Statistics Norway

Nico Keilman

Documents

The Accuracy of the United Nation's World Population Projections

Preface

Users of official statistics should be informed about the quality of the data. How reliable are the figures? To what extent do they reflect reality? Population forecasts and projections produced by statistical agencies can also be considered as official statistics, and regarding quality the same principle should hold for forecast results as for observed data. But very little is known about the quality of forecasts and projections, in particular when it concerns developing countries.

The aim of this report is to analyse the accuracy of the United Nation's world population projections since 1950. By comparing projected numbers with corresponding real figures for the period 1950-1990 I assess the quality of the projections. This way I hope to contribute to providing insight into the uncertainty around the results of current UN projections.

Preliminary findings of this project have been presented at the IIASA Task Force Seminar "Rethinking International Population Projections", Laxenburg, 6-8 June 1996. Research assistance by Svenn-Erik Mamelund and Bjørn Møller, the help by Liv Hansen in producing the figures, and comments by seminar participants and by Helge Brunborg are gratefully acknowledged. The project has been supported by grant no. 111939/730 of the Norwegian Research Council (NFR), as part of their recent initiative to stimulate demographic research and education.

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1. Introduction

An important aspect of the usefulness of population projections and forecasts is their accuracy. Although other aspects, such as the information content (e.g. has only total population been projected, or also age groups? which regional level?) and the usefulness for policy purposes (e.g. does the projected trend imply immediate policy measures?) are relevant as well, the degree to which the forecast may be expected to reflect real developments in the future is a key factor in assessing its quality.

For industrialized countries we know some common characteristics concerning the accuracy of historical forecasts and projections, see Keilman (forthcoming) for an overview. Ex-post comparisons between projected and observed trends in population variables have revealed that the forecast accuracy of fertility is better than that of mortality - behaviourally determined variables are difficult to forecast. Yet large errors have been found for both the young and the old after a forecast period of 15 years (errors up to +30 per cent for the age group 0-4, and -15 per cent or lower for women aged 85+ are not uncommon). This suggests that those old forecasts supplied useful information perhaps up to 10-15 years ahead, but certainly not longer. Finally, detailed studies for a few countries have found only a weak association between improvements in forecast accuracy and the introduction of more sophisticated forecast methods.

These findings relate to the accuracy of forecasts produced for industrialized countries. Much less is known about the reliability of population forecasts for developing countries. Inoue & Yu (1979) investigated the errors in total population size of six rounds of United Nations projections, with base years from 1950 to 1970 and observed data for the period 1950-1975. They found a consistent overestimation of the projected growth rate in developing countries after 1960, which was explained to a large extent by the rapid slowdown of population growth in China. They also concluded that errors in the base population and in the growth rate of population immediately preceding the starting year were important determinants for errors in the projected population size of developing countries. Keyfitz (1981) and Stoto (1983) analysed, for various countries in the world, errors in projected population growth rates in projections made by the United Nations during the 1950s and 1960s. Important findings were that errors varied strongly by region and by base year: regions in which population growth was high had large errors, as did forecasts made in the early 1950s. Moreover, Keyfitz concluded that the error in the growth rate was more or less independent of forecast duration. These conclusions were confirmed by Pflaumer (1988), who analysed the predicted growth rates in 101 countries with at least a million inhabitants (excluding China). Forecasts were those made by the UN between 1963 and 1978, and actual growth rates applied to the period 1960-1980. Pflaumer found also some evidence for an improvement over time in the accuracy of the projected growth rates. Furthermore, errors were relatively small in countries with large population sizes.

The purpose of this report is to extend the analyses of the United Nation's projections mentioned above, which were focused on growth rates and total population sizes. I investigate the accuracy of the UN projections of the age structure and birth and death rates in seven major regions of the world: Africa, Asia, Europe, the USSR, Latin America, Northern America, and Oceania. I also include findings for a few large countries which may dominate their region: China and India (Asia), and the USA (Northern America). UN-forecasts made between 1951 and 1988 have been evaluated. Projected numbers on total population size, crude birth rate, crude death rate, age structure in five-year age groups and dependency ratios for the period 1950-1990 were compared with corresponding ex-post observed numbers. I try to answer two broad questions in this report. First, does accuracy differ strongly among regions? In other words, are population trends in some regions easier to project than those in other regions? And second, did the UN-projections improve over time? The results indicate that the latter was indeed the case, not only because base line population estimates were improved, but also because unforeseen declines in birth rates became less important for projection errors. Furthermore, to prepare projections is more difficult for some regions than for others. Age structure projections for the former USSR and for Asia show larger errors than on average. For Asia this is explained by errors in base populations. When errors in the base population are removed and hence one considers errors caused by wrong assumptions regarding fertility and mortality only, the age structure of the former USSR is still very inaccurate, but also that of Oceania, Northern America and Europe.

In Section 2, I first present a number of simple error measures that have been used for the evaluations. Next I list the UN-projections that have been selected for the evaluation and give a brief historical account of main aspects of these projections. I discuss the problem of which data should be used as a yardstick against which the projected numbers can be compared. I opt for the most recent data, but the consequence is that I am confronted with a problem which is caused by the continuous revision of "observed" population numbers. The last issue taken up in Section 2 is a solution to this problem. Section 3 contains the main findings. The accuracy of total population size is briefly presented. Most attention is given to errors in crude birth and death rates and in the age structure of the subsequent forecasts in the various regions. In addition to errors in forecast results by five-year age group, duration, base year, and region I present observed and forecasted values for the young and the old age dependency ratios. A number of implications of the findings for population forecasting, as well as recommendations, are given in Section 4.

The main text focuses often on the accuracy results for the world as a whole for various indicators (total population, birth and death rates, five-year age groups, and dependency ratios). Errors in these indicators have also been computed for each of the seven major regions, and sometimes for India, China and the USA as well. The region-specific results are presented in this report in the form of tables and figures in the Appendix, but only briefly referred to in the text.

2. Data and methods

2.1. Measuring accuracy

Many errors analysed in this report depend on the size of the population or that of subgroups, for instance errors in total population size or in five-year age groups. In order to facilitate comparison between regions and over time, one has to correct for the unequal sizes of these (sub-)populations. Therefore, many measures presented here are relative errors, such as the percentage error (PE) or the absolute percentage error (APE). PE is defined as

$$PE=100.(\text{forecast-observation})/\text{observation}.$$

Thus, a positive PE indicates that the forecast has been too high, and a negative value reflects an underestimation. APE is the absolute value of PE. When we have the errors in a series of old forecasts, we can compute mean errors for those forecasts. The Mean Absolute Percentage Error (MAPE) is the average error when the direction of the error is ignored. It provides an average measure of accuracy - it tells us by how much the forecasts were wrong, but we do not know whether they were too high or too low. The Mean Percentage Error (MPE) takes the direction into account. It provides an average measure of bias: a positive MPE indicates that forecasts tended to be too high on average, and a negative MPE reflects too low forecasts. When forecast results are not size dependent (e.g. crude birth rate, or dependency ratio) I simply define the error as the forecast minus the observed value.

2.2. The United Nation's projections between 1950 and 1985

Table 1. UN-population forecasts analysed in this report

No.	Label	Source (year of publication)	Base year	Remark
1.	1950I	Population Bulletin of the United Nations 1 (1951) Sales no. E52.XIII.2	1950	Only total population by region for 1980
2.	1950I	Future population estimates by sex and age. Report I: The population of Central-America (including Mexico), 1950-1980 (1954) Sales no. 1954.XIII.3. Report II: The population of South-America 1950-1980 (1955) Sales no. 1955.XIII.4. Report III: The population of South-East Asia 1950-1980 (1959) Sales no. 1959.XIII.2. Report IV: The population of Asia and the Far East 1950-1980 (1959) Sales no. 1959.XIII.3	1950	Same as no. 1, but the reports give 5-year age groups for the years 1955(5)1980.
3.	1950II	Proceedings of the World Population Conference 1954 Vol. III (1955) Sales no. E.55.XIII.8, pp. 265-328	1950	Update of 1950I; only total population by region for 1955(5)1980
4.	1950III	The future growth of the world population (1958) Population Studies 28. Sales no. E.58.XIII.2	1950	Update of 1950II; 5-year age groups for 1960; broad age groups for 1960 and 1975; total population for 1960(5)1990
5.	1960	World population prospects as assessed in 1963 (1966) Sales no. E.72.XIII.2	1960	Broad age groups for 1965(5) 1980
6.	1965	World population prospects as assessed in 1968 (1973) Population Studies 53 Sales no. E.72.XIII.4	1965	5-year age groups up to 70+ for 1970(5)1990
7.	1970	World population prospects as assessed in 1973 (1977) Sales no. E.76.XIII.4 and corrigenda	1970	Broad age groups for 1985 and 2000 only; total population for 1975(5)1990
8.	1975I	Selected demographic indicators by country 1950-2000: Demographic estimates and projections as assessed in 1978 (1980) ST/ESA/SER/.R/38	1975	Five-year age groups for 1975, 1980, and 1990; total population and broad age groups for 1975(5)1990
9.	1975II	Demographic indicators by country: Estimates and projections as assessed in 1980 (1982) Sales no. E.82.XIII.5 and corrigendum	1975	Five-year age groups for 1975(5)1990; update of no.8
10.	1980I	World population prospects: Estimates and projections as assessed in 1982 (1985) Sales no. E.83.XIII.5	1980	Five-year age groups for 1980(5)1990
11.	1980II	Global estimates and projections of population by sex and age: The 1984 assessment (1987) ST/ESA/SER/.R/70	1980	Update of no. 10
12.	1985I	Global estimates and projections of population by sex and age: The 1988 revision (1989) ST/ESA/SER/.R/93	1985	Five-year age groups for 1985 and 1990
13.	1985II	The sex and age distribution of population: The 1990 revision of the United Nations global population estimates and projections (1991) Sales no. E.90.XIII.33	1985	Update of no. 12

The twelve UN-projections that were analysed are listed in Table 1. They are labelled in this report by base year. The last base year that is included is 1985. For some base years, the forecast was revised a few years later: 1950I, II and III, 1975I and II, 1980I and II, and 1985I and II. Frejka (1994, 7) and El-Badry & Kono (1986) give useful historical accounts, which will now be summarized.

UN-projections are based on the cohort-component approach for all countries in the world, except for those with a population size of under 150,000 persons (this limit has been lowered several times). A base population by sex and five-year age group is exposed to an assumed set of mortality and fertility rates, and to net immigration numbers by age and sex. This leads to numbers of deaths, births and net migrants for the first five projection years, and these numbers are used to update each sex-age group in the base population to find the next age group five years later. When applied repeatedly, this results in projections of population size and characteristics every fifth year and projections for demographic indicators for continuous five-year periods. Four variant assumptions are formulated for fertility in each country (high, medium, low, and constant). Mortality has only one variant, and migration usually also one variant.[1]

Compared to the situation in the 1950s, the projections have expanded in regional and age detail, in time coverage, and in methodological sophistication (El-Badry & Kono 1986). For instance, Africa was absent from the 1950I series, due to the unreliability or even lack of data. Country detail was only available for Latin America and the Far East. The 1950II series attempted to derive country projections from the projected totals in each of 25 regions. A more innovative series was produced in the 1950III projections, based on the theory of demographic transition and on stable population theory.

The 1960 and 1965 series used stable and quasi-stable population theory and indirect estimation methods in order to estimate basic indicators from incomplete data. Available computer facilities made it possible to prepare the 1965-projections by age and sex for each country, and to compute a large number of other indicators. Various sets of model schedules for fertility, mortality and migration were applied. Backward projections, starting from the base year 1965 and going back to 1950, were also prepared for each country.

These developments continued into the 1970s. More detailed indicators were computed, the complex link between socioeconomic, political and cultural factors in fertility and mortality change was taken into account, and base line data were improved. The World Fertility Survey (1974-82) greatly contributed to the understanding. Finally, in the 1980s, the cycle of revisions was shortened from every five years to every two years. Moreover, better software for projections permits the staff in the Population Division of the UN nowadays to try many different fertility, mortality and migration assumptions.

The findings in the following sections illustrate to what extent these gradual improvements in projection approach have resulted in increased accuracy.

For most forecasts, more than one variant has been computed by the UN, typically a high, a medium and a low variant. In such cases I limited the analysis to the medium variant, as this is the one users most probably often select as the best guess. Since the focus in this report is on comparative accuracy across regions and over time, I do not expect that the choice for the medium variant has had any large impact upon the conclusions. This assumption is supported by the findings of Inoue & Yu (1979,

[1] For most countries migration is relatively small and the UN did not assume any future migration until the first round of projections starting from 1990. The revised 1990-round however accommodated to the continuing extensive migratory movements within Europe and the rapid growth in the number of refugees in Africa and elsewhere, and assumptions on migration were heavily revised.

Table 2), who showed that percentage errors for the world's total population size had the same sign across variants (high, medium and low) in 16 of the 21 cases they analysed.

2.3. Observed population numbers

Observed population numbers have been taken from UN (1994).[2] The UN prefers to speak of "estimates" instead of "observations". This is understandable, because the UN continuously revises previously published demographic numbers for many countries, as new data become available and better techniques are being developed. However, to avoid confusion with the notions of "projection" and "forecast" I shall use the word "observation", not "estimate".[3]

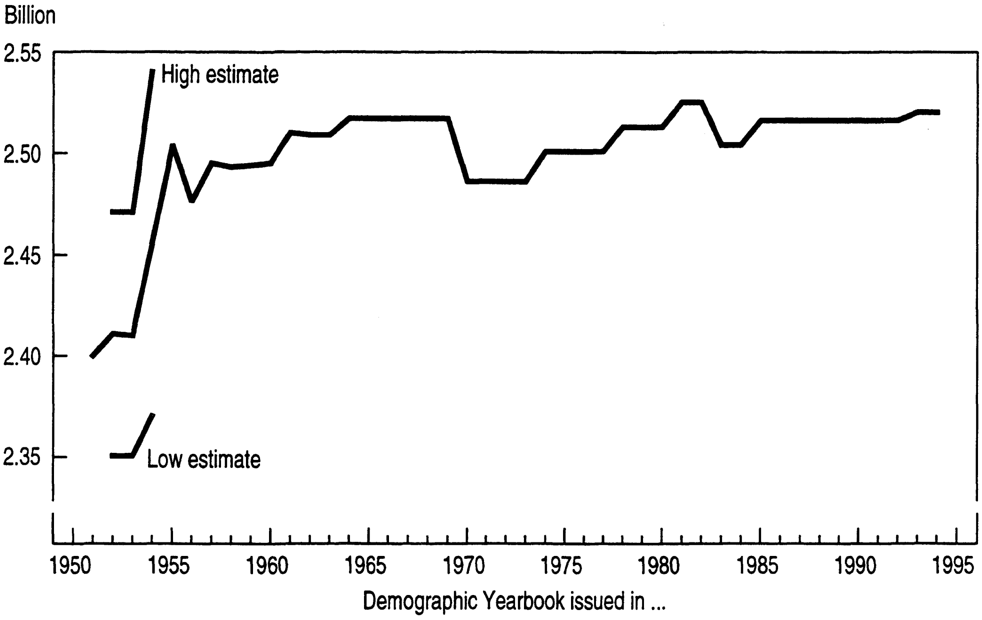
The frequent revision of observed data poses a problem. Not only does it have direct implications for the accuracy of the base population, but indirectly also for the population growth in the period prior to the base year, and probably in the first few projection years as well (Inoue & Yu 1979). El-Badry & Kono (1986, 37) note that the 1950III projections included an upward revision of the world population compared to the previous round, mainly because the base population of China had to be increased by 100 million after the results of the 1953 census became available. This led in turn to substantial reductions in assumed mortality levels. Such surprises have also occurred in recent years, and not only in developing countries. Poursin (1994, 20) reminds us of the November 1991 census in Nigeria which resulted in a population size of 88 million, 35 million lower than the 123 million that had been expected. In the 1990 round of censuses in Europe, Italy counted almost 1 million persons less than expected on the basis of vital statistics, and Portugal missed half a million persons (Cruijsen & Eding 1995, 10).

Against which yardstick should one evaluate projected numbers? For instance, the world's population size as of 1950 has been revised on many occasions. I checked the 1951 to 1994 issues of the UN Demographic Yearbook, and found mid-year estimates for the world's total population of 1950 as shown in Figure 1. Frequent revisions, carried out in the light of new data and better methods, have led to increasingly higher estimates of the 1950-population size. The upward adjustment after the Chinese census in 1953 is clearly visible. The Yearbooks of 1952, 1953 and 1954 give an interval for the world population, ranging from a low 2.35-2.37 billion to a high 2.47-2.54 billion. Both the intervals and the arithmetic averages for these years are included in Figure 1. Since the 1960s there seems to be agreement on a number of roughly 2.5 billion, but even in 1992 small adjustments were still carried out. Then the question arises with which number we should compare the base year population of the 1950I forecast (and which sources we should use for evaluating other forecast results). If we make use of the 1951-number of the population size in 1950, we do justice to the circumstances under which the *forecasters* had to work. Although better data about the situation in 1950 became available in later years, the forecasters could not possibly have known the revised figures. But there are two objections against selecting the early number. First, the earliest data for 1950 were probably outdated when observed population trends for later years were assessed. This may cause inconsistencies in the time series. Second, from the point of view of the *user*, the most recent data for the year 1950 have to be preferred, because these may assumed to be closest to the real (but for many countries unknown) numbers. Therefore I have chosen to base the observations for the period 1950 to 1990 on the most recent source, i.e. data published in UN (1994).

[2] Because the forecasts evaluated here apply to the period 1950-1990, before the USSR dissolved, I have chosen to maintain the USSR as one of the regional entries. Observed numbers published in UN (1994) for the 15 states of the former USSR have been aggregated.

[3] I make no distinction in this report between a forecast and a projection.

Figure 1. Mid-year estimates of world population size for 1950



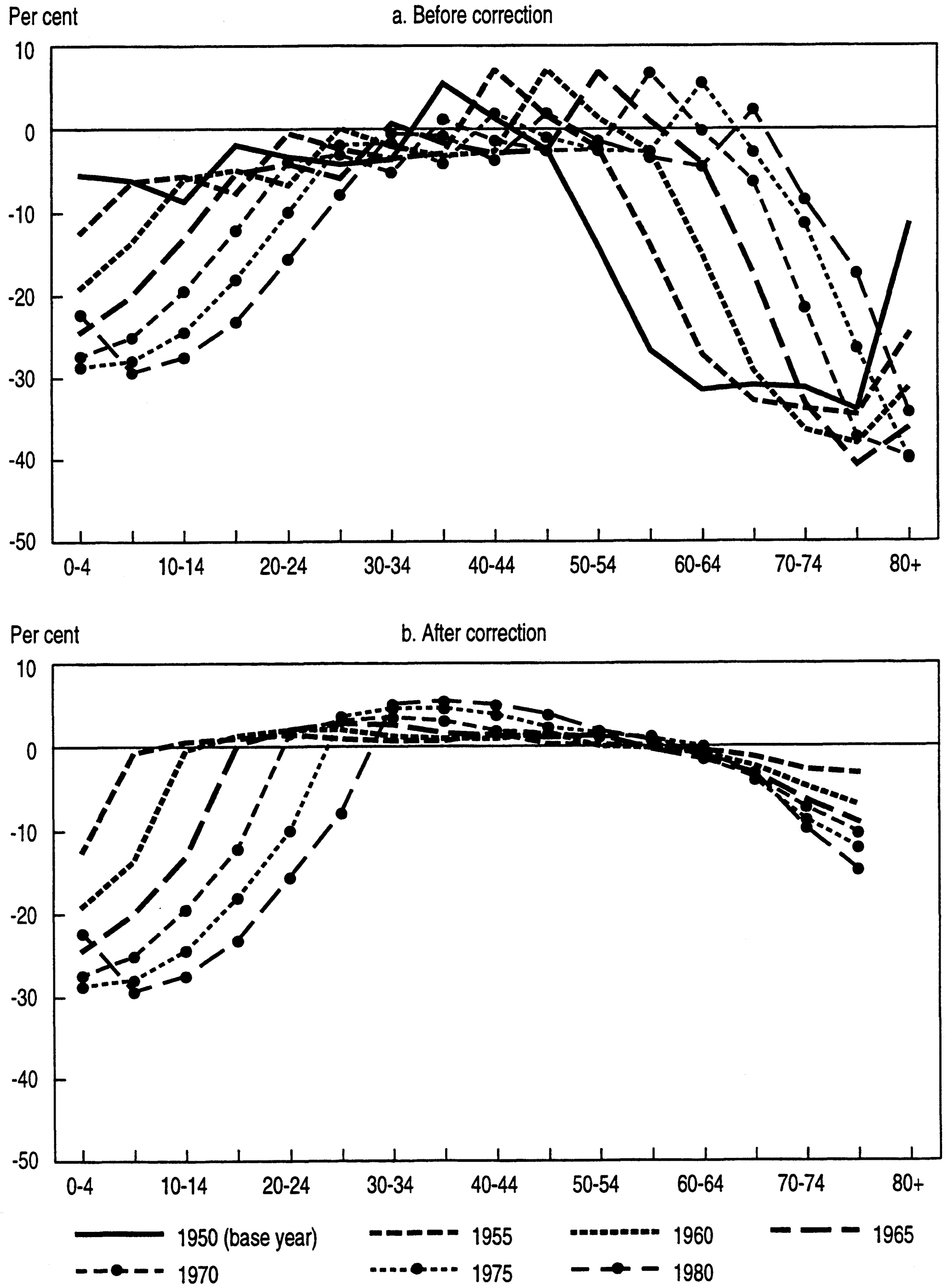
2.4. A correction method

The disadvantage of taking the most recent data as my yardstick is, of course, that this creates an error in the forecast's base population. In some cases the revision has been so large that the base year error dominates forecast errors in subsequent years. Moreover, the base year errors are strongly age-dependent, and these errors propagate through the age structure in later years. As a consequence, an observed forecast error in the age structure after, say, five years in the forecast period, is the result of two error sources: 1. the initial error in the base year population, caused by an error in the data, and 2. an error caused by wrong assumptions on fertility, mortality and migration during the five-year period since the base year. I have used a simple procedure, which isolates the error due to wrong assumptions from the forecast error, and removes the error in the base population.

As an example, consider Figure 2a which shows percentage errors by age for the 1950I-projections for Central-America, as compared with observations for every fifth year between 1950 and 1980. An error of +5% in the age group 35-39 in 1950 comes back every five years as an error of the same magnitude in the next five-year age group. But much more striking is the pattern of rapidly falling errors for age groups between 35-39 and 75-79 in 1950 (from +5 per cent down to -35 per cent) which repeats itself in later years for higher age groups. Thus Figure 2a mixes errors due to wrong assumptions (too high death rates and too low birth rates) with errors that were already present in the base population, caused by revisions of "observed" data. The correction method simply assumes that the percentage error for each age group in Figure 2a is the sum of the percentage error caused by wrong assumptions and the percentage error in the base population. This means that errors in the age structure caused by wrong assumptions alone can be isolated by subtracting the error in the base population by age from the errors for later years, thereby following five-year birth cohorts. For example, the percentage error in age group 35-39 in 1950 is subtracted from that of age group 40-44 in 1955, and from that of age group 45-49 in 1960, etc.[4] This correction was applied to the error in each five-year age group. Corrected percentage errors (CPE) by age for the 1950I-projections for

[4] In general, a corrected percentage error for age group x in year t, written as CPE(x,t), is found as the difference between two percentage errors PE(x,t)-PE(x-n,t_0), where t_0=t-n represents the base year and n the forecast duration.

Figure 2. Percentage errors in projected age structures, 1950I projections.
Central-America



Central America are displayed in Figure 2b. The underestimation of the elderly is much smaller here than in the case of uncorrected errors in Figure 2a. The correction removed the effect of errors in the base population: corrected errors for the elderly are caused by wrong death rates - in this case, too pessimistic assumptions for the age group 60+.[5] The positive errors for adults between 20 and 50 are a combination of two factors: first, and probably most important, too low outmigration, and second too

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[5] The correction procedure assumes that the error in the base population is independent of that caused by wrong assumptions. Although this may seem a reasonable assumption, it is not always valid. An example of dependence between errors in the base population and those in extrapolated mortality levels was given earlier for the case of China. I assume that such a dependence is small enough to be neglected in the forecasts with base years 1965 and later.

low mortality. Corrected errors in the base year are all zero by definition, and therefore omitted from Figure 2b. Cohorts born after 1950 were not included in the base population. For these cohorts, no correction is necessary and thus the uncorrected values are given in Figure 2b.[6] Five-year cohorts cannot be followed into the highest open-ended age group (80+) and therefore corrected errors have been computed up to age 75-79.

In Section 3.3, both corrected and uncorrected percentage errors in the age structure will be analysed. Mean errors in the age structure for the world as a whole and for the seven regions have been calculated. Forecasts with base years 1950 and 1960 had very little age detail and are therefore left out. For each age group, the mean error was taken over the subsequent forecasts, controlling for forecast duration. Thus I present mean errors for the base population and for the age structure at forecast durations of five years and ten years ahead. Results for a duration of 15 years have also been computed (see Figures A1-A7 in the Appendix), but these will not be commented upon, because they are based on two or three observations only.

3. Results

3.1. Total population

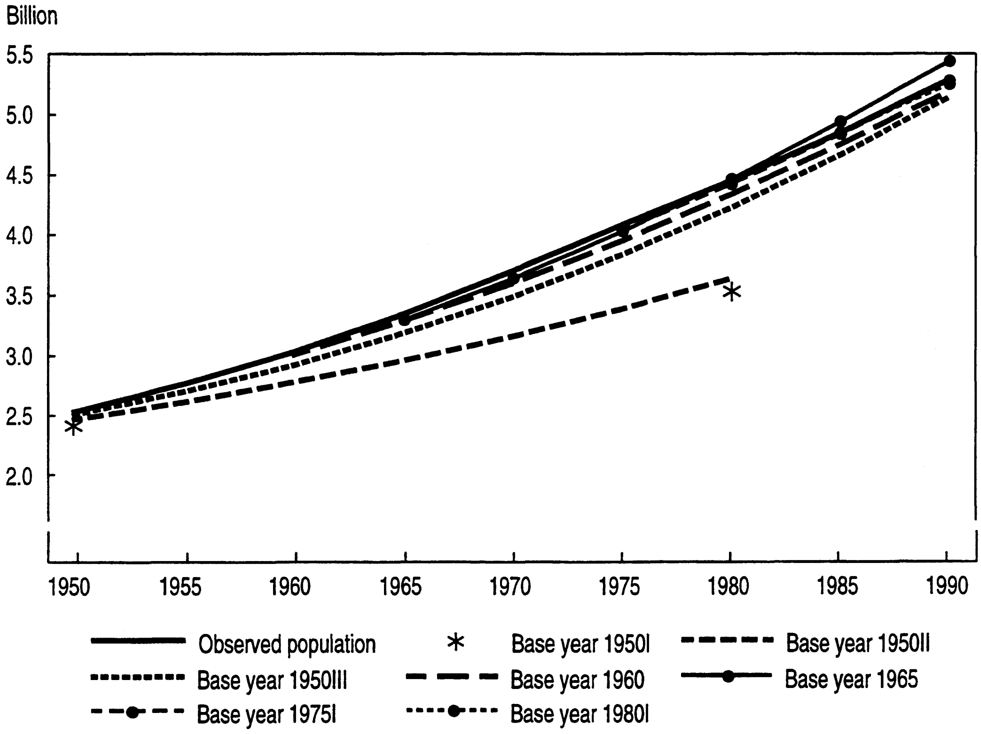
The accuracy of total population size is easy to examine, but the disadvantage is that underlying errors in births and deaths may have compensated each other. Figure 3 shows that the first two forecasts for the world as a whole with base year 1950 (i.e. 1950I, for which we only have results for 1950 and 1980, and 1950II, with results up to 1980) had both too low population growth and a base population which was too small. The underestimation of China's population by 100 million is part of the explanation. The 1950III forecast and those made later on were much more accurate. The forecasts with base years 1970, 1975II, 1980II, 1985I and 1985II are not included in Figure 3 because total population size in these forecasts is very close to the observed figures. Noteworthy is the 1965-forecast, for which the growth rate was too low until 1975, and too high in the years thereafter. The result was that the world's projected population size crossed the observed size in 1980, and was higher than the observations in the decade thereafter. This is mainly caused by the 1965-projection for India, in which annual growth rates were too high by 3.5 to 4.5 promille points in the period 1965-1980. But also unforeseen drops in birth rates in Europe, Northern and Latin America have contributed to this trend. The developments for Africa and Asia turn out to be largely similar to those in for the world as a whole.

3.2. Birth and death rates

I have selected the crude birth rate (CBR) and the crude death rate (CDR) as indicators for the evaluation of fertility and mortality forecasts. Data on the CBR- and CDR-forecasts have been published, or could be constructed, for eleven forecasts and all seven major regions. Other indicators, such as the total fertility rate (TFR) and the life expectancy at birth are to be preferred for the analyses (at least in principle), because they are independent of the age structure. Hence errors in the forecasts of the TFR or the life expectancy are not influenced by errors in the forecasts of age structures. But the necessary data have only been found for eight forecasts (1965, 1970, 1975I, 1975II, 1980I, 1980II, 1985I, 1985II). Errors in the life expectancy at birth will be presented graphically in the concluding section. Those in the TFR will not be discussed here, as previous analyses for the Netherlands and Norway have shown that the overall behaviour in these errors was not very different from that in the CBR (Keilman 1990; Texmon 1992). Apparently, the influence of errors in the age structures on those in the TFR has been small.

[6] This disregards second-order effects caused by errors in the number of women aged 15 to 50 in the base population.

Figure 3. Total population, observed and projected. World



A first view
Table 2 presents the errors in crude death rates in ten forecasts for the world as a whole. The 1950I forecast is not included. It built on vital rates continuing at the 1946-48 level, which led to CDR-forecasts of between 22 and 25 deaths per year per thousand inhabitants for the whole forecast period. The 1950III-forecast was the first one, as far as I could trace, which had an explicit extrapolation for mortality. The death rates and errors therein apply to the eight five year periods from 1950-55 to 1985-90. There are three dimensions in the errors for a given region: the calendar year or period for which the errors have been computed, the base year, and the forecast duration (calendar year of observation minus base year).[7] Therefore I present three types of averages: by period (average taken over base years), by base year (over periods), and by duration (over base years). The latter average has been computed alongside the main diagonal (for duration 0-5 years) and sub-diagonals (for longer durations) of the table. For instance, the mean error of 2.6 promille points at a duration of 15-20 years was computed as the average of 7.6 (forecast 1950III, period 1965-70), 1.8 (forecast 1960, period 1975-80), 0.2 (forecast 1965, period 1980-85), and 0.9 (forecast 1970, period 1985-90).

First we note that all errors in Table 2 are positive: real mortality levels were always lower than projected ones.[8] In the 1950III round of forecasts, the crude death rate was assumed to fall slowly, from 25 per thousand throughout the 1950s, to 21 per thousand in the 1960s and the beginning of the 1970s, reaching an ultimate level of 17 per thousand from 1975 onwards. The data that we now have, forty years after the forecast was made, indicate that these levels were too pessimistic by 7 promille points on average. The situation became considerably more favourable beginning with the 1965-forecast: since then, mean errors have been around 0.6 promille points only. Ignoring averages computed on the basis of less than four observations, there is a clear tendency of improvement over

[7] The three dimensions are not independent. This dependency is accounted for in a multivariate analysis below.
[8] Because all errors have the same sign, each mean error is identical to the corresponding mean absolute error (MAE), and the MAEs are not presented here.

Table 2. Errors in projected crude death rates (promille points) by base year, forecast period, and forecast duration. World

Period (1 Jan.)	Forecast's base year 1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Duration in years	Mean error
1950-55	5.2										5.2	0-5	1.0
1955-60	7.7										7.7	5-10	1.6
1960-65	5.4	0.3									2.9	10-15	1.7
1965-70	7.6	1.0	0.6								3.1	15-20	2.6
1970-75	9.3	1.9	1.1	1.1							3.4	20-25	3.6
1975-80	6.0	1.8	0.6	0.9	0.5	0.4					1.7	25-30	3.7
1980-85	6.7	1.2	0.2	0.7	0.4	0.3	0.3	0.2			1.3	30-35	6.7
1985-90	7.7	1.4	0.3	0.9	0.8	0.8	0.7	0.6	0.6	0.5	1.4	35-40	7.7
Mean error	7.0	1.3	0.6	0.9	0.6	0.5	0.5	0.4	0.6	0.5	2.2		2.2

time: during the period 1970-1990, mean errors were more than halved. During the first 20 years of forecast duration, the mean error increased more than twofold, from 1.0 to 2.6 promille points.

Errors in crude birth rates are shown in Table 3. Here we note that the forecasts with base years 1980I and 1980II had too low birth rates, as indicated by the minus signs. Hence the mean error in those two forecasts was -0.5 and -0.7 promille points for the whole of the 1980s. The 1950III-forecast overestimated the falling crude birth rates for the world by 5.5 promille points. The forecasts of the 1960s and 1970s had too high birth rates as well, but much less so. When we look at period averages it becomes clear that it was relatively difficult to give accurate forecasts of the CBR during the years 1970-85, as absolute errors are between 2.4 and 3.3 promille points on average. Increasing uncertainty in the CBR as forecast duration grows is reflected by the mean absolute error in the last column, which grows from 0.6 promille points in the first five years of the average forecast to 2.8 promille points for periods of 15-20 years ahead.[9]

In principle, it is easier to give an accurate extrapolation for mortality than for fertility - after all, everyone dies, and the only uncertainty connected to mortality is around the timing of death, whereas for fertility we have to guess not only the timing (mean age at childbearing), but also the number of children a woman gets. Yet, the overall mean absolute error (MAE) in the CBR is 2.3 promille points, which is almost equal to that for the CDR (2.2 points, see Table 2). This suggests that it has been equally difficult to give accurate extrapolations for mortality as for fertility for the period and forecasts studied in this report. The poor quality of vital data, in particular for Africa and Asia in the 1950s, explains this counterintuitive finding. Table 4 shows that the overall MAE for mortality in Africa and Asia was higher than the corresponding overall MAE for the world as a whole. For the other regions the error was much lower, ranging from 0.6 promille points for Northern America and Oceania to 1.5 points for the former USSR. A comparison with the last column in Table 4 demonstrates that in Europe, the Americas, and Oceania, i.e. in regions with relatively good data, fertility was indeed more difficult to extrapolate than mortality

[9] Uncertainty concerning mortality and fertility increases rapidly when we look further ahead into the future. Also when I analysed the net effect of fertility and mortality, i.e. world population growth rates, I noted an increase in forecast uncertainty. Mean absolute errors in projected annual growth rates were 1.3, 2.0, 2.4, 3.1, and 2.4 promille points for durations 0-5, 5-10, 10-15, 15-20, and 20-25 years, respectively. On the other hand, Keyfitz (1981) and Pflaumer (1988) found in their analyses that the error in the growth rate was more or less *independent* of forecast duration. These apparently contradictory findings are explained by different definitions of growth rates. Keyfitz and Pflaumer analysed overlapping durations (0-5 years, 0-10 years, 0-15 years, etc.), whereas I looked at subsequent durations (0-5, 5-10, 10-15, etc.). Errors computed for overlapping durations show less variability than those defined for subsequent durations.

Table 3. Errors in projected crude birth rates (promille points) by base year, forecast period, and forecast duration World

Period (1 Jan.)	Forecast's base year 1950 III	1960	1965	1970	1975 I	1975 II	1980 I	1980 II	1985 I	1985 II	Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
1950-55	1.6										1.6	1.6	0-5	0.2	0.6
1955-60	3.4										3.4	3.4	5-10	0.9	1.5
1960-65	1.7	-1.4									0.2	1.6	10-15	1.6	1.8
1965-70	3.2	-0.9	0.0								0.8	1.4	15-20	2.8	2.8
1970-75	6.1	1.5	2.3	0.6							2.6	2.6	20-25	3.5	3.5
1975-80	8.7	3.3	3.8	2.8	1.1	0.2					3.3	3.3	25-30	5.2	5.2
1980-85	9.4	2.3	3.3	2.5	1.0	-0.1	-0.3	-0.5			2.2	2.4	30-35	9.4	9.4
1985-90	10.1	1.6	2.2	1.5	0.7	-0.4	-0.8	-0.9	0.2	0.2	1.4	1.9	35-40	10.1	10.1
Mean error	5.5	1.1	2.3	1.9	0.9	-0.1	-0.5	-0.7	0.2	0.2	2.0	-		2.0	-
Mean absolute error	5.5	1.8	2.3	1.9	0.9	0.2	0.5	0.7	0.2	0.2	-	2.3		-	2.3

Table 4. Mean error and mean absolute error in projected crude death rates and crude birth rates (promille points) by major region, projections with base years as in Tables 2 and 3, period 1950-1990

	Crude death rates		Crude birth rates	
	Mean error	Mean absolute error	Mean error	Mean absolute error
Africa	2.3	2.8	-0.1	0.9
Asia	3.4	3.4	2.6	3.2
Europe	-0.2	0.4	1.5	1.7
USSR	-1.5	1.5	0.9	1.2
Northern America	0.3	0.6	2.5	3.0
Latin America	0.8	1.4	3.2	3.5
Oceania	0.2	0.6	1.9	2.4
China[1]	1.9	1.9	-0.5	2.4
India[1]	-0.1	0.5	0.8	1.8
USA[1]	0.6	0.6	2.0	2.0
World	2.2	2.2	2.0	2.3

[1] Forecasts 1965, 1970, 1975I, 1975II, 1980I, 1980II, 1985I, and 1985II; period 1965-90.

Improvement over successive rounds

When a new forecast is published, the user will most likely disregard the previous one. But is this a good strategy? In other words, does a new forecast show smaller errors than the old one? The series of birth and death forecasts given in Tables 2 and 3 for the whole world (and for the seven regions, in corresponding tables contained in the Appendix), give us the possibility to answer this question.

Table 5. Reduction in error in CBR-forecasts in subsequent rounds (promille points)[1]

	Base year								
	1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I
	compared to base year ...								
	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II
Africa	-0.7	1.2	0.0	0.0	-0.3	-1.2	0.4	0.5	0.0
Asia	8.6	-0.5	0.9	1.9	0.1	-0.6	-0.1	2.2	0.2
Europe	0.9	-1.0	1.7	1.6	0.4	0.1	0.1	0.5	0.1
USSR	2.7	0.8	0.7	0.2	-0.1	0.1	0.2	0.1	0.0
Northern America	-1.5	2.0	3.7	1.5	-0.4	1.1	-0.0	-0.6	0.0
Latin America	2.7	0.2	0.7	0.5	2.1	0.6	0.2	0.6	0.4
Oceania	0.4	-0.2	1.1	3.4	-0.1	0.3	0.4	-0.1	0.1
World	4.7	-0.4	1.1	1.3	0.7	-0.3	-0.2	0.7	0.0

[1] A positive values implies a smaller error in the current forecast than in the previous one, a negative value indicates a larger error.

Table 5 gives, per region, the reduction in errors in CBR from one forecast round to the next one. The comparison between two forecasts is limited to the periods they have in common. For instance, for the world as a whole, the CBR-forecast of 1960 was better by 4.7 promille points than its predecessor, the forecast with base year 1950III. This value has been computed from Table 3, by taking the difference between the mean absolute error for the 1960-forecast (in promille points) during the period 1960-85, and the mean value of absolute errors for the 1950III-forecast that apply to the same period (also in promille points).

Large improvements occurred between 1950III and 1960, in particular due to better CBR-forecasts for Asia. But in recent decades the reduction in the errors is very small. Northern America is a peculiar case: we can trace an improvement in only four cases, whereas in three other forecasts (base years 1960, 1975II, and 1985I) the values are negative and the user would have done better by sticking to the old forecast. This feature is not restricted to Northern America, as negative values also appear for other regions in Table 5. See, for instance, the 1980I-round for Africa and Asia. Latin America shows the best performance, with improvements throughout at an average level of 0.7 promille points beginning in 1965. The USSR is next best on the list with only one negative value, but the improvements have been much more modest than in Latin America.

Also CDR-forecasts show the largest improvement between 1950III and 1960, in particular in Africa and Asia (Table 6). In Africa, the pattern is more or less alternating, with negative values for the forecasts of 1965, 1975I, and 1980II, and positive ones in the other years. All regions have at least one forecast in which the error was larger than that in the previous forecast, although the negative values in Asia, Europe, USSR, Latin America, and Oceania are limited (less than 0.4 points in absolute value).

The many negative numbers in Tables 5 and 6, and the low values of those that are positive leave a sobering impression. Progress is very slow: although the general pattern is definitely towards smaller errors, reductions are small for recent forecasts.

Table 6. Reduction in error in CDR-forecasts in subsequent rounds (promille points)[1]

	Base year ...								
	1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I
	compared to base year ...								
	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II
Africa	11.0	-0.3	0.3	-0.6	0.2	0.7	-1.9	2.0	0.2
Asia	8.7	1.8	-0.3	0.4	0.2	0.1	0.4	-0.0	0.1
Europe	0.7	0.2	0.0	-0.1	0.1	0.1	-0.2	0.1	0.0
USSR	0.9	0.9	0.1	0.4	0.0	-0.4	-0.0	1.5	0.0
Northern America	-0.7	0.2	-0.3	0.4	0.9	0.1	0.1	0.3	-0.1
Latin America	3.9	-0.3	0.4	0.2	-0.1	0.0	0.0	0.1	0.1
Oceania	0.3	0.6	-0.2	-0.1	0.0	0.4	0.0	0.2	-0.1
World	5.9	0.9	-0.4	0.3	0.1	0.0	0.1	0.0	0.1

[1] A positive values implies a smaller error in the current forecast than in the previous one, a negative value indicates a larger error.

Analysis of variance: period and region effects

The three dimensions of period, base year, and duration are perfectly correlated: once we know two of them, the third one can be derived. Therefore, the simple marginal averages in Tables 2 and 3 do not give an entirely correct impression of the errors by period, duration or base year. For instance, the mean errors for the 1950s contain errors for short durations only, whereas mean errors for the 1980s are a mixture of errors for short and long durations. Since errors tend to grow when duration increases, the means for subsequent periods are not fully comparable. A multivariate (or Age-Period-Cohort-type of) model may be used to disentangle the effects of period, duration and base year and to obtain better estimates for the effects of these three dimensions, see Keilman (1991) for an application. However there are so few entries in Tables 2 and 3 that precise estimates are hard to obtain. Instead a more simple analysis of variance was carried out in order to discover common regional and period effects in the errors.

The focus is on two questions. 1. Do certain regions have systematically higher or lower errors in birth and death rates than other regions? 2. Was it more or less difficult to give accurate forecasts in recent periods than in earlier years? In order to avoid the correlation between period, base year and duration noted above, the latter variable was controlled for by selecting all errors for a duration 0-5 years from Tables A1-A14. A two-way analysis of variance (ANOVA) was carried out for tracing possible regional and/or period effects in the errors. Similar ANOVAs were performed for durations 5-10 and 10-15 years. In order to enhance interpretation, the absolute values of the errors were analysed.[10] Let X_{ij} denote the error for period i and region j, given a certain duration. The assump-5 tion is that all errors are normally distributed with common variances, and means m_{ij} that are specific for each combination of period and region. The null hypotheses are that there are no period effects ($m_{ij}=m_j$ for all i) and no region effects ($m_{ij}=m_i$ for all j). There is no forecast with base year 1955, and therefore no period effects could be estimated for periods 1955-60 at duration 0-5, period 1960-65 at duration 5-10, and period 1965-70 at duration 10-15. In case of multiple base years (i.e. 1950I, II, and III; 1975I and II etc.) there is a fair chance for correlation between the errors of forecasts with the same base year. In that case the last base year was somewhat arbitrarily selected for the analysis, and the first base year was left out. The errors are expressed per thousand (in fact, promille points), and hence the effects can also be interpreted as per thousand. The results are shown in Table 7.

[10] When signed errors are analysed, instead of absolute errors, both positive and negative values for the estimates may result. In that case it will be hard to compare the relative accuracy between regions or between periods.

Table 7. ANOVA results for absolute errors in birth and death rates by duration

	Crude birth rates Duration (years)			Crude death rates Duration (years)		
	0-5	5-10	10-15	0-5	5-10	10-15
Regional effects			per thousand			
Africa	1.2	1.0	0.8	1.4	2.0	2.0
Asia	0.8	2.8	3.0	1.9	3.2	3.1
Europe	0.3	1.2	1.7	0.4	0.4	0.4
USSR	0.2	0.5	1.0	0.8	1.1	0.1
Northern America	1.1	2.5	3.9	0.6	0.5	0.6
Latin America	1.3	2.1	3.1	1.0	1.4	1.2
Oceania	0.9	1.6	2.8	0.3	0.4	0.8
P-value (per cent)	0.02	0.02	0.02	0.17	0.18	0.20
Period effects						
1950-55	1.9	-	-	3.4	-	-
1955-60	-	2.1	-	-	4.2	-
1960-65	1.3	-	2.1	0.7	-	3.5
1965-70	0.3	1.5	-	0.5	0.9	-
1970-75	0.6	1.9	2.1	0.5	0.5	1.2
1975-80	0.5	2.3	3.7	0.5	0.8	0.8
1980-85	0.7	1.1	2.7	0.7	0.7	0.8
1985-90	0.5	1.0	1.2	0.1	0.7	0.6
P-value (per cent)	0.00	0.23	0.06	0.00	0.01	0.02

For fertility we note a significant region effect for all durations. Similar to Table 4, the former USSR has very small errors in the CBR. Forecasting fertility has clearly been difficult for Northern and Latin America, as well as for Asia for durations between 5 and 15 years. The relative ordering of the regions for duration 10-15 years is almost the same as that for the mean absolute error (irrespective of duration) in Table 4: large errors for the Americas and Asia, and small ones for Africa and the USSR. But for short durations, Asia comes out with relatively small errors and Africa with large errors. Except for the effects in Africa, all region effects increase when forecast duration grows.

As to period effects, there are only significant ($P < 5$ per cent) effects for fertility at short durations, although period effects for a forecast horizon of 10-15 years are almost significant ($P = 6$ per cent). For durations up to five years ahead, fertility forecasting was clearly difficult in the periods 1950-55 and 1960-65.

Some periods and/or regions may have had large errors simply because the level of the Crude Birth Rate was high. After all, the error is defined here as the (absolute value of the) difference between observed and projected CBR. Indeed, a simple plot with estimated region and period effects against the average observed CBR for each period and for each region, respectively, revealed strong positive correlations (0.64 for regions, and 0.81 for periods, both at durations 0-5 years). In order to correct for this level dependency, an additional ANOVA was performed for the relative error in the CBR at a duration of 0-5 years, with the observed value as the reference value. The result was again significant effects for both regions ($P = 0.00$) and periods ($P = 1$ per cent). In this case, Northern America (6 per cent), Oceania (4 per cent), and Latin America (4 per cent) had high estimates, and Europe (2 per cent) and the former USSR (1 per cent) low estimates. Thus the effects for Africa and Asia found in Table 7 are level dependent. The relative ordering of period effects did not change.

The pattern for mortality is the opposite of that for fertility: region effects are not significant, but period effects are. In general, period effects grow with increasing duration, but not as fast as region effects for errors in birth rates. There is a clear cohort-like effect of the 1950-forecast: high estimates for periods 1950-55, 1955-60 and 1960-65 for durations 0-5, 5-10, and 10-15 years, respectively.

When the error for the period 1950-55 is omitted from the analysis for errors 0-5 years ahead, the period effects after 1960 remain the same, but these effects become non-significant (P = 18 per cent). The conclusion is that there is no significant improvement over time in the mortality forecasts, except for initially large errors connected to the 1950-forecast which were disappeared beginning with the 1960-forecast.

Since the dependent variable in the analyses was the absolute value of the error, the assumption on normally distributed errors is probably not satisfied. Therefore one must be cautious with respect to the conclusions formulated above. On the other hand, an additional non-parametric analysis for errors in the birth rates for a duration of 10-15 years resulted in significant region effects (P = 4 per cent) and non-significant period effects (P = 18 per cent), similar to the ANOVA-results. Estimated effects (in the form of medians) were highest in Northern America (3.4 promille points) and Latin America ((3.3 points), and lowest in the former USSR (1.1 points) and Africa (1.0 points). Thus the relative ordering is also the same as that for the ANOVA-results. This suggests that the assumption on a normal distribution of the independent variable, although not correct, has no strong bearing upon the general conclusions.

Cross-correlations

Are errors in death rates independent of those in birth rates? There are several reasons to suspect dependence:

- When data quality is poor, methods are underdeveloped and sufficient manpower for analysis and forecasting is lacking, one may assume that this leads to errors both in CBR- and CDR-extrapolations, and a positive correlation between unsigned errors.
- In developing countries, mortality and fertility may exert positive effects on one another, or other factors related to economic and social development (education, income, health and contraceptive services) may affect both fertility and mortality (Lee 1996).
- Wars, famines or AIDS may have a negative effect on both fertility and survival, resulting in a negative correlation between the fertility and mortality errors (Alho forthcoming).

For countries where mortality is low, a correlation between mortality and fertility errors seems unlikely.[11]

Table 8 gives for each region the correlation between errors in the CBR and the CDR. Both unsigned and signed errors have been analysed. I also investigated how sensitive the conclusions are for choice of base years: one set of results concerns all base years contained in Tables 2 and 3 (35 observations), the other one is restricted to base years 1970 and later (n=16).

The assumption on a correlation for developing countries is mildly supported by the estimates for Asia: three out of four estimates for that region are around +0.8 and significant (at the five per cent level). The assumption does not receive general support for the cases of Africa and Latin America. Somewhat surprising are the high and significant estimates for Northern America concerning the forecasts since 1970. I think this is due to a mere coincidence in those forecasts. First, the large over-estimations in fertility (due to unforeseen drops in the birth rates) gradually disappeared and turned into underestimations for the forecasts made in the 1980s (caused by an unexpected acceleration in period fertility in the second half of the 1980s after an initial delay in childbearing), see Table A12. At the same time, mortality forecasts became more accurate - errors in forecasts beginning with 1980I are smaller than those in the forecasts of the 1970s (Table A5). The strong correlation is not visible on the long term (forecasts made since 1950), because these are dominated by the large fertility errors in the forecasts of the 1960s connected to the baby boom in the United States (even the 1950III-forecast shows large positive errors in the CBR beginning in 1965, see Table A12). More or less the same

[11] Indeed I found no dependence between errors in deaths and births forecasts for the Netherlands and Norway, once I controlled for forecast duration (Keilman forthcoming).

Table 8. Correlations between errors in Crude Birth Rates and errors in Crude Death Rates

	Forecasts 1950III-1985 (n=35)		Forecasts 1970-1985 (n=16)	
	Signed errors	Absolute errors	Signed errors	Absolute errors
Africa	0.115	0.155	0.480	0.077
Asia	0.780*	0.769*	0.762*	0.416
Europe	0.077	-0.051	0.320	0.320
USSR	-0.587*	0.653*	0.348	0.418
Northern America	-0.176	0.111	0.915*	0.738*
Latin America	0.132	0.306	-0.650*	-0.185
Oceania	0.310	0.345*	0.303	0.315
World	0.725*	0.725*	0.416	0.448

* Significantly different from zero at the five per cent level (Fisher's z-test).

phenomenon occurred in Europe. Errors in mortality forecasts were a general phenomenon in industrialized countries in the 1960s, when improvements in life expectancies stagnated (Preston 1974). However, the decline in fertility errors over the period 1970-1990 is much weaker in Europe than in Northern America. For instance, fertility overestimations in the forecasts of 1960 and 1965 for Europe (Table A10) were only half those for Northern America. At the same time, CBR-errors in the forecasts made in the 1980s for the period 1985-1990 are positive, contrary to the situation for Northern America.

A different dependency is that between regions. Do errors in one region tend to be systematically higher or lower than those in an other region? Lee (1996) suggests this will be the case because unexpected trend shifts in mortality and fertility developments have been or will be similar across regions: gains against heart disease and cancer, the appearance of new diseases that are resistant to antibiotics, the timing of the European fertility transition, the rapid fall in birth rates both in developed and developing countries, etc. Stoto (1983) found strong evidence for such interregional correlations when he analysed the error in the UN growth rate forecasts. Table 9 provides insight in the patterns for fertility and mortality forecasts.

The upper panel shows a positive correlation between fertility errors in developed regions: Europe, Northern America and Oceania correlate with one another with a coefficient r of between 0.7 and 0.8. But also the correlation between Latin America and each of these three regions is strong. All four regions have experienced a considerable drop in birth rates after the war. When I restrict the analysis to the forecasts with base year 1970 or later, Northern America, Latin America, and Oceania are still positively correlated with one another, but the positive association with Europe is only maintained for Latin America. Correlations between Africa and other regions in Table 9 are rather weak.

Concerning mortality errors, the lower panel reveals that Africa, Asia and Latin America are very strongly correlated with one another (r=0.93-0.94). This pattern is explained by the poor quality of the data in the 1950s and 1960s. Mortality assumptions for the three regions were far too pessimistic, and this caused very large positive errors in the three regions (Tables A1, A2, and A6). The pattern disappears for later forecasts. When I only consider the forecasts of 1970 and later, the correlations between the three regions become insignificant in two cases (Africa-Asia: -0.401; Africa-Latin America: +0.351) and it turns negative in one case (Asia-Latin America: -0.841). Europe is negatively correlated with each of the three regions in Table 9 ($-0.87<r<-0.73$). This is explained by the unfavourable trends in death rates in the 1960s, which led to too optimistic mortality assumptions in the forecasts with base years 1950III, 1960, and 1965 (Preston 1974), and hence negative errors in the CDR. For later forecasts, errors were positive because life expectancies increased again, at a faster pace than forecasters could foresee. When European errors turn from negative to positive around 1970, and Asian errors fall steeply between 1950 and 1990, the result is a negative correlation

Table 9. Interregional correlations for errors in CBR- and CDR-forecasts

	Africa	Asia	Europe	USSR	Northern America	Latin America	Oceania
				CBR			
Africa	1.000						
Asia	0.114	1.000					
Europe	0.279	0.615*	1.000				
USSR	0.080	0.666*	0.458*	1.000			
Northern America	-0.042	0.381*	0.708*	0.505*	1.000		
Latin America	0.400*	0.632*	0.814*	0.481*	0.699*	1.000	
Oceania	0.245	0.438*	0.809*	0.251	0.789*	0.848*	1.000
				CDR			
Africa	1.000						
Asia	0.933*	1.000					
Europe	-0.734*	-0.868*	1.000				
USSR	0.576*	-0.501*	0.183	1.000			
Northern America	-0.233	-0.302	0.271	0.309	1.000		
Latin America	0.935*	0.938*	-0.806*	-0.450*	-0.273	1.000	
Oceania	0.413*	0.222	0.016	-0.288	0.300	0.377*	1.000

* Significantly different from zero at the five per cent level (Fisher's z-test).

coefficient. To the extent that stagnation in survival improvement in developed countries will not repeat itself, the negative correlation can be considered as a coincidence. Indeed, CDR-errors for European forecasts with base years 1970-1985 are no longer significant (at the five per cent level).

What are the implications of these findings on correlations? Stochastic population forecasts require assumptions concerning among others the dependence between components of change, and, in the multiregional case, that between regions for each component. For instance, in their single-region stochastic forecast for the United States, Lee and Tuljapurkar (1994) assumed perfect independence between fertility and mortality. They could justify this assumption on theoretical and empirical grounds. However, an illustrative calculation carried out by Alho (forthcoming) for twelve regions in the world assumes independence between regions for mortality and for fertility, and also independence between these two components in each region, more or less on intuitive grounds. His 95 per cent probability interval for the world population in 2030 is 3251 million wide (between 8255 and 11506 million). When he assumes that instead of twelve there are only six independent regions (six sets of pairwise dependent regions), the interval widens by a factor 1.41 (assuming equal population sizes, equal error variances for the twelve regions, and still independence between fertility and mortality in each region). Perfect correlation, i.e. one world which consists of twelve perfectly correlated regions, would widen the interval by a factor 3.46 even (Lee 1996)!

Alho and Lee had to make ad-hoc assumptions on error correlations, because carefully estimated correlations are not available. The estimates given in tables 8 and 9 constitute only a first step. Much work remains to be done. First of all, correlations have to be estimated for many more regions than just seven. That seems to be a straightforward task. Much more complicated is the issue whether correlations estimated for historical forecasts also apply to future forecasts. If error patterns would have been stable over various forecast rounds this would be justified. But many results in this report indicate that the patterns are not at all stable over subsequent rounds. At any case, the high correlations found here for some errors suggest that intervals computed on the basis of assumed independence may well be far too narrow.

3.3. Age structure

World

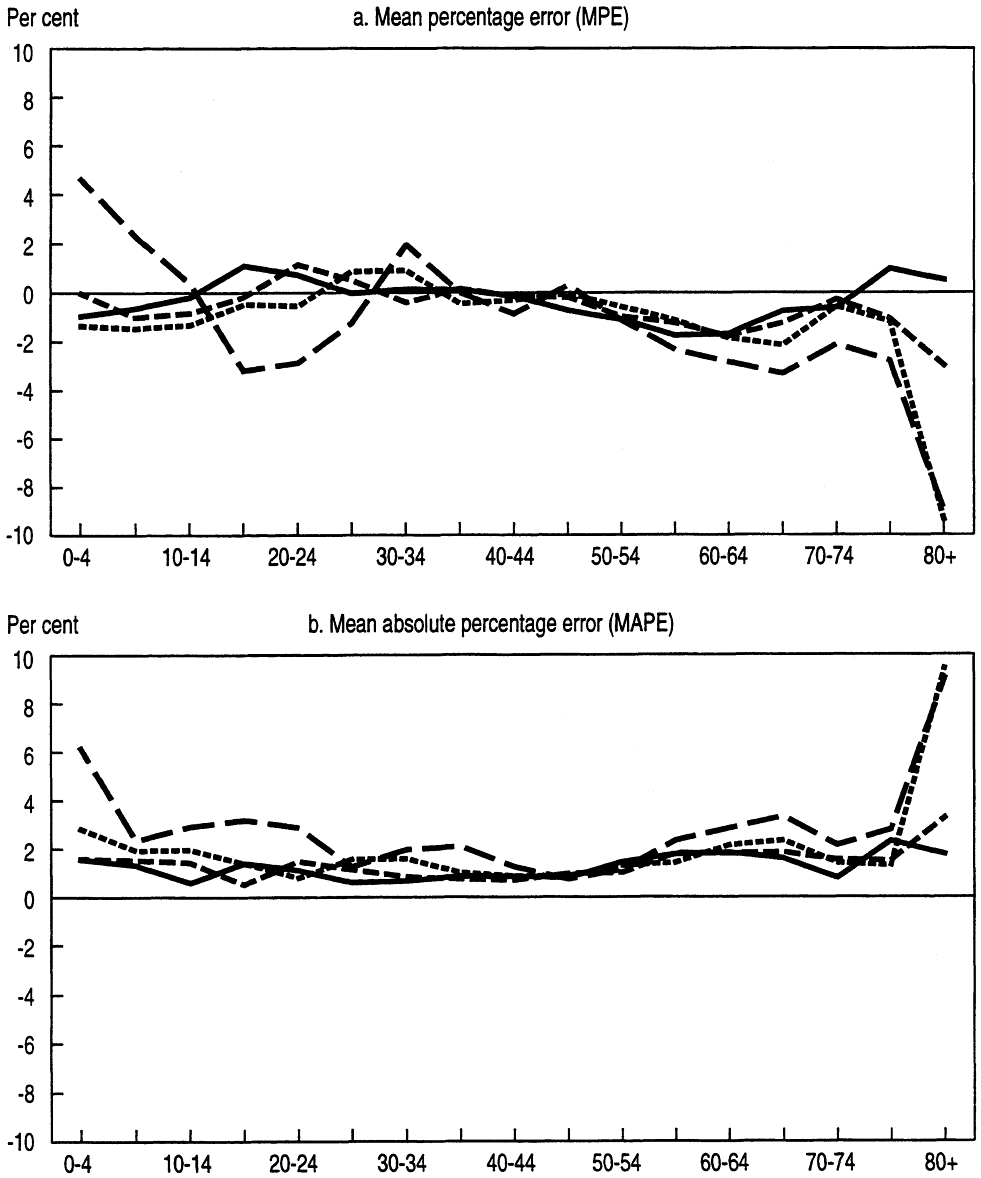
Figure 4 shows mean errors in the age structure for the world as a whole. Both uncorrected (Figures 4a and 4b) and corrected errors (Figures 4c and 4d) are displayed. Means were computed over the subsequent forecasts, controlling for age group and forecast duration. Forecasts with base years 1950 and 1960 had very little age detail (see Table 1) and are therefore left out. Similar figures displaying errors in the age structures for the seven regions are contained in the Appendix, Figures A1-A7.

Concerning forecasts of the world's age structure since 1965, the Mean Percentage Error (MPE) is very modest for most age groups, see Figure 4a. Except for the population aged 80+, the mean errors are limited to between -2 and +2 per cent. (The results for a duration of 15 years should not be given much weight, as these are based on only three observations.) The underestimation of the age group 40-70 lasted until the 1980II forecast. It can be explained by the failure to appreciate the pace of mortality declines which already characterized the global population forecasts in the 1940s and 1950s made by the UN and others (Coale 1983; Lee 1991). Beginning with the 1980II forecast the errors for the over 40s are much smaller. A comparison with Figure 4b indicates that there is only a small degree of compensation of positive and negative errors, because also MAPEs are modest. After correction for bias in the base population, the errors up to ten years ahead become less than one per cent in absolute value, see Figure 4c. Note that age groups 0-4 and 5-9 in Figure 4 have larger errors at a duration of ten years than five years ahead. Indeed, fertility assumptions become more uncertain when forecast duration increases, as was established in Section 3.2. The same can be noted for age group 80+, which is determined by mortality assumptions. The effect is even stronger for developed countries, see below.

Inoue & Yu (1979) found that until the 1965 rounds, the dominant source of error was in the base line data. Starting with the 1965 round, the errors in the base population were relatively small, so that the major source of error was in the forecast assumptions. However, El-Badry & Kono (1986, 39) locate the diminishing importance of base population errors in the 1970s, i.e. a decade later than Inoue & Yu did. These apparently conflicting conclusions must be seen in the light of the revision of data for real trends. Inoue & Yu evaluated the forecasts against data as assessed in 1978, whereas El-Badry & Kono had access to the 1984 assessment. The fact that I have used data as assessed in 1994 explains why, according to my findings, it took even longer than El-Badry & Kono assumed before the errors in the base populations became relatively small. Figure 5 shows that the percentage errors in the base population of world forecasts with base years between 1965 and 1980I are between -4 and +3 per cent for ages up to 35 (with clear cohort effects when subsequent forecasts are compared). For higher ages the pattern is sloping downwards, down to between -4 and -8 per cent for the elderly. The underestimation of the elderly is a consistent feature of the base populations for the forecasts made in the 1960s and 1970s, but it disappears with the 1980II forecast. From then on, errors are between -1 and +1 per cent at almost all ages, and no clear age patterns are present any longer.[12] In case future revisions will lead to even higher estimates for the number of elderly in the world during the 1980s, base population errors of forecasts 1980II and later will become larger than shown here, of course.

[12] The errors in the base populations of the forecasts with base years 1975I and 1985II are very similar to those of 1975II and 1985I, respectively. Hence they are not included in the figure.

Figure 4. Percentage errors in projected age structures. World



Base population for the projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II

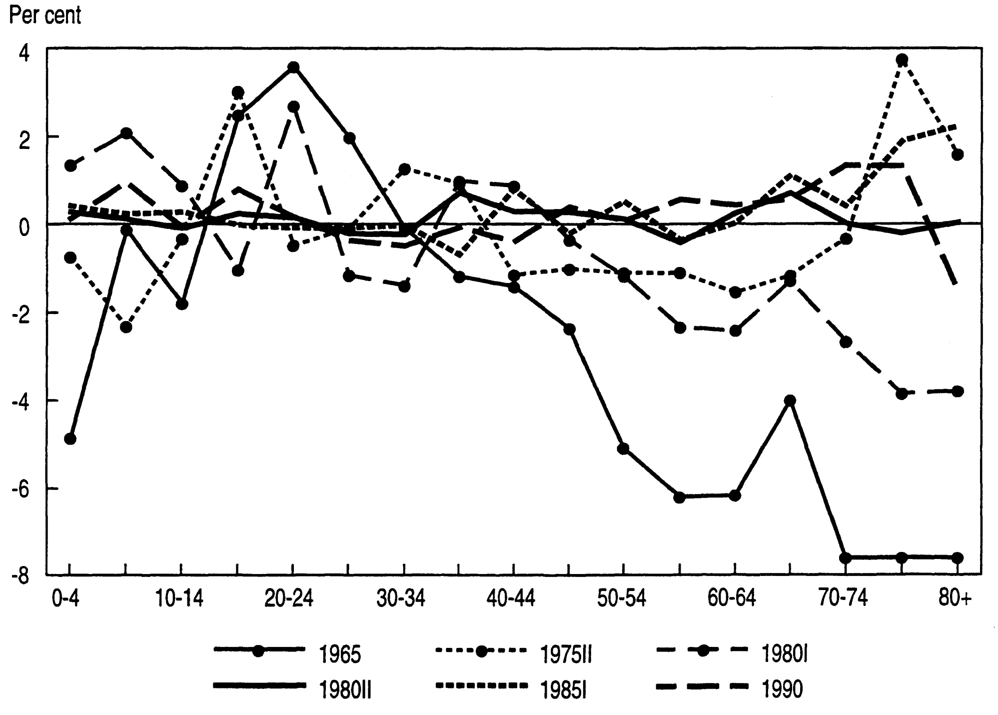
After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II

After 10 years, projections 1965*, 1975II, 1980I and 1980II

After 15 years, projections 1965*, 1975I and 1975II

* Not including the open ended age group 70+

Figure 5. Percentage errors in age-specific base population of world forecasts, by base year



Africa
Young adults (15-40) and older age groups (55-80) have been underestimated in African forecasts since 1965, see Figure A1. The pattern is mildly sloping downwards with advancing age (except for age group 80+). When we correct for errors that are already present in the base population, the resulting error pattern becomes almost flat at a level close to zero (Figures A1c and A1d). Hence the pattern in the MPE in Figure A1a has been caused mainly by errors in the base populations, and much less so by wrong fertility and mortality assumptions in the forecasts.

Asia
Asian forecasts since 1965 have a pronounced error pattern for the age groups over 40, see Figure A2a. After correction for errors in the base population (Figures A2c and A2d), the errors for this age group are more than halved, indicating that wrong mortality assumptions have had less impact than wrong base population data. One explanation for the underestimation of children below 15 up to ten years ahead is too low fertility rates in the four forecasts beginning with 1975II, for which the mean error in crude birth rates has been -1.1 promille points (see Table A9).[13] The birth rates in the five forecasts from 1950III to 1975I were far too high, but two of these (base years 1950III and 1960) lacked age detail and could therefore not be included in the age structure errors. Much of the error for children under 15 in Asia is caused by the births forecasts for India and China, see Tables A18 and A19. Chinese actual birth rates were higher (by 1.9 promille points on average) than those foreseen in the six forecasts beginning with 1975 - for India, the two forecasts with base year 1980 assumed too low birth rates (also 1.9 points on average).

Forecasts for the age structure of China are characterized by large base line errors, underestimations of the age groups 0-10 (between -6 and -15 per cent after a forecast duration of ten years), small errors

[13] Too low infant and child mortality may also have contributed to the error.

up to age 70 (plus or minus one per cent), and rapidly increasing errors for the elderly (up to ten per cent after ten years for the age group 80+). The overestimation of the elderly diminishes somewhat after correction for base population errors, but mortality assumptions have obviously been too optimistic. Since 1965, crude death rates forecasts have been too high by 1.9 promille points on average, although most of these errors show up in the forecasts of 1965 and 1970 (5.1 and 2.7 points, respectively, see Table A15). For later forecasts a clear improvement is visible and the errors are much smaller (1.7 promille points or less).

Europe and Northern America

Quite striking are the relatively large errors for Europe and Northern America since 1965 (Figures A3 and A5). The pattern is familiar from accuracy studies for industrialized countries. It is characterized by strong positive errors (overestimations) at young ages, and equally strong negative errors (underestimations) at more advanced ages. The overestimations among the young in the two regions started around 1965, and were caused by unexpected strong falls in birth rates. The elderly were underestimated because forecasters have been too pessimistic regarding mortality, in particular for women. This pattern has also been established for various individual countries: the United Kingdom, the Netherlands, Canada, Denmark, Norway, and Czechoslovakia (females only; numbers of elderly males were overestimated), see Keilman (forthcoming). Thus not only fertility trends but also those for mortality have been difficult to extrapolate for these countries. The UN-projections for Europe and Northern America are not an exception in this regard. European birth forecasts of 1965 and 1970 were too high by 3 and 2 promille points (Table A10), whereas the average error was 1.5 points (1.7 points for the unsigned errors). The overestimation of birth rates was even stronger in Northern America: 5.7 and 4.7 points for the forecasts of 1960 and 1965 (Table A12), well above the average error of 2.5-3.0 points.

Unforeseen immigration has caused moderate errors at ages between 20 and 30 for the two regions.[14] The negative values indicate that immigration has been underestimated. Because base year populations show only minor errors in Europe and Northern America, corrected errors are not very different from uncorrected errors.

Detailed information about forecasts of the age structure in the United States is only available beginning with the 1975I forecast. But since the US population represented 90-92 per cent of the population of Northern America between 1950 and 1990, the findings reported for Northern America are generally also valid for the USA, see Table A20.

The former USSR

There are two striking features in the error patterns of forecasts for the former USSR in Figure A4. First, the errors are much more irregular than those for other regions, both before and after correction for base population errors. A possible explanation is a sudden recent improvement in data quality. The UN note the problems with mortality data in particular (UN 1995, 25). This issue deserves further analysis. Second, there is a substantial overestimation of the age groups 65 and over. The latter feature is explained by too low death rates used in nearly all forecasts for which we have data. Mortality trends in the former USSR indicated significant health problems already before its dissolution. Between 1970 and 1985, life expectancy stagnated, and for males even declined. These trends came unexpectedly and the earlier levels were not well enough reflected in the available data. The result was that on average, forecasts for crude death rates were 1.5 points too low, see Table A4. This was caused by the forecasts of 1950III and 1960 in particular. More recent forecasts have smaller errors, and the two with base year 1985 have been on target during he years 1985-90.

[14] The underestimation in the age group 15-19 in Northern America is probably due to too pessimistic mortality assumptions, in particular regarding the so-called «accident hump» in the age pattern of mortality.

Latin America

For Latin America (Figure A6), the error pattern for the youngest age groups is similar to that of Europe and Northern America, due to the unforeseen fall in birth rates which started in the mid-1960s. For instance, whereas observed crude birth rates in Latin America fell by 0.3 percentage points during each five year interval between 1960 and 1980, the projected decrease according to the forecasts made between 1960 and 1975 never exceeded 0.13 percentage points for the same period. Errors caused by wrong mortality assumptions are much more moderate than those due to high birth rates, as witnessed by the age groups above 60. Note that the forecasts for adults between 20 and 35 have been too high on average, which indicates that outmigration from Latin America (i.e. South and Central America, and the Caribbean) was higher than expected. At the same time, forecasts for that age group for Northern America (i.e. USA and Canada, plus three small countries with less than 150,000 inhabitants) were too low (see Figure A5), suggesting that at least part of the unforeseen outmigration from Latin America was directed towards Northern America. The UN forecasts do not include assumptions on migration between countries, only net immigration or net emigration for a single country. Therefore this issue could not be analysed further.[15] Note also that the errors for the elderly are of the same magnitude as those for adults between 20 and 35 (when corrected for the errors in the base population). Thus unforeseen outmigration has had the same relative impact on the age group 20-35 as too pessimistic mortality assumptions had on the age group 60 and over.

Oceania

The general pattern of errors in age structure forecasts since 1965 for Oceania is similar to that for Europe and Northern America: too many children (ages 0-10), too few elderly (75+), and quite accurate forecasts for the intermediate age groups, see Figure A7. The underestimation of children at a forecast duration of up to 10 years in Oceania is smaller than that in the other two regions. Was the overestimation of fertility in Oceania less severe than in Europe and Northern America? This is unlikely. The crude birth rates for forecasts since 1965 up to 10 years ahead were too high by 1.0 point on average (Table A14). For Europe and Northern America, the corresponding errors were only 0.6 and 0.9 points, respectively. Thus the overestimation of fertility in Oceania was larger than that in the other two regions - yet the error in the number of children was smaller. I assume that unexpected immigration to Oceania also contributed to the forecast errors for children under 10 years of age. Between 1965 and 1990, the two typical immigration countries Australia and New Zealand represented 77-80 per cent of Oceania's population. Immigration is not included in the forecasts for these countries (nor for the other countries belonging to Oceania). This results, all other things equal, in an underestimation of migration sensitive age groups, i.e. 0-10 and 20-45. For young children, the net result of fertility and immigration was a moderate overestimation. The assumption that unexpected immigration contributed to forecast errors for children under 10 receives some support from the positive errors for age groups 15-19 (5 years ahead only) and 30-44 in Figure A7, although wrong mortality assumptions for these age may have blurred the picture. Due to the lack of reliable migration data this issue could not be analysed further.

A summary view of errors in age structures

A summary view of the errors in age structures is given in Table 10, which contains simple averages (over all age groups) of the age-specific errors in the base populations and for forecasts five and ten years ahead. Thus each line in Figure 4 for the world, and in corresponding figures for the regions, is summarized in just one number. This resulted in Column 1 with average percentage errors. Average absolute percentage errors (Column 2) are obtained on the basis of mean absolute percentage errors by age, again by computing averages over all age groups. Columns 3 and 4 are calculated on the basis of errors in age structures (ages 0-79) corrected for bias in the base population. The averages in Table

[15] For every five-year period since 1955, natural growth in Latin America was slightly higher than total population growth, see UN (1995, 502). If there would be no errors in the measurement of births, deaths and total population, this would indeed indicate net *emigration*. But possible census underenumeration combined with underregistration of births and deaths make it problematic to assess the direction of migration streams this way, let alone the levels.

10 are obviously quite crude for the regions with pronounced age patterns, but they allow us to make an approximate comparison between regions with regard to the errors in age structure forecasts.

Table 10. Average values for errors in forecasts of age structures (per cent)

		Before correction for base population errors		After correction for base population errors	
		Average of percentage errors (1)	Average of absolute percentage errors (2)	Average of percentage errors (3)	Average of absolute percentage errors (4)
Africa	base year	-1.10	2.17	0	0
	5 years ahead	-1.19	2.23	0.07	0.59
	10 years ahead	-1.42	2.65	0.24	1.19
Asia	base year	-0.71	2.21	0	0
	5 years ahead	-0.96	2.54	-0.26	0.65
	10 years ahead	-2.03	3.06	-0.97	1.34
China	base year	1.16	3.97	0	0
	5 years ahead	0.95	4.42	-0.31	0.89
	10 years ahead	0.06	5.04	-0.99	2.19
India	base year	-2.97	5.83	0	0
	5 years ahead	-3.24	6.05	-0.27	1.57
	10 years ahead	-4.98	6.83	-1.47	2.81
Europe	base year	0.18	0.48	0	0
	5 years ahead	-0.19	1.05	-0.09	0.76
	10 years ahead	-0.20	1.96	0.15	1.50
USSR	base year	1.28	3.93	0	0
	5 years ahead	1.07	3.69	0.72	1.24
	10 years ahead	1.66	3.52	1.69	2.36
Northern America	base year	-0.39	0.64	0	0
	5 years ahead	-1.19	1.98	-0.52	1.38
	10 years ahead	-1.48	3.61	0.02	2.35
USA	base year	-0.28	0.53	0	0
	5 years ahead	-1.18	2.00	-0.61	1.40
	10 years ahead	-1.77	3.19	-0.29	1.86
Latin America	base year	-0.22	1.77	0	0
	5 years ahead	0.50	2.01	0.46	0.71
	10 years ahead	1.14	2.31	1.17	1.56
Oceania	base year	0.19	1.13	0	0
	5 years ahead	0.25	1.75	0.48	1.30
	10 years ahead	-0.42	2.52	0.14	1.80
World	base year	-0.30	1.26	0	0
	5 years ahead	-0.62	1.40	-0.10	0.37
	10 years ahead	-1.25	2.01	-0.38	0.68

Age structures in the former USSR and Asia have clearly been more difficult to predict than those in other regions, judging from Column 2. Column 1 demonstrates that population numbers by age in Northern America, Africa, and Asia have been too low on average. For the latter region, this was mainly caused by the strong underestimations for India. Column 2 indicates that age structure forecasts in Africa and in Northern America were only slightly better than those in Asia. European age structures have been easiest to forecast. However, this was mainly due to the better data quality for the base population in this region, a feature that Europe shares with the USA, and, to a certain extent, also Oceania. Column 4 suggests that European errors in the age structure caused by wrong assumptions are on average much larger than those for the world as a whole. They are lowest in Africa and Asia, and highest in India, Northern America, and the former USSR.

Errors increase with forecast duration in all regions except the USSR. The errors in Column 2 indicate that forecast uncertainty starts at a low level and increases quickly in Europe and in the USA. On the other hand, in Africa, Asia and Latin America the errors begin at a much higher level due to problems with the base population, but grow more slowly. When a correction is made for errors in the base population (Column 4), it turns out that the increase in forecast uncertainty is modest for a group of regions consisting of Africa, Asia, Europe, and Latin America. India is an outlier in Asia in this respect: after ten years, the average error is 2.8 per cent, which is nearly more than twice as high as that in the whole of Asia (and three times as high as the corresponding error for the world).

3.4. Dependency ratios

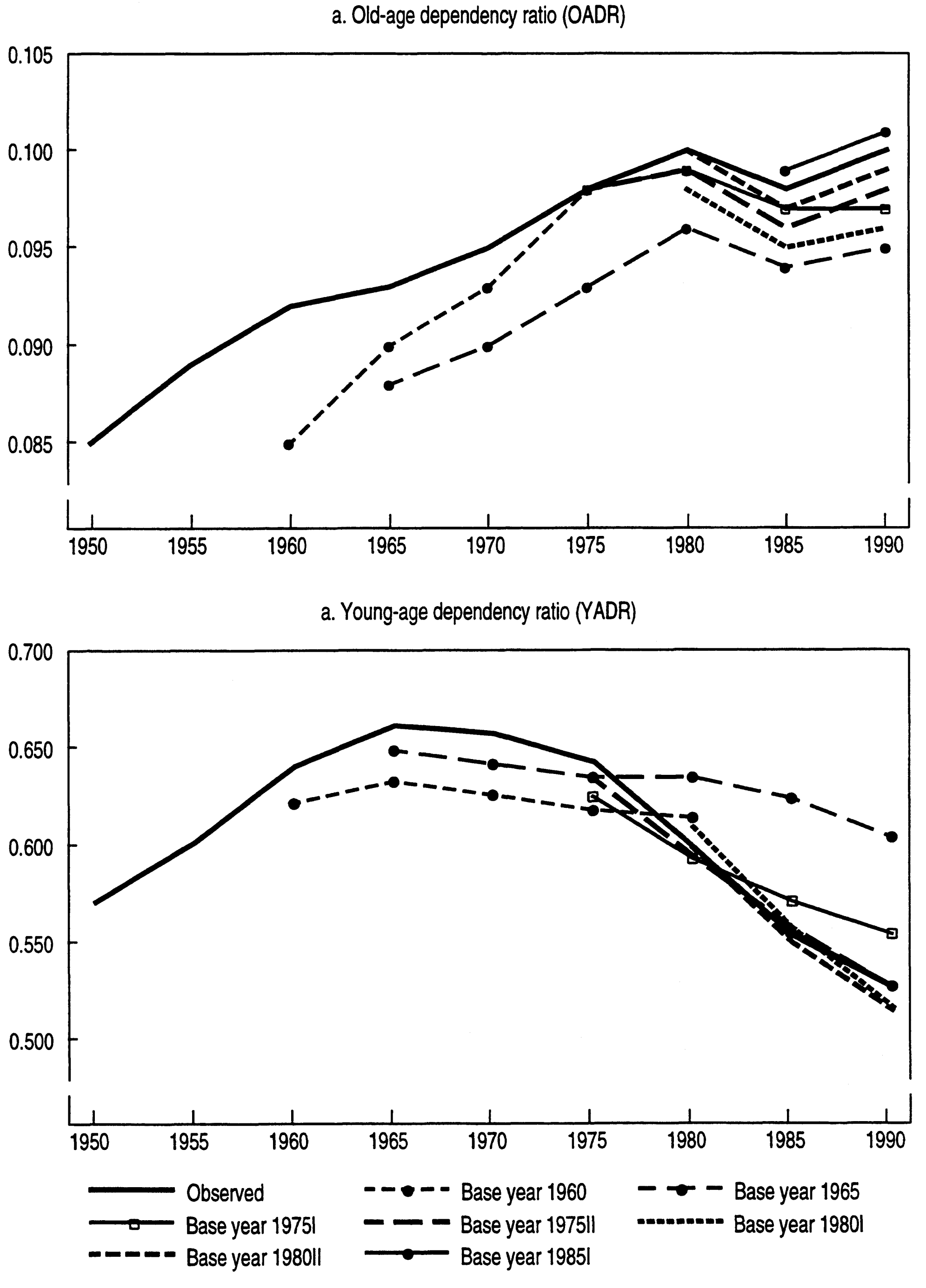
An important indicator that summarizes a population's age structure is the dependency ratio, which relates the number of persons under 15 (young age dependency ratio) or 65 and over (old age dependency ratio) to the number aged 15-64 (or slightly different dividing lines between young, adult and elderly age brackets). Surprisingly, given their relevance for policy purposes, very little attention has been given to the forecast accuracy of these dependency ratios.

This report includes figures for the old-age dependency ratio (OADR) and the young-age dependency ratio (YADR) for the world (Figure 6), as well as for the seven regions (Figures A8-A14 in the Appendix). I shall mainly comment on the findings for the world and for Europe and Northern America, the two regions with an aged population. Because of the lack of age detail in the forecasts made in the 1950s and the one with base year 1970, these are not included in the figures. I also left out the 1985II-forecast as its dependency ratio values are very close to those for the forecast with base year 1985I.

Although Figures A3 and A5 suggest large overestimations of young age groups and large underestimations for the elderly in Europe and Northern America, these errors are relative to the actual value of each age group. The dependency ratio, however, relates each of the two age groups to the (much larger) population of working ages, and the forecast accuracy of the dependency ratios may well be fairly high. This is indeed the case for the world's OADR-projections, which were accurate by half a percentage point for projections starting in 1975 or later, see Figure 6.[16] The OADR for Europe (Figure A10) is much more accurate than that for Northern America (Figure A12), for which the predictions have been too low by approximately one percentage point until 1980II. The explanation is the smaller errors in death rates in Europe, see Section 3.2. Young age dependency ratios for the whole world clearly reflect the unforeseen declines in birth rates, in particular in Latin America and Northern America. Since 1975, the YADR has been quite accurate in Asia, Europe, USSR, and Oceania.

[16] The small dip in observed and projected OADRs in 1985 is explained by developments in Europe (see Figure A10), notably the strong fluctuations in fertility at the end of the first world war and in the years immediately thereafter (see Chesnais 1992, Appendix 1). General optimism that the war was over should have led to an increase in fertility in 1918 and 1919, but the Spanish Flu in the same years took its toll. Marriage dissolution by the death of one or both spouses led to fewer conceptions than expected. At the same time, pregnant women and infants had high death rates due to the pandemic (Åman 1990). The result was that birth cohorts 1918 and 1919 are relatively small in many countries, and this is still visible in the age structure. Presumably the same is the case for the former USSR, but empirical evidence is lacking here.

Figure 6. Observed and projected dependency ratios. World



4. Conclusions and recommendations

When compared with ex-post observed real trends, the twelve sets of populations projections that the United Nations prepared between the 1950s and the end of the 1980s show a clear tendency over time towards better accuracy. Part of this improvement is due to better data for base populations. The number of elderly persons for the world as a whole has been systematically underestimated by up to 8 percentage points in the base populations for the forecasts made in the 1960s and 1970s. This feature disappeared in the 1980s, when errors in the world's base population became as small as between -1 and +1 per cent in almost every five-year age group. Not only the base population, but also implied crude death rates have become more accurate: forecast errors for the CDR were particularly large in the 1950s and 1960s. On the other hand, errors in long term (10-15 years) crude birth rate forecasts were still at a relatively high level up to the period 1980-85.

Not surprisingly, there is considerable regional heterogeneity in the accuracy of the UN projections. Even on the very aggregate level of only seven major regions (Africa, Asia, Europe, the former USSR, Northern America, Latin America, and Oceania) and a few large countries (India, China, and the USA) the differences are clear. Mortality has been relatively difficult to project in Africa and Asia. The mean error in crude death rates, computed over all forecasts and the whole period 1950-1990, was higher by one third and by half, respectively, in these two regions, compared with the error for the world as a whole. But these mortality errors for Africa and Asia must have been spread more or less evenly over the age groups, because the projected age structures for these two regions do not show any larger errors for adult and elderly persons than those for the world as a whole. The poor quality of mortality data in the 1950s and 1960s has led to a strong regional correlation in mortality errors between Africa, Asia and Latin America. Concerning fertility, errors in crude birth rates for Asia (+ 40 per cent), Northern America (+ 30 per cent), Latin America (+ 57 per cent), and Oceania (+ 4 per cent) are above the world average. Because Europe, Northern and Latin America, and Oceania experienced a steep and largely unforeseen fall in their birth rates in the recent past, there are strong regional correlations in birth rate errors between these four regions.

The mean errors in the world's projected age structures are very modest: around 2 per cent on average for five year age groups even when the forecast period is 10 years. Asia has a pronounced error pattern for the age groups over 40, due to an underestimation in the base population. Quite striking are the relatively large errors for Europe and Northern America: strong positive errors at young ages caused by unforeseen declines in birth rates in the 1960s and 1970s, and equally strong negative errors at more advanced ages, for which forecasters have been too pessimistic regarding mortality. The same pattern has been established for the accuracy of age structures projected by statistical agencies in a number of individual countries. Latin America has also experienced a rapid fall in birth rates between 1960 and 1980, and this shows up as errors for the youngest age groups at similar levels as those for Northern America. Unforeseen outmigration from Latin America has had some impact on the age group 20-35. On the whole, age structures in the former USSR and in Asia have been more difficult to predict than those in other regions. The fact that errors were smallest in Europe is mainly due to relative good data quality for the base year populations and not so much due to better assumptions concerning mortality and fertility. Indeed, average errors in European age structures caused by wrong assumptions alone are relatively high (1.5 per cent at a forecast duration of 10 years) - larger than those for the world as a whole (0.7 per cent). They are lowest in Africa (1.2 per cent) and Asia (1.3 per cent), and highest in India (2.8 per cent), Northern America, and the former USSR (both 2.4 per cent).

Too low projections for young adults (15-34) in Europe and Northern America are probably due to unforeseen immigration - for Latin America we can see an overestimation in these age groups. The more detailed treatment of international migration in the most recent (base year 1990II) set of UN projections will hopefully reduce the errors in this age group in current and future projections. On the other hand, the notoriously bad quality of migration data leads to not too much optimism. At the same time one should take into account that too high or too low levels for the accident hump in the age pattern of mortality might also have contributed to the under- and overestimations of numbers of young adults.

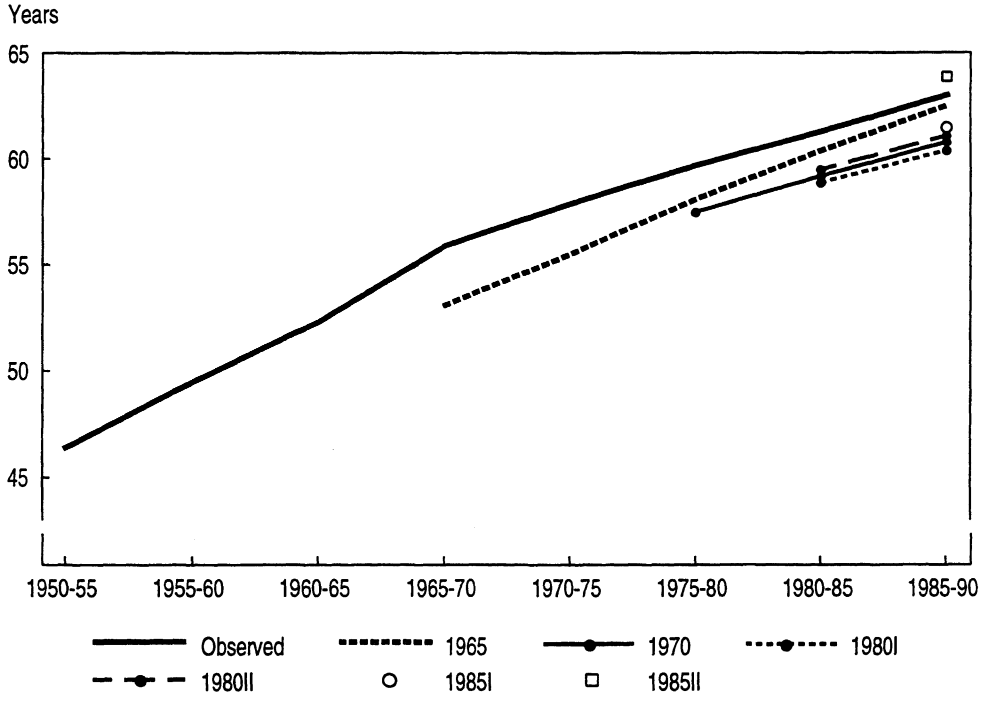
There are two main factors that have had a strong impact on the accuracy of the United Nation's projections. The first is the quality of the data regarding real trends. Among others, this shows up in large errors in the base year population for projections made in the 1960s and 1970s, in particular for Africa, Asia (both the region as a whole and China and India), and the former USSR. The second important factor is a sudden change in real trends. The unexpected fall in birth rates in Europe, the Americas and Oceania during the 1960s and 1970s was already referred to above. But also the fact that improvements in life chances stagnated in many industrialized countries in the 1960s shows up in projection errors, viz. errors regarding death rates and numbers of elderly in Europe and Northern America.

For an appropriate appreciation of the findings in this report one has to remember that not only the forecasts, but also data on actual population trends are uncertain. Future revisions for countries with poor data for the period 1950-1990 may lead to different conclusions. Hence my findings should be interpreted with caution.

How can the errors observed for historical forecasts be used when one tries to assess the uncertainty connected to the current or future forecasts made by the United Nations? Can we simply assume that forecasting today is as difficult as it was in the past, and use the historical errors? At first sight, this would be too conservative. After all, there is a clear improvement in accuracy over time. Base line errors have become less important for developing countries, and for the developed countries there is no sign that the dramatic fall in birth rates that occurred in the 1960s and 1970s will repeat itself, or that it will be reversed. Yet we have to be prepared for surprises. The UN-projections, as most projections produced by official agencies, are surprise-free. They are based on an assumption of steady social and economic developments. In reality we have seen that unanticipated trends can suddenly show up. The decline in life expectancy in Central and Eastern Europe is an example. Migration from countries struck by war, famine or simply unfavourable economic development is another case in point. As a consequence it would be good to keep the historical errors in mind when we make a best guess today of the predictability of the world's population. Simply considering the UN's low, medium and high variants is not enough, as these do not take account of errors in mortality, migration or base population data - only uncertainty around fertility levels are included. Therefore I conclude with two recommendations on projection variants.

A first recommendation is that the UN consider to include more than one variant for mortality. A comparison between observed and projected life expectancies at birth in Figure 7 shows that mortality assumptions have almost invariably been too pessimistic. With the exception of the 1985II-series, projected life expectancies were lower than observed ones. But we also see that there was not a systematic lag between observed and projected values. For instance, the life expectancies contained in the 1965-projections come closest to observed ones, whereas those of the projections with base years between 1970 and 1985I are much lower. As late as 1985I, the underestimation was 1.5 years for the period 1985-90. Two years later when the 1985II-projections were prepared, the assumed level was suddenly too high by 0.9 years. In summary, Figure 7 shows clearly how difficult it is to extrapolate mortality. At the same time, this component can cause important errors in forecast results. The findings in this report show clearly that errors are relatively large for the elderly in Europe, Northern America, and the former USSR. For the near future, the AIDS epidemic only adds to the uncertainty as no national life tables that include AIDS-induced mortality are yet available for high-prevalence countries.

Figure 7. Life expectancy at birth, observed and projected. World



Thus difficulties with extrapolation together with considerable impact on the results should lead the UN to consider including several sets of mortality assumptions, for instance a low, a medium and a high set of life expectancies. High, medium and low sets of projection results can be prepared for each country by combining high fertility with high life expectancy, medium fertility with medium life expectancy, and low fertility with low life expectancy. Then the high and low projection variants can still be "... thought to bracket the probable range of future population change for each country ..." (UN 1993, 84), as is the case with the variants in current UN-forecasts.

Several other agencies that prepare official population projections work with more than one mortality variant, and their number is increasing. For instance, a survey among 30 statistical agencies in industrialized countries carried out in the mid-1980s showed that eight of these prepared several mortality variants (Hämäläinen 1992, 82). Four of the fifteen countries that currently make up the European Union did so at that time. By 1994, nearly half of these EU-countries worked with more than one mortality variant (Cruijsen & Keilman 1994).

A second suggestion is to include base population variants for countries for which such data are not reliable. The forecasts since 1965 for which we have data showed considerable errors in the base population of Africa, Asia (including China, and, in particular, India), and the former USSR. Although the situation clearly has improved over time, the available data for a number of developing countries are still of poor quality. The UN Demographic Yearbooks of 1952, 1953 and 1954 do not give one single number for the estimated mid-year population of the world as of 1950, but a range. This was the result of the considerable uncertainty around the actual figures. The same can be done today for those countries for which recent estimates for the population by age and sex are deemed unreliable. A low, medium and high variant of the base population would then reflect the uncertainty that exists already from the very beginning of the forecast period.

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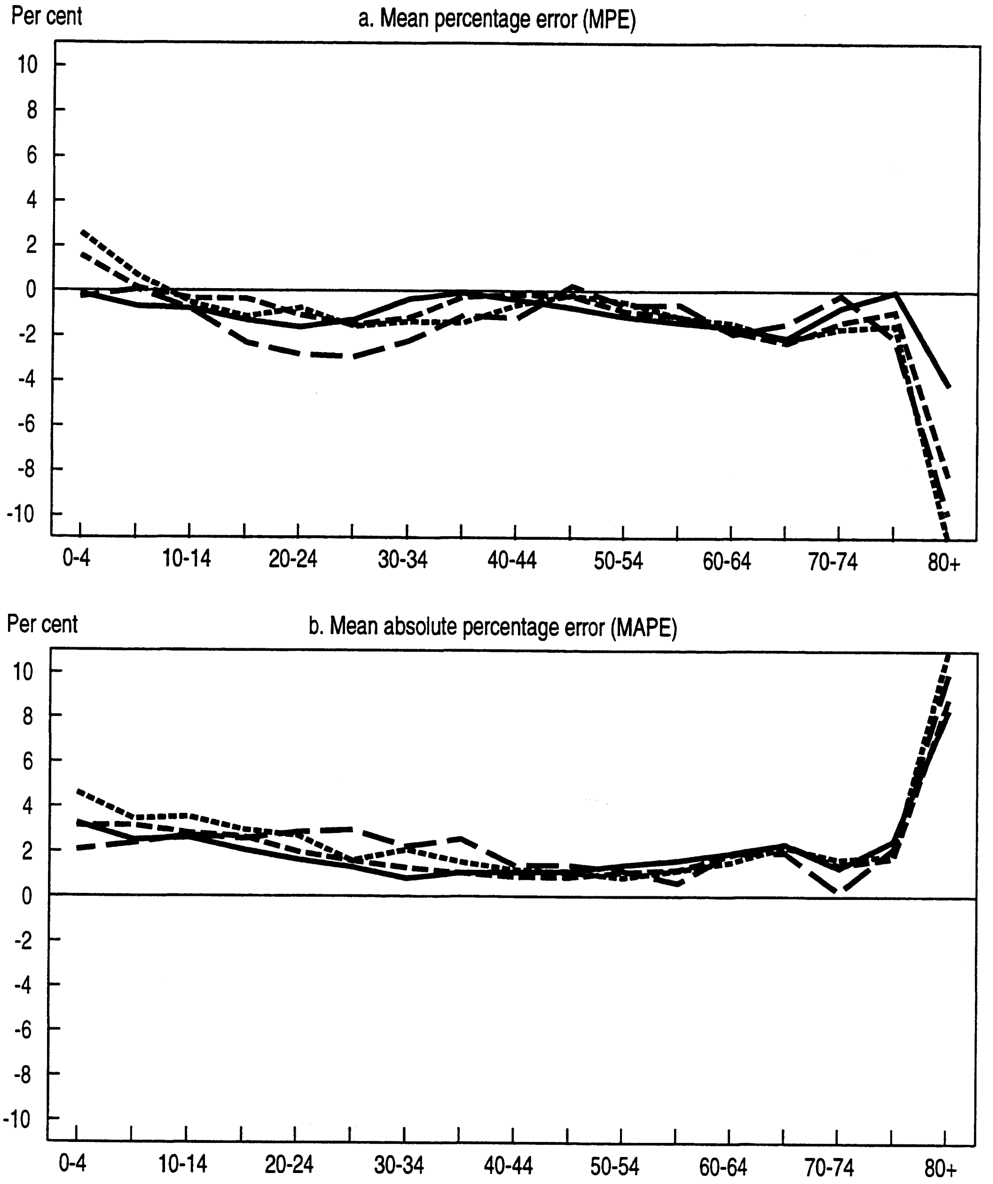
Figures and tables by region

Figure A1. Percentage errors in projected age structures. Africa



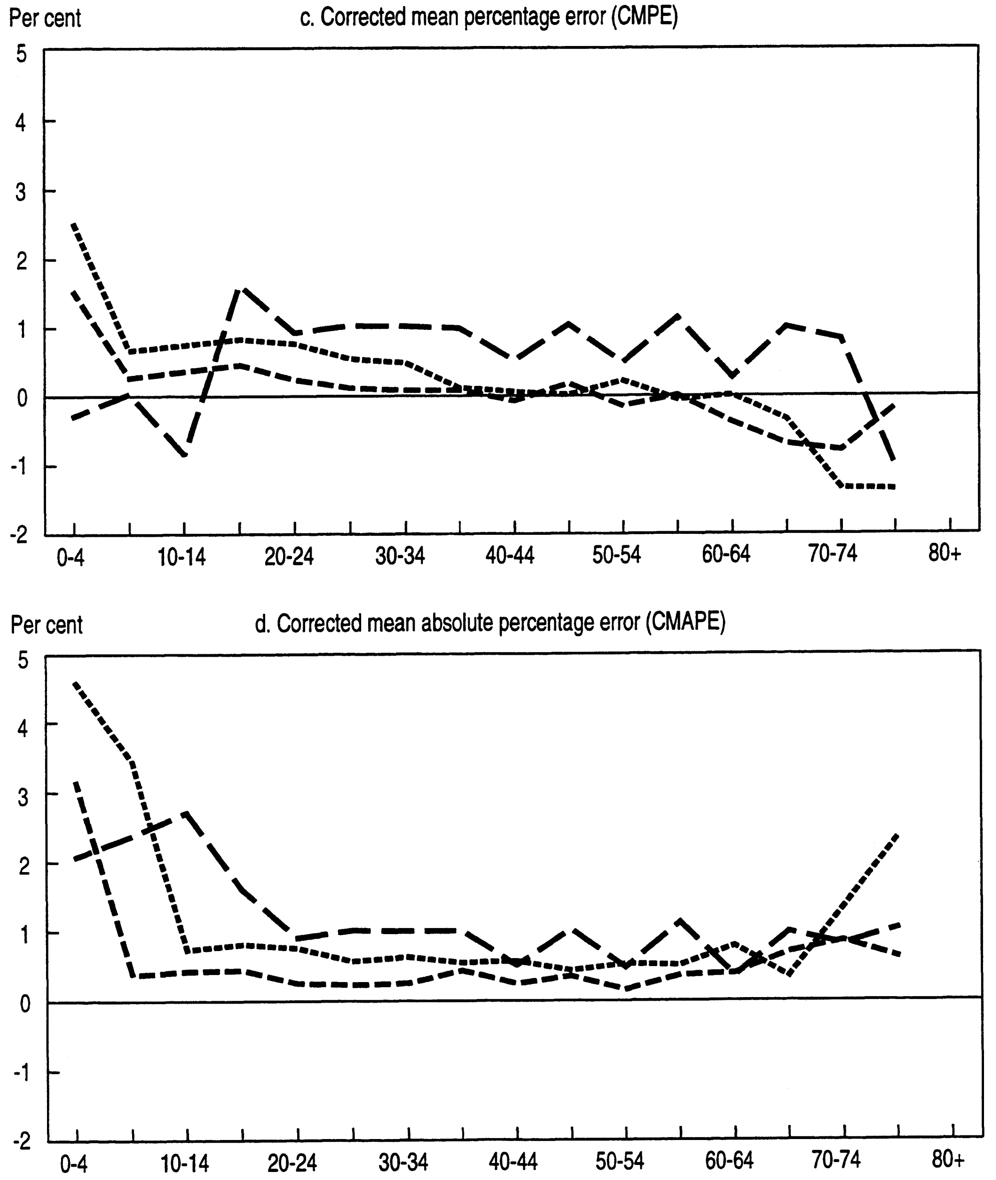
Base population for the projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II

After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II

After 10 years, projections 1965*, 1975II, 1980I and 1980II

After 15 years, projections 1965*, 1975I and 1975II

* Not including the open ended age group 70+



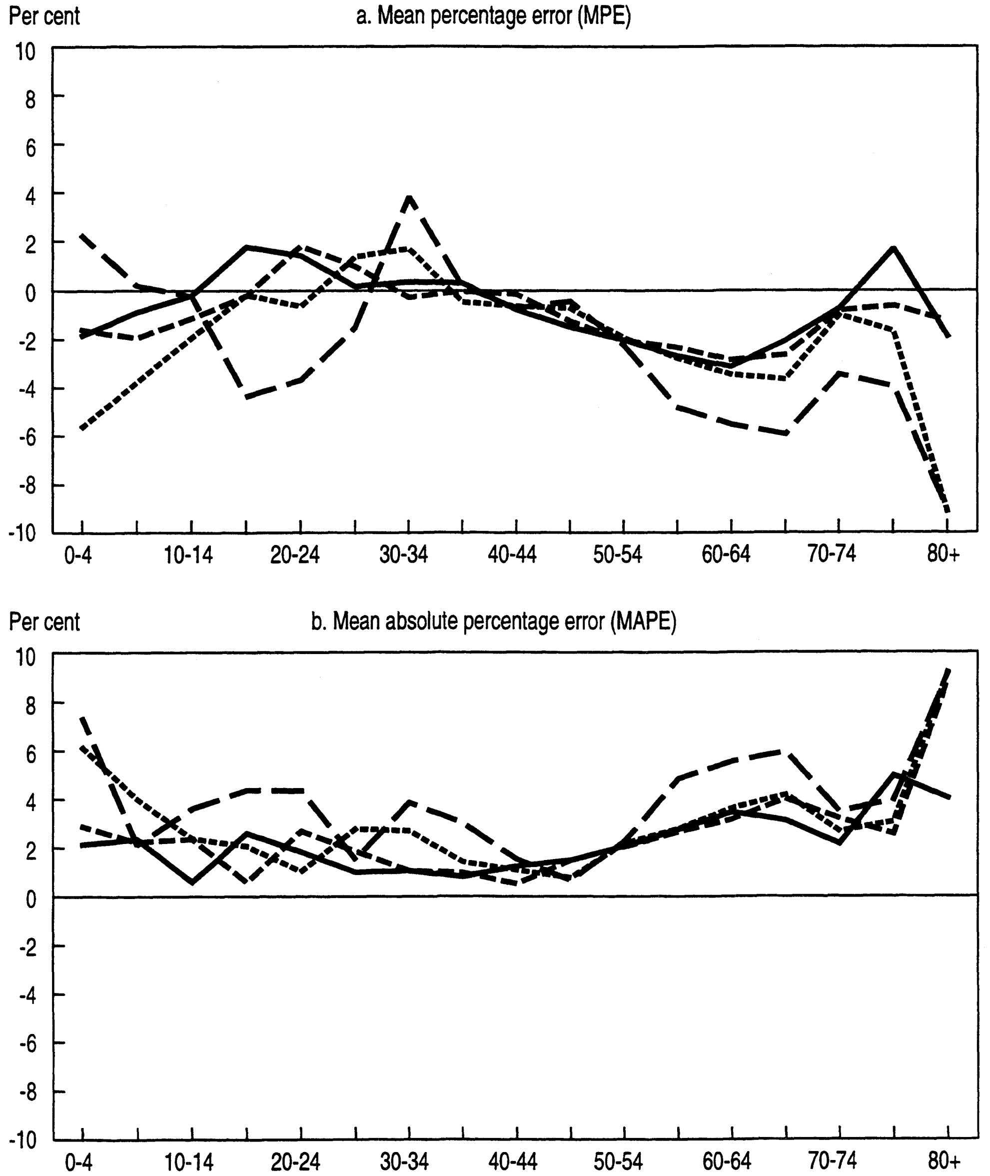
After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II

After 10 years, projections 1965*, 1975II, 1980I and 1980II

After 15 years, projections 1965*, 1975I and 1975II

* Not including the open ended age group 70+

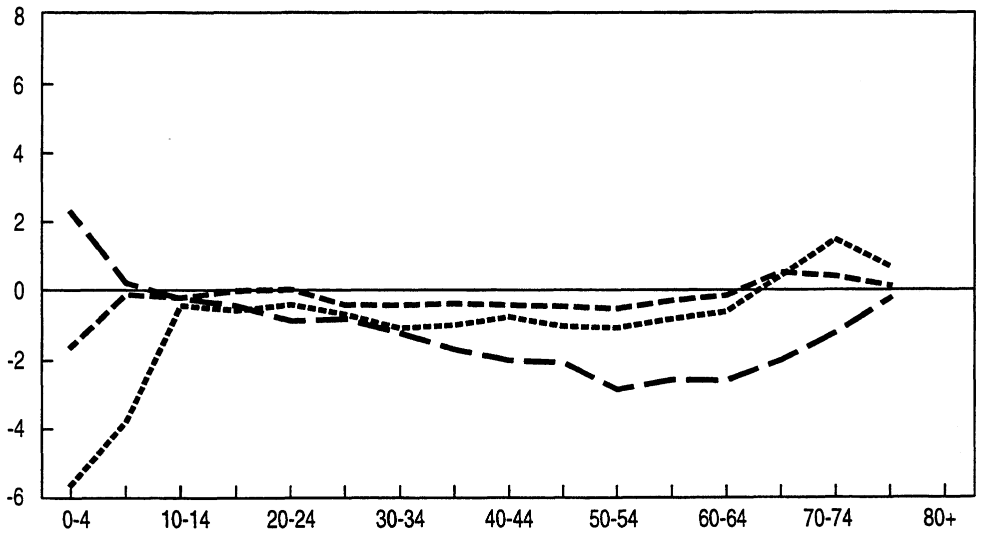
Figure A2. Percentage errors in projected age structures. Asia



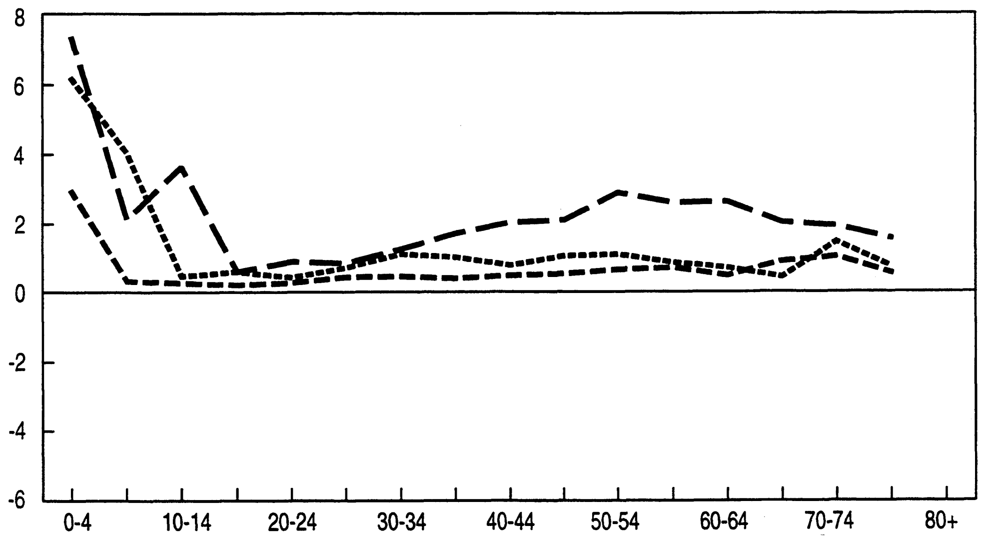
Base population for the projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II
After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II
After 10 years, projections 1965*, 1975II, 1980I and 1980II
After 15 years, projections 1965*, 1975I and 1975II

* Not including the open ended age group 70+

Per cent c. Corrected mean percentage error (CMPE)



Per cent d. Corrected mean absolute percentage error (CMAPE)



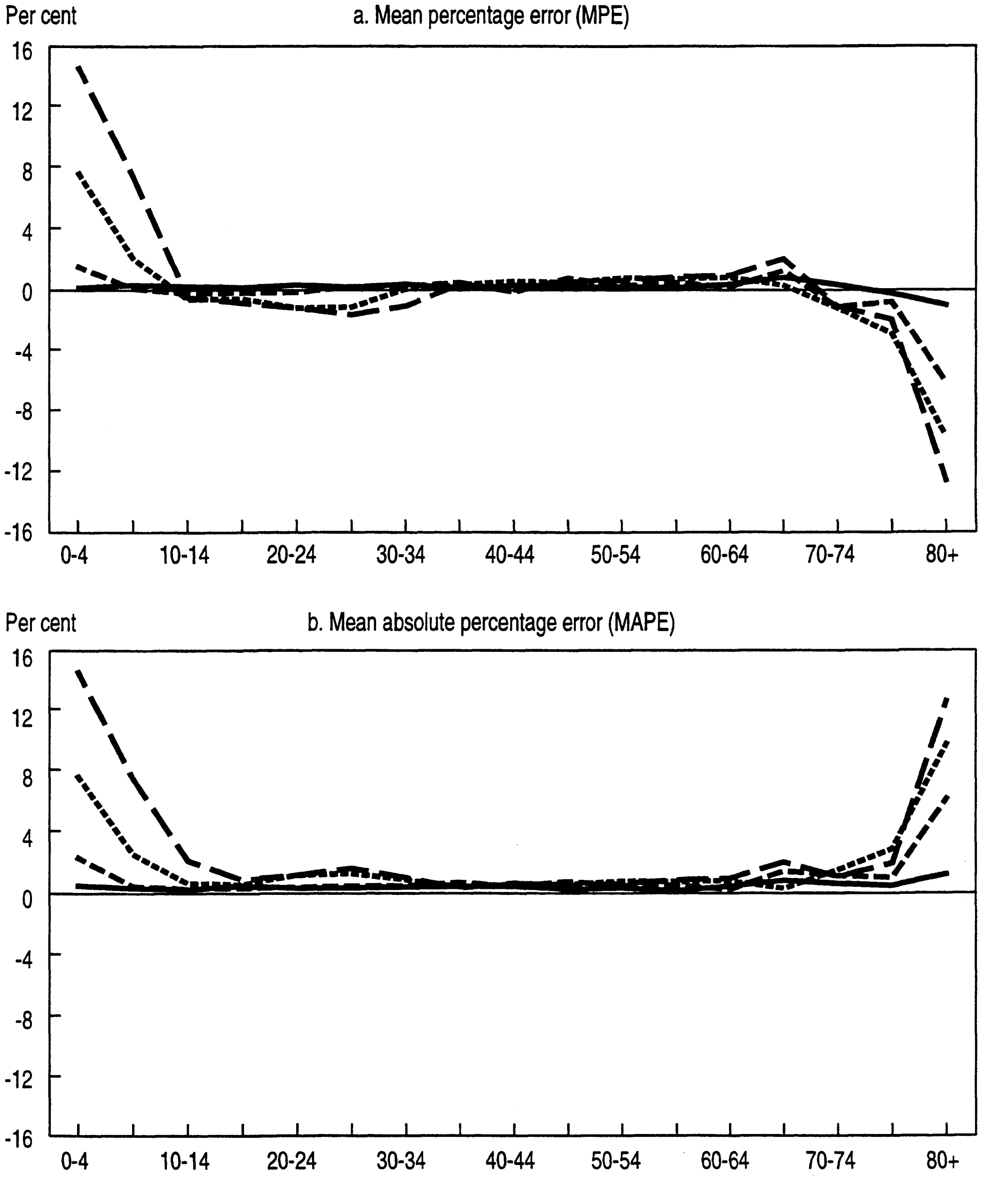
After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II

After 10 years, projections 1965*, 1975II, 1980I and 1980II

After 15 years, projections 1965*, 1975I and 1975II

* Not including the open ended age group 70+

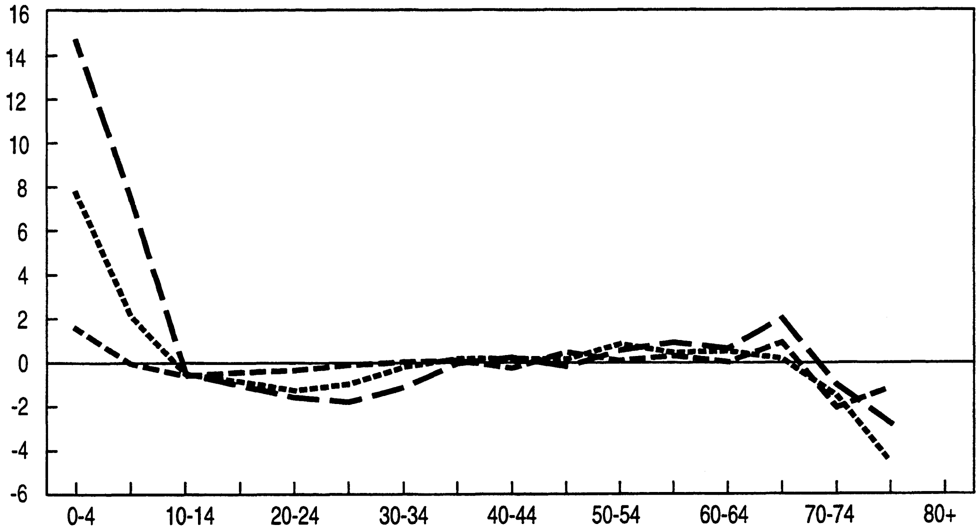
Figure A3. Percentage errors in projected age structures. Europe



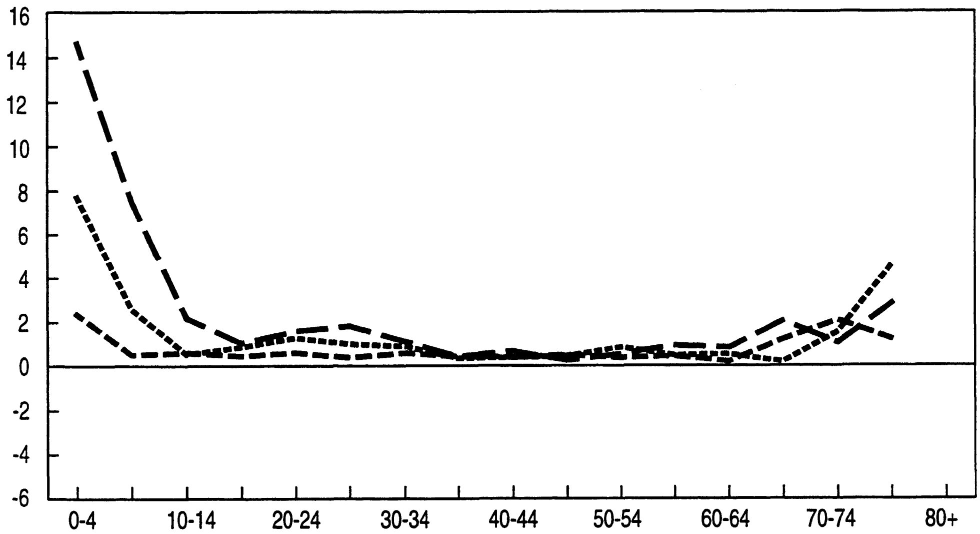
Base population for the projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II
After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II
After 10 years, projections 1965*, 1975II, 1980I and 1980II
After 15 years, projections 1965*, 1975I and 1975II

* Not including the open ended age group 70+

Per cent c. Corrected mean percentage error (CMPE)



Per cent d. Corrected mean absolute percentage error (CMAPE)



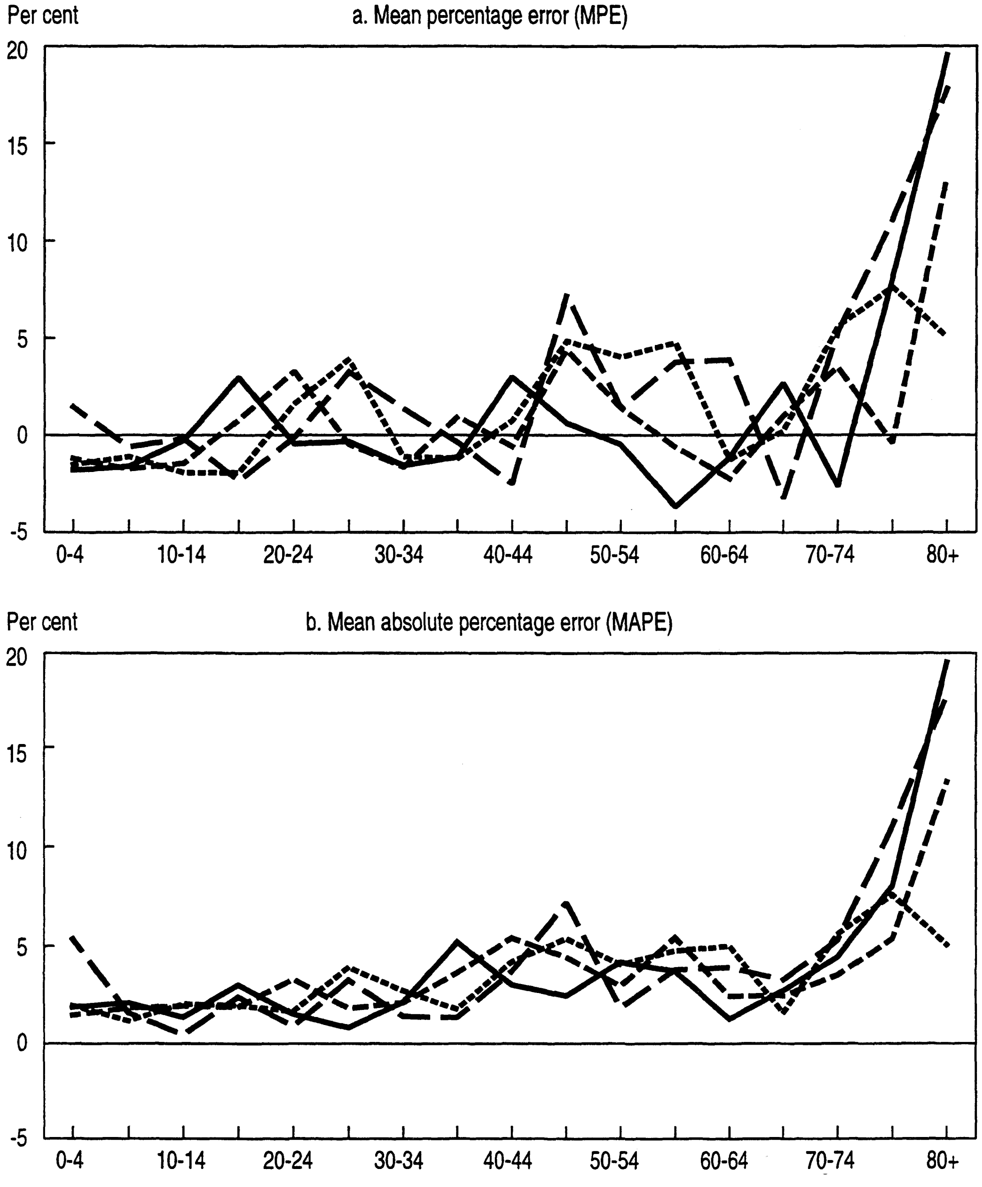
After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II

After 10 years, projections 1965*, 1975II, 1980I and 1980II

After 15 years, projections 1965*, 1975I and 1975II

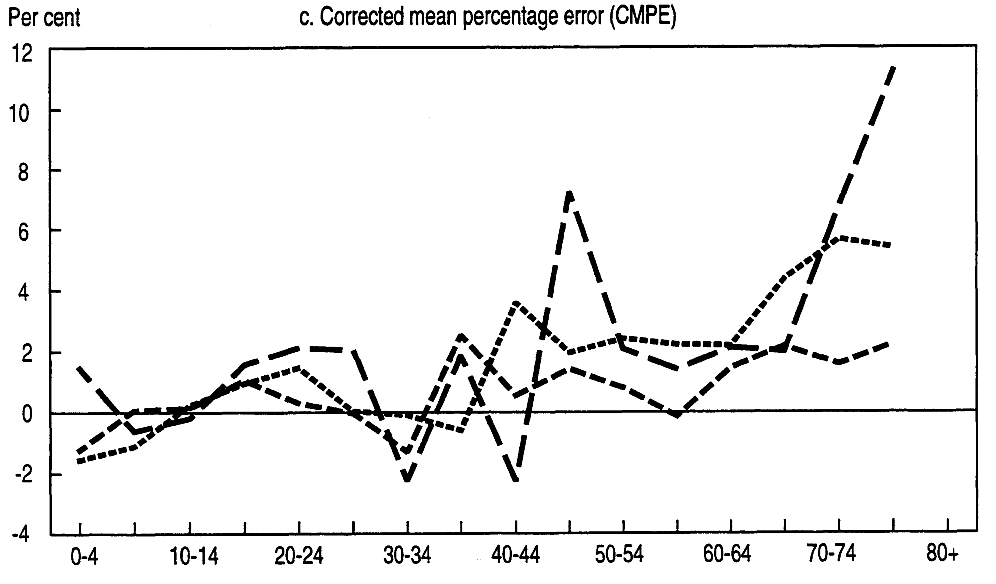
* Not including the open ended age group 70+

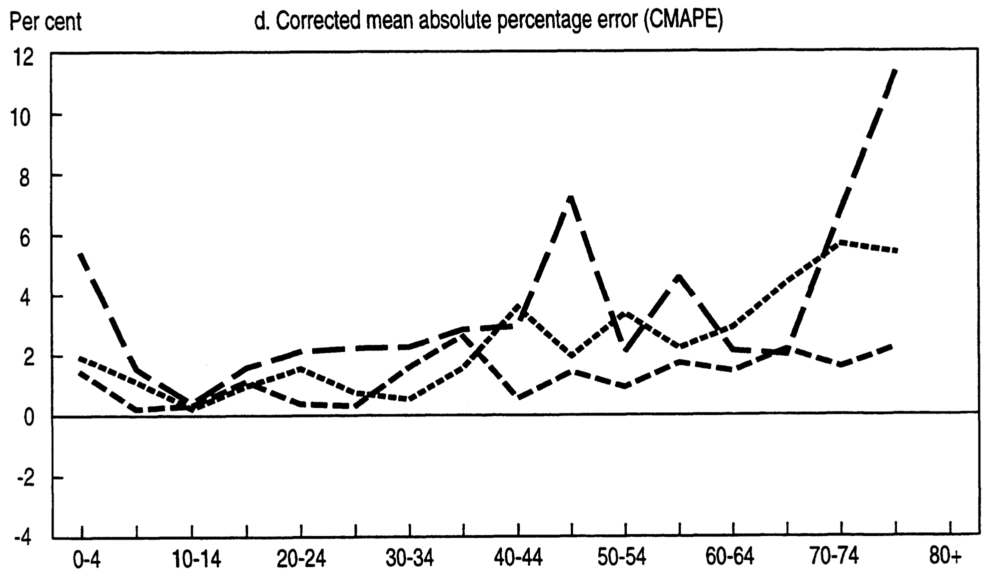
Figure A4. Percentage errors in projected age structures. USSR



Base population for the projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II
After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II
After 10 years, projections 1965*, 1975II, 1980I and 1980II
After 15 years, projections 1965*, 1975I and 1975II

* Not including the open ended age group 70+

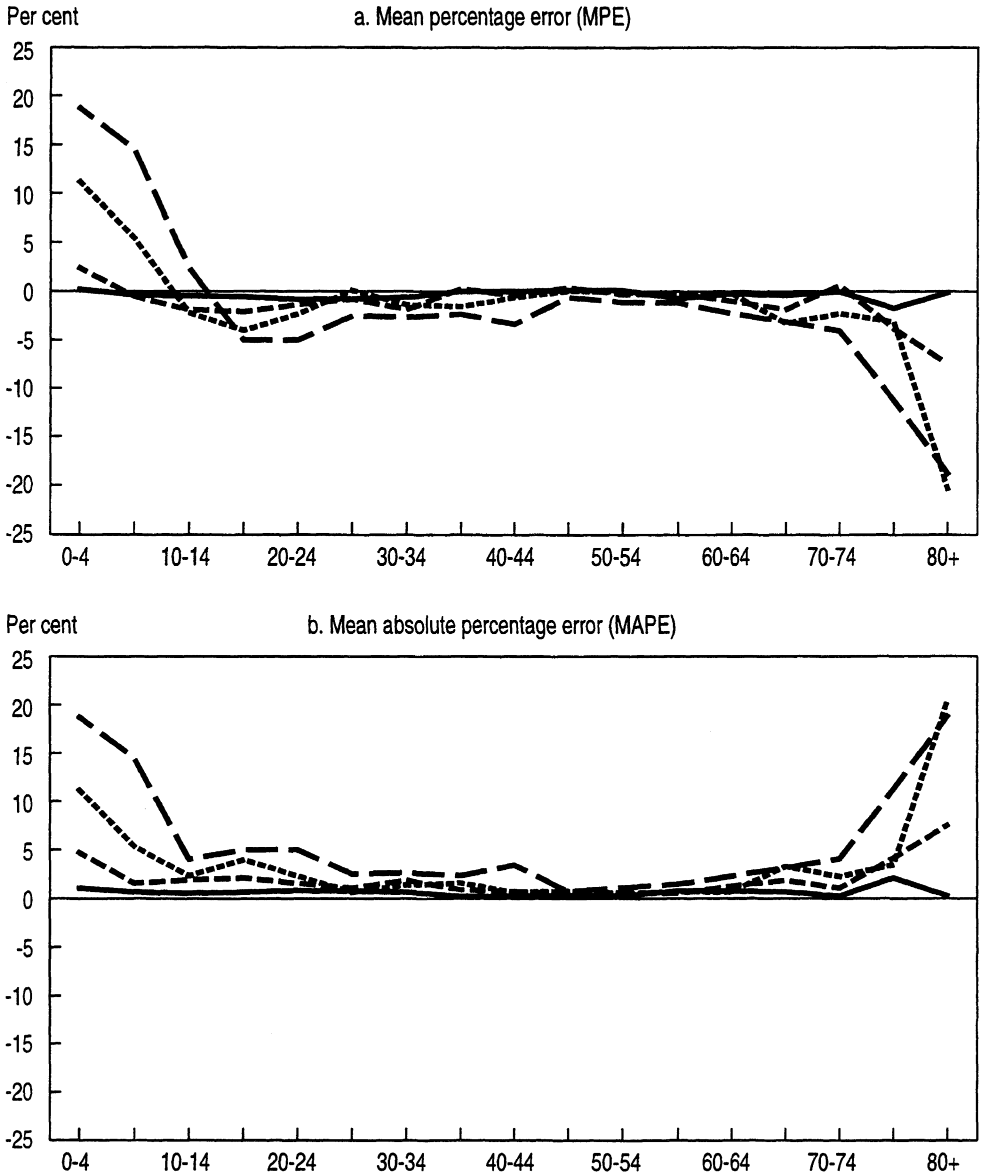




- - - - - After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II
.... After 10 years, projections 1965*, 1975II, 1980I and 1980II
— — — After 15 years, projections 1965*, 1975I and 1975II

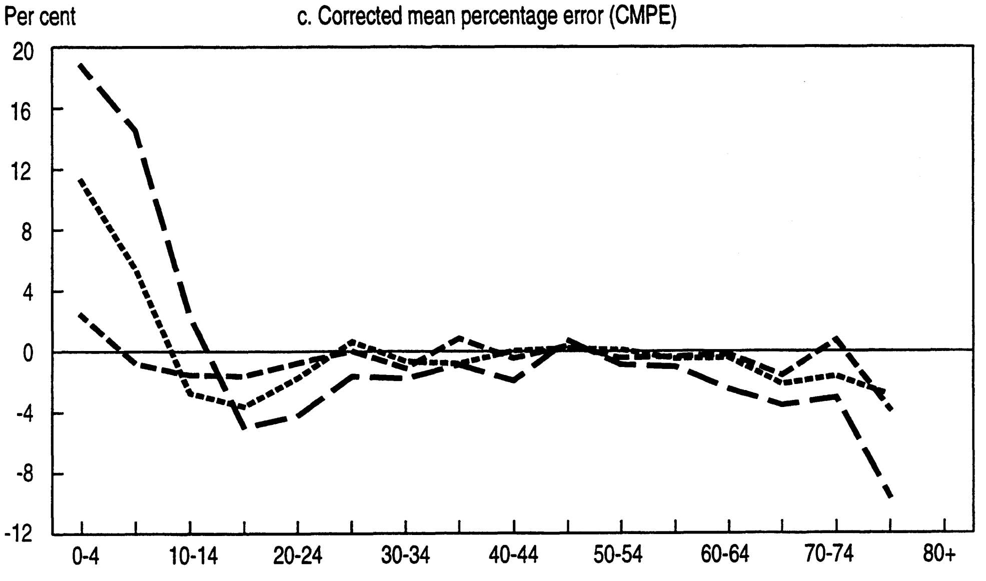
* Not including the open ended age group 70+

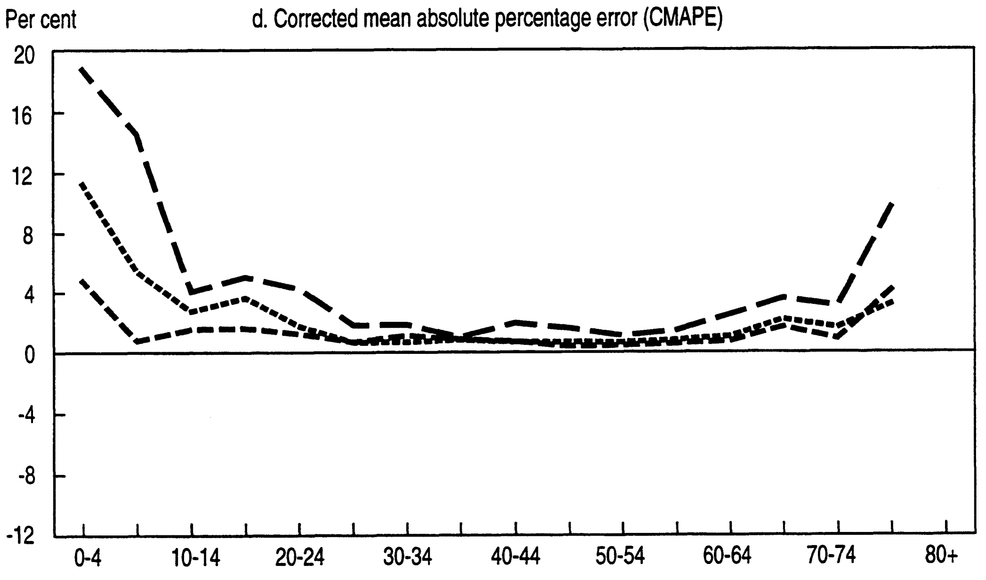
Figure A5. Percentage errors in projected age structures. Northern America



Base population for the projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II
After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II
After 10 years, projections 1965*, 1975II, 1980I and 1980II
After 15 years, projections 1965*, 1975I and 1975II

* Not including the open ended age group 70+





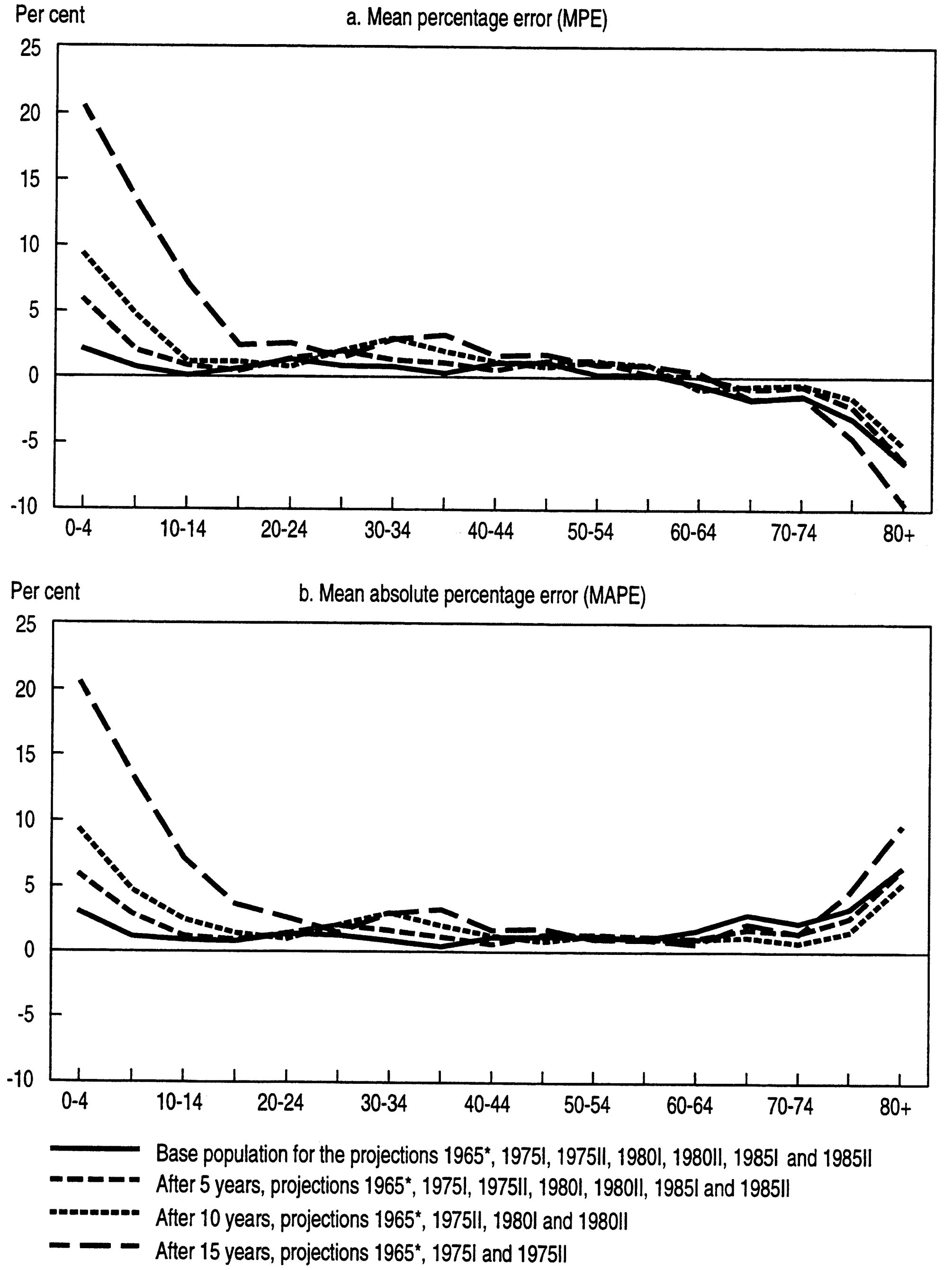
After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II

After 10 years, projections 1965*, 1975II, 1980I and 1980II

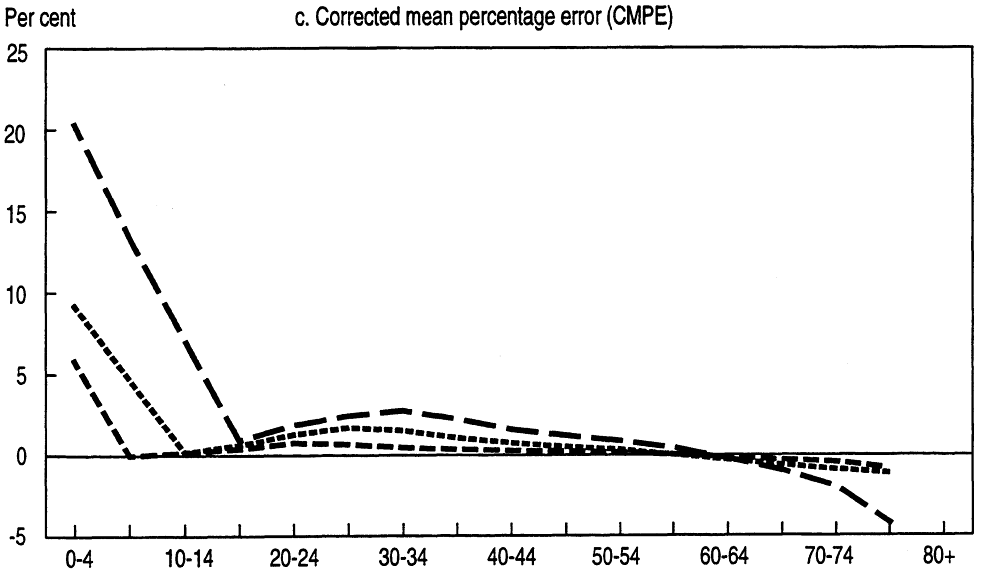
After 15 years, projections 1965*, 1975I and 1975II

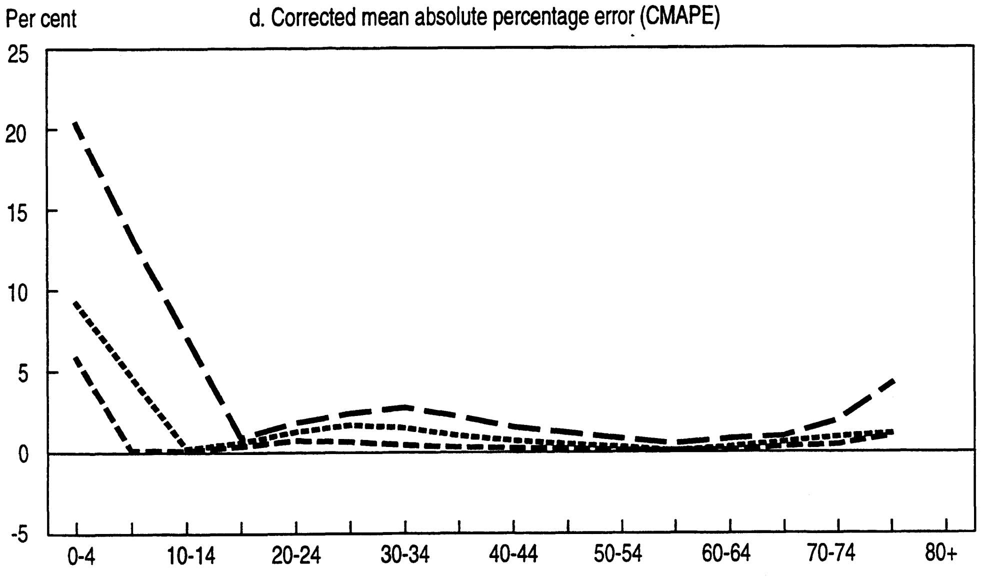
* Not including the open ended age group 70+

Figure A6. Percentage errors in projected age structures. Latin America



* Not including the open ended age group 70+





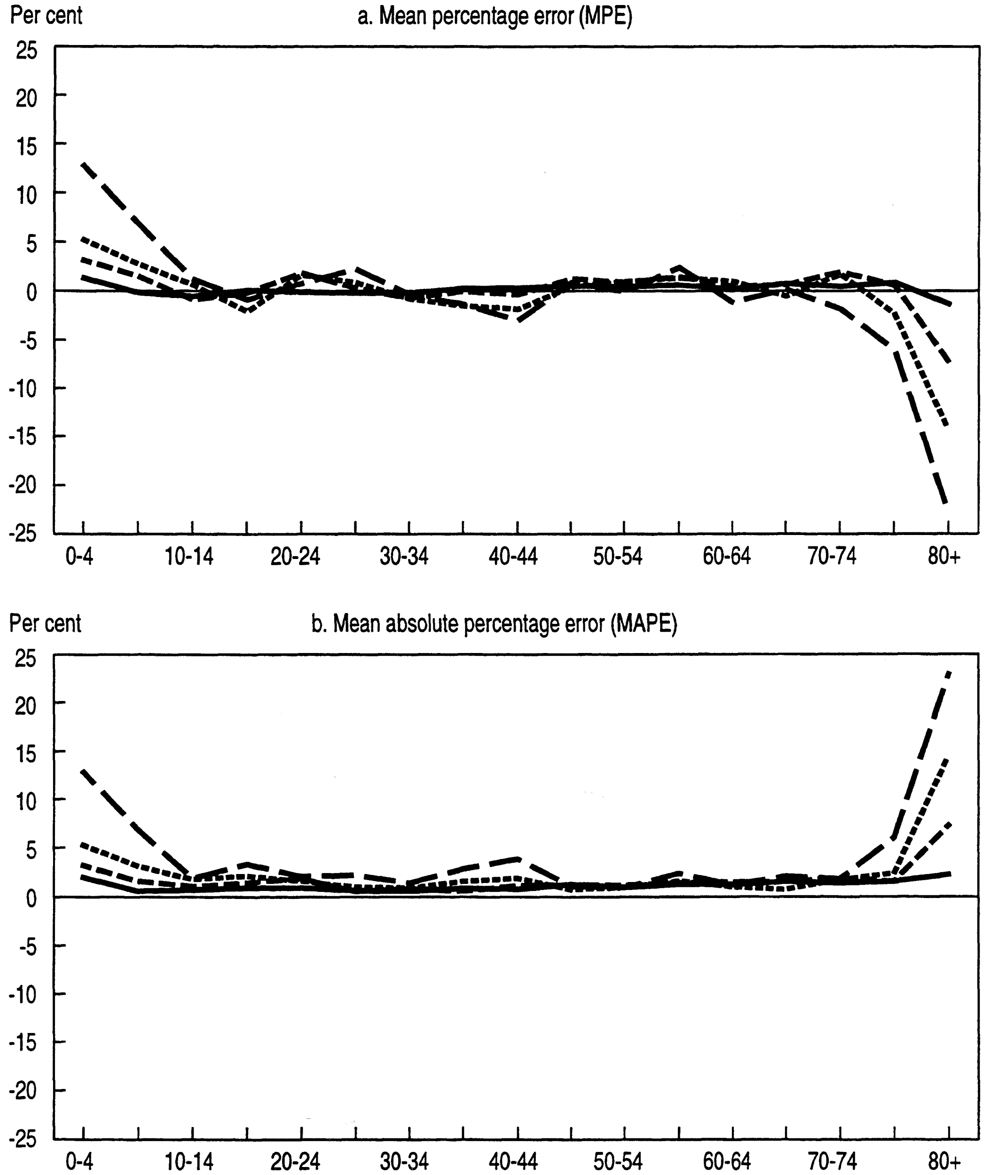
After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II

After 10 years, projections 1965*, 1975II, 1980I and 1980II

After 15 years, projections 1965*, 1975I and 1975II

* Not including the open ended age group 70+

Figure A7. Percentage errors in projected age structures. Oceania



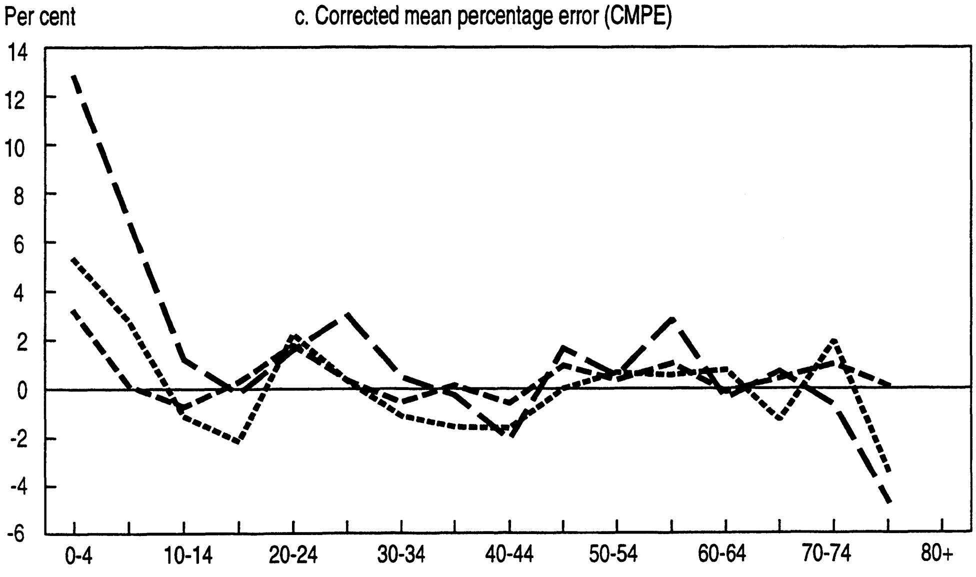
Base population for the projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II

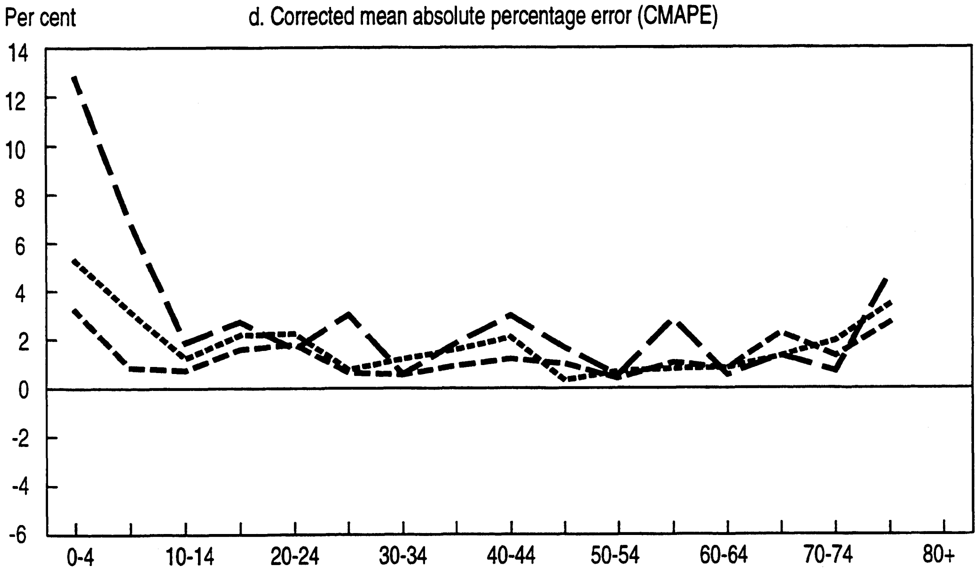
After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II

After 10 years, projections 1965*, 1975II, 1980I and 1980II

After 15 years, projections 1965*, 1975I and 1975II

* Not including the open ended age group 70+





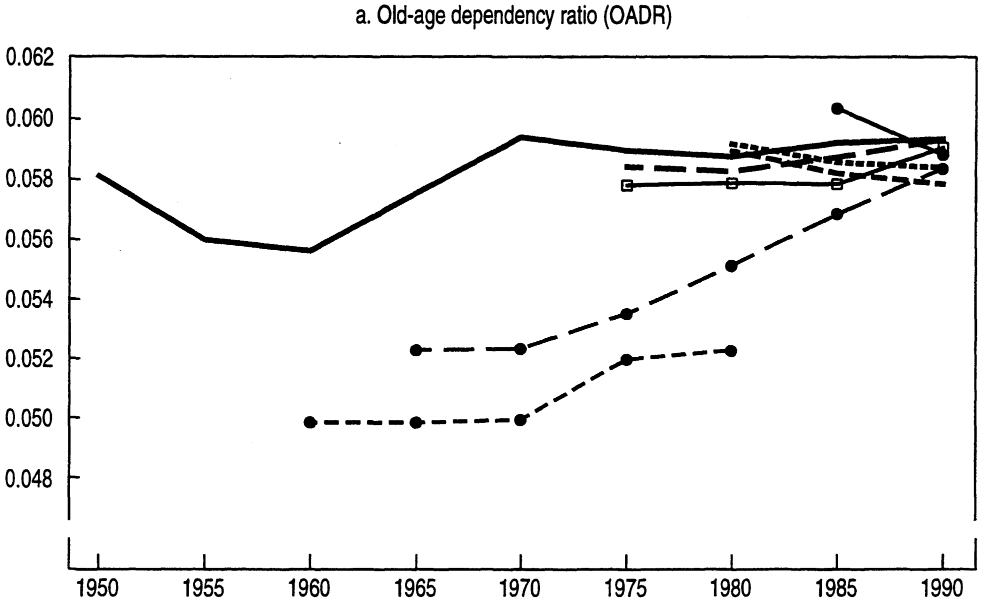
After 5 years, projections 1965*, 1975I, 1975II, 1980I, 1980II, 1985I and 1985II

After 10 years, projections 1965*, 1975II, 1980I and 1980II

After 15 years, projections 1965*, 1975I and 1975II

* Not including the open ended age group 70+

Figure A8. Observed and projected dependency ratios. Africa



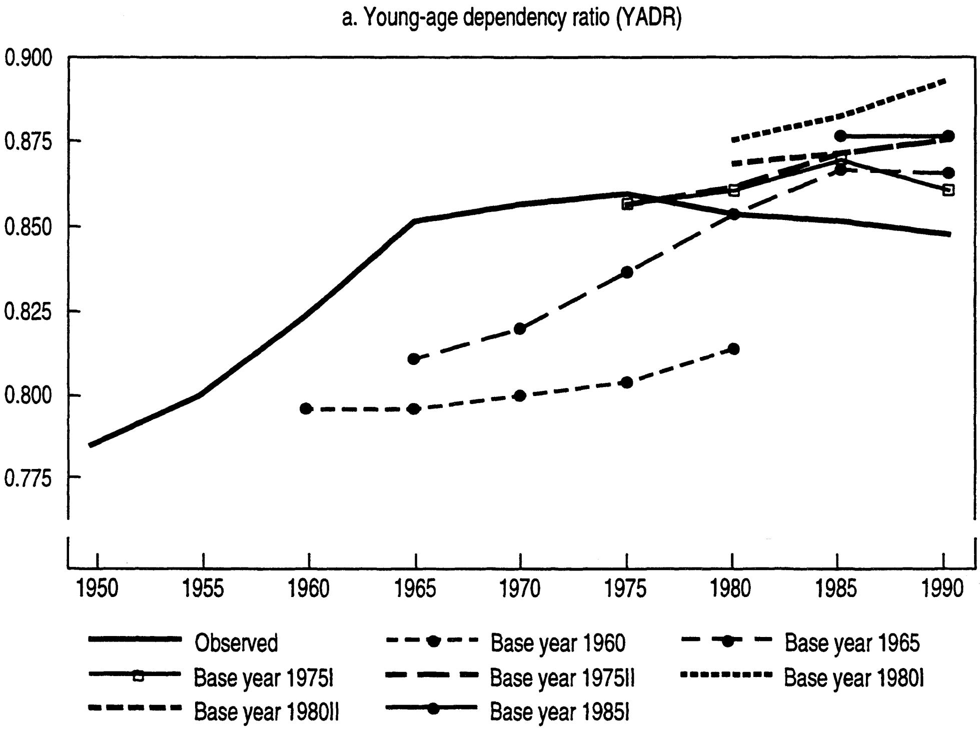


Figure A9. Observed and projected dependency ratios. Asia

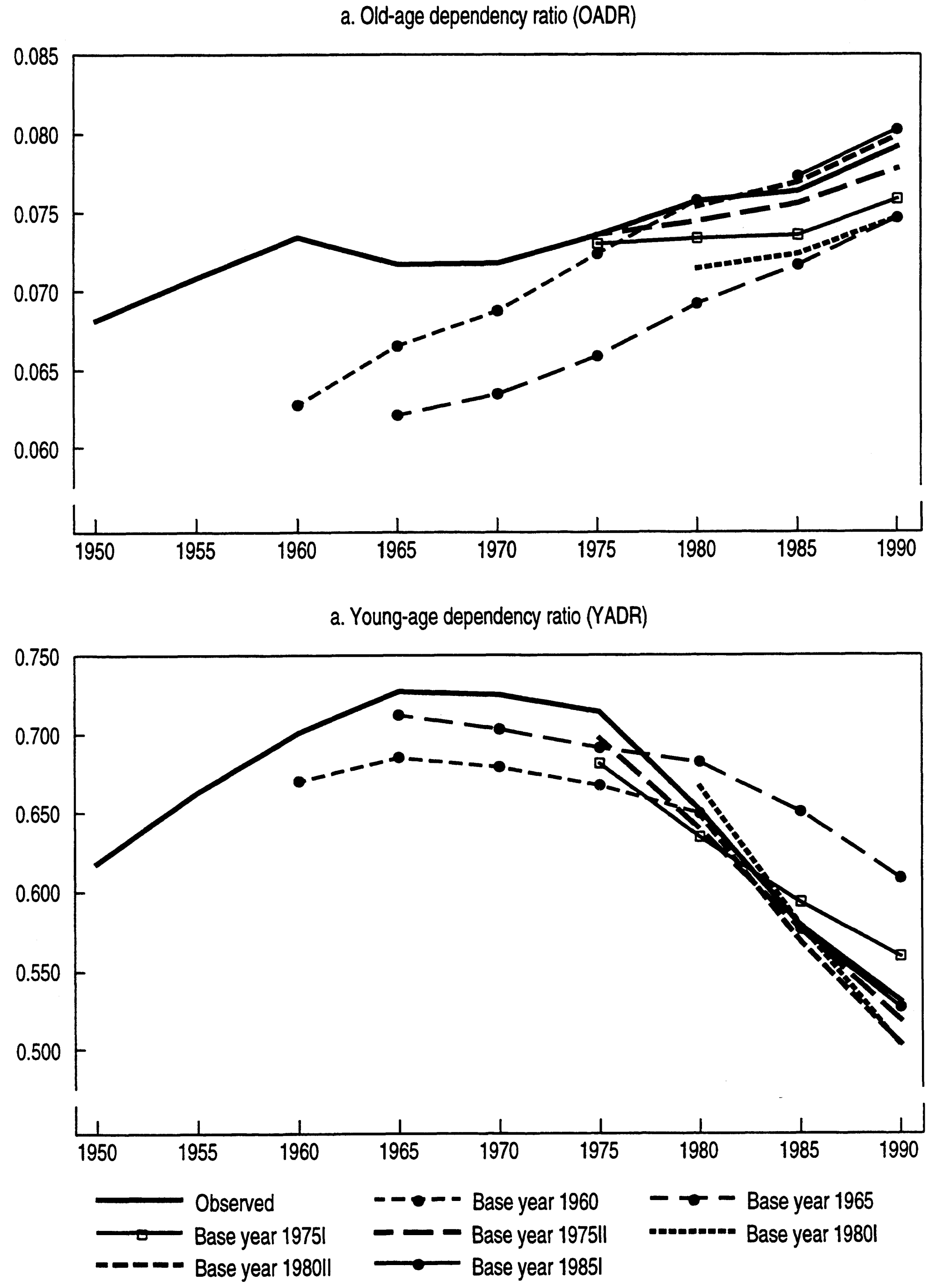


Figure A10. Observed and projected dependency ratios. Europe

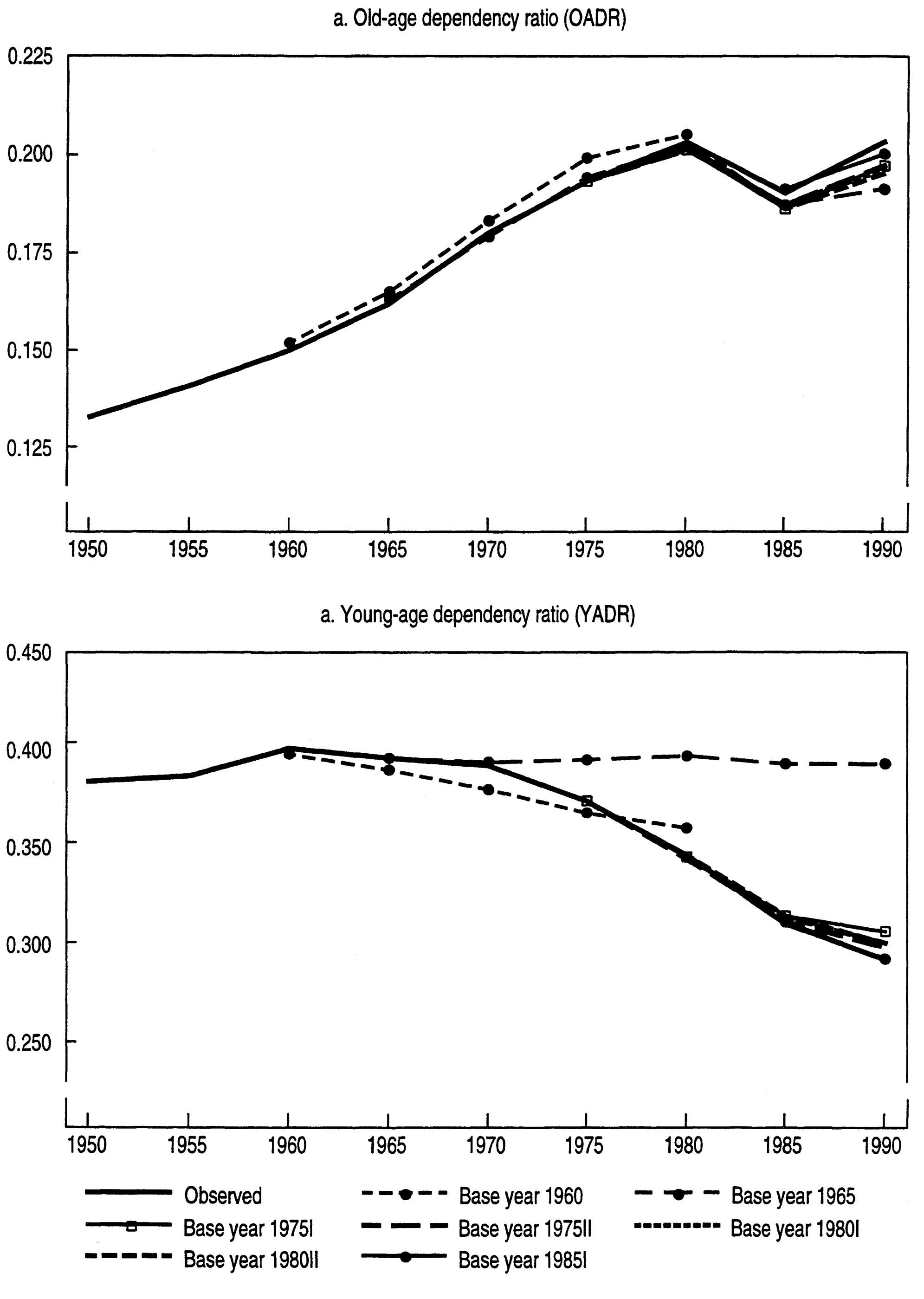


Figure A11. Observed and projected dependency ratios. USSR

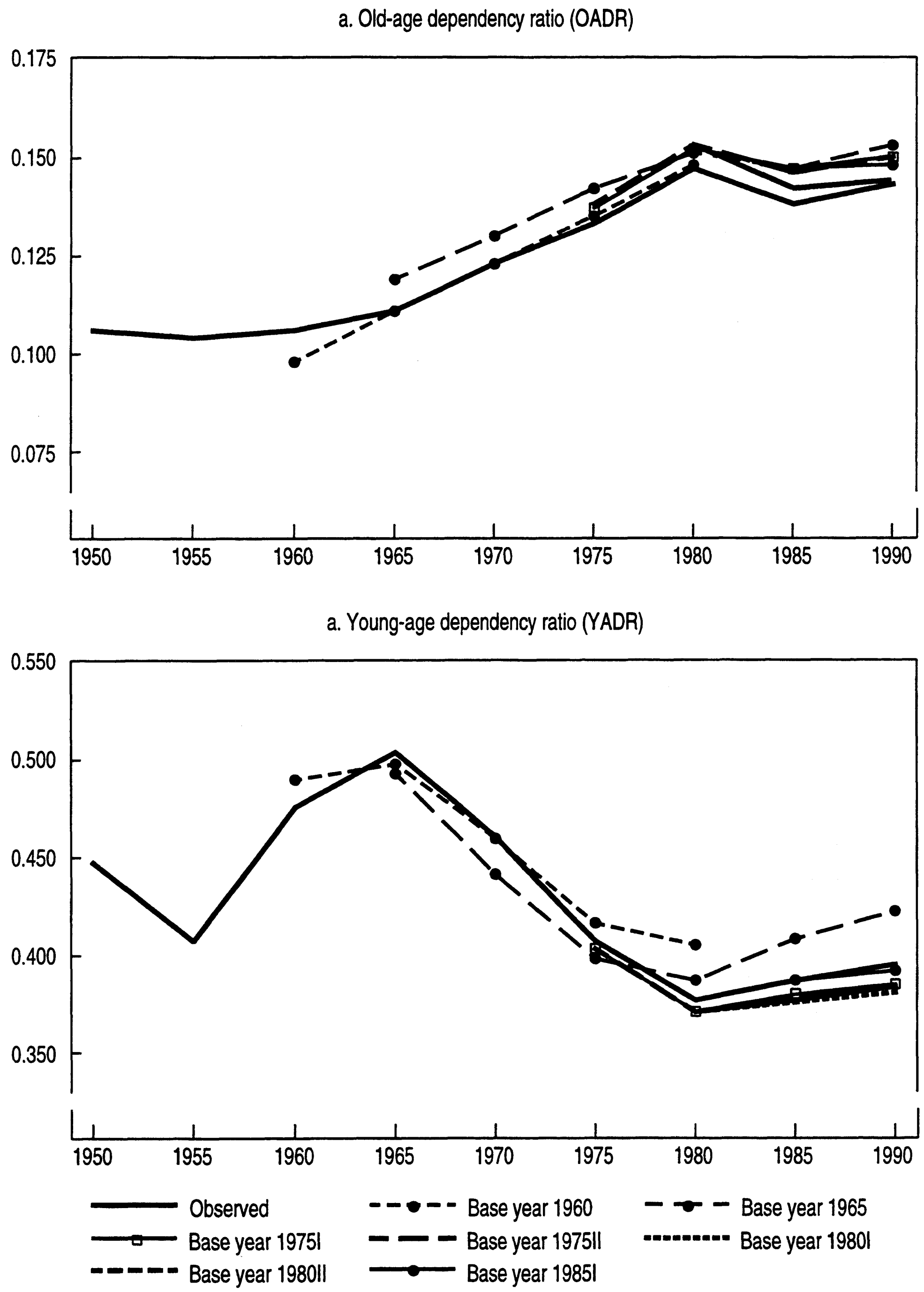


Figure A12. Observed and projected dependency ratios. Northern America

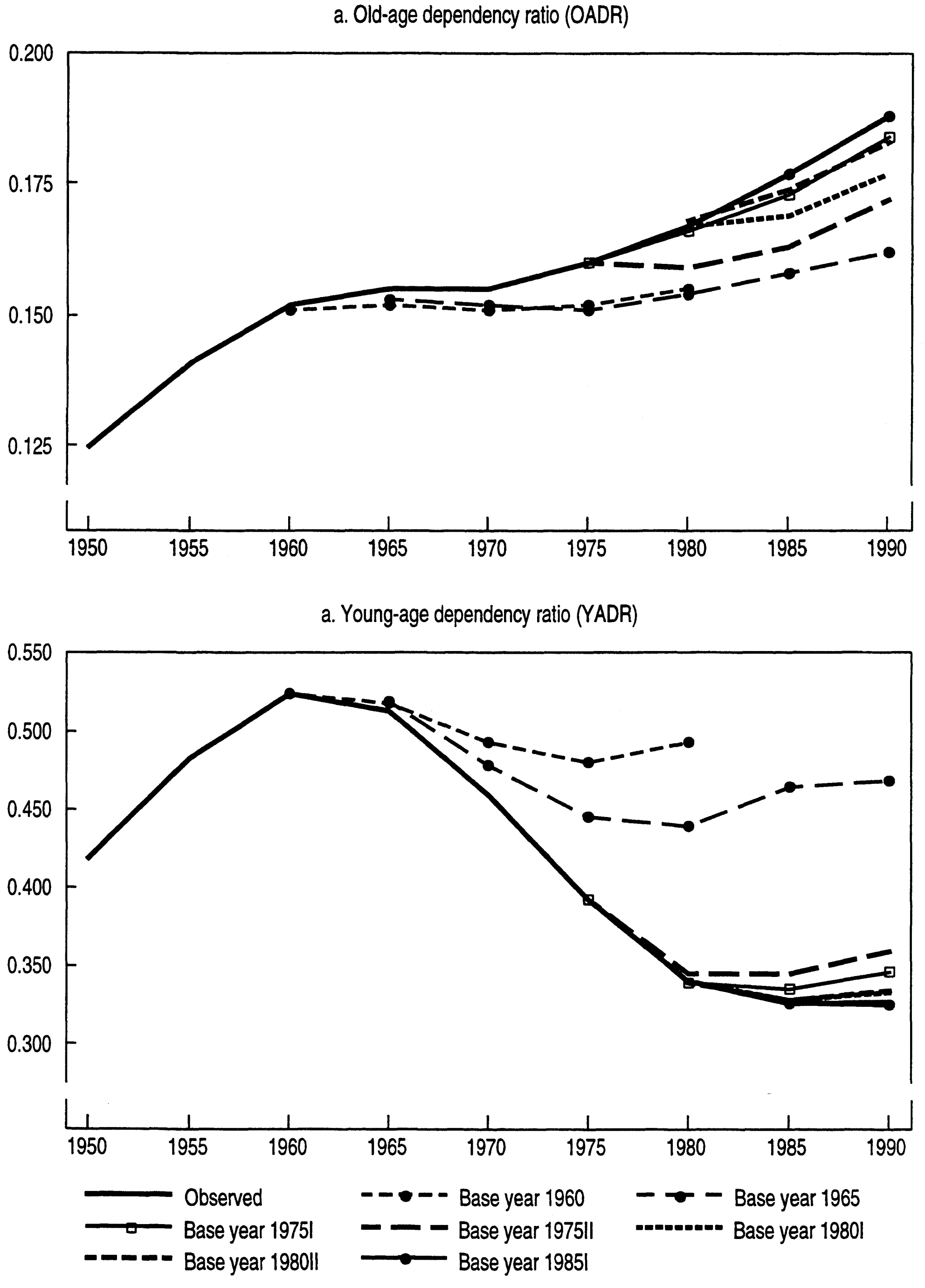


Figure A13. Observed and projected dependency ratios. Latin America

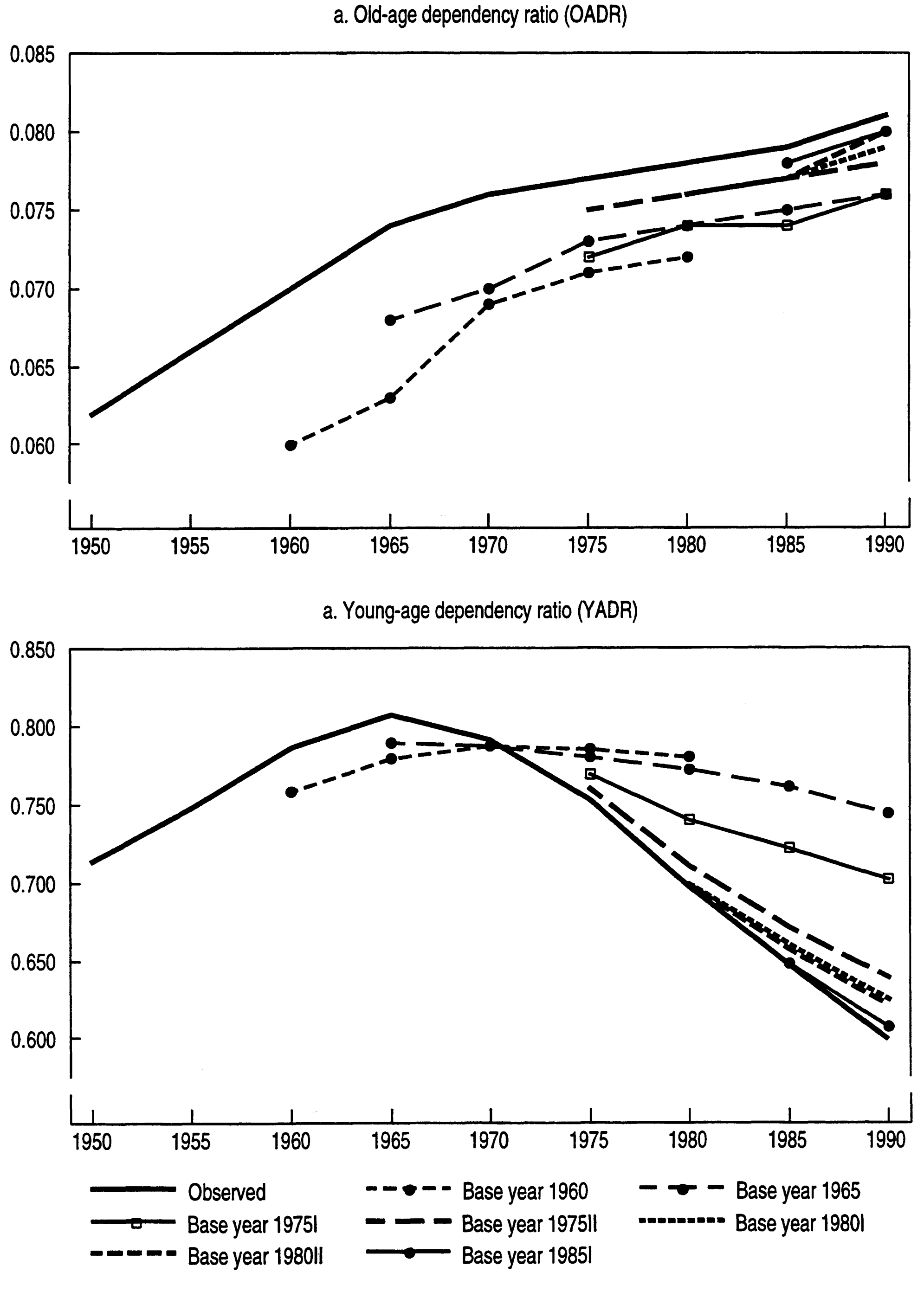


Figure A14. Observed and projected dependency ratios. Oceania

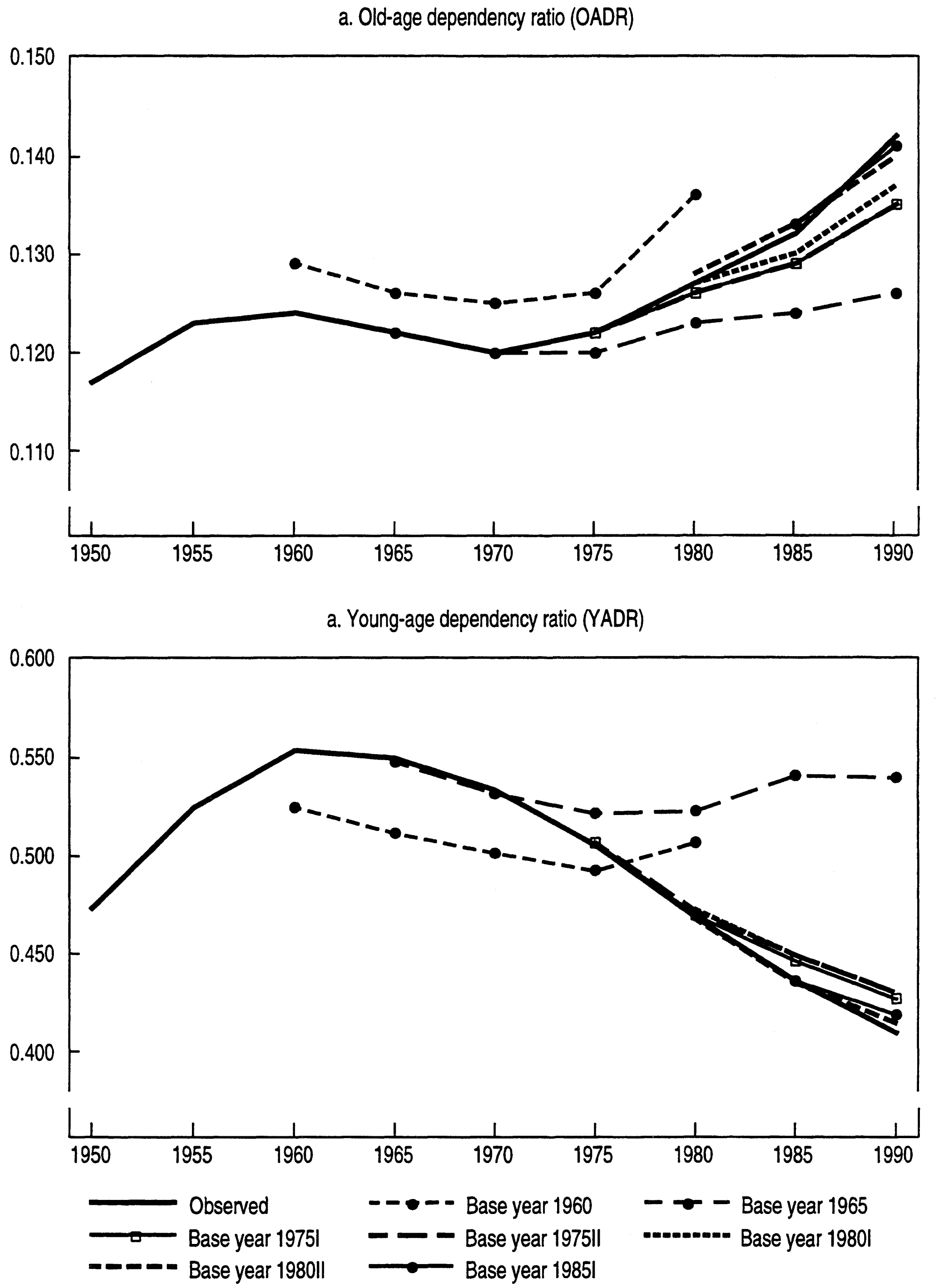


Table A1. Errors in projected crude death rates (promille points) by base year, forecast period and forecast duration. Africa

Period (1 Jan.)	Forecast's base year 1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
1950-55	6.2										6.2	6.2	0-5	0.8	1.1
1955-60	8.4										8.4	8.4	5-10	1.1	1.6
1960-65	8.1	-0.4									3.9	4.3	10-15	1.0	1.8
1965-70	10.1	0.0	0.4								3.5	3.5	15-20	2.3	3.0
1970-75	11.8	0.3	0.0	0.6							3.2	3.2	20-25	3.7	4.3
1975-80	11.3	0.4	-0.5	0.3	-0.6	-0.5					1.7	2.3	25-30	6.0	6.0
1980-85	12.5	0.2	-1.1	-0.3	-1.1	-0.9	0.0	1.8			1.4	2.2	30-35	12.5	12.5
1985-90	14.3	0.7	-1.0	-0.2	-1.0	-0.8	0.2	2.2	0.2	0.0	1.4	2.1	35-40	14.3	14.3
Mean error	10.3	0.2	-0.4	0.1	-0.9	-0.7	0.1	2.0	0.2	0.0	2.3	-		2.3	-
Mean absolute error	10.3	0.3	0.6	0.4	0.9	0.7	0.1	2.0	0.2	0.0	-	2.8		-	2.8

Table A2. Errors in projected crude death rates (promille points) by base year, forecast period and forecast duration. Asia

	Forecast's base year												
Period (1 Jan.)	1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Duration in years	Mean error
1950-55	8.9										8.9	0-5	1.5
1955-60	12.6										12.6	5-10	2.6
1960-65	9.3	1.2									5.3	10-15	2.7
1965-70	12.9	2.9	1.4								5.8	15-20	4.6
1970-75	14.6	3.2	1.3	1.2							5.1	20-25	5.8
1975-80	9.3	3.5	1.3	1.5	0.9	0.6					2.9	25-30	5.6
1980-85	10.3	2.5	0.8	1.3	0.9	0.6	0.5	0.1			2.1	30-35	10.3
1985-90	11.0	1.9	0.3	1.0	0.8	0.6	0.5	0.1	0.1	0.0	1.6	35-40	11.0
Mean error	11.1	2.5	1.0	1.3	0.9	0.6	0.5	0.1	0.1	0.0	3.4		3.4

Table A3. Errors in projected crude death rates (promille points) by base year, forecast period, and forecast duration. Europe

Period (1 Jan.)	Forecast's base year										Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
	1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II					
1950-55	-2.0										-2.0	2.0	0-5	-0.2	0.3
1955-60	-1.5										-1.5	1.5	5-10	-0.2	0.4
1960-65	-1.2	-0.2									-0.7	0.7	10-15	-0.2	0.3
1965-70	-1.4	-0.5	-0.2								-0.7	0.7	15-20	-0.3	0.4
1970-75	-1.4	-0.3	-0.1	0.0							-0.5	0.5	20-25	-0.4	0.6
1975-80	-0.4	0.0	0.0	0.2	0.2	0.1					0.0	0.2	25-30	0.0	0.4
1980-85	-0.5	0.2	0.1	0.2	0.3	0.2	0.2	0.4			0.1	0.3	30-35	-0.5	0.5
1985-90	-0.7	0.3	0.1	0.0	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.2	35-40	-0.7	0.7
Mean error	-1.1	-0.1	0.0	0.1	0.2	0.1	0.1	0.3	0.0	0.0	-0.2	-		-0.2	-
Mean absolute error	1.1	0.3	0.1	0.1	0.2	0.1	0.1	0.3	0.0	0.0	-	0.4		-	0.4

Table A4. Errors in projected crude death rates (promille points) by base year, forecast period and forecast duration. USSR

Period (1 Jan.)	Forecast's base year										Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
	1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II					
1950-55	-2.2										-2.2	2.2	0-5	-0.8	0.8
1955-60	-0.6										-0.6	0.6	5-10	-1.1	1.1
1960-65	-1.2	0.0									-0.6	0.6	10-15	-1.3	1.3
1965-70	-1.8	-0.7	-0.1								-0.9	0.9	15-20	-2.0	2.0
1970-75	-2.6	-1.5	-0.6	-0.7							-1.4	1.4	20-25	-2.3	2.3
1975-80	-3.0	-2.7	-1.7	-1.6	-1.1	-1.0					-1.9	1.9	25-30	-2.8	2.8
1980-85	-3.7	-2.9	-2.0	-1.7	-1.3	-1.3	-1.4	-1.4			-2.0	2.0	30-35	-3.7	3.7
1985-90	-3.6	-2.5	-1.5	-1.3	-0.9	-0.9	-1.5	-1.5	0.0	0.0	-1.4	1.4	35-40	-3.6	3.6
Mean error	-2.3	-1.7	-1.2	-1.3	-1.1	-1.1	-1.5	-1.5	0.0	0.0	-1.5	-		-1.5	-
Mean absolute error	2.3	1.7	1.2	1.3	1.1	1.1	1.5	1.5	0.0	0.0	-	1.5		-	-1.5

Table A5. Errors in projected crude death rates (promille points) by base year, forecast period and forecast duration. Northern America

Period (1 Jan.)	Forecast's base year: 1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
1950-55	-0.4										-0.4	0.4	0-5	0.4	0.5
1955-60	-0.3										-0.3	0.3	5-10	0.5	0.5
1960-65	-0.2	2.0									0.9	1.1	10-15	0.6	0.6
1965-70	-0.3	0.6	0.2								0.2	0.4	15-20	0.3	0.5
1970-75	0.0	0.1	0.4	0.3							0.2	0.2	20-25	-0.3	0.6
1975-80	0.5	-0.1	0.9	1.0	0.5	0.6					0.6	0.6	25-30	-0.6	1.1
1980-85	0.5	-1.3	0.7	1.1	0.7	0.6	0.6	0.4			0.4	0.7	30-35	0.5	0.5
1985-90	0.4	-1.7	0.4	1.0	0.8	0.6	0.3	0.3	0.0	0.1	0.2	0.6	35-40	0.4	0.4
Mean error	0.0	-0.1	0.5	0.9	0.7	0.6	0.5	0.4	0.0	0.1	0.3	-		0.3	-
Mean absolute error	0.3	1.0	0.5	0.9	0.7	0.6	0.5	0.4	0.0	0.1	-	0.6		-	0.6

Table A6. Errors in projected crude death rates (promille points) by base year, forecast period and forecast duration. Latin America

Period (1 Jan.)	Forecast's base year										Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
	1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II					
1950-55	3.5										3.5	3.5	0-5	0.2	0.8
1955-60	5.3										5.3	5.3	5-10	0.5	1.1
1960-65	3.7	-1.1									1.3	2.4	10-15	0.4	1.0
1965-70	5.0	-1.1	-1.0								1.0	2.4	15-20	0.9	1.6
1970-75	6.3	-0.6	-0.8	-0.5							1.1	2.1	20-25	1.6	2.6
1975-80	3.3	-0.3	-0.8	-0.4	-0.3	0.2					0.3	0.9	25-30	1.5	1.8
1980-85	4.2	-0.6	-0.8	-0.3	-0.1	0.4	0.4	0.4			0.5	0.9	30-35	4.2	4.2
1985-90	4.8	-0.3	-0.9	-0.4	-0.2	0.4	0.4	0.4	0.3	0.2	0.5	0.8	35-40	4.8	4.8
Mean error	4.5	-0.7	-0.9	-0.4	-0.2	0.3	0.4	0.4	0.3	0.2	0.8	-		0.8	-
Mean absolute error	4.5	0.7	0.9	0.4	0.2	0.3	0.4	0.4	0.3	0.2	-	1.4		-	1.4

Table A7. Errors in projected crude death rates (promille points) by base year, forecast period and forecast duration. Oceania

Period (1 Jan.)	Forecast's base year										Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
	1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II					
1950-55	-0.3										-0.3	0.3	0-5	0.1	0.3
1955-60	0.8										0.8	0.8	5-10	0.3	0.5
1960-65	-0.5	0.3									-0.1	0.4	10-15	-0.1	0.8
1965-70	-0.2	-0.2	-0.2								-0.2	0.2	15-20	-0.1	0.6
1970-75	0.4	-2.2	-0.3	-0.3							-0.6	0.8	20-25	0.1	0.3
1975-80	1.3	-1.3	0.2	0.3	0.3	0.3					0.2	0.6	25-30	0.7	0.7
1980-85	1.9	-0.4	0.4	0.6	0.7	0.7	0.3	0.2			0.6	0.7	30-35	1.9	1.9
1985-90	2.1	0.1	0.2	0.5	0.7	0.6	0.3	0.3	0.1	0.2	0.5	0.5	35-40	2.1	2.1
Mean error	0.7	-0.6	0.1	0.3	0.6	0.6	0.3	0.3	0.1	0.2	0.2	-		0.2	-
Mean absolute error	0.9	0.8	0.3	0.4	0.6	0.6	0.3	0.3	0.1	0.2	-	0.6		-	0.6

Table A8. Errors in projected crude birth rates (promille points) by base year, forecast period and forecast duration. Africa

Period (1 Jan.)	Forecast's base year: 1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
1950-55	-2.2										-2.2	2.2	0-5	-0.1	1.1
1955-60	-1.8										-1.8	1.8	5-10	0.1	1.0
1960-65	-1.7	-3.2									-2.5	2.5	10-15	-0.5	0.8
1965-70	0.0	-1.6	-0.2								-0.6	0.6	15-20	-0.3	0.4
1970-75	0.5	-1.4	0.1	-0.2							-0.3	0.6	20-25	-0.3	0.8
1975-80	0.1	-1.3	0.2	-0.2	0.1	0.1					-0.2	0.3	25-30	-0.5	0.6
1980-85	1.0	-1.6	0.2	-0.2	0.0	0.6	1.4	0.9			0.3	0.7	30-35	1.0	1.0
1985-90	2.6	-1.2	0.2	-0.1	-0.5	0.7	2.2	1.8	1.3	1.3	0.8	1.2	35-40	2.6	2.6
Mean error	-0.2	-1.7	0.1	-0.2	-0.1	0.5	1.8	1.4	1.3	1.3	-0.1	-		-0.1	-
Mean absolute error	1.2	1.7	0.2	0.2	0.2	0.5	1.8	1.4	1.3	1.3	-	0.9		-	0.9

Table A9. Errors in projected crude birth rates (promille points) by base year, forecast period and forecast duration. Asia

Period (1 Jan.)	Forecast's base year 1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
1950-55	3.1										3.1	3.1	0-5	0.1	0.8
1955-60	6.4										6.4	6.4	5-10	0.8	2.5
1960-65	4.5	-1.4									1.5	3.0	10-15	2.0	2.5
1965-70	5.6	-1.5	0.0								1.4	2.4	15-20	3.6	3.6
1970-75	9.2	0.9	2.0	0.0							3.0	3.0	20-25	4.4	4.4
1975-80	13.3	4.0	4.7	3.9	1.4	0.0					4.6	4.6	25-30	7.0	7.0
1980-85	14.6	2.4	3.6	3.2	1.0	-0.6	-1.0	-1.2			2.7	3.4	30-35	14.6	14.6
1985-90	15.2	0.7	1.5	1.1	0.1	-1.6	-2.4	-2.4	-0.2	0.0	1.2	2.5	35-40	15.2	15.2
Mean error	9.0	0.8	2.4	2.1	0.8	-0.8	-1.7	-1.8	-0.2	0.0	2.6	-		2.6	-
Mean absolute error	9.0	1.8	2.4	2.1	0.8	0.8	1.7	1.8	0.2	0.0	-	3.2		-	3.2

Table A10. Errors in projected crude birth rates (promille points) by base year, forecast period and forecast duration. Europe

Period (1 Jan.)	Forecast's base year: 1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
1950-55	0.2										0.2	0.2	0-5	0.1	0.3
1955-60	0.8										0.8	0.8	5-10	0.8	1.1
1960-65	-0.7	-0.9									-0.8	0.8	10-15	1.4	1.7
1965-70	0.3	-1.1	0.3								-0.2	0.6	15-20	2.5	2.5
1970-75	2.3	0.6	2.2	0.4							1.4	1.4	20-25	3.4	3.4
1975-80	3.6	2.0	3.5	1.7	0.1	0.0					1.8	1.8	25-30	3.6	3.6
1980-85	4.6	3.1	4.5	2.7	1.0	0.7	0.6	0.5			2.2	2.2	30-35	4.6	4.6
1985-90	5.1	3.5	4.7	3.2	1.6	0.9	0.8	0.6	0.1	0.0	2.1	2.1	35-40	5.1	5.1
Mean error	2.0	1.2	3.0	2.0	0.9	0.5	0.7	0.6	0.1	0.0	1.5	-		1.5	-
Mean absolute error	2.2	1.9	3.0	2.0	0.9	0.5	0.7	0.6	0.1	0.0	-	1.7		-	1.7

Table A11. Errors in projected crude birth rates (promille points) by base year, forecast period and forecast duration. USSR

Period (1 Jan.)	Forecast's base year 1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
1950-55	-1.3										-1.3	1.3	0-5	-0.2	0.2
1955-60	-0.3										-0.3	0.3	5-10	0.1	0.4
1960-65	1.9	0.0									0.9	0.9	10-15	0.6	0.9
1965-70	6.1	1.5	0.0								2.5	2.5	15-20	2.1	2.4
1970-75	5.9	0.9	0.4	-0.3							1.7	1.9	20-25	2.9	2.9
1975-80	3.7	1.6	1.5	0.1	0.0	0.0					1.2	1.2	25-30	3.0	3.0
1980-85	2.9	1.9	1.3	-0.4	-0.3	-0.3	-0.3	-0.1			0.6	0.9	30-35	2.9	2.9
1985-90	3.6	2.3	1.0	-0.6	-0.2	0.4	-0.3	-0.1	0.0	0.0	0.6	0.9	35-40	3.6	3.6
Mean error	2.8	1.4	0.8	-0.3	-0.2	0.0	-0.3	-0.1	0.0	0.0	0.9	-		0.9	-
Mean absolute error	3.2	1.4	0.8	0.4	0.2	0.2	0.3	0.1	0.0	0.0	-	1.2		-	1.2

Table A12. Errors in projected crude birth rates (promille points) by base year, forecast period and forecast duration. Northern America

Period (1 Jan.)	Forecast's base year										Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
	1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II					
1950-55	-2.6										-2.6	2.6	0-5	0.0	0.9
1955-60	-2.6										-2.6	2.6	5-10	1.3	2.0
1960-65	-2.2	0.4									-0.9	1.3	10-15	2.7	3.4
1965-70	2.0	3.3	1.3								2.2	2.2	15-20	4.7	4.7
1970-75	4.3	6.9	4.6	0.8							4.2	4.2	20-25	5.6	5.6
1975-80	5.9	8.5	6.6	2.4	0.2	1.2					4.1	4.1	25-30	6.6	6.6
1980-85	5.4	7.8	6.5	2.8	1.4	1.7	0.4	0.3			3.3	3.3	30-35	5.4	5.4
1985-90	5.2	7.2	4.7	1.7	0.9	0.9	-0.1	-0.2	-0.8	-0.8	1.9	2.3	35-40	5.2	5.2
Mean error	1.9	5.7	4.7	1.9	0.8	1.3	0.1	0.0	-0.8	-0.8	2.5	-		2.5	-
Mean absolute error	3.8	5.7	4.7	1.9	0.8	1.3	0.3	0.3	0.8	0.8	-	3.0		-	3.0

Table A13. Errors in projected crude birth rates (promille points) by base year, forecast period and forecast duration. Latin America

Period (1 Jan.)	Forecast's base year														
	1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
1950-55	-2.1										-2.1	2.1	0-5	0.8	1.5
1955-60	-1.4										-1.4	1.4	5-10	2.0	2.4
1960-65	-0.9	-1.3									-1.1	1.1	10-15	3.2	3.5
1965-70	2.2	1.2	0.6								1.3	1.3	15-20	4.4	4.4
1970-75	4.9	3.1	2.5	1.8							3.1	3.1	20-25	5.5	5.5
1975-80	7.5	4.7	4.1	3.6	2.9	1.1					4.0	4.0	25-30	6.6	6.6
1980-85	9.8	5.1	5.3	4.8	4.3	2.1	1.6	1.4			4.3	4.3	30-35	9.8	9.8
1985-90	12.1	5.7	6.4	5.5	5.1	2.8	2.0	1.8	1.2	0.8	4.3	4.3	35-40	12.1	12.1
Mean error	4.0	3.1	3.8	3.9	4.1	2.0	1.8	1.6	1.2	0.8	3.2	-		3.3	-
Mean absolute error	5.1	3.5	3.8	3.9	4.1	2.0	1.8	1.6	1.2	0.8	-	3.5		-	3.6

Table A14. Errors in projected crude birth rates (promille points) by base year, forecast period and forecast duration. Oceania

Period (1 Jan.)	Forecast's base year										Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
	1950III	1960	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II					
1950-55	-1.7										-1.7	1.7	0-5	0.1	0.9
1955-60	-1.6										-1.6	1.6	5-10	1.0	1.4
1960-65	-2.8	-1.8									-2.3	2.3	10-15	1.6	2.5
1965-70	-0.6	-0.2	0.0								-0.3	0.3	15-20	3.6	3.9
1970-75	0.1	0.8	1.7	0.9							0.9	0.9	20-25	3.7	3.7
1975-80	5.1	4.6	5.0	4.2	0.7	0.9					3.4	3.4	25-30	5.4	5.4
1980-85	6.0	5.7	6.3	4.7	1.3	1.4	1.1	0.7			3.4	3.4	30-35	6.0	6.0
1985-90	6.3	5.7	5.2	4.0	0.8	0.9	0.7	0.3	0.4	-0.3	2.4	2.5	35-40	6.3	6.3
Mean error	1.4	2.5	3.6	3.5	0.9	1.1	0.9	0.5	0.4	-0.3	1.9	-		1.9	-
Mean absolute error	3.0	3.1	3.6	3.5	0.9	1.1	0.9	0.5	0.4	0.3	-	2.4		-	2.4

Table A15. Errors in projected crude death rates (promille points) by base year, forecast period and forecast duration. China

	Forecast's base year										
Period (1 Jan.)	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Duration in years	Mean error
1965-70	4.2								4.2	0-5	1.4
1970-75	7.0	4.0							5.5	5-10	1.9
1975-80	5.1	2.8	2.1	0.7					2.7	10-15	2.2
1980-85	3.9	2.2	1.7	0.1	0.2	0.1			1.4	15-20	2.8
1985-90		1.6	1.3	0.0	0.1	-0.1	0.0	0.0	0.4		
Mean error	5.1	2.7	1.7	0.3	0.2	0.0	0.0	0.0	1.9		1.9

Table A16. Errors in projected crude death rates (promille points) by base year, forecast period and forecast duration. India

Period (1 Jan.)	Forecast's base year: 1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
1965-70	-0.8								-0.8	0.8	0-5	0.1	0.4
1970-75	-1.1	-0.1							-0.6	0.6	5-10	0.1	0.6
1975-80	-1.2	0.0	0.0	1.2					0.0	0.6	10-15	-0.2	0.7
1980-85	-1.7	-0.4	-0.1	1.0	0.7	-0.3			-0.1	0.7	15-20	-1.1	1.1
1985-90		-0.4	-0.1	1.1	0.9	-0.3	0.1	0.1	0.2	0.4			
Mean error	-1.2	-0.2	-0.1	1.1	0.8	-0.3	0.1	0.1	-0.1	-		-0.1	-
Mean absolute error	1.2	0.2	0.1	0.8	0.8	0.3	0.1	0.1	-	0.5		-	0.5

Table A17. Errors in projected crude death rates (promille points) by base year, forecast period and forecast duration. USA

Period (1 Jan.)	Forecast's base year: 1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Duration in years	Mean error
1965-70	0.1								0.1	0-5	0.4
1970-75	0.5	0.2							0.4	5-10	0.6
1975-80	1.0	1.1	0.5	0.7					0.8	10-15	1.0
1980-85	0.8	1.2	0.8	0.6	0.7	0.5			0.8	15-20	1.0
1985-90		1.1	0.9	0.7	0.4	0.3	0.1	0.1	0.5		
Mean error	0.6	0.9	0.7	0.7	0.6	0.4	0.1	0.1	0.6		0.6

Table A18. Errors in projected crude birth rates (promille points) by base year, forecast period and forecast duration. China

	Forecast's base year												
Period (1 Jan.)	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
1965-70	-3.9								-3.9	3.9	0-5	-1.4	1.6
1970-75	1.8	-1.4							0.2	1.6	5-10	-0.9	2.7
1975-80	6.3	3.7	0.6	-0.2					2.6	2.7	10-15	0.7	3.5
1980-85	5.2	2.2	-0.5	-1.2	-2.1	-1.6			0.3	2.1	15-20	1.5	3.8
1985-90		-2.3	-2.5	-3.1	-5.1	-3.8	-1.7	-1.0	-2.8	2.4			
Mean error	2.4	0.5	-0.8	-1.5	-3.6	-2.7	-1.7	-1.0	-0.5	-		-0.5	-
Mean absolute error	3.4	2.4	1.2	1.3	3.6	2.7	1.7	1.0	-	2.4		-	2.4

Table A19. Errors in projected crude birth rates (promille points) by base year, forecast period and forecast duration. India

Period (1 Jan.)	Forecast's base year 1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Mean absolute error	Duration in years	Mean error	Mean absolute error
1965-70	2.6								2.6	2.6	0-5	0.7	1.4
1970-75	2.8	1.7							2.3	2.3	5-10	0.3	2.3
1975-80	3.2	4.0	2.2	0.6					2.5	2.5	10-15	1.2	2.1
1980-85	0.8	2.4	1.0	-1.2	-0.6	-2.1			0.1	1.4	15-20	1.4	1.4
1985-90		2.0	0.8	-1.8	-1.4	-3.2	0.7	0.7	-0.3	1.5			
Mean error	2.4	2.5	1.3	-0.8	-1.0	-2.7	0.7	0.7	0.8	-		0.8	-
Mean absolute error	2.4	2.5	1.3	1.2	1.0	2.7	0.7	0.7	-	1.8		-	1.8

Table A20. Errors in projected crude birth rates (promille points) by base year, forecast period and forecast duration. USA

	Forecast's base year										
Period (1 Jan.)	1965	1970	1975I	1975II	1980I	1980II	1985I	1985II	Mean error	Duration in years	Mean error
1965-70	0.7								0.7	0-5	0.5
1970-75	4.3	0.2							2.3	5-10	2.0
1975-80	6.4	1.8	-0.2	0.9					2.2	10-15	3.4
1980-85	7.0	2.9	1.9	2.2	0.8	0.8			2.6	15-20	4.8
1985-90		2.6	2.1	2.1	1.0	1.0	0.4	0.4	1.4		
Mean error	4.6	1.9	1.3	1.7	0.9	0.9	0.4	0.4	2.0		

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B *Returadresse:*
Statistisk sentralbyrå
Postboks 8131 Dep.
N-0033 Oslo

Statistics Norway
P.O.B. 8131 Dep.
N-0033 Oslo

Tel: +47-22 86 45 00
Fax: +47-22 86 49 73

ISSN 0805-9411

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