Population projections for planning and policy

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PREFACE

An earlier draft of this paper was presented at the Eighth Summer Seminar in Population, held at the East-West Center, Honolulu, in June 1977. Financial support for this publication was provided by the Office of Population, Agency for International Development.
ABSTRACT The aim of this paper is to sketch a procedure for population projection that requires a minimum of significant parameters for the estimation of future trends. The intention is to shift as far as practicable from the appearance of a bookkeeping system to one in which the somewhat crude model elements are apparent and thus their inescapable lack of certainty is displayed. The crudest and simplest population projection model is one in which only the future rate of growth is estimated and all subgroups are distributed proportionally as at the base date. Even with unreliable measures, such a model can nearly always be improved, because past history has generally established a structure and dynamics relation that implies the model's inadequacy for the estimation of future internal relations (for example, age composition). It is possible to do somewhat better, but the elaboration of the calculations to beyond the degree of reliability of the estimates has led to dangerous misunderstandings.

The difficulty of establishing a mutual understanding between demographers on one hand and administrators and planners on the other has been a topic of concern to both groups. It is hard to judge whether advances are being made, but examples of deep and unfortunate failures continue to occur. In the crucial area of population forecasts, planners and policy makers frequently do not grasp what the demographer is saying. The poor performance of the population projections of the mid-1960s to 1970s, in Europe and elsewhere, consequent on rapid falls in fertility, has been a serious setback to the claims of demography to be an effective planning and policy-guiding discipline (Bourgeois-Pichat, 1976). It can be argued that the use of the word "projection" in the previous sentence is the main defense; that scientists can only work out the consequences of well-defined, reasonable assumptions; that they cannot anticipate the initiation of sharply new trends. Forecasting errors in other topics, for example in economics or marketing, have been equally frequent, but estimates of future populations have tended to be judged in a different way; criticism is greater because expectations are higher.

It would be foolish to blame the inadequacies of administrators and planners for the weaknesses in communication. If demographers believe that they can make a useful contribution to socioeconomic management by calculating population projections, they must find the
strategy and the language to convey that contribution effectively. In fact, a minority in the profession seems to hold the view that forecasting is essentially impossible and should not be attempted. Presumably from the Olympian vantage point the efforts of planners to take account of future population influences must be ignored as scientifically impure. But this may again simply reveal the lack of understanding of how demographic knowledge may be supplied as much as how it may be accepted.

Because of the suspicions that both administrators and demographers have about the uses of projections, it may be helpful to ask some basic questions about their function and presentation. The technical problems of calculation are liable to lead to the construction of a conceptual world relatively little influenced by the real one, and there is some suspicion that population projections have been based on such models. In isolation this is not necessarily a criticism, since there are many ways in which the calculation procedures can be applied to advance demographic knowledge apart from use in forecasting. But in forecasting the appropriateness of the methodology to the mode of use is important.

In general, planners are provided with one set of estimates of future populations or believe themselves to be so provided. In some cases it is the policy of the central organization to publish only one projection from the current time because of the fear that disagreements and discrepancies among governmental agencies might arise if there were a choice. In other situations alternative projections are presented but with an explicit or implicit indication that one is preferred—for example, by the use of the word "medium" or statements about plausibility. The administrator tends to seize the apparent certainty of specified numbers in a planning or policy assessment where the other factors seem less reliable.

The appearance of accuracy is supported by the procedure for the calculation of the forecast or preferred projection. The component method, which is universally applied except for crude approximations, is essentially a piece of accounting arithmetic. The initial population is divided into the subgroups (states) of interest by location, sex, age group, marriage, family characteristics, and so on. The numbers at one interval of time later are counted by subtracting movements out through deaths and emigration, adding movements in through births and immigration, and allowing for changes of state. The estimation of the volume of the movements is normally expressed as a proportion of the group that is left (a probability of movement), although for some
purposes, notably migration, the size of the group joined may be taken into account or absolute figures used. The advance to a future interval of time is done in the same way by applying the set of changes specified as appropriate. A simple representation of the calculation is

\[ N_j(h+1, k+1, \ldots) = \sum_j N_j(h, k-1) p_{ji} \]

where \( h \) is age group and \( k \), etc., other time-interval classifications such as marriage duration. \( p_{ji} \) is the proportion of persons who change from state \( j \) to \( i \) in the interval, with \( p_{ji} \) allowing for both deaths and movements from \( i \) to other states. New entrants to the population—that is, for \( h \) equal to zero—are obtained by applying age-specific-state fertility rates to the averages of the numbers of women at the start and end of the intervals, reducing births to the life table stationary population of the first age group, and dividing among males and females.

Several simplifications are made in the above description. Problems of multiple changes of state in an interval are ignored. The difficulties of reconciling discrepant estimates, such as the totals of males and females married in a monogamous society or of the number of emigrants from subregions with corresponding immigrants in a closed population, are not dealt with. But these are bookkeeping operations with no importance for the present purpose. The inaccuracies that can arise from neglecting them are trivial for planning and policy applications and in general well within the reliability of the initial numbers. Over the moderate time span for which the estimates are needed there is no harm in accepting small deviations from precision. For long-range theoretical uses of projection, however, exact reconciliations are necessary because otherwise massive distortions are liable to accumulate. A parallel situation arises in life table calculations, where the actuary requires extreme smoothness in the progression of mortality rates by age to ensure a fine graduation of social insurance payments and benefits. But the demographer can accept much wider tolerances for the analysis of population dynamics. The seemingly exact accounting process may be another reason why consumers of population projections have tended to hold exaggerated expectations of accuracy. The providers of the forecasts face a dilemma. If the calculations are claimed to be soundly based they are accepted too readily, but if serious doubts are put forward, with perhaps the provision of alternative paths, they lose all credibility. The latter has now happened in much of Europe. Projection methods are required that demonstrate more obviously the limitations of the inputs without destroying the plausibility of the outcome.
NEEDS OF THE PLANNER AND POLICY MAKER

Before such projection techniques are suggested, it is helpful to consider more closely the needs of the planner and policy maker. There are, of course, many needs, but rarely, if ever, are all the relevant factors specifiable in detail. Population numbers underlie needs for services of all kinds, but demands and usage depend on economic standards, attitudes, communication, tastes, and the nature and location of the supply. The supply often has a laborforce component but the provision is heavily influenced by costs, organizational structure, and so on. The rather obvious point being made is that normally planning is conditioned by large areas of uncertainty. In such a context a high degree of accuracy in population numbers is a convenience but not a necessity. The fact that so often these numbers are regarded as a fixed, immutable element in the plan and so seldom like the other factors as part of a broad spectrum of possibilities is the result of misunderstandings that must be corrected. Of course, the degree of sensitivity to the population forecasts varies widely. For example, such forecasts are essential to the organization of universal primary education, although even here the estimations of teacher supply and building capacity, etc., introduce uncertainty within which population forecasting errors may be swallowed. On the other hand, in the planning of tertiary education, population growth may account for only a minor part of increased demand. Good planning and policy making must therefore be flexible, capable of progressive adjustment to allow for deviations from assumptions and changes in conditions. The population element is no different from others in this respect and it is surprising that this point has not been more generally recognized.

Above all, planners need an appreciation of the degree of flexibility that must be incorporated in their proposals to allow for potential deviations from the current trends upon which the central projection is based. If these trends are regular, there should nevertheless be some guidance on the more likely irregularities that could occur; if they are erratic, possible approaches to a steadier state should be indicated. Perhaps most important of all is the development of an early warning system to spread the information that alternative paths to the original trend extrapolation are beginning to demand more attention. The time lag between the formulation of the estimates that enter a projection and the putting into operation of the plan based on the outcome is often a considerable one. There are plenty of examples in which it has become clear that the population assumptions are implausible just about the time implementation begins to take place. It has been argued
that early warning might lead to unjustified nervousness about decisions, but surely caution in the face of uncertainty and the adoption of strategies that allow for change are exactly what are required. The standard projection systems (or at least their presentation) do not meet these needs because of inadequate indications of options, failure to distinguish the critical factors from the trivial, unnecessary complexity, and hence slow response to significant alterations in trend.

MODEL SELECTION IN PLACE OF ACCOUNTING

The key to a projection approach that would harmonize with planning and policy needs, yet would conform with demographic forecasting uncertainties, is the explicit formulation of the process as one of model selection rather than accounting. Emphasis should be on the models and what their characteristics are rather than on the computations. Although comment on the choice of future trends in such demographic components as fertility and mortality that are incorporated in a projection may be regarded as a form of model selection, the form remains at a comparatively naive and elementary level. The aim should therefore be to develop an effective description of how the population components change over time, and the description should incorporate as few significant parameters as possible. For fitting models to the future, trend indicators are always limited and uncertain. The best that can be hoped, therefore, is that plausible estimates of the one or two main effects can be arrived at. An integrated system would be one in which the linkages among major change components (fertility, marriage, mortality, migration) and between these and population structure were specified; but that is not, at present, practicable. Instead, moves toward this goal, but operating with the components separately, will be considered.

It is possible to simplify the models by constructing them in relational form—that is, by using initial, current measures rather than the natural age or duration scale. Thus the functional expression of the force of mortality in terms of age is complex, but the main trends over time in these forces of mortality for a particular population may be simpler. The search for such time-change models is an empirical exercise. It may be aided by the corollary that if an effective model exists for a component there must be a transformation of the age (duration) scale that gives a simple, functional expression for the measures on the transformed scale. Useful transformations may be sought through the modification of functions (for example, by reduction in the number of parameters) that give reasonable models on the natural scale, but this does not necessarily give the optimum result.
Until recently more effort has been put into the study of mortality than into fertility models, but even here the emphasis has been on the description of variation of sex-age patterns among populations rather than of paths of change over time. On the assumption that changes in demographic patterns have the same form in all populations at a particular stage of development, the cross-sectional relations become time-series ones on average. There seems to be a rough empirical justification for this conclusion, but further research is needed to provide a firmer and more detailed knowledge of the types of mortality development. In principle it is possible to translate the standard model life table systems (United Nations, 1955; Coale and Demeny, 1966; Lederman and Breas, 1959; Bourgeois-Pichat, 1962) into relational schemes by expressing the age-specific measures for the different levels of mortality as a sequence of changes over time. This would be cumbersome, however, and require massive tabulations, unless the crude approximation of describing current mortality for the population under consideration by one of the life tables in the model set was adopted. In addition, decisions would be required about paths for the systems dependent upon more than one parameter.

PROJECTING MORTALITY TRENDS: THE LOGIT SYSTEM

The logit model mortality system fits in directly with projection aims because it is based on a functional relation between age measures for different life tables. For the present application it can be written as:

\[ Y(x,t) = \alpha(t) + \beta(t) Y(x,0) \]

where \( Y(x,t) \) stands for \( \frac{1}{2} \log \left( \frac{\{1-f(x,t)\}}{f(x,t)} \right) \) or the logit of \( \{1-f(x,t)\} \), \( f(x,t) \) being the period life table survivorship to age \( x \) at time \( t \). The two parameters \( \alpha(t) \) and \( \beta(t) \) fix mortality at time \( t \) in relation to the measures at time \( 0 \)—i.e., \( Y(x,0) \) in the transformed definition. The time point, which is defined as zero, is open to choice in particular applications. At \( t=0 \), \( \alpha(0) \) is equal to zero and \( \beta(t) \) to one. If \( \beta(t) \) is kept equal to one and \( \alpha(t) \) is decreased from zero at a constant rate, the level of mortality improves along a pattern path that keeps the relation between adult and childhood mortality similar to that at time zero. By this is meant that an average relationship for populations of the mortality level signified by \( Y(x,0) \) will remain so for the levels of \( Y(x,t) \); the characteristics of relatively higher or lower adult mortality compared with childhood mortality would equally be retained. Movements in \( \beta(t) \) from one alter this relationship.

Examination of the trends in \( \alpha(t) \) and \( \beta(t) \) over time in populations
with a history of accurate mortality measurement (e.g., the Scandinavian countries and Britain) has revealed characteristics of $\alpha(t)$ which suggest the value of the logit system model for projecting mortality (Brass, 1971). A constant rate of fall in $\alpha(t)$ corresponds to a decreasing rate of rise in life expectancy in good accord with the empirical evidence of this experience. Thus, if life expectancy at age zero is 40, a decrease in $\alpha(t)$ of 0.1 adds 3.4 years, but the corresponding addition at an expectancy of 73 is 1.8 years. The behavior of $\beta(t)$ is more complex. In low-mortality countries $\beta(t)$ has tended to rise as improvements in adult mortality (particularly for males) have slowed or even ceased, but there have been periods in the past when spurts took place for the older sections of the population. In populations with moderate to high mortality the relation between death incidences for adults and children varies greatly. If the average $\beta$ is taken as one, life tables with values as low as 0.6 to as high as 1.6 have been constructed from data of fair reliability. The impact of a trend in $\beta(t)$ is on the age distribution of deaths and hence also on the age distribution of the living. On the other hand, the latter effect develops rather slowly.

The characteristics of the logit mortality model system as outlined above lead to a simple recipe for projections for planning. Normally it will be best to keep $\beta(t)$ fixed at the value one unless the child-adult mortality relation is extreme and there are good indications that a return toward the average has been initiated; only strong trends will be of much significance up to (say) fifteen years ahead. Concentration must be on the specification of the rate of change in $\alpha(t)$. In the developed countries over long periods of time $\alpha(t)$ has tended to decrease by 0.50 in about 40 years, but the fluctuations in shorter intervals have been considerable (Brass, 1971). Countries in which the mortality transition began comparatively recently have experienced much faster falls in $\alpha(t)$, but in a number of these the rate of change has slowed considerably. The central projection should, in general, be based on the change in $\alpha(t)$ over the preceding ten to fifteen years unless this change differs greatly from the long-term norm noted above, when a shift toward it will be justified.

**PROJECTING FERTILITY TRENDS: THE RELATIONAL GOMPERTZ MODEL**

The estimation of future fertility is both more critical and more difficult than the projection of future mortality. The reason is that in populations where mortality is moderate to low and under fairly strong medical controls (typically when planning becomes important), change
in the mortality level is reasonably regular and has a modest and direct
effect on growth. In contrast, trends in fertility can be dramatic and
unexpected, with large impacts on growth and age distributions. Much
of what has already been said about mortality models is also applicable
to the corresponding constructions for fertility by age of woman, al­
though in this case more attention has been paid to functional rela­
tions with the natural scale rather than empirical systems (Avery,
1970). In fact, the only sophisticated empirical attempts are the re­
cent Coale-Trussell models (Coale and Trussell, 1974), and even these
are composed partly of functional elements. Since the system has four
parameters (one for level and three for pattern), a good fit to the cur­
rrent age-specific fertility rates can generally be achieved. The specifi­
cation of the paths of change of the shape parameters can also be ap­
proached in a sensible way, since two relate to age at marriage (average
timing and rate of extension with age) and one relates to level of fam­
ily limitation. Nevertheless, four parameters are a heavy and unneces­
sary burden for forecasting, particularly when there is as yet little ob­
servation of the changes in pattern over time.

A promising alternative is a relational Gompertz model. Well based
research (Martin, 1967; Wunsch, 1966; Romaniuk and Tawny, 1969;
Brass, 1974) has demonstrated that a fair description of observed dis­
tributions is

\[ F(x) = FA \cdot S^x, \]

where \( F(x) \) is cumulative fertility to age \( x \), \( F \) is the total fertility (equal to \( F(u) \), where \( u \) is the upper age of child­
bearing), and \( A \) and \( B \) are constants lying between zero and one. By
taking logarithms of both sides twice, one obtains an equation linear
in age. Suppose there is some transformation of the age scale to \( y \), say,
for which the Gompertz function is a better representation of the fer­
tility pattern for all population. Empirical evidence strongly supports
this assumption. Then elimination of \( y \) gives a linear relation between
the double logarithms for any two fertility patterns. This is an im­
proved representation compared with the simple Gompertz function.
For convenience the functional relation is written in exactly the same
form as for mortality,

\[ Y(x,t) = \alpha(t) + \beta(t) \cdot Y(x,0) \]

but here \( Y(x,t) \) is \( \log_e \{- \log_e F(x,t) / F(t) \} \) and the \( t \) in the \( F(x,t) \) and
\( F(t) \) cumulated fertility measures denotes the point of time.

The \( \alpha(t) \) and \( \beta(t) \) are analogous in meaning to the same parameters
in the mortality model but the implications for projections are quite
different. Since everyone dies, it is the timing parameter \( \alpha(t) \) that spec­
ifies what we ordinarily mean by level of mortality; but for fertility
it is the number of children born over the reproductive period per woman, denoted by \( F(t) \). The timing parameter for fertility \( a(t) \) moves very much in accord with the mean age of the specific fertility distribution, whereas \( \beta(t) \) changes inversely with the spread or standard deviation. It can be argued that direct use of the shifts in mean and standard deviation as relational model parameters without transformation would be satisfactory and simpler for projection. This may be true, but the Gompertz formulation allows more neatly for the changes in fertility rates at the ends of the reproductive period, which come with large shifts in the timing of family building. As yet there has been little study of the paths of change in \( a(t) \) and \( \beta(t) \), and they are subject to diverse influences. Postponement of marriage tends to raise \( a(t) \), as does reduced widowhood; the former increases \( \beta(t) \) but the latter lowers it. Rising divorce and separation will act in opposition to decreased widowhood. Family limitation will tend to raise \( a(t) \) and \( \beta(t) \), but wider birth spacing may have a counteracting effect.

Of the three parameters, \( F(t) \) is clearly the dominant one in its influence on growth rates and age structure. The part played by changes in \( \beta(t) \) can be ignored for the present purpose. The changes represent shifts in the allocation of births to younger and older women in comparison with the numbers born at mid-reproduction ages; growth and structure consequences are small. The timing trends measured by \( a(t) \) can, however, be of considerable significance. The postponement or advancement of births, even in the absence of changes in \( F(t) \), can substantially alter birth and hence growth rates and, consequently, age distribution. In fact, over fairly short time spans it is difficult to distinguish the parts played by trends in \( F(t) \) and \( a(t) \). The projection model is then \( Y(x,t) = a(t) + Y(x,0) \) with \( Y(x,t) = \log_{e} \left\{ -\log_{e} F(x,t) / F(t) \right\} \). Since fertility changes for cohorts appear as time period movements in \( a(t) \), as well as \( F(t) \), there is likely to be compounding when estimates for the future are based on recent trends. For short-term projections this is likely to be an advantage rather than a limitation since the combined effects will be about right as long as the process continues. Over longer periods the problems are greater because the constraints on movements in \( a(t) \) are more severe than those on \( F(t) \). Alternative hypotheses about the paths of \( F(t) \) and \( a(t) \) are therefore hardly avoidable but probably not critical compared with the essential difficulty of forecasting \( F(t) \) alone.

NUPTIALITY AND MARITAL FERTILITY

The above examination refers to fertility by age of woman. Akers
(1965) has argued, however, that better results are likely to be obtained if nuptiality is projected separately and births arrived at from future estimates of marital fertility, allowance being made for additions of the illegitimate. The claims are essentially that the trends in the two components are little, if at all, connected and that mixing them confuses the estimation and makes it less efficient. For some situations there is substance in the assessment, notably if the proportions marrying before the end of the reproductive period are changing rapidly as in Europe in the 1940s and 50s. Clearly, a rise or fall in the proportion cannot continue indefinitely and a tracing of logical alternative paths would, in general, result in estimates for trends in fertility different from those that might be deduced from changes in family size when marriage is ignored. It is, in fact, quite easy to incorporate nuptiality and marital fertility into the model system described above. The form of the equation $Y(x,t) = \alpha(f) + \beta(t) Y(x,0)$ can still be used, but for nuptiality $Y(x,t)$ is $\log_e \{-\log_2(M(x,t)/M(t))\}$ where $M(x,t)$ is the proportion of women married by age $x$ at time $t$ and $M(t)$ is the proportion ultimately marrying; for marital fertility $Y(x,t)$ is $\log_e \{-\log_2(G(x,t)/G(t))\}$ or $\frac{1}{2}\log_e [\{G(t) - G(x,t)\}/G(t)]$ where $G(x,t)$ and $G(t)$ are the cumulated specific fertility rates to marriage duration (not age) $x$ and the end of childbearing, respectively. The nuptiality model is a good representation and it appears that $M(t)$ can usually be fixed independently of $t$ at about 0.98 for practical purposes. It has not yet been established whether the Gompertz or logit form of relational model (or indeed some other) works best for fertility by marriage duration.

If there is a direct need for future estimates of the married population, the model, as described above, should be used. The complications introduced by its incorporation for fertility projections are hard to justify, however. The volume and timing of marriage are both altered by the $\alpha(t)$ and $\beta(t)$ parameters. For calculating the number of births in a given period, parameters are required for the cumulated total fertility over marriage and also for timing within marriage. Only the $\beta(t)$ measure for the marital fertility model can be held constant. Even if it is assumed that paths of change of marital fertility are independent of age at marriage, four parameters have to be specified for the future instead of the two needed if nuptiality is bypassed. In addition the problems of marriage dissolution by widowhood and divorce have to be dealt with explicitly. It can also be queried whether the separation of nuptiality and marital fertility is valid even in theory, since changes in nuptiality add to or subtract from the exposure to risk.
categories, women who may have special characteristics. Again, in many populations the mating behavior cannot be described simply by the classification of women as currently married and "other," particularly in view of the available data on nuptiality (e.g., Marino, 1970). In practice, therefore, little can be gained by the sophistication of nuptiality plus marital-fertility projections, provided that the time horizon is fairly short and there are guards against the possible interpretation of temporary alterations in marriage tempo and volume as consistent and continuous trends in fertility level. Indeed, much can be lost by the increased complexity if it diverts attention from the major factors of change dominating the projections, confuses planners about the essential simplicity of alternative patterns of the population dynamics, and makes more difficult the quick calculation of these alternatives when new information modifies the balance of plausibility. The $\alpha(t)$ parameter in the age-specific fertility model responds strongly to consistent trends in nuptiality although it is also influenced by many other effects, such as reductions in widowhood and increased family limitation by older mothers. The problem of the separation of movements in fertility due to alterations in risk exposure from those due to the behavior of the exposed is closely related to the difficulty of distinguishing between trends in $F(t)$ and $\alpha(t)$. Too little is as yet known about this, and much more analysis of the measurements is required, even for countries with adequate series of records.

MIGRATION

The incorporation of migration into projections is normally done in a simple scheme because of the lack of a satisfactory theory for doing otherwise. Thus the level and sex-age distribution of net migration of the recent past may be continued into the future. Alternatively the level may be made proportional to the population size. There is no particular difficulty in introducing parameters of change in level and age distribution for migration which could be fitted to past trends. The problem is the lack of detailed observations from which to formulate and justify a convenient model. Relational functions of the type described previously for mortality and fertility (particularly the former, since age distributions of the living and dying have some common features) can work quite well but, with present knowledge, are probably too elaborate.

COHORT AND PERIOD APPROACHES

Before the implications of the component models for the overall pro-
jection strategy are assessed, the merits of cohort as compared with
time-period approaches must be considered. This paper deliberately
takes the latter viewpoint, although it could be reframed without dif­
culty to reflect the former. The issue is not the models, but how the
parameters of significant change can best be defined and estimated.
The basic argument for the cohort approach lies in the belief that the
experience by a group of “contemporaries” (the cohort) of marriage,
fertility, and mortality can best be understood from the cumulated
history of events, particularly at older ages, by which a large share of
the events has occurred. Fluctuations over time in the events can be
irrelevant to the ultimate outcome if there is compensation for devia­
tions from the path to a fixed point. Specifically, in the most impor­
tant practical case, cohorts may achieve the same total fertility but
have their births at different times over the reproductive years in
reaching it. If this is true, better forecasts may be achieved by concen­
trating on the trends in the performance of cohorts. Opposed to this
view is the alternative one that the impact of immediate factors is so
strong that their effects, on mortality or fertility, dominate what may
be called cohort goals.

There is substance in both these contentions and ideally an analysis
allowing for both cohort and time-period influences and their interac­
tions is desirable. For research into the nature and determinants of
population change such an approach is essential, but it is doubtful
whether to adopt it for forecasts over short to moderate intervals
ahead is a sensible approach. In practice, projections of this kind have
to be formulated in time intervals since it is the birth, death, and mi­
gration rates over time that govern growth and age distributions—al­
though cohort consistencies, if they existed, would be critical for long­
range projections. Alterations in tempo may be relatively unimportant
if the projection period is many decades, but they are of equal rele­
vance to cohort measurement movements for the more immediate fu­
ture. The solution often adopted is a combination of the two methods,
notably for fertility, with estimates of “normal” levels and trends
based on extrapolation for cohorts but time fluctuations being intro­
duced where necessary. If changes are regular no problems arise, but
that is true of any extrapolation procedure. On the other hand, the
measures for completed cohorts reflect the family building patterns of
some years in the past. Sharp fluctuations in the more recent periods,
whether due to tempo changes or to alterations in cohort levels, create
discrepancies and there is no satisfactory system for reconciling them.
In effect there must be concentration on the series of measures in time,
and the cohort values are essentially irrelevant to the short-term projections. For these reasons it is suggested here that forecasts for planners and policy makers be based on time-period extrapolations, although this recommendation does not preclude the use of cohort approaches for long-range projections. An analogy is weather prediction, in which different techniques have evolved for immediate as compared with long-term forecasting.

CONCLUDING REMARKS

The procedure for population projection described in this paper is the consistent application of relational models in which the current measures by sex and age are varied in a way that accords with empirical evidence on patterns of change. A small number of parameters has been specified as essential. These are measures of level for mortality, level and tempo for fertility, and, probably, level for migration—although the last has not been adequately investigated. Other factors may be taken into account in fixing the future values of parameters, notably nuptiality movements, but it is recommended that these should not appear directly in the projection calculations. Forecasting of numbers married may be made separately on a basis that does not contradict the primary calculations.

Normally the central projection should be computed from an extrapolation of trends in these parameters over the recent past (a period of some ten years). But there is a necessity to produce a considerable number of alternatives. The alternatives selected must be related to the characteristics of planning and policy making as well as to an assessment of the demographic forces. At present there is no reasonable way to define a probable range of outcomes; and to approach the problem with a hidden assumption of this kind, as is often done, falsifies the issue. At any date there is the reasonably plausible assumption that, for some time at least, trends will continue in much the same way as in the recent past, with a band of doubt of vague extent due to possible errors in the estimation of these trends. In the short run, this band is not likely to be very wide and the calculation of variant direct extrapolation is of limited value. But experience shows that over longer periods sharp changes in trends are not only liable to occur but also likely to do so; their direction can sometimes be predicted with reasonable confidence from the history of other populations, but the size and, even more, the point of initiation must be highly speculative. Once such a sharp change has taken place a new path of plausibility replaces the old. It is the responsibility of demographers to draw plan-
ners’ attention to potential shifts in plausibility that could seriously affect their schemes—with foresight if possible and, at least, with alacrity when the signs appear.

I have elsewhere suggested (Brass, 1974) that the projection of fertility levels in England and Wales and other countries with similar demographic conditions might best be done by using cyclic functions that have different amplitudes and periodicities. I made this suggestion not because I believe anything so regular would occur but because cyclic functions are a convenient device for introducing the sharp changes in the direction of trend that have characterized the measures from the 1930s to the present. In countries that have not yet achieved low death and birth rates, for example, the kinds of trend deviation that might be anticipated are a flattening out of mortality falls after a rapid decrease (or vice versa) and a steep drop in fertility following negligible or slow change. The types of alternative projections proposed, therefore, can be visualized as a branching system in which, say five years ahead, forks begin to emerge from the main stem and, another five years later perhaps, these fork again. The outcome is a network of paths about the plausible one that might replace it at a future time. A strong case exists for preparing many variant projections, but a tactical question is whether only a few of them should be made available to planners and policy makers.

Another line of development is the supply of auxiliary tabulations from which planners can produce their own projections easily whenever there are indications that trend deviations may be starting to occur. To a first approximation, as long as the horizon does not extend to beyond 15 or 20 years, the interactions due to variations in the significant parameters from the central path will be small compared with the direct effects. A conceivable device, therefore, is to construct measures that can be multiplied by cumulated deviations from the central trends to give new estimates. Of course, this possibility would stem from the fewness of the parameters that have been retained as significant. A scheme of this type would require further research to determine the most effective and simple means, but there are no insuperable obstacles. The close association of the planner with the forecasting process in this way may be the most promising avenue, whereby a better knowledge of the problems of uncertainty can be disseminated.
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