Demography (2014) 51:299–315
DOI 10.1007/s13524-013-0245-x

Is the Demographic Dividend an Education Dividend?

Jesús Crespo Cuaresma · Wolfgang Lutz · Warren Sanderson

Published online: 4 December 2013

Abstract The effect of changes in age structure on economic growth has been widely studied in the demography and population economics literature. The beneficial effect of changes in age structure after a decrease in fertility has become known as the "demographic dividend." In this article, we reassess the empirical evidence on the associations among economic growth, changes in age structure, labor force participation, and educational attainment. Using a global panel of countries, we find that after the effect of human capital dynamics is controlled for, no evidence exists that changes in age structure affect labor productivity. Our results imply that improvements in educational attainment are the key to explaining productivity and income growth and that a substantial portion of the demographic dividend is an education dividend.

Keywords Demographic dividend · Economic growth · Education · Age structure · Education dividend

Introduction

The introduction of the concept of the demographic dividend was an important step forward in untying the Gordian knot of the relationship between demographic change and economic growth. That relationship had been hotly contested for decades

J. Crespo Cuaresma
Wittgenstein Centre for Demography and Global Human Capital (IIASA, VID/ÖAW, WU),
Vienna University of Economics and Business, Welthandelsplatz 1, 1020 Vienna, Austria
e-mail: jcrespo@wu.ac.at

W. Lutz (✉) · W. Sanderson
Wittgenstein Centre for Demography and Global Human Capital (IIASA, VID/ÖAW, WU),
International Institute for Applied Systems Analysis, Schlossplatz 1, 2361 Laxenburg, Austria
e-mail: lutz@iiasa.ac.at

W. Sanderson
e-mail: Warren.Sanderson@stonybrook.edu

W. Sanderson
Department of Economics, Stony Brook University, Stony Brook, New York 11794-4384, USA

(Ehrlich 1968; Ehrlich and Ehrlich 1990; Simon 1981, 1982), and in the end, no strong scientific consensus emerged from the debate (National Research Council 1986). These early contributions focused primarily on changes in total population size and did not address changes in the composition of the population according to various potentially relevant characteristics of people.

Bloom and Williamson (1998) focused on the relationship between age structure change and economic growth and thus explicitly introduced age as a relevant source of population heterogeneity into the analysis. Other potentially relevant sources of population heterogeneity—which play an important role as a potential catalyst of the demographic dividend—are labor force participation and the level of educational attainment. Although the work of Bloom and Williamson as well as several other key papers on this issue did include education in their specifications, the now widely used and popularized concept of the demographic dividend refers only to changes in age-dependency ratios (based on fixed intervals of chronological age), whose evolution over the course of demographic transition presumably results in a demographic window that first opens and then closes in a predictable way as the old-age dependency ratio starts to increase (UNFPA 2011). In contrast to this dominant focus on changing age distributions, recent studies of the effect of changes in age-specific educational attainment showed that indeed improvements in education seem to be a key driver of economic growth (see Lutz et al. 2008) and have predictive power for future income developments (see Crespo Cuaresma and Mishra 2011). In this article, we step back to take a fresh look at the question of how the effect of improving education relates to that of changing age structure—or, in other words, the extent to which the demographic dividend is really an education dividend.

Improving education can affect economic growth through various channels. Higher skill levels of the labor force can directly translate into higher productivity and into better and faster take-up of new technologies. The direct effects of educational attainment on labor productivity constitute the centerpiece of the model developed by Mankiw et al. (1992), which generalizes the Solow model of economic growth by adding human capital as an extra production factor. Mankiw et al. (1992) showed that this human capital–augmented specification can explain income differences across countries better than the standard Solow model (Solow 1956). Subsequent empirical studies, however, were not able to systematically unveil robust positive effects of education on economic growth at the aggregate level (see, e.g., Benhabib and Spiegel 1994; Pritchett 2001). Temple (1999) attributed such a lack of empirical support for positive education effects to outliers in global cross-country educational attainment data sets; the overall quality of such data has often been claimed responsible for such a puzzling empirical regularity by Krueger and Lindahl (2001), De la Fuente and Domenech (2006), and Cohen and Soto (2007), among others. Benhabib and Spiegel (1994, 2005), on the other hand, emphasized the role played by education as a catalyst of innovation and technology adoption in modelling the effects of education on income growth. Based on the insights provided by Nelson and Phelps (1966), such a theoretical framework implies that economic growth is affected not only by the accumulation of human capital but also by its stock. The empirical results provided by Benhabib and Spiegel (1994, 2005) indicated that this channel of technology adoption appears to be extremely important in explaining income growth experiences across countries.

In addition, education is an important factor for improving the health status of the population and also tends to contribute to the quality of governance more generally

(Samir and Lentzner 2010; Lutz et al. 2010; Pamuk et al. 2011). Importantly, female education is one of the key factors—if not the single most important factor—in inducing fertility decline and hence in driving the declining young-age dependency ratio, which is the key factor in the demographic dividend argument. A vast body of literature documents and analyzes this pervasive effect of female education on fertility, particularly for societies still in the process of demographic transition (e.g., Bongaarts 2010; Cochrane 1979; Cochrane et al. 1990; Skirbekk and Samir 2012). Lutz and Samir (2011) illustrated the major effect of female education on population dynamics by showing that when assuming identical trajectories of education-specific fertility rates, different scenarios of future school enrollment trends can lead to a difference of more than 1 billion in the projected world population size as soon as 2050. In this sense, education could be seen as a key trigger of the fertility decline that in consequence kick-starts the demographic dividend. The timing of this effect would be such that to produce a declining proportion of 0- to 20-year-olds—assuming a 30-year average generation length—it is the education of 30- to 50-year-old women that matters. These timing issues appear important when it comes to the interpretation of modeling results.

In this article, we build on the prior literature by making an explicit distinction between the "productivity" effect and the "translations" effect, by articulating the two avenues through which human capital acquisition operates and measuring their separate contributions to economic growth, and by taking changes in labor force participation rates and changes in investment into account. For consistency, our empirical strategy here is to use the same conditional convergence model used in most other studies of the demographic dividend and to use the same sort of aggregated human capital variable as in previous studies. Our results indicate that after the (robust) growth effects of educational improvements are conditioned away, the demographic dividend is reduced exclusively to a quantitatively small translation effect.

The article is structured as follows. In the next section, we briefly review some of the key contributions to the literature dealing with the demographic dividend, with a specific view of the treatment of education in those models. We then revisit the empirics of these associations, using improved data as compared with previous studies. In the concluding section, we discuss the results and suggest further lines of future investigation.

Demographic Dividend Models

We can date the modern literature on the demographic dividend as beginning with Bloom and Williamson (1998), who originally called the phase in which age structure change resulted in more rapid economic growth the "demographic gift." The explosion of interest that followed was the result of five factors. First, Bloom and Williamson showed that age structure change accounted for approximately one-third of the East Asian economic miracle and was thus quantitatively large. Second, the econometric approach that they used was the standard conditional convergence framework used in many prior studies of economic growth. This approach was well understood and widely accepted and has subsequently been used in most studies of the demographic dividend. Third, the demographic dividend analysis provided a framework in which prior empirical studies of the determinants of economic growth could be consistently integrated. Fourth, the approach lent itself to an interesting comparison of the economic futures of

Southeast Asian and South Asian economics. Finally, many people had strong *a priori* beliefs that demography and economic growth had to be strongly connected, a belief that, until the Bloom and Williamson papers, did not have a convincing empirical justification.

Education and the demographic dividend were linked from the beginning. Bloom and Williamson (1998) studied the rate of real gross domestic product (GDP) per capita growth in 78 countries between 1965 and 1990. One of their independent variables was the level of human capital in 1965, measured as the log of the average years of postprimary schooling of the population 25+ years old, based on data in Barro and Lee (1993). The results for the education variable were reported only for their ordinary least squares (OLS) regressions and not the instrumental variable ones. In all those regressions, the education variable always had a positive and statistically significant coefficient. Bloom and Williamson (1998), however, did not discuss in depth the importance of education changes to the East Asian economic miracle.

Kelley and Schmidt (2005) developed the demographic dividend model by making a distinction between the demographic determinants of the growth of output per person of working age (the "productivity effect") and the growth of output per capita resulting from changes in the share of the working-age population in the total population (the "translations effect"). They studied per capita economic growth in 86 countries over four periods—1960–1970, 1970–1980, 1980–1990, and 1990–1995—and found that demographic changes worldwide accounted for approximately 20 % of economic growth, with a greater effect seen in Asia and Europe. The human capital variable was the log of the average years of postprimary schooling for males aged 25 and older and functioned as part of the productivity effect. In all their regressions, the coefficient of the education variable was statistically insignificant.

The productivity effect has been studied in detail in more recent contributions. Bloom et al. (2009) showed that in a panel of countries, a reduction in fertility increases female labor force participation and thus increases the proportion of the working-age population who are in the labor force. Lee et al. (2000, 2003) introduced the concept of the second demographic dividend, which occurs when an aging population accumulates more wealth and that additional wealth is productively invested in the economy. Such effects hinge on the different patterns of economic behavior over the life cycle and their interaction with the institutional setting: in particular, with the existing transfer system (see Lee et al. 2008; Mason and Lee 2006). Lee and Mason (2010) emphasized the role that capital accumulation plays in aging economies. In particular, this contribution concentrates on the theoretical linkages among aging, human capital accumulation, and subsequent economic growth, thus counting as part of the second demographic dividend some of the effects that are analyzed in our empirical model.[1]

Lutz et al. (2008) extended the demographic dividend model in two ways. First, they distinguished two mechanisms for human capital to influence economic growth: (1) through the direct effect of the productivity of workers and (2) indirectly through its effect on the rate of total factor productivity growth. Second, they used the new IIASA-VID education database (Lutz et al. 2007) to disaggregate education effects by both age and level of educational attainment. These data are more consistent and more detailed than previously existing data sources. Educational attainment distributions for four

[1] See also Lee and Mason (2011) for a more general account of the potential effects of the second demographic dividend.

educational categories have been reconstructed by five-year age groups and sex, using methods of multidimensional population dynamics that also incorporate educational mortality differences. Using data for 101 countries over six 5-year periods from 1970–2000, they found that the direct productivity effect is particularly strong for older workers with secondary education, while younger workers with tertiary education have the greatest effect on the speed of total factor productivity growth.

Revisiting the Empirics of Age Structure, Education, and Income

The Modeling Set-Up

We adopt a modeling framework that is in the spirit of the literature on demographic dividend effects yet differs significantly in the details. The approach used for the statistical evaluation of the effect of demographic dynamics on economic growth is based on simple decompositions of output per capita into output per worker and a variable that captures changes in age structure and labor force participation.

We start our analysis by considering an aggregate production function given by

$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{1-\alpha}, \tag{1}$$

where Y_{it} is total output in country i at time t, A_{it} is total factor productivity (TFP), K_{it} is the capital stock, and L_{it} is total labor input. Considering variables per worker, the production function given by Eq. (1) can be written as

$$y_{it} = A_{it} k_{it}^{\alpha}, \tag{2}$$

where $y_{it} = Y_{it} / L_{it}$ is GDP per worker, and $k_{it} = K_{it} / L_{it}$ is capital per worker. In growth rates, Eq. (2) can be written as

$$\Delta \ln y_{it} = \Delta \ln A_{it} + \alpha \Delta \ln k_{it}. \tag{3}$$

Because income per capita instead of income per worker is typically used for growth regressions, the relationship between total population, working-age population, and labor force needs to be taken into account in order to differentiate pure accounting effects from causal links among employment, age structure, and income growth. Notice that

$$y_{it} = \frac{Y_{it}}{L_{it}} = \frac{Y_{it}}{N_{it}} \frac{N_{it}}{L_{it}} = \tilde{y}_{it} \frac{N_{it}}{L_{it}}, \tag{4}$$

where $\tilde{y}_{it}$ denotes GDP per capita, and N_{it} refers to total population. Combining Eqs. (3) and (4) to obtain an expression for income per capita,

$$\Delta \ln \tilde{y}_{it} = \Delta \ln y_{it} + \Delta \ln L_{it} - \Delta \ln N_{it} = \Delta \ln A_{it} + \alpha \Delta \ln k_{it} + \Delta \ln L_{it} - \Delta \ln N_{it}. \tag{5}$$

Assuming that TFP growth is constant over time, the empirical implementation of Eq. (5) implies regressing the growth rate of income per capita on the growth rate of capital per worker, the growth rate of the labor force, and the growth rate of population. The parameters associated with the last two variables should equal 1 and −1, respectively, if changes in the labor force share do not have productivity effects and affect only income per capita through the accounting channel exposed in Eq. (4).

If we assume that, because of technology adoption and income convergence dynamics, the growth rate of TFP depends on the distance to the global technology frontier as proxied by the level of labor productivity, this specification can be rewritten as a (linear) function of the level of income per worker:

$$\Delta \ln \tilde{y}_{it} = \delta + \mu \ln y_{it-1} + \alpha \Delta \ln k_{it} + \Delta \ln L_{it} - \Delta \ln N_{it}. \quad (6)$$

This specification implies thus that the growth rate of TFP can be decomposed into a secular trend, captured by the parameter δ, and (assuming a negative μ parameter) conditional convergence dynamics, which make TFP growth linearly dependent on the (lagged) income per worker of the country. Using the fact that

$$\ln y_{it} = \ln \tilde{y}_{it} + \ln\left(\frac{N_{it}}{W_{it}}\right) + \ln\left(\frac{W_{it}}{L_{it}}\right) = \ln \tilde{y}_{it} - \ln\left(\frac{W_{it}}{N_{it}}\right) - \ln\left(\frac{L_{it}}{W_{it}}\right),$$

where W_{it} denotes working-age population,

$$\Delta \ln \tilde{y}_{it} = \delta + \mu \ln \tilde{y}_{it-1} - \mu \ln\left(\frac{W_{it-1}}{N_{it-1}}\right) - \mu \ln\left(\frac{L_{it-1}}{W_{it-1}}\right) + \alpha \Delta \ln k_{it} + \Delta \ln L_{it} - \Delta \ln N_{it}. \quad (7)$$

This specification implies that the working-age share and the participation rate should be added to the economic growth specification in addition to the growth rate of the labor force and total population. Parameter estimates of the same size and opposite sign of that of the initial income level for these two variables imply that changes in the participation rate and the working-age share affect economic growth exclusively through the accounting channel described earlier.

The production function given by Eq. (1) does not consider human capital as either an input of production or a determinant of TFP growth. We can easily generalize the production function to include human capital (see, e.g., Benhabib and Spiegel 1994; Hall and Jones 1999):

$$Y_{it} = A_{it} K_{it}^{\alpha} H_{it}^{1-\alpha},$$

where $H_{it} = h_{it} L_{it}$, and human capital per worker is denoted by h_{it}, which in turn is defined as

$$h_{it} = \exp \theta s_{it},$$

where θ refers to the returns to schooling, and s_{it} are the average years of schooling of the labor force. The corresponding specification for the model with human capital is given by

$$\Delta \ln \tilde{y}_{it} = \Delta \ln A_{it} + \alpha \Delta \ln k_{it} + \Delta \ln L_{it} - \Delta \ln N_{it} + (1-\alpha)\theta \Delta s_{it}. \quad (8)$$

Assuming the dependence of technology growth on the distance to the technology frontier, the specification is then given by

$$\Delta \ln \tilde{y}_{it} = \delta + \mu \ln \tilde{y}_{it} - \mu \ln\left(\frac{W_{it-1}}{N_{it-1}}\right) - \mu \ln\left(\frac{L_{it-1}}{W_{it-1}}\right) + \alpha \Delta \ln k_{it} + \Delta \ln L_{it} - \Delta \ln N_{it} + (1-\alpha)\theta \Delta s_{it}. \quad (9)$$

In addition, the overall human capital stock (average years of schooling) is often assumed to affect the growth rate of TFP by acting as a catalyst of technology creation and technology adoption (see, e.g., Benhabib and Spiegel 1994, 2005). This view of the role of human capital leads to an econometric specification where, in addition to the change in average years of schooling, the level of education also enters the model as a determinant of TFP growth; thus,

$$\Delta \ln A_{it} = \delta + \rho s_{it} + \mu \ln \tilde{y}_{it-1} - \mu \ln\left(\frac{W_{it-1}}{N_{it-1}}\right) - \mu \ln\left(\frac{L_{it-1}}{W_{it-1}}\right).$$

Such a TFP growth specification can be included in Eq. (8) to obtain the more general econometric specification, which is given by

$$\Delta \ln \tilde{y}_{it} = \delta + \rho s_{it-1} + \mu \ln \tilde{y}_{it} - \mu \ln\left(\frac{W_{it-1}}{N_{it-1}}\right) - \mu \ln\left(\frac{L_{it-1}}{W_{it-1}}\right) + \alpha\Delta \ln k_{it} + \Delta \ln L_{it} - \Delta \ln N_{it} + (1-\alpha)\theta\Delta s_{it}. \tag{10}$$

The Empirical Evidence

We confront the preceding different specifications with a panel data for 105 countries over the period 1980–2005, divided into five-year periods. The selection of countries was exclusively determined by the availability of the required data. The source of our data and the list of countries included in the analysis are presented in the appendix. All the specifications estimated include country and period fixed effects. The inclusion of the lagged income per capita term on the right side of some of the models presented implies that the estimation of panel data models with country fixed effects, so as to obtain inference from within-country dynamics, is not straightforward. Standard OLS estimation methods would lead to biased estimates given that we do not take into account the correlation between the error term (which includes a country-specific fixed effect) and the lagged dependent variable. Generalized method of moments (GMM) methods have been proposed by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1999) to overcome the endogeneity problem by using lagged values of first differences and levels of the explained variable as instruments. In our empirical implementation, we use the Blundell-Bond "system" GMM estimator (Blundell and Bond 1999) for models that include lagged income per capita as an explanatory variable. The Blundell-Bond method has been shown to perform best for highly persistent variables, as is the case of income per capita.

The estimation of the different specifications is presented in Table 1. For the models estimated by GMM (those which include the initial income per capita level as a regressor), we include the usual specification tests related to instrumentation (Sargan test for overidentifying restrictions) and to the characteristics of the residuals (the standard tests for first- and second-order residual autocorrelation). We account for the potential endogeneity of the growth rate in the labor force and the change in years of schooling, which are measured over the same five-year period as the dependent variable and may be thus correlated with shocks to economic growth.[2] We instrument these

[2] At longer horizons than those considered in our model, the endogeneity problems could be more complex, since shocks to income could also be correlated with the age structure variables. Because we use five-year periods as a time unit, there are no reasons to expect that contemporaneous shocks to economic growth affect the age-structure variables given the ample lag between fertility dynamics and the change in the share of working-age population to total population.

Table 1 Panel regression estimates for the income growth model, 1980–2005

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln k_{it}$	0.419*	0.582**	0.589**	0.564**	0.559**	0.492**
	[0.160]	[0.165]	[0.126]	[0.133]	[0.102]	[0.111]
$\Delta \ln L_{it}$	—	0.797*	1.479*	1.961**	1.609**	1
		[0.376]	[0.658]	[0.485]	[0.510]	(imposed)
$\Delta \ln N_{it}$	—	0.89	0.37	0.187	0.348	−1
		[0.997]	[1.052]	[1.081]	[0.979]	(imposed)
$\ln \widetilde{y}_{it-1}$	—	—	−0.043	−0.064	−0.110*	−0.178*
			[0.0479]	[0.0437]	[0.0479]	[0.085]
$\ln(L_{it} / W_{it})$	—	—	0.302	0.557*	0.519†	0.178*
			[0.326]	[0.271]	[0.288]	[0.085]
$\ln(W_{it} / N_{it})$	—	—	0.871	1.391*	0.995	0.178*
			[0.790]	[0.623]	[0.619]	[0.085]
Δs_{it}	—	—	—	0.131	0.400*	0.717*
				[0.170]	[0.177]	[0.306]
s_{it-1}	—	—	—	—	0.0405**	0.0671*
					[0.0128]	[0.0335]
Test for Accounting Effect: Growth Rates (p value)	—	.1538	.3767	.0503	.1350	—
Test for accounting effect: Levels (p value)	—	—	.5035	.0201	.1941	—
Test for Accounting Effect: Growth Rates and Levels (p value)	—	—	.7144	.0505	.3918	—
Sargan Test (p value)	—	—	.1323	.2457	.5433	.2665
AR(1) Test (p value)	—	—	.0032	.0017	.0026	.0522
AR(2) Test (p value)	—	—	.1768	.2548	.2918	.1741
Observations	521	521	521	521	521	521
Number of Countries	105	105	105	105	105	105

Notes: Robust standard errors are in brackets. The dependent variable is the growth rate of GDP per capita over the corresponding five-year period. The panel data set spans information for 105 countries over the period 1980–2005, divided into five-year periods. Tests for accounting effects refer to the tests of the restrictions described in the text. Sargan Test is the p value of the Sargan test for overidentifying restrictions. AR(p) Test is the p value of the test for pth order autocorrelation of the residuals. All specifications include country and period fixed effects. Variables that are in growth rates or changes are measured over the corresponding period. All other variables are measured in the first year of the period.

$^{\dagger}p < .10$; $*p < .05$; $**p < .01$

covariates using two lags of the variables and their first difference, as is done for the lagged income level in the framework of the Blundell and Bond (1999) method. As theoretically expected, the growth rate of the labor force is significantly and positively related to economic growth, with estimates that range between 0.8 and 2. The growth rate of population, on the other hand, does not enter the model significantly in any of the specifications, although its effect is on average positive. The fourth specification presented in Table 1, which includes the growth rates of the labor force and total population together with the participation rate and the working-age share, as well as the change in years of schooling, shows demographic dividend effects which are above the pure translation effects defined by Eq. (4). The estimation results of this model would lead us to conclude that the participation and age structure effects that follow fertility declines have direct productivity and economic growth-enhancing effects. Furthermore, the effect of education would be deemed to be statistically insignificant, and human capital investments would not appear to have a clear return in terms of income growth.

In the fifth column of Table 1, we consider education to affect economic growth not only as an input of the production function through the augmentation of labor income but also as a determinant of total factor productivity, as in Nelson and Phelps (1966). The variable measuring average years of schooling has a significant positive effect on economic growth, and its inclusion as an extra regressor renders the parameter attached to the change in educational attainment also positive and significant. Furthermore, the returns to education implied by the parameter estimate associated with Δs_{it} are approximately 18 %, well above those usually found in the microeconometric literature. Theoretically, this is precisely what would be expected from returns to education at the macroeconomic level, where externalities are likely to be quantitatively much larger than at the individual level.

Most importantly, the pure demographic effects (excluding education) implied by the parameters attached to the labor participation and working-age share variables are now not significantly different from the pure translation effects because, theoretically, the models are built on output per worker but, empirically, income per capita is used. Column 6 in Table 1 estimates the restricted model, imposing the parameter restrictions implied by the existence of translation effects. Such a regression implies that the estimated effects of the human and physical capital variables are to be interpreted as direct effects on income per worker. The size of the effect of human capital improvements in this specification appears accordingly much larger than in the rest of the regressions.

The relative role of age structure and labor force participation versus human capital dynamics, assuming that the translation effect is in place, can be evaluated by assessing the quantitative effect of typical variations in the corresponding variables. Obtaining the within-country standard deviation of the ratio of the labor force to total population and its growth rate, as well as of mean years of schooling and its change, we can calculate the size of the effect of typical in-sample variations of our variables of interest on income growth. In Table 2, we present the resulting effects of a change by 1 (within-country) standard deviation of these variables on yearly income per capita growth implied by Model 6 in Table 1, as well as the effect corresponding to typical changes in the physical capital accumulation variable. In addition to presenting the composite demographic dividend effect from changes in the share of the labor force over total population, we also present the effects of a 1 standard deviation change in the share of labor force over working-age population (keeping the share of working-age population over total population constant), as well as the pure age structure effect emanating from changes in the share of working-age population to total population (keeping labor participation constant).

The results are presented evaluating the variation of the age-structure/participation, physical, and human capital variables in the full sample as well as in subsamples defined by income groups according to the World Bank. Compared with the human

Table 2 Size of effects on economic growth

		Within-Country SD	Effect on Yearly Income Growth
Full Sample	$(\Delta\ln L_{it} - \Delta\ln N_{it})$	2.93 %	0.59 %
	$(\Delta\ln L_{it} - \Delta\ln W_{it})$	2.00 %	0.40 %
	$(\Delta\ln W_{it} - \Delta\ln N_{it})$	1.95 %	0.39 %
	$\ln(L_{it} / N_{it})$	4.98 %	0.18 %
	$\ln(L_{it} / \mathrm{W}_{it})$	2.79 %	0.10 %
	$\ln(W_{it} / N_{it})$	3.30 %	0.12 %
	Δs_{it}	0.081	1.17 %
	s_{it}	0.689	0.92 %
	$\Delta\ln k_{it}$	13.73 %	1.35 %
High-Income Countries: OECD ($N = 23$)	$(\Delta\ln L_{it} - \Delta\ln N_{it})$	2.86 %	0.57 %
	$(\Delta\ln L_{it} - \Delta\ln W_{it})$	2.82 %	0.56 %
	$(\Delta\ln W_{it} - \Delta\ln N_{it})$	1.40 %	0.28 %
	$\ln(L_{it} / N_{it})$	4.31 %	0.15 %
	$\ln(L_{it} / \mathrm{W}_{it})$	3.39 %	0.12 %
	$\ln(W_{it} / N_{it})$	2.19 %	0.08 %
	Δs_{it}	0.065	0.93 %
	s_{it}	0.560	0.75 %
	$\Delta\ln k_{it}$	4.50 %	0.44 %
High-Income Countries: Non-OECD ($N = 3$)	$(\Delta\ln L_{it} - \Delta\ln N_{it})$	6.56 %	1.31 %
	$(\Delta\ln L_{it} - \Delta\ln W_{it})$	1.56 %	0.31 %
	$(\Delta\ln W_{it} - \Delta\ln N_{it})$	5.41 %	1.08 %
	$\ln(L_{it} / N_{it})$	6.85 %	0.24 %
	$\ln(L_{it} / \mathrm{W}_{it})$	2.58 %	0.09 %
	$\ln(W_{it} / N_{it})$	4.81 %	0.17 %
	Δs_{it}	0.131	1.88 %
	s_{it}	0.855	1.15 %
	$\Delta\ln k_{it}$	12.04 %	1.18 %
Low-Income Countries ($N = 30$)	$(\Delta\ln L_{it} - \Delta\ln N_{it})$	2.10 %	0.42 %
	$(\Delta\ln L_{it} - \Delta\ln W_{it})$	1.12 %	0.22 %
	$(\Delta\ln W_{it} - \Delta\ln N_{it})$	1.88 %	0.38 %
	$\ln(L_{it} / N_{it})$	2.78 %	0.10 %
	$\ln(L_{it} / \mathrm{W}_{it})$	1.51 %	0.05 %
	$\ln(W_{it} / N_{it})$	2.36 %	0.08 %
	Δs_{it}	0.091	1.31 %
	s_{it}	0.685	0.92 %
	$\Delta\ln k_{it}$	13.08 %	1.29 %
Lower Middle-Income Countries ($N = 32$)	$(\Delta\ln L_{it} - \Delta\ln N_{it})$	3.33 %	0.67 %
	$(\Delta\ln L_{it} - \Delta\ln W_{it})$	2.07 %	0.41 %
	$(\Delta\ln W_{it} - \Delta\ln N_{it})$	2.07 %	0.41 %
	$\ln(L_{it} / N_{it})$	5.05 %	0.18 %
	$\ln(L_{it} / \mathrm{W}_{it})$	2.18 %	0.08 %

Table 2 (continued)

		Within-Country SD	Effect on Yearly Income Growth
	$\ln(W_{it} / N_{it})$	3.93 %	0.14 %
	Δs_{it}	0.088	1.26 %
	s_{it}	0.766	1.03 %
	$\Delta \ln k_{it}$	12.30 %	1.21 %
Upper Middle-Income Countries ($N = 17$)	$(\Delta \ln L_{it} - \Delta \ln N_{it})$	2.51 %	0.50 %
	$(\Delta \ln L_{it} - \Delta \ln W_{it})$	1.83 %	0.37 %
	$(\Delta \ln W_{it} - \Delta \ln N_{it})$	1.36 %	0.27 %
	$\ln(L_{it} / N_{it})$	7.69 %	0.27 %
	$\ln(L_{it} / \mathrm{W}_{it})$	4.31 %	0.15 %
	$\ln(W_{it} / N_{it})$	4.26 %	0.15 %
	Δs_{it}	0.058	0.84 %
	s_{it}	0.687	0.92 %
	$\Delta \ln k_{it}$	10.61 %	1.04 %

capital effects, the size of the translation effects is relatively small in the full sample, even if the role of labor participation changes is included in this quantification. The pure age structure effect, summarized in the estimated income growth response to changes in the share of working-age population, is in turn significantly smaller after labor participation changes are deducted (roughly two-thirds of the combined age and participation effect). The relative size of the realized human capital effects in low-income countries, which present only limited growth effects due to the accounting channel, is particularly large. The group of lower–middle income countries appears to have benefitted from both relatively large translation effects and even larger human capital effects on economic growth in comparison to the rest of the sample, with the exception of the small and heterogeneous group of non-OECD high-income countries (formed by Equatorial Guinea, the Bahamas, and Singapore). Capital accumulation (both in the form of physical and human capital) exert the most sizable effects in income growth in all groups of countries. As economic theory predicts, the economic growth effects of physical capital accumulation (capital deepening) appear particularly relevant for developing economies and emerging economies.

Summarizing the set of results presented earlier, we can conclude that not properly accounting for the role of education as a determinant of economic growth would have led us to believe that the beneficial income growth effects took place directly through changes in age structure. After we control for both the stock and improvement in human capital, we find that statistically, the change in educational attainment levels is the primal source of the demographic dividend effects present in the data. Empirically, the pure effect of changes in age structure on economic growth appears to take place exclusively through translation effects related to the measurement of income as GDP per capita instead of GDP per worker. Given that our preferred specifications control for both educational attainment and labor force dynamics, the estimated effects of human capital go beyond the role that the variable plays as a determinant of labor force participation. It is the increased productivity and technology innovation or adoption capabilities of more-educated individuals in the labor force that appear particularly relevant as an explanatory factor of growth differences in GDP per worker within countries for our sample.

Although the models estimated and presented here were developed to roughly resemble the earlier landmark studies on the demographic dividend, a few noteworthy differences should be kept in mind when comparing the results:

- Our model considers convergence in terms of output per worker, not output per person of working age, as is the case in most of the other studies. Because we had access to new data on labor force participation, this seemed the more appropriate specification in the spirit of the underlying economic growth model.
- As a consequence of the availability of these labor force data, we explicitly included the labor force participation rate as a variable in the model. To our knowledge, this has not been done by earlier studies. This also has implications for what is defined to be the translation effect and productivity effect. If the model is specified only in terms of persons of working ages, an underlying increase in, for example, female labor force participation shows up as an increase in productivity of persons in working age. In our model, this effect can be directly measured and is interpreted as part of the translation effect.
- Unlike earlier empirical studies on the demographic dividend, we explicitly include data on investment in our models. In the framework of the estimation of aggregate production functions, statistical tests for the existence of translation effects—such as those performed in the demographic dividend literature—would be based on misspecified models if the physical capital component is not included.[3] Although potential effects of changes in the age structure on physical capital accumulation cannot be ruled out (following the rationale described in, for example, Lee and Mason 2010, 2011), our results indicate that these alone are not sufficient to explain the size of the effects that had been hitherto attributed to the demographic dividend.
- Many of the earlier studies also included life expectancy at birth as an explanatory variable in the equations. We also did this initially, but because its effect consistently turned out to be insignificant, we decided to not include it in the table of results presented here.
- Unlike many of the earlier studies that did include indicators of the level of education in the form of mean years of schooling of the adult population, we include both the level of the education variable and its change over time. As the results presented earlier show, this makes an important difference with respect to the importance of the education variable to economic growth. As described earlier, our analysis also uses a new and more internally consistent set of education data as provided by the IIASA-VID reconstructions.

[3] Given the focus of our analysis on human capital, the linkage between age-structure changes and physical capital accumulation is not explored in further detail. The second dividend literature (see, e.g., Lee and Mason 2010) emphasizes how age-structure dynamics affect physical capital accumulation through behavioral differences across the life cycle. Although the potential existence of such effects deserves further scrutiny in the context of the econometric specifications put forward in this analysis, a more systematic quantitative assessment goes beyond the scope of this study.

Keeping these differences in the estimated models and used data in mind, the significantly different findings that we obtain appear to result primarily from three factors:

1. The educational attainment data used here are more consistent across countries and over time than the Barro and Lee (2001) data. These differences are discussed in detail in Lutz et al. (2007), Lutz et al. (2008), and Lutz and Samir (2011). The higher consistency is essentially a consequence of the demographic back-projections (including consideration of educational mortality differences), where by definition, the education categories stay consistent, unlike in the official data reported by countries to UNESCO where categories tend to be unstable (Lutz et al. 2007).
2. The estimation method used in this study is state of the art. Using dynamic panel GMM methods, we are able to avoid biases in the estimation that originate from the panel structure of the data set.[4]
3. A key difference seems to lie in the way the education variable is treated. By including only the level or the change in educational attainment, previous studies evidently lost relevant information, which we include by adding both to the model in the spirit of the endogenous growth literature.

Conclusions and Paths of Further Research

Using an improved data set and state-of-the-art panel methods, we show that the labor productivity effects, which are claimed to accompany the demographic dividend, can be explained through the changes in educational attainment level that take place hand in hand with fertility declines. The remaining effect of changes in the age structure on economic growth does not appear statistically different from the standard translation effect because of the changes in dependency ratios during the demographic transition. The size of the translation effect related to age structure changes is found to be very small. Our results imply that the successful historical examples of demographic dividend effects need to be understood in the context of the educational expansion that accompanied the observed changes in age structure. In this respect, they confirm the results of Collins and Bosworth (1996) and Rodrik (1998), among others, which identify human capital accumulation as one of the key factors explaining the sustained income growth rates in East Asia between the 1960s and 1990s.

This article should be seen as only a first step in a broader assessment of the effects of changes in population composition according to a larger number of relevant individual characteristics on economic growth. Here, we limited our focus to (chronological) age, labor force participation, and educational attainment. The models were defined in a way to be roughly compatible with the most influential previous models in the demographic dividend literature. Our statistical analysis shows that the explicit consideration of both the levels and the changes in educational attainment adds significant explanatory power and deserves to be a key component of any future study on the demographic dividend. Because empirically a declining young-age dependency ratio tends to come along with

[4] This point does not seem to make a decisive difference. Our results are broadly consistent with those in Lutz et al. (2008), where standard OLS models with fixed effects are used.

the increasing educational attainment of the adult population, simple models that consider only fixed age intervals and disregard education can thus falsely attribute the productivity enhancing effect of education to a declining young-age dependency ratio and thus the typically preceding fertility decline. Our results show precisely the role of human capital in offering the explanation for the effects that the first demographic dividend literature tends to systematically find. In spite of the fact that second demographic dividend effects related to higher human capital accumulation (such as those in Lee and Mason (2010)) are supported by our results, the mechanisms highlighted in our model setting are not explicitly related to aging societies, as is the case with this strand of the literature.

A further extension of the analysis should use the age, sex, and distribution detail of the newly reconstructed human capital data. Because in most countries the younger cohorts are better educated than the older ones, the use of mean years of schooling of the entire adult population above a certain age (as is done in most economic studies) cannot reflect these intercohort differences. Another potential topic of study is the degree to which differential expansion rates of the different educational attainment categories affect economic growth and how this interacts with the changing age structure.

Finally, human capital is based not only on formal education and labor force participation but also on skills, cognitive functioning, and health. Although these dimensions are clearly more difficult to quantify, and hardly any time series with consistent data exist, more could be done using existing data for subsets of countries, such as the OECD or EU, for which more standardized surveys exist (Hanushek and Woessmann 2008). An explicit inclusion of age-specific health and cognition indicators could also help to address the problems of using longer time series based on conventional chronological age.

The answer to the question posed in the title of this paper is “yes,” what previous studies have identified as an age structure dividend really is dominantly an education dividend.

Acknowledgement We would like to thank the participants in the New Directions in the Economic Analysis of Education Conference at the University of Chicago and at the 2013 annual meeting of the Population Association of America for helpful comments. Funding for this work was made possible by the European Research Council (ERC) Advanced Investigator Grant focusing on “Forecasting Societies’ Adaptive Capacities to Climate Change” (ERC-2008-AdG 230195-FutureSoc).

Appendix: Data and Variables

Table 3 presents the list of countries included in the analysis. All countries for which data are available are used, with the exception of oil exporters. Income per capita data are sourced from the Penn World Tables (PWT) 6.3 (Heston et al. 2009). Capital stock data are obtained using the perpetual inventory method based on investment rates from the PWT 6.3. Labor force, working-age population, and total population are obtained from the World Bank World Development Indicators. The educational attainment variable is the mean years of schooling for persons aged 15–64, sourced from the IIASA-VID data set.

Table 3 Countries in the sample

Algeria	Chile	Guinea-Bissau	Mexico	Sierra Leone
Angola	China	Haiti	Mongolia	Singapore
Argentina	Colombia	Honduras	Morocco	Somalia
Australia	Comoros	Hungary	Mozambique	South Africa
Austria	Congo, Rep.	India	Nepal	Spain
Bahamas	Costa Rica	Indonesia	Netherlands	Sri Lanka
Bangladesh	Cote d'Ivoire	Ireland	New Zealand	Sweden
Belgium	Cuba	Italy	Nicaragua	Switzerland
Belize	Denmark	Japan	Niger	Syria
Benin	Djibouti	Jordan	Nigeria	Tanzania
Bolivia	Dominican Republic	Kenya	Norway	Thailand
Brazil	Ecuador	Korea	Pakistan	Togo
Bulgaria	Egypt	Lao PDR	Panama	Tunisia
Burkina Faso	El Salvador	Liberia	Paraguay	Turkey
Burundi	Equatorial Guinea	Madagascar	Peru	Uganda
Cambodia	Ethiopia	Malawi	Philippines	United Kingdom
Cameroon	Finland	Malaysia	Poland	United States
Canada	France	Maldives	Portugal	Uruguay
Cape Verde	Ghana	Mali	Rwanda	Vietnam
Cent. Af. Rep.	Greece	Mauritania	Sao Tome and Principe	Zambia
Chad	Guatemala	Mauritius	Senegal	Zimbabwe

References

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies, 58,* 277–297.

Arellano, M., & Bover, O. (1995). Another look at the instrumental-variable estimation of error-components models. *Journal of Econometrics, 68,* 29–51.

Barro, R. J., & Lee, J. W. (1993). International comparison of educational attainment. *Journal of Monetary Economics, 32,* 363–394.

Barro, R. J., & Lee, J. W. (2001). International data on educational attainment: Updates and implications. *Oxford Economic Papers, 53,* 541–563.

Benhabib, J., & Spiegel, M. (1994). The role of human capital in economic development. Evidence from aggregate cross-country data. *Journal of Monetary Economics, 34,* 143–173.

Benhabib, J., & Spiegel, M. (2005). Human capital and technology diffusion. In P. Aghion & S. Durlauf (Eds.), *Handbook of economic growth* (Vol. 1, pp. 935–966). Amsterdam, The Netherlands: Elsevier.

Bloom, D. E., Canning, D., Fink, G., & Finlay, J. E. (2009). Fertility, female labor force participation, and the demographic dividend. *Journal of Economic Growth, 14,* 79–101.

Bloom, D. E., & Williamson, J. G. (1998). Demographic transitions and economic miracles in emerging Asia. *World Bank Economic Review, 12,* 419–455.

Blundell, R., & Bond, S. (1999). *GMM estimation with persistent panel data*: *An application to production functions* (IFS Working Paper No. W99/04). London, UK: Institute for Fiscal Studies. Retrieved from http://ideas.repec.org/p/ifs/ifsewp/99-04.html

Bongaarts, J. (2010). The causes of educational differences in fertility in sub-Saharan Africa. *Vienna Yearbook of Population Research, 8,* 31–50.

Cochrane, S. H. (1979). *Fertility and Education. What do we really know?* Baltimore, MD: Johns Hopkins University Press.
Cochrane, S. H., Khan, M. A., & Osheba, I. K. T. (1990). Education, income, and desired fertility in Egypt: A revised perspective. *Economic Development and Cultural Change, 38,* 313–339.
Cohen, D., & Soto, M. (2007). Growth and human capital: Good data, good results. *Journal of Economic Growth, 12,* 51–76.
Collins, S. M., & Bosworth, B. P. (1996). Economic growth in East Asia: Accumulation versus assimilation. *Brookings Papers on Economic Activity, 2,* 135–203.
Crespo Cuaresma, J., & Mishra, T. (2011). The role of age-structured education data for economic growth forecasts. *Journal of Forecasting, 30,* 249–267. doi:10.1002/for.1171
De la Fuente, A., & Domenech, R. (2006). Human capital in growth regressions: How much difference does data quality make? *Journal of the European Economic Association, 4,* 1–36.
Ehrlich, P. R. (1968). *The population bomb*. New York: Ballantine.
Ehrlich, P. R., & Ehrlich, A. H. (1990). *The population explosion*. New York: Simon & Schuster.
Hall, R. E., & Jones, C. I. (1999). Why do some countries produce so much more output per worker than others? *The Quarterly Journal of Economics, 114,* 83–116.
Hanushek, E. A., & Woessmann, L. (2008). The role of cognitive skills in economic development. *Journal of Economic Literature, 46,* 607–668.
Heston, A., Summers, R., & Aten, B. (2009). *Penn world table version 6.3*. Philadelphia: Center for International Comparisons of Production, Income and Prices, University of Pennsylvania.
Kelley, A., & Schmidt, R. (2005). Evolution of recent economic-demographic modeling: A synthesis. *Journal of Population Economics, 18,* 275–300.
Krueger, A., & Lindahl, M. (2001). Education for growth: Why for whom? *Journal of Economic Literature, 39,* 1101–1136.
Lee, R., Lee, S.-H., & Mason, A. (2008). Charting the economic life cycle. *Population and Development Review, 34*(Suppl.), 208–237.
Lee, R., & Mason, A. (2010). Fertility, human capital and economic growth over the demographic transition. *European Journal of Population, 26,* 159–182.
Lee, R., & Mason, A. (2011). *Population aging and the generational economy: A global perspective*. Cheltenham, UK, and Ottawa, Canada: Edward Elgar and International Development Research Centre.
Lee, R., Mason, A., & Miller, T. (2000). Life cycle saving and the demographic transition: The case of Taiwan. *Population and Development Review, 26*(Suppl.), 194–219.
Lee, R., Mason, A., & Miller, T. (2003). Saving, wealth and the transition from transfers to individual responsibility: The cases of Taiwan and the United States. *The Scandinavian Journal of Economics, 105,* 339–357.
Lutz, W., Crespo Cuaresma, J., & Abbasi-Shavazi, M. J. (2010). Demography, education, and democracy: Global trends and the case of Iran. *Population and Development Review, 36,* 253–281.
Lutz, W., Crespo Cuaresma, J., & Sanderson, W. C. (2008). The demography of educational attainment and economic growth. *Science, 319,* 1047–1048.
Lutz, W., Goujon, A., Samir, K. C., & Sanderson, W. C. (2007). Reconstruction of populations by age, sex and level of educational attainment for 120 countries for 1970–2000. *Vienna Yearbook of Population Research, 5,* 193–235.
Lutz, W., & Samir, K. C. (2011). Global human capital: Integrating education and population. *Science, 333,* 587–592.
Mankiw, N. G., Romer, D., & Weil, D. W. (1992). A contribution to the empirics of economic growth. *Quarterly Journal of Economics, 107,* 407–437.
Mason, A., & Lee, R. (2006). Reform and support systems for the elderly in developing countries: Capturing the second demographic dividend. *GENUS, LXII*(2), 11–35.
National Research Council. (1986). *Population growth and economic development: Policy questions*. Washington, DC: National Academy Press.
Nelson, R. R., & Phelps, E. S. (1966). Investment in humans, technological diffusion, and economic growth. *The American Economic Review, 56,* 69–75.
Pamuk, E. R., Fuchs, R., & Lutz, W. (2011). Comparing relative effects of education and economic resources on infant mortality in developing countries. *Population and Development Review, 37,* 637–664.
Pritchett, L. (2001). Where has all the education gone? *World Bank Economic Review, 15,* 367–391.
Rodrik, D. (1998). TFPG controversies, institutions and economic performance in East Asia. In Y. Hayami & M. Aoki (Eds.), *The institutional foundation of economic development in East Asia* (pp. 79–105). London, UK: Macmillan.

Samir, K. C., & Lentzner, H. (2010). The effect of education on adult mortality and disability: A global perspective. *Vienna Yearbook of Population Research, 8,* 201–235.

Simon, J. L. (1981). *The ultimate resource*. Princeton, NJ: Princeton University Press.

Simon, J. L. (1982). Paul Ehrlich, saying it is so doesn't make it so. *Social Science Quarterly, 63,* 381–385.

Skirbekk, V., & Samir, K. C. (2012). Fertility-reducing dynamics of women's social status and educational attainment. *Asian Population Studies, 8,* 251–264.

Solow, R. M. (1956). A contribution to the theory of economic growth. *Quarterly Journal of Economics, 70,* 65–94. doi:10.2307/1884513

Temple, J. (1999). A positive effect of human capital on growth. *Economics Letters, 65,* 131–134.

UNFPA. (2011). *Impact of demographic change in Thailand*. Bangkok, Thailand: United Nations Population Fund.