World Population in 2050: Assessing the Projections. discussion

Wolfgang P. Lutz*

I would like to follow up on the last sentence of the excellent presentation by Joel Cohen. It is indeed true that the lag between new methodological developments and their actual implementation by statistical agencies is regrettably long, but I think there is some hope that the speed of applying innovations has been accelerating over this century. This is the case in many other areas, and it would be surprising if it were not the case in the field of population forecasting. I would assess with a probability of well above 90 percent that by the end of this century, institutional procedures for projecting population will include probabilistic elements.

In the following, I would like to mention three additional aspects complementing the important remarks made by Cohen.

New Methods

Actually, things are evolving rapidly with respect to the application of new forecasting methods. A recent issue of the international scientific journal *Nature* features an article, "The End of World Population Growth," that presents a new method of probabilistic population projections (Lutz, Sanderson, and Scherbov 2001). This method represents a possible synthesis of several competing approaches to dealing with the issue of uncertainty in future population trends. I will quickly describe the alternative methods and present some results from the synthesis approach that underlies the *Nature* article.

*Leader, Population Project, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Since the cohort component method of projection is taken as a standard, the differences between alternative probabilistic approaches to population forecasting refer only to the modeling of future fertility, mortality, and migration rates. Here one can distinguish between (a) the specific process chosen for representing the time series of these vital rates, and (b) the basis for the specific assumptions made about the future range of uncertainty.

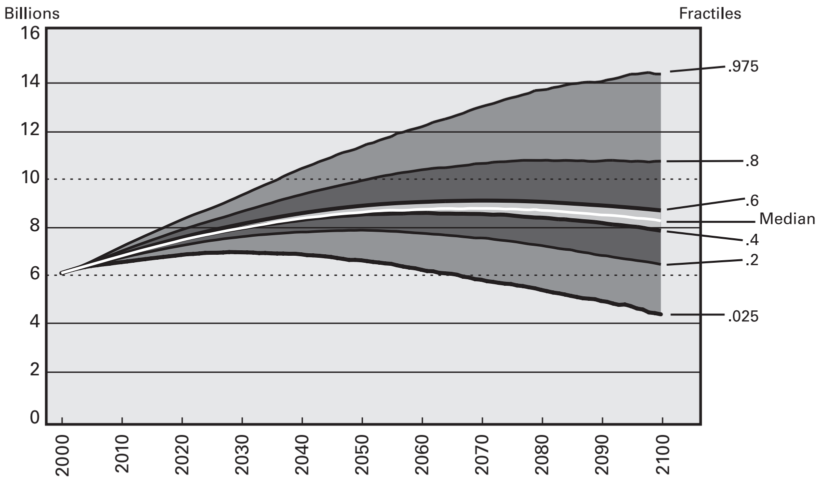
The literature essentially has presented two ways of specifying the time series of vital rates: (1) processes with annual fluctuations (see Lee 1998; Lee and Tuljapurkar 1994; Lee and Carter 1992; Alho 1990) and (2) piece-wise linear scenarios (see Lutz, Sanderson, and Scherbov 1997, 1996; Lutz and Scherbov 1998). While the second way has the advantage of conforming to the current practice of scenario definition in statistical offices around the world (including the United Nations 1999 and the World Bank 2000), the first way can produce more realistic annual outcomes, given that the possible levels are bounded. We have chosen a moving-average model with annual fluctuations.

The literature suggests three approaches to deriving assumptions about the future range of uncertainty surrounding the components: (1) compute a measure of the future error from the ex post analysis of past projections (Stoto 1983; Alho 1997; Keilman 1999), (2) apply time series models (Lee 1999; Tuljapurkar, Li, and Boe 2000; Lee and Tuljapurkar 1994), and (3) have well-informed experts make assumptions based on explicitly stated substantive arguments (Lutz and Scherbov 1999). The three approaches are not mutually exclusive, and (1) and (2) also include expert judgment.

In the *Nature* study we take a step toward a synthesis of the three approaches. Our process specification uses a time series model. Given that, at the level of world regions, lack of data makes empirical estimation impossible, we explicitly consider existing national-level parameter estimates (Lee and Tuljapurkar 1994; Lee and Carter 1992). The ex post analysis of past errors enters our study in two ways: (1) The substantive assumptions made on fertility and mortality changes are informed by the analysis of past errors in those components (Keilman 1999; Bongaarts and Bulatao 2000), and (2) Our results at the regional level are compared to the results of an ex post error analysis of global UN projections documented in the National Research Council (NRC) report.

For the specific purpose of estimating the probabilities that population growth in different world regions will end during this century, we wanted to err on the side of higher variance (that is, lower probability of population growth ending in this century); accordingly, we followed the general rule to produce intervals that were at least as large as those in the NRC report at the level of major world regions. Combining this with argument-based expert judgment (Bongaarts and Bulatao 2000; Lutz 1996), we saw substantive reasons for assuming a larger uncertainty in

Figure 1
Total World Population



many regions as a result of new factors such as HIV/AIDS, the situation in the former USSR, and the indeterminancy of long-range, post-transitional fertility levels affecting an increasing number of countries.

Figure 1 shows forecasted distributions of world population sizes (fractiles), as taken from Lutz, Sanderson, and Scherbov (2001). The results show about an 85-percent probability that world population will reach a maximum over the course of this century and then start to decline. There is also about a 60-percent probability that world population will not reach 10 billion before 2100, and around a 15-percent probability that in 100 years, world population will be even lower than today.

Extreme Events

Cohen identified a very important qualification that needs to be made with respect to conventional population projections, namely, the assumed absence of extreme events. High-impact, low-probability events such as a lethal global pandemic, a major war, or a serious meteoric impact certainly have the potential for altering the future course of population significantly.

What should scientists do with this qualification? Should we just live with it and ignore it for our practical work, only remembering in the back of our minds that things could indeed turn out differently? Another possible approach is to try to define low-probability scenarios that assume certain hypothetical demographic consequences of certain hypothetical events of unknown magnitude, structure, and timing. Because of the many unknowns, a science fiction novel could be more consistent than such scenarios. In the first edition of *The Future Population of the World* (Lutz 1994), we showed some examples of the possible consequences of major disasters, such as a Malthusian overshooting of carrying capacity in Africa that would lead to the immediate death of half of the population between the years 2060 and 2065. We did this mostly to show the outside world that demographers are not completely ignoring the possibility of catastrophic events. Although it is of some interest to study what such a hypothetical event might do to the age structure and population dynamics after the event, we decided not to include these calculations in the 1996 revision of the book (Lutz 1996) because we felt that they were simply too arbitrary—assumptions made out of the blue without any empirical or theoretical basis.

Moreover, there may be another, more promising way to deal with this issue, in the context of probabilistic population projections. If the uncertainty distributions for future vital rates are defined in such a way that, at the very tail ends of the distributions, some very high-impact, very low-probability events are included, this may in fact capture the issue to some degree. Of course, we know little about the probabilities of such events or their magnitude, but our knowledge may be more than zero. It may be possible to calculate the risk of a major meteorite based on past observations, for instance; it is more difficult with respect to possible new diseases or possible rapid increases in life expectancy. But engineers did not shy away from calculating in exact quantitative terms the risks for certain nuclear accidents (and they have been taken as the basis for serious discussions in national parliaments) even though very little is known about the probabilities of the different factors that can lead to such a disaster. I doubt that the intentional shutting down of the security system that led to the Chernobyl accident was factored into these calculations. Still, it may be worth thinking a bit further along these lines. As a matter of fact, we do have such long tails in the distributions underlying the *Nature* article, and in one out of the 2,000 simulations, we actually get a mortality increase of catastrophic magnitude (higher than the impact of AIDS in Southern Africa).

Projections of Population by Level of Education

Another area where conventional population projections are in need of renewal and expansion of focus is the explicit incorporation of other major covariates in addition to age and sex. Level of education and rural/urban place of residence are two prime candidates for such explicit inclusion in population projections, because both fertility and mortality tend to vary greatly with level of education and place of residence. Making this important hidden source of heterogeneity explicit and including it in the form of multistate population projections significantly affects the projected population dynamics. If, for example, the proportion of women of reproductive age with secondary education increases in a certain country (say, Algeria) with high educational fertility differentials, then over time fertility will decrease, even if fertility within each educational group remains constant.

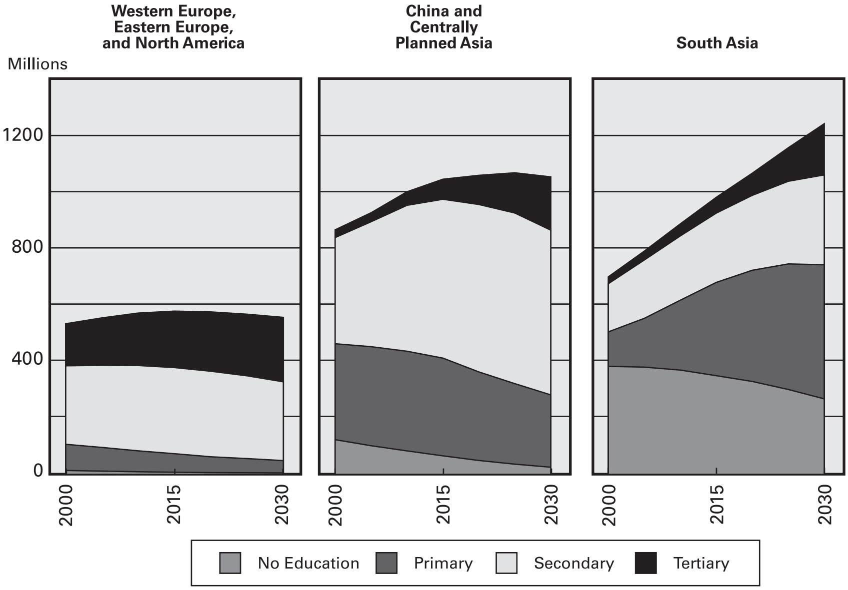
In addition to this purely demographic effect, variables such as place of residence and education are very important in their own right. In the June 2001 issue of *Population and Development Review,* we produced the first global population projections by level of education. I would like to share with you one of the findings that relates to human capital in international economic competition.

The changing educational composition of the population is very significant at different levels: It matters greatly for individual development and individual life changes. It makes a big difference for a nation's institutional and economic performance. It also matters for the relative weights, productivity, and competitiveness of major world markets. In this context, it is useful to look at absolute numbers of workers by skill levels rather than at the proportions. For three economic mega-regions of the future (Europe and North America together, China, and South Asia), Figure 2 compares trends in the size of the working-age population (ages 20 to 65) by educational attainment. The data are taken from the "American scenario," which assumes convergence by 2030 to today's U.S. school enrollment levels. At present, China clearly has the most numerous working-age population of the three regions, but its educated population (secondary and tertiary together) is still smaller than that of Europe and North America together. South Asia is far behind, with less than half the size of the other two regions.

Over the next twenty years, South Asia is expected to surpass China in terms of the total size of its working-age population. But in terms of educational composition, the difference between the two regions will be stunning. While in China in 2030, 73 percent of the working-age population will be better educated (secondary plus tertiary), in South Asia the better-educated share will be only 40 percent. The main reason for this divergence lies in differences between the two regions in investment in primary and secondary education over the past two decades.

Among the three major world regions, Europe and North America will continue to have the highest educational levels of working-age population, but in terms of absolute numbers of educated people, they will clearly fall behind China. Over the next three decades China's educated working-age population is likely to increase from 390 million to 750 million, while that of Europe (without the former Soviet Union) and North America together will hardly increase, from 430 million in 2000 to

Figure 2
Population Aged 20 to 65 Years, by Level of Education



Note: Data represent the "American" scenario, which assumes convergence to U.S. school enrollment levels by 2030 in the three economic mega-regions.
Source: Lutz and Goujon (2001).

510 million in 2030. These significant future changes in the numbers of skilled workers are likely to have far-reaching consequences for the regions' roles in the global economic system.

In conclusion, many exciting new issues still remain in the field of population projections. Resolving them can contribute to making demographic forecasts more informative and useful for organizations, like the Federal Reserve, that need such data.

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