S E R I E

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población y desarrollo

Demographic models for projections of social sector demand

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Abstract

This paper presents three demographic models useful for projections of social sector demand. The first model is a probabilistic national population forecast based on the collective experience of UN member states. It offers a set of probabilistic forecasts as a complement to the official UN scenario forecasts. The second model forecasts the population by age and educational level using data from a single census. Forecasts are presented for Chile which show dramatic changes in the educational composition of the elderly population and in the working-age population in the near future. These trends are likely to have important implications for reductions in poverty and future economic growth. The third model examines the effects of changes in population age structure on social sector demand. As an example, some likely effects of population aging on the Chilean government budget are examined. Each of the 3 models presented in this paper are based on relatively simple accounting frameworks. Though simple, the models provide interesting insights into the future demography of countries and the economic and fiscal implications of these changes.

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I. The Random Country Model for Probabilistic Population Forecasts

Most national population forecasts are based on expert opinion about the likely future course of mortality, fertility, and immigration. The forecaster uses his or her knowledge about social, economic, and cultural forces to develop scenarios about the future demography of the country of interest. Typically, three scenarios are evaluated: a baseline scenario which represents the forecaster's best guess about the future and a high and a low scenario bracketing the baseline forecast which are generally viewed as providing some sense of uncertainty around the baseline forecast.

These traditional scenario forecasts have been criticized on several grounds (Lee and Tuljapurkar, 1994 and Keilman, Pham, and Hetland, 2002). First, expert opinion is often biased. In particular, experts are usually too pessimistic about future gains in life expectancy. That is, national forecasts have consistently overstated future mortality rates – resulting in underestimation of the elderly population. Experts also appear to be biased in forecasting fertility in that they are unduly influenced by the recent past. When fertility is high, they tend to forecast continued high fertility. When fertility is low, they tend to forecast continued low fertility.

Second, high-low scenarios provide an inconsistent measure of our uncertainty over the length of the forecast. Typically, they are too narrow in the first years of the forecast and too wide in the last years of the forecast. This is due to the fact that although fertility might be unusually high for a few years in a row, it is exceedingly improbable that it would remain unusually high in every year of the forecast. Therefore, forecasters using scenarios are confronted with a difficult dilemma: the high scenario must be high enough in the early years to account for a chance run of several years worth of “high” values – but the high scenario should must be lower over the long-run reflecting the fact that such a chance run for every year of the forecast is exceedingly unlikely. The high-low scenario approach does not account for the cancellation of unusually high and unusually low values over the course of the simulation.

In a similar vein, the scenarios must couple together the same set of extreme values for each of the three components of mortality, fertility, and immigration in every year of the simulation. For example, in the high population scenario, the forecaster typically couples high fertility with high immigration and low mortality in every year of the forecast. The forecasts ignore other possible combinations. This leads to inconsistent prediction intervals across different variables of interest.

Some demographers have proposed the use of stochastic population forecasts as a means of overcoming these difficulties. Long historical series of data on fertility, mortality, and immigration are analyzed and forecast using time-series methods. Monte Carlo methods based on repeated draws from distributions defined by the time-series estimates provide thousands of population projections which define prediction intervals. This method clearly addresses the problem of inconsistent prediction intervals in traditional high-low scenario forecasts. However, it is less clear to what extent these stochastic models overcome the key problem of expert bias. Indeed, it is frequently the practice in such models to replace the central forecast of the time-series model with a forecast provided by expert opinion.

In this report, I present a new method for probabilistic population forecasts which I call the Random Country Model (RCM). The RCM approach differs in some key respects from those models developed by Lee and Tuljapurkar (1994), the United States Congressional Budget Office (2001), and the United States Social Security Administration (2005). Those models are all based on time-series analysis, while the Random Country Model is based on a non-parametric sampling technique.

Those models analyze data for a single national population. The Random Country Model is based on the collective experience of 192 UN member countries. Those models stress the unique historical experience of the country of interest, while the RCM approach stresses the shared experience of countries. For example, in forecasting the future path of the total fertility rate, RCM assumes that UN member countries with similar Total Fertility Rates are being exposed to the same set of unknown social forces which shape their future demographic trajectory. By contrast, a forecast based on expert judgment uses (implicitly or explicitly) information about these social forces and their future impacts. Examples of such factors include the one child family policy in China, the anti-smoking campaigns in California, national immigration laws, changing educational distributions, changing labor force demand, etc.

Typically, those traditional models analyze a very long time series of data which span 50 to 100 years. In contrast, I am using a sample of convenience: the UN data set on World Population Prospects (2004) which includes data for the period 1950 through 2005. This post-1950 historical record misses some of the 1940s baby boom experienced in the US and several other countries. In addition, it includes the experience of many countries which never experienced the post-war baby boom. Therefore, the stochastic forecast of fertility based on the UN post-1950 experience will be less likely to predict baby booms than stochastic forecasts based solely on US historical data.

Finally, those traditional probability forecasts frequently replace the time-series prediction of central tendency with an alternative forecast based on expert judgment. In contrast, the Random Country Model uses the central tendency revealed by the historical experience of UN member countries rather than replacing that central tendency with a forecast based on expert judgment. Of course, there are many plausible reasons for expecting that the future will be radically different than the past. Nevertheless, it is useful to begin with the null hypothesis that the future will be like the past. In evaluating our scenarios against the backdrop of these probabilistic forecasts, we are prodded to think carefully about what novel forces will interrupt the continuity of past trends, or what conditions in our country of interest make it unique and unlikely to share the common experience of UN member countries.

In his Theory of Justice, the philosopher John Rawls (1971) posits that the ideal just society would be created under conditions in which the participants constructed a social contract behind a "veil of ignorance" in which they were unaware of what role they would subsequently play in the society. This veil of ignorance was a crucial element in Rawl's scheme in order to remove the bias of the participants. In a similar manner, these probabilistic forecasts are undertaken behind a veil of ignorance in which we purposively strive to remove the biases that form the basis of expert opinion.

The Random Country Model is based solely on 4 characteristics of the country in question. These 4 country-specific factors are the total fertility rate (TFR), life expectancy at birth for both sexes combined (e0), the net migration rate (NMR), and the population count by age and sex. The Random Country Model uses the collective experience of 192 UN member countries over the 55 year period from 1950 to 2005 in order to forecast the future trajectories of fertility, mortality, and migration. The Random Country Model using only these 4 factors as starting0020proceeds to generate 1,000 population forecasts. For any variable of interest, at any point in time, we have a list of 1,000 possible values. The sorted list for a particular variable defines our probability interval for that variable. For example, we have 1,000 possible values for the total population in the year 2050. Table 1 presents a summary of these values for Chile. In 2050, half of our 1,000 population forecasts lie above 21.9 million and half below. Less than 5% of our forecasts lie above 27.5 million and less than 5% lie below 17.6 million. Or in other words, our probabilistic forecasts define a 95% prediction interval for the population of Chile in 2050 of 17.6 million to 27.5 million inhabitants.

Asian crisis may have been unsound to start with, but the magnitude of the losses associated with them were determined even more by the major macroeconomic shocks that these regions experienced, which were probably.

Thus, the investment and savings decisions that determine macroeconomic behaviour and performance are based on opinions and expectations on the uncertain evolution of economic variables rather than on risk probability distributions that can be known *ex-ante*. In a word, markets are necessarily imperfect when time is involved, as the information necessary to correct such "market imperfection" will never be available.

Table 1
POPULATION OF CHILE IN 2010, 2025, AND 2050 BASED ON RANDOM COUNTRY MODEL FORECAST
(in millions)

Percentile	2010	2025	2050
95th	17.4	21.0	27.5
75th	17.2	20.1	23.7
50th	17.2	19.6	21.9
25th	17.1	19.0	20.3
5th	16.9	18.3	17.6

Source: Author's calculation based on RCM.

These probabilistic forecasts might be considered anti-expert in the sense that we are purposively attempting to restrict our expert knowledge about the country we are forecasting. These forecasts offer a vision of the future rooted in the past. In that sense, they can be considered as the most natural null hypothesis about the future. The variations in demography that we have observed in the past serve as our guide to the future. This is not to argue that the future must look like the past. But rather that it is useful to begin with this null hypothesis. It will lead to better understanding and evaluations of subsequent scenario forecasts based on expert knowledge.

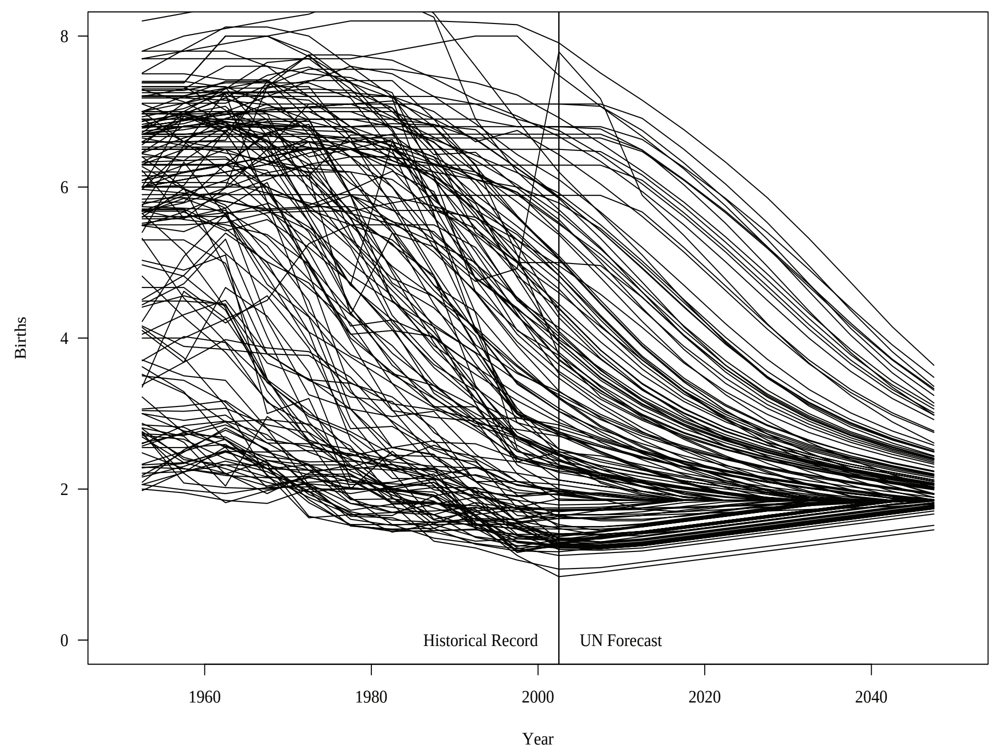
The Random Country Model consists of 4 key steps:

- Select path of TFR, e0, and NMR by repeated random draws from a set of similar UN member countries.
- Forecast the population based on the standard cohort component method using the sample path of TFR, e0, and NMR. The summary values of TFR, e0, and NMR are translated into age-specific values using standardized age patterns of fertility, mortality, and net migration.
- Repeat Steps 1 and 2 numerous times (typically 1,000 or 10,000).
- Calculate predictive distributions for variables of interest (population size, dependency ratios, etc).

A. Forecasting fertility

Figure 1 presents the fertility history and fertility projections for each of 192 UN member countries for the period 1950 through 2050 based on the UN estimates and scenarios. The data are based on 5 year intervals for the Total Fertility Rate (TFR). The left side of the graph represents the historical record and the right side the UN scenario forecasts. The central feature of the historical record has been the decline in fertility. This is more evident when we present the data as a density distribution. Figure 2 shows the distribution of TFRs by deciles. In 1950, half of UN member countries had TFR above 6.0. By 2005, less than 10% had a TFR above 6.0. The median TFR had dropped from 6.0 to 2.7.

Figure 1
TOTAL FERTILITY RATE BY COUNTRY: 1950 TO 2050

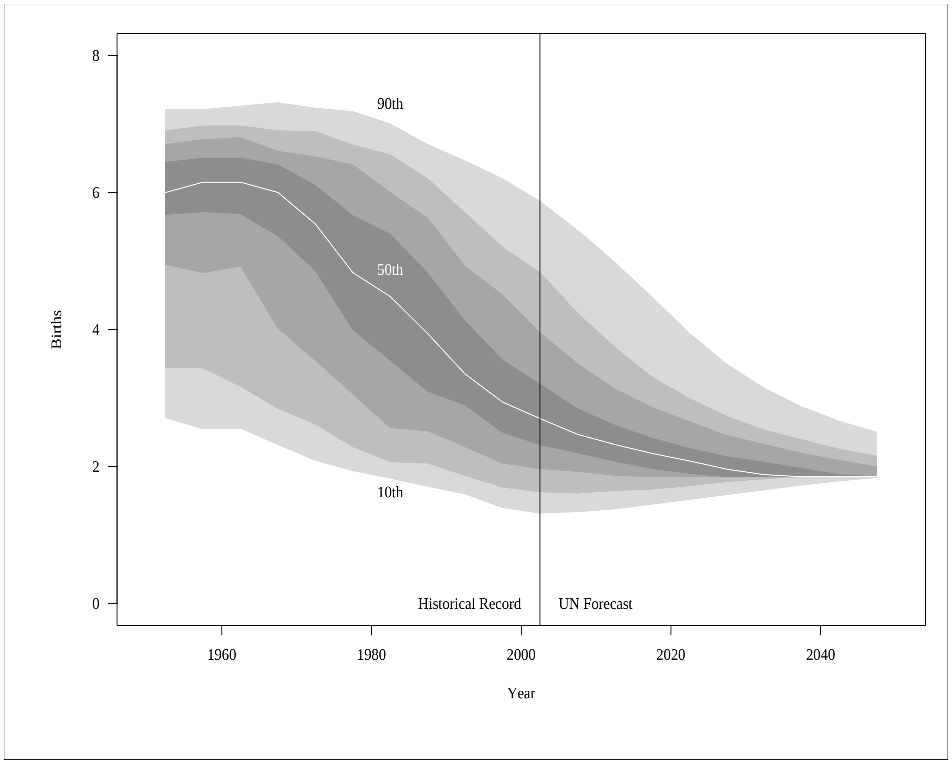


Source: UN (2005).

Using UN data from 1950-2005 we have 192 countries with 11 observations each, for a total of 2,112 TFR values. In the Random Country Model, the derivation of the sample path of TFR proceeds as follows. Imagine the starting year TFR is 7.0. I then select 100 of the TFR values which are closest to 7.0. From this group of TFRs, I randomly select one value. I then observe what happened in that country in the following 5 year period. This value represents our prediction of TFR for the next period in the forecast. We then repeat the process for the length of the forecast.

Figure 2

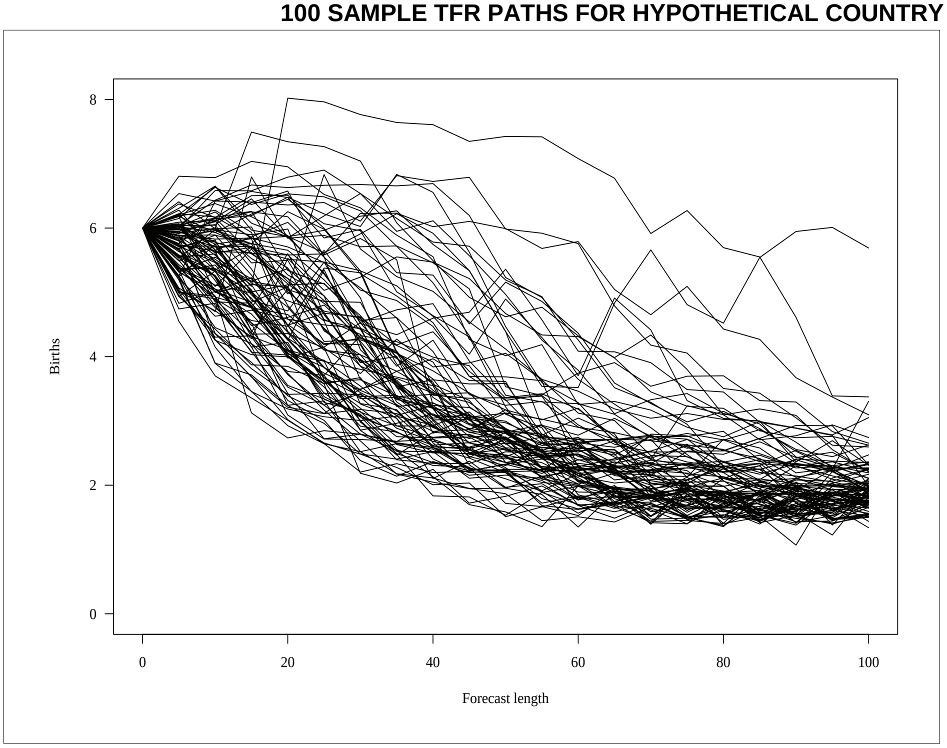
TOTAL FERTILITY DISTRIBUTION BY DECILES: 1950 TO 2050



Source: Author's calculation based on UN (2005).

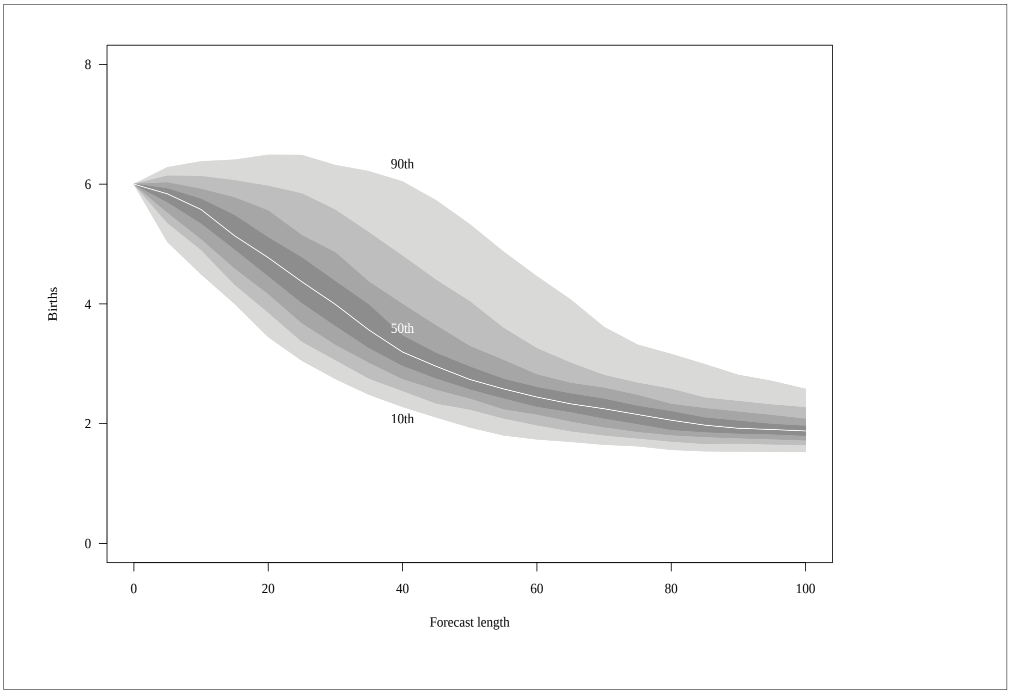
Figure 3

100 SAMPLE TFR PATHS FOR HYPOTHETICAL COUNTRY



Source: Author's calculation based on RCM.

Figure 4
DISTRIBUTION OF TFR SAMPLE PATHS FOR HYPOTHETICAL COUNTRY



Source: Author's calculation based on RCM.

One key issue with this sampling strategy is how to define similar countries. I have chosen to define similarity by selecting the 100 points with TFRs closest to our country of interest. One could also define similarity in terms of some fixed value: for example, all those countries whose TFR is within 0.25 of our country of interest.

Another issue in this approach involves the extent to which the current level of fertility is influenced by the past levels of fertility. This model assumes that the current level of fertility is only influenced by the most recent period fertility. Similarly, this approach assumes that, for the purposes of prediction, the experience of countries in the 1950s is just as relevant as the experience of countries in the 1990s.

The experience of countries before 1950 is completely ignored in the forecast. I am using the post-1950 period based on a sample of convenience: the UN data begin in 1950. Events such as the post-war baby boom of the 1940s are not recorded in the UN historical record and so are not represented in the forecast. This is one reason why my probabilistic forecasts of TFR have much smaller probability intervals than those generated by Lee-Tuljapurkar who base their forecast on a long time series of US data. Lee-Tuljapurkar 95% prediction interval for the TFR of the United States in 2050 are centered on 1.95 and span the range from a high of nearly 3.0 to a low of 0.8. In contrast, my 95% prediction interval for the TFR of the U.S. in 2050 span the range from a high of 2.4 to a low of 1.5 --- approximately half the width of the Lee-Tuljapurkar prediction interval.

In addition, Lee-Tuljapurkar methods for forecasting TFR use probabilistic methods only to define the variation about a trend and not the trend itself. Time-series methods are used to fit the historical series of the TFR. Were these same methods used to predict the TFR, the prediction would have a mean equal to that of the historical series (since the time-series is fit to a mean de-trend series). In the Lee-Tuljapurkar method, instead of using the historical long run average, the trend itself is based on expert judgment about the likely future course of the TFR. So for example in the US, a long-run average of 1.95 is used in the Lee-Tulja forecast. By contrast, the Random Country Model is based on the experience of UN member countries. As is evident in Figures 1 and 2, the central feature of the fertility experience has been the fertility transition from high to low fertility levels. So, my probabilistic forecast will reflect this movement. If a country starts with a high level of TFR, repeated random draws from the sample of TFRs will lead to a repeat of the historical experience of the fertility transition. Figure 3 shows the first 100 sample TFR paths for a hypothetical country with an initial TFR of 6.0. Figure 4 shows the predictive distribution for 1,000 sample TFR paths.

What about the "post-transition" fertility levels? In practice, my method will lead to a long-run forecast of TFR based on the 100 lowest TFR points. The average of these 100 lowest TFR countries for the 1950-2005 period was 1.5. However, based on analysis by Bongaarts and Feeney (1998) we believe that some of these TFRs are transient values generated by a switch in fertility patterns from early to late childbearing. The switch leads to a temporary depression in the level of TFR in the range of 0.2 to 0.3 children. That is, after all cohorts have transitioned to the new childbearing pattern, the period TFR would rise by 0.2 to 0.3 children. Therefore, the low fertility of many UN member states observed in the data can reasonably be expected to represent transitional states and should not serve as the basis of our long run forecasts. Some adjustment in the TFR forecast is needed. At the moment, I have simply assumed that tempo effects are currently about 0.25 births and will dissipate within a generation. This method leads to a long-run future in which all countries will converge to a similar low-level of fertility of 1.85 births per women. This turns out to be identical to the long-run value chosen by the UN forecasters in their middle scenario.

Table 2

TOTAL FERTILITY RATE FOR CHILE IN 2050 COMPARING UN FORECAST WITH RANDOM COUNTRY MODEL (RCM) FORECAST

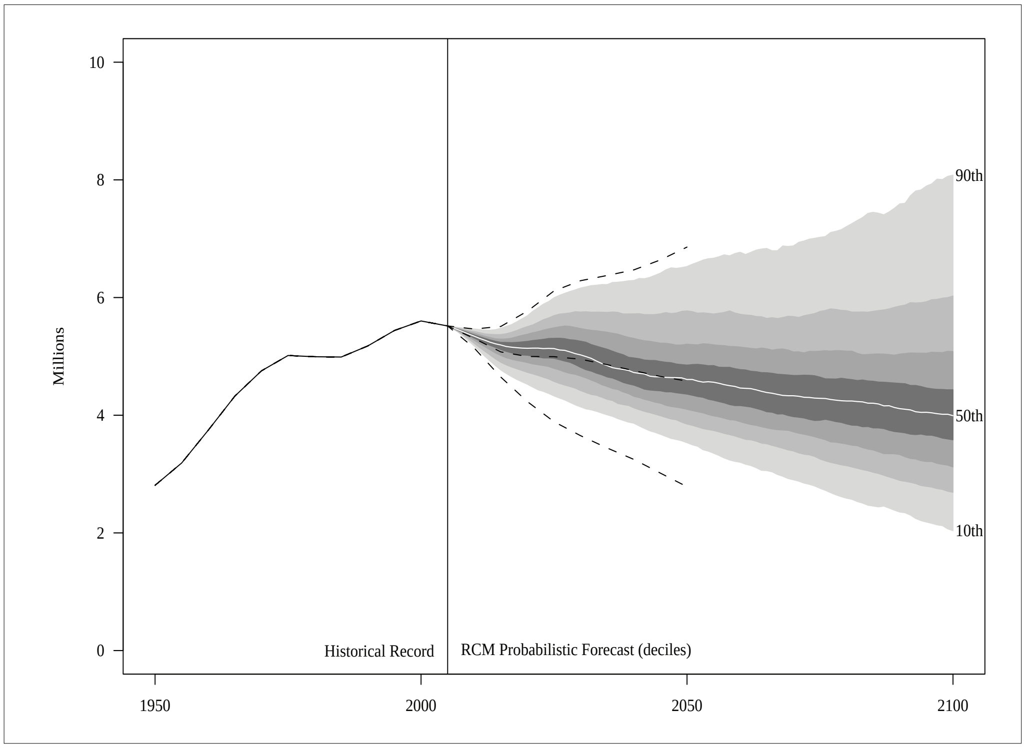
Forecast				
UN Forecast (TFR in 2050)	**Low**	**Middle**	**High**	**Range**
	1.35	1.85	2.35	1.00
	5th Percentile	**Median**	**95th Percentile**	**Range**
RCM Forecast (TFR in 2050)	1.43	1.80	2.34	0.91
RCM Forecast (Average TFR from 2005 to 2050)	1.62	1.83	2.33	0.71

Source: UN (2005) and author's calculations based on RCM.

At this point, I have implemented the UN probabilistic forecast in only 3 countries: Chile, Brazil, and the United States. So, I must be cautious in generalizing the results. But it appears that the UN high-low TFR forecasts are quite close to my 95% TFR forecasts for estimates of the annual TFR. Table 2 presents the comparison of UN scenario forecasts and my Random Country Model probabilistic forecasts for 2050. From this we can draw two conclusions. First, the UN fertility forecasts are quite consistent with the historical experience of UN member countries. Second, the UN high-low TFR forecasts most likely represent year-to-year extremes which might be expected to cancel over time. That is, fertility is unlikely to be consistently high or consistently low as predicted by the UN forecasts. Instead, as the RCM forecast indicates, average TFRs over the length of the forecast would fall in a more narrow range. This means that the UN high-low population forecasts define a range of births much larger than the experience of UN member countries would indicate. However, this effect will mainly be seen at the end of the UN forecast in 2050 – when we become increasingly skeptical of the validity of the historical experience in forecasting the future. Figure 5 compares the UN scenario forecasts of the Chilean population under age 20 to my UN probabilistic forecasts. The effects of these differences in TFR are clearly evident in 2050.

Figure 5

POPULATION UNDER AGE 20 IN CHILE: 1950 TO 2100 BASED ON HISTORICAL ESTIMATES, UN FORECAST, AND RCM FORECAST



Source: UN (2005) and author's calculations based on RCM.

The Total Fertility Rate is defined as the sum of the age-specific fertility rates. I translate the forecast of TFR into a set of age-specific rates based on a Lee type transformation in which we define a base-level set of age-specific fertility rates (ax) and a second set of transforming factors (bx) which are added to the ax factors in multiples of k so as to reach the target TFR level. That is, age-specific fertility is defined as:

$$f(x) = a(x) + k^* b(x).$$

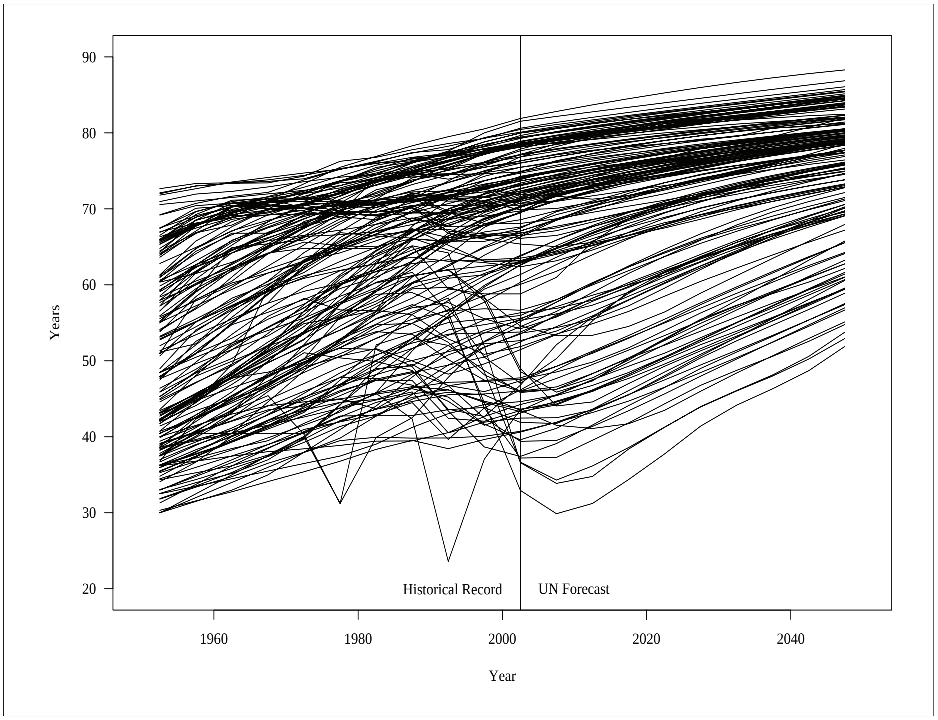
So, we have a one-parameter family of age-specific fertility schedules defined by the single parameter k and the fixed age schedules of ax and bx. In the current implementation of the model, I am using ax and bx values derived from time-series analysis of historical US data. In subsequent versions of the model I will attempt to use UN data to derive ax and bx values based on two sets of age-specific fertility rates: a high set based on member countries with TFRs above 5 and a low set with TFRs below 2.5.

B. Forecasting mortality

Like fertility, the sample path for life expectancy in the Random Country Model is selected based on the experience of UN member countries from 1950 to 2005. Figure 6 below shows this experience along with the UN forecasts for the period 2005-2050.

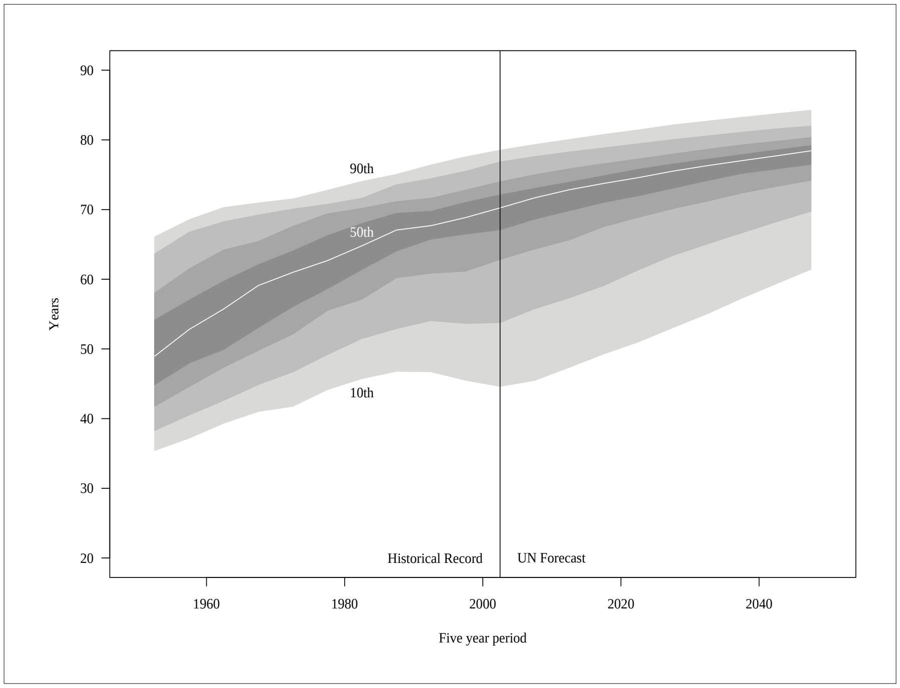
Figure 6

LIFE EXPECTANCY AT BIRTH BY COUNTRY: 1950 TO 2050 BASED ON HISTORICAL ESTIMATES AND UN FORECAST



Source: UN (2005).

Figure 7
LIFE EXPECTANCY DISTRIBUTION BY DECILES: 1950 TO 2050 BASED ON HISTORICAL ESTIMATES AND UN FORECAST



Source: Author's calculation based on UN (2005).

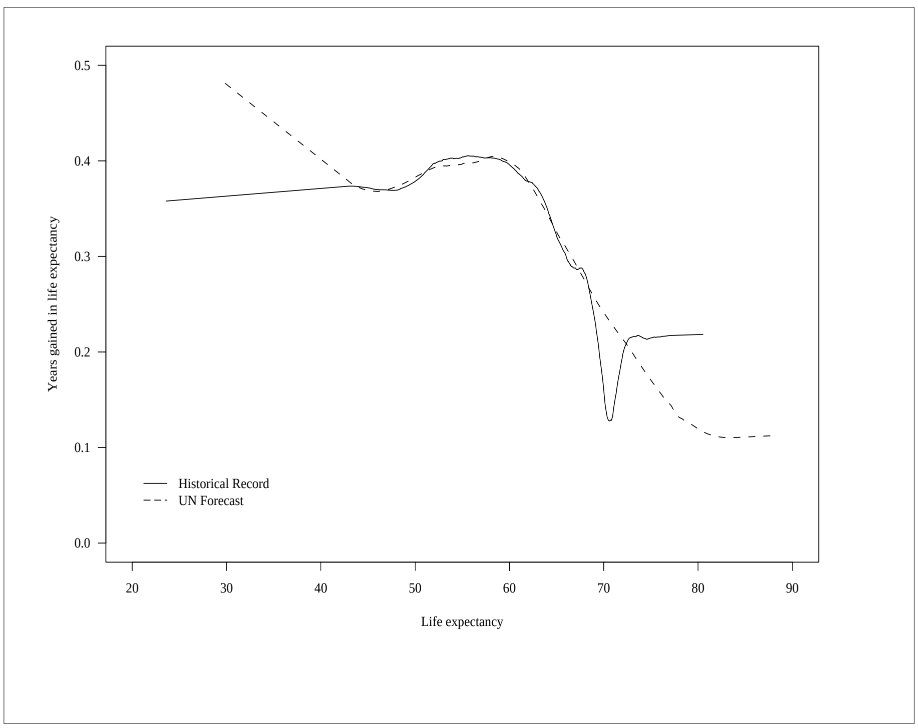
As evident in Figure 7, the defining feature of this experience has been the general upward trend in life expectancy which characterizes the mortality transition. In 1950-54, median life expectancy among countries was 49 years. Within 50 years, median life expectancy had risen to 70 years.

The derivation of the sample path of e0 proceeds as follows. Imagine the starting year e0 is 70. I then select 100 e0 values which are closest to 70. From this group of countries, I randomly select one country. I then observe what happened in that country in the following 5 year period. This value represents our prediction of the change in e0 for the forecast. For example, e(0) may have increased by 1 year in the 5 year period. So, we add 1 year to the current e(0) in our country of interest and this forms our projection of e(0) for the next 5 year period. We now have a country in which e(0) is 71. We then repeat the process for the length of the forecast.

Owing to the upward trend in the data, all countries will eventually reach into the higher ranges of e(0). How then should we make predictions for e(0) projections in these higher ranges and beyond? My solution is to use the experience of UN member countries whose e(0) lies above 75 – representing 161 observation points. These countries, on average, experienced gains in life expectancy of about 1 year in every 5 year period or about 0.2 years annually. There are no signs in the historical data that we are approaching any limits to life expectancy. Therefore, my forecasts based on the observed historical experience will also show no signs of approaching a limit. Of course, one may well argue that there is no historical record for countries with life expectancy beyond 90 – so there is no historical basis on which to make such forecasts.

Figure 8 shows the average annual gains in life expectancy based on the historical experience of UN member countries as a solid line. The dashed line in the graph represents the average gains based on the UN forecast. Two key differences emerge between the historical experience and the UN scenario forecast: at lower levels of e(0) the UN forecasts much more rapid increases than observed historically – plausibly due to faster catch-up growth in the future. At the higher levels of e(0), the UN forecasts much slower growth in e(0) than has been observed historically. This growth is about half as fast as historically observed. This projected slowdown is curious and I suspect it may be an unintended consequence of other assumptions in the UN scenario forecasts. For example, imagine that they explicitly or implicitly assume a limit to life expectancy. Then in order to avoid a situation in which high life expectancy countries exceed such limits, they must posit slowed gains in e(0) at very high life expectancies. It would be natural, then, to simply assume some graduation in rates of improvements from the very rapid improvements seen in countries with life expectancy in the 60s to their assumed slow rate of gains for countries as they approach limits to life expectancy. Because the Random Country Model is based on the trends observed in the historical experience, it forecasts gains in life expectancy at twice the rate projected by the UN. Another interesting result evident in Figure 8 is the low life expectancy gains of a group of countries with life expectancy in the low 70s.

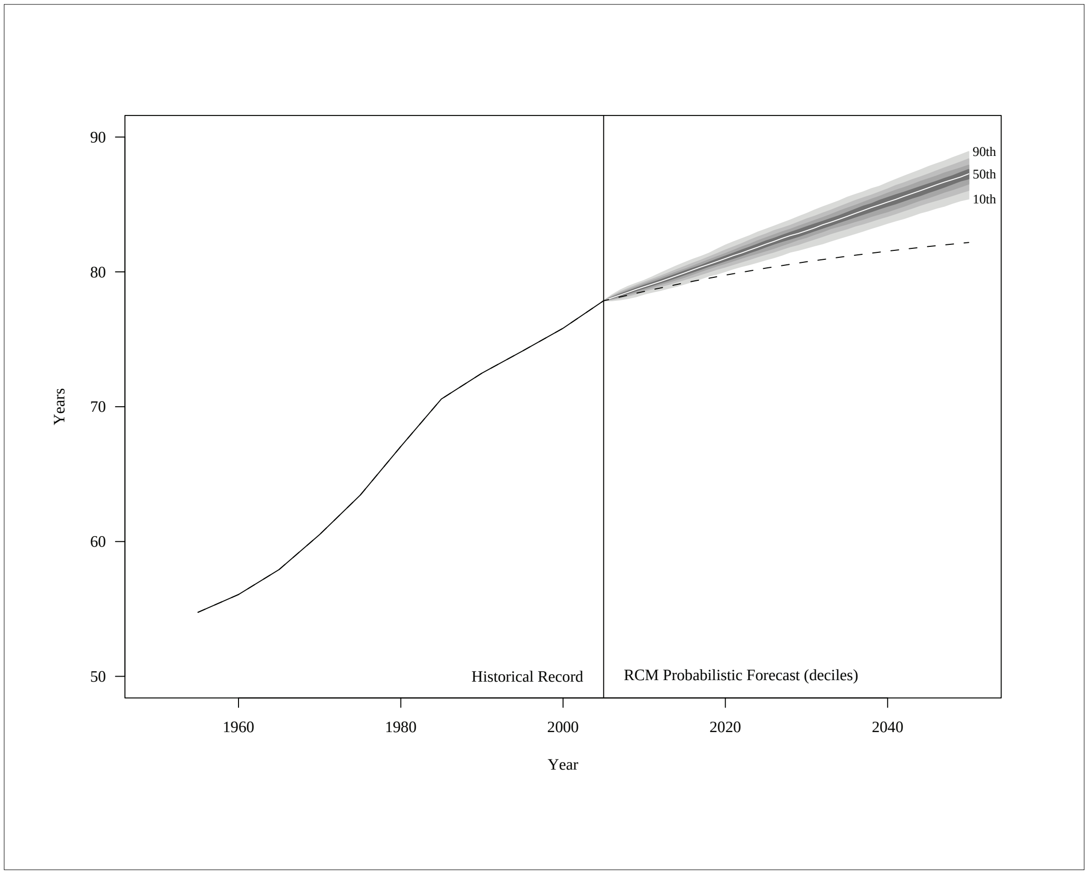
Figure 8
GAINS IN LIFE EXPECTANCY AS A FUNCTION OF CURRENT LIFE EXPECTANCY



Source: Author's calculation based on UN (2005).

Figure 9

LIFE EXPECTANCY AT BIRTH IN CHILE: 1950 TO 2050 BASED ON HISTORICAL ESTIMATES, UN FORECAST, AND RCM FORECAST



Source: UN (2005) and author's calculation based on RCM.

The Random Country Model uses the UN historical record and so leads to a future in which life expectancy in all countries will be increasing at the same long-run rate of 0.22 years annually. That is, there is a convergence to the same rate of increase. This implies that, in general, there is no "catch-up" growth by lagging countries to leading countries within group of high life expectancy countries (e0>75). However, there is considerable "catch-up" growth for countries below this threshold as evident in Figure 8. Countries with life expectancy in the 50s and 60s have been improving life expectancy at about twice the pace of countries with life expectancy above age 70. In the current implementation of the model, the life expectancy forecast of all high life expectancy countries are based on random draws from the same underlying distribution -- no matter when a country passes the high life expectancy threshold of 75. Therefore, in general there will be no long-run convergence among high life expectancy countries. The countries should largely maintain their positions based on when they cross the high life expectancy threshold. For example, life expectancy in the US is predicted to be higher than that of Chile over the next 100 years, simply because the US had higher life expectancy than Chile at the start of the simulation.

Figure 9 shows the probabilistic life expectancy for Chile along with the UN forecast. The UN forecast calls for an e(0) of 82.2 by 2050 in Chile. The Random Country Model forecast is considerably more optimistic with a median value of 87.3 in 2050, with 95% prediction interval from 84.9 to 89.4. These RCM probabilistic forecasts for Chile predict that the majority of Chileans born in 2005 will live to see the 22nd century.

There are several striking features of the forecasts. First, the UN life expectancy forecast is quite a bit below that of the Random Country Model forecast. In fact, by 2025, the UN forecast lies below the 95% prediction interval of our model. Based on the historical experience of UN countries, we would judge this outcome to be exceedingly unlikely.

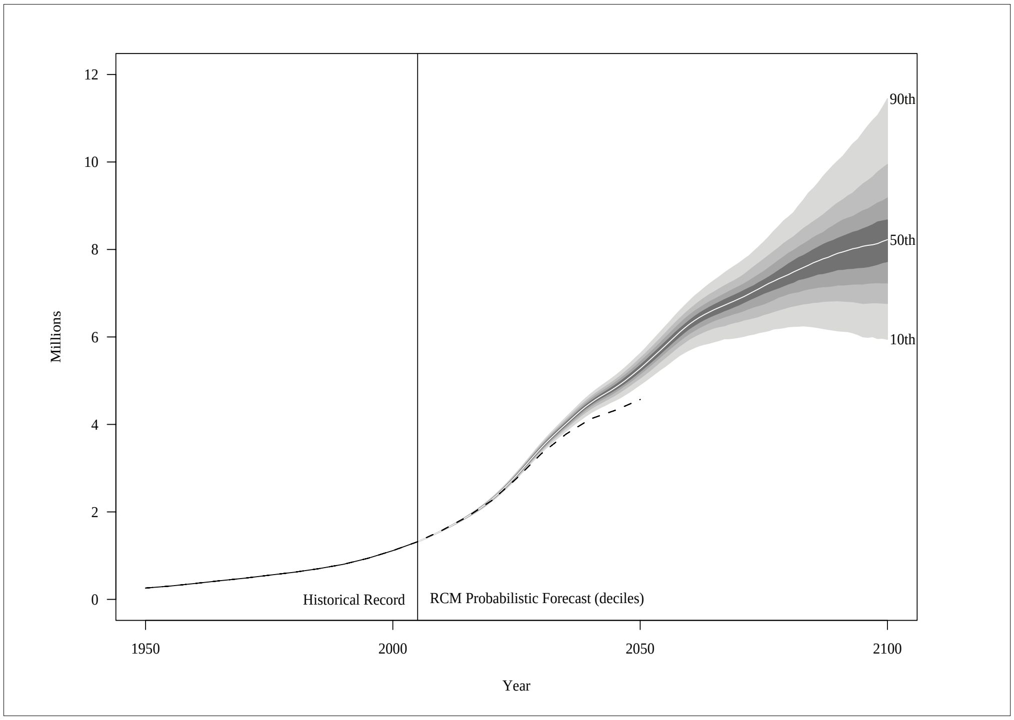
Second, in the RCM forecast life expectancy is increasingly nearly linearly. Oeppen and Vaupel (2002) note that record female life expectancy in the life-expectancy leading country has been rising over a 160 year period at an annual rate of 0.243 years – while for men it has been rising at somewhat slower rate of 0.222. These values are remarkably close to those used in the Random Country Model forecast (0.218) based on the recent historical experience of high life expectancy countries.

Based on my probabilistic projections for 3 countries (Chile, Brazil, and the US), I would conclude that the UN forecast of life expectancy are unduly pessimistic and represent a distinct break with the historical experience of UN member countries. The UN scenario forecast lies well below the lower 95% prediction interval for e0 in each of these 3 countries.

Interestingly, this large difference in life expectancy does not matter much for predicting the size of the elderly population in the near-term future. Figure 10 shows the UN probabilistic prediction of the population age 65 and older for Chile from 2005-2100 along with the UN scenario forecast. For the first 20 years of the forecast, the UN forecast is quite close to my median forecast. This reflects two facts: the first is that e(0) forecasts begin at a common point and slowly diverge over time. Second, past fertility trends, not life expectancy, are the major determinant of the increasing number of elderly.

Figure 10

POPULATION AGE 65 AND OLDER IN CHILE: 1950 TO 2100 BASED ON HISTORICAL ESTIMATES, UN FORECAST, AND RCM FORECAST



Source: UN (2005) and author's calculation based on RCM.

Life expectancy at birth is a summary measure of the age-specific mortality rates experienced by a population at a point in time. I translate the forecast of e0 into a set of age-specific rates based on Lee-Carter types transformations in which we define a base-level set of age-specific mortality rates (ax) and a second set of transforming factors (bx) which are added to the ax factors in multiples of k so as to reach the target e(0) level. That is, the log of age-specific mortality is defined as:

$$\log(m(x)) = a(x) + k^* b(x)$$

So, we have a one-parameter family of age-specific mortality schedules defined by the single parameter k and the fixed age schedules of ax and bx. In the current implementation of the model, I am using ax and bx values derived from time-series analysis of historical US data. In subsequent versions of the model I will attempt to use UN data to derive ax and bx mortality parameters based on two sets of age-specific mortality rates: a high set based on member countries with e0 in the range of 50-65 and a low set with e0 above age 75.

In addition, the current implementation does not take account of the unique age-specific mortality rates in the country of interest. Instead, it assumes that all countries with the same life expectancy have the same age-specific pattern of mortality. In practice, this means the forecast of age-specific mortality rates will represent a distinct break with the historically observed age-specific mortality rates. An important revision to the current model would be to base the forecast of mortality rates on the most recent set of observed mortality rates (as the ax factors), while taking the forecast changes in rates based on a common set of bx factors based on either the US data or UN member countries as outlined in the preceding paragraph.

Finally, the forecast is based on the average life expectancy of both sexes combined – rather than on separate forecasts for men and women. In future revisions, I should take account of the sex difference in mortality in each country and likely changes in this difference over the future.

C. Forecasting migration

There is considerable controversy over how to best incorporate assumptions about net migration into long run forecasts. Most countries set legal limits on the number of in-migrants. Many demographers favor forecasts in which net migration continue at their current level throughout the length of the forecast. They argue that this forecast represents a status-quo evaluation of current policy. Other demographers point out that legal limits to immigration are often “soft limits.” For example, the United States sets strict numerical limits on immigration, but certain groups of immigrants (spouses of US citizens) are admitted without limit. Special exceptions are often granted for refugee populations. Mass amnesties have been granted for legalization of immigrants who entered illegally. In addition, demographers argue that social forces shape immigration in the long-run and current legislated limits should be expected to change over the course of a long-run forecast. For a recent discussion of these issues in the context of forecasting the US population, see Technical Panel on Assumptions and Methods (2003).

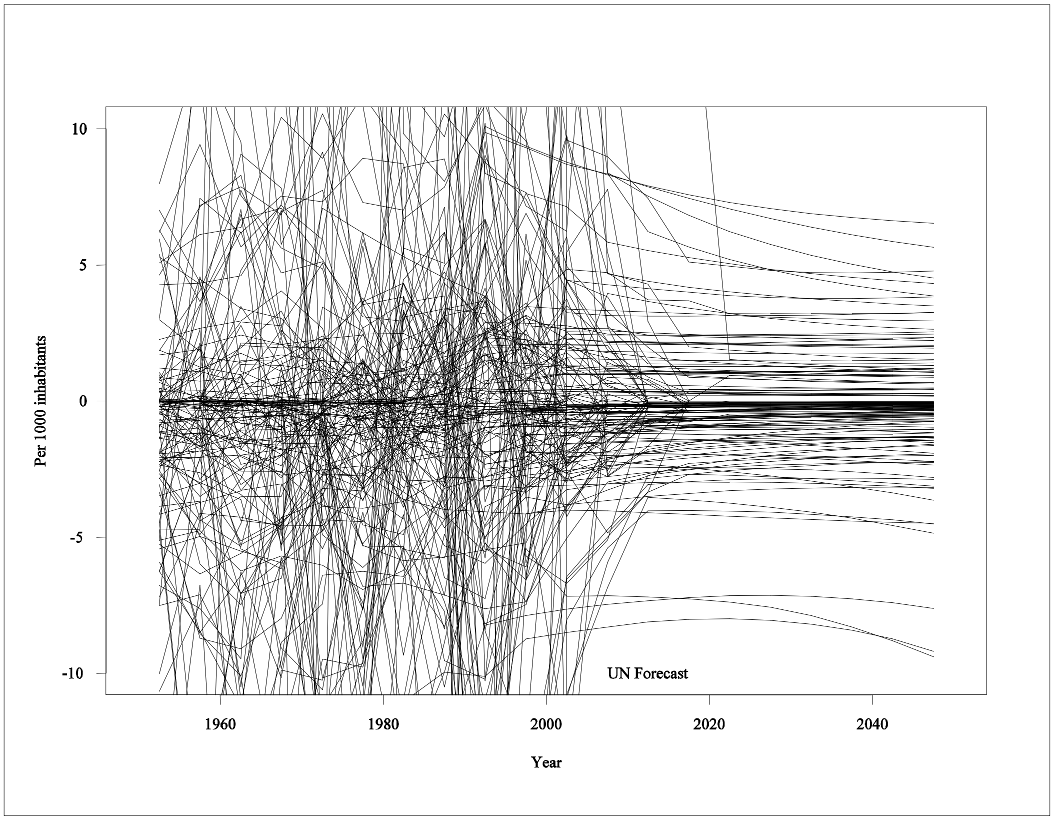
Stochastic population forecasts have generally included only deterministic forecasts of net migration. Recently, Miller and Lee (2005) proposed a stochastic forecast for net migrants to the U.S. based on a time-series analysis of US immigration. Here, I propose to use the historical data for net migration to UN member countries whose population exceed 2.5 million in 1950. I am excluding small countries from the sample on the grounds that they are un-representative of most populations – they tend to have dramatic swings in net migration which are extremely uncommon in larger populations.

Figure 11 shows net migration rate by country as observed in the period 1950-2005 and as forecast for the period 2005-2050 by the United Nations. When looking at these figures, one is struck by the discontinuity between the left and right sides of the graph. On the left side, one sees the extreme variability of net migration observed over the past 55 years. On the right side, one sees a distinctly orderly pattern of migration.

Herein lies, one of the strengths of the probabilistic forecast of migration. In the deterministic scenario forecasts, demographers are faced with a difficult problem. Despite the past variability of net migration, they must forecast only a few paths (low, middle, and high) for future net migration. In the probabilistic forecast, this variability observed in the past translates into great uncertainty about the future course of migration. This uncertainty about future net migration is not hidden from policy makers, but is plainly evident for all to see in the probabilistic forecast. Figure 12 shows the probabilistic net migration forecast for the United States based on the Random Country Model.

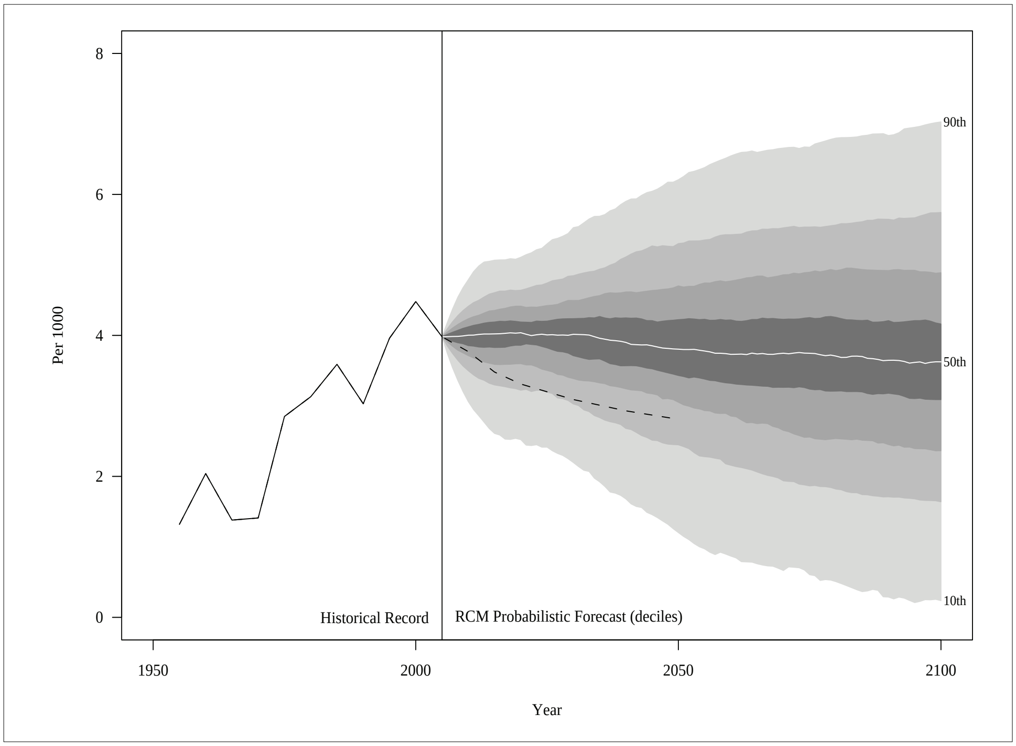
Figure 11

NET MIGRATION RATE: 1950 TO 2050 BASED ON HISTORICAL ESTIMATES AND UN FORECAST



Source: UN (2005).

Figure 12
US HISTORICAL NMR AND FORECAST AVERAGE NET MIGRATION RATE SINCE 2005 BASED ON HISTORICAL ESTIMATES, UN FORECAST, AND RCM FORECAST



Source: UN (2005) and author's calculation based on RCM.

The sample paths for the net migration rate are generated in much the same way as fertility. One important difference concerns how I select countries similar to the country of interest. I select countries whose net migration rate and whose TFR are similar to the country of interest. I am using TFR to crudely differentiate countries into low-fertility/receiving countries and high-fertility/sending countries.

It does not really make sense to forecast net migration for any country independently of net migration of the other countries since immigrants to one country are emigrants from another country. That is, we know that net migration for the world must be zero. There is nothing in my probabilistic forecasts which guarantees that stochastically generated net migration rates would add up to zero when weighted by each country's population. However, they are being drawn from a distribution in which net migration is zero. Another problem with this approach is that we expect that over time as more countries complete the demographic transition, sending pressures might decrease and lead to reductions in net migration. I have not attempted to model this in any way.

The net migration rate is a summary measure representing the number of net migrants divided by the population size. In order to translate numbers of net migrants into net migrants by age, I make use of a standard age distribution of net migrants. I have based this standard age distribution on data used by the US Census for its population forecasts.

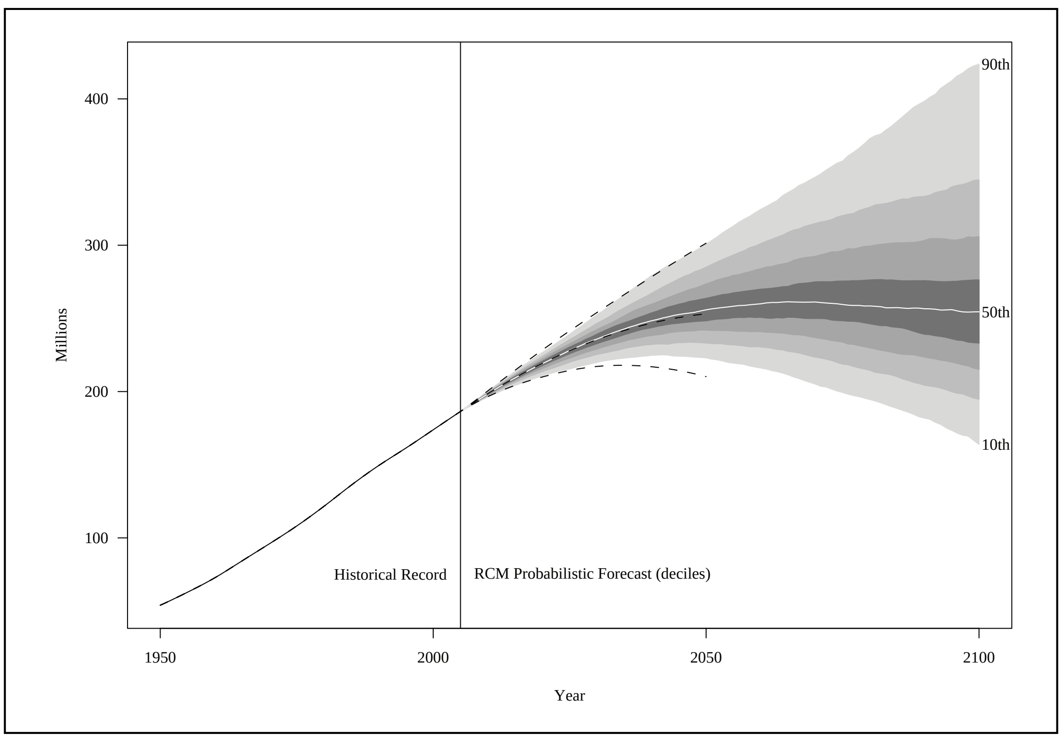
D. Forecasting the population by age and sex.

In the Random Country Model, these probabilistic forecasts of the total fertility rate, life expectancy at birth, and the net migration rate are used to generate 1,000 population forecasts. Each population forecasts contains data on the population by single year of age and sex for each year from 2005 to 2100. The number of population forecasts is arbitrarily set. In past work, we have generally found that the probability bounds defined by 10,000 simulations are similar to those defined by 1,000 simulations. The length of the forecast horizon is also arbitrarily set to reach the year 2100.

The set of 1,000 population forecasts can be summarized in a number of ways. For example, Figure 13 shows the probability interval for the total population of Chile. Here we see that the high-low probability bounds of the UN forecasts conform closely to the 95% probability interval. Figure 14 and 15 show the probability interval for the total population of Brazil and the United States. Again, we see close correspondence between the 95% probability interval in the Random Country Model and the high-low forecast of the UN.

Figure 13

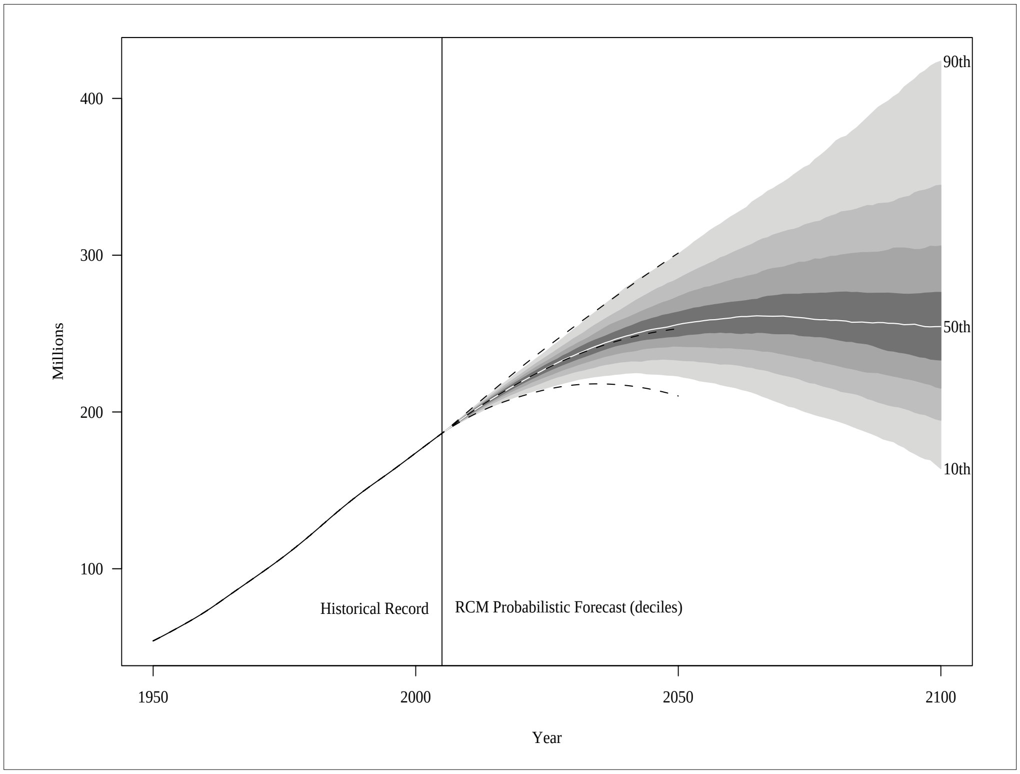
POPULATION OF CHILE: 1950 TO 2100 BASED ON HISTORICAL ESTIMATES, UN FORECAST, AND RCM FORECAST



Source: UN (2005) and author's calculation based on RCM.

Figure 14

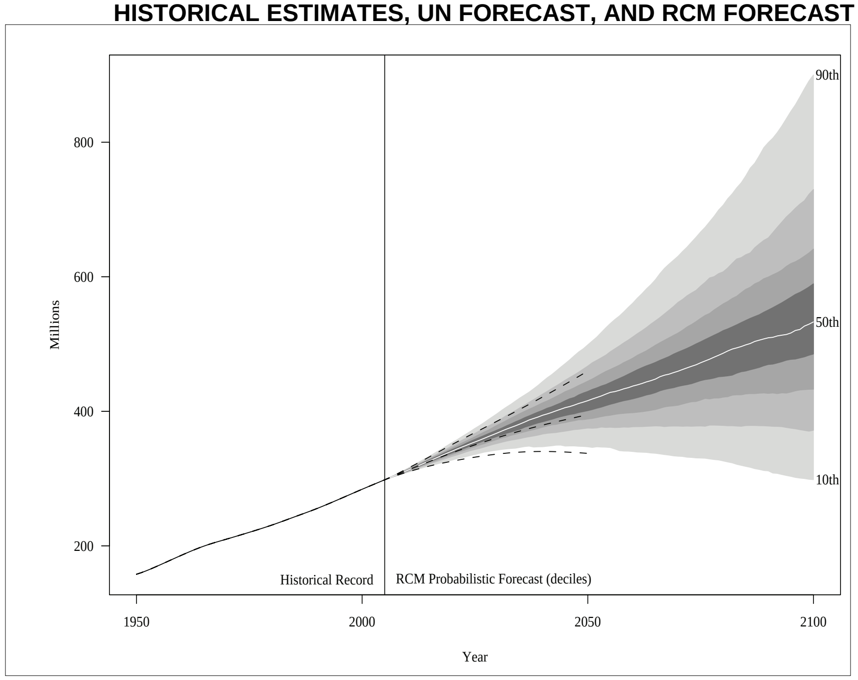
POPULATION OF BRAZIL, 1950 TO 2100 BASED ON HISTORICAL ESTIMATES, UN FORECAST, AND RCM FORECAST



Source: UN (2005) and author's calculation based on RCM.

Figure 15

POPULATION OF UNITED STATES OF AMERICA, 1950 TO 2100 BASED ON HISTORICAL ESTIMATES, UN FORECAST, AND RCM FORECAST



Source: UN (2005) and author's calculation based on RCM.

E. Summary

These Random Country Model probabilistic population forecasts use the collective experience of UN member countries as the basis for projecting future demographic trends and measuring our uncertainty about those trends. Based on this analysis, we can conclude that UN scenarios appear to be much more pessimistic about future increases in longevity than past experience would indicate. In addition, UN scenarios show much less variation in future net migration than past experience would indicate. These characteristics are likely to be common features of most national scenario forecasts. So, I suspect that the two biggest surprises countries will face in the next few decades will be: (1) a larger than expected elderly populations and (2) unexpected shifts in net migration (from net exporter to net importer as well as from high net migration to lower net migration).

There are two important senses in which the probability forecasts can be way off target. First, the future may be very unlike the past. As the length of the forecast horizon increases, our confidence in the validity of the model decreases. This decrease in confidence in the model is distinct from the prediction intervals shown in the graphs. Those prediction intervals only reflect our uncertainty about future demographic events under the assumption that our model is valid. Second, the model assumes that future events are mainly shaped by social and economic forces which countries experience in common. It ignores the uniqueness of countries. For this reason, we can find large difference between a probabilistic model which stresses commonality of countries and scenario models which typically are stories about the uniqueness of countries.

II. Population projection by educational level

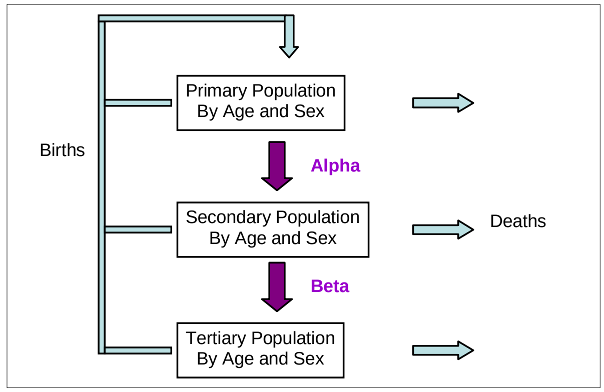
In this chapter, I develop a simple method for forecasting the population by age, sex, and education level: the Educational Census Method. Rather than relying on multiple data sources to derive the changes in educational enrollment rates, I use data on educational attainment from a single Census. This means that it should be relatively easy to generate comparable education forecasts across many countries. Chile is used as an illustrative example in which to explore the implications of the changing educational composition of the working-age population for the size and productivity of the work force.

A. The three box model

I use a simple three box model to forecast the population by age, sex, and education level (Primary, Secondary, and Tertiary). Figure 16 presents the basic scheme.

Figure 16

3 BOX EDUCATION MODEL



Source: Author.

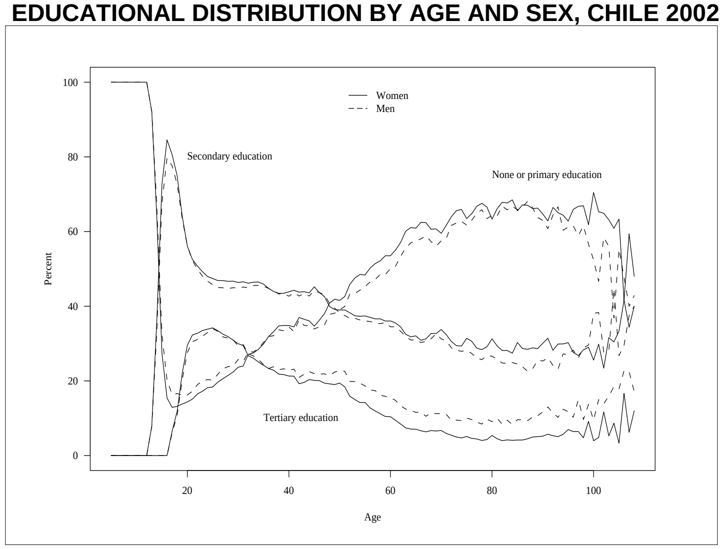
The projection model assumes the mortality and fertility are unaffected by education level. In later revisions, the model should allow these rates to differ. Migrants are assumed to have the same educational distribution as the native population. Population is projected using the cohort-component method. Births are assigned to the Primary Education population. At age 16, alpha percent of the Primary Education progress to the Secondary Education population. At age 24, beta percent of the Secondary population progress to Tertiary population. This model abstracts from the more complex grade-progression ratio method in which student populations are forecast by grade level (Lapkoff and Gobalet, 2006).

B. Estimating alpha and beta progression ratios

One of the strengths of this simple model is that only two educational parameters need to be forecast. Two simple alternative scenarios would be: (1) a No Progress Scenario in which alpha and beta progression rates are fixed at their current levels or (2) a Continued Progress Scenario in which alpha and beta progression rates continue increasing according to the recent historical trend. Estimates for both are easily available using Census data. Figure 17 shows the educational distribution of the Chilean population by age and sex based on the Chilean census of 2002.

Figure 17

EDUCATIONAL DISTRIBUTION BY AGE AND SEX, CHILE 2002

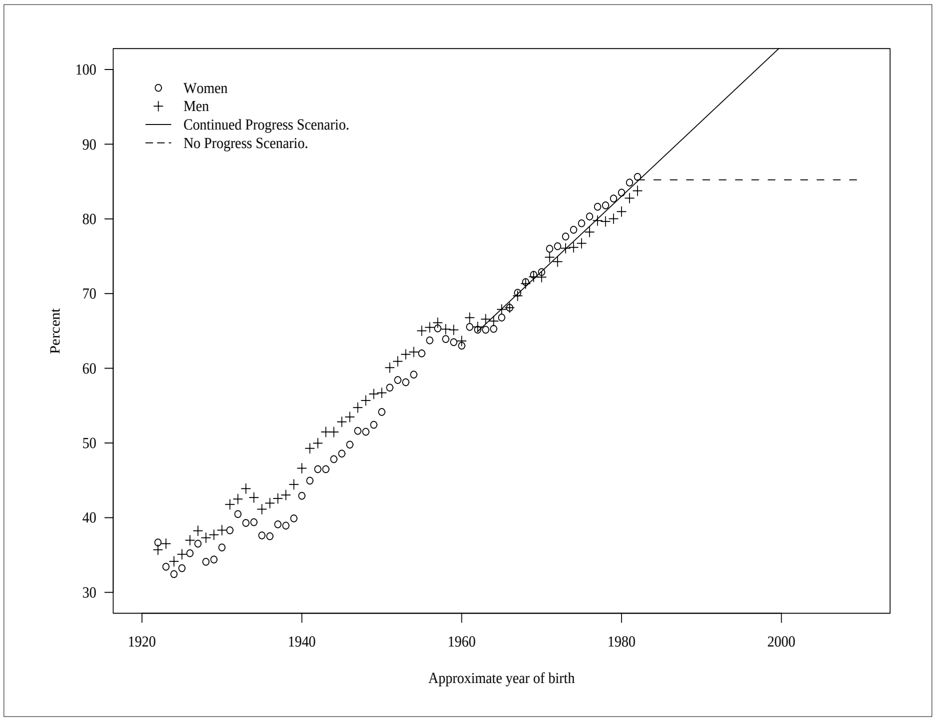


Source: Author's calculation based on Chilean Census 2002.

Using the census data, we can calculate the percent of the population with at least a secondary education by year of birth. This reflects the alpha progression rate, or proportion of population progressing from primary to secondary education levels for these birth cohorts. This measure is not exactly equivalent to the alpha rate experienced by the cohort – since mortality and immigration have altered the educational distribution over time. Figure 18 presents the alpha rate for Chilean birth cohorts in the 20th century based on the 2002 Census. The steady progress of the educational system over the past 60 years is quite evident.

Figure 18

PROGRESSION TO SECONDARY EDUCATION LEVEL, CHILE 2002



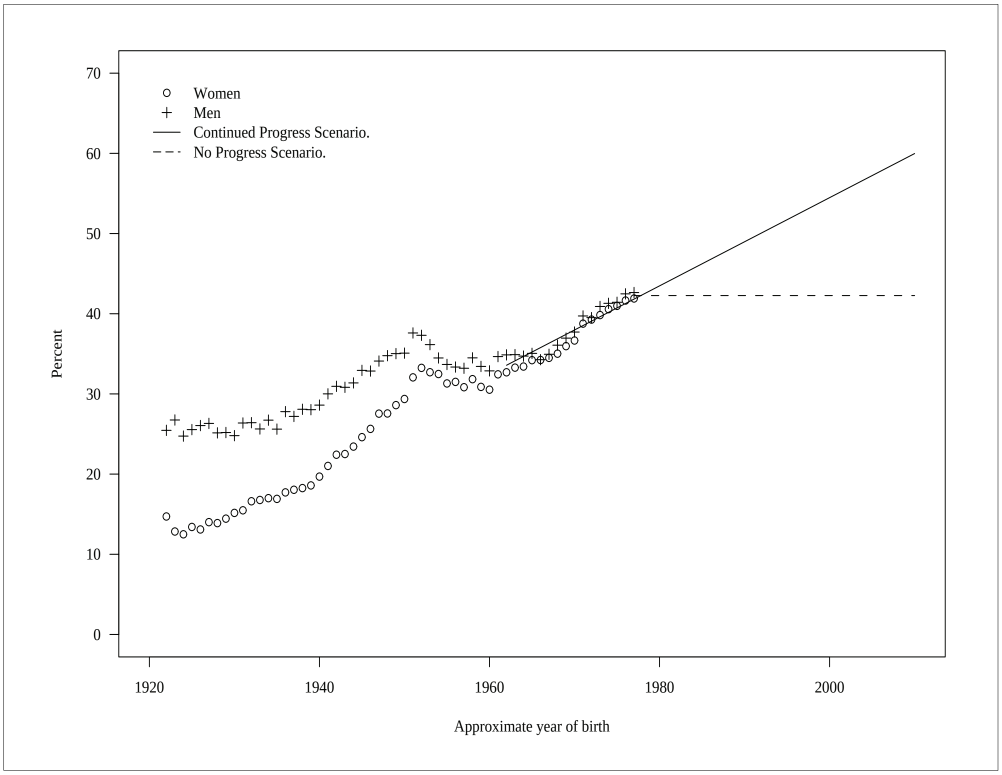
Source: Author's calculation based on Chilean Census 2002.

We present two alternative educational scenarios for Chile. In the No Progress scenario, alpha remains fixed at the current value observed in the Census and only 85% of the population would progress beyond primary schooling to secondary or beyond. The alternative forecast is based on the trend in the last 25 years. In this Continued Progress forecast, the alpha rate reaches its maximum rate for cohorts born in the year 2000 and later – showing that Chile has reached universal primary school enrollment.

In a similar fashion, we can use census data to derive the beta progression rate for birth cohorts. We define the measure as the ratio of the population with tertiary education to the population with at least secondary education. Figure 19 presents the results for Chile based on the 2002 Census.

Figure 19

PROGRESSION TO TERTIARY EDUCATION LEVEL, CHILE



Source: Author's calculation based on Chilean Census 2002.

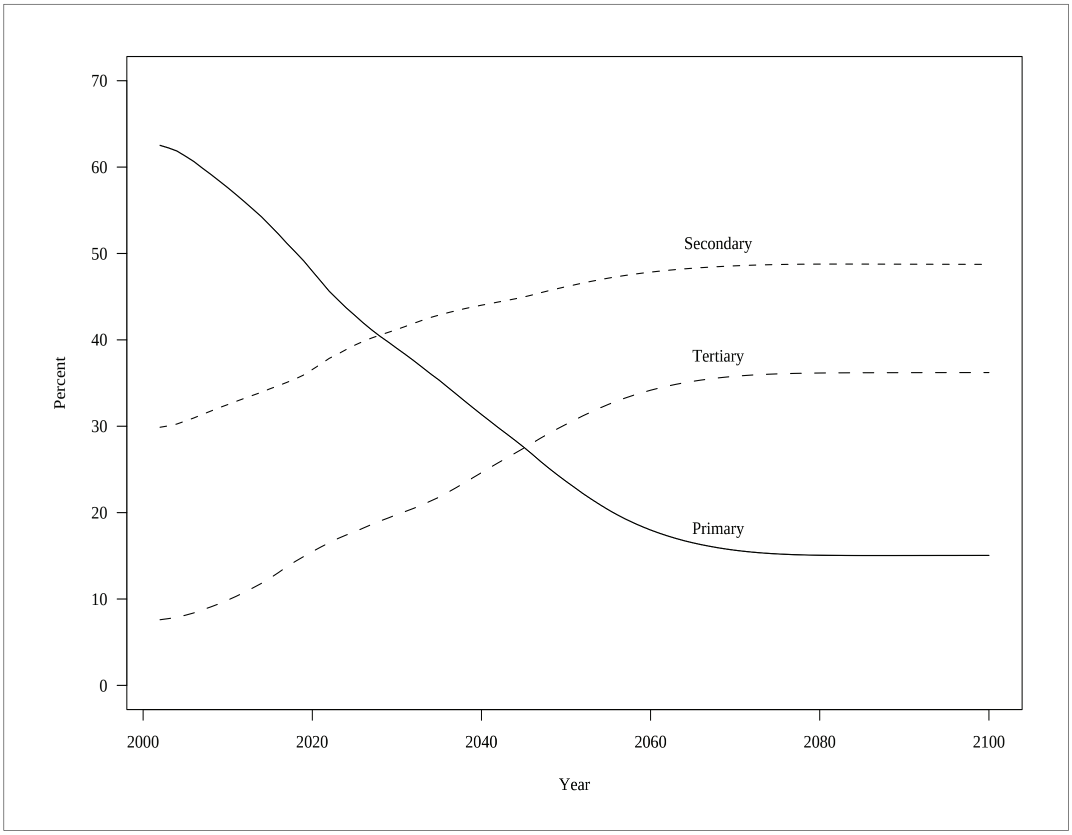
Here, too we note the progress over the century, but a distinct slowdown is evident for cohorts born in the late 1950s. Presumably, this was due to disruption of educational system during the military overthrow of the civilian government in 1973. Those born in 1955 would have been 18 in 1973. Apparently, this was a lasting legacy of the installation of a military dictatorship. Once those 18 and 19 year olds missed the opportunity to attend college, they were never able to attend college subsequently. Another striking feature is that, at the start of the century, women had much lower educational attainment than men. But for cohorts born in the last half of the century, men and women have had similar educational experiences.

There are two alternative forecast scenarios for beta, the tertiary progression ratio. In the No Progress scenario, the beta rate remains at its current level observed in the census – which in Chile means 40% of those with secondary education progress to the tertiary level. In the Continued Progress scenario, the beta rate continues to increase based on the trend observed in the last few decades.

C. Shifts in educational distribution among the elderly

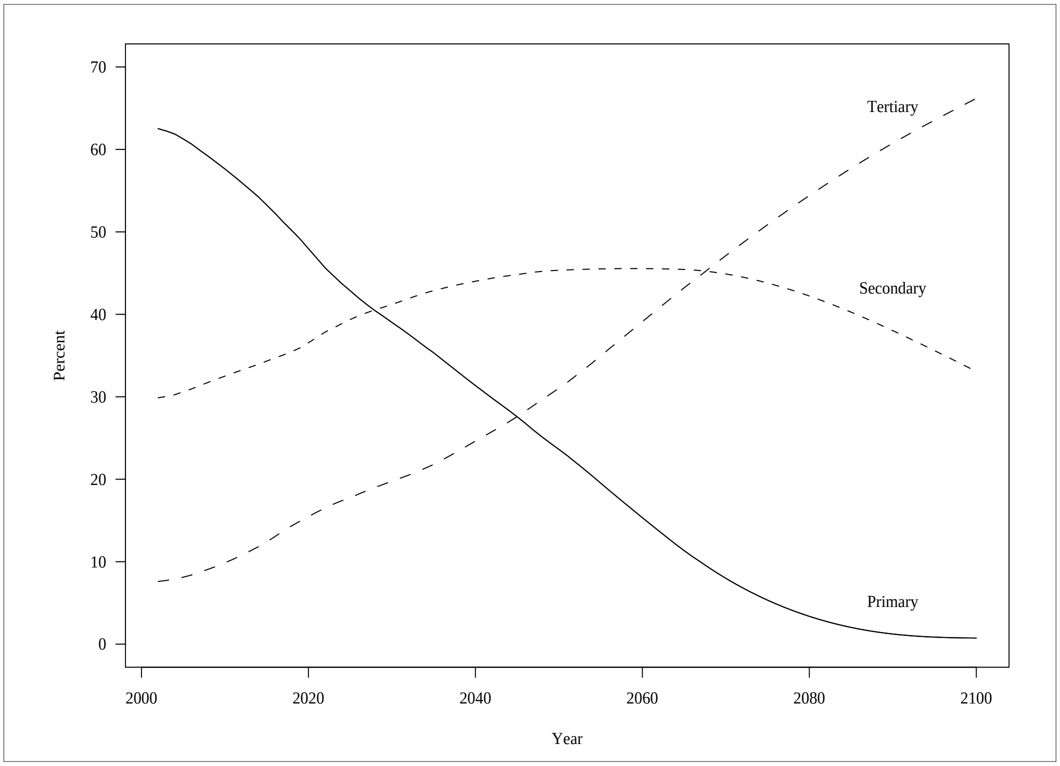
Figures 20 and 21 present the results for forecasting the educational distribution among Chilean elderly population from 2002 thru 2100 under our two scenarios. Unsurprisingly, the Continued Progress scenario does not begin to diverge from the No Progress scenario until 40 to 50 years in the future when graduates of today's educational system turn 65. The main result evident in the figures is the rapid change in the educational composition of the elderly population in the next few decades – a reflection of the expansion of the educational system during the 20th century. Presumably, this rapid educational transition will have profound implications for the health, wealth, and well-being of the elderly population in the future.

Figure 20
EDUCATIONAL DISTRIBUTION OF ELDERLY POPULATION, CHILE 2002-2100, NO PROGRESS SCENARIO



Source: Author's calculation based on Educational Census Method.

Figure 21
EDUCATIONAL DISTRIBUTION OF ELDERLY POPULATION, CHILE 2002-2100, CONTINUED PROGRESS SCENARIO

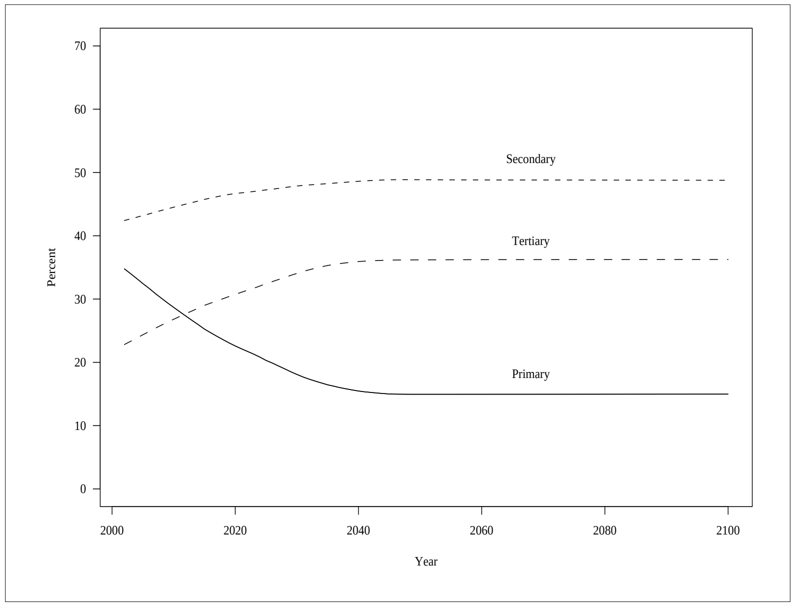


Source: Author's calculation based on Educational Census Method.

D. Work force projections

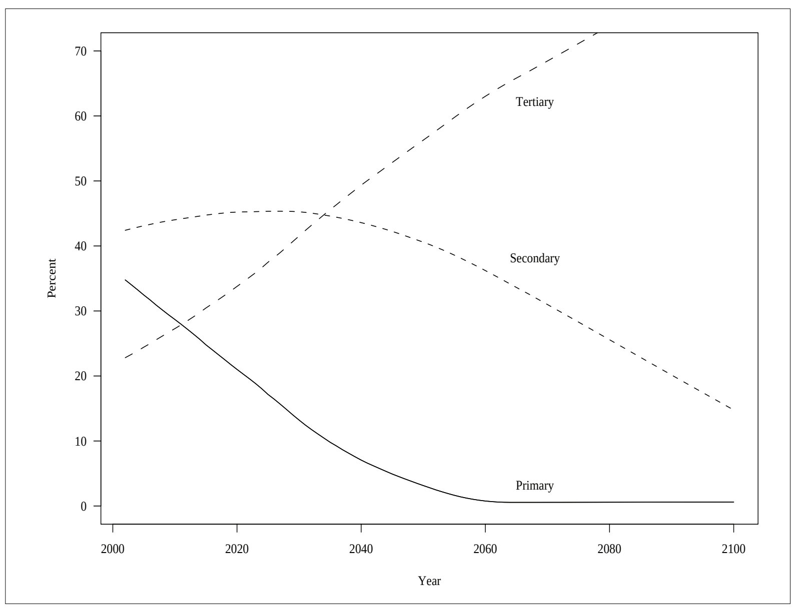
Like the elderly population, the working-age population (age 25-64) is also projected to undergo a dramatic shift in its educational composition. The Continued Progress scenario is substantially different from the No Progress scenario in both the short-run as well as the long-run. In the No Progress scenario (shown in Figure 22), educational progression rates are fixed at their current levels. Over the next 45 years, the educational distribution of the working age population (age 20 to 45) continues to change as older, less educated workers and replaced by the younger, higher educated workers. Those with secondary education are the largest educational group – accounting for nearly one-half of the working-age population. In the Continued Progress scenario (shown in Figure 23), educational progression ratios continue to increase at their current trends. In this case, those with university education become the largest education group within a few decades and continue to increase in size – accounting for 80% of the working age population by the end of the century.

Figure 22
EDUCATIONAL DISTRIBUTION OF WORKING-AGE POPULATION CHILE 2002-2100, NO PROGRESS SCENARIO



Source: Author's calculation based on Educational Census Method.

Figure 23
EDUCATIONAL DISTRIBUTION OF WORKING-AGE POPULATION CHILE 2002-2100, CONTINUED PROGRESS SCENARIO

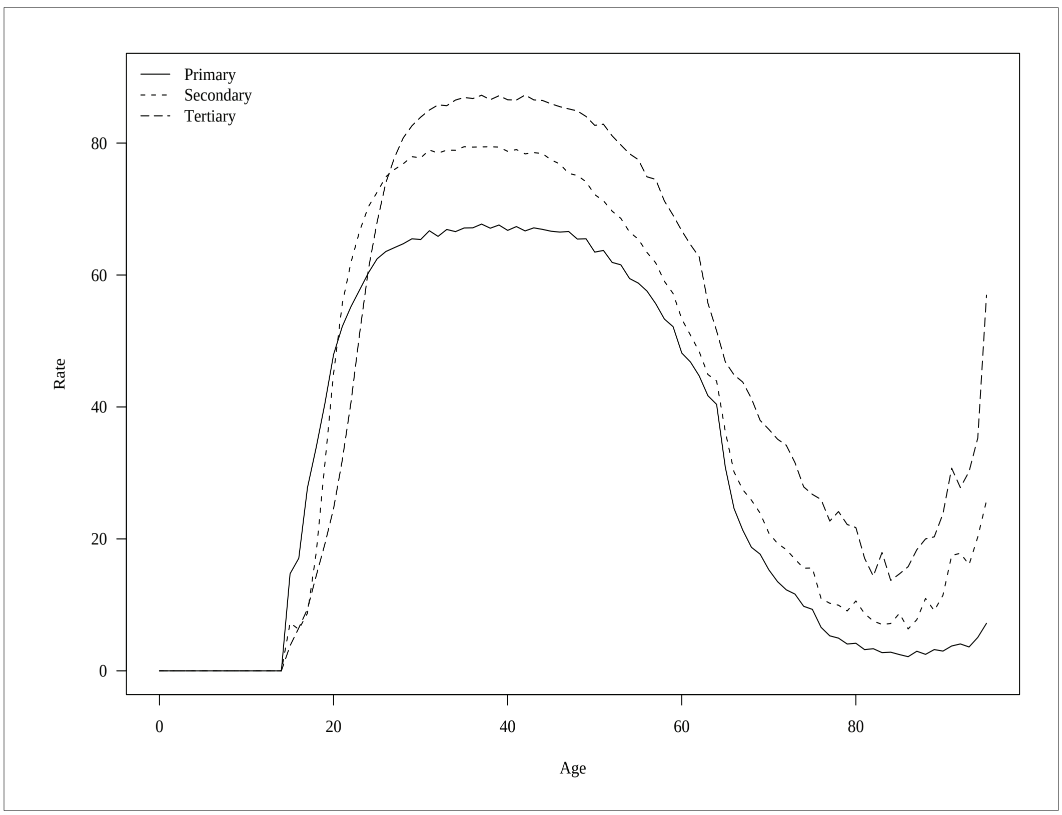


Source: Author's calculation based on Educational Census Method.

Observed cross-sectional correlations between education and employment and wages can be used a basis for workforce projection. In cross-sectional data, we observe that those with higher education levels are more likely to be employed and are more likely to receive higher wages. Of course, correlation does not imply causation and so considerable caution is warranted in using this as a basis for projection. On the other hand, there is little doubt that human capital is an important driving force of economic development.

As a first step, I consider the difference in labor force participation rates by age, sex, and education level. Figures 24 and 25 present the results for Chilean men and women based on the 2002 Census. Table 3 summarizes the data in a measure of the expected years of work prior to age 65 by education level and sex. For example, if a university-educated person experienced the same labor force participation rates over their lives as those experienced by university-educated workers today, they would work for 34 years on average from birth until age 65. This is the maximum work expectancy of any group in Chile. The minimum work expectancy is 10 years -- for women with education at the primary level or below. In 1981, a privatized pensions system (AFP) was introduced in Chile in which workers save for their own retirement. The government offers a "safety net" in that workers who contribute for a minimum of 20 years qualify for a minimum pension guarantee. I note in passing that it is clear from Table 3 that woman are at a serious disadvantage in qualify for this guarantee.

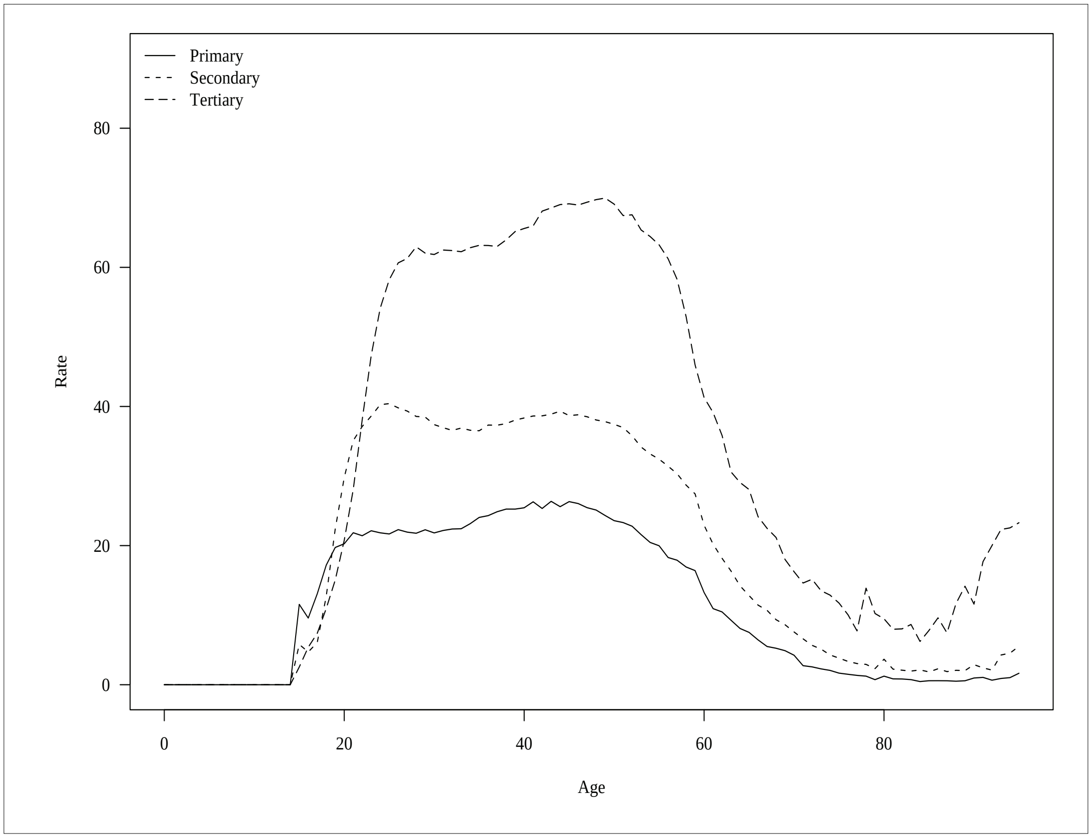
Figure 24
MALE LABOR FORCE PARTICIPATION RATES BY AGE AND EDUCATION



Source: Author's calculation based on Chilean Census 2002.

Figure 25

FEMALE LABOR FORCE PARTICIPATION RATES BY AGE AND EDUCATION



Source: Author's calculation based on Chilean Census 2002..

Table 3

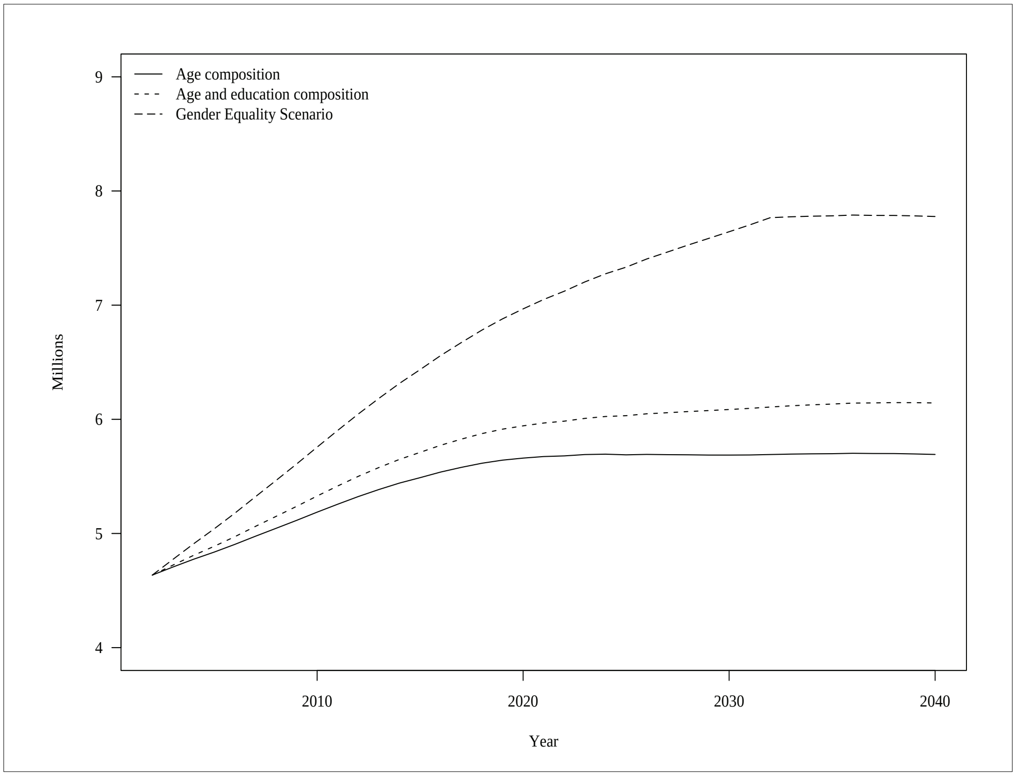
EXPECTED YEARS OF WORK BY SEX AND EDUCATION LEVEL, CHILE 2002 THE EXPECTED YEAR OF WORK RELATIVE TO THOSE OF MEN WITH UNIVERSITY EDUCATION IS LISTED IN PARENTHESIS

Education level	**Men**		**Women**	
	Years	Percent	Years	Percent
Primary	29	85%	10	29%
Secondary	32	94%	16	47%
Tertiary	**34**	**100%**	**26**	**77%**

Source: Author's calculation based on Chilean Census 2002.

The shifts in the educational distribution of the working age population could potentially lead to increases in the size of the workforce. Using the labor force participation rates by education and sex, I project the changes in the size of the labor force under our two educational scenarios. Under the No Education Progress scenario, the changing educational distribution very slightly increases the size of the workforce as shown in Figure 26. I also consider a Gender Equality scenario in which women's labor force rates converge to those of men over the next 30 years. In this case, we see enormous gains in the size of the workforce. Rather than reaching a plateau in 25 years of about 6 million workers, the work force continues to increase – reaching nearly 8 million workers. In this scenario, about 80,000 additional workers would be entering the work force each year for the next 30 years.

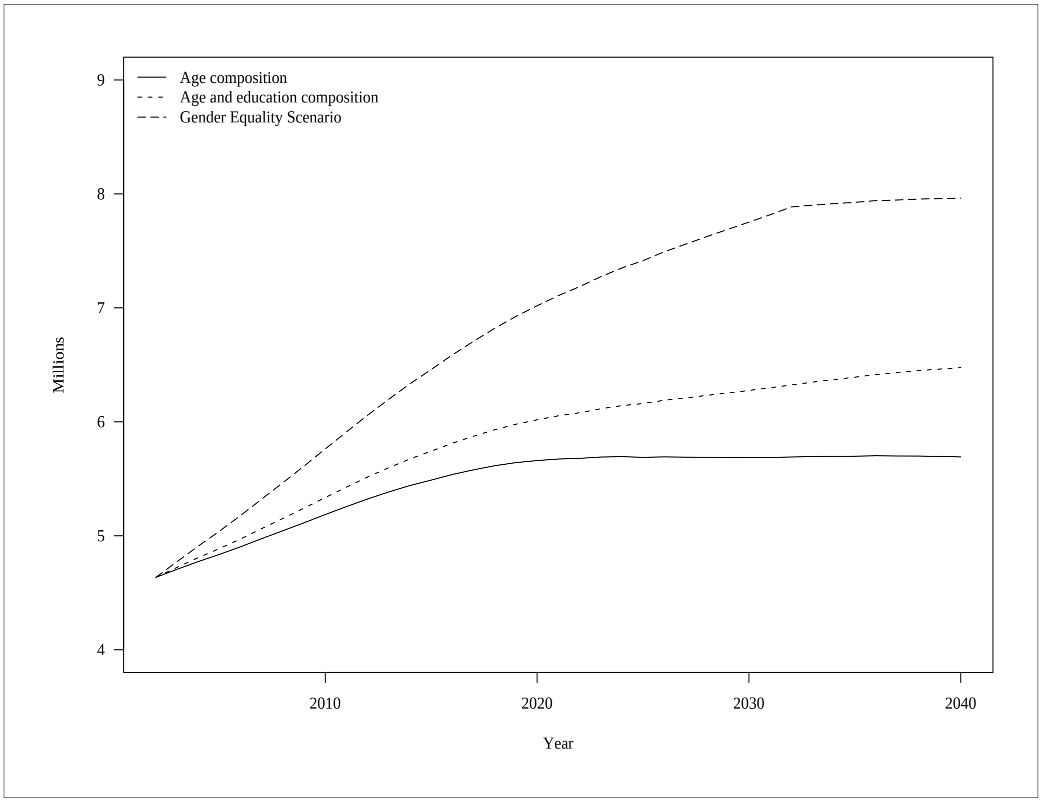
Figure 26
WORK FORCE, CHILE 2002-2100
NO PROGRESS SCENARIO



Source: Author's calculation based on Educational Census Method.

Under the Continued Education Progress scenario, the changing education distribution slightly increases the size of the workforce – but its effect is most evident in the latter part of the 21st century as seen in Figure 27. In contrast, the Gender Equality scenario in which women's labor force participation rates converge to those of men within the next generation shows very rapid increases in workforce size. From this analysis, I would conclude that changing educational distribution is likely to have only a slight impact on the size of the labor force. If Chile realizes rapid growth in its labor force size in the next 30 years, it will be because of the expansion of employment opportunities for women in the formal sector. This is not to suggest that education has no effect on the labor force. Rather, the main economic payoff from investment in education is increases in the productivity of the workforce – rather than an increase in the size of the workforce. Let us now turn to estimating the magnitude of this effect.

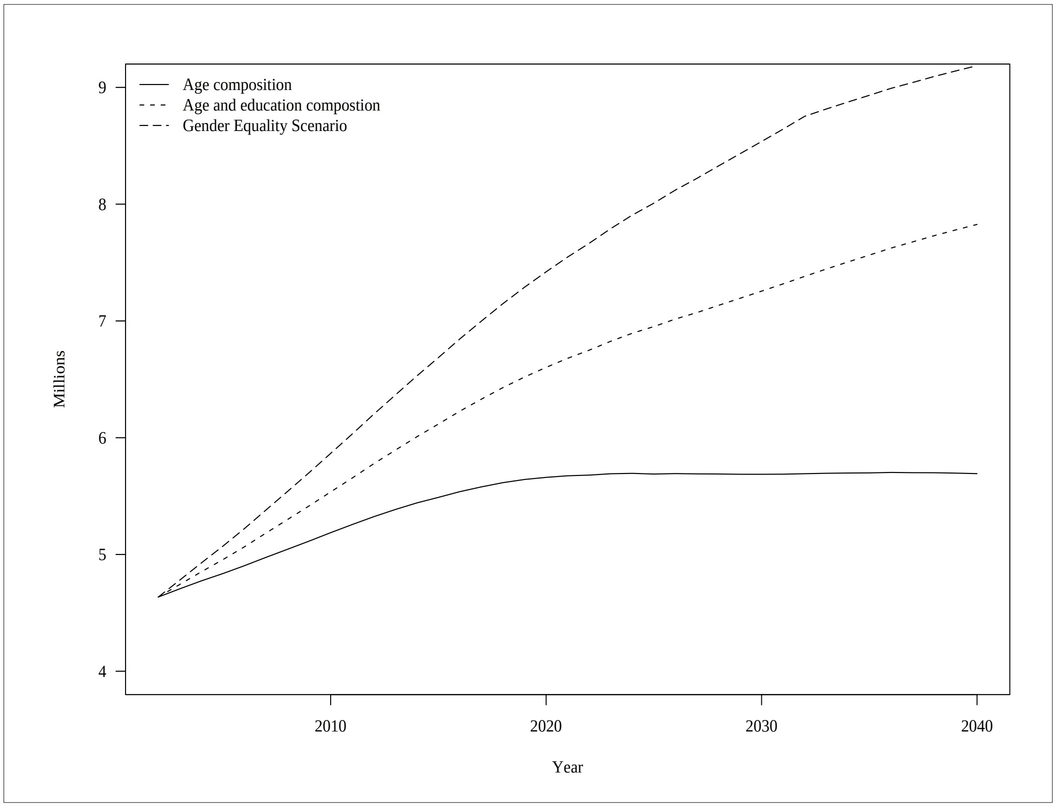
Figure 27
WORK FORCE, CHILE 2002-2100
CONTINUED PROGRESS SCENARIO



Source: Author's calculation based on Educational Census Method.

We can forecast the workforce adjusted for the changing skill level due to the changing educational distribution. We might assume that the observed wage differential among different education groups reflects differences in worker productivity due to skill level. These differentials are large. For example, in the United States workers with university degrees earn 1.75 times as much as workers with only secondary education. By differentially weighting each worker by his or her education level, we can derive estimates of the effective work force size. Figure 28 presents the projection of the effective workforce for Chile. The effective Chilean workforce is projected to increase rapidly in the next 40 years – owing to the forecast shifts in the educational distribution. These productivity increases are equivalent to adding an additional 50,000 workers per year for the next 40 years.

Figure 28
EFFECTIVE WORKFORCE, CHILE 2002-2100
CONTINUED PROGRESS SCENARIO



Source: Author's calculation based on Educational Census Method.

The scenario results are summarized in Table 4 listing the potential Chilean work force in 2035. The baseline forecast shows very slow growth in the labor force over the next 30 years – with an annual growth rate of about 0.6%. The outlook for economic growth stemming from growth in labor supply is bleak. Considering the impact of the changing educational composition of the labor force, dramatically changes this outlook. If higher educated workers have higher productivity than other workers, then the forecast predicts rapid growth in the labor force in the next generation – of 1.4% per year. Finally, regardless of the effects of changing educational distributions, increases in female labor force participation would have very large effects on the labor force.

Table 4
POTENTIAL CHILEAN WORK FORCE IN 2035

	Work force Potential Size (Millions)	Annual Growth Rate
Scenario: Continued Education Progress		
Age composition	5.7	0.6%
Age and education composition	6.6	1.0%
Age and education composition, With productivity effects	7.6	1.4%
Scenario: Continued Education Progress and Gender Equality		
Age and education composition	8.1	1.6%
Age and education composition, With productivity effects	8.9	1.9%

Source: Author's calculation based on Educational Census Method.

E. Summary

This chapter presented a simple two parameter model for forecasting the future population by age, sex, and educational level. The strength of this simple approach is that it can be easily used to provide forecasts of educational distributions based on educational data collected from a single census. It would be easy to apply this model to provide such estimates for all Latin American countries. Another feature of the model is that the census data also provides a retrospective look at the progress of the educational system over the past 80 years.

As an example of the model, I forecast the Chilean population by age, sex, and educational level from 2002-2100 – under two alternative scenarios: No Education Progress and Continued Education Progress. In the example of Chile, we forecast dramatic shifts in the educational distribution of the elderly population which may imply equally dramatic changes in pension and health programs for the elderly. The forecast also shows the possibility of rapid increases in the effective workforce in Chile – reflecting productivity gains due to changes in the educational distribution of workers.

III. Budget forecasts for key social sectors

In this chapter, I develop a simple model for forecasting the impact of shifts in the population age structure on key social sector budgets. These 4 are public pensions, education, health, and employment. In addition, I examine the broader fiscal and economic effects of these demographic changes as reflected in the fiscal tax ratio and the economic support ratio. Chile is used as an illustrative example of these forecasting techniques.

A. Accounting identities

In developing budget forecasts for key sectors we can begin by examining several simple accounting identities for decompositions of aggregate expenditures.

Perhaps the simplest is to examine aggregate expenditures as the multiplicative sum of per-capita expenditures and total population size.

[1] $B(t) = b(t) * p(t)$.

Where $B(t)$ = aggregate budget expenditures at time t

$b(t)$ = per-capita budget expenditures at time t

$p(t)$ = total population size at time t.

We can add more demographic detail by considering age:

$$[2]\ B(t) = \text{sum}\ \{ b(x,t) * p(x,t) \}$$

Where $b(x,t)$ = per-capita budget expenditure at age x and time t

$p(x,t)$ = population at age x and time t.

We can add socio/economic detail by considering education:

$$[3]\ B(t) = \text{sum}\ \{ b(e,x,t) * p(e,x,t) \}$$

Where $b(e,x,t)$ = per-capita budget expenditures for education e, age x, and time t.

$p(e,x,t)$ = population for education e, age x, and time t.

Any of these accounting identities could be used for forecasting budgets. The population components are easily forecast using the models developed in Chapters I and II. The main difficulty lies in forecasting the age-specific and education-specific spending components. One solution is to assume the budgetary factors remain fixed at their current levels (i.e., $b(x,t) = b(x,2005)$). In this manner, we can assess the pure effect of the changing demographic components on budget expenditures while holding spending rates constant. This is the main method used for this analysis.

Alternatively, simple forecast rules could be developed for how the budget factors change over time. Perhaps the simplest is to assume that these budget factors increase at some fixed rate over time. That is, the budget factors maintain their age shape and simply increase in level over time.

$$[4]\ B(t) = \text{sum}\ \{ e^{(r*t)} * b(2005) * p(x,t) \}$$

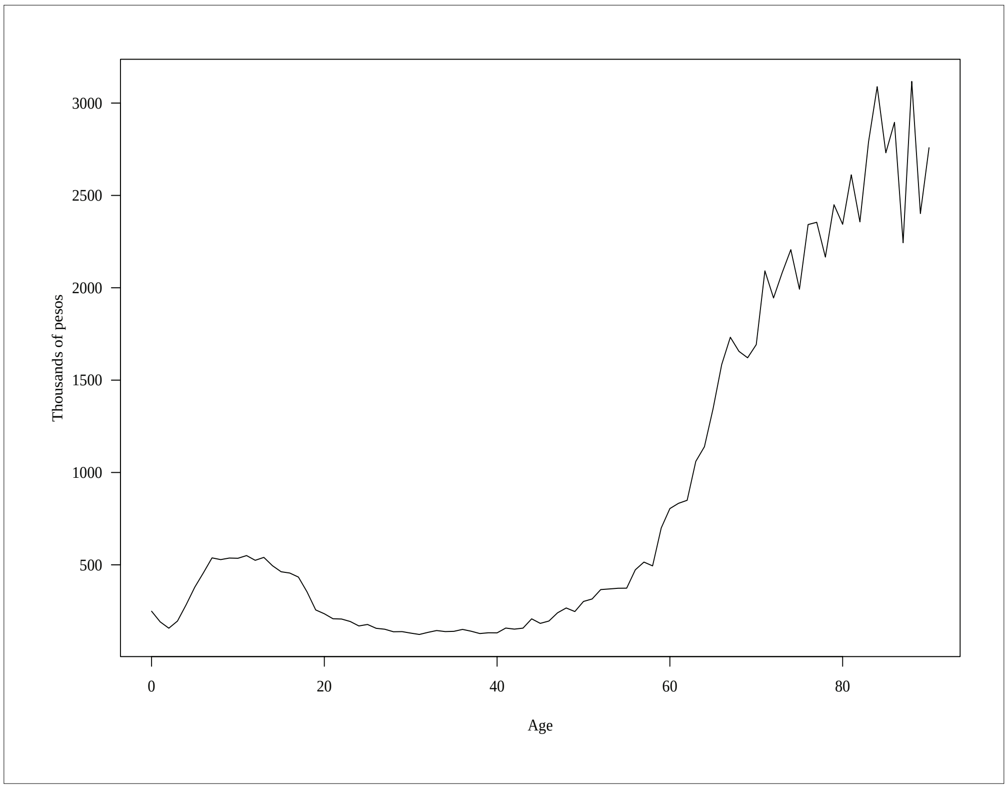
Where r is the rate of increase over time. r is often taken as the growth rate of labor productivity.

Frequently, per-recipient costs of government programs are assumed to increase at the rate of labor productivity growth or wage rate. Payments for many government programs (for example U.S. Social Security retirement benefits) are explicitly linked to wages. In addition, salaries are the main cost of providing many government programs. For these reasons, we often assume that costs per recipient increase as the wage rate increases. Ryan Edwards (2003) provides an extensive discussion of such budget accounting identities used in budget forecasts for the United States.

B. Budget forecasts for Chile

Jorge Bravo (2006) has compiled estimates of age-based government transfers in Chile. Figure 29 presents the result of this analysis – showing average receipt of government transfers by age. In 2004, such transfers accounted for the majority of government expenditures – 64% of the total budget.

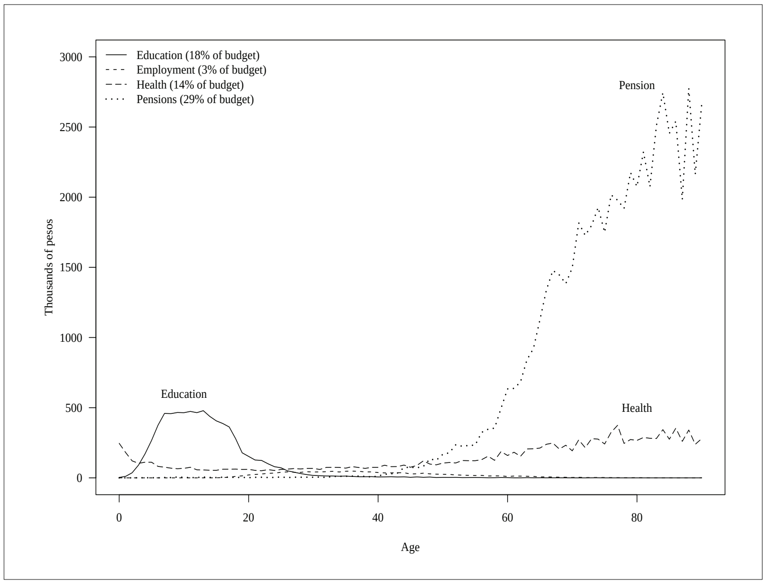
Figure 29
AVERAGE GOVERNMENT TRANSFERS RECEIVED BY AGE, CHILE 2004



Source: Bravo (2006).

Figure 30 presents age profiles of transfers for 4 main categories: Pensions, Education, Health, and Employment. Public pensions dominate – accounting for 29% of the total budget. More is spent on education (18% of the budget) than health (14%). Spending on employment is relatively small (3% of the budget).

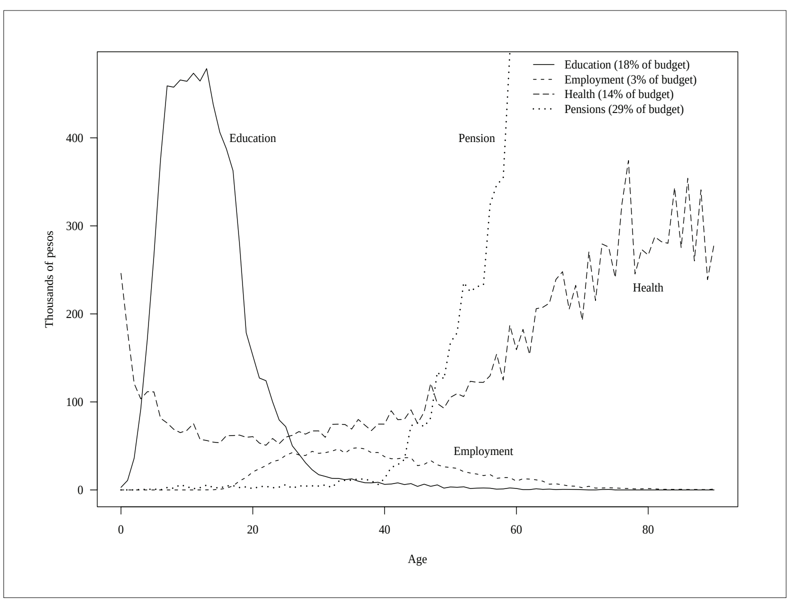
Figure 30
AVERAGE GOVERNMENT TRANSFERS RECEIVED BY AGE AND TYPE, CHILE 2004



Source: Bravo (2006).

Since pension expenditures are so large for the elderly, it is difficult to distinguish the separate age patterns of spending on education, health, and employment. Figure 31 presents a re-scaled version of the data. Here we see more clearly the distinctive age patterns of the three non-pension programs. Educational expenditures concentrated among the young – especially the elementary and secondary school ages. Employment programs are concentrated among the working age population. Health expenditures have a characteristic J-shape curve – closely corresponding to the age-shape of mortality.

Figure 31
AVERAGE GOVERNMENT TRANSFERS RECEIVED BY AGE AND TYPE, CHILE 2004

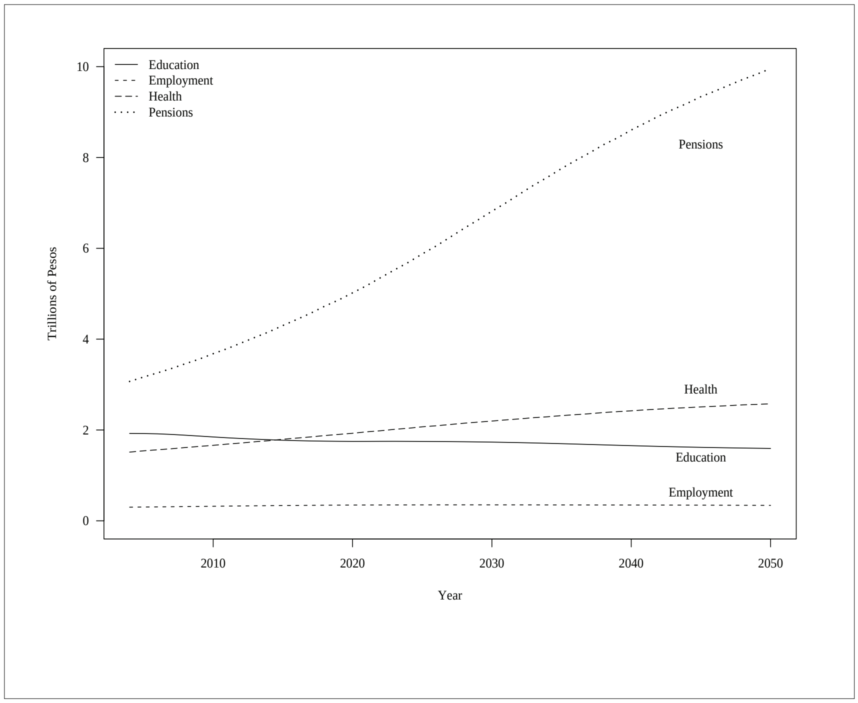


Source: Bravo (2006).

Holding these age profiles fixed, we can isolate the effects of changing demography on budget expenditures using the simple accounting identity: B(t) = b(x)*p(x,t). Figure 32 presents the results of the forecast over the next 50 years. In this scenario, population aging leads to significant increases in pension expenditures – doubling in the next 30 years and tripling within 50 years. Health expenditures are also likely to increase due to demographic forces – but more modestly – increasing to 1.5 times current levels within 30 years and 1.7 times current levels within 50 years. Employment expenditures would increase by about 15% over the next 50 years. Population aging also results in a decrease in education expenditures. These would decline by about 10% over 30 years and by about 17% over 50 years.

Figure 32

BUDGET FORECAST BY SECTOR



Source: Author's calculations based on Demographic Budget Forecast.

Of course, age-specific spending rates are unlikely to remain fixed over time and changes in these rates could re-enforce or mitigate these demographic induced changes. Chile's public pension system provides an excellent illustrative example. In 1981, Chile adopted a new joint private-public pension system in which workers contributed to their own private retirement accounts (AFP). As a safety-net for poorer workers, the government guaranteed to provide a minimum pension (PM) for those who contributed at least 20 years to their private accounts in the AFP system. In addition, for those who did not contribute for 20 years, the government provides a very small subsistence pension (PA). In addition, there are pension systems for the military and police which were not privatized in the 1981 reform and continue to function as traditional PAY-GO systems funded out of current revenues. At the initiation of the reform in 1981, workers could choose whether to switch into the new privatized pension system (AFP) or stay in the old pension system (INP). But all new entrants to the labor market (with the exception of the Armed Forces and Police) were placed in the new privatized system. As these cohorts age, there is an on-going transition of workers and later retirees from the old public system (INP) to the new joint private-public system (AFP+PM+PA).

Among retirees, the transition to the new system is just beginning. The vast majority of current retirees are receiving benefits paid out from the old INP system. So, the age-profiles of pensions used in our scenario forecast mainly reflect these INP payments. It is best to think of our forecast as the hypothetical costs that the Chilean government would have incurred had the old pay-go system continued to function. In the absence of pension reform, population aging in Chile would be projected to lead to a tripling of pension costs over the next 50 years.

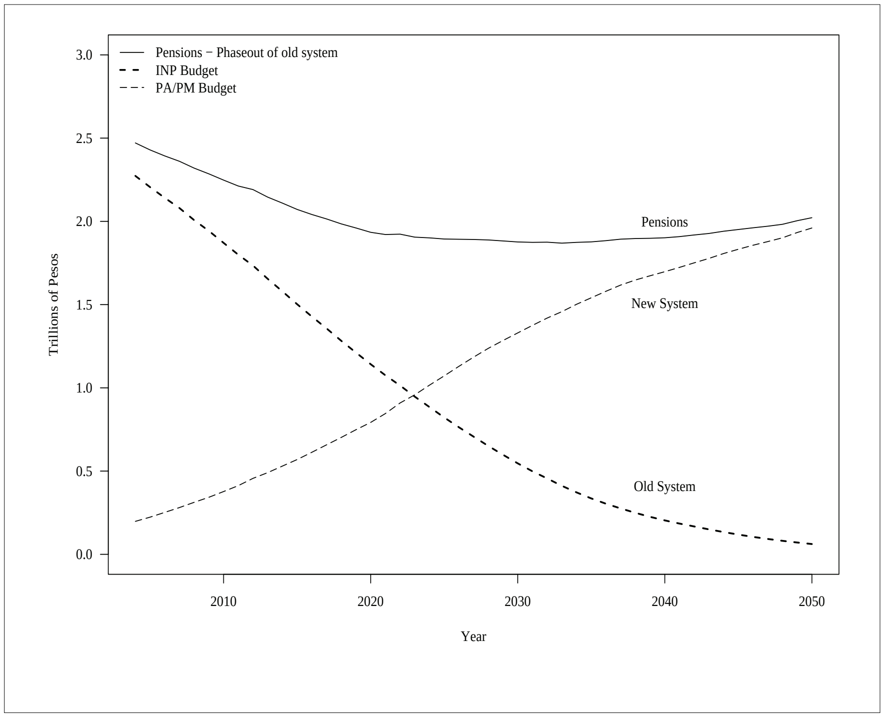
Given the pension reform, it is obvious that the government pension costs would be substantially reduced as the burden of funding pensions is shifted from public taxes to private contributions. The extent of this reduction depends on a complex set of factors which are difficult to forecast. As a crude estimate, we might begin by looking at recent estimates of coverage provided by the superintendent of the AFP system. Larraín (2005) estimates that about 50% of workers will have sufficient funds in their private accounts to fund their own retirements. Of the remaining 50% of workers who are in need of government assistance, only 1 in 5 would have the necessary 20 years of work in which to qualify for the minimum pension guarantee. The vast majority would be in need of a subsistence pension from the government. So, based on these coverage estimates we would forecast that under the mature private-public system, 50% of retirees would utilize private funds for their retirement (AFP), 40% of retirees would be in need of a subsistence pension (PA), and 10% of retirees would qualify for the minimum pension guarantee (PM).

Costs of the new joint private-public system would be substantially lower than the old pension system. We can attempt a crude estimation of the savings as follows. About half of workers would be funded privately and the half who would need government support would mainly be receiving subsistence pensions. We might assume that the average payment per recipient for subsistence pension (PA) is 40% of the average payment in the old INP system and those for minimum pension (PM) is 70% of the average payment in the old INP system. Therefore, under the new mature system, pension costs to the government would be about one-fourth (23% = .50*0 + .40*.40 + .10*.70) as high as the old system. In the Private-Public Scenario, the effects of population aging would be offset by these changes in benefits – so that rather than tripling pension costs would be reduced by 25% relative to current levels. About half of this would be due to reductions in coverage and about half due to reductions in payments per recipient.

We can attempt to model more systematically the transition from the old to new system by using the age profile of participants (workers and retirees) in the old INP system. As this cohort dies out, the INP budget declines. In a similar manner, the budget costs associated with the minimum pension guarantee (PM) and the subsistence pension (PA) would be expected to increase as the cohorts who are participants in the new system enter into their retirement years. Figure 33 presents the forecast for the INP, PA, and PM budgets. As expected, the effects of population aging are offset by the changes in rates brought about by the transition to the new private-public pension system. This crude analysis could be refined in several ways. It does not consider the payment of the outstanding “responsibility bonds” which were issued in response to workers who switched to the private system from the public system. When these workers retire, the government issues a payment into their private pensions plans (AFP) in recognition of the contributions of these workers to the old system. In addition, as noted in Chapter II, the educational composition of the Chilean elderly population will change dramatically in the coming decades. Since higher educated workers can be expected to have less need for government assistance, this educational shift has important consequences for the forecast of pensions and other programs.

Figure 33

PENSION BUDGET FORECASTDUE TO DEMOGRAPHIC CHANGE AND TRANSITION TO NEW PRIVATE-PUBLIC SYSTEM



Source: Author's calculation based on Demographic Budget Forecast.

We can also consider changes in the educational budget over time from expansion of the educational system. Recall from Chapter 2 that one of our alternative scenarios was to allow educational progress to continue on trend. We can derive changes in the age profile of educational expenditures by assuming that changes in enrollment rates lead to proportional increases in spending by age. I assume those aged 13 to 17 are attending high school and those 18 to 25 are attending college. Changes in educational promotion rates (alpha and beta in Chapter II) lead to increases in educational spending in those age groups. Because a large fraction of college students are attending private colleges, the increases in educational attainment do not lead to very dramatic increases in public spending. Nevertheless, the forecast shows that reduction in educational spending due to declines in school aged population are offset by funding for increased educational attainment. Educational expenditures in 2050 would be at about the same level as educational expenditures in 2004 (not accounting for cost increases due to wage growth).

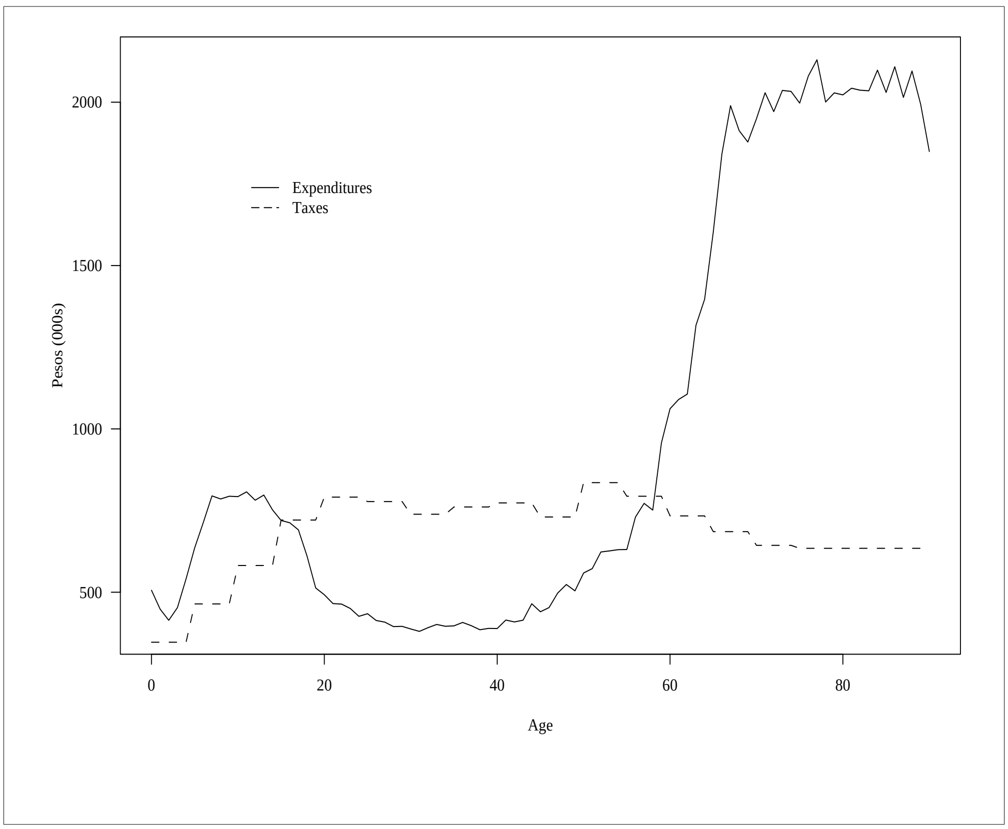
Four important revisions to the current model would greatly improve its usefulness. First, we should explicitly model anti-poverty programs in addition to pensions, education, health, and employment. Second, we should allow for policy decisions with respect to the expansion/contraction of these programs. Third, it would be useful to provide baseline forecasts of program expansion based on UN member country experience. Finally, we should develop a model in which cohort-specific changes of rates are easily implemented. We have seen the usefulness of this in the example of the pension transition in Chile.

C. Fiscal tax ratios

The fiscal tax ratio is a convenient measure of the fiscal impact of population aging. Using the age profiles of public expenditures (transfers and non-transfers) and the age profiles of taxation, we can estimate fiscal tax ratios. That is, we weight the population by the age-profile of expenditures to estimate aggregate expenditures of the government. In a similar manner, we can weight the population by the age-profiles of taxes to estimate aggregate taxes. The ratio of the two gives us the fiscal tax ratio. In the absence of public debt (and public assets), total taxes would equal total expenditures. The fiscal tax ratio would always be 1.0. Over time, as the population age composition changes, the ratio of tax payers to tax recipients also changes. The changes in the fiscal tax ratio can be used to evaluate these population changes in terms of the increases or decreases in tax rates necessary to reestablish a fiscal balance.

Consider the case of Chile. Using data from Bravo (2006), we identify 64% of expenditures as having an explicit age component. The other 36% are assigned on a per-capita basis to each age. These are expenditures for public goods and services such as police and fire protection, national defense, transportation, etc. Figure 34 presents this data. Revenues are collected from many sources. Some are collected on sale of national resources like copper. These are not age-assignable revenues. Age assignable revenues include things like the tax on consumption (VAT), taxes on property, and taxes on income. I do not currently have data on any of these taxes, but instead assume for illustrative purposes that taxes are paid in proportion to consumption.

Figure 34
GOVERNMENT EXPENDITURES AND TAXES BY AGE, CHILE 2004

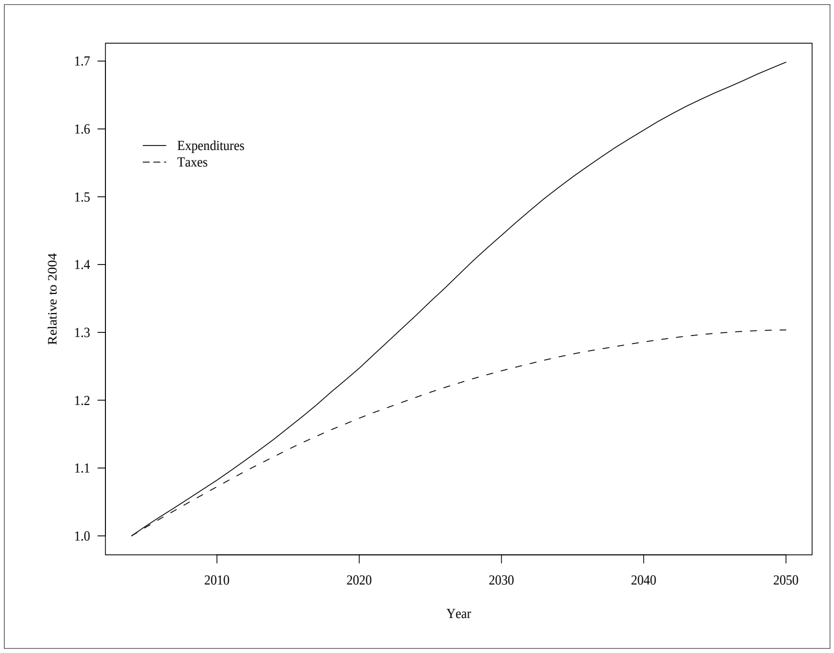


Source: Bravo (2006).

With these two profiles along with our population projection, we can forecast aggregate expenditures and taxes for Chile. This is shown in Figure 35 and it is an evaluation of the demographic influences on general government budgets in terms of expenditures and taxes. Programs grow or shrink in size only due to changes in demography. The forecast does not consider changed in the generosity of programs in terms of who qualifies for benefits or the amount of benefit per recipient. Within 30 years, expenditures are 40% higher and within 50 years government expenditures would be 70% higher – solely due to demographic effects. On the tax side, government revenues are also expected to increase – which will partially offset in the short run the increases in expenditures. Within 30 years, tax revenues would be 20% higher and within 50 years tax revenues would be 25% higher.

Figure 35

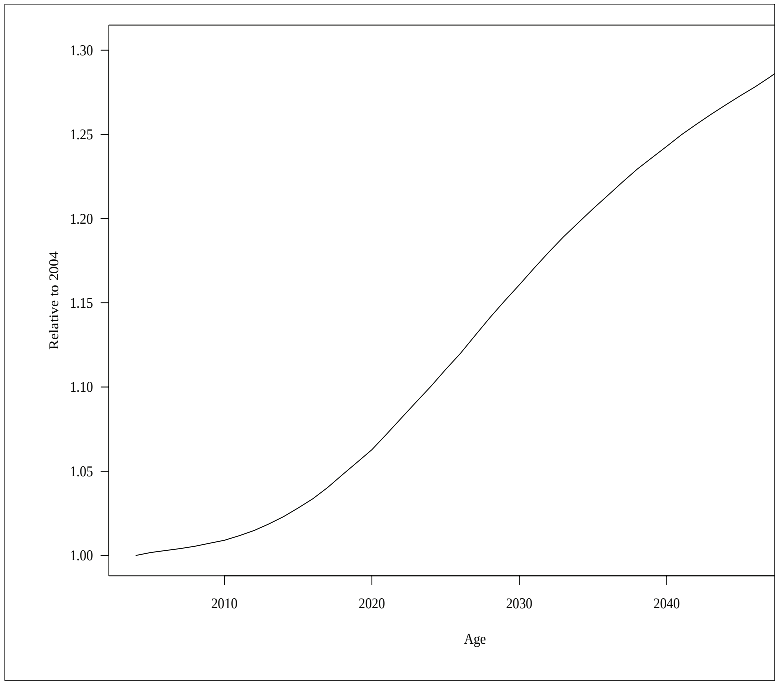
GOVERNMENT EXPENDITURES AND TAXES: CHILE 2004-2050



Source: Author's calculation based on Demographic Budget Forecast.

Figure 36 presents the fiscal tax ratio: the ratio of expenditures to taxes. It is a measure of the fiscal pressures due to demographic change. Over the next 15 years, demographic pressures are relatively modest – leading to either a 5% increase in taxes or a 5% reduction in benefits. Over the 50 year horizon, demographic pressure would lead to a 30% increase in taxes or a 30% reduction in benefits. As noted earlier, this forecast ignores the transition to the new private-pension system – which limits the effects of population aging on public pensions.

Figure 36
FISCAL TAX RATIO: CHILE, 2004 TO 2050

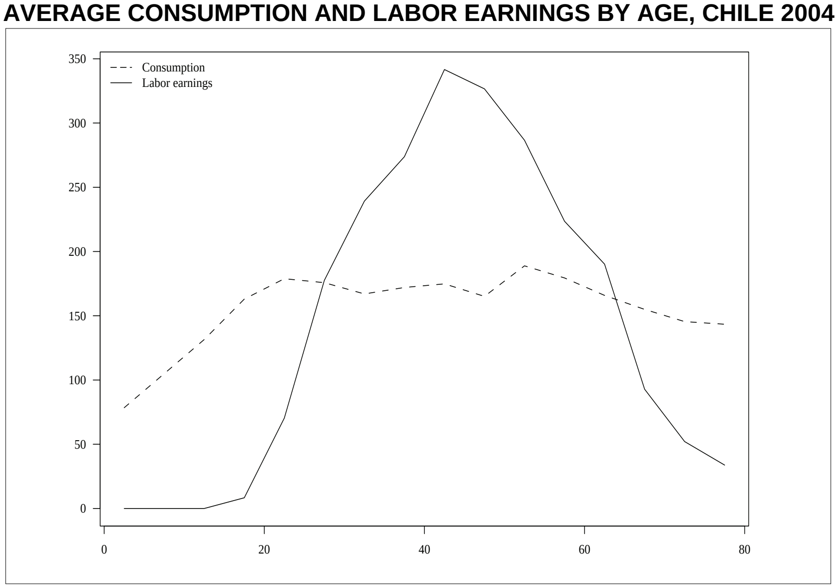


Source: Author's calculation based on Demographic Budget Forecast.

D. Economic support ratios

In a similar manner, we can also construct estimates of the changing ratio of consumers to producers as the population ages. Figure 37 presents average consumption and labor earnings by age in Chile in 2004 – based on data provided by Bravo (2005).

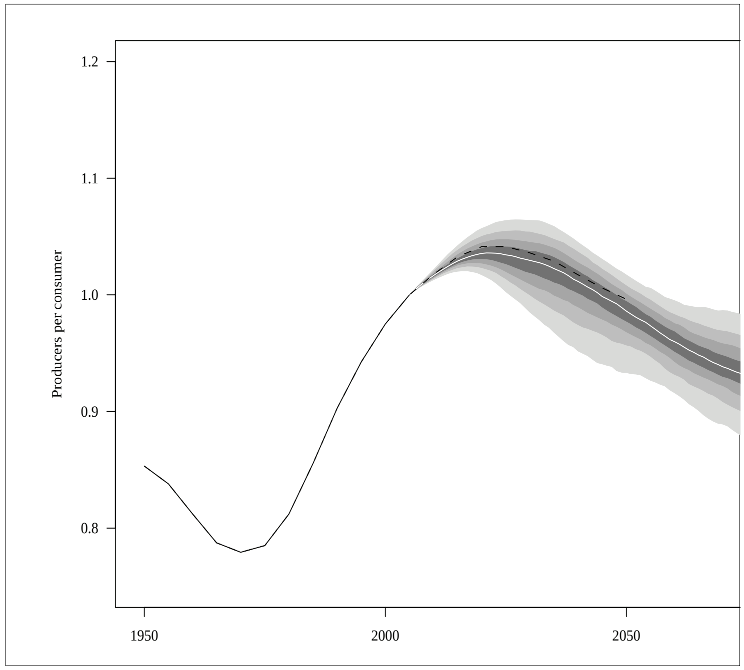
Figure 37
AVERAGE CONSUMPTION AND LABOR EARNINGS BY AGE, CHILE 2004



Source: Bravo (2005).

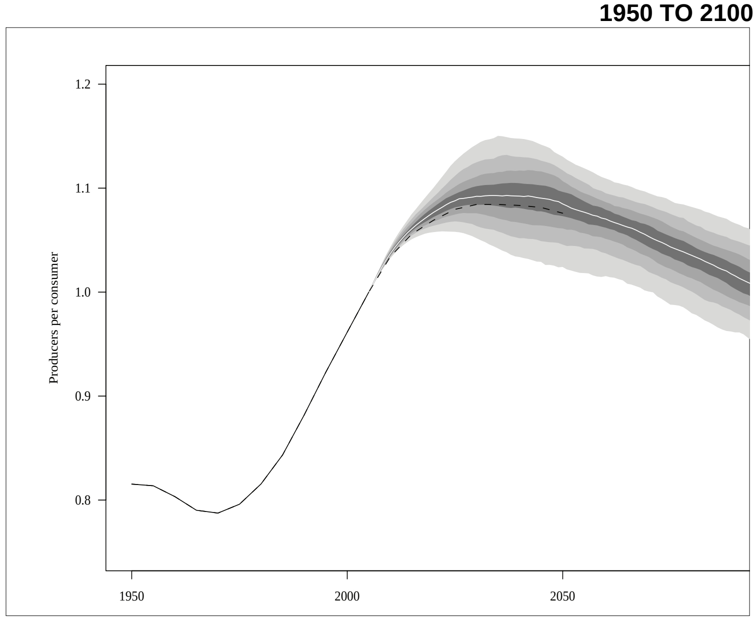
Using the probabilistic population forecasts developed in Chapter I, we can derive a probabilistic forecast of the Economic Support Ratio (the ratio of producers to consumers). Figures 38, 39, and 40 present these results for Chile, Brazil, and the United States.

Figure 38
ECONOMIC SUPPORT RATIO: CHILE, 1950 TO 2100



Source: Author's calculations based on Random Country Model.

Figure 39
ECONOMIC SUPPORT RATIO: BRAZIL, 1950 TO 2100

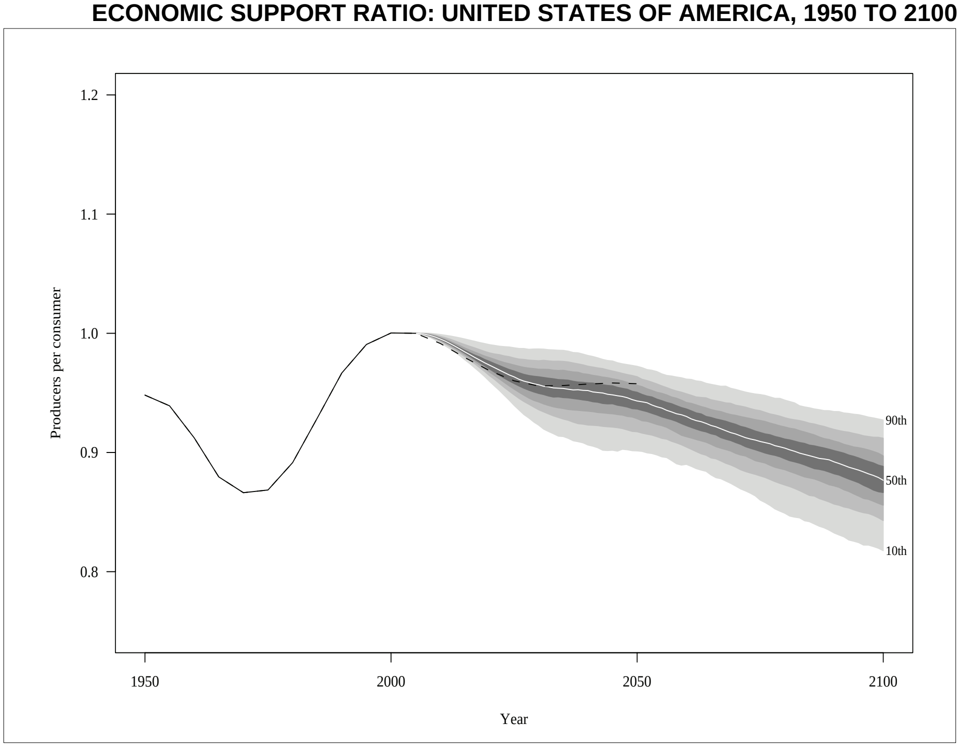


Source: Author's calculations based on Random Country Model.

Both Chile and Brazil have seen a 20% increase in the ratio of producers to consumers over the past few decades – indicating that changes in demography have favorably affected the balance of production relative to production. Such demographic effects have been referred to as the "demographic dividend." Due purely to the shifting age composition of the population, per-capita consumption could have increased by 20% with no additional work effort (or alternatively, work effort could have decreased by 20% with no loss in per-capita consumption). Demographic changes in the United States were less favorable, but still significant as seen in Figure 40.

Figure 40

ECONOMIC SUPPORT RATIO: UNITED STATES OF AMERICA, 1950 TO 2100



Source: Author's calculations based on Random Country Model.

But the real impact of the demographic dividend is in the extent to which it might have been invested in physical or human capital and therefore helped to fuel subsequent economic growth. In addition, the increased demand for wealth which accompanies the increasing amount of time spent in retirement can generate a type of second demographic dividend (Mason, 2005) as workers boost savings in anticipation of their retirement years. An ambitious, multi-country accounting of the age dimension of National Accounts called National Transfer Accounts is current underway (Lee and Mason, 2004 and Mason, et al. 2005). This accounting will allow close examination of the demographic dividend and how it was allocated – with important implications for understanding differences in economic growth around the world.

E. Summary

This chapter presented a simple model for isolating the effects of changes in population age structure on 4 .,/ key social sector budgets: pensions, education, health, and employment. Chile was presented as an illustrative example. Other things being equal, population aging would lead to significant increases in tax burden – with taxes 30% higher within 50 years. However, other things are not expected to be equal. In the case of Chile, the transition to a private-public pension system is expected to greatly reduce pension costs and offset the projected increases due to population aging. The case of Chile is a cautionary tale. Unlike the models presented in Chapter I and II, budget forecasting is an exercise which requires a great deal of country-specific expertise concerning policy rules and regulations which govern expenditures.

IV. Conclusions

Three projection models were presented in this article. In concluding, I want to emphasize the novel features of these models and their possible applications.

Chapter I presented the Random Country Model population forecast based on the collective historical experience of UN member countries.

The model can be easily replicated in all countries. In addition, this model could be used for probabilistic forecasts for Latin America and other regions of the world or the world as a whole. It would be a useful complement to the official UN scenario forecasts.

Like other stochastic models, it attempts to quantify our uncertainty about the future using variation observed in the past.

Unlike most other stochastic and deterministic models, it stresses the common demographic experience of countries – rather than the uniqueness of countries.

Other types of projection models (e.g. budget forecasts) can use these Random Country Model probabilistic population forecasts as model inputs in order to measure the impact of our uncertainty about the future population.

Comparison of UN scenario forecasts with the probabilistic forecasts based on the Random Country Model showed that the UN scenario forecasts are considerably more pessimistic about future longevity gains than past experience would indicate. In addition, there is considerable variability in immigration rates which are not reflected in UN scenario forecasts. Therefore, the two biggest surprises that countries will likely face are (1) a larger than expected elderly population and (2) shifts in immigration levels (from high to low and from net exporter to net importer).

Chapter II presented a forecast of the educational composition of the population by age and sex based on educational attainment data from a single census.

The model can be easily replicated in all countries for which we can obtain educational attainment by age. The data burden is considerably reduced by relying on a single census – rather than attempting to obtain trends in educational enrollment rates over time from multiple sources.

If census data are available for other years, the model could be used to construct a very long historical time series of the educational distribution of the population.

The changing educational distribution of populations throughout the world over a considerable time period could be calculated using this model.

Such changes in educational distribution would be useful in their own right as measures of social progress but additionally would be important inputs into economic growth models.

It would be interesting to observe the extent to which the rapid economic growth observed in some regions in the world in the 1980s and 1990s were the product of “an educational dividend” rather than a “demographic dividend.” The window of opportunity accompanying the surge in the working age population as a share of total population known as the “demographic dividend” is already rapidly closing in Latin America and now represents a lost opportunity. On the other hand, the window of opportunity from a surge in the highly educated working-age population is just beginning to open in Latin America.

Chapter III presents a model for forecasting budgets of key social sectors, as well as the impact of demographic changes on taxes (fiscal tax ratio) and on general economic well-being (via the economic support ratio).

It is easy to assess the relative impact of demographic change on government budgets, other things being equal. The difficulty lies in assessing these demographic impacts in the context of changing age-specific rates. The case of the pension transition in Chile serves as a cautionary tale – pointing out the difficulty involved and the need for expert country-specific knowledge about policy rules and regulations.

Despite such difficulties, it is important to continue to develop these models since population aging is likely to have profound effects on program expenditures, tax levels, and the general economy.

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