Chapter 2

Demographic Transition and Economic Growth in China, India and Pakistan

2.1 Introduction

The world population tripled over the past half-century and much of this increase was accounted for by developing and emerging economies. One question that has attracted a lot of attention in the literature concerns the economic consequences of rapid population growth. In most neoclassical modeling it is assumed that the labor force growth rate is equal to the population growth rate (Kelley and Schmidt, 2005). This assumption is relevant in the longer run when both population size and the distribution of the population across different age groups stabilize, but it is less relevant in periods of demographic transition when mortality and fertility rates change from high to low levels. Economic growth may boost temporarily when during the process of demographic transition the number of working-age adults grows large relative to the dependent population, and slow down when a population ages rapidly (Bloom and Williamson, 1998; Kelley and Schmidt, 2005).

The objective of this chapter is to determine the effect of demographic transition on economic growth in China, India and Pakistan, not only in the past but also in the future. Although demographic transition will only boost economic growth

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in countries that are passing through the middle phase of the demographic transition process, developed countries that have reached the last phase of the demographic transition process in which the population ages will be included too. This is because sufficient variation in the data is a prerequisite for obtaining significant effects and these countries offer additional information about the types of effects that occur not only if the number of working-age adults grows large, but also if the number of working-age adults starts decreasing again. In total, we use data from seventy countries located in different regions of the world and being in different phases of the demographic transition process. The data set covers the period 1961-2003. Only when computing the contribution of demographic changes to economic growth and when forecasting the growth potential of demographic changes, we will restrict the data set to China, India and Pakistan.

To evaluate the impact of demographic transition on economic growth, we use an augmented Solow-Swan neoclassical growth model extended to include demographic variables (Mankiw et al., 1992; Barro and Sala-i-Martin, 1995; Asian Development Bank, 1997; Bloom and Williamson, 1998; Kelley and Schmidt, 2005). The type of demographic variables that will be included is motivated by a transition of this model formulated in output per worker growth into a comparable model formulated in output per capita growth. This transition extends the framework proposed by Bloom and Williamson (1998).

One relevant question asks to what extent differences found in the contribution of demographic variables are attributable to the way in which applied econometricians analyze a given body of data. One part of the literature uses data in a cross-section, while another part combines time-series and cross-sectional data. Mankiw et al. (1992) and Barro and Sala-i-Martin (1995) are classic references of the first approach, while Islam (1995) is the most prominent example of the second. Within the literature that combines time-series and cross-sectional data, considerable discussion also arises about two concerns: the appropriate time length to use when a total sample period is divided into several shorter periods, and the inclusion of fixed effects. For example, whereas Bloom and Williamson (1998) adopt a cross-section model, Kelley and Schmidt (2005) adopt a panel data model including country and time-period fixed effects. In this chapter we apply the cross-section as well as the panel data approach and test for endogeneity for some of the explanatory variables to find out which
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econometric model best describes the data.

Our particular interest in Pakistan, India and China is mainly due to three reasons. First, all three countries are emerging economies with impressive economic growth rates in the recent past. Second, they are in the top ten worlds ranking of countries based on population size. In this respect, it should be noted that these three economies account for nearly forty percent of world population. Third, all three countries are passing through the process of demographic transition but at a different pace and over a different time period. Therefore, it is pertinent to explore the impact of demographic transition on their economic performance both in the past and in the future.

This chapter is structured as follows. In section 2.2, we present a detailed comparative analysis of the process of demographic transition in China, India and Pakistan. In section 2.3, we describe the augmented Solow-Swan model extended to include demographic variables that is used for testing the empirical relationship between the demographic transition process and economic growth and, in section 2.4, we present and discuss the empirical findings. Based on this model, we calculate the relative contribution of demographic variables to economic growth in China, India and Pakistan over the period 1961-2003 in section 2.5. In section 2.6, we map the future prospects of the demographic transition process on economic growth in China, India and Pakistan over the period 2005-2050. In the concluding section we summarize our main findings.

2.2 Demographic transition and demographic dividend in Pakistan, India and China

Since we are particularly interested in the effect of demographic transition on the economies of Pakistan, India and China, we briefly describe the process of demographic transition and the main factors behind this process in these three countries.

Figure 2.1 shows that the demographic transition process started with a decline of the Crude Death Rate (CDR) in the early 1950s. This decline proceeded most rapidly in China, followed by India and Pakistan. Over the period 1950-2000, the decline of the CDR was the lowest for Pakistan. The decline in mortality was accompanied by an increase in life expectancy. Over the period 1950-2000, life
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expectancy at birth rose by 28.9 years for China, 26.2 years for India, and 19.5 years for Pakistan. Although not shown, the Infant Mortality Rate (IMR) also declined. This decline ran analogously to the decline of the crude death rate and the increase in life expectancy.

The fall in infant mortality induced parents to reduce fertility, the second phase of the demographic transition process, although they did not adjust immediately. Except for Pakistan, the Total Fertility Rate (TFR) started to decline in the late 1960s (Figure 2.2). One explanation for the sharp decline in China after 1970 is the introduction of the so-called wan xi shao birth control campaign (later marriages, longer interval between births, and fewer children). This policy was followed by the family planning program of "one child policy" in 1979. One of the effects was that the Contraceptive Prevalence Rate (CPR) — the percentage of women between 15-49 years who are practicing, or whose sexual partners are practicing, any form of contraception — increased. For example, it rose from 64.4 percent in 1981 to 77.3 percent in 1987. It should be stressed that India was actually the first country to adopt a family planning program (1951) with full government support. Initially, it was a clinic-based program but in the 1960s this program was extended to include efforts by media and health workers to motivate couples to accept contraception.

The CPR, however, was and still is lower than that in China. It rose from 4.4 percent in 1967 to only 52 percent in 2004. A similar pattern occurred in Pakistan. In 1952, the Family Planning Association of Pakistan initiated efforts to control rapid population growth. Three years later the government began to fund the association and emphasized the need to reduce population growth in its First Five-Year Plan (1955-60). However, population policy was suspended during the 1960s for political and religious reasons. In 1980 the Population Division was renamed the Population Welfare Division and transferred to the Ministry of Planning and Economic Development. This agency was charged with the delivery of both family planning services and maternal and child health care. Pakistan's CPR rose from 3.3 percent in 1979 to 27.6 percent in 2000.
Figure 2.1: Demographic transition in China, India and Pakistan

Demographic Transition in China
- Crude birth rate
- Crude death rate

Demographic Transition in India
- Crude birth rate
- Crude death rate

Demographic Transition in Pakistan
- Crude birth rate
- Crude death rate

Source: United Nation Population Division
Due to the sharp decline in fertility, China was and still is the first of these three countries that saw its fertility rate fall below replacement level, namely in 1995. According to projections of the United Nations (2008), India will not be able to achieve this level before 2025 and Pakistan not before 2050.

The pace and timing of the demographic transition process in these three countries cause(d) divergent trends in population growth and the distribution of the population across different age groups. Figure 2.3 graphs the share of the working-age population (15-64), of children (0-14), and of people aged 65 and over (65+) to the total population. Since 1975 the share of the working-age population increased for all three economies, while the share of children decreased. Up until now, the share of elderly people is below or around 10 percent and therefore not a serious problem for these countries.

Due to concentration of population in productive ages, opportunities for economic growth tend to rise. First, a higher concentration of population in productive ages may lead to an increase in labor supply, provided that labor market can absorb the large number of workers in a productive way. Second, since fertility decline can free up time from child care, relatively more women are likely to enter the labor market, both in terms of participation and in number of hours (Bloom et al., 2009; Choudhry and Elhorst, 2010). Third, because of lower mortality and longer life spans, the willingness to invest in human capital and to save increases, as a result of which the labor force becomes more productive (Cervellati and Sunde, 2009) and prospects for investment improve (Mason, 2001; Schultz, 2004; Fang and Wang, 2005). Taken together, these effects are known as the Demographic Dividend effect (Bloom et al., 2002). The period in which these positive effects are expected to occur is called the potential window of opportunity (WOP). The WOP for China, India and Pakistan is presented in Figure 2.3 and depends on the (expected) distribution of population across different age groups over the period of 1950-2050. This figure shows that the share of the working-age population in China will reach its peak in 2010 (72%). Although the share of children will still be declining, the share of older people will already increase at that time. The WOP will remain open till 2020. In India and Pakistan, the share of the working-age population will reach its peak in 2040 (69%)

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2 Expected values are based on United Nations (2008).
and 2045 (67%), respectively. The WOP, which opened in the 1990s in these two countries, is expected to remain open until the middle of this century.

**Figure 2.2: Comparative analysis of total fertility rate**

![Graph showing comparative analysis of total fertility rate for China, India, and Pakistan from 1950 to 2050.](image)

Source: United Nation Population Division

### 2.3 Demographic transition and economic growth: Theory

To explain economic growth we adopt the augmented Solow-Swan model (Mankiw et al., 1992), which is characterized by the following expression for the steady-state output per worker $y_t$ at time $t$

\[
\ln(y_t) = \ln(A_{r,T}) + gT + \frac{\alpha}{1 - \alpha - \beta} \ln(s) + \frac{\beta}{1 - \alpha - \beta} \ln(h_{r,T}) - \frac{\alpha + \beta}{1 - \alpha - \beta} \ln(\tau + g + \delta) \quad (2.1)
\]

where $T$ denotes the time span of the growth period considered, $A_{r,T}$ is the state of technology at the beginning of the observation period, $\alpha$ is the cost share of physical capital and $\beta$ of human capital in production under a Cobb-Douglas technology, $s$ is the fraction of income invested in physical capital (the saving rate) and $h$ invested in human capital, $\tau$ is the labor force growth rate, $g$ is the rate of technological progress, and $\delta$ is the depreciation rate.
Figure 2.3: Population dynamics by age groups

Panel 1: Population Distribution by Age Group-China

Panel 2: Population Distribution by Age Group-India

Panel 3: Population Distribution by Age Group-Pakistan

The convenient growth-initial income-level regression equation is a linear approximation to the growth rate of output per worker, which is derived from a linear approximation to the dynamics around the steady state in (2.1) using a Taylor expansion (see Mankiw et al., 1992, pp. 422-423). This yield

\[
\frac{\ln(y_t / y_{t-1})}{T} = \gamma_0 + \gamma_1 \ln(y_{t-1}) + \gamma_2 \ln(s_t) + \gamma_3 \ln(h_{t-1}) + \gamma_4 \ln(\tau_t + g + \delta) + \varepsilon_t, \tag{2.2}
\]

where

\[\gamma_0 = (1-e^{-\lambda T})[\ln(A_{t-1}) + gT]/T, \quad \gamma_1 = -(1-e^{-\lambda T})/T, \quad \gamma_2 = \frac{\alpha}{1-\alpha-\beta}(1-e^{-\lambda T})/T, \]

\[\gamma_3 = \frac{\beta}{1-\alpha-\beta}(1-e^{-\lambda T})/T, \quad \text{and} \quad \gamma_4 = -\frac{\alpha + \beta}{1-\alpha-\beta}(1-e^{-\lambda T})/T \quad \text{(see Barro and Sala-i-Martin, 1995; Islam, 1995).}
\]

In its simplest version, \(\varepsilon\) represents a normally distributed and independent error term, as a result of which (2.2) can be estimated by Ordinary Least Squares (OLS). This model implies that economies tend toward the same equilibrium growth path for capital, and hence output per worker, except for differences in \(s, h, \tau, g\) and \(\delta\). The annual speed of convergence implied by the parameter estimate of \(\gamma_1\) is \(\lambda = -\ln(1+\gamma_1 T)/T\), although it is important to note here that absolute (or unconditional) convergence, i.e. the idea that a country grows faster the further it is from its own steady state, may change if we allow for explanatory variables that have different values across countries. This is because differences among the explanatory variables of economic growth correspond to different steady-state positions. A poor country may still grow faster than a rich country, but only conditional upon the variables determining its steady-state position. This is true for all explanatory variables that are considered in addition to the initial income level.

According to Bloom et al. (2001), the neoclassical Solow-Swan model ignores a critical dimension of population dynamics: populations' evolving age structure. Since each age group in a population behaves differently, and the distribution across age groups changes, economic growth may be boosted or slow down temporarily. Whereas prime-age adults supply labor and savings, the young require education and the aged health care and retirement income. Consequently, economic growth may boost when the number of working-age adults grows large relative to the dependent population, and slow down when a population rapidly ages. Estimates by Bloom and Williamson (1998) and Kelley and Schmidt (2005) indicate that successively one-
third of East Asia's economic growth over the period 1965-1990 and 44 percent of Asia's economic growth over the period 1960-1995 can be attributed to population dynamics. At the same time, Bloom and Williamson (1998) warn that the demographic gift when the number of working-age adults grows large merely represents a growth potential. Whether this potential is used properly or not depends upon the policy environment as reflected by quality of institutions, labor policies, openness to trade, macroeconomic management, and education policies.

In many studies on economic growth, output per capita rather than output per worker is the main focus of analysis (Barro and Sala-i-Martin, 1995). Bloom and Williamson (1998) show that output per capita is identical to

\[ y = \frac{N}{L} \times \frac{Y}{N} \quad (2.3) \]

where N is the total population and L is the labor force. When taking natural logs and converting this expression to growth rates, one obtains

\[
\ln \left( \frac{Y}{N} \right) - \ln \left( \frac{Y}{N} \right)_{t+T} = \ln \left( \frac{Y}{L} \right) - \ln \left( \frac{Y}{L} \right)_{t+T} + \ln \left( \frac{L}{N} \right) - \ln \left( \frac{L}{N} \right)_{t+T}. \quad (2.4)
\]

This equation splits per capita output growth into two components: a component measuring productivity per worker and a component that transforms output growth per worker to output growth per capita. The first component is the dependent variable of the augmented Solow-Swan model when it is divided by the time span T (since \( \gamma_t = \frac{Y_t}{L_t} \)), while the second component can be rewritten as

\[
\ln \left( \frac{L}{N} \right) - \ln \left( \frac{L}{N} \right)_{t+T} = \ln \left( \frac{L}{L_{t+T}} \right) - \ln \left( \frac{N}{N_{t+T}} \right) = \tau - n. \quad (2.5)
\]

According to Kelley and Schmidt (2005), this component can take three different forms:

- The labor force growth rate is equal to the population growth rate, \( \tau-n=0 \).
- \( \tau-n \approx wa-n \), where the variable "wa" represents the growth rate of the working-age population, i.e., the population aged 15 to 64.
- \( \tau-n = [\tau-lf] + [lf-wa] + [wa-n] \). This decomposition is different from (4) in that it assumes that L represents the number of labor hours and \( \tau \) the growth rate in
the number of labor hours, and "lf" the labor force growth rate. This transformation takes full advantage of the components of labor change.

The first assumption is employed in most neoclassical theoretical modeling and most relevant in the longer run when both population size and the age distribution stabilize. It is less relevant when studying the impact of demographic transition, because this process marks a period within which the age distribution changes tremendously. Bloom and Williamson (1998) adopt the second transformation, because the growth rate of the working-age population is seen as a simple but useful proxy for the labor market effects that occur over the period of demographic transition, and because this proxy can be treated as an exogenous variable to the model. The third transformation also requires data on the number of labor hours and the labor force participation rate of the working-age population, which in addition may not be treated exogenous to the model.

Kelley and Schmidt (2005) argue that the modeling framework proposed by Bloom and Williamson (1998) to address imbalanced age-structure changes over the demographic transition process is not sufficient to capture the multi-faceted role of demography in economic growth. In addition to the population growth and the working-age population growth variables, they also propose demographic variables such as the population shares of younger and of older people, as well as population size and density. However, a theoretical framework to justify these variables is lacking.

Some studies have debating the question whether more factors should be included to explain economic growth. Sala-i-Martin et al. (2004), Cuaresma and Doppelhofer (2006), and Islam (2008) argue that mono-causal theories of economic performance (productivity measured as economic growth per worker), although valid, are less useful as it appears, because they find, using advanced econometric techniques, that a good number of variables have robust partial correlation with economic growth. In an overview paper, Durlauf and Quah (1999, p. 276) count 36 different categories and 87 specific examples of variables that have been included in previous studies. At the same time, Durlauf and Quah argue that the lessons that can be drawn from these models are unpersuasive. First, many studies fail to clarify whether the additional variables they consider can be interpreted in the light of some economic theory. Second, even if they can and appear to be statistically significant, it
is not always clear what exercise a researcher conducts by adding particular control variables. Since growth explanations are so broad, it is often difficult to identify a particular economic theory. Brock and Durlauf (2001) refer to this problem as the "open-endedness" of theories of economic growth. To justify additional variables, such as the demographic variables in Kelley and Schmidt (2005), we therefore extend the transition model of Bloom and Williamson (1998), while control variables that cannot be justified theoretically will be left aside in this study.

The population growth rate, \( n \), can be rewritten as a weighted average of the population growth rates of different age groups

\[
n = s_{0-14}n_{0-14} + s_{15-64}n_{15-64} + s_{65+}n_{65+},
\]

where \( s \) denotes the population share of a particular age group and \( n \) the growth rate of that age group. Note that the three age groups, 0-14, 15-64 and 65+, may be considered as the main age groups representing the demographic transition process and that \( n_{15-64} \) represents the population of working-age.

Collecting terms from (2.2), (2.5) and (2.6), the annual GDP per capita growth rate can be written as a function \( f \) of the following demographic variables

\[
\frac{1}{T} [\ln\left(\frac{Y}{N}\right)_{t} - \ln\left(\frac{Y}{N}\right)_{t-1}] = f(\ln(\tau_{t} + g + \delta), \tau - (s_{0-14}n_{0-14} + s_{15-64}n_{15-64} + s_{65+}n_{65+})].
\]

Table 2.1 gives an overview of demographic variables used in a selection of previous studies, which are representative for the kind of variables that have been considered over the last fifteen years. Brander and Dowrick (1994) consider the birth rate and the population growth rate. They find that high birth rates reduce economic growth because both investment and labor supply will fall. Since the birth rate and the population share of people aged 0-14 are closely related to each other, this variable fits within (2.7). Barro (1996, 2008) and De Gregorio and Lee (2003) use the total fertility rate to capture the impact of population change on economic growth. On the short-term, a higher fertility rate means that increased resources must be devoted to childrearing, rather than production of goods. Just as the birth rate, this variable fits within (2.7). On the long-term, a portion of the economy's investment must be used to provide capital for new workers (after children have grown up), rather than to raise...
capital per worker. This effect is reflected by the variable $\ln(\tau+g+\delta)$ since its coefficient $\gamma_4$ is expected to be negative.

Table 2.1: Demographic variables included in previous studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Demographic Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brander and Dowrick (1994)</td>
<td>Birth rate and population growth rate</td>
</tr>
<tr>
<td>Barro (1996, 2008)</td>
<td>Total fertility rate</td>
</tr>
<tr>
<td>Kelley and Schmidt (1995)</td>
<td>Population growth rate, population density, crude birth rate, lagged crude birth rate and crude death rate</td>
</tr>
<tr>
<td>Bloom and Williamson (1998)</td>
<td>Population growth rate, working-age population growth rate</td>
</tr>
<tr>
<td>Kelley and Schmidt (2005)</td>
<td>Child dependency, old-age dependency, population density, population size</td>
</tr>
<tr>
<td>Crenshaw et al. (1997)</td>
<td>Population growth rate, population (15+), population (0-14)</td>
</tr>
<tr>
<td>De Gregorio and Lee (2003)</td>
<td>Total fertility rate</td>
</tr>
<tr>
<td>Fang and Wang (2005)</td>
<td>Total dependency ratio</td>
</tr>
<tr>
<td>Hongbin and Zhang (2007)</td>
<td>Birth rate, youth dependency ratio, growth of labor force share, migration rate</td>
</tr>
<tr>
<td>Azomahou and Mishra (2008)</td>
<td>Population growth rate, population (15-64), population (0-14), population (65+)</td>
</tr>
<tr>
<td>Bloom et al. (2008)</td>
<td>Youth-age and old-age population shares</td>
</tr>
</tbody>
</table>

Kelley and Schmidt (1995) augments the growth model with population growth, population density and components of population growth (crude death rate, crude birth rate and the crude birth rate lagged fifteen years in time). The inclusion of the current and the lagged birth rate is meant to distinguish between the supposed negative resource-using effects of births from the positive labor supply effects of past births. Population density is included to cover land stock per capita to signify positive inducements to technical change caused by pressure on resources created by population growth. The last variable, however, does not follow from (2.7).

Bloom and Williamson (1998) consider the growth rate of both the working-age population and the total population to translate a traditional neoclassical model formulated in output per worker growth into a comparable model formulated in output per capita growth. This means that they replace $\tau$ by $n_{15-64}$ and do not decompose $n$ into different age group. In a follow-up study (Bloom et al., 2008), they also consider the youth-age and old-age population shares. Kelley and Schmidt (2005) consider the child and old-age dependency ratios. Since these variables are defined as $s_{0-14}$ and $s_{65+}$ and as $s_{0-14}/s_{15-64}$ and $s_{65+}/s_{15-64}$, respectively, they perfectly fit within (2.7).

Other studies reported in Table 2.1 use variables describing the size of different age groups or dependency ratios and confirm the observation that the focus has been shifted from population growth rates towards its distribution across different
age groups. The inclusion of these variables is often justified by the distinct economic behavior of different age groups.

Although the decision which variables to use is partly a matter of taste, statistical considerations may be important too. Following Bloom and Williamson (1998), we approach $\tau - n$ by $\omega - n = n_{15-64} - n$, the growth differential between the working-age population and the total population. The advantage of $n_{15-64}$ over $\tau$ is that the first variable may be treated exogenous to the model. If $\tau$ were to be measured by either the number of labor hours or the number of people participating in the labor market, it will partly depend on the rate of economic growth, and thus be endogenous to the system. At the same time, it should be realized that $\tau$ will also depend on child dependency (or the birth/fertility rate) and old-age dependency. A reduction of child dependency can free up time from child care and can increase female labor supply, both in terms of participation and in number of hours (Choudhry and Elhorst, 2010). A reduction of old-age dependency may reduce tax and social security contributions paid by employed people needed to finance retirement income and health care of the elderly and therefore also increase labor supply (Elhorst and Zeilstra, 2007). For this reason, we follow Kelley and Schmidt (2005) and also consider child and old-age dependency ratios. Except that they determine the population growth rate, as pointed out in (2.7), they also affect labor supply, which is important since the replacement of labor force growth rate $\tau$ by the working-age population growth rate $n_{15-65}$ has the side effect that $\tau$ is no longer part of the model. The variables $s_{0-14}/s_{15-64}$ and $s_{65+}/s_{15-64}$ not only compensate for this but also perfectly fit within (2.7). The coefficients of these two dependency ratios are expected to be negative.

Bloom and Williamson (1998), among others, split the variable $\tau - n$ into $\tau$ and $n$ to test whether their coefficients are different. However, since the correlation coefficient between the growth rates of the working-age population and of the total population is rather high (in our sample 0.92), their evaluation might be undermined by multicollinearity issues. Including variables in a regression that are highly correlated may cause the coefficients to have the wrong sign or implausible magnitudes and to have high standard errors and low significance levels even if they are jointly significant and

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4 Kelley and Schmidt (2005) include the child and old-age dependency ratios because they might affect the saving rate, a variable they do not include. However, we believe that the impact of these dependency ratios on labor supply is more important, because changes in labor supply affect the transition of the Solow-Swan model formulated in output per worker growth into a comparable model formulated in output per capita growth. Moreover, we control for the saving rate.
the $R^2$ for the regression is high (Greene, 2008, p. 59). The coefficient of the variable $\tau-n$ is expected to be positive. If the growth rate of the working-age population exceeds the growth rate of the population, economic growth may be boosted temporarily, and vice versa. Most likely, its coefficient is also smaller than 1.$^5$

2.4 Demographic transition and economic growth: Empirics

For our empirical analysis we use data from 70 countries over the period 1961-2003. The data set consists of developing as well as developed countries at different phases of the demographic transition process. Table 2.1A in the appendix gives an overview of the countries included arranged by continent.

Data on GDP per capita are taken from the Groningen Growth and Development Centre (http://www.ggdc.net) and expressed in constant price purchasing power parities (PPP). Demographic variables are taken from World Development Indicators (World Bank, 2007). The working-age population is defined as the population 15-64 years of age, while the child and old-age dependency ratios are obtained by dividing the population aged 0 to 14 and aged 65 and over by the working-age population, respectively. The saving rate is measured as gross domestic saving in percentage of GDP and taken from World Development Indicators (World Bank, 2007), while human capital is measured as the tertiary gross enrolment rate and taken from World Bank (2000).

The first column of Table 2.2 reports the estimation results when using the data in one single cross-section, i.e., if $T=42$ and the number of observations equals the number of countries in the sample (70). The average annual growth rate over the entire period 1961-2003 (multiplied by 100) is explained by both the initial level of per capita GDP and the tertiary gross enrolment rate in 1963 and the averages of the growth differential between the population of working-age and the total population, the child and old-age dependency ratios, and the saving rate for the period 1961-2003. Employing the single cross-section approach has three potential drawbacks. First, it only utilizes data at the beginning and the end of the sample period. Second, it erroneously assumes that variables like the growth differential between the population of working-age and the total population, and the child and old-age dependency ratios

$^5$ Usually, $(g+\delta)$ is assumed to be the same for all economies and to be equal to 0.05 (Mankiw et al. 1992; Islam 1995). Replacing $\gamma\ln(\tau+0.05)+\tau$ by $\gamma^*\ln(\tau)$ will have the effect that $\gamma^*<1$ since $\gamma<0$, unless the approximation of $\tau$ by $n_{15-64}$ is not adequate and the restriction that the coefficients of $\tau$ and $-n$ are the same does not hold.
are constant over the sample period. Third, it overlooks the possibility that different growth paths may lead to similar results in terms of convergence.

Table 2.2: Effect of demographic transition on economic growth

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Cross Section</th>
<th>TSCS</th>
<th>Fixed Effects</th>
<th>Fixed Effects Instrumental Variable Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log initial GDP per capita</td>
<td>-0.83 (-4.32)</td>
<td>-0.55 (-2.79)</td>
<td>-1.69 (-3.91)</td>
<td>-2.72 (4.60)</td>
</tr>
<tr>
<td>Growth differential between working-age population and total population</td>
<td>3.56 (5.99)</td>
<td>1.32 (5.51)</td>
<td>0.55 (2.06)</td>
<td>0.60 (1.59)</td>
</tr>
<tr>
<td>Log of child dependency ratio</td>
<td>-2.71 (-3.46)</td>
<td>-3.54 (6.15)</td>
<td>-1.76 (1.98)</td>
<td>-3.32 (-1.96)</td>
</tr>
<tr>
<td>Log of old-age dependency ratio</td>
<td>0.45 (0.80)</td>
<td>-0.77 (1.74)</td>
<td>-0.47 (-0.50)</td>
<td>-0.68 (1.18)</td>
</tr>
<tr>
<td>Log of tertiary gross enrolment rate</td>
<td>-0.003 (-0.15)</td>
<td>-0.013 (1.44)</td>
<td>-0.005 (-0.40)</td>
<td>0.014 (0.82)</td>
</tr>
<tr>
<td>Log of saving rate</td>
<td>0.54 (1.63)</td>
<td>0.92 (4.77)</td>
<td>1.20 (5.12)</td>
<td>1.06 (4.08)</td>
</tr>
<tr>
<td>Constant</td>
<td>5.51 (2.38)</td>
<td>1.39 (2.07)</td>
<td>10.87 (2.68)</td>
<td>10.77 (1.14)</td>
</tr>
</tbody>
</table>

| Number of cross sectional units | 70 | 70 | 70 | 70 |
| Observations(unbalanced panel) | - | 540 | 540 | 463 |
| \(R^2\) | 0.65 | 0.28 | 0.48 | 0.42 |

LR-test, significance country FE 232.70 0.00

Hausman test (FE vs. RE) 34.24 0.00

Significance of time FE
F statistic/ chi-2 statistic in IV model 12.11 6.33 43.16 0.00

Sargan-Hansen test over identifying restrictions Chi-square (1) 1.24 0.00 0.31

Davidson-MacKinnon test of exogeneity F(2,378) 1.22 0.29

p-values in parentheses.
The coefficient of tertiary gross enrolment rate is multiplied with 100 to make results presentable.
In column 4, the child and old-age dependency ratios are instrumented by lagged values of the population growth rate, the working-age population growth rate and life expectancy.

Results in the second column of Table 2.2 are obtained by moving to cross-sections for shorter periods. In such a pooled regression, the average annual growth rate over each period is explained by the initial level of per capita GDP and the tertiary gross enrolment rate for that particular period, as well as the averages of the growth differential between the population of working-age and the total population, the child and old-age dependency ratios, and the saving rate for that particular period. The question that arises what the appropriate length of such periods is. A time span of
just one year is possible since the underlying data set provides annual information. However, often yearly time spans are said to be too short for studying growth convergence because short-term disturbances may loom large in such brief time spans (Islam, 1995). Therefore, we consider five-year time spans, T=5, just as in Islam (1995). Since our data set is not balanced, the number of observations in this regression is smaller than 630, namely 540 (growth periods considered are 1961-65, 1966-70, 1971-75, 1975-80, 1981-85, 1986-90, 1991-95, 1996-2000, 2001-2003).

A possible objection to pooling time-series cross-section data is that this approach does not control for fixed effects. Islam (1995) argues that fixed effects should be included, since the strategy of replacing the term \((1-e^{-\lambda T})[\ln(A_{t-T}) + gT]\) in the growth-initial income-level regression with just a constant and a normally distributed error term, \(\gamma_0 + \epsilon\), is flawed. Since \(A_{t-T}\) not only reflects technology but also such factors as resource endowments, climate and institutions, \(A_{t-T}\) is anything but constant among different countries, and could probably be correlated with one or more of the explanatory variables in the regression model. Replacing this variable with a normally distributed error term and then estimating the model by OLS thus violates the condition that the explanatory variables are independent of the error term. A better solution is to replace \(A_{t-T}\) by a conventional error term as well as a dummy variable for each country in the sample, since the latter does not need to be uncorrelated with the other explanatory variables in the model. Since the rate of technological process, \(gT\), may also change over time, this variable is replaced by time-period fixed effects. The results of this model are reported in the third column of Table 2.2. For reasons of space, the country and time-period fixed effects are not reported.

A necessary and sufficient condition for convergence is that the coefficient of the initial GDP per capita level is negative. For all regression results summarized in Table 2.2, this condition is satisfied. The coefficient of the variable measuring the growth differential between the working-age population and the total population is positive and significant for all of regressions whose results are reported in Table 2.2. The coefficient appears to be greater than one for the first two regression specifications (single cross-section model and TSCS model) and smaller than one for the third regression specification (fixed effects model). Overall, these results imply that the hypothesis that economic growth may be boosted temporarily in case the
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growth rate of the working-age population exceeds the growth rate of the population, and vice versa, is supported by the data.

As expected, the child dependency ratio has a negative and significant effect for all regression results summarized in Table 2.2. The coefficient of the old-age dependency ratio appears to be positive for the first regression specification (single cross-section model) and negative for the second and the third regression specifications (TSCS model and fixed effects model). However, in neither of these cases it is significant. Recently, Bloom et al. (2008) also found that the old-age population share does not have a significant effect on economic growth. One explanation is that we do not have countries in our sample that have completed the demographic transition process. Most developed countries just reached the last phase of this process, that is, the period in which the population ages, as a result of which negative effects, if present, have not yet been able to manifest themselves. Another explanation is that some studies have debated the proposition that population aging causes negative effects (Mason and Lee, 2004).

The saving rate has a positive effect for all regression results summarized in Table 2.2, although it is only significant in the TSCS model and the fixed effects model. The tertiary gross enrolment rate appears to be insignificant for all regression results summarized in Table 2.2.

The $R^2$ of the TSCS approach over a five-year time span amounts to 0.28, which is considerably less than the $R^2$ of the single cross-section approach of 0.65. The explanation is that the increase in the number of observations also amplifies the variation in the dependent variable. The $R^2$ of the fixed effects model increases to 0.48, which can be explained by its only focusing on the time-series variation between observations. To investigate the hypothesis that the country fixed effects are not jointly significant, we performed a Likelihood-Ratio (LR) test. The results indicate that we must reject this hypothesis. To test whether random effects can replace these fixed effects, we performed Hausman's specification test (Baltagi, 2005). The results again are in favor of the fixed effects model. For this reason we will use this model to isolate the impact of demographic variables on economic growth. The reason to abandon the single cross-section model is that this model, just as the TSCS model, does not control for fixed effects. Another reason is that the coefficient of the demographic variable measuring the growth differential between the working-age
population and the total population and the coefficient of the old-age dependency ratio take less plausible values than in the fixed effects model (greater than 1 and greater than 0, respectively). Besides, we already discussed three potential drawbacks of the single cross-section approach.

One potential objection is that the child and old-age dependency ratios are not exogenous. Problems of reverse causation may bias the estimated impact on economic growth. To test for reverse causality, we re-estimated the fixed effects model by 2SLS. Child dependency and old-age dependency were instrumented with five-year lagged values of the population growth rate, the working-age population growth rate and life expectancy. The coefficient estimates are reported in the fourth column of Table 2.2, as well as the results of two specification tests.

To test the joint hypothesis that the instruments are valid and the model is correctly specified, we applied the Sargan-Hansen test of over identifying restrictions. The joint null hypothesis is that the instruments are valid instruments, that is, uncorrelated with the error terms, and that the excluded instruments are correctly excluded from the estimated equation. Under the null, the test statistic is distributed as chi-squared in the number of (I-K) over identifying restrictions, where I is the total number of instruments. A rejection casts doubt about the validity of instruments. However, we find that the joint hypothesis cannot be rejected.

To test the hypothesis that the specified endogenous regressors can actually be treated as exogenous, we ran the Davidson and MacKinnon (1993) test of exogeneity for a regression equation with fixed effects. The null hypothesis states that an ordinary least squares estimator of the same equation will yield consistent estimates: that is, any endogeneity among the regressors would not have deleterious effects on OLS estimates. Under the null, the test statistic is distributed $F(M,N_{obs}-K)$, where $M$ is the number of regressors specified as endogenous in the original instrumental variables regression, $N_{obs}$ is the total number of observations and $K$ is the number of regressors. A rejection indicates that the instrumental variables fixed effects estimator should be employed. Since the five-percent critical value of this density function is 3.04, the null cannot be rejected, which implies that the child and old-age dependency ratios may be

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6 Another objection might be that the impact of child and old-age dependency cannot be evaluated using this model because it controls for the saving rate too. However, the coefficient estimates appeared to be robust against excluding the saving rate.
Demographic Transition and Economic Growth in China, India and Pakistan

treated as exogenous explanatory variables. A similar result was found by Bloom and Williamson (1998) and Kelley and Schmidt (2005).

Table 2.3: Effect of demographic transition on economic growth: sensitivity analysis fixed effects model

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Deleting one percentile from each variable</th>
<th>Outlier treatment</th>
<th>Ten year time spans</th>
<th>Jackknifing country by country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log initial GDP per capita</td>
<td>-2.23</td>
<td>-1.74</td>
<td>-2.23</td>
<td>-1.70</td>
</tr>
<tr>
<td></td>
<td>(-5.13)</td>
<td>(-3.99)</td>
<td>(-6.83)</td>
<td>se=0.43</td>
</tr>
<tr>
<td>Growth differential between working-age population and total population</td>
<td>0.51</td>
<td>0.59</td>
<td>0.37</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>(1.96)</td>
<td>(2.20)</td>
<td>(1.87)</td>
<td>se=0.27</td>
</tr>
<tr>
<td>Log of child dependency ratio</td>
<td>-2.78</td>
<td>-1.80</td>
<td>-1.74</td>
<td>-1.76</td>
</tr>
<tr>
<td></td>
<td>(-2.90)</td>
<td>(-1.92)</td>
<td>(-2.28)</td>
<td>se=0.95</td>
</tr>
<tr>
<td>Log of old-age dependency ratio</td>
<td>-0.31</td>
<td>-0.38</td>
<td>-0.32</td>
<td>-0.47</td>
</tr>
<tr>
<td></td>
<td>(-0.34)</td>
<td>(-0.40)</td>
<td>(-0.41)</td>
<td>se=0.93</td>
</tr>
<tr>
<td>Log of tertiary gross enrolment rate</td>
<td>-0.002</td>
<td>-0.006</td>
<td>-0.009</td>
<td>-0.007</td>
</tr>
<tr>
<td></td>
<td>(-0.012)</td>
<td>(-0.402)</td>
<td>(-0.767)</td>
<td>se=0.04</td>
</tr>
<tr>
<td>Log of saving rate</td>
<td>1.33</td>
<td>1.25</td>
<td>0.82</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td>(5.52)</td>
<td>(5.19)</td>
<td>(3.96)</td>
<td>se=0.24</td>
</tr>
<tr>
<td>Constant</td>
<td>14.66</td>
<td>11.28</td>
<td>16.76</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.64)</td>
<td>(2.78)</td>
<td>(5.08)</td>
<td></td>
</tr>
</tbody>
</table>

t values in parentheses, se= standard error

To investigate whether the results are robust, Table 2.3 finally reports the results of different robustness checks of the fixed effects model. The first column gives the result when deleting one percentile on both ends of the distribution of each variable. This leads to a reduction of twelve observations. The second column gives the results when a fraction of the lowest and the highest values of each explanatory variable are set equal to a lower and an upper bound, respectively. The third column gives the results when the data are measured over time spans of ten years, which, just as time spans of five years, is common practice in the growth literature. Since the countries included in the sample are different in size and economic development, we also investigated whether the results are driven by one particular country. For that purpose, one country has been taken out of the sample at a time (jacknifing). Since the sample consists of 70 countries, we so obtained 70 observations for each coefficient estimate.
Chapter 2

and its corresponding standard error (se). The last column of Table 2.3 reports the mean coefficient estimate and the mean standard error. In neither of these cases, we need to reject the null hypothesis that the estimates of one particular coefficient in the fixed effects model reported in Table 2.2 and its counterpart in one of the columns of Table 2.3 have the same expected value. This indicates that the results of the fixed effects model are robust.

Cuaresma and Doppelhofer (2006) have found that nonlinearities and threshold effects among development of economic growth may be important too. For this reason, a quadratic functional form has been estimated too, which may be considered a second-order Taylor expansion to the dynamics of the steady state [see equations (1) and (2)]. However, even though a fraction of the second-order terms was found to be significant, this approach is problematic from a forecasting point of view. In the next section, we map the future prospects of the demographic transition process on economic growth in China, India and Pakistan over the period 2005-2050, based on demographic changes over that period projected by the United Nations (2008). If the economic growth model is extended to include second-order terms between the demographic and economic variables, such as the saving rate and the tertiary gross enrolment rate, these economic variables need to be projected as well. Since these data are not available and predicted values of these explanatory variables would create new uncertainties, the analysis in the next section has been limited to results obtained for the linear fixed effects model.

2.5 The impact of demographic transition

To determine the contribution of the demographic transition process to past economic growth in China, India and Pakistan, the coefficient estimates of the demographic variables in the fixed effects model are multiplied with the country-specific growth rates of the demographic variables, averaged over the period 1963-2003. The contribution of the old-age dependency ratio is also determined, even though its coefficient in Table 2.2 turned out to be insignificant. We will come back to the implications of this in the concluding section.

The results, which are reported in Table 2.4, show that the decline in child dependency was the major contributor to GDP per capita growth in these three countries. The growth differential between the working-age population and the total
population also had a positive effect on economic growth, but its contribution was much smaller. The old-age dependency ratio had a negative effect. To determine the overall contribution of the demographic variables, the individual contributions have been summed. The overall contribution appears to be positive for all three economies and the highest for China. Over the period 1963-2003, China's annual GDP per growth rate was 7.24 percent and 3.35 percentage points of this growth rate, i.e., 46 percent can be attributed to demographic variables. India grew by 2.62 percent per year of which 39 percent can be attributed to demographic variables, and Pakistan grew with 2.57 percent per year of which 25 percent can be attributed to demographic variables. The results for India and Pakistan are different from those of China because the demographic transition process in these two countries started much later (see Figure 2.1).

Bloom and Williamson (1998) found that one-third of East Asia's economic growth over the period 1965-1990 can be attributed to population dynamics. However, they did not consider demographic variables other than the growth rates of the working-age population and of the total population. Kelley and Schmidt (2005) found that 44 percent of Asia's economic growth over the period 1960-1995 can be attributed to population dynamics, of which 16 percentage points as a result of the growth differential between the working-age population and the total population and 28 percentage points as a result of other demographic variables. Our results corroborate Kelley and Schmidt's finding that other demographic variables, among which the child dependency ratio in particular, are relatively more important than the growth differential.

Table 2.2A in the appendix decomposes the results reported in Table 2.4 into four periods: 1963-70, 1971-80, 1981-90, 1991-2000. This table reconfirms that the child dependency ratio was the major contributor to GDP per capita growth in most periods, although there are notable exceptions. In addition, it shows the temporary nature of population dynamics on economic growth. For example, whereas the old-age dependency ratio was not a serious threat for China in the first three decades, the size of the negative effect obtained for the 1990s indicates that this may change soon. Furthermore, whereas the contribution of the child dependency ratio on China's GDP per capita growth rate was 6.20 percentage points and relatively important in the 1980s, it was negative and relatively unimportant in the 1960s. These figures are
explained by the introduction of the wan xi shao birth control campaign after 1970 and the one child policy in 1979. Just as in China, the decline in child dependency in India had a positive effect on economic growth in the last three decades. However, whereas the contribution of this variable in China already started to decline in the 1990s, it still increases in India. Since the demographic transition process in Pakistan started much later than in China and India, the first positive contribution of the decline in child dependency in Pakistan is obtained for the 1990s.

Table 2.3A in the appendix shows that the child dependency ratio will continue to decline in China, India and Pakistan, but there are significant differences among these countries. In China, the child dependency ratio will stabilize after 2035, whereas it will continue to decline in India and Pakistan up to 2050. Consequently, this decline is expected to have a greater positive impact on economic growth in these two countries than in China. The old-age dependency ratio will continue to increase in all three countries, which will have a negative impact on economic growth. Finally, whereas the growth differential between the working-age population and the total population is expected to have a positive effect on economic growth in India and Pakistan over the period 2005-2050, it will have a negative effect in China. Table 2.5 shows that as an overall result of these three projections, population dynamics are expected to have a positive effect on economic growth in India and Pakistan and a negative effect in China. The overall effect amounts to 1.49, 1.97 and -0.79 percent, respectively. It is the expected old-age dependency ratio of 0.38 in China in 2050 that may be held largely responsible for this negative effect. Since the old-age dependency ratio in India and Pakistan in 2050 will still be rather low (0.20 and 0.15, respectively), these results reconfirm the conjecture that the window of opportunity of China will close in 2020, whereas it will remain open in India and Pakistan until the middle of this century.
## Table 2.4: Contribution of demographic transition process to past economic growth, 1961-2003

<table>
<thead>
<tr>
<th>Countries</th>
<th>Average annual growth rate of real GDP per capita</th>
<th>Average growth differential between working-age population and total population (Diff)</th>
<th>Average growth rate child dependency ratio (CD)</th>
<th>Average growth rate old-age dependency ratio (OD)</th>
<th>Estimated Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>7.24</td>
<td>0.56</td>
<td>-1.87</td>
<td>0.54</td>
<td>0.31 3.29 -0.25 3.35</td>
</tr>
<tr>
<td>India</td>
<td>2.62</td>
<td>0.23</td>
<td>-0.70</td>
<td>0.72</td>
<td>0.13 1.24 -0.34 1.03</td>
</tr>
<tr>
<td>Pakistan</td>
<td>2.57</td>
<td>0.11</td>
<td>-0.23</td>
<td>-0.37</td>
<td>0.06 0.40 0.17 0.64</td>
</tr>
</tbody>
</table>

*The average growth rates are calculated using data from the World Bank.*

---

Demographic Transition and Economic Growth in China, India and Pakistan
Table 2.5: Expected contribution of demographic transition process to economic growth, 2005-2050

| Country | Average growth differential between working-age population and total population (Diff) | Average growth rate child dependency ratio (CD) | Average growth rate old-age dependency ratio (OD) | Estimated Contribution Diff CD OD Total |
|---------|---------------------------------|--------------------------|----------------------|-----------------------|-----------------------------------|
| China   | -0.307                          | -0.46                    | 3.04                 | -0.18                 | 0.84 -1.92 -0.79                  |
| India   | 0.290                           | -1.43                    | 2.51                 | 0.17                  | 2.67 -1.58 1.49                  |
| Pakistan| 0.718                           | -1.38                    | 1.81                 | 0.42                  | 2.58 -1.14 1.97                  |

Our results show that China has been able to take advantage of the growth potential offered by the demographic transition process. Whether India and Pakistan will also be able to realize the growth potential is still to be seen. There are three serious obstacles. First, whereas the literacy rate in China is 91 percent by now, more than one-third of the adult population in India is still illiterate and approximately one-half of the adult population in Pakistan. Second, India and Pakistan seem to have leap into the post-industrial phase without industrializing their economies. Whereas the manufacturing sector is the dominant sector in China (with a GDP share of almost 50 percent in 2006), the services sector is the dominant sector in India and Pakistan (approximately 55). Third, China's reform process, which began in the late 1970s, started in the agricultural sector rather than in the manufacturing and financial sectors. Pakistan, and to a lesser extent India, introduced reforms as a result of deteriorating external sector conditions and under the support of international financial institutions’ (IFIs) adjustment and stabilization programs. The focus of these reforms was on financial, fiscal, trade and manufacturing sectors rather than on the agricultural sector, the initial source of rapid economic growth in China. In this respect, a comparison of the impact of these reforms on economic growth in China and India is revealing. In 1978, at the inception of its reforms, China's per capita GDP\(^7\) was $165 (in constant 2000 US dollars), whereas it was $231 in India. China caught up with India in per capita GDP terms in 1984 ($259 vs. $250), and surpassed it in 1986 ($311 vs. $267). In the first post-reform decade, the Chinese economy grew at 9.6 percent, while the Indian economy grew at 5.7 percent in the corresponding post-reform decade (1990s).

\(^7\) Data source: World Development Indicators
To realize the growth potential caused by the demographic transition process, Pakistan and India should create a more productive and better skilled workforce, stimulate investments and create a much bigger market for goods and services. They also need to stimulate industrialization, since it has greater multiplier effects on other sectors of the economy. The expected increase of the working-age population may also be absorbed by greater investments in infrastructure that can employ relatively large numbers of unskilled labor and that do not require much capital. To meet the challenges of an aging population, China should establish a sustainable pension system and should consider an increase of the retirement age in order to reduce the number of people dependent on this system.

2.6 Conclusions

By extending the framework proposed by Bloom and Williamson (1998) meant to address imbalanced age-structure changes when mortality and fertility rates change from high to low levels, we have demonstrated that three demographic variables may temporarily boost or slow down economic growth during a process of demographic transition: the growth differential between the population of working-age and the total population, the child dependency ratio and the old-age dependency ratio.

An empirically relevant question asks to what extent differences found in the contribution of demographic variables are attributable to the way in which applied econometricians analyze a given body of data. To be able to answer this question, we have estimated an augmented Solow-Swan model extended to include these three demographic variables using the data in cross-section over the entire sample period, by moving to time-series cross-sectional data pooled over periods of five years, and to panel data including country and time-period fixed effects. We found that the coefficient of the growth differential between the population of working-age and the total population is positive and significant and of the child dependency ratio is negative and significant for these three regression specifications. By contrast, the coefficient of the old-age dependency ratio appeared to be positive for the first regression specification and negative for the last two regression specifications. However, in neither of these cases it was significant. Although these results may therefore said to be robust to the kind of econometric specification being adopted, we also found that the fixed effects model best described the data when these specifications were tested against one another.
Based on this model, we found that population dynamics explain 46 percent of economic growth in per capita GDP in China over the period 1961-2003, 39 percent in India, and 25 percent in Pakistan. We also found that the decline in child dependency was the major contributor to GDP per capita growth. These results corroborate Kelley and Schmidt's argument that the growth differential between the population of working-age and the total population, as in Bloom and Williamson (1998), is not sufficient to address the multi-faceted role of demography in economic growth. Furthermore, population dynamics are expected to have a positive effect on economic growth in India and Pakistan over the period 2005-2050, and a negative effect in China. Even though the coefficient of the old-age dependency ratio was found to be insignificant and thus ambiguous, it is the expected increase of this ratio that may be held responsible for this negative effect in China. One explanation for its insignificance is that most developed countries just reached the last phase of the demographic process that is the period in which the population ages, as a result of which negative effects, if present, have not yet been able to manifest themselves. In other words, even though the impact of the old-age dependency ratio is ambiguous, policymakers in China better remain alert.