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PREFACE

The *Population Bulletin of the United Nations* presents brief articles relating to population which, by their nature, do not require separate publication. Material for the *Bulletin* is selected in the light of the interests and needs of Governments, international organizations, research institutions and individuals engaged in social and economic research, as well as the public interested in population.

The first seven issues of the *Population Bulletin* were prepared by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat between 1951 and 1963. In accordance with the endorsement and recommendation of the Population Commission at its eighteenth session, the *Bulletin* has been reinstated as a United Nations publication, beginning with the publication of *Bulletin* No. 8 in 1977. As in the past, the *Bulletin* will be prepared by the Population Division.

It is expected that most of the articles to be published in the *Bulletin* will be prepared by the United Nations Secretariat in pursuance of the programme of work recommended by the Economic and Social Council and the Population Commission. Studies by consultants and reports of meetings organized by the United Nations, or excerpts from such studies and reports, may also be included. In addition, contributions will be solicited from the specialized agencies of the United Nations, the secretariats of the regional commissions and scholars.

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EXPLANATORY NOTES

The following symbols have been used in the tables throughout the report:

Three dots (...) indicate that data are not available or are not separately reported

A dash (—) indicates that the amount is nil or negligible

A blank in a table indicates that the item is not applicable

A minus sign (–) indicates a deficit or decrease, except as indicated

A full stop (.) is used to indicate decimals

A slash (/) indicates a crop year or financial year, e.g., 1970/71.

Use of a hyphen (-) between dates representing years, e.g., 1971-1973, signifies the full period involved, including the beginning and end years.

Reference to "tons" indicates metric tons, and to "dollars" ($) United States dollars, unless ortherwise stated.

Annual rates of growth or change, unless otherwise stated, refer to annual compound rates.

Details and percentages in tables do not necessarily add to totals, because of rounding.

THE PREDICTABILITY OF FERTILITY IN DEVELOPED COUNTRIES

Charles F. Westoff *

SUMMARY

A review of fertility in the countries of the developed world indicates a declining trend and very low level, with impending negative growth a definite possibility for an increasing number of countries. An argument is developed that neither conventional population projections nor the use of data on birth expectations is likely to produce accurate short-term forecasts. On the other hand, the long-term social trends that have been responsible for the historical decline of fertility are irreversible and some have not yet run their full course, so that continued low fertility over the long term seems likely. Some demographic trends in marriage, divorce, cohabitation, remarriage, illegitimacy and the status of women are reviewed for Denmark, Sweden and the United States of America, which seem to be in the forefront of radical changes in marriage patterns. These changes in turn are seen as both responding and contributing to the forces responsible for low fertility.

There have been several reviews of recent fertility trends in the developed countries [1] and, with few exceptions, they indicate a widespread decline and convergence. The exceptions are in some of the Eastern European countries, in which fertility appears to have increased since the early 1970s. Since these increases are thought to result mainly from changes in abortion laws and short-term timing changes in first and second births rather than from the radical effects of pro-natalist economic policies of from any widespread changes in attitudes, the chances are that the reversal of the decline in eastern Europe will be temporary and that a resumption of the lower fertility pattern can be expected. [2] Thus, the general picture in most of the developed countries has been one of declining and/or very low fertility, with the result that some 26 of the 33 developed countries are at, below, or only slightly above the replacement level. Despite this low fertility, the populations of this part of the world, because of the age structure, would continue to increase by about one quarter, assuming the continuation of a net reproduction rate of unity from the early 1980s. Nevertheless, some countries are rapidly approaching zero population growth and several have passed that stage and are currently experiencing more deaths than births (Austria, the German Democratic Republic, the Federal Republic of Germany and Luxembourg).

In a recent review of demographic trends in Europe, [3] Bourgeois-Pichat concludes that the best extrapolation of current fertility trends is a projection in which fertility declines until 1986 and then levels off at a gross reproduction rate of 0.75 (a total fertility rate slightly above 1.5). Little change in mortality is envisioned. Under such a schedule, by about 1980 deaths would begin to exceed births (as they have already in the four countries just mentioned) in Belgium, Denmark, Czechoslovakia, Hungary, Norway, Sweden and the United Kingdom. By 1990, negative population growth would also occur in Bulgaria, Finland, Greece, Italy and Switzerland; by 2000, France and the Netherlands would be added to the list and the populations of the remaining countries in Europe would begin to decline in subsequent decades. Collectively, the

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[1] See, for example, *World Population Prospects as Assessed in 1973* (United Nations publication, Sales No. E.76.XIII.4); *Fertility and Family Planning in Europe around 1970 : A comparative Study of Twelve National Surveys* (United Nations publication, Sales No. E.76.XIII.2); György T. Acsádi and Gwendolyn Johnson-Acsádi, "Determinants of recent trends in fertility in developed countries", and Jerzy Berent, "Fertility trends and policies in Eastern Europe in the 1970s" (unpublished papers for the Conference on the Social, Economic and Health Aspects of Low Fertility, held at the National Institute of Child Health and Human Development, Washington, D.C., in March 1977); D. V. Glass, "Recent and prospective trends in fertility in developed countries", *Philosophical transactions of the Royal Society of London*, March 1976; Jean Bourgeois-Pichat, "Baisse de la fécondité et descendance finale", *Population* (Paris), November-December 1976, pp. 1045-1117; Charles E. Westoff, "The populations of the developed countries", *Scientific American*, vol. 231, No. 3 (1974), pp. 108-120.

[2] Berent, *op. cit.* See also Jean Bourgeois-Pichat, "The economic and social implications of demographic trends in Europe up to and beyond 2000", *Population Bulletin of the United Nations, No. 8-1976* (United Nations publication, Sales No. E.76.XIII.3), pp. 34-88. In Hungary, for example, the increases in fertility in 1974-1976 were largely due to increases in first and second births; the average birth order did not increase (see András Klinger, "Fertility and family planning in Hungary", *Studies in Family Planning*, vol. 8, No. 7 (July 1977), pp. 166-176).

[3] Jean Bourgeois-Pichat, "The economic and social implications of demographic trends in Europe up to and beyond 2000", *loc. cit.*

population of Europe and the Soviet Union would begin to decline around 2000. Although such low fertility has never existed for an actual cohort (the lowest on record being 1.8 for the 1907 cohort in England and Wales), it can be argued that the development of modern contraceptive technology and the increasing availability of legal abortion makes such a level quite possible over sustained periods.

The question of obvious policy significance is: what really will happen in the future? Will fertility continue to decline, will it level off somewhere around replacement, or will it rise? Can we eventually expect stabilization around some low value or, as some demographers hypothesize, will there be cyclical fluctuations in fertility,[4] leading perhaps to another baby boom in the next generation?

As E. Grebenik has remarked in a discussion of Brass's recent paper on population prediction, "it is perhaps salutary to remind ourselves that there is only one feature that all demographic predictions have had in common, and that is that they have all been falsified by events."[5] The United States Bureau of the Census has found it necessary to make more than a dozen revisions of its projections in the last three decades. It has become almost a cliché that the demographer's record in predicting population growth is a dismal one; nonetheless, the demand for such predictions is insistent. The argument that projections are not predictions is unconvincing, since we regularly publish high, medium, and low projections, which are assumed to encompass the probable limits of likely alternatives and are so interpreted by the consumers of such information regardless of the methodological qualifications. Population forecasts are "inherently judgmental."[6]

The simple fact of the matter, it seems to me, is that demographers are in only a marginally better position than other observers of society (whether social scientists or journalists) to forecast future fertility. The demographer does know the history of fertility and is therefore likely to have some basis for assessing the frequently accordion-like behaviour of period birth rates. But when it comes to assessing future trends in fertility in terms of their presumed social and economic determinants, the demographer is at a loss: he has no sound basis for inferring that a change of a particular magnitude in this or that social or economic variable will produce a change in fertility or for predicting the likelihood of such changes.

Our theory of the determinants of secular trends in fertility is mostly a hotchpotch of historical insights, plausible speculations and empirical evidence derived largely from cross-sectional studies of contemporary populations. We know quite a lot about contraceptive behaviour. We know also about the association of cumulative fertility with education and religion, with rural urban residence, and with race and ethnicity (in some countries). Our knowledge of its association with income and wife's employment is complex and incomplete. Our assumptions about the effects of housing on fertility are mainly speculative. Even where knowledge is most secure, as in the studies of differential cumulative fertility, the assumption that cross-sectional relationships can be converted into relationships with current fertility measures over a period of time is a weak one. The most sophisticated methodology for population projection can only extrapolate the built-in fertility assumptions, and these are either moderate variants of recent trends or are based on data on the number of children expected, derived from sample surveys of married women of reproductive age.

When introduced in 1955 in the first national fertility survey in the United States of America,[7] the idea of using women's own expectations regarding their future reproductive behaviour was disarmingly plausible. Consumer surveys had successfully forecast the sales of consumer durable goods by asking about expected purchases of automobiles and refrigerators. Why couldn't the same logic be applied to the number of births? Early evidence during the late 1950s and early 1960s was encouraging in that aggregate fertility over five-year periods was reasonably consistent with mean expectations of different age categories. But none of the surveys between 1965 and 1970 in the United States or Canada, for example, provided the slightest indication of the collapse of fertility that was to occur only a few years later. In 1975, on the basis of a further interview with the couples first interviewed in the 1970 National Fertility Study,[8] the proportion intending to have additional children overestimated fertility over the five-year period by the same margin of error that would have occurred had the period fertility rate in 1970 been used as the basis for prediction. The results at the individual level were hardly reassuring: a third of those intending to have another child did not have one, while an eighth of those intending to have no further children were fertile. (The predictive value of individual intentions was, however, at least as good as the best demographic predictor: marriage duration.) Another analysis of Current Population Survey data revealed that the expectations of women under 30 years of age in 1971 regarding their fertility in the next five years were 11 per cent too high.[9]

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[4] W. Brass, "Perspectives in population prediction - illustrated by the statistics of England and Wales", *Journal of the Royal Statistical Society*, vol. 137, part 4 (1974), pp. 532-570; R. A. Easterlin, "The American baby boom in historical perspective", *American Economic Review*, vol. 51 (5 December 1961); Ronald Demos Lee, "Demographic forecasting and the Easterlin hypothesis", *Population and Development Review* (New York), vol. 2, Nos. 3 and 4 (September/December 1976), pp. 459-468. See also Nathan Keyfitz, "On future population", *Journal of the American Statistical Association*, vol. 67 (June 1972), p. 361, where it is suggested that there is a great amount of variability around replacement.

[5] E. Grebenik, "Discussion of Professor Brass's paper", in W. Brass, *loc. cit.*, pp. 572-573.

[6] D. B. Pittenger, "Population forecasting standards: some considerations concerning their necessity and content", *Demography*, vol. 14, No. 3 (August 1977), pp. 363-368.

[7] R. Freedman, P. K. Whelpton and A. Campbell, *Family Planning, Sterility and Population Growth* (New York, McGraw-Hill, 1959).

[8] Charles F. Westoff and N. B. Ryder, "The predictive validity of reproductive intentions", *Demography*, vol. 14, No. 4 (November 1977).

[9] M. O'Connell and M. J. Moore, "New evidence on the value of birth expectations", *Demography*, vol. 14, No. 3 (August 1977), pp. 255-264.

One begins to suspect from this record that fertility intentions or expectations have all the period sensitivity of the more conventional period rates, that is, they reflect that period's economic and social milieu and the picture it affords of the near future. Easterlin asserts, quite correctly it seems to me, that "the evidence is more consistent with the view that changes in behaviour precede those in attitudes, rather than vice versa". [10] When fertility is stable, expectations seem to provide decent estimates; when fertility is changing rapidly (our knowledge is limited to declining rates), then expectations are of less use for short-term prediction. Their usefulness as predictors of completed cohort fertility may be more stable but the ability of newly-married women to forecast their completed family size 15-20 years later is questionable. The woman, in effect, is being asked to make a complex calculation, in which her and her husband's current and future preferences, their fecundability and their ability to control unintended fertility have all to be balanced. Accurate aggregate prediction depends on the cancelling of errors, of underestimates and overestimates. Now that highly effective methods of fertility control are becoming increasingly common (three quarters of the couples in the United States of America using contraception in 1975 were either sterilized or using the pill or the intra-uterine device (IUD) and nearly half of all the couples who had been married for 10-24 years were surgically sterilized), the incidence of unwanted births can be expected to decline and aggregate estimates may show an upward bias. The emergence of the "perfect contraceptive population" [11] can also be expected to increase the probability that annual fertility rates will fluctuate more because the decision to have or to postpone an intended birth will become more responsive to changes in the couple's (society's) social and economic milieu. Perceptions of one's future income, the woman's work situation, housing, changes in fashion with respect to attitudes toward children, all these and many other "determinants" of fertility can change rapidly and easily upset short-term predictions. Natural or uncontrolled fertility in past centuries was easier to predict.

This line of argument simply concludes that short-term prediction of fertility within limits of error tolerable for many planning purposes seems unlikely in countries with low fertility. Are we therefore to conclude that population projections are so uninformed that they are likely to be useless, if not misleading?

It is important to emphasize that the vulnerability of population projections derives from the difficulties of anticipating future reproductive behaviour. The future numbers and age-structure of the existing population can be projected with great confidence. In addition, a very important use, indeed perhaps the greatest scientific value, of population projections is to illustrate the demographic implications of different assumptions about the future course of fertility. The policy debates within the United States Commission on Population Growth and the American Future were framed by two alternative assumptions about future growth: that it would follow a two-child or a three-child average. The numerical and age-composition effects of these two projections were then evaluated for their economic, environmental, governmental and social significance and implications for planning. Interestingly, in the light of the present discussion of rapidly changing fertility, even this range of fertility failed to encompass the actual value of period fertility, which only a few years later fell significantly below replacement level. In retrospect, it would have been more instructive to have included an assumption of a 1.5 fertility rate.

Aside from the dubious predictive value of short-term projections of fertility, are we also unable to offer any assessment of the most likely long-term reproductive prospects of the developed countries? One prominent school of thought, associated primarily with the work of Richard Easterlin, offers a theory for forecasting fertility on a generational cycle. [12] The basic notion is that fertility responds positively to the perception of economic opportunity, which, in turn, is related to the supply of labour. This translates into a negative correlation between the size of a cohort and its fertility, a correlation that has been empirically demonstrated for several generations in the twentieth century in the United States. Small cohorts born in the 1930s were the parents of the baby boom in the expansive 1950s; the large cohorts of the 1950s who encountered greater educational and job competition, in part because of their sheer numbers, have sharply curtailed their own fertility in the 1970s. This in turn leads to the prediction of a new baby boom in the 1990s.

Such a basis for forecasting is attractive because of its theoretical grounding, but there are problems. It leads to an expectation of cyclical patterns for which there are only really two historical examples (illustrated above); no evidence for anything similar has yet been adduced for other countries; and perhaps more importantly, it ignores what appear to be fundamental changes in the status of women. For reasons discussed below, another sustained baby boom does not seem likely when other social changes are taken into account.

Most students of the subject would agree that any prognosis of long-term fertility trends involves an assessment of the historical social and economic trends that seem to determine fertility. An analysis of the factors associated with the demographic transition in nineteenth century Europe (by Ansley Coale and others) has thus far succeeded in emphasizing the complexity and multiplicity of "causes" of the decline of fertility in different nations and at different times. Without trying to assess the independence and magnitude of each factor, the usual litany of socio-economic changes subsumed under the heading of modernization includes the transformation of agrarian economies and rural society into an industrial urban society in which the economic value of children has changed radically; the ever-widening literacy and education of the masses, especially women; the declining authority of tradition and religion; individualism and an ethic of social mobility; the undermining of the function of the

[10] Richard Easterlin, "Relative economic status and the American fertility swing", in Eleanor Sheldon, ed., *Social Structure, Family Life Styles and Economic Behaviour* (Philadelphia, J. B. Lippincott, 1973), p. 209.

[11] L. Bumpass and C. F. Westoff, "The 'perfect contraceptive' population", *Science*, vol. 169 (September 1970), pp. 1177-1182.

[12] Ronald Demos Lee, *loc. cit.*

family by other social institutions; the increasing equality of the sexes; and the development and availability of fertility control technology. Each of these social changes and its implications for declining fertility is the subject of an essay in itself. The main point to emphasize here is that none of these historical changes shows any indication of reversing itself, and some, such as the changing status of women and the improvement and increasing access to the means of fertility control, have been accelerating in recent decades. There is no radical reversal of any long-term social change that would imply a change in the small-family norm. In fact, if we look more closely at current social trends or their demographic outcome, we see signs that the institution of marriage may be changing in still newer ways and that fertility may decline to new lows. The theory that the historical demographic transition will terminate in a magical balance of births and deaths at low levels may be more aesthetic than realistic. The current evidence from the United States of America and from two Scandinavian countries that historically seem to be in the avant-garde of social change in the developed world reveals a significant constellation of social-demographic changes.

Marriage. The proportion of unmarried young women is increasing. In the United States of America, the proportion not married by ages 20-24 has increased from 28 per cent in 1960 to 45 per cent by 1977. In Denmark, this figure rose between 1970 and 1975 from 44 to 59 per cent. [13] In Sweden, the number of marriages declined by 30 per cent between 1966 and 1975. [14]

Divorce. The divorce rate rose 45 per cent between 1970 and 1975 in the United States of America and has reached the level where, at 1975 rates, at least one of every two marriages sooner or later would be dissolved. A recent estimate indicates that a third of all children in the United States will spend a significant amount of time with a divorced or separated parent. [15] In Sweden, the number of divorces tripled over the decade ending in 1975.

Cohabitation. In Denmark, about one quarter of all women aged 18-25 are living with a man to whom they are not married. The number of such relationships increased by half between 1974 and 1976. In the United States of America an estimated [16] nearly 1 million unmarried couples were living together in 1976—about 2 per cent of all couples living together. This figure will undoubtedly increase. In Sweden, recently, about 12 per cent of all couples living together (aged 16-70) were not married. [17]

Remarriage. Since such a high proportion of divorced persons remarry, there seems little reason to think of divorce as a reflection on the institution of marriage itself. But we also see signs of change here. The remarriage rate shows some indications of beginning to decline in the United States of America and in Sweden it has declined by about half since 1965.

Illegitimacy. In the United States of America there was a record high proportion of illegitimate births (14.3 per cent of all births) in 1975. Significantly, the greatest increase occurred among white women 25-29 years old, which suggests that out-of-wedlock childbearing may be becoming more acceptable. In Denmark, the proportion of illegitimate births doubled in a decade, to 18.8 per cent in 1974; in Sweden, the number tripled, so that illegitimate births now represent about a third of all births.

One could argue that all of these changes simply mean that formal marriage in the sense of the legal contract is just going out of style, at least in the early stages of "coupling", and that the rate of living together in monogamous unions is not basically changing. Indeed, research in Denmark suggests that for some couples cohabitation is the experimental or trial marriage. In a sample survey of such couples, about a third said, in fact, that they were living together as an experiment and about 14 per cent claimed that cohabitation was economically advantageous, while a quarter simply rejected the necessity for the legal formality of marriage. Nevertheless, it seems plausible to infer that such informal arrangements will hardly contribute to increasing fertility and that there will probably be less stability in the early (more fertile) years of marriage than in past generations. As the observer of the Danish scene concludes, these changes "make marriage a less 'weighty' commitment than formerly". [18]

Status of women. In recent decades there has been a pronounced increase in the proportion of women employed outside the home. In the United States of America, the proportion of women in the prime childbearing years (20-34) who work, has increased from less than 40 per cent in 1960 to about 60 per cent in 1976 and is projected [19] to reach about two thirds by 1990. A female labour force participation rate of about 60 per cent is projected by the ILO for women of reproductive age by the year 2000 for Europe as a whole. [20]

There is a considerable body of research literature on the subject of the relationship between fertility and women's work. Much of it is ambiguous with respect to the causal sequences involved and there are certainly institutional child-care arrangements that make it easier for the mother to work. Nevertheless, there is little doubt that women's work and fertility are on the whole negatively related [21] and that the future will probably see increasing proportions of working women.

The increasing equality of the sexes, however, still has a long way to go in the economic sphere. Although educa-

[13] Louis Roussel, "Démographie et mode de vie conjugale au Danemark", *Population* (Paris), March-April 1977, pp. 339-359.

[14] France Prioux-Marchal, "Le mariage en Suède", *Population* (Paris), July-October 1974, pp. 824-852. See also Jean Bourgeois-Pichat, "The economic and social implications of demographic trends in Europe up to and beyond 2000", *loc. cit.*, p. 64.

[15] Paul C. Glick, "Social change and the American family", paper presented at the National Conference on Social Welfare, to be published in *Social Welfare Forum* (Irvington-on-Hudson, New York, Columbia University Press).

[16] *Idem.*

[17] *Idem.*

[18] Louis Roussel, *loc. cit.*

[19] United States of America, Bureau of Labor Statistics, *New Labor Force Projections to 1990*, Special Labor Force Reports, No. 197 (Washington, D.C., 1976).

[20] Estimated from graphic figures in Jean Bourgeois-Pichat, *loc. cit.*, p. 70.

[21] William Butz and Michael P. Ward, "The emergence of countercyclical U.S. fertility" (Santa Monica, California, The Rand Corporation, 1977).

tional differences between the sexes have greatly diminished and more and more women are working, there is still a wide difference in the economic status of men and women. There is a disproportionate concentration of women in the less remunerative occupations and women are paid less in the same occupations. In the United States, among year-round full-time workers receiving an income in 1975, the earnings of women 20-44 years of age were 61 per cent of men's earnings. [22] Significantly, that ratio remains unchanged at different levels of education.

Nonetheless, the future trend of women's economic status seems fairly clear. Increasing proportions of women will have the option of financial independence, although genuine economic equality is no doubt generations away. Indeed, such equality may never materialize, although it may be approximated to some significant degree. But imagine a society in which men and women are economically equal and independent. What will be the consequences for marriage and fertility?

Marriage can be regarded historically (and unromantically) as an economic exchange system, in which the woman has traded her childbearing, domestic and sexual services for the man's economic and social status and protection. If that economic inducement fades away, what function will marriage perform? Sex and companionship are certainly available without the commitment implied by marriage. The main remaining function would be the legitimization of offspring, but the very forces that will undermine marriage will also reduce fertility. Moreover, childbearing outside marriage will probably become increasingly acceptable.

[22] Calculated from United States of America, Bureau of the Census, *Current Population Reports*, Series P-60, No. 106 (June 1977).

If this is a reasonable interpretation of the evidence and if this diagnosis is even only approximately correct, then fertility in the developed countries seems destined to fall to very low levels, probably below replacement, unless nations invest considerable resources in programmes to induce more women to have more children. At least half a dozen countries already seem uncomfortable with such trends. (What such programmes and their potential demographic effectiveness might be are wide-ranging questions and beyond the scope of this essay; it seems evident, however, that much more than trivial baby bonuses will be required.) It is not difficult to envisage a society in which perhaps a third of the women would never have any children, which would mean that the remaining two thirds would have to be persuaded to reproduce at an average rate of three births per woman to maintain replacement.

In looking into the long-range future, it is important to remind ourselves of the past: for a century or longer fertility has been declining more or less steadily in most of the developed countries and in only a few countries was there a sustained post-war baby boom (the baby boom being more the exception to be "explained"). So, to return to the question of how predictable future fertility in the developed countries is, we should depend on the observation that all of the forces that have historically led to the decline have not changed—indeed to all intents and purposes they are mostly irreversible—and some of the critical forces, especially in connexion with the status of women, have not yet run their course. There is little basis for suggesting a rise in fertility (although one should not ignore an unpredictable swing in fashion that might temporarily restore the prestige of maternity). Short-run fluctuations will undoubtedly occur and, except for changes implicit in demographic structure, are at this stage of our knowledge largely unpredictable. The long-term trend seems fairly clear.

NEW METHODS FOR FORECASTING FERTILITY: AN OVERVIEW

Ronald D. Lee *

SUMMARY

This paper reviews some new approaches to the forecasting of fertility that are primarily of relevance for developed countries. It concludes that methods based on leading socio-economic theories give contradictory forecasts and are as yet inadequately tested. The use of data on expectations collected from surveys appears to disguise the problem of predicting fertility change rather than solve it. However, recent work does suggest several useful new methods for prediction based on persistent aspects of the internal structure of fertility variation. First, it is essential to analyse the autocovariance structure of fertility, using techniques such as those advocated by Box and Jenkins. Secondly, if age-specific or parity-specific rates are analysed, it is essential to take account of their cross-correlations over a period of time. Thirdly, the purely random component of variation can safely be ignored. Fourthly, all the above points hold true whether or not some additional model for trends in the mean level of fertility is used. Fifthly, an advantage of these procedures is that explicit confidence intervals can be supplied to the user, and work published so far suggests that such intervals will be much larger than those usually attached to official forecasts.

A second potentially useful approach is the statistical separation of period and cohort effects, each of which can then be projected, possibly with the aid of the time-series methods just discussed. In any case, estimates of exogenous change in contraceptive failure rates can be used to adjust *ceteris-paribus* forecasts, or perhaps to adjust the basic data before their analysis.

INTRODUCTION

In recent years there have been excellent reviews of general demographic forecasting methods by Keyfitz (1972), Henry (1972) and Brass (1974). This paper, which exclusively concerns fertility, will place more selective emphasis on some relatively new approaches, which are chiefly appropriate for developed countries. These are (*a*) the use of stochastic population models and statistical time-series methods; (*b*) the use of survey data on contraceptive failure and expected fertility; and (*c*) the use of behavioural models of fertility, including the neo-classical home production model, the Easterlin relative-income hypothesis and eclectic regression models.

STOCHASTIC POPULATION MODELS AND STATISTICAL TIME-SERIES METHODS

Stochastic models for confidence intervals

In the past decade, a number of studies, noting the unreliability of demographic forecasts, have sought to formalize our uncertainty about future population movements. These studies have therefore been more concerned with providing confidence regions for forecasts than improving the forecast levels. Muhsam and Hoem have discussed the practical importance of such confidence regions, and the way in which they can be combined with the cost function of the forecast-user.

Besides measurement error, there are two sources of uncertainty: first, an intrinsic randomness due to the fact that at the individual level constant demographic rates are really probabilities; and secondly, unforeseen changes over a period of time in the rates themselves. (For a more detailed breakdown, see Hoem, 1973.) The first source of uncertainty has been studied in detail by Sykes (1969), Pollard (1969), Schweder (1971), and Schweder and Hoem (1972). The conclusion to be drawn from this work is clear: when dealing with populations of even moderate size, such a source of forecast error can safely be ignored. This theoretical conclusion is neatly illustrated by Spencer's (1976) empirical study of the temporal variability of demographic events by size of population.

This leaves unforeseen temporal variation in the rates as the principal source of error in forecasting, a conclusion that will surprise nobody. A number of studies have considered the way in which the variability of fertility is transformed, by the age structure of reproduction, into

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the variability of births (Sykes, 1969; Lee, 1974; Schweder and Hoem, 1972; Schweder, 1971). The variances and covariances of age-specific fertility can be estimated from the past history of fertility, and thus practical forecasting with confidence intervals becomes possible. While this approach starts out merely to provide confidence intervals for forecasts of births, it inevitably ends by proposing new methods for forecasting levels of fertility, since official methods are too complex and subjective to formalize in a suitable way. The resulting methods for forecasting tend to emphasize the historical averages of the series, rather than the persistence of current values. While this approach has considerable merit, particularly as a corrective to demographers who frequently extrapolate current levels, it certainly does not exploit all the information available in the past behaviour of the fertility series. More recently, methods taking fuller advantage of the past have been proposed.

Time-series models

The publication in 1970 of the Box and Jenkins study on the forecasting of time series led to an increased interest in forecasts based on the internal structure of a time series, as expressed by simple models. Saboia (1974 and 1977) has applied these techniques directly to birth series for Sweden, Norway and Mexico, completely bypassing such staples of demographic analysis as age structure and the distinction between events and rates, and Pollard (1970) analysed the Australian time series of births in a similar vein. Lee (1974) attempted to synthesize the traditional demographic model with the time series techniques, in a forecast of fertility and births in the United States of America. A different approach was suggested by Brass (1974), who proposed fitting sine waves to fertility series for purposes of extrapolation; such methods, however, have been superseded by the Box-Jenkins techniques, except for strictly periodic series.

All these methods attempt to exploit the internal structure of the demographic series, on the necessary assumption that crucial aspects of that structure (mean or trend in mean, variance, auto-correlation) are invariant over time. Since they all require long data-series of at least several decades, this assumption is hard to accept, particularly when unprecedented and abrupt changes in contraceptive technology and practice are occurring.

An additional difficulty with the time-series models is that assumptions about trends are strictly mechanical and fail to incorporate our best prior information, or any social or demographic theory. For example, many demographers would subscribe to the notion of a demographic transition in which fertility declines from a high to a low mean level and then fluctuates, perhaps within the bounds of from one to three or four children per woman. One might try fitting logistics to long historical series of the total fertility rate (or age-parity-specific rates), and then use Box-Jenkins techniques to model the residuals. This procedure would treat some of the variance in fertility as "explained" by transition theory, and exclude it from the measure of over-all uncertainty.

Statistical analyses of cohort, period, age and parity effects

Although most demographers have come to view cohort fertility measures as more fundamental than period ones, and therefore as a more satisfactory basis for forecasting, there is little hard evidence that the belief is justified, and it was recently questioned by Brass (1974). In the extreme view, cohort measures are merely a weighted average of prior period measures, and have no additional behavioural basis. Thus, although they will perforce change more slowly and smoothly than period rates, they will contain no additional information and their use will convey no advantage.

There have been several attempts to determine statistically the relative importance of cohort *versus* period effects as explanators of variance in the age-parity-time matrix of fertility rates (Rosenberg and others, 1975; Sanderson, 1977; Winsborough and Dickenson, 1972; Cutright and others, 1975), although there are well-known difficulties in such an approach (Mason and others, 1973). The general conclusion is that there is little to choose between period and cohort components as explanators of variance when combined with age, and the best results are obtained by using all three components (see, for example, Cutright and others, 1975 and Winsborough and Dickenson, 1972); however, some writers (Rosenberg and others, 1975) claim that the cohort measures provide a firmer basis for forecasting. In principle, this statistical procedure allows one to isolate a cohort component even for currently young age groups; the projection of future fertility can then be based on these values.

A less elaborate approach to the forecasting of a cohort's fertility early in its reproductive career is to fit a model schedule, such as the Gompertz curve suggested by Farid (1973); since, however, this method does not first abstract systematically from period effects before calculating the cohort effect, it seems distinctly inferior, except when sufficient data for the decomposition are not available.

A related approach is to fit an analytic curve to period age-specific fertility schedules, and then to use time-series methods to forecast each parameter (see Mitra and Romaniuk, 1973). This might well be a satisfactory compromise between simply forecasting the total fertility rate (as in Lee, 1974) and forecasting each age-parity-specific rate individually (as Passell, 1976).

Logistic type models

Another approach, combining mechanical, behavioural and formal statistical elements, is the fitting of logistic type curves to series of total population size. Extensive early applications were made by Pearl (1924). However, the method for attaching confidence intervals was derived later by Schultz. The Pearl forecast of United States population, based on census data for 1790-1910 inclusive, was within the 95 per cent confidence bounds for all subsequent censuses up to and including 1950 (see Davis, 1963). The method has recently been generalized and reapplied to United States data by McNeil (1974). An obvious difficulty with the method is that only the size of the population is forecast. More fundamentally, the method is

widely distrusted as being founded on an arbitrary choice of mathematical function with no basis in social theory. In recent years, concern with the natural limits to human population growth has given the approach a new intellectual respectability.

Survey data

Survey measures of fertility expectations

An apparently straightforward approach is to ask an appropriate sample of women or couples how many children they expect to have, and when. Such surveys are routinely carried out in a number of countries, and their potential for forecasting has been widely discussed (Freedman, Whelpton and Campbell (1959); Siegel and Akers (1969); Ryder and Westoff (1971); O'Connell and Moore (1977); Blake (1974); Freedman and others (1977)). The basic methodology was developed and applied in Freedman, Whelpton and Campbell (1959), and official United States forecasts over the past decade have used expectations as the basis for projecting completed fertility. Whelpton and others (1966) used data on expectations to forecast successfully the inception of the fertility decline in the United States of America; subsequently, however, these forecasts were criticized on methodological grounds by Ryder and Westoff (1971). A method for measuring the intensity of fertility preferences has been developed and applied by Coombs and others (1975).

The soundness of the method for short-run forecasts requires that the fertility behaviour of cohorts should conform to their average expectations, and that their average expectations should remain stable over a period of time. For longer-run forecasts, it is also necessary that expectations be similar across cohorts. The major difficulty with this approach, in my opinion, is that fertility expectations change in time within and between cohorts, as socio-economic conditions change; thus the last two requirements of the method are not satisfied. It may be no easier to predict future expectations from current expectations than it is to predict future fertility from current fertility. Both tasks are easy under static conditions and difficult under fluid ones. In fact, all the official United States forecasts based on expectations data have in effect assumed total fertility to be constant at base-period levels (see Lee, 1976: 460), and since both expectations and fertility have subsequently changed rapidly, the forecasts have not been very successful. There is clearly some danger that the use of data on expectations may justify the placing of undue emphasis on current conditions.

A second problem, much less formidable than the first, lies in the translation of expectations concerning desired numbers into actual forecasts of period fertility rates, given a changing context of contraceptive failure rates: Menken and Lee are working in this area. Lee (1977) develops a model in which period fertility rates depend on the proportion of couples wanting at least one additional child. The birth rate among these "nonterminator" couples depends on the desired birth interval, and on contraceptive failure rates in terms of timing. An additional component of period fertility is due to contraceptive failure rates, in terms of numbers, among "terminators".

Changes in contraceptive practice

Many of the surveys that elicit responses on fertility expectations also gather information that can be used to study contraceptive failure. These help to document the effects of technical and social innovations in contraception, such as the pill, IUD, sterilization and abortion. Some of the change in choice of method and success of method is endogenous, but a portion is genuinely exogenous. In the United States of America a decomposition of the decline in unwanted fertility shows that about half is attributable to the change in the contraceptive methods used, and the other half to lower failure rates for a given method (see Ryder, 1973). The endogenous component of change can be roughly approximated by this second source of decline. The exogenous portion can be used to adjust downwards whatever the *ceteris-paribus* fertility forecasts would have been.

Behavioural models

The methods considered so far did not attempt to base forecasts of future fertility on an analysis of the causes of fertility variation, but any dramatic improvement in the unimpressive forecasting record of demographers requires a contribution from this source. I will discuss several recent approaches to the development of behavioural models suitable for forecasting, at least in developed countries.

The home production model

In recent years, many economists have worked on the so-called "home production" model of fertility (see the papers collected in T. W. Schultz, 1974). The major thesis, which is given an elegant mathematical formulation, is that the activity of raising children is more time-intensive than alternative activities and that therefore, when people's time becomes more valuable with rising wage rates, child-rearing becomes more expensive in relation to alternative activities. Thus, although rising incomes may lead people to choose more children, this effect is generally overwhelmed by a negative price effect leading people to replace child-rearing by other, less time-intensive, activities. The same argument suggests that people (and women in particular) will increase their labour supply as wages rise. Furthermore, rising incomes will lead people to devote greater resources to each child, which additionally increases the cost of children and leads to a decline in fertility (see Becker and Lewis, 1973).

Demographers may rightly claim that, whatever the formal apparatus of the theory, its basic insights are hardly new. There are, however, some non-obvious implications of the theory (for example, that men's education or wages should be positively related to fertility while women's should be negatively related) that there is not space to discuss here.

This theory has been applied to variations over a period of time in United States fertility (Kenny, 1977, Butz and Ward, 1977) and, not surprisingly, it leads to the conclusion that fertility is likely to fall still lower in the future as women's wages rise. More precise forecasts require not

only an estimated model, but also forecasts of the independent variables; nonetheless, the qualitative forecast would be very useful, if it were convincing.

The home production model of fertility outlined above is most properly applied to marital fertility. However, the general theory of household behaviour has also been applied to decisions concerning marriage and divorce, and some time-series analyses have been conducted (Michael, 1977). These may provide a basis for forecasting future trends in the marital status of a population, which would in turn be useful for forecasting fertility.

The Easterlin hypothesis

This theory was developed by Easterlin (1961, 1968, 1973) to explain fertility variations in the United States of America and has more recently been applied to other developed countries (Easterlin and Condran, 1976; Brunborg and Lettenstrom, 1976; O'Connell, 1977). Easterlin emphasizes the role of income in relation to aspirations, arguing that aspirations, which are acquired in the parental home, rise systematically, although unevenly, with economic growth. When couples perceive themselves as being relatively well off, the wife works less and her fertility is higher; when the couples perceive themselves as having a low relative income, fertility is reduced. Empirical time-series studies tend to confirm the theory (Wachter, 1975; Lindert, 1977; Lee, 1976; Easterlin, 1973), while micro-level cross-sections yield mixed results (Ben Porath, 1975; Thornton, 1977; Deborah Freedman, 1963).

The principal forecasting implication is that sustained growth in *per capita* income could be quite consistent with constant fertility, if income growth just matched aspirations; fluctuations in income growth, however, would lead to fluctuations in fertility. To make more specific forecasts, forecasts of relative income would be required.

A second component of the Easterlin hypothesis, tying the relative income of an age group to its size, greatly increases the power of the theory for forecasting purposes, since it makes it possible to construct a closed model containing only demographic variables. Such closed models have been estimated for various countries (Easterlin and Condran, 1976; O'Connell, 1977; Lee, 1974), and formal models embodying the closed demographic relations have been developed (Lee, 1970, 1974, 1976; Keyfitz, 1972; Samuelson, 1976). Lee (1976), the United States Bureau of the Census (1975) and Goldberg (1977) have used the hypothesis to develop forecasts.

The appeal of this approach in relation to other behavioural models is that, because it is a closed demographic model, it does not require prior forecasts of other independent variables. The difficulty is that the theory is insufficiently tested, although Easterlin (1961) and Grauman (1960) did use it successfully to predict the baby boom. Another decade's experience may well be required before the method can be adequately evaluated.

It should be noted that the Easterlin hypothesis and home production model frequently lead to contradictory conclusions (see Lindert, 1977, and Sanderson, 1976, however). Secular economic growth leads to increasing female activity in the labour force and falling fertility in the home production model, while according to the Easterlin hypothesis both fertility and participation in the labour force would fluctuate around a fairly constant mean level.

Eclectic regressions

There have been a number of regression analyses of fertility change over a period of time, particularly in the United States of America, which rely less closely on some particular underlying theory (for example, Land and others, 1977; Venieris, Sebold and Harper, 1973; Gregory, Campbell and Cheng, 1972). Some of these are undertaken with improved forecasting methodology in mind. In my view such studies have been less valuable than others because without a well-articulated theory there is a tendency to include variables that may well be endogenous, without taking adequate statistical precautions. And there is also a tendency to accept results with high R^2s (R being the coefficient of determination), even when there is no clear rationale for expecting the estimated relations to persist in the future.

SUMMARY AND CONCLUSIONS

It is my reluctant conclusion that analysis of the internal structure of fertility behaviour still provides the best available basis for forecasting. Methods based on leading behavioural theories give contradictory forecasts and are as yet inadequately tested. The use of data on expectations gathered through surveys appears to disguise the problem of predicting fertility change rather than solve it. Recent work does, however, suggest improved methods for prediction based on persistent aspects of the structure of fertility variation. There are several useful lines to pursue. One is the time-series analysis of fertility. Here several points have emerged from the work of the past few years. First, it is essential to analyse the autocovariance structure of fertility, using techniques of the Box-Jenkins type. Secondly, if age-specific or parity-specific rates are analysed, it is essential to take account of their cross-correlations over a period of time. Thirdly, the purely random component of variation can safely be ignored. Fourthly, all of the above points hold true whether or not some additional model for trends in the mean level of fertility is used. Fifthly, an advantage of these procedures is that explicit confidence intervals can be supplied to the user, and work published so far suggests that such intervals will be much larger than those usually attached to official forecasts. Of course, all these approaches have drawbacks, as discussed earlier.

A second potentially useful approach is the statistical separation of period and cohort effects, each of which can then be projected, possibly with the aid of the time-series methods just discussed. In any case, estimates of exogenous change in contraceptive failure rates can be used to adjust *ceteris-paribus* forecasts, or perhaps to adjust the basic data before their analysis.

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FUTURE OUTLOOK FOR MORTALITY DECLINE IN THE WORLD

Jean Bourgeois-Pichat *

SUMMARY

This paper is a follow-up to a study carried out by the author in 1952, in which an analysis of exogenous and endogenous causes of death in Norway was used to establish a biological limit; albeit a temporary one, for mortality decline. The paper examines the trends in each of these two major groups of causes in a number of developed countries, by age and for each sex separately, and, using data for Norway, describes the method used to calculate the limit mortality table for current limits corresponding to endogenous mortality. It is estimated that the biological limit for life expectancy at birth is 80.3 years for females and 73.8 years for males. The figures present an upward revision of the 1952 findings, which yielded life expectancies at birth of 78.2 and 76.3 years for females and males respectively. The difference between the two sexes is thus 6.5 years instead of the 1.9 years estimated in the earlier study.

THE ONSET OF MORTALITY DECLINE

For millenia, mortality was considered by mankind as a natural phenomenon over which human beings had little, if any, influence. The main objective of every individual on earth was to prepare for his death as well as possible according to his religious beliefs and there was a general consensus that the time of death was in the hands of God and there was no way of interfering with a decision taken at such a high level.

The idea that man was not entirely powerless against mortality emerged slowly from the medical progress made during the eighteenth century in Europe. The great break through did not come until later, but the practice of inoculation, for example, was sufficiently successful for it to be applied to Louis XVI of France, to prevent him dying from small pox. A few years later, the work of Jenner led to the replacement of inoculation by vaccination. Thus paving the way for two centuries of unceasing progress.

The achievements of the eighteenth century, limited though they may have been, were sufficient to modify completely ideas on the inevitability of death, and the pessimism of the past was replaced by an extreme optimism. Nothing seemed impossible and the following extract from Condorcet's *Esquisse d'un tableau historique des progrès de l'esprit humain* (Outlines of a Historical View of the Progress of the Human Mind), [1] written in 1793, serves as a perfect illustration of the new spirit that was abroad in the world and represents what might then have been the future outlook for mortality decline.

> The organic perfectibility or degeneration of animal and vegetal species may be considered to be a general law of nature, to which mankind is also subject. There is no doubt whatsoever that preventive medicine, a more healthy diet, better housing, a way of life designed to develop strength through exercise and prevent its destruction by excess and, finally, the disappearance of the two most active causes of degradation, extreme poverty and extreme wealth, will extend the duration of human life and will assure man of a more steady state of health and a stronger constitution. There is a general realization that the progress of preventive medicine, which rational thought and a new social order have rendered more efficient, will, in the long run, cause communicable diseases to disappear together with other diseases caused by climatic conditions, diet or the kind of work in which a person is engaged. It would not be difficult to prove that it will be possible, in the future, to extend this expectation to almost all other diseases, the true causes of which will, in all probability, one day be discovered. Is it then, absurd to assume that this progress may continue indefinitely? And that a time will come when death will be the result of an accident or the effect of the increasingly slow process of destruction of the vital forces, and, finally, that limits will no longer be set for the lapse of time between birth and the destruction of life? Of course, man will not become immortal, but is it not possible to believe that the interval between the moment man's life begins and the time when, in a natural way, without being subjected to sickness or accident, he finds it difficult to continue to exist, will go on increasing indefinitely? *

This was a very optimistic outlook for someone who was under sentence of death. Of course, Condorcet was only expressing general principles. But, just 13 years later, in 1806, François Duvillard published what is probably the first demographic study on the consequences of a further mortality decline for population trends. His book, entitled *Analyse et tableaux de l'influence de la petite*

* Chairman, Committee for International Co-ordination of National Research in Demography, Paris, France.

[1] Published in 1933 by Bovin et Cie (Paris).

* Unofficial translation.

vérole sur la mortalité à chaque âge et de celle d'un préservatif tel que la vaccine peut avoir sur la population et la longévité (Analysis and tables showing the influence of smallpox on mortality by age and the effect that vaccination can have on population and the longevity of mankind) was the beginning of a long series of studies on the subject. From time to time, since the beginning of the nineteenth century, studies have been published that have tried to gauge the possible effect on mortality of the best sanitary conditions known at the time of writing, and these studies were surveyed in a recent article by Roland Pressat. [2]

I became a member of this group of writers in 1952, when I published in *Population* an article entitled *Essai sur la mortalité biologique de l'homme* (Essay on man's biological mortality). [3]

The concept of a temporary limit on mortality decline

In 1952, medicine had just embarked on the revolution brought about by the discovery of antibiotics. For the first time, mankind was able to envisage the complete disappearance of infective and parasitic diseases. There have been three broad phases in the long fight against these diseases. The first method of avoiding them is to prevent contact with the enemy: public health measures and individual hygiene have been used to this end. If, in spite of all precautions, contact does occur, the second step is to create conditions that will render the meeting harmless: vaccination is based on this principle. Finally, if the second method is not available, the enemy must be dealt with on the spot. For a long time, the only possible approach was the first one. We have seen how research in the eighteenth century paved the way for the second method. The third did not become practicable until the discovery of the sulpha some 40 years ago, drugs followed by the discovery of antiobiotics just after the Second World War.

These three methods work very efficiently against exogenous causes of mortality. A different approach is necessary to combat endogenous causes and, so far, nothing comparable to vaccination, sulpha drugs or antibiotics has been found. Mortality due to endogenous causes can, therefore, be considered at any given time as a temporary limit, and fresh discoveries will be necessary in order to prolong it. This very simple—possibly too simple—idea was the basis of my study in 1952. Statistics on causes of death were used to separate deaths due to exogenous causes from deaths due to endogenous causes, as follows:

(a) *Exogenous deaths*

(i) Deaths due to infective and parasitic diseases

(ii) Deaths due to diseases of the respiratory system

(iii) Deaths due to accidents, poisonings and violence (external causes)

(b) *Endogenous deaths*

(i) Deaths due to neoplasms

(ii) Deaths due to diseases of the circulatory system

(iii) Deaths due to all other causes

Table 1 reproduces the two basic tables of the 1952 study. The death rates for endogenous causes in 1949 were taken as representing at that time the biological limit of mortality decline. On a graph where age is put in abscissa and the logarithm of the death rates in ordinate, the six endogenous rates of 1949 can be adjusted fairly well by a straight line. This straight line is assumed to represent the biological limit below age 30. Finally, a special study of infant mortality provided us with an estimate of endogenous deaths occurring a short time after birth.

Evolution of the limit of mortality decline over the past 25 years

Twenty-five years have passed since these calculations were made. What happened during that period is the subject of the present paper.

In 1952, Norway was chosen because at that time it had the lowest level of mortality; the study drew on the statistics on causes of death published by the Norwegian Bureau of Statistics. In 1977, Norway still had one of the lowest mortality levels, a characteristic it shared with Sweden and the Netherlands. For the sake of continuity, we shall use the Norwegian data, as published in the WHO *Annual Epidemiological and Vital Statistics.*

It is not very easy to obtain homogenous series, for two reasons:

(*a*) The age-grouping has changed over a period of time; and

(*b*) the International Classification of Diseases has been revised since the 1952 study: the sixth revision was made in 1948; the seventh revision in 1955 and the eighth revision in 1965.

Let us look first at the age groups. Starting with 1966, 10 year age groups are considered as follows: 25-34 years, 35-44 years, 45-54 years, 55-64 years, 65-74 years and 75 years and over. Before 1951, the age groups were 30-39 years, 40-49 years, 50-59 years, 60-69 years and 70 years and over: and from 1951 to 1965, quinquennial groups were given. The only way to obtain a homogenous series was, therefore, to use for the period 1951-1973 (1973 is the latest year for which WHO has published data) the 10 year grouping appearing from 1966 onwards in the WHO *Annuals.*

The three revisions of the International Classification of Diseases, which occurred in 1948, 1955 and 1965, did not change the content of the six broad groups of causes indicated in table 1, except for the deaths due to diseases of the respiratory system, but the effect on the size of the endogenous group is small. The basic data are assembled in annex tables A.1-A.15.

[2] Roland Pressat, "Les tables de mortalité en l'absence de certaines causes de décès", *Canadian Studies in Population*, vol. 1, 1974, pp. 61-73.

[3] *Population* (Paris), vol. 7, No. 3 (juillet-septembre 1952).

TABLE 1

Norway: age-specific death rates according to six broad groups of causes of deaths, 1935 and 1949

(Rates per 100,000 population)

	1935						1949					
	30-39 years	*40-49 years*	*50-59 years*	*60-69 years*	*70-79 years*	*80-89 years*	*30-39 years*	*40-49 years*	*50-59 years*	*60-69 years*	*70-79 years*	*80-89 years*
Infective and parasitic diseases	184	132	132	168	229	425	54	58	62	84	128	219
Diseases of the respiratory system	35	56	98	254	853	2 741	5	16	37	115	471	2 198
Accidents, poisonings and violence (external causes)	46	52	60	84	155	370	32	44	51	61	105	440
Total exogenous causes	265	240	290	506	1 237	3 536	91	118	150	260	704	2 857
Neoplasms	24	94	240	575	1 081	2 081	24	82	238	495	1 122	1 935
Diseases of the circulatory system	34	95	268	848	2 737	8 021	17	56	217	760	2 583	7 850
Other causes	73	127	182	374	790	1 712	39	71	146	272	736	1 878
Total endogenous causes	131	316	690	1 797	4 608	11 814	80	209	601	1 527	4 441	11 663
All causes	396	556	980	2 303	5 845	15 350	171	327	751	1 787	5 145	14 520

TABLE 2

Norway: age-specific death rates according to six broad groups of causes of deaths, 1951

(Rates per 100,000 population)

	30-39 years	40-49 years	50-59 years	60-69 years	70-79 years
Infective and parasitic diseases	24	25	40	56	77
Diseases of the respiratory system	2	4	14	45	269
Accidents, poisonings and violence (external causes)	30	45	52	71	119
Total exogenous causes	56	74	106	172	465
Neoplasms	32	89	227	477	982
Diseases of the circulatory system	16	64	233	815	2 645
Other causes	38	63	134	290	1 843
Total endogenous causes	86	216	594	1 582	4 470
All causes	142	290	700	1 754	4 935

Before analysing these data, it is worthwhile comparing the statistics for 1951 with those for 1949. Table 2 shows that, in two years, the modifications, if any, were very small. The series 1951-1973 can, therefore, be used for studying what has occurred since 1952.

Let us look at the results.

Endogenous causes of death

Table 3 shows that mortality due to infectious and parasitic disease continued to decline drastically from 1951 to 1973. It has almost completely disappeared below 45 years of age.

Mortality due to diseases of the respiratory system has increased since 1949. This is partly due to modifications introduced by the seventh revision of the International Classification of Diseases. This new classification began to be applied in WHO *Annuals* in 1965. Annex A.15 gives the additions introduced by the seventh revision in the content of deaths due to diseases of the respiratory system. It shows that these additions explain only part of the increase observed from 1949 to 1973. This observation might lead to the revision of the inclusion of diseases of the respiratory system in the group of exogenous causes. These diseases appear quite resistant to the present treatment. We continued to group them with the exogenous causes in order not to alter the comparison with the 1952 calculations, but the question remains open for future studies.

Mortality due to external causes increased from 1951 to 1973, particularly for women.

Endogenous causes of death

Since 1951, mortality due to endogenous causes has increased for men and decreased for women. For men, the increase is particularly important between 45 and 75 years of age. Table 3 shows that the increase is mainly due to diseases of the circulatory system and, to a lesser extent, to neoplasms. Mortality due to other endogenous causes has decreased.

For females, the decrease was mainly been in deaths due to other endogenous causes, but it has also been evident in deaths from diseases of the circulatory system. Mortality due to neoplasms has also decreased slightly at certain ages, but has increased at others, clearly indicating a resistance to treatment.

In the 1952 article, the phenomenon that had taken place between the pre-war and the post-war periods was compared to the erosion of soil composed of two kinds of rock: soft rock and hard rock. Erosion had carried away the soft rock, gradually revealing the hard rock beneath it. Over the last 25 years, this phenomenon has continued, but while the "soft rock" has been disappearing the level of the "hard rock" has risen in relation to men and sunk in relation to women.

MALE ADULT MORTALITY IN THE DEVELOPED WORLD

These movements throw some light on the trend of adult mortality from all causes that has been observed during the last 25 years. The quinquennial mortality rates by age for Norway for the period 1950-1973, for men and for women, are given in tables 4 and 5 respectively.

For women, the rates have declined constantly throughout the period. For men over 45 years of age, the rates are at their lowest in the 1950s, generally around 1951, and at their highest in the 1970s. This is due to the combined effect of decreasing exogenous mortality and increasing endogenous mortality. Recently, at certain ages only, the general trend seems to have been reversed and the decline appears to be stronger than the increase.

This phenomenon is not peculiar to Norway: it is observed in all developed countries and, depending on the level at which it occurs and the rhythm it follows, the combined effects can be very different. We have taken the male death rates for the age group 55-59 years, to show the variety that exists. Table 6 gives the rates for selected developed countries for the period 1949-1973 (for an illustration of the data in the table, see figure I). They call for the following comments.

TABLE 3

Norway: age-specific death rates, by broad groups of causes of death expressed as a percentage of the corresponding rates for 1951

(*Rates per million population*)

Causes of death	*Males*						*Females*					
	25-34 years	*35-44 years*	*45-54 years*	*55-64 years*	*65-74 years*	*75+ years*	*25-34 years*	*35-44 years*	*45-54 years*	*55-64 years*	*65-74 years*	*75+ years*
Infective and parasitic diseases	2	4	11	18	28	52	2	6	9	50	36	77
Diseases of the respiratory system	147	71	162	231	223	166	227	61	214	166	152	119
External causes (accidents, poisonings, violence)	115	107	110	117	120	103	211	107	232	118	95	96
All exogenous causes	67	67	74	98	128	138	39	33	84	101	107	111
Diseases of the circulatory system [a]	107	172	169	145	144	121	72	81	72	76	81	100
Neoplasms	97	117	102	122	133	106	76	104	105	90	87	104
Other endogenous causes [a]	53	77	80	85	75	62	37	54	70	54	54	50
All endogenous causes	68	111	121	133	129	102	56	75	82	77	81	85
All causes	67	89	109	128	128	106	49	65	82	79	83	89

[a] Percentages of 1953 rates.

TABLE 4

Norway: age-specific male death rates

(Rates per 10,000 population)

	25-29 years	30-34 years	35-39 years	40-44 years	45-49 years	50-54 years	55-59 years	60-64 years	65-69 years	70-74 years	75-79 years	80-84 years	85 years and over
1973	12	13	19	26	43	75	125	190	309	518	805	1 246	2 218
1972	10	15	19	28	46	70	122	192	312	507	774	1 238	2 161
1971	11	13	21	29	45	74	119	195	339	512	802	1 257	2 189
1970	10	14	19	31	49	77	123	195	328	521	779	1 238	2 214
1969	12	16	18	29	47	73	125	207	339	528	791	1 233	2 221
1968[a]	10	14	19	30	47	73	116	202	346	509	775	1 240	2 130
1967	10	14	18	29	47	72	115	192	325	480	762	1 197	2 112
1966[a]	11	12	18	25	45	69	123	191	312	496	762	1 247	2 217
1965	12	15	19	31	43	76	117	193	310	474	752	1 225	2 131
1964	12	13	19	27	43	70	117	193	307	461	751	1 234	2 144
1963	12	12	18	29	42	70	128	191	317	499	802	n.a.	n.a.
1962	12	15	23	25	40	73	116	188	302	477	743	1 241	2 232
1961	11	16	19	28	41	69	114	192	285	466	741	1 204	2 275
1960	13	14	19	26	39	65	109	189	286	459	742	1 229	2 195
1959	14	16	16	27	40	67	103	181	281	453	730	1 181	2 127
1958	12	13	16	27	42	71	113	183	275	467	736	1 209	2 155
1957	15	13	18	28	41	67	108	177	272	431	705	1 135	2 190
1956	11	15	17	25	40	68	108	175	271	443	728	1 163	2 167
1955	13	15	20	26	38	69	113	166	257	411	685	1 101	2 158
1954	13	15	18	28	40	66	105	167	281	431	727	1 148	2 125
1953	13	16	17	28	43	66	103	164	263	439	679	1 144	2 183
1952	15	16	22	29	44	69	102	159	257	428	679	1 194	2 092
1951	15	21	23	26	42	70	102	147	244	396	689	1 147	2 244
1950	15	16	21	29	44	69	107	164	266	424	758	n.a.	n.a.
1949													

[a] Estimates.

TABLE 5

Norway: age-specific female death rates

(Rates per 10,000 population)

	25-29 years	30-34 years	35-39 years	40-44 years	45-49 years	50-54 years	55-59 years	60-64 years	65-69 years	70-74 years	75-79 years	80-84 years	85 years and over
1973	4	6	8	15	22	39	53	90	145	290	544	961	1 944
1972	4	5	9	14	26	35	57	91	158	298	527	955	1 907
1971	5	7	10	14	23	33	56	88	160	311	536	967	1 966
1970	4	5	10	15	24	35	58	89	169	305	531	1 001	1 864
1969	4	6	10	16	28	39	60	103	176	314	589	1 001	1 827
1968 [a]	4	5	9	16	24	36	59	99	178	320	583	1 057	1 818
1967	4	6	10	14	21	38	59	99	175	316	577	975	1 998
1966 [a]	4	6	10	16	25	38	58	100	154	321	574	1 028	2 099
1965	4	5	10	15	25	34	60	104	166	326	573	1 063	1 998
1964	4	7	10	16	22	37	59	104	189	336	625	1 110	2 042
1963	4	6	10	16	26	39	62	108	186	380	684	n.a.	n.a.
1962	4	6	10	17	25	40	63	104	185	341	590	1 080	2 136
1961	4	7	12	16	25	38	62	108	176	331	584	1 100	2 088
1960	5	7	11	14	24	34	66	103	193	333	624	1 058	2 235
1959	4	7	11	19	26	40	62	110	199	328	591	1 063	2 215
1958	5	7	11	15	28	41	62	103	191	342	626	1 098	2 235
1957	5	9	11	16	27	37	65	105	180	345	629	1 097	2 197
1956	6	8	11	16	27	43	63	107	180	350	609	1 079	2 124
1955	7	9	13	18	27	42	64	108	193	327	600	1 061	2 204
1954	7	8	12	18	28	46	69	111	185	351	627	1 105	2 167
1953	6	11	13	17	29	44	72	108	195	346	605	1 054	2 119
1952	10	10	12	21	29	44	75	119	194	367	629	1 081	2 064
1951	10	10	15	21	29	45	70	114	187	342	598	1 076	2 180
1950	9	12	15	20	34	48	73	126	210	358	673	n.a.	n.a.
1949													

[a] Estimates.

TABLE 6

Death rates for males 55-59 years old, 1949-1973

(Rates per 10,000 population)

	1949-1953	1954-1958	1959-1963	1964-1968	1969-1973
Finland	231	211	210	216	214
Scotland	205	203	203	191	188
United States of America	198	185	185	190	183
France	181	177	169	163	155
Switzerland	155	146	145	137	123
Denmark	119	123	128	133	128
Netherlands	109	116	124	131	132
Norway	104	109	116	118	123
Czechoslovakia	n.a.	173	163	158	176
Sweden	118	112	109	107	108
Japan	194	176	163	143	123

First, the level of the rates varies greatly from one country to another, the highest rate being approximately double the lowest one. The trends are also different and may be divided into three broad groups.

The first group is composed of countries in which the rates declined steadily from 1949 to 1973. In this group, Switzerland and Finland represent the two extreme levels and also the two extreme rhythms of decline. The lowest rates and the most rapid decline are found in Switzerland. The highest rates are in Finland, where the decline has been very slight. Most countries of western and southern Europe fall between these two extremes. The United States of America is also represented in the upper range of this group.

The second group is composed of Denmark, the Netherlands and Norway. In these three countries, the rates have increased steadily from 1949 to 1973, although recently they have shown a tendency to stabilize.

The third group is composed of countries of Eastern Europe, Sweden and Israel. The rates began to decline after 1949 until around 1965. Then the trend was reversed and an increase took place. Sweden and Czechoslovakia mark the two limits of this group.

Finally, Japan is in a category by itself. Like the countries in the first group. Japan has seen a steady decline in male death rates from 1949 to 1953, but the decline has been a drastic one, so much so that, starting from the level of the United States of America in 1949, death rates dropped to the level of Norway by 1973.

In reality, the differences among these groups are purely artificial ones, resulting from the phenomenon described in detail for Norway, i.e. a decline in mortality from exogenous causes and an increase in mortality from endogenous causes.

By 1973, six countries (Denmark, Japan, the Netherlands, Norway, Sweden and Switzerland) had reached more or less the same level of male mortality—in fact, the lowest one ever registered. Since the rate for Norway was close to the mean for the six countries, the endogenous rates for Norway in 1973 can be taken as a measure of the biological mortality corresponding to the present status of medicine, as was done in 1952. In calculating the corresponding biological mortality table, we are assuming that the 10-year death rates approximate the 10-year death rates in the mortality table, but this will be true only if the age composition of the population in the 10-year interval is identical to the age composition of the stationary population. Such is not the case, but the differences are probably small.

In a mortality table, the death rate from x to $x+10$ [noted as $m(x+5)$] can be calculated approximately as follows: let us note Qx, the probability at age x of dying before age $(x+10)$ years. If $S(x)$ is the survival function, $S(x)Qx$ is equal to the deaths occurring from x to $x+10$ in the mortality table. $S(x+5)$ is approximately equal to $S(x)-\frac{1}{2}S(x)Qx$ and the death rate in the mortality table from x to $(x+10)$ is approximately equal to:

$$m(x+5) = \frac{S(x)Qx}{10\left[S(x)-\frac{1}{2}S(x)Qx\right]}$$

$$= \frac{Qx}{10\left(1-\frac{Qx}{2}\right)}. \qquad \text{[Formula (1)]}$$

The force of mortality at age $(x+5)$ noted as $\mu(x+5)$ is linked to Qx as follows:

$$\mu(x+5) = -\frac{1}{10}\log(1-Qx).$$

This relation assumes that the force of mortality has a linear variation from x to $x+10$.

From formula (1) we get:

$$Qx = \frac{10m(x+5)}{5m(x+5)+1},$$

then

$$1-Qx = \frac{1-5m(x+5)}{1+5m(x+5)},$$

TABLE 7

Norway: females, 1973. Application of formula (2) to calculate the force of mortality μ $(x + 5)$ by using the 10-year endogenous death rate m $(x + 5)$

x + 5 (years)	Age groups (years)	m (x + 5) [a]	5 m (x + 5)	1—5 m (x+5)	1+5 m (x+5)	μ (x+5) [b]
30	25-34	0.000324	0.001620	0.998380	1.001620	0.000324
40	35-44	0.001022	0.005110	0.994890	1.005110	0.001022
50	45-54	0.002678	0.013390	0.986610	1.013390	0.002678
60	55-64	0.006410	0.032050	0.967950	1.032050	0.006412
70	65-74	0.019027	0.095135	0.904865	1.095125	0.019085

[a] Endogenous death rates for 1973 from annex table A.4.

[b] $\mu (x + 5) = -\frac{1}{10} \log \frac{1 - 5\, m\,(x + 5)}{1 + 5\, m\,(x + 5)}$.

$$\mu(x+5) = -\frac{1}{10} \log \frac{1-5m(x+5)}{1+5m(x+5)}. \qquad \text{[Formula (2)]}$$

The first step consists in applying formula (2) to calculate $\mu(x+5)$. Table 7 gives the details of the calculation for females. It should be noted that $\mu(x+5)$ is very close to the death rate $m(x+5)$.

If, on a graph, $(x+5)$ is put in abcissa and $\log \mu(x+5)$ in ordinate, the five points are approximately on a straight line. The endogenous force of mortality follows the law of Gompertz, at least from 30 to 70 years. The adjustment by a straight line has been calculated as indicated in table 8. First natural logarithms of the five values of $\mu(x+5)$ are calculated, and also the variation of the logarithms by 10-year intervals. The mean of the five logarithms is supposed to represent the adjusted value $\mu(50)$ and the mean of the four variations is supposed to represent a 10-year variation on the adjusted straight line. Finally, it is assumed that the straight line is also valid at under 30 years and over 70 years. It is then easy to calculate the classical function of the mortality table.

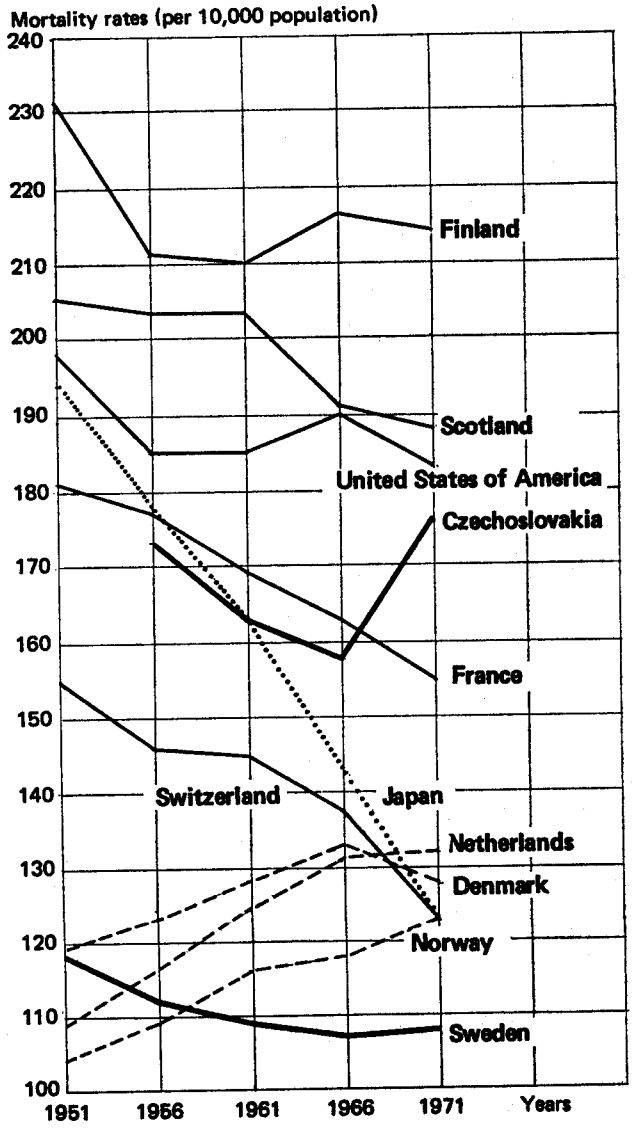
TABLE 8

Norway: females, 1973. Straight-line adjustment of the force of mortality μ $(x + 5)$ in table 7

x + 5 (years)	Log μ (x + 5)	Variations
30	—8.033477	
40	—6.885994	1.147483
50	—5.922685	0.963309
60	—5.049584	0.873101
70	—3.958853	1.080731
Mean	—5.970119	1.016156

Table 9 (illustrated by figure II) gives details of the calculations and the following comments may be pertinent.

Figure I. Death rates for males 55-59 years old, selected developed countries, 1949-1973



In column (2), we find for age 50 the mean of table 8 and in each five-year interval the variation of the logarithm is equal to half of the mean variation of table 8. Knowing $\log \mu(x)$, it is easy to calculate $\mu(x)$ in column (3). In column (4), we have calculated the yearly probability of dying at age x using the formula:

$$\mu(x) = -\log(1-q(x)).$$

We shall come back later to the use of $q(x)$.

In column (5), we find the integral of $\mu(x)$ for the intervals indicated in column (6). For example, on the line corresponding to age 20 we have the value

$$\frac{\mu(20)+\mu(25)}{2} \times 5 = \frac{0.000121+0.00020}{2} \times 5 = 0.0008050.$$

In column (7), the integral of $\mu(x)$ is cumulated from age 0 and, finally, in column (8), we obtain the surviving function $S(x)$ by applying the classical formula:

$$S(x) = e^{-\int_0^x \mu(x)dx}$$

The expectation of life at age 0 is obtained by using the formula

$$e_0 = \int_0^w s(x)dx.$$

In practice, this integral is obtained by summing $S(x)$, from which we get 16.575110, subtracting 0.5, from which we get 16.075110 and multiplying the results by 5. The final answer is:

$$e_0 = 80.37555$$

Figure II, illustrating table 9, is composed of two halves. The left half corresponds to the straight-line adjustment of the five forces of mortality in table 7. As can be seen, the adjustment is fairly good and is also valid for age 20. It is clear from the graph that, from 20 to 70 years of age, endogenous mortality in Norway in 1973 follows the Gompertz law. Curve A corresponds to the mortality rates for all causes and curve B to the mortality rates declared to be endogenous in the statistics on causes of death. From 20 to 70 years, curve B practically coincides with the straight-line adjustment. The area between curve A and curve B represents mortality declared be due to exogenous causes.

Mortality at the beginning of life

We are assuming that the straight line continues to represent endogenous mortality below age 20. In other words, we are assuming that mortality in the area between curve B and the straight line is due to exogenous causes in spite of the fact that it is said to be due to endogenous causes.

TABLE 9

Norway: calculation of the endogenous life table for females, 1973

Age (x) (years) (1)	*Log μ (x)* (2)	*μ (x)* (3)	*2 (x)* (4)	*Integral of μ (x)* (5)	*Age groups (years)* (6)	*Cumulative integral of μ (x)* (7)	*Surviving function S (x)* (8)
0	−11.050899	0.000016		0.0001050	0- 4	0.0001050	1.000000
5	−10.542821	0.000026		0.0001750	5- 9	0.0002800	0.999895
10	−10.034743	0.000044		0.0002925	10- 14	0.0005725	0.999720
15	− 9.526665	0.000073		0.0004850	15- 19	0.0010575	0.999428
20	− 9.018587	0.000121		0.0008050	20- 24	0.0018625	0.998943
25	− 8.510509	0.000201		0.0013400	25- 29	0.0032025	0.998139
30	− 8.002431	0.000335		0.0022275	30- 34	0.0054300	0.996803
35	− 7.494353	0.000556		0.0037000	35- 39	0.0091300	0.994585
40	− 6.986275	0.000924	0.000924	0.0061525	40- 44	0.0152825	0.990912
45	− 6.478197	0.001537	0.001536	0.0102275	45- 49	0.0255100	0.984834
50	− 5.970119	0.002554	0.002551	0.0169975	50- 54	0.0425075	0.974813
55	− 5.462041	0.004245	0.004236	0.0282500	55- 59	0.0707575	0.958383
60	− 4.953963	0.007055	0.007030	0.0469550	60- 64	0.1177125	0.931688
65	− 4.445885	0.011727	0.011659	0.0780450	65- 69	0.1957575	0.888952
70	− 3.937807	0.019491	0.019302	0.1297175	70- 74	0.3254750	0.822212
75	− 3.429729	0.032396	0.031877	0.2156025	75- 79	0.5410775	0.722184
80	− 2.921651	0.053845	0.052421	0.3583500	80- 84	0.8994275	0.582121
85	− 2.413573	0.089495	0.085607	0.5956100	85- 89	1.4950375	0.406802
90	− 1.905495	0.148749	0.138215	0.9899600	90- 94	2.4849975	0.224240
95	− 1.397417	0.247235	0.219043	1.6454050	95- 99	4.1304025	0.083326
100	− 0.889339	0.410927	0.336965	2.7348175	100-104	6.8652200	0.016076
105	− 0.381261	0.683000	0.494901	4.5455225	105-109	11.4107425	0.001043
110	+ 0.126817	1.135200	0.678645	7.5550825	110-114	18.9658250	0.000011
115	+ 0.634895	1.886824	0.848448	12.6888000	115-119	31.6546250	0.000000
120	+ 1.142973	3.188696	0.958774				
Sum of $S(x)$							16.575110

Figure II. Female biological mortality limit, Norway, 1973

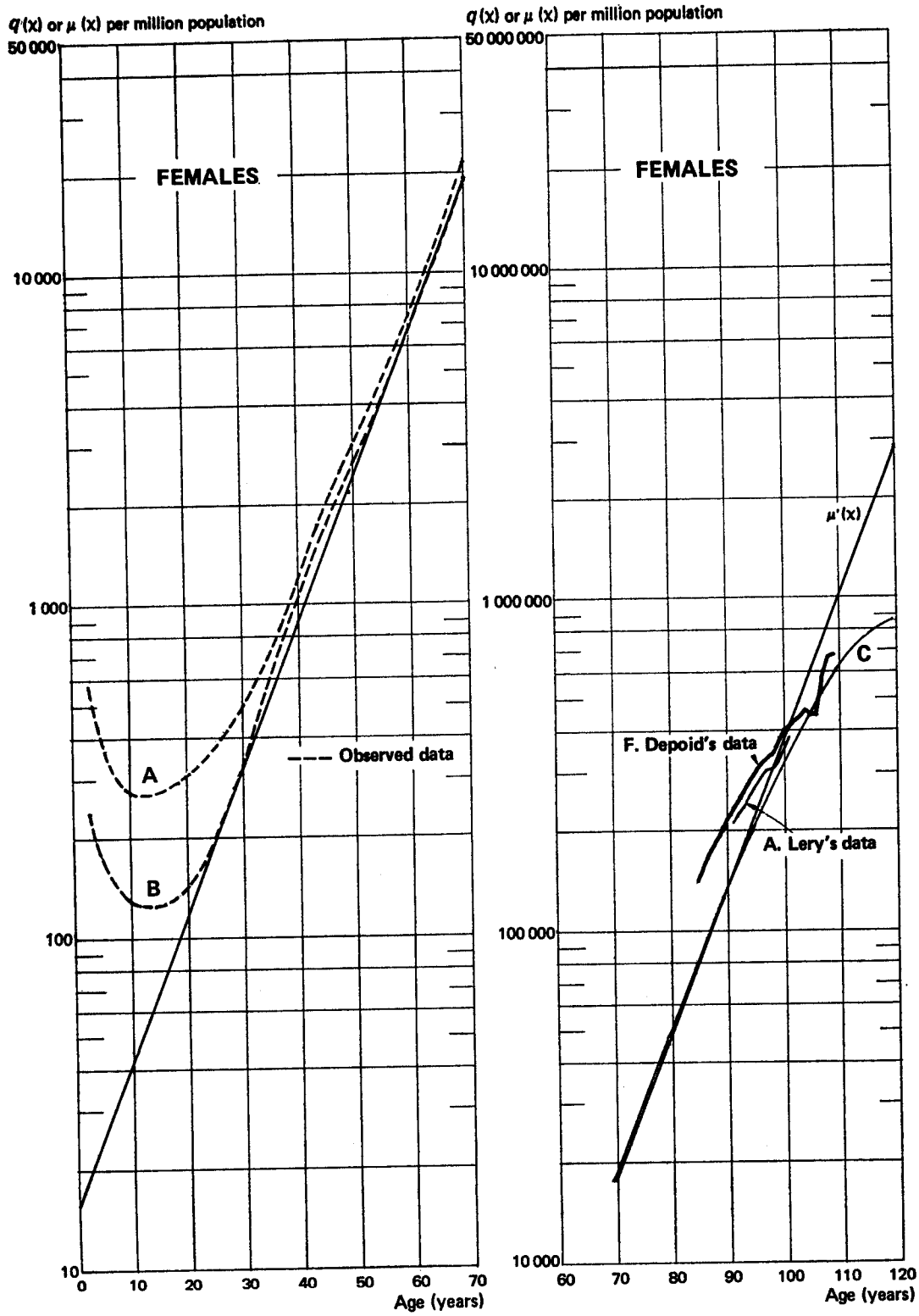


TABLE 10

Norway: males, 1973. Application of formula (2) to calculate the force of mortality $\mu\ (x + 5)$ by using the 10-year endogenous death rates $m\ (x + 5)$

$x + 5$ (years) (1)	Age groups (years) (2)	$m(x + 5)$ [a] (3)	$5\,m(x + 5)$ (4)	$1 - 5\,m(x+5)$ (5)	$1 + 5\,m(x+5)$ (6)	$\mu(x+5)$ [b] (7)
30	25-34	0.000430	0.002150	0.997850	1.002150	0.000430
40	35-44	0.001407	0.007035	0.992965	1.007035	0.001407
50	45-54	0.005054	0.025270	0.974730	1.025270	0.005055
60	55-64	0.013840	0.069200	0.930800	1.069200	0.013862
70	65-74	0.035983	0.179915	0.820085	1.179915	0.036379

[a] Endogenous death rates for 1973 from annex table A.11.

[b] $\mu\ (x + 5) = -\frac{1}{10} \log \frac{1 - 5\ m\ (x + 5)}{1 + 5\ m\ (x + 5)}$.

This assumption does not seem unrealistic in view of the continuous progress being made in combating child mortality, after the first few days of life. During those first few days, however, endogenous factors are at work and mortality is much higher than the level corresponding to the straight line. For the time being, we shall ignore this endogenous infant mortality. In other words, the life table in table 9 represents the mortality of human beings who survive the first few days following birth. A correction will be made later on to allow for mortality in early infancy.

Mortality at old age

The right half of figure II corresponds to the age span above 70 years. We still have the straight-line adjustment and a curve, C, which corresponds to the yearly probability of death (see table 9, column (4)). The adjustment of a Gompertz function is generally done on the yearly probability of death, but if the straight-line adjustment is valid for $q(x)$, it is not valid for the force of mortality $\mu(x)$ and, more generally, for any other probability of death calculated on an interval other than one year.

The method consisting in adjusting a straight line on the logarithm of the yearly probability of death therefore gives undue advantage to the one-year interval. It would be more satisfactory to assume that the straight-line adjustment is valid for the force of mortality $\mu(x)$, which is the position that has been adopted here.

Up until 80 years of age, there is practically no difference between $\mu(x)$ and $q(x)$ but the right half of figure II shows that, beyond 80 years of age, $q(x)$ deviates more and more from $\mu(x)$ as the age increases. In fact, $\mu(x)$ on the straight line increases indefinitely, whereas $q(x)$ cannot exceed unity. Curve C cannot go beyond the ordinate 1,000,000 in the right half of the figure.

It would be very interesting to compare the straight-line adjustment and curve C with observed data. Unfortunately, the observations above 80 years of age are very imprecise and the probabilities of death are rarely calculated. They are generally read on the straight-line adjustment. Two recent studies shed some light on mortality at a very advanced age.

In the review *Population*, Françoise Depoid, using a method devised by Paul Vincent, succeeded in calculating yearly probabilities of death above 85 years of age for the period 1945-1970 for France, the Netherlands, Sweden and Switzerland.

At the time of the 1962 Census, the French Bureau of Statistics, (INSEE) carried out a special survey to check the accuracy of statements of age by people over 90 years old. A similar check was made on the deaths of these people between 1963 and 1966. It was then possible to calculate precise yearly probabilities of death. [5]

The Depoid and Lery curves should be compared with curve C. The three curves have a similar shape and the calculations of Ms. Depoid and Mr. Lery therefore confirm our analysis.

The calculation of the endogenous mortality tables for females has been described in considerable detail and the endogenous mortality tables for males can therefore be dealt with rather more briefly. Tables 10-12 for males correspond to tables 7-9 for females, and figure III illustrates table 12. The expectation of life at age 0 is equal to (15.265659—0.5)5 = 73.82829.

TABLE 11

Norway: Males, 1973. Adjusted by a straight line of the force of mortality $\mu\ (x + 5)$ in table 10

$x + 5$	$Log\ \mu\ (x + 5)$	*Variations*
30	−7.751725	
40	−6.566296	1.185431
50	−5.287377	1.278919
60	−4.278590	1.008787
70	−3.313764	0.954826
Mean	−5.4395504	1.106991

[4] Françoise Depoid. "La mortalité des grands vieillards", *Population*, (Paris), vol. 28, Nos. 4-5 (juillet-octobre 1973) pp. 755-792.

[5] Alain Lery, "Mortalité des personnes très âgées", *Les Collections de l'INSEE*, (Series D, No. 49, pp. 111-124.

Figure III. Male biological mortality limit, Norway, 1973

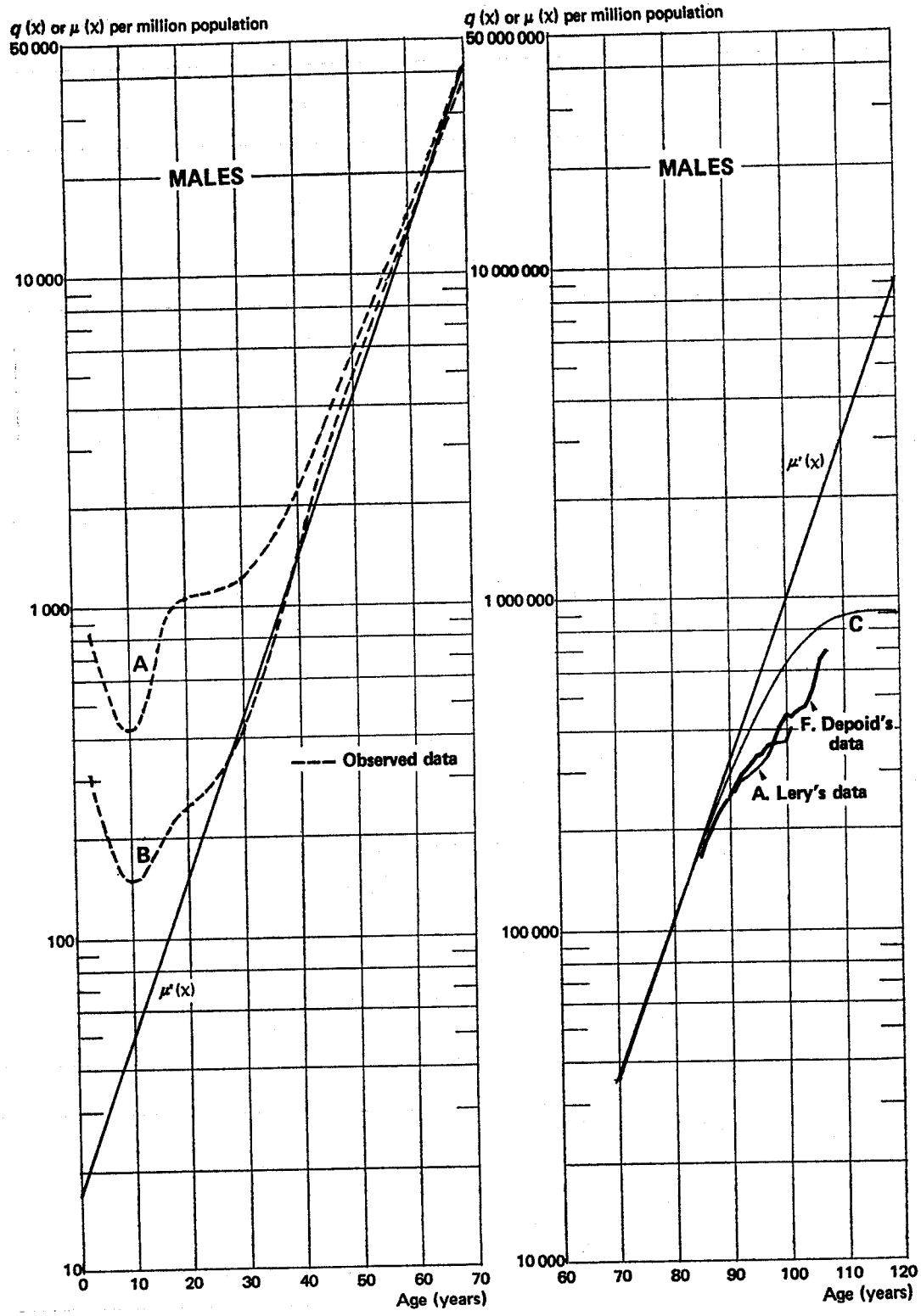


TABLE 12

Norway: calculation of the endogenous life table for males, 1973

Age (x) (years) (1)	*Log μ (x)* (2)	μ (x) (3)	Q (x) (4)	*Integral of μ (x)* (5)	*Age groups (years)* (6)	*Cumulative integral of μ (x)* (7)	*Surviving function* S (x) (8)
0	−10.974500	0.000017		0.000118	0-4	0.000118	1.000000
5	−10.421005	0.000030		0.000205	5-9	0.000323	0.999882
10	− 9.867510	0.000052		0.000355	10-14	0.000678	0.999677
15	− 9.314015	0.000090		0.000617	15-19	0.001295	0.999322
20	− 8.760520	0.000157		0.001075	20-24	0.002370	0.998706
25	− 8.207025	0.000273		0.001868	25-29	0.004238	0.997632
30	− 7.653530	0.000474		0.003247	30-34	0.007485	0.995771
35	− 7.100035	0.000825	0.000825	0.005650	35-39	0.013135	0.992543
40	− 6.546540	0.001435	0.001434	0.009827	40-44	0.022962	0.986951
45	− 5.993045	0.002496	0.002493	0.017093	45-49	0.040055	0.977300
50	− 5.439550	0.004341	0.004332	0.029730	50-54	0.069785	0.960737
55	− 4.886055	0.007551	0.007523	0.051713	55-59	0.121498	0.932594
60	− 4.332560	0.013134	0.013048	0.089945	60-64	0.211443	0.885593
65	− 3.779065	0.022844	0.022585	0.156443	65-69	0.367886	0.809415
70	− 3.225570	0.039733	0.038954	0.272105	70-74	0.639991	0.692196
75	− 2.672075	0.069109	0.066775	0.473277	57-79	1.113268	0.527297
80	− 2.118580	0.120202	0.113259	0.823180	80-84	1.936448	0.328484
85	− 1.565085	0.209070	0.188662	1.431775	85-89	3.368223	0.144215
90	− 1.011590	0.363640	0.304859	2.490318	90-94	5.858541	0.034451
95	− 0.458095	0.632487	0.468731	4.331465	95-99	10.190006	0.002855
100	+ 0.095400	1.100099	0.667162	7.533810	100-104	17.723816	0.000038
105	+ 0.648895	1.913425	0.852426	13.103715	105-109	30.827531	0.000000
110	+ 1.202390	3.328061	0.964137	22.791573	110-114	53.619104	
115	+ 1.755885	5.788568	0.996938	39.641870	115-119	93.260974	
120	+ 2.309380	10.068180	0.999958				
Sum of $S(x)$ ...							15.265659

The straight-line adjustment for males is less satisfactory than it is for females: for example, it is not valid for age 20. At advanced ages, the curves for yearly probabilities of death calculated by Ms. Depoid and Mr. Lery are below the curve for Norway; the latter curve corresponds to 1973, while the Depoid and Lery curves correspond to the period 1945-1970. We have seen that endogenous male mortality during this period increased between 30 and 70 years of age. If an increase also took place above age 70, it would be normal to find the curve for Norway above the other two curves.

Excess of male over female mortality

It is interesting to measure the excess of male mortality over female mortality. This is generally done by comparing the yearly probabilities of death for males and females. In so doing, we again give undue advantage to the one-year interval, and it is better to compare the force of mortality for males and females rather than the yearly probabilities. Figure IV shows the results of the two calculations. The use of the yearly probabilities indicates a maximum for the excess of male mortality whereas the use of the force of mortality shows a constant increase with age of excess male mortality. The maximum is artificial and is due to the fact that the yearly probability $q(x)$ is always below unity. At the end of life, yearly probabilities are very close to unity, both for males and females, and excess male mortality tends towards zero.

The real phenomenon is a steady increase of excess male mortality with age.

Infant mortality

One thing remains to be discussed: endogenous mortality at the very beginning of life. It is not easy to separate endogenous from exogenous deaths by using statistics on causes of death for the first years of life. It has been explained elsewhere [6] that there is a general tendency to overstate endogenous mortality and that a better estimate could be obtained by using a biometrical method based on the distribution of exogenous deaths by age during the first years of life. It can be shown that the infant mortality rate from four weeks to one year multiplied by 1.25 gives a good estimate of exogenous mortality. The difference from the total rate is equal to the endogenous mortality.

[6] Jean Bourgeois-Pichat, "Um método biométrico para se distinguir, no mortalidade infantil, as causas endógenas das causas exógenas" (A biometrical method of separating endogenous from exogenous infant mortality), *Encontro Brasileiro de Estudos Populacionais*, (Rio de Janeiro, Fundação Instituto Brasileiro de Geografia e Estatistica, 1976).

TABLE 13

Norway: endogenous infant mortality for males, 1936-1973

	Biometrical method	*Statistics on cause of death* [a]	*Difference*
1936	197		
1937	197		
1938	186		
1939	189		
1940	171		
1941	152		
1942	147		
1943	163		
1944	150		
1945	145		
1946	139		
1947	156		
1948	140 [b]		
1949	127	166	39
1960	132	174	42
1951	132	176	44
1952	127	166	39
1953	116	160	44
1954	114	159	45
1955	120	158	38
1956	121	163	42
1957	116	150	34
1958	130	156	26
1959	129	154	25
1960	116	146	30
1961	127	149	22
1962	125	155	30
1963	117	141	24
1964	121	142	21
1965	123	144	21
1966	106	128	22
1967	116	132	16
1968	102	121	19
1969	107	120	13
1970	102	116	14
1971	106	119	13
1972	90	101	11
1973	93	105	12

[a] Categories A 126-135 of the 1965 revision of the ICD, or the corresponding category of the previous revision.

[b] In 1952, a limit of 130 had been assumed in extrapolating the 1936-1940 trend.

However, with the tremendous progress made in reducing exogenous mortality, the difference between the biometrical endogenous rate and the endogenous rate obtained by using statistics on causes of death, tends to disappear and the two methods yield rates which, in Norway, are very close to each other, as can be seen in table 13.

In 1952, by extrapolating the 1936-1948 trend, a limit of 130 endogenous deaths for 10,000 male live births and 90 for 10,000 female live births had been assumed. In the event, the results were much better. In 1973, the infant endogenous mortality rates per 10,000 live births were as follows:

	Biometrical method	*Statistics on causes of death* [a]
Male	93	105
Female	60	67

[a] Categories A 126 - A 135 of the 1965 revision of the WHO International Classification of Diseases (ICD).

— It is difficult to make any forecasts. For the endogenous infant mortality limit, we propose 0.0009 for males and 0.0006 for females.

— Endogenous mortality mainly occurs during the first few days of life. For the correction of the two previous life tables, we shall assume that this endogenous mortality occurs instantaneously at birth. The survival function continues to start at unity for age 0, but at $0+E$ it becomes 0.9991 for males and 0.9994 for females. Expectation of life at birth therefore has to be multiplied by these two coefficients. We thus obtain:

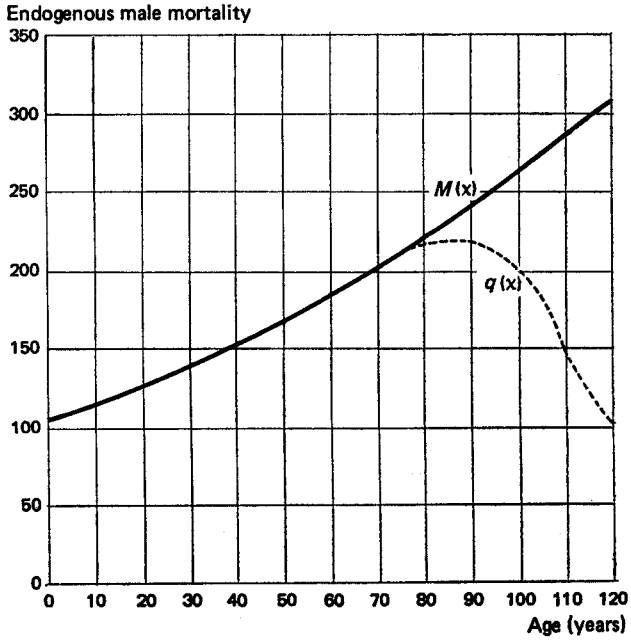
For males	e_0	73.8
For females	e_0	80.3
	Difference	−6.5

— These two values are to be compared with those obtained in 1952:

For males	e_0	− 76.3
For females	e_0	78.2
	Difference	−1.9

— A substantial increase in the excess of male over female mortality is to be noted. This increase is in line with what has been observed recently in the developed countries.

Figure IV. Endogenous male mortality by age, Norway, 1973
(Endogenous female mortality = 100)



ANNEX

Tabulated age-specific death rates

TABLE A.1

Norway: age-specific male mortality from infective and parasitic diseases, [a] 1951-1973

(Rates per million population)

	Age groups (years)					
	25-34	*35-44*	*45-54*	*55-64*	*65-74*	*75+*
1973	4	20	58	114	277	620
1972	14	29	80	155	304	641
1971	12	10	60	141	299	314
1970	9	14	72	171	288	587
1969	9	37	80	202	438	667
1968	5	4	100	102	372	557
1967	0	13	68	202	291	426
1966	19	25	81	165	341	435
1965	15	53	62	183	401	579
1964	24	36	91	217	364	607
1963						
1962						
1961	47	58	128	296	552	792
1960						
1959						
1958						
1957						
1956	94	171	261	499	771	776
1955						
1954						
1953	213	298	375	679	1 053	1 217
1952						
1951	499	471	538	639	974	1 197
1950						
1949						

[a] For the period 1951-1964, see categories B1-B17 of the abbreviated list of 50 causes for tabulation of mortality in the World Health Organization's International Classification of Diseases, 1948 or 1955 revision. The abbreviated list was not affected by the 1955 revision.

For the period 1965-1968, see categories A1-A43 of the intermediate list of 150 causes for tabulation of morbidity and mortality in the 1955 revision of the ICD.

For the period 1969-1973, see categories A1-A44 of the list of 150 causes in the 1965 revision of the ICD. Until 1969, the group of infective and parasitic diseases was not altered by the changes made in the 1965 revision. In that revision, the whole group was reorganized quite extensively: some categories were grouped together and some new categories were introduced. The following three have a bearing on the Norwegian data: A5 (enteritis and other diarrhoeal diseases), A21 (other bacterial diseases) and A29 (other ural diseases). It is difficult, however, to make even a rough estimate of the effects of these changes.

TABLE A.2

Norway: age-specific male mortality from diseases of the respiratory system, [a] 1951-1973

(Rates per million population)

	Age groups (years)					
	25-34	35-44	45-54	55-64	65-74	75+
1973	22	40	136	613	2 444	13 114
1972	90	49	190	669	2 663	14 392
1971	12	43	152	536	2 296	13 084
1970	21	90	172	778	3 123	14 092
1969	34	91	196	744	3 231	13 155
1968	14	37	96	409	2 069	12 020
1967	25	44	100	431	1 811	10 724
1966	10	32	120	405	1 898	11 786
1965	0	40	157	397	2 030	11 693
1964	24	36	91	310	1 054	9 223
1963						
1962						
1961	28	35	55	312	1 095	8 629
1960						
1959						
1958						
1957						
1956	12	23	105	241	870	8 023
1955						
1954						
1953	19	44	91	288	1 116	8 129
1952						
1951	15	56	84	265	1 094	7 907
1950						
1949						

[a] For the period 1951-1964, see categories B30-B32 of the ICD abbreviated list of 50 causes for tabulation of mortality.

For the period 1965-1968, see categories A87-A96 of the intermediate list of 150 causes for tabulation of morbidity and mortality in the 1955 revision of the ICD.

For the period 1969-1973, see categories A89-A96 of the intermediate list in the 1965 revision of the ICD.

The move in 1965 from the abbreviated list to the intermediate list altered the content of the group of diseases of the respiratory system: B30 is identical to A88; B31 is identical to A89-A91; and B32 is identical to A92-A93. This means that, from 1965 to 1968, deaths due to categories A87 (acute upper respiratory infections), A94 (hypertrophy of tonsils and adenoids), A95 (empyema and abscess of lung), A96 (pleurisy) and A97 (all other respiratory diseases) were added to the group (categories B30-B32) used before 1965 (see table A.15).

The move in 1969 to the intermediate list in the 1965 revision led to the following changes: B30 is identical to A90; B31 is identical to A91-A92; and B32 is idenical to A93. This means that, from 1969 to 1973, deaths due to categories A89 (acute respiratory infections), A94 (hypertrophy of tonsils and adenoids), A95 (empyema and abscess of lung) and A96 (other diseases of the respiratory system) were added to the group (categories B30-B32) used before 1965 (see table A.15).

In 1969, there is a sudden increase in deaths due to bronchitis, which could be the result of a change in the classification. Before 1969, these deaths were probably classified as diseases of the circulatory system.

TABLE A.3

Norway: age-specific male mortality from external causes—accidents, poisoning and violence, [a] 1951-1973

(Rates per million population)

	Age groups (years)					
	25-34	*35-44*	*45-54*	*55-64*	*65-74*	*75+*
1973	752	782	800	1 024	1 310	3 362
1972	657	760	764	1 020	1 330	2 650
1971	684	897	821	977	1 315	3 176
1970	697	887	881	987	1 130	2 613
1969	769	750	880	1 004	1 238	3 102
1968	680	830	810	960	1 175	2 716
1967	621	683	797	879	1 142	3 064
1966	569	659	838	1 018	1 045	2 830
1965	730	641	837	875	1 317	2 987
1964	574	543	890	910	1 147	3 417
1963						
1962						
1961	676	695	800	920	1 170	3 167
1960						
1959						
1958						
1957						
1956	639	627	907	1 128	988	2 899
1955						
1954						
1953	580	672	789	973	1 190	2 876
1952						
1951	654	729	730	877	1 094	3 257
1950						
1949						

[a] For the period 1951-1964, see categories BE47-BE50 of the ICD abbreviated list of 50 causes for tabulation of mortality.

For the period 1965-1968, see categories AE138-AE150 of the intermediate list of 150 causes for tabulation of morbidity and mortality in the 1955 revision of the ICD.

For the period 1969-1973, see categories AE138-AE150 of the intermediate list in the 1965 revision of the ICD.

The group of external causes was not affected by these changes.

TABLE A.4

Norway: endogenous mortality. Age-specific male mortality not due to infective and parasitic diseases, diseases of the respiratory system or external causes, 1951-1973

(Rates per million population)

	Age groups (years)					
	25-34	*35-44*	*45-54*	*55-64*	*65-74*	*75+*
1973	430	1 407	5 054	13 840	35 983	97 916
1972	448	1 500	4 761	13 752	36 233	96 632
1971	494	1 584	4 955	14 338	35 741	99 348
1970	480	1 491	5 133	13 799	36 785	97 948
1969	541	1 517	4 798	14 294	37 179	99 035
1968	521	1 588	4 898	14 072	36 312	98 649
1967	543	1 651	4 923	13 515	35 905	97 573
1966	589	1 459	4 617	13 745	35 619	99 419
1965	618	1 806	4 891	13 748	34 201	98 325
1964	632	1 707	4 579	13 797	34 596	100 316
1963						
1962						
1961	609	1 552	4 443	14 041	33 224	101 835
1960						
1959						
1958						
1957						
1956	582	1 227	4 006	11 938	31 721	97 688
1955						
1954						
1953	637	1 255	4 157	11 047	30 487	93 790
1952						
1951	631	1 266	4 189	10 390	27 995	95 920
1950						
1949						

NOTE. The figures in this table have been obtained by subtracting the data shown in tables A.1-A.3 from the data for deaths from all diseases.

TABLE A.5

Norway: age-specific male mortality from diseases of the circulatory system, [a] 1953-1973

(Rates per million population)

	Age groups (years)					
	25-34	*35-44*	*45-54*	*55-64*	*65-74*	*75+*
1973	104	630	2 761	8 007	23 404	65 062
1972	84	619	2 528	7 953	22 739	65 263
1971	113	710	2 777	8 070	22 206	65 425
1970	128	643	2 764	8 131	23 095	65 120
1969	171	672	2 519	8 434	23 317	65 456
1968	141	657	2 553	8 052	21 777	63 078
1967	140	674	2 561	7 743	21 978	63 149
1966	63	612	2 377	8 005	21 875	64 601
1965	112	719	2 400	7 864	20 530	62 541
1964	165	556	2 158	7 415	21 287	65 652
1963	72	599	2 263	7 702	21 619	68 031
1962	96	557	2 248	7 340	20 691	66 031
1961	137	585	2 238	7 296	19 317	65 476
1960	136	458	2 009	6 929	19 640	64 803
1959	120	513	1 987	6 475	18 955	60 433
1958	120	469	1 973	6 871	19 556	62 133
1957	104	426	1 824	6 287	18 125	58 051
1956	127	339	1 772	5 918	18 307	60 413
1955	127	387	1 813	6 009	16 981	55 806
1954	94	388	1 597	5 503	17 240	55 286
1953	97	366	1 631	5 508	16 307	53 771

[a] For the period 1953-1964, see categories B22-B24 of the ICD abbreviated list of 50 causes for tabulation of mortality, plus categories A85 and A86 of the intermediate list of 150 causes for tabulation of morbidity and mortality.

For the period 1965-1968, see categories A79-A86 of the intermediate list in the 1955 revision of the ICD.

For the period 1969-1973, see categories A80-A88 of the intermediate list in the 1965 revision of the ICD.

The group of diseases of the circulatory system was not affected by these changes.

TABLE A.6

Norway: age-specific male mortality from neoplasms, [a] 1951-1973

(Rates per million population)

	Age groups (years)					
	25-34	35-44	45-54	55-64	65-74	75+
1973	158	428	1 318	3 931	9 041	17 333
1972	184	463	1 386	3 791	9 008	17 708
1971	210	427	1 304	3 709	8 873	18 340
1970	180	469	1 310	3 676	8 758	17 640
1969	180	425	1 228	3 689	8 918	16 653
1968	164	439	1 222	3 717	8 775	17 994
1967	173	445	1 204	3 358	8 313	16 482
1966	180	367	1 150	3 198	8 302	16 197
1965	195	460	1 313	3 586	8 357	16 285
1964	194	532	1 220	3 751	7 984	15 394
1963	155	409	1 196	3 743	8 175	17 046
1962	255	455	1 134	3 569	8 000	14 609
1961	170	380	1 017	3 860	8 250	14 841
1960	217	423	1 095	3 639	7 851	15 770
1959	195	395	1 148	3 807	7 775	15 767
1958	179	377	1 351	3 640	7 731	15 100
1957	213	465	1 203	3 471	8 038	15 322
1956	151	440	1 219	3 706	8 089	14 810
1955	179	426	1 223	3 845	7 649	14 442
1954	117	388	1 251	3 255	7 438	15 729
1953	220	434	1 309	3 292	8 159	15 008
1952	134	354	1 243	3 675	8 312	15 798
1951	163	366	1 298	3 216	6 818	16 402

[a] For the period 1953-1964, see category B18 of the ICD abbreviated list of 50 causes for tabulation of mortality.

For the period 1964-1968, see categories A44-A59 of the intermediate list of 150 causes for tabulation of morbidity and mortality in the 1955 revision of the ICD.

For the period 1969-1973, see categories A45-A61 of the intermediate list in the 1965 revision of the ICD. In the 1965 revision, deaths due to benign neoplasms and neoplasms of unspecified nature (category A61) were added to the group.

TABLE A.7

Norway: other endogenous deaths. Age-specific male mortality not due to infective and parasitic diseases, diseases of the respiratory system, neoplasms, diseases of the circulatory system or external causes, 1953-1973

(Rates per million population)

	Age groups (years)					
	25-34	*35-44*	*45-54*	*55-64*	*65-74*	*75+*
1973	168	349	975	1 902	4 538	15 521
1972	180	418	847	2 008	4 486	13 661
1971	171	447	874	2 559	4 662	15 583
1970	172	379	1 059	1 992	4 932	15 188
1969	190	420	1 051	2 174	4 944	16 926
1968	216	492	1 123	2 303	5 760	17 577
1967	230	532	1 158	2 414	5 624	17 942
1966	346	480	1 090	2 542	5 442	18 621
1965	311	637	1 178	2 298	5 314	19 499
1964	273	620	1 201	2 631	5 325	19 270
1963						
1962						
1961	302	587	1 188	2 885	5 657	21 518
1960						
1959						
1958						
1957						
1956	304	498	1 015	2 314	5 325	22 465
1955						
1954						
1953	320	455	1 217	2 247	6 021	25 011
1952						
1951						
1950						
1949						

NOTE. The figures in this table have been obtained by subtracting the data in tables A.5 and A.6 from the data shown in table A.4.

TABLE A.8

Norway: age-specific female mortality from infective and parasitic diseases, [a] 1951-1973

(Rates per million population)

	Age groups (years)					
	25-34	*35-44*	*45-54*	*55-64*	*65-74*	*75+*
1973	8	20	25	156	180	508
1972	7	0	76	118	213	597
1971	4	10	56	80	102	489
1970	13	29	40	67	234	420
1969	19	24	48	90	157	451
1968	15	9	56	64	190	208
1967	5	13	24	120	152	125
1966	5	22	48	121	188	215
1965	10	21	61	118	107	332
1964	10	25	66	124	158	317
1963						
1962						
1961	10	75	55	123	237	371
1960						
1959						
1958	—					
1957						
1956	68	71	84	151	278	617
1955						
1954						
1953	182	178	219	275	432	741
1952						
1951	327	317	288	309	503	658
1950						
1949						

[a] See table A.1, foot-note [a].

TABLE A.9

Norway: age-specific female mortality from diseases of the respiratory system, [a] 1951-1973

(Rates per million population)

	Age groups (years)					
	25-34	*35-44*	*45-54*	*55-64*	*65-74*	*75+*
1973	34	25	150	297	1 422	11 300
1972	16	55	82	271	1 636	11 561
1971	17	45	72	282	1 474	11 295
1970	22	33	116	343	1 738	12 388
1969	24	99	144	384	1 731	12 594
1968	15	56	88	234	1 261	12 325
1967	15	26	40	222	1 086	10 407
1966	15	40	100	266	1 100	11 571
1965	25	21	52	242	1 217	11 028
1964	15	21	37	200	989	10 229
1963						
1962						
1961	20	39	38	247	904	9 759
1960						
1959						
1958						
1957						
1956	25	31	53	140	875	8 836
1955						
1954						
1953	24	16	46	193	1 093	9 501
1952						
1951	15	41	70	179	934	9 500
1950						
1949						

[a] See table A.2, foot-note [a].

TABLE A.10

Norway: age-specific female mortality from external causes—accidents, poisoning and violence, [a] 1951-1973

(*Rates per million population*)

	Age groups (years)					
	25-34	35-44	45-54	55-64	65-74	75+
1973	114	106	195	263	574	3 617
1972	134	130	178	271	576	3 525
1971	124	133	136	243	491	3 696
1970	99	154	191	277	669	3 554
1969	80	160	143	280	546	3 724
1968	54	123	147	255	593	3 581
1967	110	115	188	254	610	4 201
1966	70	125	209	233	588	3 903
1965	45	155	147	217	584	3 894
1964	75	99	152	205	567	3 942
1963						
1962						
1961	64	91	148	256	538	4 461
1960						
1959						
1958						
1957						
1956	34	130	173	173	507	4 398
1955						
1954						
1953	75	73	114	228	547	3 789
1952						
1951	54	99	84	223	604	3 770
1950						
1949						

[a] See table A.3, foot-note [a].

TABLE A.11

Norway: endogenous mortality. Age-specific female mortality not due to infective and parasitic diseases, diseases of the respiratory system or external causes, 1951-1973

(*Rates per million population*)

	Age groups (years)					
	25-34	*35-44*	*45-54*	*55-64*	*65-74*	*75+*
1973	324	1 022	2 678	6 410	19 027	76 658
1972	313	946	2 686	6 667	20 064	76 669
1971	431	1 034	2 569	6 584	20 935	77 699
1970	305	1 067	2 588	6 647	20 612	76 763
1969	346	1 016	2 953	7 262	21 366	77 818
1968	374	1 064	2 659	7 235	22 029	79 989
1967	369	1 062	2 691	7 196	21 859	80 502
1966	413	1 093	2 702	7 179	22 074	81 945
1965	383	1 071	2 682	7 528	21 605	83 031
1964	458	1 158	2 685	7 520	23 537	88 665
1963						
1962						
1961	465	1 181	2 857	7 771	22 662	87 468
1960						
1959						
1958						
1957						
1956	589	1 132	3 140	7 822	23 790	88 349
1955						
1954						
1953	591	1 232	3 255	8 154	24 041	89 358
1952						
1951	577	1 356	3 262	8 313	23 571	90 125
1950						
1949						

[a] See the note to table A.4.

TABLE A.12

Norway: age-specific female mortality from diseases of the circulatory system, [a] 1953-1973

(Rates per million population)

	Age groups (years)					
	25-34	*35-44*	*45-54*	*55-64*	*65-74*	*75+*
1973	57	187	669	2 483	11 170	53 825
1972	30	195	725	2 694	11 737	54 268
1971	64	232	634	2 731	12 365	54 982
1970	36	174	682	2 729	12 544	54 179
1969	52	184	766	2 863	12 574	55 240
1968	39	229	672	3 004	12 934	55 826
1967	55	182	771	2 997	12 915	55 329
1966	50	186	711	3 008	13 063	57 118
1965	50	235	698	3 116	12 835	57 412
1964	60	201	761	3 187	14 298	61 984
1963	70	275	810	3 348	15 544	67 368
1962	94	239	707	3 322	14 493	59 826
1961	78	228	730	3 182	13 655	59 118
1960	80	160	719	3 249	14 170	60 000
1959	88	178	828	3 424	13 848	59 684
1958	58	218	771	3 258	14 271	62 115
1957	78	195	802	3 185	13 768	59 868
1956	76	137	770	3 237	14 467	58 880
1955	53	199	796	3 446	13 665	57 420
1954	76	225	900	3 551	13 475	58 562
1953	79	230	931	3 266	13 780	53 875
1952						
1951						
1950						
1949						

[a] See table A.5, foot-note [a].

TABLE A.13

Norway: age-specific female mortality from neoplasms, [a] 1951-1973

(Rates per million population)

	Age groups (years)					
	25-34	*35-44*	*45-54*	*55-64*	*64-74*	*75+*
1973	148	612	1 549	3 060	5 533	10 858
1972	173	530	1 524	2 995	5 655	11 026
1971	196	562	1 481	2 846	5 722	9 937
1970	161	675	1 499	2 912	5 220	10 737
1969	169	560	1 708	3 314	5 851	10 317
1968	156	590	1 519	2 913	6 028	10 841
1967	130	608	1 418	2 928	5 750	10 596
1966	90	601	1 379	2 878	5 781	10 860
1965	131	525	1 350	3 126	5 298	10 310
1964	186	611	1 420	2 967	5 603	10 273
1963	155	494	1 471	3 058	5 558	10 851
1962	134	578	1 586	3 029	5 167	10 326
1961	107	642	1 511	3 113	5 482	10 282
1960	198	638	1 311	3 179	4 948	10 963
1959	129	702	1 524	3 197	5 727	10 342
1958	196	584	1 662	3 134	5 729	10 487
1957	226	582	1 382	3 307	5 856	10 763
1956	229	596	1 699	3 188	5 828	10 640
1955	234	650	1 685	3 186	5 648	11 350
1954	245	627	1 642	3 477	6 785	11 336
1953	186	590	1 671	3 272	5 924	11 567
1952	207	621	1 693	3 407	7 239	12 910
1951	195	588	1 479	3 386	6 378	10 420
1950						
1949						

[a] See table A.6; foot-note [a].

TABLE A.14

Norway: other endogenous mortality. Age-specific female mortality not due to infective and parasitic diseases, diseases of the respiratory system, neoplasms, diseases of the circulatory system or external causes, 1953-1973

(Rates per million population)

	Age groups (years)					
	25-34	35-44	45-54	55-64	65-74	75+
1973	119	223	460	877	2 324	11 975
1972	110	221	437	978	2 672	11 375
1971	171	240	454	1 007	2 848	12 780
1970	108	218	407	1 006	2 848	11 847
1969	125	272	479	1 085	2 941	11 261
1968	179	245	468	1 318	3 067	13 322
1967	184	272	502	1 271	3 194	14 577
1966	173	306	612	1 293	3 230	13 967
1965	202	311	634	1 286	3 472	15 309
1964	212	346	504	1 366	3 636	16 403
1963						
1962						
1961	280	311	616	1 476	3 525	18 068
1960						
1959						
1958						
1957						
1956	284	399	671	1 397	3 495	18 829
1955						
1954						
1953	326	412	653	1 616	4 337	23 916
1952						
1951						
1950						
1949						

[a] See the note to table A.7.

TABLE A.15

Norway: age-specific mortality from all other respiratory diseases (A 96 or A 97)

(Rates per million population)

Cause of death (ICD)	Age groups (years)					
	25-34	35-44	45-54	55-64	65-74	75+
			Males			
A96						
1973	...	...	...	...	...	...
1972	8	0	12	28	165	474
1971	4	0	12	56	160	549
1970	0	19	12	81	168	520
1969	4	9	4	86	240	517
A97						
1968	0	4	16	78	365	432
1967	0	0	12	99	385	596
1966	0	0	20	110	371	682
1965	0	4	33	112	356	505
			Females			
A96						
1973	...	...	...	. .	...	...
1972	0	20	0	13	72	316
1971	4	0	8	40	79	199
1970	0	0	12	13	114	229
1969	0	0	4	32	99	259
A97						
1968	0	5	16	32	59	336
1967	0	13	4	51	91	188
1966	5	13	8	42	125	280
1965	10	4	8	33	83	299

DEMOGRAPHIC ASPECTS OF CHANGES IN LEVELS AND PATTERNS OF CONSUMPTION

Wuu-Long Lin *

SUMMARY

This study illustrates by means of a consumption model the impact of selected demographic and economic factors on consumption levels and commodity patterns. Four components of the changes of commodity consumption levels in the economy are examined: rural-to-urban household migration, changes in the number of household units, in household size, and in household budget.

The study confirms findings that demographic factors are the most important in changing consumption levels, accounting for about 72 to 79 per cent of incremental food expenditure and about 61 to 64 per cent of incremental non-food expenditure in the economy under alternative scenarios of projected economic-demographic conditions. Not only are demographic factors crucial in determining levels of consumption, but they are also significant in changing patterns of consumption away from food.

INTRODUCTION

The object of this study is to present a conceptual framework and to illustrate quantitatively how changing consumption levels and their commodity patterns in a country can be explained by selected demographic and economic variables. A heuristic projection is made of incremental changes of commodity consumption expenditure under alternative exogenous or policy variables, including household budget, household size, household units in rural and urban areas and rural-to-urban migration. The numerical illustrations are based upon the 1961 Philippines household survey data.

A feature of this exercise is that it integrates micro and macro consumption analysis. The point of departure is the household in rural and in urban areas, for which the micro consumption behavioural relations are formulated with household budget and household size as the two explanatory variables. While total household expenditure or income plays a key role in determining consumption levels and patterns, both are also determined to a large extent by the household size and its sex and age composition. As indicated in Kleiman's study, based on United States data for the period 1850-1960, "as the size of household varies, economies of scale in the consumption of food amount to as much as 40 per cent of the relative change in household size". [1] The macro consumption behavioural relations are obtained by aggregating across the estimated micro household consumption functions, allowing for total numbers of households in rural and urban areas and for internal migration.

In the following sections the theoretical explanation of the effects of demographic change on household expenditure are examined, the model is described in non-technical terms and data and projected results are discussed. The mathematical formulation of the model is presented in the annex to the present paper. [2]

DEMOGRAPHIC CHANGES AND CONSUMPTION LEVELS AND PATTERNS

Conventional explanations of observed consumption patterns usually focus on Engel's analysis. Food expenditure, for example, is expected to occupy a declining proportion of household budgets as income rises, though absolute expenditure increases. By inference, non-food expenditure plus saving tends to increase in relative importance.

This straightforward application of Engel's analysis may not always yield satisfactory results, in part because it ignores household composition by sex and age, and also ignores possible economies of scale as household sizes change. Past efforts to modify the Engel function to include demographic variables have involved the construction of "adult consumer equivalent" scales. These may be defined as the expenditure attributed to each household member, as a proportion of some standard

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[1] See E. Kleiman, "Age composition, size of households, and the interpretation of per capita income", *Economic Development and Cultural Change*, vol. 15, No. 1, (October 1966), p. 44.

[2] The user's manual for the computer programme and the computer list used for this study appear in appendices II and III of an earlier version of the present paper, entitled "Demographic changes and consumption patterns" (ESA/P/WP.62).

household member, normally a male adult. Another approach is to introduce "income" and "specific" economies of scale in household consumption for each commodity, as suggested by Prais and Houthakker, [3] which also makes it possible to relate changes in household consumption to size of household.

The commodity expenditure in this study is disaggregated into food and non-food components. The explanatory variables in the micro model consist of household budget and household size for regression analysis. Household units in rural and urban areas and their internal migration are added in the accounting equations of the macro model. These will be discussed further below.

Household unit and household budget

The household, rather than the individual or family, has been adopted as the unit of analysis, since many items of consumer expenditure are for the household as a unit and some items such as rentals, are not divisible among individuals in the same household unit. [4]

Of the economic variables, only household budget has been selected as an explanatory variable in this consumption analysis. Other economic variables, such as price and substitution effects, are not within the scope of the analysis. In fact, using cross-section data, as here, all households tend to pay the same price for a given commodity in a given period.

The choice of household budget instead of household income as an explanatory variable is based on three considerations. One is that this measure is a better proxy for permanent income than is current income. The reaction of consumption expenditure to an increase in income may depend, as argued by Prais and Houthakker, on whether such an increase is expected to continue in the future. This assumption implies that the distribution of expenditure among commodities depends on the level of household budget. [5] Secondly, the standard of living can be better measured by expenditure than by income. [6] It is possible, for instance, that expenditure by classes with very low incomes may exceed their income, with negative savings, in order that subsistence may be maintained. Finally, it has been observed that data on household budget obtained from household surveys are in general more accurate than those on income. The reasons for this are several. Higher-income groups may underreport income because of fear of taxation. For lower-income classes, income in kind may be underestimated or reported at producer's prices, which are lower than retail prices. The use of income data also requires taxation information in order to derive disposable income, data which are not generally available from household surveys.

Household size

Since households vary considerably in size and composition, and since both of these affect levels and patterns of consumption, consideration should be given in the analysis to both variables. Allowance can be made for the effects of household composition through the use of adult consumer equivalents, which take into account the effect of sex and age composition on household consumption. [7] This effect is not incorporated in the study, however, since the reported data on households did not provide a decomposition by sex and age.

With regard to household size, it has also been observed that, as a result of economies of scale, consumer behaviour in larger households may be more economical than in smaller ones with respect both to specific items and to all items of consumption taken together, the implication being that the smaller the household is, the higher the *per capita* expenditure required to provide a given standard of living. The effects on consumption of changes in size of household can best be explained by adopting the concepts of "income" and "specific" economies/diseconomies of scale in household consumption, introduced by Prais and Houthakker. The "income" effect is the resultant of lower income *per capita* when household size increases at a given household income. A lower *per capita* income will naturally lead to changes in consumption levels and patterns. The "specific" effect is the measurement of commodity consumption due to change in household size and is commonly explained in terms of economies (or diseconomies) of scale. These specific economies (or

[3] See S. J. Prais and H. S. Houthakker, *The Analysis of Family Budgets* (Cambridge, Cambridge University Press, 1971), rev. ed., chaps. 9 and 10.

[4] A household can be defined as a socio-economic unit, consisting of individuals who live together to share food and other essentials for living, whereas the family only comprises, members of a household who are related by kinship, i.e. with the exclusion of domestic help, guests, boarders etc. For a discussion of the concept of household and family see, *Manuals on Methods of Estimating Populations. Manual VII. Methods of Projecting Households and Families* (United Nations publication, Sales No. E.73.XII.2), p. 5.

[5] Prais and Houthakker, *op. cit.*, p. 81.

[6] The use of expenditure as an indicator of standard of living must, however, be qualified. First, the cost of living is usually lower in rural than in urban areas, especially for foodstuffs. Secondly, consumer prices may vary with the level of income or expenditure, in that higher-income classes may pay higher prices but the quality of the goods purchased may possibly be better. Therefore, the use of household expenditure as an indicator of standard of living may exaggerate the results if the data are not adjusted to the cost of living.

[7] Adult consumer equivalents are usually estimated on the basis of consumption scales, where weights are assigned according to sex and age groups. Such weights may be based either on the observation of actual consumption patterns or on studies of requirements for nutritional and protein intake. When the latter method is used, consideration should be given to variations of these energy requirements of persons according to sex and age as well as physical activities, body size, body composition, climate etc. For details see Food and Agriculture Organization, *Energy and Protein Requirements : Report of a Joint FAO/WHO* Ad Hoc *Expert Committee, Rome, 22 March - 2 April 1971* (Rome, 1973). Various tables of *per capita* energy requirements by sex and by age are included in the report. If data on the proper weight for adult consumer equivalents are not available, one of the simplest and most usual ways of assigning weight is the following: 1.0 for males over 15; 0.9 for females over age 15; and 0.5 for children under age 15. It should be noted, however, that the above weighting factor for adult consumer equivalents is only based on the energy consumed and does not take into account the variation in non-food consumption among persons. For example, it is not uncommon for a non-adult to occupy the same dwelling-space as an adult. For the estimation of adult consumer equivalents for specific commodity items, see Prais and Houthakker, *op. cit.*, p. 141.

diseconomies) of scale mean that changes in household size (leaving *per capita* income unaltered) result in comparatively fewer (more) changes in *per capita* expenditure on any specific item. The "over-all" effect is the sum of income and specific effects.

Rural-urban migration

Given the fact that income levels in urban areas tend to be higher than in rural areas, urbanization would tend to accelerate the changes in relative consumption of food and non-food items. Migration to the cities will have this effect to the extent that in-migrants are assimilated in the urban economy by achieving urban levels of income and adopting urban patterns of consumption.

In view of the economies of scale in consumption that may be realized by the larger household, and assuming that the average household size in urban areas is smaller than in rural areas, urban households will, however, require a higher *per capita* expenditure (income) than rural households in order to attain a given standard of living. In other words, part of the higher *per capita* expenditure (income) in urban areas may be offset by the negative effect of diseconomies of scale associated with the smaller size of household.

THE MODEL: NON-TECHNICAL DESCRIPTION

A consumption model developed by Kelley[8] has been adopted for the present study. It aims at identifying the effect of selected demographic-economic variables on the level and composition of commodity expenditure. Through a mathematical derivation, incremental household consumption in the economy is decomposed into four separate components: changes in the number of household units, changes in average household size, rural-urban household migration and changes in mean household budget. A technical description of the mathematical model is presented in the annex to the present study,[9] and a non-technical description is given below.

Two commodities are distinguished, food and non-food, and consumption functions for rural and urban areas are specified. In all, there are thus four consumption functions. The model can be readily modified to include more goods and more regional detail, and to take into account other socio-economic variables such as occupation.

The derivation of the consumption model starts from a micro consumption function, which is then aggregated into macroconsumption. First, it is assumed that commodity consumption expenditure per household is determined by household size and household budget, in both urban and rural areas. Both linear and log-linear equations are used. The budget constraints are imposed on the linear consumption functions but not on the log-linear ones. They imply that the sum of estimated food and non-food expenditure be equal to household budgets. With these budget constraints (see also annex, equation (11)), the parameters, both in rural and urban areas (reported in table 1) have the following properties of relationships: (*a*) the sun of constant terms for food and non-food items equals 0, (*b*) the sum of marginal propensities to consume food and non-food items with respect to household budget equals 1.0, and (*c*) the sum of the effects of household size on food and non-food expenditure equals 0.

Secondly, given the micro-economic relationships estimated for rural and urban areas, macro-economic relationships are approximated by multiplying the estimated micro-equations by total number of households. This approximation will be exact if it is assumed that all households behave according to the specified consumption function, allowances being made for the variance of rural and urban consumption differentials, as has been done in this study. In the final step, incremental changes of country-wide consumption are obtained simply by taking the first derivative of the macroconsumption function with respect to time, where changes in numbers of rural and urban households and internal migration enter into the model to play their role in affecting country-wide consumption.

The figure below presents the causal linkages between household consumption changes and selected economic-demographic variables for a two-commodity case; the different shapes of diagrams and arrows in the figure are designed to demonstrate their specific meanings. The consumption illustrated in the figure includes two commodities: A and B, rural (or urban) consumption is the product of total numbers of rural (or urban) households multiplied by consumption expenditure per household.

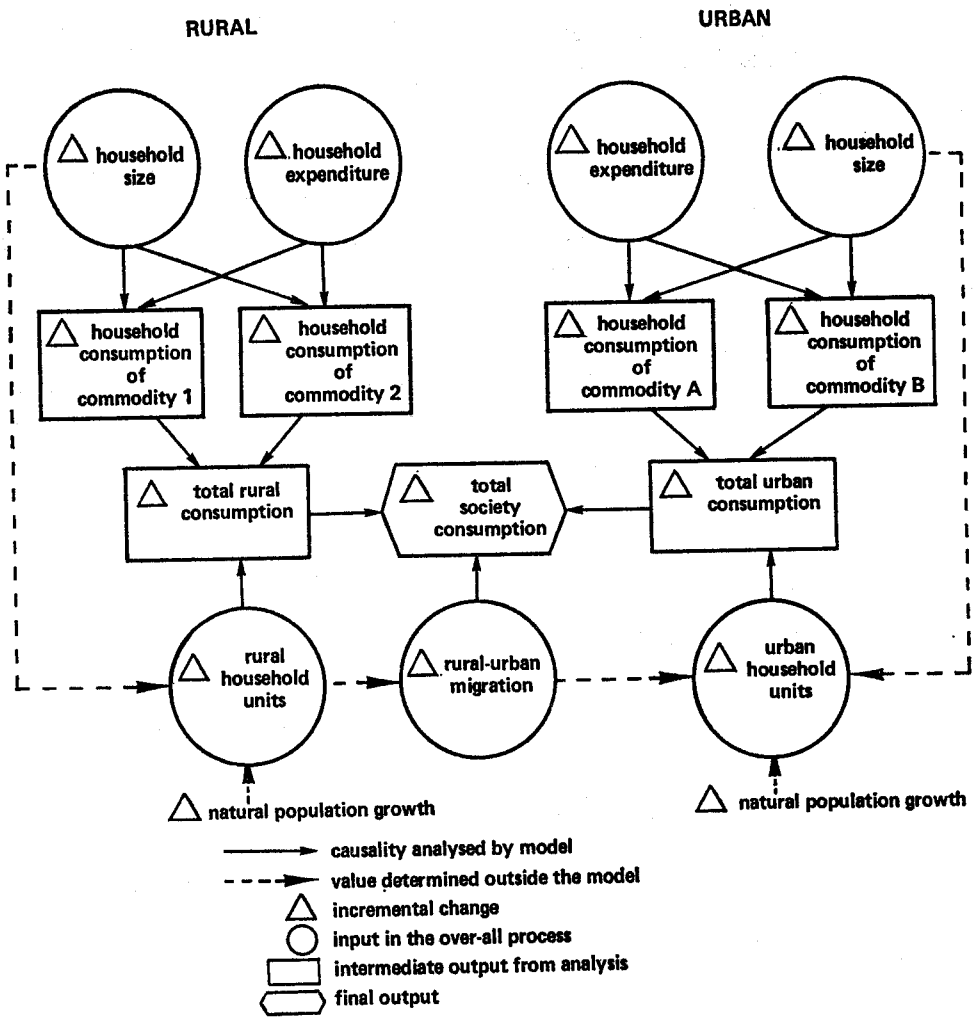
The diagram presented in the figure corresponds to the final result of the mathematical derivation of this consumption system, that is, incremental changes in total consumption expenditure for a commodity in the economy D' (see annex, equation (5), for linear consumption functions and equation (5.1) for log-linear consumption functions).

The treatment of rural-urban migration in this system may create problems in that it assumes that all such migration takes the form of movements of family units or has the same effect. Not infrequently, however, such migration consists of movements of individuals or sub-families or of families whose composition is different from that of the average rural household (e.g. young couples without children or with only a few children). In the first case migration may imply a decrease in household size in rural areas but not a change in the number of households. In the second case, however, migration may effect the average size of rural households. Conversely, in urban areas migration does not necessarily increase the number of households in so far as individuals or migrant families may be joining urban households that are already in existence (e.g. in the case of relatives), but, as in rural areas, migration may affect average household size. No explicit account has been taken here of these specific aspects of the migration process.

[8] Allen C. Kelly, "Demand patterns, demographic change, and economic growth", *The Quarterly Journal of Economics*, vol. LXXXIII, No. 1 (February 1969), pp. 110-126.

[9] To illustrate the methodology, both the linear and Cobb-Douglas forms of consumption function are presented in the annex. In the linear from of consumption equations, budget constraints are also imposed, in that the sum of estimated household expenditure on food and on non-food is set equal to the household budget.

Causal linkage between changes in household consumption and selected economic-demographic variables



Estimated parameters and data used for projection

The parameters needed for this study can be classified into two categories. One category consists of the estimated regression coefficients of the food and non-food consumption functions respectively for rural and urban areas (see annex, equation (2) or (2.1)). The other consists of the alternative sets of assumptions pertaining to demographic and economic changes for projections, including the changes in household size, household units, rural-urban migration, and household budget. These are discussed below.

Estimated equations and parameters

For demonstration purposes, the data are taken from the 1961 consumption survey in the Philippines, in which reported data are in grouped means, on the basis of 12 observations in rural areas and 12 in urban areas. [10] The explanatory variables include household budget and household size. The regression coefficients for both linear and log-linear forms of consumption functions, for food and non-food items are reported in tables 1 and 2. [11]

[10] Philippines, Bureau of the Census and Statistics, *Family Income and Expenditures, 1961*, Philippine Statistical Survey of Households Bulletin Series No. 14 (Manila, Department of Commerce and Industry, 1962). Urban areas include metropolitan Manila, provincial capitals, chartered cities and *poblactiones*, while rural areas include the *barrios* of all municipalities other than provincial capitals. A summary of the data obtained in the survey is also given in Food and Agriculture Organization of the United Nations, *Review of Food Consumption Surveys, 1970* (Rome, 1970), vol. IA.

[11] The parameters reported in tables 1 and 2 are not exactly the same as the ones in Kelley, *loc. cit.*, although both studies use the same 1961 data from the Philippines. No attempt is made here to investigate the discrepancies, which may be due to differences in commodity aggregation for food and non-food consumption or to other factors.

The parameters are estimated by generalized least squares.[12] All the equations estimated have good fits, with adjusted R^2 as high as 0.97 and 0.98. These high values are to be expected when, as in the present case, the data used represent grouped means. With the exception of two household-size parameters, for non-food consumption in rural and in urban areas in the log-linear consumption functions, all estimated parameters are statistically significant at the 5 per cent level.

As discussed previously, the estimated parameters for linear consumption functions under budget constraints in urban or rural areas must satisfy specified equalities. For example, the sum of constant term, which is 481.62 for food consumption and 481.62 for non-food consumption in urban areas, equals 0. Likewise, the sum of the marginal propensities to consume with respect to household budget, which is 0.32 for food and 0.68 for non-food consumption, equals 1.0; and by the same token the sum of household size effects, which is 171.31 for food and —171.31 for non-food consumption, equals 0 (see table 1).

TABLE 1

Estimated parameters of linear consumption functions for food and non-food items, urban and rural areas, Philippines, 1961

(*Pesos*)

Regression coefficients	*Urban areas*		*Rural areas*	
	Food consumption	*Non-food consumption*	*Food consumption*	*Non-food consumption*
a	−481.62	481.62	−97.93	97.93
b	0.32	0.68	0.41	0.59
c	171.31	−171.31	71.57	−71.57
Adjusted R^2	0.97	0.98	0.98	0.97
Degree of freedom	0	10	10	10

NOTE. Household consumption = $a + b$ * household budget + c * household size.

The economic interpretation of these parameters is quite straightforward. For example, the parameter of 0.41 in table 1 in the linear equation form is the marginal propensity to consume, meaning that an increase of one peso in household expenditure in rural areas will result in an increase of 0.41 pesos in food consumption. In the log-linear equation of table 2, the parameter 0.25 is the elasticity of food consumption expenditure with respect to household size, also in rural areas, indicating that a 1 per cent increase in household size in rural areas will result in an increase of 0.25 per cent in food consumption.

[12] The data used for the present regression analysis are the grouped means of the household survey, where the frequency is different in each expenditure class. In such a case, the appropriate method of regression analysis is that of generalized least squares (GLS). This application of GLS to the grouping of observations means that the observation of each grouped means is weighted by the appropriate frequency in each expenditure class. For further discussion see J. Johnston, *Econometric Methods*, 2nd ed. (New York, McGraw-Hill, 1972), pp. 228-237.

TABLE 2

Estimated parameters of log-linear consumption functions for food and non-food items, urban and rural areas, Philippines, 1961

Regression coefficients	*Urban areas*		*Rural areas*	
	Food consumption	*Non-food consumption*	*Food consumption*	*Non-food consumption*
Log a	0.76	−2.75	0.74	−3.01
Log b	0.71	1.26	0.74	1.36
Log c	0.32	0.09 [a]	0.25	−0.15 [a]
Adjusted R^2	0.98	0.98	0.98	0.98
Degree of freedom	10	10	10	10

NOTE. Log household consumption = log $a + b$ * log household budget + c * log (household size).

[a] Not significantly different from 0 at the 5 per cent level.

Household budget effect

This effect is widely discussed in literature and needs no elaboration here. As expected, the effect of the mean household budget on non-food consumption, with respect either to the marginal propensity to consume or to elasticity, is consistently higher than the effect on food consumption, both in urban and in rural areas. Indeed there is a saturation point in food consumption, which will not increase indefinitely in response to the increase of total budget or income. This follows from Engel's law that food expenditure occupies a declining proportion of household budget as household budget (income) increases, although the food expenditure in absolute terms should increase as household budget (income) increases. By inference, non-food expenditure will tend to increase in relative importance.

Household size effect

This effect can best be explained by distinguishing between the concept of "specific" and "income" effects as discussed above. The over-all effect of these two components will vary depending on the commodity. It has been suggested[13] that food consumption accounted for by household size can best be explained by a dominance of income effects over specific effects. An increase in household size requires additional food consumption, especially for necessities such as cereals. However, for non-food expenditure, specific effects override income effects because of the economies of scale.

As shown in table 1 and 2, the effect of household size on food consumption is consistently positive, and consistent with the *a priori* expectations of income effects overriding specific effects on food consumption as noted above. It may also be noted that the effect of household size on food consumption in urban areas is higher than in rural areas. This is because the addition of another member to the household means that the given household budget or income *per capita* has to go further. Therefore it is plausible to expect that, in response to an increase in house-

[13] Kelley, *loc. cit.*, p. 118.

hold size, urban households with a higher per household budget than rural ones are able to spend more on the necessities such as food, than households in rural areas. This also implies that income effects on food consumption override possible economies of scale, particularly in urban areas.

On the other hand, it appears from tables 1 and 2 that the effect of household size on non-food consumption where the sign is negative is consistent with the expectations of the economies-of-scale theory. For instance, the marginal propensity to consume non-food items as affected by household size is —71.57 in rural areas and —171.31 in urban areas, in contrast with the positive sign for food consumption with a marginal propensity to consume of 71.57 in rural areas and 171.31 in urban areas. Incremental non-food consumption as a result of an increase in household size tends to diminish, with a particularly significant effect in the case of consumer durables included as part of non-food consumption in this study. This negative effect is relatively greater in urban than in rural areas. It is natural to expect that economies of scale in urban areas are greater than in rural areas because of more advanced merchandising and marketing and the greater likelihood of competition in urban areas. This also implies that, given the same level of budget or income *per capita*, an urban household may be able to attain a higher standard of living than one of the same size in rural areas and that a larger household may be able to attain a higher standard of living than a smaller household, either in rural or in urban areas, because of the economies of scale in consumption.

Assumptions of demographic and economic changes

To conduct alternative sets of projection for this study, besides the parameters estimated for the consumption functions as discussed previously, the following data are also needed: changes in household units and their distribution between rural and urban areas, rural-urban household migration, changes in household size and household budget in rural and urban areas. The length of time adopted is five years. The growth rates, as reported, are in terms of compound growth unless otherwise specified.

To contrast the implication of the effects of different demographic and economic changes on levels of consumption expenditure and commodity patterns, four alternative sets of assumptions have been formulated. The data used are hypothetical but might approximate possible situations in developing countries.

TABLE 3

Economic-demographic data in the base period

Region	*Household units (thousands)*	*Household size*	*Expenditure per household budget (pesos)*
Urban	1 500	4.80	2 000
Rural	3 000	5.15	1 500

TABLE 4

Alternative assumptions of economic and demographic changes during a five-year period

Alternative assumptions	*Natural increase in household units (thousands)*	*Fraction of increase in household units corresponding to*		*Rural-urban household migration (thousands)*	*Increase in household size (persons)*		*Increase in per-household budget (pesos)*	
		Urban	*Rural*		*Urban*	*Rural*	*Urban*	*Rural*
Alternative I (basic path)	585	0.33	0.67	225	0.05	0.05	150	100
Alternative II (lower urban population growth, higher migration) [a]	551	0.29	0.71	255	—0.14	0.05	150	100
Alternative III (higher urban income, higher migration) [a]	585	0.33	0.67	255	0.05	0.05	200	50
Alternative IV (lower urban population growth) [a]	551	0.29	0.71	225	—0.14	0.05	150	100

NOTES. Alternative I: (*a*) The assumption of a natural increase in numbers of household units corresponds to population growth, with an annual compound rate of about 2.5 per cent in both rural and urban areas; (*b*) total household migration within the five-year period is 7.5 per cent of rural households in the base period; (*c*) the per-household budget in urban areas, with an assumed annual compound growth rate of 1.46 per cent, is slightly higher than that in rural areas, where the growth rate is assumed to be 1.30 per cent.

Alternative II: (*a*) The assumption of rural population growth is the same as in alternative I, with an annual compound growth rate of about 2.5 per cent; the growth of urban population, however, is assumed to be slower, with an annual compound growth rate of about 2.0 per cent; (*b*) the assumed increase in household size of 0.05 members within the five-year period is the same as in alternative I; urban household size, however, shows a decrease of 0.14 members, in contrast with the 0.05 increase in alternative I; (*c*) household migration as a ratio of rural households in the base period is 8.5 per cent within the five-year period, which is higher than the 7.5 per cent in alternative I.

Alternative III: The assumptions are the same as in alternative I, except that the increase in budget per household in urban areas is higher than the increase in rural areas, thus implying a more uneven income distribution; moreover, household migration is higher than in alternative I.

Alternative IV: Assumptions are the same as in alternative II, except that household migration is lower.

[a] Compared with alternative I.

Table 3 presents the economic-demographic data in the base period; and table 4 presents four alternative assumptions of economic-demographic changes, and a summary of the major features of these assumptions. These assumed economic-demographic changes in each alternative are purported to be interrelated. For instance, a more uneven income distribution against rural areas will induce more rural-urban migration.

Alternative I is assumed to be the basic path for comparative purposes. It is characterized by the same increase in household size and the same natural growth rate of population for both rural and urban areas, but by a higher growth rate of per-household budget in urban than in rural areas. Under this scenario, it is assumed that, within the five-year period considered, both rural and urban areas will have the same increase in household size of 0.05 persons and that the number of household units will increase by 585,000, 33 per cent of which will be in urban areas and 67 per cent in rural areas. The resultant statistics under this assumption corresponds to a rate of population growth of approximately 2.5 per cent for both rural and urban areas. [14] Assumed household migration is 225,000 within the five-year period, based on the assumption of a rate of migration of about 1.5 per cent of rural household annually. The increase of per-household budget in urban areas is higher than the increase in rural areas.

Alternative II is designed to illustrate the effects of a lower growth rate of urban than rural population and to depict a more rapid migration as compared with alternative I. In addition, alternative II assumes decreasing household size in urban areas, whereas the increase in household size in rural areas is the same in alternative I and II. The natural increase in household units is assumed to be lower for urban areas in alternative II than in alternative I, but the same for rural areas.

Alternative III is the same as alternative I, except that the changes in per-household budget in urban areas compared with rural areas are higher, thus implying a more uneven distribution of urban-rural expenditure or income. Under these circumstances, it is natural to assume that household migration in alternative III is also higher than in alternative I. The only difference between alternatives IV and II is that the former has a lower migration rate.

THE PROJECTED RESULTS AND THEIR INTERPRETATION

Only the linear consumption function, the parameters of which are shown in table 1, has been selected for the experiment of alternative projection, partly because of the constraint it imposes on the household budget. Projected statistical results are reported in tables 5-9, in which a distinction is made between incremental commodity expenditure and total commodity expenditure per household or for the whole economy. It should be mentioned that this study, and the discussion of findings that follows, are not so much concerned with the precise magnitude of statistical results in absolute terms, as with the relative importance of demographic elements. The main characteristics of consumption levels and their patterns of variation under alternative I will be discussed in greater detail. In the case of alternatives II, III and IV, only the relative significance of the statistical results will be analysed. The major characteristics of variations in consumption patterns in the four alternatives will also be discussed, and the statistical results will be shown in tables 8 and 9.

Alternative I. The results from alternative I are reported in tables 5, 6 and 7. Table 5 presents the projected output with incremental food and non-food consumption expenditure decomposed into four components: changes in household size, household units, rural-urban migration and household budget. Tables 6 and 7 report, respectively, the per-household consumption and total food and non-food expenditure of the economy in rural and urban areas for the base and projected periods.

The major findings under alternative I can be summarised as follows:

(1) The results in table 5 show that demographic factors contribute significantly to an explanation of both incremental food and non-food expenditure in the economy. The demographic factors as a whole account for 75 per cent of incremental food consumption (i.e. the sum of 3 per cent, 69 per cent and 3 per cent) and for 60 per cent of incremental non-food expenditure (i.e. the sum of —3 per cent, 52 per cent and 11 per cent) attributed respectively to changes in household size, household units and rural-urban migration. In contrast, the effect of mean household budget on commodity consumption accounts only for the remainder of the incremental expenditure, 25 per cent in the case of food and 40 per cent in the case of non-food items. These findings, of course, also imply that a straightforward application of Engel's analysis by using household budget as the only explanatory variable will lead to a biased interpretation of consumption behaviour.

(2) As expected, the most important factor to which changes of total consumption levels in the economy can be attributed, is population growth. The change in the number of household units is the strongest demand force, accounting for 69 per cent of incremental food expenditure and 52 per cent of incremental non-food expenditure (see table 5). On the other hand, contrary to Kelley's findings, [15] the effect of household size on total consumption is not important, although the signs (3 per cent for incremental food consumption and —3 per cent for incre-

[14] In this study the assumed data are in terms of household units, and population figures and the growth rates are derived from the data on household units and household size. The comparability of the natural growth rates of the population and total household units in this study depends in part on the relative magnitude of rural and urban household size in the base period, and its relative change in the projected period. In this connexion the question arises whether the household size in urban or in rural areas, either in the base period or in the projected period should be used to convert migrant population into household migration.

[15] Kelley, *loc. cit.* According to his study on the Philippines, the effect of the change in household size on consumption is substantially higher than the effect due to the change in household expenditure. Part of his findings can be explained by the fact that the assumed value of *per capita* expenditure growth in the Philippines in the period considered was low (only 0.5-1 per cent of increase per year), thus reducing its role in explaining the change of consumption pattern.

mental non-food consumption) are consistent with what is to be expected. Of a necessity, food consumption will increase as household size increases, whereas incremental non-food consumption, in response to an increase in household size, will tend to decrease as a result of economies of scale in consumption. Such economies of scale can arise in different ways, such as discounts on the purchase of larger quantities, sale of minimum quantities of certain commodities, the possibility of fuller utilization of portions of foodstuffs that are otherwise discarded, and the greater likelihood that used clothes will be handed on to younger children. This also means that of two households with the same level of budget *per capita*, the larger household will enjoy a higher standard of living.

Rural-urban migration has a relatively small effect on incremental food consumption (3 per cent), but plays an important role in determining incremental non-food expenditure in the economy, with a share of 11 per cent (table 5). The relatively stronger impact of migration on incremental non-food than on incremental food expenditure can be attributed to the fact that the marginal propensity to consume is higher for non-food than for food items, while increases in household budgets are higher in urban than in rural areas. At this point, however, it should be noted that immigrants are assumed in this study to achieve the level of urban income and to adopt urban consumption patterns as soon as they arrive. Consumption in urban areas is characterized by a higher ratio of non-food to food consumption than in rural areas. No allowance is made here for cases in which there is a considerable delay in adjusting to new consumption patterns. If this qualification were incorporated into the model, migration would probably contribute much less towards the shift of consumption from food to non-food items.

TABLE 5

Projected output (alternative I)

Effects accounted for by	*Incremental food consumption*		*Incremental non-food consumption*	
	Millions of pesos	*Percentage*	*Millions of pesos*	*Percentage*
Change in household size: Urban—0.05 (0.21 per cent increase [a]); rural—0.05 (0.19 per cent increase [a])	24	3	−24	−3
Change in number of household units: 585,000 (2.5 per cent increase [a])	536	69	439	52
Rural-urban migration: 225,000 (1.5 per cent of rural households [a])	21	3	91	11
Change in household expenditure: Urban—150 pesos (1.5 per cent increase [a]); rural—100 pesos (1.3 per cent increase [a])	194	25	331	40
TOTAL	775	100	837	100

[a] All percentage increases are in terms of annual compound growth rates.

TABLE 6

Consumption expenditure per household (alternative I)

	Urban			*Rural*		
	Total	*Food*	*Non-food*	*Total*	*Food*	*Non-food*
Increment of per household expenditure (pesos)	150	56	94	100	44	56
Percentage distribution	100	37	63	100	44	56
Percentage distribution of food and non-food expenditure per household						
Base period	100	49	51	100	59	41
Projected period [a]	100	48	52	100	58	42
Annual compound growth rate (percentage)	—	1.1	1.8	—	1.0	1.7

[a] Figures computed for a five-year period.

(3) Interest is not confined to the importance of economic-demographic elements in explaining the consumption level discussed above: the study also directs its attention towards commodity composition. The effects of an increase in per-household budget on the composition of consumption can be illustrated by the results of table 6, which assume an increase of household budget of 100 pesos in rural areas and 150 pesos in urban areas. Under such conditions, out of 100 pesos of increased budget per household in rural areas, 56 pesos are spent on non-food items (a share of 56 per cent); and out of 150 pesos increased budget per household in urban areas, 94 pesos are spent on non-food items (a share of 63 per cent). These resultant increments of expenditure on food and non-food items may be attributed to changes in both household budget and household size. As would be expected, most "incremental" household budget shifts are towards non-food consumption, both in rural and in urban areas, but the effect is more pronounced in urban areas. Even though the shares of incremental food and non-food items in household expenditure differ substantially, a dramatic change cannot be expected in total per-household consumption patterns within a short period. For example, in the five-year period, non-food expenditure as a ratio of per-household budget increases from 41 per cent to 42 per cent in rural areas, and from 51 per cent to 52 per cent in urban areas, both very minor shifts.

Regarding total consumption expenditure for the whole economy, the assumptions of comparatively high natural growth rates of population, together with a higher growth of per-household budget in urban than in rural areas, lead to a higher growth rate of total commodity expenditure in urban than in rural areas. As can be seen from table 7, the annual compound growth rate is 6.9 per cent for non-food items and 6.2 per cent for food in urban areas, compared with 2.8 per cent for non-food items and 2.1 per cent for food in rural areas.

TABLE 7

Total consumption in the economy (alternative I)

	Urban		*Rural*	
	Food	*Non-food*	*Food*	*Non-food*
Incremental consumption expenditure in the economy (millions of pesos)	519	608	287	277
Percentage distribution of food and non-food expenditure in the economy				
Base period	49	51	59	41
Projected period [a]	48	52	58	42
Annual compound growth rate (percentage)	6.2	6.9	2.1	2.8
Total household units (thousands)				
Base period	1 500		3 000	
Projected period [a]	1 920		3 165	

[a] Figures computed for a five-year period.

TABLE 8

Incremental household consumption expenditure and number of food and non-food items under alternative assumptions, accounted for respectively by changes in household size, household units, rural-urban migration and changes in household expenditures

Effects accounted for by	*Incremental food consumption*		*Incremental non-food consumption*	
	Millions of pesos	*Percentage*	*Millions of pesos*	*Percentage*
Change in household size				
Alternative I	24	3	−24	−3
Alternative II	−25	−4	25	3
Alternative III	24	3	−24	−3
Alternative IV	−25	−4	25	3
Change in number of household units				
Alternative I	536	69	439	52
Alternative II	502	72	405	47
Alternative III	536	72	439	54
Alternative IV	502	73	405	48
Rural-urban migration				
Alternative I	21	3	91	11
Alternative II	24	3	103	12
Alternative III	24	3	103	13
Alternative IV	21	3	91	11
Change in per-household budget				
Alternative I	194	25	331	39
Alternative II	194	28	331	38
Alternative III	157	21	293	36
Alternative IV	194	28	331	39
Total				
Alternative I	775	100	837	100
Alternative II	696	100	864	100
Alternative III	740	100	812	100
Alternative IV	693	100	852	100

TABLE 9

Shifts in consumption patterns per household and in the economy under alternative assumptions

(*Percentage*)

Alternative assumptions	Incremental expenditure per household						Total incremental expenditure of the economy					
	Urban			Rural			Urban			Rural		
	Total	Food	Non-food	Total	Food	Non-food	Total	Food	Non-food	Total	Food	Non-food
Alternative I	100	38	62	100	44	56	100	46	54	100	51	49
Alternative II	100	16	84	100	44	56	100	40	60	100	50	50
Alternative III	100	36	64	100	48	52	100	45	55	100	54	46
Alternative IV	100	16	84	100	44	56	100	40	60	100	51	49

In sum, it appears that demographic factors are, to an overwhelming extent, the crucial explanatory variables in determining the shifts of incremental consumption in the economy away from food. Urbanization, internal migration and other demographic variables such as household size, play an important role in determining the consumption pattern as well.

Alternative II. In contrast with the major assumptions of alternative I, in alternative II it is assumed that there will be a lower growth rate of urban household units and more rapid migration. Urban household size decreases under alternative II instead of increasing, as assumed in alternative I. However, an increase in household size in rural areas is assumed in both alternatives I and II (see table 4).

The effect of household size on the level and pattern of consumption is determined by the over-all and combined effects of possible economies of scale due to the increase in rural household size and the possible diseconomies of scale associated with a decrease in urban household size. As reported in table 8, it has been found that the effect of household size change accounts for 3 per cent of incremental non-food consumption under alternative II, contrasting with the negative effect of −3 per cent under alternative I. This may possibly be explained by the fact that, as urban households decline in size, diseconomies of scale arise and these diseconomies of scale override the economies of scale associated with the increase in rural household size.

Non-food expenditure in urban areas may be used to illustrate the effect of household size on per-household consumption expenditure. The only change in the value assumed for the explanatory variables compared with alternative I is the decrease in household size while per-household budget is kept constant. According to table 9, the proportion of incremental expenditure for non-food consumption increases from 62 per cent under alternative I to 84 per cent under alternative II.

As noted under alternative I, household units and rural-urban migration are among the most important factors influencing commodity expenditure changes in the economy. Given the differentials of rural-urban consumption behaviour, with a higher propensity towards non-food consumption in urban areas, assumptions of decreasing urban household units would be accompanied by decreasing non-food consumption but more rural-urban migration would be accompanied by increasing non-food consumption. As expected, household unit effect accounts for 47 per cent of incremental non-food consumption in the economy under alternative II, revealing a decrease from 52 per cent under alternative I; and rural-urban migration effect accounts for 12 per cent of incremental non-food consumption under alternative II, revealing an increase from 11 per cent under alternative I (see table 8). The over-all effects on non-food consumption will comprise the combined effects of the forces behind the changes in numbers of household units and rural-urban migration. As shown in table 9, the proportion of total incremental expenditure of the economy on non-food items increases from 54 per cent under alternative I to 60 per cent under alternative II.

Alternative III. Alternative III is characterized by a more uneven rural-urban household budget (as a proxy of uneven income distribution) and more migration compared with alternative I.

The higher per-household budget in urban areas under alternative III would naturally mean that a higher proportion of its incremental expenditure per household would be devoted to non-food items, with a share of 64 per cent under this alternative compared with 62 per cent under alternative I (see table 9). On the other hand, a higher proportion of incremental expenditure per rural household is for food consumption, with a share of 48 per cent under alternative III compared with 44 per cent under alternative I. A probable explanation is that, given the lower household budget in rural areas, a comparatively higher proportion of incremental household expenditure under alternative III will be spent on food compared with alternative I. The effect of rural-urban migration alone on commodity expenditure will be examined further under alternative IV.

Alternative IV. The only difference between alternative II and IV is that the latter assumes that there will be a lower rate of household migration, thus implying that the total number of rural household units under alternative IV will be higher than under alternative II.

As a consequence of the assumed lower migration under alternative IV, this factor carries less weight in determining incremental consumption in the economy than it does under alternative II. Table 8 shows that both incremental food and non-food consumption in absolute terms accounted for by the rural-urban migration effect decreases from alternative II to alternative IV—21 million pesos of incremental food consumption under alternative IV, representing a decrease of 3 million pesos from alternative II, and 91 million pesos of incremental non-food consumption under alternative IV, representing a decrease of 12 million pesos from alternative II. The above findings are more or less as expected. They can be attributed to our assumed value for migration, in that less rural-urban migration means fewer households to be assimilated into the urban pattern of consumption, characterized by the high importance of non-food consumption. Nevertheless, to the extent that migratory movements represent only a small proportion of total population, their relative effects on total incremental consumption in the economy under the two alternatives do not differ much. As shown in table 8, migration effects account for 11 per cent of incremental non-food expenditure under alternative IV, with a decrease of only one percentage point from alternative II, and for 3 per cent of incremental food expenditure under alternative IV, expenditure remaining unchanged with respect to alternative II.

Compared with alternative I, the major changes of assumption under alternative IV include lower natural increase in the number of household units, lower growth rate of urban household units and decreasing household size in urban areas. Other assumptions remain the same for alternatives I and IV, including migration, increasing household size in rural areas, and increasing household budget in rural and urban areas.

Under alternative IV, there is a dramatic shift away from food in consumption patterns of incremental expen-

whereas in rural areas there is, of course, no change with respect to alternative I. Table 9 shows that the proportion of non-food expenditure increases from 62 per cent under alternative I to 84 per cent under alternative IV, an increase of 22 percentage points for the incremental expenditure per household in urban areas. Total incremental expenditure in the economy amounts to 60 per cent for non-food items under alternative IV, an increase of 6 percentage points from alternative I. These changing patterns are the same as for alternative II. Changes in household size, together with changes in the number of household units in urban areas, are the major factors behind the changing pattern of total incremental expenditure.

The above illustrations, although not exhaustive, attempt to contrast the major differences under the alternative assumptions. Additional alternative assumptions could, of course, be added for the study of specific issues.

Concluding remarks

In this paper an attempt has been made to demonstrate explicitly, using a model plus statistical results, that selected demographic factors contribute significantly to changes in levels and patterns of consumption. For demonstration purposes, four alternatives were considered.

Alternative I, using a moderate set of assumptions for the selected economic-demographic variables, confirmed, in accordance with Engel's law, that a higher proportion of incremental expenditure per household is devoted to non-food items than to food. The former account for 56 per cent of per-household budget in rural areas and 62 per cent in urban areas. However, Engel's law, with household budget as the only explanatory variable, does not provide an adequate explanation of the shift in consumption patterns away from food. Population growth, the economies or diseconomies of scale in consumption associated with changing household size and rural-urban migration affect both levels and patterns of consumption. It was found that the over-all effects of the selected demographic variables proposed under alternative I account for 75 per cent of incremental food expenditure in the economy and for 60 per cent of incremental non-food expenditure. The remainder is attributed to household budget effects, which account for 25 per cent of incremental food expenditure and 40 per cent of incremental non-food expenditure in the economy.

Alternative assumptions of changes in household size, population growth, more uneven rural-urban income distribution and more rapid rural-urban migration, or a combination of these, were selectively incorporated into the model for alternatives II-IV. The signs of the resultant changes of food and non-food consumption pattern are consistent with what, *a priori*, might be expected. All of them reveal that demographic factors alone, including household size, number of household units and rural-urban migration, are the most important factors in determining consumption levels and commodity patterns. They account for between 72 and 79 per cent of incremental food expenditure and for between 61 and 64 per cent of incremental non-food expenditure under the three alternatives.

diture per urban household, as well as in the economy,

The findings in this study must be qualified by noting that the model adopted here does not take into account other possible effects, such as regional price variations, on differential rural-urban expenditure patterns. Also, differences in tastes and other social and occupational factors are not incorporated. Needless to say, the statistical results reported in this study are also dependent upon the quality of the data used and the validity of the underlying assumptions.

There are several directions in which the present work may be extended. First, price variables can be incorporated into the model. Combined use of time series and cross sectional data would, moreover, make it possible to investigate the intertemporal changes and intratemporal variations in consumers' tastes.

Secondly, intercountry comparisons may also be useful in tracing possible differences of consumption behavior due to economic-demographic differences among countries. The present model can also be easily extended to include more details of commodity disaggregation. Disaggregating the food variable would facilitate nutritional evaluation.

The findings suggest that demographic factors, including rural-urban migration, household size and units proposed in this study, would also be important elements in explaining shifts in consumption patterns away from food as well as differentials in rural-urban consumption. They thereby shed light on development policies affecting agricultural production and industrial structure.

ANNEX

Mathematical derivation of the model

The model of household consumption behaviour presented below covers two commodities in rural and urban areas. [a] A more generalised model can be made, including a greater number of commodities and wider regional classifications, but this will not be attempted here.

The following three subjects are discussed below: (*a*) the decomposition of consumption functions; (*b*) changes in rural and urban consumption; and (*c*) budget constraints.

The decomposition of consumption functions

To derive the mathematical formulation of the model, let us define the variables and parameters as follows:

The variables

d_r, d_u = average household consumption of a commodity in rural and urban areas.
D = total consumption of the commodity in the economy.
h_r, h_u = average household size in rural and urban areas.
H_r, H_u = number of household units respectively in rural and urban areas.
$H = H_r + H_u$ = total number of household units.
X_r, X_u = average per household expenditure in rural and urban areas.

[a] Allen C. Kelley, "Demand patterns, demographic change, and economic growth", *The Quarterly Journal of Economics*, vol. LXXXIII, No. 1 (February 1969), pp. 110-126.

k = fraction of the changes in household units taking place in rural areas, that is, $1.0 - k$ in urban areas.

M = number of households migrating from rural to urban areas.

The regression coefficients

a_r, a_u = the constant terms of consumption functions in rural and urban areas.

b_r, b_u = regression coefficients of mean household budget in rural and urban consumption functions. In linear functions, it is the marginal propensity to consume, i.e. b units of commodity consumption change associated with a one-unit change in household budget. In the Cobb-Douglas function, b is the elasticity of commodity consumption with respect to household budget, i.e. b units of percentage change in commodity consumption associated with a 1 per cent change in household budget.

c_r, c_u = regression coefficients of mean household size in rural and urban consumption functions. In the linear equation, it is c units of commodity consumption change associated with a one-unit change in household size; and in the linear-log function it means c units of percentage change in commodity consumption associated with a per cent change in household size.

To demonstrate the methodology and underlying assumptions, a linear consumption function is first presented and illustrated. The corresponding derivation for a Cobb-Douglas form of consumption function, i.e. an exponential or linear logarithmic function, is reported next.

Case I | linear consumption function

Total consumption expenditure in the economy for a commodity, denoted as D, equals the sum of rural and urban consumption as stated in equation (1), where total rural (urban) consumption is obtained by multiplying the number of rural (urban) household units by the level of consumption per household.

In equation (2), rural (urban) consumption per household is expressed as a function of household budget and household size. By substituting equation (2) in equation (1), equation (3) is obtained; that is, total consumption expenditure in the economy is determined by per-household budget, household size and total number of household units in both rural and urban sectors.

(1) $$D = H_r d_r + H_u d_u.$$

(2) $$d_r = a_r + b_r X_r + c_r h_r$$

and

$$d_u = a_u + b_u X_u + c_u f_u.$$

(3) $$D = H_r (a_r + b_r X_r + c_r h_r) + H_u (a_u + b_u X_u + c_u h_u).$$

Primes (′) denote time derivatives. For example, H' is the time derivative of H or, in discrete terms, the increment of household units per year.

In equation (4) below, the increment in the number of rural household units is the natural growth of household units in rural areas minus the number of households migrating from rural to urban areas; thus the number of urban households is the residual of total household numbers after deducting household numbers in rural areas.

By taking the time derivative of equation (3) and substituting expressions for H'_r and H'_u from equation (4), the final result stated in equation (5) is obtained.

(4) $$H'_r = kH' - M$$

and

$$H'_u = (1.0 - k) H' + M.$$

(5) $$D' = [k(a_r+b_r X_r+c_r h_r)+(1.0-k)(a_u+b_u X_u+c_u h_u)]H'$$ (Household units effect)

$$+ [c_r H_r h'_r + c_u H_u h'_u]$$ (Household size effect)

$$+ [(a_u+b_u X_u+c_u h_u)-(a_r+b_r X_r+c_r h_r)]M$$ (Rural-urban migration effect)

$$+ [b_r H_r X'_r + b_u H_u X'_u]$$ (Average household budget effect)

As indicated in equation (5), the increment of commodity consumption expenditure can be decomposed into four components: change in the number of household units, change in household size, rural-urban household migration and change in household budget. Each component can be further divided into the effects accounted for by rural and urban regions, respectively.

Case II: Cobb-Douglas form of consumption function

The derivation procedure and the notation used for the Cobb-Douglas form of consumption function is the same as the one as shown above.

(11) $$D = H_r d_r + H_u d_u.$$

(2.1) $$d_r = a_r X_r^{b_r} h_r^{c_r}$$

and

$$d_u = a_u x_u^{b_u} h_u^{c_u}$$

(3.1) $$D = H_r (a_r X_r^{b_r} h_r^{c_r}) + H_u (a_u X_u^{b_u} h_u^{c_u}).$$

(4.1) $$H'_r = k H' - M$$

and

$$H'_u = (1.0 - k) H' + \mathrm{M}.$$

(5.1) $$D' = [k (a_r X_r^{b_r} h_r^{c_r}) + (1.0 - k) (a_u X_u^{b_u} h_u^{c_u})] H'$$ (Household units effect)

$$+[H_r a_r c_r X_r^{b_r} h_r^{c_r-1.0} h_r + H_u a_u c_u X_u^{b_u} h_u^{c_u-1\,0} h_u]$$ (Household size effects)

$$+ [a_u X_u^{b_u} h_u^{c_u} - a_r X_r^{b_r} h_r^{c_r}] M$$ (Rural-urban migration effect)

$$+ [H_r a_r b_r X_r^{b_r - 1.0} h_r^{c_r} X'_r + H_u a_u b_u X_u^{b_u - 1.0} h_u^{c_u} X'_u]$$ (Average household budget effect)

In this study, two commodities, food and non-food, are distinguished, respectively, for rural and urban regions. Therefore, there are four consumption functions corresponding to equation (2) (or equation 2.1); that is, food consumption in the rural and urban areas; and non-food consumption in rural and urban areas.

Increments of Rural and Urban Consumptions

The above model has potential implications with respect to changing urbanization as it affects rural and urban consumption patterns and levels and as these, in turn, affect the growth of industrial patterns and accompanying economic development.

Let an asterisk (*) denote the new commodity consumption level after the changes in household units, household size, migration and household budget. This new commodity consumption, in discrete terms, can be easily obtained as follows:

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[b] For reference purposes, the derivation of equation (5) is presented step by step, as follows:

$D' = [H_r (a_r + b_r X_r + c_r h_r)]' + [H_u (a_u + b_u X_u + c_u h_u)]'$ (From equation (3) in the text)

$= H_r (b_r X'_r + c_r h'_r) + H'_r (a_r + b_r X_r + c_r h_r) + H_u (b_u X'_u + c_u h'_u) + H'_u (a_u + b_u X_u + c_u h_u)$

$= H_r (b_r X'_r + c_r h'_r) + (kH' - M) (a_r + b_r X_r + c_r h_r) + H_u(b_u X'_u + c_u h'_u) + [1.0-k)H'+M](a_u+b_u X_u+c_u h_u)$ (Substituting H'_r, H'_u from equation (4) in the text)

$= [k(a_r+b_r X_r + c_r h_r)+1.0-k)(a_u+b_u X_u+c_u h_u)] H'$ (Household units effect)

$+ [c_r h'_r H_r + c_u h'_u H_u]$ (Household size effect)

$+ [(a_u + b_u X_u + c_u h_u) - (a_r + b_r X_r + c_r h_r)] M$ (Rural-urban migration effect)

$+ [b_r H_r X'_r + b_u H_u X'_u]$ (Average household budget effect)

Case I: linear consumption function

$$D^*_r = (H_r + H'_r)[a_r + b_r(X_r + X'_r) + c_r(h_r + h'_r)] \quad \text{(Rural consumption)} \tag{6}$$

and

$$D^*_u = (H_u + H'_u)[a_u + b_u(X_u + X'_u) + c_u(h_u + h'_u)] \quad \text{(Urban consumption)}$$

Case II: Cobb-Douglas function

$$D^*_r = (H_r + H'_r)[a_r(X_r + X'_r)^{b_r} (h_r + h'_r)^{c_r}] \quad \text{(Rural consumption)} \tag{6.1}$$

$$D_u^* = (H_u + H'_u)[a_u(X_u + X'_u)^{b_u} (h_u + h'_u)^{c_u}] \quad \text{(Urban consumption)}$$

It will be noted that rural-urban household migration has already been included in the increment of rural and urban household units, H'_r and H'_u.

Budget constraints

The budget constraints require that the sum of household food and non-food expenditure be equal to the household budget. This also implies that the estimated coefficients of the consumption system presented above must be restricted so as to satisfy the budget constraints.

The budget constraints are applied to the linear equation forms. To demonstrate this restricted estimation, we choose rural consumption in equation (2) as an illustration. Let the superscript f, denote food consumption and n denote non-food consumption. Then food and non-food consumption functions in linear form for rural areas corresponding to equation (2) can be rewritten as equations (7) and (8) in the following manner:

$$d^f_r = a^f_r + b^f_r X_r + c^f_r h_r \tag{7}$$

$$d^n_r = a^n_r + b^n_r X_r + c^n_r h_r. \tag{8}$$

The budget constraint is:

$$d^f_r + d^n_r = X_r. \tag{9}$$

By substituting equations (7) and (8) in (9) and rearranging the terms, equation (10) is obtained:

$$(a^f_r + a^n_r) + (b^f_r + b^n_r - 1.0)\, X_r + (c^f_r + c^n_r)\, h_r = 0. \tag{10}$$

Thus the conditions of restricted estimates for estimating the system of equations (7) and (8) under the budget constraints of equation (9) can be specified as follows: [c]

$$a^f_r + a^n_r = 0.0, \qquad b^f_r + b^n_r = 1.0 \tag{11}$$

and

$$c^f_r + c^n_r = 0.0.$$

Alternatively, the above can also imply that only one of equations (7) and (8) needs to be estimated, and the remaining parameters of the consumption system can be computed from equation (11) as derived from equation (10).

[c] When household size as defined in the model is in terms of adult consumer equivalents, the common practice is to apply a single adult equivalent scale to all commodity sectors. However, this may not be valid even in the (2) sector case and it could be far from valid in a highly disaggregated application, since the specific effect of the household size will differ from commodity to commodity. In these situations it may be more appropriate to introduce sex and age structure and weights for each commodity as an explanatory variable in equations (2) and (2.1). In such a case, the final budget constraints of equation (11) would not apply, since the variable of household size could differ from one commodity to another.

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A CRITIQUE OF THE ARTICLE "CHOICE OF POLICY MEASURES TO AFFECT FERTILITY: A COMPUTER MICROSIMULATION STUDY" [1]

Robert G. Potter *

SUMMARY

This brief critique addresses itself to some of the opportunities afforded by a new computerized model featured in the article by Shunichi Inoue entitled "Choice of policy measures to affect fertility: computer microsimulation study". [1] It is argued that for several reasons, this apparatus is not likely to see much use as a routine methodology either for projecting population or for target-setting. On the other hand, thanks to the very wide scope of factors and interactions treated, combined with relatively modest running costs, it commands considerable promise as an analytical device.

INTRODUCTION

A powerful and basic approach to the study of period fertility is to treat its dynamics as occurring at the level of birth or marriage cohorts. Age-schedules of period or cross-sectional fertility are viewed as comprising simply the concurrent segments of natality experience of several contributing cohorts. Change in period fertility depends both on "cohort effects", in which successive cohorts alter their characteristics, and on "period effects", changes that touch simultaneously all cohorts currently of relevant ages.

This perspective is rigorously adhered to in the article by Shunichi Inoue entitled "Choice of policy measures to affect fertility: a computer microsimulation study", [1] hereafter referred to simply as "the report". What is impressive about the computerized scheme of analysis presented and applied in the report is its full implementation of the cohort approach, including provision for both cohort and period effects.

More specifically, each cohort of 15-year-olds is followed to age 50 by means of a Monte Carlo microsimulation of fertility based on the biodemographic (or "family-building") approach to cohort fertility initiated by Henry, [2] systematized by Sheps and Menken, [3] and contributed to by Barrett, Bongaarts, Holmberg, Jacquard, Leridon, Mode, Singh, Venkatacharya, and many others. [4] Like the most ambitious of the models developed within this tradition, which are generally based on Monte Carlo procedure, the present one treats the fertility histories of individual women as the outcome of an interplay of factors encompassing aspects of mortality, nuptiality, fecundity, fertility aspirations and fertility control.

The microsimulation of fertility is embedded in a larger computer program designed to generate up to 13 cohorts. When interpreted as consecutive 5-year birth cohorts and properly aggregated cross-sectionally, they determine the period fertility schedules of seven synthetic cohorts, spanning a projection period of 35 years. To represent cohort change over a period of time, the characteristics of each cohort may be established independently of each other; in addition, for a subset of the dimensions included in the model, period changes, affecting all cohorts of childbearing age, can be introduced on a quinquennial basis.

Two options for using the total apparatus are available. By itself, with proper input, the computer program suffices to generate a schedule of age-specific birth rates for each cohort and for each synthetic cohort derivative from them. It also summarizes these age-schedules of fertility by total fertility rates and standardized crude birth rates. Alternatively, in what is necessarily a two-step analysis, the seven age-schedules of period fertility are first derived and then used as part of the input for a genuine cohort-component population projection of 35 years' duration.

It will be argued below that the present apparatus is not likely to see much use as a routine methodology either for projecting populations or for target-setting. However, it does have considerable promise as an analytical device, suitable for exploring, in hypothetical populations closed to migration, the relationships between cohort and period

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[1] *Population Bulletin of the United Nations, No. 10* (United Nations Publication, Sales No. E.78.XIII.6).

[2] Many of Louis Henry's fundamental writings are collected in *On the Measurement of Human Fertility; Selected Writings of Louis Henry*, M. C. Sheps and E. Pierre-Adamcyk, tr. and ed. (New York, Elsevier Publishing Co., 1972).

[3] Mindel C. Sheps and Jane A. Menken, *Mathematical Models of Conception and Birth* (Chicago, University of Chicago Press, 1973).

[4] For a valuable review of this literature, see Henri Leridon, *Human Fertility: The Basic Components* (Chicago, University of Chicago Press, 1977).

fertility as mediated by a wide variety of factors. In a more applied vein, it offers an analytical tool for appraising, in a few carefully selected national settings, the demographic impacts of policy packages placing different profiles of emphasis upon delayed marriage, unhurried mortality decline, reduced family size goals, and augmented utilization of one or another form of family planning.

Population projection

There are several considerations militating against use of the present apparatus as a basis for routine projections of populations.

First of all, fully fledged cohort-component projection calls for a two-step analysis, deriving the age-schedules of period fertility as cross-sections of cohort experience and then combining these schedules with other data for the projection process itself.

Secondly, making fertility a function of 14 input dimensions, some of them composite, for each of which an initial level and path of change across cohorts has to be presaged, is not an efficient way of increasing demographic predictability.

Thirdly, in order to achieve sets of reasonably stable age-specific birth rates with a Monte Carlo model, a sizable sample will be needed for each 5-year cohort contributing experience, which will have the undesirable effect of escalating the running costs.

Fourthly, the data requirements of the fertility model far exceed the informational resources of many, if not most, developing countries. Considerable ingenuity has gone into reducing these requirements through the use of model distributions. Nevertheless, it is admitted by the author of the report that there are several items—e.g., the highly refined rates of contraceptive and induced abortion practice—that presuppose that a world fertility survey or some equivalent inquiry has recently occurred in the country under study.

A fifth reason may be even more decisive than the rest. The first seven cohorts have to be defined in such a way that, when aggregated cross-sectionally, they yield an age-schedule of fertility that reasonably approximates the observed age-specific birth rates of the base period. The applications of the models for evaluating fertility in Japan and policy measures in Pakistan that are described in the report suggest that not a little data searching and trial and error application of the microsimulation are needed to achieve this match.

Target-setting

Cohort-component projections designed to distinguish marital status and to make marital age-specific birth rates responsive to assumptions about the acceptance, continuation and effectiveness of family planning methods are seeing increasing use as a target-setting technique. Examples of this are to be found in the work of Lee and Isbister,[5] Bogue and others,[6] Stolnitz,[7] in two studies put out by the Economic and Social Commission for Asia and the Pacific (ESCAP),[8] and, most recently, in the work of Nortman and others based on the computerized TABRAP/CONVERSE model.[9] Not being biodemographic microsimulations operating at the pregnancy level but rather demographic macrosimulations operating at the birth level, these schemes handle the aspects of induced abortion, postpartum anovulation and secondary sterility far more indirectly and awkwardly than does the present apparatus. Furthermore, target-setting schemes have traditionally been formulated in terms of acceptance, continuation and effectiveness rates of various contraceptives. Reliance by the present model upon the concept of extended use-effectiveness limits attention to use and effectiveness rates. Yet this heterodoxy may be commendable, given the situation characterizing so many populations today, namely, manifold contraceptives and multiple sources of supplies and rapid shifting from one to another by individual couples.

Other aspects, however, weigh against the present apparatus as a convenient device for routine target-setting. Because most demographic goals are formulated in terms of crude birth rates or crude growth rates rather than total fertility rates,[10] a fully fledged population projection is usually necessary to confirm that the goal would be reached within the interval specified by a given augmentation of family planning activity. With the present scheme, the set of changes that will bring about a predesignated decline of the crude birth rate has to be derived by trial and error, unlike the direct solution afforded by TABRAP. So many dimensions of input mean an indefinite number of possible solutions. The sampling variability associated with the Monte Carlo procedure constitutes a problem inasmuch as a particular specification of input may fall short of a demographic goal in one run but exceed it in the next. And again, data requirements

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[5] B. M. Lee and J. Isbister, "The impact of birth control programs on fertility", in B. Berelson, ed., *Family Planning and Population Programs; a Review of World Developments. Proceedings of the International Conference on Family Planning Programs, Geneva, August 1965* (Chicago, University of Chicago Press, 1966), pp. 737-758.

[6] D. J. Bogu, S. Edmonds and E. J. Bogue, *An Empirical Model for Demographic Evaluation of the Impact of Contraception and Marital Status on Birth Rates: with Computerized Applications to the Setting of Targets and Quotas for Family Planning Programs*, Family Planning Research and Evaluation Manual No. 6 (Chicago, University of Chicago, Community and Family Study Center, 1973).

[7] George J. Stolnitz, "Estimating the birth effects of India's family planning targets: a report on statistical methodology and illustrative projections, 1968-1978", unpublished consultant's report for the United States Agency for International Development (AID), July-August 1968, pp. 1-78.

[8] "Report of the multinational study in methodologies for setting family planning targets in the ESCAP region", Asian Population Studies Series, No. 31 (ST/ESCAP/14) and "Some techniques for measuring the impact of contraception", Asian Population Studies Series, No. 18 (E/CN.11/1119).

[9] D. Nortman and others, *Birth Rates and Birth Control Practice* (New York, The Population Council, 1978).

[10] W. B. Watson and R. J. Lapham, "Family planning programs; world review 1974", *Studies in Family Planning*, vol. 6, No. 8 (1975), pp. 205-332.

narrow to a small subset the developing nations to which the present apparatus is applicable without a wholesale fabrication or borrowing of input information.

An analytical device

The special advantage of the present apparatus would seem to lie in its use as an analytical device, applicable either to hypothetical populations closed to migration or to selected empirical populations carefully chosen, at least in part, for their abundant data. Because of certain compromises accepted in order to reduce data requirements and the costs of making runs, it is a moot point whether the present microsimulation of fertility has any great advantage over a number of other Monte Carlo simulations for the purpose of investigating cohort fertility. For example, with respect to the sensitivity analysis given in table 4 of the report, whose conclusions contrast somewhat with those of Bongaarts [11] and Trussell, [12] it is debatable whether any valid generalizations about the relative importance of factors governing natural fertility can be drawn without recognizing natural fecundability as a factor that varies among populations.

Better results may be anticipated for uses that exploit the capacity of the present model to relate levels and trends of period fertility to the detailed characteristics of constituent cohorts.

Interpreting the past

One major use to which the apparatus may be put is to test hypotheses about past fertility trends. This function is well illustrated by the reports analysis of the Japanese fertility model. Simulated here is the period fertility of Japan from 1945-1949 to 1965-1969, during which interval natality plunged from a high to a low level within 10 years and then maintained that low level for the additional 10 years examined. It is alleged that the parameter choices found to simulate these dramatic events lend credence to the notions that the high fertility level of 1945-1949 owes much to postponement of marriage and childbearing during the war years, while the subsequent plunge of fertility is ascribable to an increased effectiveness of contraception and an expanded practice of induced abortion in the service of persisting low sizes of desired family.

If one may hazard a guess, the hardest part of the analysis probably lay in formulating the characteristics of the seven cohorts contributing to the fertility schedule of the base period. Anyway, the total fertility rate of this schedule stands somewhat above its empirical counterpart. To obtain a reasonable fit with the sets of age-specific fertility rates, it was found necessary to modify the model age-distribution of first marriage. To his credit, the author does not try to argue that the adopted sequence of parameter assignments is the only one that might have successfully mimicked the 20 years of period fertility. Nevertheless, a good deal of significance can be attached to the fact that hypotheses for which there is considerable circumstantial evidence find added support from the present analysis.

Policy evaluation

There is an even more important way of exploiting the present apparatus as an analytical tool, namely, by using it to quantify the effects of various policy packages in given population settings. The scope of the model is such that these packages may encompass a variety of goals with respect to mean age of marriage; expectation of life; proportion having a desired family size and its mean level; spacing preferences; and rates of use of one or another contraceptive, induced abortion, or sterilization among eligibles.

As long as interest extends no further than age-specific and total fertility rates, the analysis scheme as programmed suffices. However, a deeper evaluation of policy effects is achieved through a fully fledged population projection as defined earlier. Any rapid drop in fertility over a period of time tends to produce an adverse "middle heavy" age distribution which in turn retards the decline of the crude birth rate and, to an even greater extent, decelerates the decline in the rate of natural increase. [13] Therefore, when fertility is declining, to standardize the crude birth rate on the initial age distribution is to overestimate, perhaps grossly, its decline.

Besides tracing out the demographic consequences of sets of population policies, there are three collateral issues that the present methodology is well suited to investigate. The effect upon period fertility from a given change of a single factor is sensitive to the values assigned to other parameters. In a deft analysis, the results of which are summarized in table 8 and 9 of the report, it is demonstrated for the Pakistan context that single variable changes, e.g. delayed marriage, reduced sizes of desired family, increases in the practice rate of contraception or of abortion etc.—that appear large still may have surprisingly small effects on period fertility. One suspects that the paltry influence of a rise in contraception or abortion rate among limiters may be attributed in part to equating desired family size with numbers of living children wanted when the mother is age 50, which operational definition, on account of modest life expectations, translates into even higher parities required for becoming limiters. Interestingly enough though, two or more simultaneous changes can prove mutually reinforcive and admit of much more appreciable reductions of fertility.

While studies of this nature have been undertaken with the aforementioned target-setting macrosimulations, the range of interacting variables has usually been limited to initial age distribution, ambitiousness of demographic goal, level and trend of mortality, proportions married by age, and age patterns of acceptance and continuation of perfectly effective contraceptives including steriliz-

[11] J. Bongaarts, "Intermediate fertility variables and marital fertility rates", *Population Studies*, vol. 30, No. 2 (1976), pp. 227-241.

[12] T. J. Trussell, "Natural fertility: measurement and use in fertility models". (Paper presented at the seminar on natural fertility, held in Paris from 24-27 March 1977 by the Institut national d'études démographiques).

[13] "Some techniques for measuring the impact of contraception...", pp. 51-57.

ation.[14] Studies based on the TABRAP/CONVERSE model have been exceptional in that they include induced abortion as well. [15] Spacing and family size preferences are entirely missing from these previous investigations as explicit variables. Thus, there would appear to be an important opportunity to extend the investigation of interactions favouring or inhibiting rapid fertility decline. The particular operationalization of desired family size carried by the present microsimulation will tend to accentuate the qualifying role played by mortality, especially when numbers of living children preferred are high.

Another issue is that if desired family size is kept constant but spacing preferences lengthened or shortened, or the means of realizing them improved, or breast-feeding shortened in a context of weak fertility control, the tempo of cohort fertility is modified, yielding predictable effects on period fertility. An excellent opportunity exists to illustrate the variety of mechanisms that can force the period total fertility rate to rise above or dip below its cohort counterparts in conformity with the general relations between period and cohort fertility proved mathematically by Ryder through his translation model. [16]

Thirdly, among cohort changes that are roughly equal in their eventual effects on total fertility, some will express themselves in period fertility more quickly than others. Basically, it is a matter of the ages of women affected. A rise of mean marriage age from a low value affects women in their teens and early twenties, cumulative cohort fertility at all subsequent ages thereafter being influenced; whereas a rise in sterilization rate, relevant only to limiters, may affect chiefly older women. Hence, even though the two equipollent changes are initiated in the same cohort, there will be a much longer delay before the change in sterilization is substantially registered on period fertility than there will be for the change of marriage age. [17] More broadly, one may hypothesize that cohort change in marriage age, length of breast-feeding, spacing preferences and frequency and effectiveness of spacing control will exert on period fertility a prompter influence than equivalent cohort changes in age at marital dissolution, desired family size, or frequency and effectiveness of family limitation efforts. A systematic investigation of the differing speeds of impact upon period fertility by various cohort changes becomes feasible with the present model. Of course, the effects on period fertility of period-dependent change will display less contrasting lags.

Desirable extensions

Modifying the microsimulation of fertility in certain ways could widen the opportunities just enumerated. The scope of population policies would be enhanced if the proportion having any spacing preferences at all were included as a parameter, instead of it being implicity assumed that all women share a common set of spacing preferences. At present only life expectation and family planning practice variables are subject to period as well as cohort change. The formulation of population policy would become more flexible if one or more aspects of fecundity and fertility aspirations were treated in the same manner. For example, there is much interest today about the fertility consequences of replacing breast-feeding with bottle-feeding, which could be explored with the present microsimulation by making length of breast-feeding subject to period change. It would seem difficult for programming reasons to render desired family size period-dependent. With a reduction in desired family size, a certain number of spacers would immediately become limiters but "not know it" until the next birth, that event being the next occasion to compare the counter of expected living children with the now lowered standard of desired family size.

Greater realism would be achieved if use-effectiveness of contraception and method choice were allowed to differ between spacers and limiters.

More insight into the influence of desired family size and changes in it from one cohort to another could be anticipated if the computer output included not merely the general distribution of numbers of living children desired but the corresponding distributions for those who do or do not become limiters and, for the former, the distribution of effective family sizes at the time of becoming limiters. Even more informative would be the bivariate distribution, giving for each number of surviving children wanted the proportion of mothers eventually becoming limiters and their effective family size distribution.

Another expansion of output would help to judge the practicability of population policies. Family planning variables, i.e. contraceptive practice rates for stopping or spacing purposes, induced abortion rates for stopping or spacing purposes and sterilization rate among limiters, are all expressed as rates specific to highly refined definitions of eligibility. The present output offers no information about absolute numbers of eligibles. Consequently, little can be learned about the numbers of users of contraception, numbers of abortions, or numbers of sterilizations and this is a severe handicap for anyone attempting to appraise the feasibility of any policy package that depends in part or entirely on the augmentation of family planning practice.

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[14] *Ibid.*, pp. 27-32 and 51-60. For a summary of relationships, see R. G. Potter, "The ESCAP target-setting system: rationale, strengths, and limitations" *in* "Report of the multinational study in methodologies for setting family planning targets in the ESCAP region...", pp. 12-16.

[15] Nortman and others, *op. cit.*, chap. 4.

[16] N. B. Ryder, "The translation model of demographic change", in *Emerging Techniques in Population Research, Proceedings of a Round Table at the Thirty-Ninth Annual Conference of the Milbank Memorial Fund, September 18-19, 1962* (New York, Milbank Memorial Fund, 1963), pp. 65-81.

[17] For a more empirical demonstration, see R. Lesthaeghe, "Nuptuality and population growth", *Population Studies*, vol. 25, No. 3 (1971), p. 424.

UNITED NATIONS/UNFPA EXPERT GROUP MEETING ON DEMOGRAPHIC TRANSITION AND SOCIO-ECONOMIC DEVELOPMENT

United Nations Secretariat *

INTRODUCTION

The question of the impact of socio-economic factors on demographic change has long been prominent in debates and literature dealing with the interrelations between population and development. The need for a better understanding of these relations, which would facilitate government action in dealing with the problem, was further emphasized in the World Population Plan of Action [1] and several resolutions adopted by the 1974 World Population Conference. [2] A major aspect of these problems is the question of the implications of economic and social development on fertility levels and changes in developing countries.

The Population Division of the United Nations Secretariat has had a long-standing interest in fertility and factors affecting its trends. One aspect of the problem was dealt with in a meeting held at Geneva in April 1976 by the Population Division, with the assistance of UNFPA, to discuss methods of measuring the impact of family planning programmes on fertility: problems and issues.

Subsequently, in response to the recommendations of the World Population Conference, the Population Division and the United Nations Fund for Population Activities, in collaboration with the Government of Turkey, (UNFPA) organized an Expert Group Meeting on Demographic Transition and Socio-Economic Development. The meeting was held from 27 April to 4 May 1977 at Istanbul. It brought together some 30 international experts, experts from developing countries where fertility declines have occurred and representatives of United Nations specialized agencies and other international organizations. A full list of participants is given in the annex to the present paper.

A number of aspects of the problem were examined at the Meeting, including current theoretical development relating socio-economic change to fertility; the variables and indicators used in the analysis; the sources of data and their utilization; the different analysis techniques and their limitations; and a sample of empirical studies. On the basis of its discussions, the Working Group developed a set of recommendations for future research and action. This paper describes briefly the purpose and scope of the Meeting and summarizes the discussions; the concluding section contains the recommendations adopted at the Meeting. The full report of the Meeting, together with the documentation submitted to it, will be published separately.

PURPOSE AND SCOPE OF THE MEETING

During the past few decades, the world has witnessed an era unique in its history. Within the span of one generation, a dramatic increase in human life expectancy occurred in most of the economically less developed countries, while fertility, the other component of population growth, did not follow a similar (but lagging) downward trend, as it would be expected to do in the context of a demographic transition. This resulted in an unprecedented proliferation of mankind. The social and economic consequences of this demographic disequilibrium, with its built-in momentum, have been the concern of national and international policy and research institutions, especially as they undermine efforts to promote and achieve economic and social growth targets. As a consequence, there is a steadily growing interest in the study of determinants and consequences of fertility behavior in the context of social economic change and in possible means for its control. In general, an answer has been sought to the following question: What are the demographic implications of social and economic change in the less developed countries of today's world? More specifically, what are the key socio-economic factors—their levels and combinations—that could be identified with various demographic regimes?

These are difficult and complex questions. The present state of our knowledge does not provide, as yet, any one answer to the important policy issues that are implied. The rest of this presentation gives a brief and sketchy typology of population research, which may illustrate some of these difficulties, followed by a summary of the discussions and, lastly, a summary of the main findings and recommendations of the Meeting.

In retrospect, progress in population research has followed a sequence that could be related to the dynamic process of the demographic transition itself. First, there was an upsurge of interest in research on the consequences of population growth at the macro and micro levels. Macro studies attempted to identify the consequences of alternative paths of population growth on the process of economic development, a notable example of which is

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* Population Division of the Department of International Economic and Social Affairs.

[1] *Report of the United Nations World Population Conference, 1974, Bucharest, 19-30 August 1974* (United Nations publication, Sales No. E.75.XIII.3), chap. I.

[2] *Ibid.*, chap. II.

the pioneering study by Coale and Hoover. [3] Micro studies were concerned with examining the impact of demographic processes on household and individual health and welfare conditions. In general, these studies were not concerned with what determined fertility behavior. Their main purpose was to alert the public to the seriousness of population growth—its opportunity cost in terms of economic growth and/or individual and family welfare.

Secondly, the emerging interest in fertility control induced research into ways of optimizing the delivery of family planning services and the development and diffusion of new contraceptive technology. Most of that research assumed given (unsatisfied) demand conditions and developed its own domain within the narrow confines of a family planning outlook. Results of a decade or more of national and international efforts in family planning programmes around the world in most cases produced neither a large nor a uniform response per unit of expenditure. Furthermore, it was not evident, in those instances where there had been a fertility decline, how much of the variance in fertility behavior could be accounted for by family planning programmes, as opposed to the influence of social and economic change. It is becoming increasingly evident that fertility is a complex phenomenon, which needs an interdisciplinary perspective, new developments on both theoretical and methodological fronts and further empirical research in order to conceptualize the basic dimensions of its determinants, consequences and feedback mechanisms.

The last few years have witnessed a resurgence of interest and intensive research on the determinants of fertility on various fronts and representing various disciplines. An important development has taken place in the socio-economic framework for the analysis of family fertility decisions within the context of a general theory of choice. Simply stated, parents attempt to have the optimum number of children that marginally balance the profitability of having an additional child with that of not having one. This is essentially a benefit-cost scheme that focuses on the net value of children to their parents over their marital life cycle and examines how these net values vary with different production and consumption streams. In this scheme, the cost of time plays a central role.

Another development is the focus on structural constraints, i.e. the type of structure of the parent's community and/or immediate environment that limits their decisions and choices, how this social context changes under various regimes of social and economic development, and the impact of such changes on reproductive norms and behaviour.

A third development is a substantial extension of the macro economic-demographic models to incorporate the complex interactions and feedback mechanisms between demographic and socio-economic variables.

For the most part, work on the determinants of fertility in the less developed countries is in an exploratory stage. There are important advances in conceptualization but there are difficult problems involved in determining the appropriate relationships, their specifications, and the use of appropriate estimation techniques. There is also the problem of finding the necessary data.

In recent years, there has been a decline in fertility in many developing countries at various levels of socio-economic development. Those trends should provide an opportunity to examine the role of socio-economic development in this apparent stage of the demographic transition in the context of developing countries, and not only through the historical experience of the more developed countries.

Summary of discussions

In general, the Group of Experts examined the current theoretical development relating socio-economic change to fertility; the variables and indicators used in the analysis; the sources of data and their utilization; the different analysis techniques and their limitations; and a sample of empirical studies. As a result, the Group developed a set of recommendations for future research and action. The discussion covered a wide range of issues and cut across boundaries of different disciplines. Many ideas were presented and debated. In the report an attempt is made to synthesize, whenever possible, the various views and to highlight unsettled issues. The following is a brief summary of the findings.

Attention was given to the development of a conceptual frame that could serve as a general guide in assessing the impact of development on fertility with a view to research in action. Because of the complex nature of the relationships being examined, it was decided that the conceptual frame should focus more on basic determinants at main points of control in demographic behaviour. A general cost-benefit framework was used as the guiding paradigm for the discussion. The level of fertility in any society was perceived as the outcome of systematic individual decision processes that were constrained by three sets of factors representing various levels of aggregation: (*a*) the individual's own personality characteristics and disposition; (*b*) the socio-economic context; and (*c*) the normative context and institutional structure. In the discussion, an attempt was made to examine the three sets of factors as they related to fertility and as they changed during the process of socio-economic development. Specific suggestions related to key variables and aggregates were highlighted. For example, it was felt that in demographic research more attention needed to be paid to the community as a structural setting for individual behaviour and interaction with the environment and, more specifically, to the indentification of the social aggregates that influenced individual cost and benefit calculations and exerted pressures on demographic plans.

It was noted that, in the course of economic development, various changes took place that influenced the conditions determining household allocation decisions, including demographic plans. They included educational or skill requirements, occupational composition, degree of urbanization, status of women, health status, equity and living standard, and values and beliefs. Most of the

[3] Ansley J. Coale and Edgar M. Hoover, *Population Growth and Economic Development in Low-Income Countries; a Case Study of India's Prospects* (Princeton, New Jersey, Princeton University Press, 1958).

changes occurred as part of the basic structural changes of society. Their influence on fertility could best be elucidated if changes in individual allocative decisions were related both to changes in prices and in social constraints. A social context for individual behaviour was outlined, defining three relative social positions that influenced individual behaviour.

In order to understand the social structure it was necessary to focus on (*a*) social classes and their roles in the ownership and management of the production process; (*b*) social groups: their roles and influence in the distribution of output and social rewards; and (*c*) shifts in the levels and distribution of social output between the corporate and private sectors of society. In that context it would be possible to anticipate the effects of changes in social structures on the basic parameters of household production and reproductive decisions.

The effect of socio-economic development on individual calculating behaviour was examined. It was felt that the provision of alternatives and options might create a trend towards more calculating behaviour, which could eventually influence fertility behaviour.

A list of variables related to fertility and its determinants was prepared, based partly on the set developed by the World Fertility Survey (WFS). It introduced, however, new variables related to the development of the conceptual frame. A set of variables related to household activities was discussed and evaluated, including time use, costs and benefits of children, and other variables related to decisions regarding the allocation of household resources. Variables related to the social context were also examined.

Data constituted a major constraint in terms of both availability and quality. A discussion of various alternatives to improve the utilization of existing data sources and the development of new data sets called for more co-ordination of existing sources of data by utilizing, for example, the same sample frames. Also, the development was proposed of national and international data banks that would serve both as a screening mechanism for quality and as a source for providing data for qualified scholars to perform additional (explanatory) analysis.

Recommendations

Conceptual frame and policy issues

In designing research and deciding on priorities in support of research, the following considerations and priorities were suggested.

Purely descriptive work focusing on associations between various socio-economic variables and fertility had been necessary and often useful. Further understanding of the complex nature of the socio-economic determinants of fertility required, however, (*a*) the development of comprehensive theoretical frameworks that were applicable for different social and cultural situations and (*b*) greater emphasis on the development and examination of specific hypotheses and the use of appropriate analytical techniques, including quantitative economic-demographic models that spelt out and computed the relevant interactions; and (*c*) future development of analytical frames and demo-economic modelling should be on the sectorial level in order to examine the relationship between socio-economic policy instruments and fertility. That would facilitate the incorporation of the fertility reduction objective into the development policies in the different sectors.

At the macro level fertility behaviour influenced population growth, which affected such things as pressure on resources, unemployment rates, savings, investment etc. In their turn, such effects represented changes in the socio-economic variables that might influence fertility behaviour. At the micro level the presence of children affected the income and opportunities of their parents, siblings and others and their feedback into the determination of fertility. It was thus desirable that the effects of children on various economic and social aspects of behaviour should be traced and a joint study of fertility should be undertaken with variables like child education, maternal and child health and survival, infant mortality, labour force participation of women etc.

It was noted that population policies, including national laws influencing some intermediate variables such as induced abortion, minimum age at marriage, availability of family planning methods and various incentive—disincentive schemes had come to be viewed as important measures in altering fertility trends in many developing countries in recent years. Studies should be conducted to find out what population-related policies existed at the national level and, paying special attention to policy measures that had a direct bearing on fertility or age at marriage, how influential and effective they were and what factors could make them more effective.

There was a consensus that the status of women was an important social variable in explaining fertility changes over a period of time as well as fertility differentials among different social groups within the same community and also among different communities and locations. Conventional socio-economic variables such as educational status, occupational status, employment status, economic activity etc., did not appear to be good indices for measuring the status of women. The role of women, it was believed, was a useful concept in the decision-making process within the family and in the community. That concept had not been given much attention, and research was needed both to test the hypothesis and to devise methodologies for the collection of such data.

The relationship between various levels of analysis

There was no consensus on preferred choice of a unit of analysis, and research would proceed with both individual and group analyses, with various levels of aggregation. The following was however, recommended:

Whenever possible, variables should be chosen so as to make it possible to compare and connect findings from various levels of aggregation. There was substantial evidence that individual fertility behaviour was greatly influenced by the culture of which the individual was a part as well as by characteristics of the individual and of the household. It was important to determine which of a variety of aggregates (or clusters) was closely related to the behaviour of individuals who comprised the aggregate.

One such group, which was considered to be of high priority in research on fertility, was the community. It was important to undertake research on the relationship between the fertility of individuals within the community, including the social sectors to which they belonged, and characteristics of those sectors and of the community. The community of interests might go well beyond the conventional boundaries of villages, and in some situations might include non-contiguous aggregates. Thus, the interrelationships of various communities, and their boundaries, needed to be explored.

More generally, both theoretical and empirical work was required to specify and test the links and feedbacks between individual and group structure and behaviour. What was required was a better characterization of the environment in institutional framework or contractual arrangements in the market structure and the technological constraints. The particular way in which economic development proceeded, the particular configuration of the involvement in the market, the change in the institutional framework, the availability of public services (such as education and health, co-operatives etc.) affected fertility in a variety of ways that had to be understood in detail. In that context, when using social groupings as units of analysis, one useful criterion for the construction of such groupings could be the form in which families were linked with the productive structure in terms of occupation and ownership of means of production. Such work would, it was hoped, help to shed light on the correspondence between time series and cross-sectional findings on the relationship between economic and social variables on fertility, and to identify more effective policy options. That area of research was considered to be of high priority.

Considering that it was sometimes hypothesized that social and economic variables, instead of acting directly on fertility, had an effect on some "intermediate" or "intervening" variables, which in turn influenced fertility, it would be interesting to study the response of such intermediate variables to social and economic change, as well as their influence on fertility. Group norms and values were mentioned as possible intermediate variables that needed further study, not only in terms of descriptions but also for the factors influencing their formation and change.

At the societal level it might be useful to study to what extent fertility changes could be explained simply by shifts in the relative sizes of different behavioural aggregates over a period of time. The aggregates chosen might be (*a*) social sectors, (*b*) occupational, (*c*) educational, (*d*) location (rural/urban, etc.), (*e*) income, (*f*) wealth, or (*g*) other socio-economic. The migration forces and changing socio-economic levels and structures over a period of time would frequently lead to fertility changes, and it would be desirable to measure the impact of changes in group membership.

In the analysis of aggregate data, especially over a period of time, explicit account should be taken of changes in the relative distribution of the various socio-economic groups. It would be desirable to include the changes in the relative size of the groups as part of the analysis, especially if such distribution in itself was responsive to social and economic change.

In order to obtain reliable aggregate variables for communities, household data must be used. In the nationwide sample surveys, however, respondents in the small communities were generally few in number. Therefore, reliable community-level factors could not be obtained from those individuals. One recommendation was that the problem should be solved during the sampling design. Keeping in mind a viable individual-community-type analysis, an optimal balance could be achieved between the number of small communities and the number of respondents within each community.

Some researchers should devote their time to exploratory studies (case studies of a small number of communities) in order to throw more light on the relationship between community variables and fertility. Because of the complex interdisciplinary nature of the problem, group effort should be encouraged. For example, it was particularly important that, when standard concepts are used, corresponding variables should be chosen. Experts from the appropriate disciplines should be consulted regarding the design of the studies.

Families and households

Much of the effect that children and adults had upon one another occurred in household activity or in various forms of support or non-market exchange. It had been suggested that such activities were associated with the value of children to the individual parent and might influence their fertility behaviour. A more detailed look at the value of children was therefore needed. The allocation of intrahousehold activities and their nature were closely related to the type of market and non-market activities of men and women outside the household and particularly to the role and status of women. Thus, it was important to study the process of and trends in family building patterns for different socio-economic and cultural groups. Time allocation, intrafamily transfers, decision-making within the household in relation to activities and opportunities at different stages of the life cycle and for different social groups, and in different community settings outside the family or the household, were promising areas of research, and there was good reason to believe that diverse reactions would be formed to different types of economic and social change. Both theoretical and methodological work would be required, as well as a more detailed measurement of economic and social variables. For example more attention should be given to the measurement of prices and cost of children, which often changed with income and required sophisticated instruments of measurement.

Marriage in its broadest sense, family formation, and family structure, although obviously basic building blocks in the life-cycle aspects of individuals and families, had not been studied systematically with fertility as an independent or intermediate variable in a behavioural framework. The economic and social determinants of family formation and marriage patterns, including female age at marriage, should be encouraged both on the conceptual and the empirical levels.

In view of the central role of the concept of reproductive intentions in virtually all socio-economic theories of fertility, and in view of the extensive efforts to collect pertinent data on the subject, as for example in the many World Fertility Surveys, it was recommended that the subject should receive intensive attention both with respect to conceptual and measurement questions.

Special attention should be given to changes that deviated from the norm, or from a pre-determined distribution: (*a*) postponement of age of marriage, (*b*) abortion, (*c*) sterilization, and (*d*) determination of family size. One could try to investigate a sub-group whose behaviour appeared to depart from certain norms and attempt to determine whether the actions involved resulted from economic pressures, and to what extent such pressures were generated by the processes of economic development. That is, the "strong reactors" should be examined intensively in the hope of learning something about the circumstances of and motivation behind "strong reactions", and to see whether they suggested any socio-economic change syndromes.

Collection and utilization of data

Recognizing the fact that many of the developing countries had in the past spent a good deal of time and resources in collecting a considerable amount of social, economic and demographic data, the Group recommended that researchers should be encouraged to use the data already available for more detailed in-depth analysis in order to understand the complex pattern of relationship between socio-economic development and fertility change. The Group also recommended that the WFS should include as a priority item for the second stage analysis, and should indeed support, analytical projects designed to provide a better understanding of the impact of socio-economic factors on fertility, particularly in those developing countries that had entered the second stage of demographic transition and were experiencing a decline in their fertility. The plans for such analysis should necessarily include utilization of the data from the WFS modules on community level variables and economic variables in countries where they had been canvassed.

Countries that were intending to participate in the World Fertility Survey, but whose plans were not yet final, were urged to make use of the community module and the economic module. They, and the other countries planning fertility surveys, should consider linking those surveys as closely as possible to other household socio-economic surveys (e.g. of income and expenditure, or of the labour force), preferably by reinterviewing the same households. That practice would greatly enrich the scope of feasible analysis on determinants of the demand for schooling and of labour force participation as well as of fertility, which must be considered in order to be determined jointly at the household level.

Without collecting new data, the WFS, and possibly other demographic surveys, could in some cases be analyzed in a slightly different framework. The available information would be completed by "macro" information from various sources, including the WFS community level module. This should be possible where the WFS has used the census frame. Samples would be restructured by community and also between countries. The results of the analysis would show the changes affecting the variables included in WFS, such as labour force participation and education as well as fertility, for various levels of socio-economic structures and development.

Countries that did not yet have a programme of regular household surveys should consider establishing one, both as a means of monitoring the rates of social development and of demographic change, and in order to permit research into the responsiveness of the latter to policy measures and into their interrelationships. Countries that carried out national household surveys were urged to make the data tapes and related documentation available to qualified researchers, in order to perform more in-depth explanatory analysis. The cost of that type of research could be reduced somewhat if researchers were drawn in earlier during the design phase. The benefit of such research in the design of social development and population policies in the country concerned was recognized by the Group.

The census was a primary source of population data. It contained much information on socio-economic characteristics, including data from the housing census that was normally integrated with it. A more effective linkage of such information with fertility change was desirable. A step in that direction would be the use of fertility trend analysis by the characteristics of the household, based on "own-children" methods: the application of checks on the accuracy of reporting of the numbers and ages of children through simple retrospective questions to women about past births, was advocated. Many censuses in relevant countries had already collected the data necessary for the use of such techniques. Their power would be greatly strengthened by the analysis of two successive censuses with similar materials, by which fertility trend measures could be extended in time and made more precise in relation to changes in the socio-economic variables. Those methods were capable of providing time series for area and social aggregates to a high degree of subdivision.

The Group emphasized the advantages of comparative rather than representative sample designs for the study of community variables in countries that already had reasonable basic demographic data. With comparative designs the community sample units could be chosen to give the maximum differentiation in the explanatory variables and thus increase the probability that significant impacts on fertility could be determined.

For a proper understanding of the determination of fertility a variety of detailed data was required on social and economic variables. Most of the available surveys in which fertility was measured in proper detail were deficient in the description of socio-economic variables that could be used for specific analysis. It was not realistic to hope for a one-time survey that would include all the information that was needed, but several approaches could improve the situation.

First, a series of narrowly spaced interviews with the same household would allow the proper measurement of fertility as well as of some socio-economic variables required for specific types of analysis.

Secondly, members of the household other than women in the childbearing ages should be interviewed in order to elicit information on socio-economic variables that were relevant for the study of fertility. Such interviews could include not only the husband but also children (concerning their own activities) and elderly persons.

Thirdly, some aspects of economic activity called for detailed questionnaires (labour force surveys, family expenditure surveys, time budgets etc.). The availability of demographic information in conjunction with those data was of great potential benefit. A group of questions on fertility could sometimes be attached to such surveys. The demographic information that fed the explanation of fertility, was not concerned with fertility alone, however; information on relevant aspects of household structure (which should be easy to get) and surviving children outside the household and relations with them could also be useful when attached to such surveys.

Lastly, given that the proper study of the determination of fertility required a life-cycle framework, special attention should be given to the measurement of socio-economic variables in a way that would make such analysis possible. That should affect the choice of longitudinal instruments in data collection.

Aside from its observations on the role of household activities and intrafamily transactions, discussed elsewhere in this report, the Group noted a number of new theories of fertility determination and related issues that were emerging, raising controversies that could not be resolved without empirical data to test the hypotheses suggested. Such data were still scanty and in some cases totally absent; any research strategy in those areas must be directed towards collecting that sort of information. It should begin with relatively intensive, specialized studies, but aim at developing instruments that would eventually lend themselves to large-scale surveys that could be repeated periodically. Such measurements posed important methodological problems for data collection and it was recommended that those issues be studied.

For most, if not all, of the collection systems that provided the materials for such studies, the data were liable to substantial misreporting. Because of the sensitivity of the complex relations examined, errors and biases in the observations created special problems. Conclusions about the impact of socio-economic variables on fertility had a low degree of credibility unless the accuracy of the data had been verified by external and/or internal cross-checks. Where that was not possible, the effects of uncontrolled errors needed to be considered. If effective checks could be built into a survey, the extra costs were more than justified by the increased reliability of the conclusions. Research was required into the data errors associated with different forms of collection, and the Group urged that advantage should be taken of the opportunities for so doing provided by the WFS.

The Group recommended that the problem of validity, one that plagued much fertility research, should be openly recognized and dealt with. In the measurement of various fertility-related dependent variables, as well as explanatory independent variables, the validity question of what was, in fact, being measured should be given serious consideration. Measurement of education was an example, where questions of validity included whether education was a proxy for other (independent) variables, or whether it was, rather, a distinct variable in its own right and, if so, whether the content or the duration of education was the key variable to be measured.

Methods and techniques

Fertility and its determinants were, it was noted, a complex time-dependent process. Little was known about the dynamic nature of that system, and a refined understanding of the stochastic nature of the multivariate system over a period of time was needed. That in itself was a very complex problem, requiring in some cases the consideration of probabilistic simulation methods such as Monte Carlo or numerical analysis techniques.

In assessing the impact of various factors on fertility, a clear distinction should be drawn between sorting or screening techniques, and hypothesis testing. The former techniques, including factor analysis, principal components analysis, step-wise regression and so on, were useful devices for the preliminary assessment and organization of a large volume of data; they could help to identify possible relationships and improve conceptualization, as well as developing typologies. In particular, techniques of grouping the units of observation according to the values they assumed for a number of multidimensional variables represented useful tools not only as exploratory methods but also as a form of building typologies both on fertility as well as on the explanatory variables. However, such screening techniques should be used in tandem with more formal hypothesis-testing techniques, such as the estimating of pre-defined models, since only the latter could provide the rigour required to assess the validity of any given theory of fertility determination.

Fertility was not determined in isolation, but was one of a number of interaction household activity variables. At the micro level, labour supply, migration and a number of other factors were likely to be determined in conjunction with fertility. At the macro level, interactions were likely to be wider still, particularly interaction with the labour market and income distribution. Interactions between family planning and fertility were likewise difficult to unravel, because the factors promoting the use of family planning were likely to be the same as the ones promoting fertility decline. Those issues implied that fertility determination should not be seen alone, but rather as one element in a wider model of socio-economic change. In consequence, fertility functions should, where possible, be estimated as part of wider recursive or simultaneous models, which also contained other key variables such as labour supply, wages, incomes, employment, migration, family planning, education demand and so on.

The onset of fertility decline was likely to be associated not only with a shift along an existing fertility function, but also with a change in the parameters of that function, suggesting that it would be important to study the cross-sectional determinants of fertility at several successive dates, since that would give some indication of the rate and direction of change. If a sufficiently large number of functions could be estimated (say four or five, spanning 20 years), models of the determination of coefficient

change over a period of time in different regions might be possible. The technique was perfectly general, and could profitably be applied to an international comparative analysis, using World Fertility Surveys in 20 or 30 countries. At the national level, countries where two or three surveys spanned the period in which fertility decline had really commenced would be interesting; adequate data appeared to exist for the Philippines, Turkey, certain states of India, and probably some Latin American countries.

ANNEX

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MEETING OF THE *AD HOC* GROUP OF EXPERTS ON DEMOGRAPHIC PROJECTIONS

United Nations Secretariat *

In view of the recent rapid changes in the demographic situation in both developed and developing countries, particularly with respect to their fertility trends, and the need to exchange expert opinions on techniques of demographic projections to incorporate such changes, the Secretary-General invited an *Ad hoc* Group of Experts on Demographic Projections to discuss, *inter alia* improvement of methods and assumptions of demographic projections in the work of the United Nations Secretariat, particularly with regard to a revision of the world population projections to be prepared in 1978.

The Group consisted of the following experts: Mr. Jean Bourgeois-Pichat (France), Mr. William Brass (United Kingdom), Mr. Ansley J. Coale (United States of America), Mr. Abdelmegid M. Farrag (Egypt), Mr. Nathan Keyfitz (United States of America), Mr. Ronald Lee (United States of America), Mr. Miloš Macura (Yugoslavia), Mr. Jacob S. Siegel (United States of America), Mr. Jorge Somoza (Argentina), Mr. K. S. Srikantan (India), Mrs. Hilde Wander (Federal Republic of Germany), Mr. Charles Westoff (United States of America), and Mr. K. C. Zachariah (India). The Group elected Mr. William Brass as Chairman, Mr. Abdelmegid M. Farrag as Vice-Chairman, and Mr. Jacob S. Siegel as Rapporteur.

The Group met at United Nations Headquarters in New York from 7 to 11 November 1977. The discussions were confined to population projections by sex and age and their components. They thus excluded specific topics of the disaggregated population projections covering the urban and rural population, the agricultural and non-agricultural population, the economically active population, population in educational categories, households and families, and other subnational populations. The Group also decided that, since time was short, it would not include in its agenda issues relating to the evaluation and estimation of demographic indicators from incomplete and defective data. The latter subject, which is closely related to work on population projections, would need a separate meeting in order to discuss adequately the important advances made therein during the last decade. The discussions thus concentrated on the following five areas:

(*a*) Review of the state of the art of demographic projections;

(*b*) Improvement of the assumptions of demographic projections with regard to:
  (i) Fertility;
  (ii) Mortality;
  (iii) Migration;

(*c*) Population policies and the development of projection assumptions;

(*d*) Consideration of socio-economic factors in demographic projections; and

(*e*) Alternatives for long-range population projections.

The detailed proceedings of the meeting will be published separately. The main purpose here is to present to readers of the *Bulletin* the recommendations made at the meeting.

General considerations

Members of the Group were unanimous in concluding that United Nations population projections were an extremely important and irreplaceable tool for demographic and economic analyses at the global, regional, and national levels. There were at least four reasons for this.

First, projections were included for every country and territory of the world; secondly the projections were internationally comparable; thirdly, more than two thirds of the countries concerned, accounting for about three quarters of the world's population, had never prepared official projections of their own, and the United Nations had been filling the gap; and fourthly, the methods, assumptions and basic demographic parameters of the projections were presented uniformly. The Group strongly recommended, therefore, that activities currently being undertaken by the United Nations in the field of demographic projections should not only be continued but should also be strengthened. The estimation of basic demographic parameters from incomplete data was an essential part of that work.

The Group also felt that population projections should be updated at least once every five years and that an interim report should be published whenever population trends and the projections became perceptibly inconsistent. Efforts should be made by the Secretariat to update the projections more frequently in order to keep up with the rapidly changing demographic situation in the world. At the same time, the Group felt it desirable for the Secretariat to maintain a programme of continuous updating of the bench-mark estimates of basic demographic parameters for use in the revision of the projections when required. Furthermore, to assure that the interim revisions received as wide a circulation as the principal publication, they should be made available in a regular publication series.

* Population Division of the Department of International Economic and Social Affairs.

The Group considered it desirable that the results should be published more promptly than in the past. However, in view of the fact that projections became somewhat outdated even during the period between their calculation and their publication, it would be desirable to include in the report some guides by which users could adjust projections to take account of the latest data. The development of such guides (for example in the form of nomograms) would enable the user to incorporate readily in the projections alternative assumptions or new information, particularly so as to allow for the deviation of actual from projected trends as they occurred.

It was agreed *ab initio* that the Group would deal only incidentally with issues relating to the evaluation and estimation of basic demographic parameters from defective data, since that was a major area for deliberation in itself. (In fact, much of the work of the Secretariat in the field of projections has actually been concerned with the evaluation and estimation of past and present demographic parameters rather than with projections.) However, since the majority of the developing countries lacked adequate current data on which to base population projections and since improvement of the base data on trends was a most important issue in improving projections, the Group recommended that more effort should be directed to that area. Current data on demographic trends could be improved in many ways, for example by undertaking more frequent (possibly quinquennial) censuses and demographic surveys. The more intensive exploitation of existing data in both developing and developed countries, particularly through the use of the newer methods of analysing trends, was one of the more effective means of strengthening the capacity for improving projections.

The Group called attention to the need to exploit and improve existing data on the interrelationships between socio-economic variables and demographic processes. More research on the relationship between socio-economic variables and demographic changes was greatly needed. Such information and the results of such research would be of considerable value in making assumptions regarding future population changes and in interpreting the resulting population projections.

In view of the fact that the terminal year of the previous population projections, namely 2000, was only 23 years away and many types of planning required at least rough indications of probable population growth for a longer period, the new round of population projections should be extended to 2025, representing a projection period of about 50 years beyond the proposed new base date. Although the figures for the total population would become subject to relatively large errors after only a few decades, the figures for the age cohorts born before the base date might be quite accurate for several decades. Even though the projections would extend to the year 2025, it was believed by some experts that the next 10 or 15 years should be given special attention, since that period was crucially important for planning and other purposes.

Most members of the Group felt that three principal variants should continue to be prepared. A quite extensive discussion was held with respect to the necessity of providing a range of uncertainty for the projections. Although it would be desirable for the "high" and "low" variants to be equal to a range of probabilistic errors, say within one or two standard deviation units, there was as yet neither the methodological nor the empirical basis for such an exercise. The Group recommended, however, that the United Nations Secretariat should draw the attention of users to the problems of uncertainty in the use of the projections.

The United Nations Secretariat should review and evaluate its past experience in making population projections and should incorporate its findings in summary form in any publication presenting new projections. One practical and simple approach to that task was to take only the medium projections made by the United Nations (but for all countries and past years) and compare them with the "actual" figures. Another approach was to tabulate the frequency with which the current figures fell within the high-low range of past United Nations projections. (The analyst should be aware of the possibility of a built-in bias resulting from the fact that some current estimates might have been designed to agree with earlier projections or with desirable trends.) In carrying out such a study, insofar as possible separate attention should be given to the components of change, sex-age groups, and the length of the projection period. The causes of significant deviations of the projections from the observed situation should be carefully documented. The systematic evaluation of projections had been neglected and more work should be done in that field.

The Group endorsed the use of the general system of projections methodology currently being employed by the United Nations Secretariat. Specifically, the existing component method of producing projections of population and its sex-age distribution should be reapplied for the next round of population projections.

Demographic trends in the recent past were an important guide to changes in the near future and thus should be given considerable weight in making projections in the short term, as had been done in the previous set of United Nations projections. The interpretation of the nature and probable continuation of those trends must be made in the context of the consideration of socio-economic trends and policy developments.

In designing the assumtions of future population changes, the role of socio-economic factors (e.g. urbanization and socio-economic group differentials) and of intermediate variables (e.g. marriage and family planning practices), as reflected in the findings of the microsimulation model (to be discussed below), should be taken into account. In that connexion, the results of the World Fertility Survey should prove particularly valuable and should also be taken fully into account.

The contents of the United Nations publication presenting the population projections should be extended to include additional (i.e. five-year) sex-age detail beyond that shown in the previous report. [1] Although such sex-age detail had been made available in special working papers and in the form of a computer tape, most users could not gain access to the materials very readily and

[1] *World Population Prospects as Assessed in 1973* (United Nations publication, Sales No. E.76.XIII.4 and corrigenda).

they would be better served if five-year age detail, at least for selected years, were incorporated directly in the main publication. Moreover, it would be desirable to include figures for single ages in some age ranges, particularly in the earlier years of the projection period.

Improving assumptions of projections

Mortality

Alternative series of mortality projections should be employed both for the developed and the developing countries. It was noted that in some developed countries there had recently been substantial reductions in mortality in later life, and that continuing and even accelerating reductions were possible; at the same time the rates of decrease in mortality in many developing countries were less than expected earlier. With the decline of fertility in some areas and its stabilization at a low level in others, mortality changes would tend to have a greater effect on tha age distribution of populations than in the past. Nevertheless, it would not be desirable to include, in the principal set of projections, series of projections based on every combination of fertility and mortality assumptions developed for the study.

Constant changes in life expectancy at birth over time were not necessarily a satisfactory way of formulating an assumption of future changes in mortality. The United Nations Secretariat should take into account the empirical evidence that increases in life expectancy tended to fall as life expectancy rose. In generating its projections of mortality and setting ultimate levels of total mortality and male-female differences, the Secretariat should take careful account of the document on the future outlook for mortality decline in the world submitted to the Meeting by Jean Bourgeois-Pichat. [2]

The Group agreed that cause-of-death analysis was one of the essential approaches to improving the formulation of mortality assumptions and interpretative evaluation of the projections for the developed countries, and it should be applied in determining the long-term improvement expected in mortality where appropriate data of good quality were available and made such an approach feasible. Cause-of-death analysis could be valuable in setting targets of ultimate values beyond those achieved by any country, but it could also be useful in charting the prospective trajectory towards any set of ultimate values.

For developing countries, mortality data were generally so weak that primary attention would have to be given to that area. For those countries, ascertaining the current level of mortality and the trends of recent mortality presented extremely difficult problems. The limited cause-of-death data that were available were not commonly useable for projections purposes. Where information on mortality was not available, one solution was to make use of supplementary information on health services.

Fertility

The Secretariat should follow the same general procedure as the one previously used to project fertility but should give attention to achieving greater standardization of those procedures than before.

Because the current period was one of particular uncertainty in the demographic situation of developing countries, the Secretariat should carefully consider whether the range between the high and low assumptions of fertility might not be widened.

It was recognized that quite different approaches might have to be followed in formulating assumptions of fertility for the developed countries on the one hand, and some of the developing countries on the other. In the case of some of the developed countries, the continuation of fertility at below-replacement level for a considerable period of time was a real possibility. Therefore, approaches other than the simple hypothesis of monotonic progress towards fertility stabilization at the replacement level should be applied. In the developing countries, identifying the time of onset of fertility decline could be improved through a better estimation of current demographic trends, including the development of better techniques and the collection of better data. The Group agreed that many elaborate hypotheses devised in the developed countries could not be usefully applied to the developing countries.

Given adequate data and a cultural setting where marriage was defined unambiguously, some experts felt that the introduction of marriage and marital status as parameters and the use of marital fertility rates in the derivation of fertility estimates would provide a more realistic framework for the projection results and enhance their interpretative value. The Group agreed that marriage factors could be incorporated for countries that had adequate data. It was noted that, because of the growing focus of attention on the status of women, changes in their composition according to marital status might become more important than in the past in influencing the level of and changes in fertility.

Taking cognizance of the fact that some countries were important in the scheme of United Nations projections because of the sheer size of their populations and of their contribution to world population growth and because they present special estimation problems as a result of their size and heterogeneity (e.g. India), the Group felt that it would be useful if variations in fertility among subnational areas in those countries, such as urban-rural areas and major subregions, could be studied more fully where relevant data were available. The results of such studies could then be taken into account in developing projections of fertility for the subnational areas and the countries where improvement in projections from that source seemed likely.

The Group was of the opinion that the Secretariat should not undertake elaborate and time-consuming studies designed to apply the cohort-fertility method of projecting fertility, except, perhaps, for a limited number of countries where the patterns of reproductive behaviour as well as of marriage and divorce tended to change radically and where satisfactory data existed.

[2] Reproduced in the present *Bulletin* (see p. 12 above).

Migration

International migration was actually or potentially an important component of population change and its possible contribution to population change should be considered for each country.

International migration was, perhaps, the most neglected area in projections studies as well as in analytical research on national population change, and the Group strongly recommended that more effort should be made to develop adequate data of that kind. Data could be secured through censuses and surveys for both the receiving and sending countries, registration data for both the receiving and sending countries, and estimation on the basis of consecutive censuses. The possibility of introducing appropriate new questions in forthcoming censuses should be considered.

Because of the variety of patterns of migration, the situation in each country must be considered separately. Where possible, net migration should be disaggregated into immigration and emigration, particularly when the relative size of such directional movements was expected to shift in the future. Age-sex patterns could also vary widely, even with similar levels of gross or net migration for the total of all ages. The impact of the age-sex pattern of migration could be more or less important, depending on the volume of migration in relation to the size of the population and the level of the growth rate of the population.

At the same time it might be possible to identify typical flows and patterns of migration on the basis of data from the developed countries and to evaluate that material in the light of current and prospective social and economic developments. The outcome of such analyses could be applied to other areas as appropriate.

Consideration of socio-economic and policy factors: models and long-range projections

Although the importance of socio-economic factors in determining population growth and its components, fertility, mortality and migration was well-established, the Group felt that the time was not yet ripe for making efforts to incorporate those factors into projections in a formal way, particularly for the developing countries. A thorough study of the relation of socio-economic factors to population growth was needed in order to improve judgements regarding future changes in fertility, mortality, and migration. The Group suggested that some disaggregation of fertility, mortality, and migration might be useful for improving the assumptions, for example by considering urban-rural distribution or other socio-economic variables such as the educational status of population when making projections of fertility.

Some members of the Group expressed concern about the consistency of the disaggregated projections (e.g. urban-rural population) with the projections of total population and about the failure to employ the urban-rural projections or other disaggregated projections in a feedback model to improve the projections of total population. The projections of total population in sex-age groups prepared by the United Nations Secretariat were the basis for projections of urban-rural population and for other types of disaggregated projections. So far, however, no attempt had been made to employ the urban-rural projections to develop projections of the total population or to consider the implications of the projections of the urban-rural population for the projections of total population. Some experts recommended that research should be carried out along those lines in order to improve techniques for projecting the total population.

The Group recommended that the United Nations Secretariat should attempt to identify promising models for use in population projections in the context of social change and economic development. It was agreed that the microsimulation model of fertility developed by the United Nations Secretariat [3] was useful for that purpose and recommended that further efforts should be expended to refine the model. Such additional aspects of fertility analysis as the interaction between the demographic and biological factors already included in the model should be considered. It was also suggested that the model should be tried out for several developing countries with appropriate data, perhaps data from the World Fertility Survey. Specifically, it was suggested that the microsimulation model should be expanded and disaggregated as far as possible using information from the World Fertility Survey. The Group strongly recommended that further experimentation be conducted with the model, using additional data and countries.

The microsimulation model of the United Nations had been designed particularly for policy-making purposes, if one assumed that the policy was successful. Conversely, the model could be especially useful for dealing with policy packages consisting of multi-compositional parts or for evaluating comparative effectiveness of different policy packages or options assuming that policy goals can be turned into policy effects. A question arose whether the model should be used only in connexion with countries with explicit family planning policies or whether it should be extended to others without explicit policies. Some experts recommended that, after some modification, including possibly an elimination of some segments, the computer program should be applied more extensively to those developing countries with good data and with sufficiently elaborated national population policies and family planning programmes.

While recognizing that population projections were of major interest to users, the Group also examined alternative sets of circumstances that could either provide a frame for the study of changing demographic interrelationships and their effects on the size and composition of the population, or be used for projecting the socio-economic characteristics of populations reflecting different patterns of social and economic development.

Models designed to simulate hypothetical changes in the components of population growth should be used for further exploration of conditions leading to a stationary population, paying special attention to the effects of changing nuptiality, alternative family patterns and

[3] Reproduced in *Population Bulletin of the United Nations, No. 10* (United Nations publication, Sales No. E.78.XIII.6).

changes in other factors conductive to low fertility. Several varieties of assumptions should be formulated in addition to the fertility stabilization model, including highly speculative assumptions for analytical purposes relating to mortality and migration as well as fertility. For example, the effect of eliminating certain endogenous diseases or of extending life expectancy well beyond the limits experienced by any country to date should be evaluated, and the effects of hypothetical migration patterns on the size and structure of receiving and sending populations should be studied.

The specialized or disaggregated population projections prepared by the United Nations and specialized agencies were mentioned as being among the immediate uses of population projections by sex and age, although the Group from the beginning expressed its intention not to hold an extensive discussion on the subject. The Group noted with satisfaction that a comprehensive set of demographic projections, consisting of six major types of projections, had been developed by the United Nations and its specialized agencies. The projections were for the population classified by sex and age groups, the economically active population (labour force supply), the agricultural and non-agricultural population, the urban and rural population, the population in educational categories (school enrolment), and households and families. Those projections were consistent with respect to the choice of sex-age groups, geographical coverage and dates of reference. Most of the projections had been derived by using sex-age specific "participation" ratios, such as labour force participation rates or headship rates, applied to the population projections distributed in sex-age groups; they were therefore consistent with one another in a limited way.

The system of six projections provided a wealth of information for the study of the socio-economic characteristics of populations and the changes in the socio-economic factors affecting population changes. Recognizing that the system was highly exogenous, the Group felt that it could be improved and, with improvement, could serve a variety of analytic purposes better. It was therefore recommended that:

(*a*) The consistency of the assumptions embodied in the sex-age specific ratios should be studied with a view to improving the consistency of the systems as a whole;

(*b*) Efforts should be made to disaggregate further the critical sex-age ratios describing the specific characteristics of the population;

(*c*) The interaction (feedback effects) of the changes in socio-economic characteristics of the population and the changes in mortality and fertility should be studied and the need for an adjustment of the assumptions to achieve consistency in the whole system should be considered.

The Group recommended that the United Nations Secretariat should study the population changes that were expected to take place as a result of the gradual establishment of the New International Economic Order, as postulated by Leontieff.[4] It was felt that the Leontieff study provided an economic framework within which the possible changes in population, labour force, employment, education etc., could be projected. At least the six types of demographic projections listed earlier, supplemented by the projections of labour force demand, should be experimented with in that manner. The object of the study should be to assess the implications of the New International Economic Order in such areas as fertility, mortality, population growth, family patterns, employment, education and the like, and thus provide needed insight into the linkages between population and socio-economic development.

The labour force supply under conditions of declining fertility deserved further study. The focus should be placed on the economic and social conditions (including the demand for labour) that, in combination with the changing age structure, determined the pattern of labour force participation ratios. The Group felt that the Leontieff study provided a useful economic framework for that purpose and recommended that new projections combining both demographic and socio-economic factors should be developed.

Further review of the research programme

It was recommended that the Secretary-General should convene another meeting of experts when appropriate, possibly during the biennium 1980-1981 with a view to reviewing and assessing the progress of work undertaken in the field of demographic projections and to improving the methods and assumptions employed. The agenda of the next meeting should also include methods of estimating basic parameters from defective data.

[4] Wassily Leontieff and others, *The Future of the World Economy; A United Nations Study* (New York, Oxford University Press, 1977).

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