. Estimates are from ordinary least squares. The sample size is 78 economies (see the appendix). Standard errors are reported in parentheses.

a. Growth rate of the economically active population minus growth rate of the total population, 1965–90.

b. Test of the null hypothesis that the population growth rate equals the negative of the growth rate of the economically active population between 1965 and 1990.

Source: Authors' calculations.

results when an instrumental variables (IV) estimator is used to account for possible reverse causality. The instruments include lagged population growth, log life expectancy in 1960 (in columns 1a and 2a), population policy indicators, and information on the religious composition of the population. Because the instruments chosen are available only for a smaller sample of countries, the OLS estimates corresponding to this sample are also included in the table. The countries excluded from the smaller sample can be found in the notes to table 4. In column 1b of table 4, the coefficients on the growth rates of the working-age

Table 4. *Instrumental Variables Estimates of the Effects of Population Growth on Economic Growth, 1965–90*

Variable	*1a*	*1b*	*2a*	*2b*
Growth rate of economically active population, 1965–90				
Instrumental variables	3.83	1.37		
	(0.82)	(1.71)		
Ordinary least squares	1.95	1.41		
	(0.40)	(0.37)		
Population growth rate, 1965–90				
Instrumental variables	–4.19	–0.92		
	(0.96)	(2.12)		
Ordinary least squares	–1.93	–0.97		
	(0.45)	(0.43)		
Difference in growth rates[a]				
Instrumental variables			3.28	2.96
			(0.65)	(0.75)
Ordinary least squares			1.95	1.60
			(0.40)	(0.38)
R^2 from first-stage regression	0.96	0.96	0.54	0.54
F-test for joint significance of instruments in first-stage regression (*ndf*, *ddf*)	2.59	0.26	2.59	0.26
	(9, 52)	(8, 50)	(9, 52)	(8, 50)
Hausman specification test (chi-square with *df*)	7.13	0.00	6.58	4.47
	(10 *df*)	(13 *df*)	(9 *df*)	(12 *df*)

Note: The dependent variable is the growth rate of real GDP per capita in 1965–90 in purchasing power parity terms. Instruments in the first-stage regression include average growth of population in 1950–60, log life expectancy in 1960 (in columns 1a and 2a), urban share of the population in 1965, population policy variables including attitudes toward fertility and population growth and whether a government agency exists to design and implement population policy, and dummy variables for economies where a majority of the population is Islamic or is Judeo-Christian. The regressions in columns 1a and 2a also include the additional variables in column a of table 2. The regressions in columns 1b and 2b include those in column b of table 2. The sample size is 70 economies (see the appendix). The following economies are not included in the data set used to calculate the estimates reported in this table due to missing data: Botswana, Haiti, Hong Kong (China), Niger, Singapore, Taiwan (China), Tanzania, and Zaire. Standard errors are in parentheses.

a. Growth rate of the economically active population minus growth rate of the total population, 1965–90.

Source: Authors' calculations.

and the total population are similar to the OLS estimates: an increase of 1 percentage point in the growth rate of the working-age population is associated with an increase of 1.37 percentage points in growth of GDP per capita, and an increase of 1 percentage point in the growth rate of the total population is associated with a decrease of 0.92 percentage point of growth in GDP per capita. In column 1b, the IV estimates, with high standard errors, lack the precision of the OLS estimates, but in columns 1a, 2a, and 2b, the IV estimates yield more precise estimates. As can be seen from columns 2a and 2b in table 4, when the coefficients on the growth rate of the economically active population and total population growth are constrained to be equal and opposite in sign, the estimated IV coefficients are almost twice as large as their OLS counterparts. All of the constrained estimates are statistically significant at all conventional levels. The similarity of the signs and significance of these estimated coefficients across the alternative specifications and estimation techniques speaks well for the robustness of the result.

Hausman specification tests (Hausman 1978) were performed to test for consistency of the OLS estimates. The test statistics, reported in each column of table 4, suggest that, in both the constrained and unconstrained versions of the model, one cannot reject the null hypothesis that the IV and OLS estimates are statistically equivalent. Although the data do not provide evidence of an endogeneity problem, *F*-statistics reported in table 4 reveal that the instruments are not jointly significant in columns 1b and 2b. Lagged life expectancy is the instrument doing all the work in columns 1a and 2a, but its validity as an instrument is itself not beyond question. Thus the IV estimates do not permit us to dismiss the possibility of reverse causality. Further analysis is clearly warranted.

Table 5 reports the results when interaction terms and regional controls are included. The table addresses two issues. Is the effect of demographic change on

Table 5. *Alternative Specifications of the Effects of Population Growth on Economic Growth, 1965–90*

Variable	*1a*	*1b*	*2a*	*2b*	*3a*	*3b*
Growth of economically active population, 1965–90	1.94 (0.66)	1.36 (0.55)	2.03 (0.43)	1.43 (0.39)	1.91 (0.45)	1.24 (0.40)
Population growth rate, 1965–90	-1.87 (0.45)	-1.01 (0.41)	-1.88 (0.43)	-1.02 (0.40)	-1.72 (0.49)	-0.78 (0.45)
Interaction between growth of economically active population and institutional quality	0.002 (0.07)	0.01 (0.06)				
Interaction between growth of economically active population and openness			-0.12 (0.31)	-0.05 (0.25)		
Asia dummy					0.81 (0.44)	0.60 (0.35)
North America dummy					0.36 (0.67)	0.67 (0.55)
South America dummy					0.08 (0.49)	0.35 (0.42)
Europe dummy					1.00 (0.60)	0.53 (0.50)
Constant	-2.43 (1.35)	-19.3 (4.3)	-2.62 (0.89)	-19.6 (4.3)	-2.89 (1.20)	-20.19 (4.4)
Adjusted R^2	0.77	0.86	0.77	0.86	0.79	0.86

Note: The dependent variable is the growth rate of real GDP per capita in 1965–90 in purchasing power parity terms. Estimates are from ordinary least squares. The regressions in columns 1a, 2a, and 3a also include the additional variables in column a of table 2. The regressions in columns 1b, 2b, and 3b include those in column b of table 2. The sample size is 78 economies (see the appendix). Standard errors are in parentheses.

Source: Authors' calculations.

economic performance conditioned by key policy variables such as "institutional quality" and "openness"? And does growth in Asia respond differently to demographic and economic conditions than growth in other regions? In columns 1a, 1b, 2a, and 2b the unconstrained versions of the model are reestimated by including interactions between the growth rate of the economically active population and a measure of the quality of institutions (Keefer and Knack 1995), on the one hand, and the growth rate of the economically active population and a measure of openness (Sachs and Warner 1995), on the other. Columns 3a and 3b explore whether any regional effect remains. There is no evidence supporting the view that the policy environment influences the linkage between population dynamics and economic performance. Further work will be required to examine the conditions that promote enjoyment of the demographic gift. See, for example, Higgins and Williamson (1997) or Bloom, Canning, and Malaney (1998). There is some weak evidence that Asia grew faster than the omitted region, Africa, even after controlling for all of these forces, but there is no strong evidence to suggest that Asia, after controlling for all of these forces, grew any faster than North America or Europe. (See Bloom and Sachs forthcoming for an analysis of the economic performance of Africa that highlights the importance of demographic and geographic factors.) There is also no evidence of a nonlinear relationship, ceteris paribus, between initial income and income growth.

We have established that growth of the dependent population slows economic growth. However, does a growing young, dependent population have the same impact as a growing elderly, dependent population? In table 6 we modify the estimation equation by inserting the growth rates of the population under 15 and over 65 in place of the growth rate of the population as a whole. The results sharpen our understanding of how dependent populations contribute to the slowdown. Table 6 reports only the coefficients on the demographic variables. The coefficient on the population under the age of 15 is negative and significant in both specifications: thus an increase of 1 percentage point in growth of the popu-

Table 6. *Effects of Growth in the Economically Active Population and the Dependent Population on Economic Growth, 1965–90*

Variable	*a*	*b*
Growth of economically active population, 1965–90	0.82	0.81
	(0.21)	(0.18)
Growth rate of population under 15, 1965–90	–0.71	–0.37
	(0.16)	(0.16)
Growth rate of population over 64, 1965–90	0.11	0.08
	(0.10)	(0.08)
Adjusted R^2	0.78	0.86

Note: The dependent variable is the growth rate of real GDP per capita in 1965–90 in purchasing power parity terms. Estimates are from ordinary least squares. Only the coefficients on the demographic variables are reported in the table. The specification used in columns a and b also include the other variables in table 2 in columns a and b, respectively. The sample size is 78 economies (see the appendix). Standard errors are in parentheses.

Source: Authors' calculations.

lation under age 15 is associated with a decrease in growth of GDP per capita of about 0.4 percentage point (column b). In contrast, a small, statistically insignificant, but positive, coefficient emerges for the elderly population. We conjecture that because the elderly continue to make important economic contributions by tending the young, by working part-time, and perhaps by continuing to save, they are a smaller net drag than are the very young, whose labor participation and savings rates are trivial in magnitude. Because the elderly are currently a small minority of the total dependent population in Asia (11 percent in 1990), the relationship between the dependent young and growth in GDP per capita dominates, accounting for the negative effect that the dependent population as a whole exerts on the growth rate of GDP per capita.

Our findings regarding the economic impact of the demographic transition can be summarized as follows. Economic growth is less rapid when the growth rate of the working-age population falls short of that of the population as a whole (an event that characterized the first phase of East Asia's postwar demographic transition prior to 1970). Economic growth is more rapid when the growth rate of the working-age population exceeds that of the population as a whole (an event that characterized the second phase of East Asia's postwar demographic transition after 1970 and overlapped with the economic miracle during the past quarter century). And economic growth is somewhat less rapid when the growth rate of the working-age population once again falls short of that of the entire population (an aging phenomenon—the graying of East Asia—that will dominate this subregion during the next quarter century).

Our interpretations of the econometric results reported in this section are, of course, limited by the validity of the underlying theoretical framework and corresponding empirical specifications and by the quality of the data. Although the estimates are wholly consistent with the predictions that emerge from the theoretical model, firmly establishing causality requires further empirical and theoretical research. For example, it would be useful to conduct analyses that (a) incorporate indicators of the quality of data contained in the Penn World Tables, (b) exploit time-series variation in the data, and (c) explore the use of alternative regressors and functional forms. Working directly with figures on growth in employment in place of growth of the working-age population would also be useful, although this would reduce the sample of countries considerably. Recent extensions of this analysis to the late nineteenth century by Williamson (forthcoming) show quite clearly that other episodes of dramatic growth have been significantly influenced by demographic transitional events, and they need more attention too.

IV. Explaining the East Asian Miracle

So far, these results seem consistent with the stylized characterization in figure 6. But they concern only hypothesis testing and statistical significance. What about economic significance? Can our improved understanding of population dynamics explain a significant part of the East Asian miracle?

Between 1965 and 1990, the working-age population in East Asia grew 2.39 percent a year, dramatically faster than the 1.58 percent rate for the entire population and the 0.25 percent rate for the dependent population (table 7). The working-age population also grew faster than the entire population in Southeast Asia, but the differences were almost half of those in East Asia, while in South Asia they were only a quarter.

These demographic differences explain at least some of the variation in economic growth across the subregions of Asia between 1965 and 1990. Combining the coefficients from the estimated growth equations in table 5 and the growth rates of the working-age and total population, table 7 indicates that population dynamics can explain between 1.37 and 1.87 percentage points of growth in GDP per capita in East Asia or as much as one-third of the miracle (1.9 / 6.11 = 0.31). If, instead, the miracle is defined as the difference between current growth of GDP per capita (a transitional rate where population dynamics matter) and the estimated steady state of 2 percent (when population is also in steady state and has no impact), then population dynamics can explain almost half of the miracle (1.9 / [6.11 – 2] = 0.46). In Southeast Asia, where the decline in fertility took place a little later and the decline in infant mortality was a little less dramatic, population dynamics still account for 0.9 to 1.8 points of economic growth or, again, as much as half of its (less impressive) miracle (1.8 / 3.8 = 0.47). In South Asia, the incipient demographic transition accounts for only 0.4 to 1.3 percentage points of economic growth, but still as much as three-quarters of a poor growth performance (1.3 / 1.7 = 0.76). The economies that benefited most from these demographic changes were Hong Kong (China), Malaysia, Republic of Korea, Singapore, Taiwan (China), and Thailand, all of which are old or new fast-growing tigers. The biggest demographic contribution seems to have been in Singapore, at 1.9 to 2.3 percentage points, but Thailand is close behind, at 1.5 to 2.3 percentage points. It is no coincidence that these tigers attracted most of Krugman's attention when he asserted that the East Asian miracle was driven mainly by high rates of capital accumulation and labor force growth (Krugman 1994).[3]

Compared with the rest of the world, East Asia was the largest beneficiary of the population dynamics associated with demographic change. Europe received only a small post–baby boom boost of 0.33 to 0.52 percentage points. Even South America's demographic impact, 0.74 to 1.54 percentage points, was smaller than East Asia's, although the demographic contribution was almost identical to

3. Krugman relied on the findings of Young (1994a, 1994b) and Kim and Lau (1994). In a recent study, however, Hsieh (1998) uses a price-based approach to calculate total factor productivity growth (TFPG) and gets much higher estimates, especially for Singapore, than those resulting from the conventional, quantity-based approaches. He attributes the differences between "primal" (quantity-based) and "dual" (price-based) estimates of TFP to errors in national accounts data on quantities of output and capital. Hsieh argues that factor price data are more reliable, because they can be observed in a marketplace.

Table 7. *Contribution of Demographic Change to Past Economic Growth, by Region, 1965–90*

Region	Average growth rate of real GDP per capita	Average growth rate of population	Average growth rate of economically active population	Average growth rate of dependent population	Estimated contribution			
					1a	1b	2a	2b
Asia	3.33	2.32	2.76	1.56	1.04	1.64	0.86	0.73
East Asia	6.11	1.58	2.39	0.25	1.71	1.87	1.60	1.37
Southeast Asia	3.80	2.36	2.90	1.66	1.25	1.81	1.07	0.91
South Asia	1.71	2.27	2.51	1.95	0.66	1.34	0.48	0.41
Africa	0.97	2.64	2.62	2.92	0.14	1.10	–0.07	–0.06
Europe	2.83	0.53	0.73	0.15	0.43	0.52	0.39	0.33
South America	0.85	2.06	2.50	1.71	1.03	1.54	0.87	0.74
North America	1.61	1.72	2.13	1.11	0.94	1.34	0.81	0.69
Oceania	1.97	1.57	1.89	1.00	0.74	1.14	0.62	0.53

Note: The averages in the first four columns are unweighted country averages. The estimated contribution is created by multiplying the coefficients on the growth rate of economically active population and the population growth rate (table 5) by the regional averages and adding the two for each of the reported specifications.

Source: Authors' calculations.

that of Asia as a whole. Furthermore, these figures for late twentieth century East Asia are far bigger than for nineteenth century Europe and the New World (Williamson forthcoming).

The future will look quite different. Table 8 offers a forecast based on the coefficients of the estimated growth model and the United Nations (1991) demographic projections up to the year 2025. In East Asia, the growth in GDP per capita attributable to demographic influences is projected to be *negative* between 1990 and 2025, declining from a positive gain of 1.37 to 1.87 percentage points between 1965 and 1990 to a *loss* of 0.14 to 0.44 percentage point up to 2025. This projected slowing of economic growth of 1.5 to 2.3 percentage points is caused solely by demographic forces. The demographically induced loss in growth is projected to be even larger in some parts of East Asia. If nothing happens to offset them, demographic events will induce a decline of 2.0 to 2.4 percentage points in the growth of GDP per capita in Hong Kong, a decline of 2.5 to 3.0 percentage points in Singapore, a decline of 1.9 to 2.2 percentage points in Korea, and a decline of 0.9 to 1.1 percentage points in Japan. In contrast, South Asia will potentially enjoy a gain of 0.77 to 1.38 percentage points in the growth rate as it leaves the early "burden" stage of the demographic transition and enters the "gift" stage, with the largest potential gains being for Pakistan and Bangladesh. Southeast Asia should register a slightly smaller demographic gift of 0.62 to 1.10 percentage points, with considerable variance across countries. The biggest potential gainer is projected to be the Philippines, and the biggest potential losers are projected to be Malaysia and Thailand.

While demographic divergence contributed to Asian economic divergence during the past quarter century, with South Asia falling behind East Asia, the demographic indicators most important to economic performance will converge across Asia from now to 2025. If our hypotheses survive further scrutiny, demographic convergence should contribute to economic convergence during the next 30 years in the region. The East Asian connection between demographic transition and economic miracle is now being replayed in South Asia and even more so in Southeast Asia. Although demographic divergence contributed to economic divergence in Asia over the past three to four decades, demographic convergence will contribute to economic convergence over the next three to four decades. Figure 7 offers a stylized characterization of those events.

V. Possible Channels of Impact

Macro evidence supports the hypothesis that demographic events matter in explaining the East Asian economic miracle. Theory seems to explain the correlation, but the hypothesis will be strengthened further if we can show evidence that the channels of impact have been working the way theory predicts. What follows suggests that demographic factors were driving not only the labor force but also a good portion of the high and rising savings and investment rates.

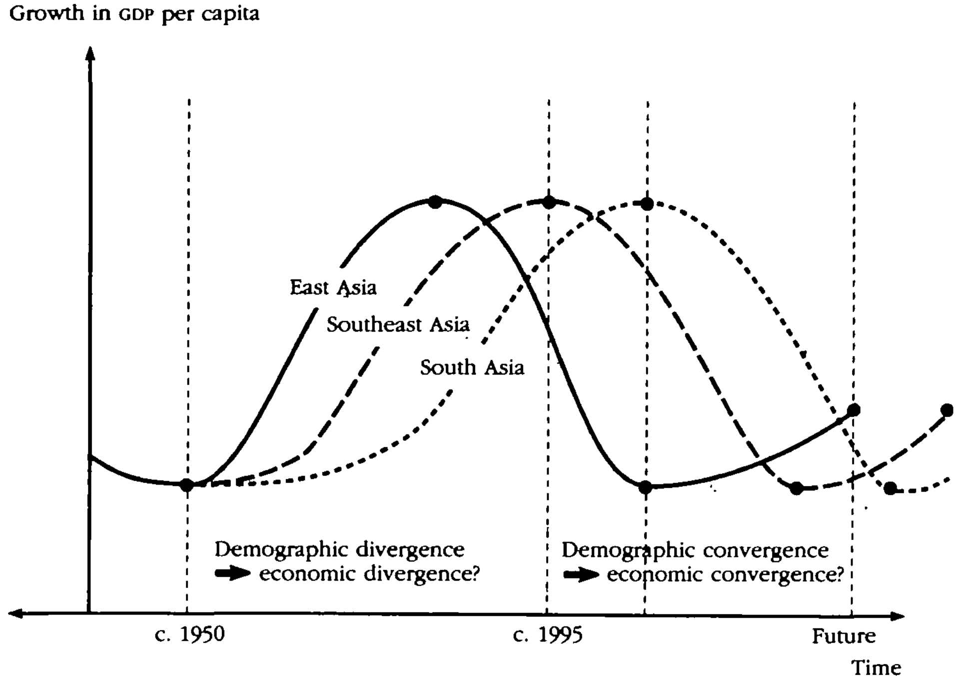
Table 8. *Contribution of Demographic Change to Future Economic Growth, by Region, 1990–2025*

Region	*Projected growth rate of population*	*Projected growth rate of economically active population*	*Projected growth rate of dependent population*	*Estimated contribution*			
				1a	*1b*	*2a*	*2b*
Asia	1.36	1.61	0.99	0.61	0.99	0.50	0.43
East Asia	0.43	0.20	0.87	–0.40	–0.14	–0.44	–0.38
Southeast Asia	1.29	1.66	0.63	0.83	1.10	0.73	0.62
South Asia	1.65	2.11	0.90	1.02	1.38	0.90	0.77
Africa	2.40	2.78	1.88	0.98	1.63	0.73	0.68
Europe	0.17	–0.004	0.48	–0.32	–0.16	–0.34	–0.29
South America	1.50	1.87	0.94	0.82	1.15	0.71	0.60
North America	1.28	1.33	1.21	0.21	0.645	0.11	0.10
Oceania	1.08	0.93	1.37	–0.22	0.24	–0.31	–0.26

Note: The averages in the first three columns are unweighted country averages. The estimated contribution is created by multiplying the coefficients on the growth rate of economically active population and the population growth rate (table 5) by the regional averages and adding the two for each of the reported specifications.

Source: Authors' calculations.

Figure 7. *Stylized Model of Economic Growth and the Demographic Transition in Asia*



The Impact of Demography on Labor Force Growth

How much of the fast-growth transition in Asia can be explained by the impact of demography on labor inputs? Elsewhere we offer some answers that are only summarized here (Bloom and Williamson 1997: table 6). Our interest, of course, is in labor inputs *per person*. Growth in labor input per person (working hours per capita, or H / P) can be separated into three parts: changing hours worked per worker (H / L), changing labor participation rates among persons of working age (L / EAP), and changing shares of the population of working age (EAP / P), the pure demographic effect. Thus per capita hours worked can be decomposed into $H / P = (H / L)(L / EAP)(EAP / P)$.

How much of Asia's economic growth can be explained by a rise in labor input per capita brought about by purely demographic forces? The answer for the period between 1965 and 1975 is very little, but for the period between 1975 and 1990, quite a lot. The rising working-age share served to augment the growth of labor input per capita by about 0.75 percentage point a year between 1975 and 1990. This implies that about 0.4 percentage point of Asia's transitional growth since 1975 (or about a tenth of growth in GDP per capita) can be explained by pure demographics.[4] The results are more striking for East Asia.

4. Calculated by multiplying the growth of labor input per capita by the output elasticity of labor. The output elasticity is taken to be 0.56, the average for the 1960s and 1970s of Japan, Hong Kong, India, Republic of Korea, Singapore, and Taiwan (Chenery, Robinson, and Syrquin 1986: table 2-2).

Growth in labor input per capita brought about by pure demography was more than 1.1 percentage points a year, equivalent to 0.6 percentage point of economic growth. The previous section estimated that demographic forces could account for 1.37 to 1.87 percentage points of the East Asian miracle. The demographic impact on labor input per capita appears to account for about 30 to 40 percent of the total demographic effect. The results for Southeast Asia are more modest—a little more than 0.6 percentage point a year and thus a little less than 0.4 percentage point of economic growth is explained by pure demographics. The results are less striking for South Asia. By itself, the pure demographic effect implies a reduction of 0.5 percentage point in growth of GDP per capita in South Asia compared with East Asia, thus contributing to economic divergence between the two regions since the early 1970s. How much of faster growth in East Asia compared with the industrial countries was due simply to these demographic forces of labor input per capita? The answer is almost 0.5 percentage point, or about four-tenths of the gap between the two.

These demographic forces of labor input per capita do not, of course, exhaust all influences on labor supply. Nor do they exhaust all demographic transitional influences on the growth rate. But are they likely to persist in the future? It depends on where in Asia we look. The fall in the pure demographic effect will be a huge 1.13 percentage points a year in East Asia, causing growth to slow by about 0.6 percentage point. In sharp contrast, the fall will raise South Asia's growth rate of GDP per capita, although not by much. The demographic influence on labor inputs will, by itself, foster a convergence of GDP per capita between the poor South and the rich East, favoring growth in the South by 0.7 percentage point. Whether South Asia will actually realize this potential is, of course, a different matter.

Will the demographic factors that are slowing economic growth be offset by Asians working harder and by participating more actively in the labor force? A more likely outcome is that Asians will work less hard as their incomes rise, just as workers before them have done in the more industrially mature countries. And fewer prime-age Asians will work, because they will be able to afford earlier retirement and will invest more in schooling. In any case, even if Asians work just as hard in the future, this will contribute nothing to growth of labor input per capita; Asians would have to work harder and harder to maintain rates of labor input per capita *growth* (as opposed to levels) in the future.

The Impact of Demography on Savings

Almost 40 years ago Coale and Hoover (1958) proposed their famous dependency hypothesis. It was based on a simple, but powerful, intuition: rapid population growth from falling infant and child mortality and high or rising fertility swell the ranks of the dependent young, thereby increasing consumption requirements at the expense of savings. Eventually, the youth dependency burden evolves into a young adult glut, and the resulting savings boom contributes to an economic miracle. Finally, the demographic transition is manifested by a large elderly burden, low savings, and a deflation of the miracle. The Coale-Hoover hypothesis suggests that some of the impressive rise in Asian savings rates can be explained by the equally impressive decline in dependency burdens, that some of the difference in savings rates between sluggish South Asia and booming East Asia can be explained by differences in their dependency burdens, and that some of the savings rate gaps between the two regions should diminish as the youth dependency rate falls in South Asia and the elderly dependency rate rises in East Asia over the next three decades.

Empirical tests of the Coale and Hoover (1958) hypothesis have yielded mixed results. Leff's (1969) study appeared to place the youth dependency hypothesis on a solid empirical footing. But later research by Goldberger (1973), Ram (1982), and others failed to confirm the dependency hypothesis and cast doubt on the validity of the empirical methods employed in the earlier studies. Theoretical developments also seemed to undermine the foundations of the dependency hypothesis. Tobin's (1967) life-cycle model held that the national savings rate should *increase* with faster population growth. The reason is simple, at least in that model: faster population growth tilts the age distribution toward young, saving households and away from older, dissaving ones. The representative-agent elaboration of Robert Solow's neoclassical growth model pointed in the same direction as Tobin's, with faster population growth resulting in higher savings rates in response to heightened investment demand (Cass 1965, Phelps 1968, and Solow 1956). However, the models just described failed to deal adequately with the dynamics implied by the demographic transition. The "age tilt" in Tobin's steady-state model occurs because the model describes a world restricted to active adults and retired dependents; it would imply a very different tilt if it also acknowledged youth dependency. Similarly, the neoclassical growth models assume fixed labor participation rates and by implication assume no change in the dependency rate, which is exactly what one would assume in a model of steady-state behavior but is inconsistent with the facts of demographic change. In effect, both models sacrifice the rich population dynamics implicit in Coale and Hoover's (1958) predictions about the Asian demographic *transition*.

In the 1980s Fry and Mason (1982) and Mason (1988) addressed the tension between the dependency rate and life-cycle models. These authors developed what they called a "variable rate-of-growth effect" model to link youth dependency and national savings rates. Their model rests on the premise that a decline in the youth dependency rate may induce changes in the *timing* of life-cycle consumption. If consumption is shifted from child-rearing to later, nonchild-rearing stages of the life cycle, aggregate savings rise with a strength that depends directly on the growth rate of national income. As a result, the model suggests that the savings rate depends on the *product* of the youth-dependency ratio and the growth rate of national income (the "growth-tilt effect"), as well as on the dependency ratio itself (the "level effect").

Under the aegis of this new model, the dependency hypothesis has enjoyed something of a renaissance. The Coale-Hoover theory has evolved into explicit economic models that, now revised, account very well for cross-country savings variations in macro time series. Almost all recent analyses of macro data confirm the Coale-Hoover effects (Collins 1991; Harrigan 1996; Higgins 1994, 1998a; Kang 1994; Kelley and Schmidt 1995, 1996; Lee, Mason, and Miller 1997; Masson 1990; Taylor 1995; Taylor and Williamson 1994; Webb and Zia 1990; and Williamson 1993), even if they receive weak support at best in household cross-sections (Deaton and Paxson 1997), a difference that future research needs to reconcile.[5]

Higgins and Williamson (1996, 1997) have estimated the largest macro impacts, and what follows uses their results. They estimate the effect of changes in population age distribution on changes in, not levels of, the savings rate as it deviated around the 1950–92 mean. Thus East Asia's savings rate in 1990–92 was 8.4 percentage points above its 1950–92 average because of its transition to a much lighter dependency burden. Similarly, East Asia's savings rate in 1970–74 was 5.2 percentage points below its 1950–92 average because of its heavy dependency burden at that time. The total demographic swing was an enormous 13.6 percentage points, which would appear to account for the *entire* rise in the savings rate in East Asia during these 20 years. The figures for Southeast Asia are similar, but not quite so dramatic. Southeast Asia's savings rate was 7.9 percentage points higher in 1990–92 than the average in 1950–92 because its dependency burden was lighter and was 3.6 percentage points lower in 1970–74, when its burden was heavier. The total demographic swing was 11.5 percentage points, a smaller figure than for East Asia, but still apparently accounting for the entire rise in the savings rate in Southeast Asia after 1970. The region with the slowest demographic transition has been South Asia, so its far more modest changes in the savings rate are predictable.

To the extent that domestic saving constrains accumulation, falling dependency rates have played an important role in East Asia's economic miracle since 1970. Indeed, assuming the increase in investment to have been equal to the increase in savings, and assuming a capital-output ratio of 4, it follows that demographic changes raised accumulation rates in East Asia by 3.4 (13.6 / 4) percentage points, thus augmenting the growth in GDP per capita by an estimated 1.5 percentage points. Given that demographic forces raised East Asian growth rates by as much as 1.87 percentage points, about three-quarters of this growth seems to have been due to capital accumulation responses. The figure is

5. Higgins (1998b) also points out that the results from analysis of the micro data and the macro data might not agree, because the data are not consistent. Specifically, "household survey data typically do not correspond to the appropriate concept of personal saving as measured by the national income accounts." He notes, as well, that data on the components of national savings (personal, corporate, and government) are difficult to find.

Lee, Mason, and Miller (forthcoming) point out that Deaton and Paxson's (1997) analysis is essentially a comparative steady-state analysis rather than a dynamic analysis, because they assume that "the age profiles of saving and income are invariant to changes in the rate of population growth." Because the effects of the demographic transition depend crucially on dynamic changes, Lee, Mason, and Miller argue that the Deaton and Paxson analysis misses such effects.

too high, of course, because of the unsupported assumption that domestic savings fully constrained investment.

The Impact of Demography on Investment

To the extent that East Asia was able to exploit global capital markets during the past quarter century, the supply of domestic savings is far less relevant than the demand for investment in determining accumulation performance. As the children of the baby boom became young adults, did the increase in new workers imply the need for investment in infrastructure to get them to work, to equip them while at work, and to house them as they moved away from their parents?

When Higgins and Williamson (1996, 1997) test this augmented Coale-Hoover hypothesis on Asia's past, changing age distributions seem to have had the predicted impact. For East Asia, demographic effects have raised investment shares by 8.8 percentage points since the late 1960s. Using the same assumptions made in the previous section on savings, this implies a rise of 1 percentage point in the growth rate of GDP per capita. In sum, demographic forces appear to have contributed 0.6 percentage point to the East Asian miracle via labor inputs per capita and 1 percentage point via capital accumulation per capita—quite consistent with the total demographic impact estimated using macro growth equations: 1.37 to 1.87 percentage points. Thus labor force growth responses might account for about one-third of the positive demographic contribution to the miracle (0.6 / 1.9), capital accumulation responses for about one-half (1 / 1.9), and other forces for the small remainder.

VI. Directions for Future Research and Conclusion

The findings presented herein are revisionist, and thus the methods and data used are likely to come under close scrutiny. Future studies will no doubt refine and revise our arguments. Already we can suggest five ways to further this line of research. First, other theoretical approaches might be explored. The standard Solow-Swan model has, after all, been criticized. New ways of thinking about growth could provide other models in which demographic dynamics and economic growth could be assessed jointly. Second, as further advances in the growth literature define the steady state more effectively, the robustness of our results can be tested and the analysis extended. Third, far more work needs to be done to establish the sources of the demographic transition in Asia after World War II: how much of the transition was due to exogenous factors and how much to endogenous? Fourth, economists and demographers may search for other dramatic episodes of growth or decline, such as the age of mass migration (Taylor and Williamson 1994 and Williamson forthcoming), the AIDS epidemic (Bloom and Mahal 1997), or the Russian mortality crisis of the early 1990s (Bloom, Canning, and Malaney forthcoming) to see if this model proves equally applicable. Fifth, other approaches to understanding simultaneity in the effect of economic growth on population need to be developed, perhaps by analyzing the effects on demographic variables of large and unanticipated variations in income per capita such as those caused by oil price shocks in the 1970s and 1980s.

With those caveats, our first major finding is that population dynamics matter in the determination of economic growth. But the overall population growth rate is not the mechanism driving economic performance. Rather, age distribution is the mechanism by which demographic variables affect economic growth. These age distribution effects seem to be purely transitional—although a full transition can take more than 50 years—and operate only when the growth rates of the working-age and dependent populations differ. The demographic transition is induced by an initial decline in infant and child mortality, which swells the youth dependency cohort until fertility rates begin to fall. It thereby helps to trigger an economic transition in which growth performance passes through three phases: initially it is impeded when the youth dependency cohort swells; it is abetted in the next phase about two decades later when the swollen cohort reaches working age; and it is modestly impeded again some decades later when this swollen cohort becomes elderly.

The second major finding is that population dynamics account for a substantial share of East Asia's economic miracle. Population dynamics account for somewhere between 1.4 and 1.9 percentage points of East Asia's annual growth in GDP per capita from 1965 to 1990, or as much as one-third of observed economic growth during the period. The economic miracle can, of course, be defined differently. Assume that the steady-state growth rate in East Asia is about 2 percent a year, in which case the "miracle" is everything in excess of that, or about 4.1 percent (6.1 percent – 2 percent = 4.1 percent). Under this definition, population dynamics could account for almost half of the miracle. One-third or one-half is certainly not everything, but it suggests that population dynamics may have been the single most important determinant of growth. Within Asia, the evidence also suggests that demographic divergence contributed to economic divergence during the same period. If Southeast and South Asia can use their midphase demographic "gift" in the same way that East Asia did earlier, demographic convergence within Asia may contribute to economic convergence in the coming decades.

In any case, although the results presented here certainly do not *prove* that population dynamics affect economic growth during transitions, they are sufficiently robust to justify additional research on the economic-demographic connection. That research, we suggest, should focus not just on aggregate population growth but also on population dynamics as they affect the age distribution.

Appendix. List of Economies Included in the Data Set

1. Botswana
2. Cameroon
3. The Gambia
4. Ghana
5. Guinea-Bissau
6. Kenya
7. Malawi
8. Mali
9. Niger
10. Senegal
11. Sierra Leone
12. South Africa
13. Tanzania
14. Tunisia
15. Uganda
16. Zaire
17. Zambia
18. Zimbabwe
19. Canada
20. Costa Rica
21. Dominican Republic
22. El Salvador
23. Guatemala
24. Haiti
25. Honduras
26. Jamaica
27. Mexico
28. Nicaragua
29. Trinidad and Tobago
30. United States
31. Argentina
32. Bolivia
33. Brazil
34. Chile
35. Colombia
36. Ecuador
37. Guyana
38. Paraguay
39. Peru
40. Uruguay
41. Venezuela
42. Bangladesh
43. China
44. Hong Kong (China)
45. India
46. Indonesia
47. Israel
48. Japan
49. Jordan
50. Korea, Fed. Rep. of
51. Malaysia
52. Pakistan
53. Philippines
54. Singapore
55. Sri Lanka
56. Syria
57. Taiwan (China)
58. Thailand
59. Austria
60. Belgium
61. Denmark
62. Finland
63. France
64. Germany, Rep. of
65. Greece
66. Ireland
67. Italy
68. Netherlands
69. Norway
70. Portugal
71. Spain
72. Sweden
73. Switzerland
74. Turkey
75. United Kingdom
76. Australia
77. New Zealand
78. Papua New Guinea

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