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WORLD POPULATION PROJECTIONS: A CONCISE HISTORY

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Abstract

The application of social and demographic theories, of demographic methods, and the utilization of data for global population projections are discussed in this paper. Early global projections, from King in 1695 to Pearl in the 1920s, projected total populations, whereas in modern projections fertility and mortality are considered separately. Notestein in 1945 was the first to apply a theory incorporating social and economic conditions of population growth. His global projection was an aggregation of separate analyses for parts of the world. This approach has been maintained by the United Nations in consecutive rounds of projections since 1951. During the 1960s Boyarsky and later Bogue prepared projections using different theoretical frameworks. In 1973 Frejka explored demographic trends needed to reach a stationary population. Most projections of the late 1970s were updated versions of earlier ones without major methodological improvements. Demography has reached a state when useful information in the form of likely ranges of future global population trends can be provided, but it is argued that whatever theoretical and methodological innovations might be in store, accurate single-path predictions will not be possible.

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"But if the World should continue to
A^o Mundi 20'000 (A.D. 16,052) it might
then have 6'500 million . . ."

Gregory King 1695

The year 1982 marks the 300th anniversary of the publication of an essay containing the first trace of a global population projection. Between then and the middle of the twentieth century, global projections consisted of extrapolations of total population numbers, the growth rates being established by the author's perception of past trends and of conditions that shape population growth. The second half of the twentieth century has witnessed the evolution of global component projections. Component in two senses: demographic components--fertility, mortality and age structure--and countries and regions as components with diverse types of population growth that are aggregated into global projections. The development of these projections has been closely linked to progress in the sciences, natural and social, to refinements of demographic methods, and to improvements in the availability of population data around the world. This paper will present a brief overview of the history of world population projections. In a closing section some speculations are offered about the general logic and significance of this human endeavor (Table 1 presents an overview of global projections).

I. The Earliest Global Projections

The first projections of the world population that were relatively elaborate and clearly articulated ranged further into the future than any other projections computed since. The author, Gregory King (1648-1712), worked meticulously within the tradition of the "art of political arithmetick" estab-

		<u>NRR=1.0 in:</u>									
Frejka	1973	2040		4030	4460	6670	10125	13025	14661	15102	
		2020		4022	4436	6422	8822	10473	11085	11169	
		2000	3645(B)	4007	4387	5923	7375	8172	8357	8389	
		1980		3953	4213	5116	5964	6286	6400	6417	
		1970		3772	3933	4746	5368	5592	5675	5691	
United Nations	1973	High		3981	4414	6638					
		Medium	3610(B)	3968	4374	6254					
		Low		3949	4316	5840					
United Nations	1974	High						15831			
		Medium	3621(B)	3988	4401	6406	9065	11163	12210	12257	
		Low						9462			
Littman-Keyfitz	1977			3968(B)	4350	5882	7353	8188	8436		
United Nations	1978	High			4436	6509		12076		14180	
		Medium	4033(B)	4415	6199	8354	9775	10495	10525		
		Low		4394	5856		8004	8029			
World Bank	1978			4033(B)		6054					
Sogue-Tsui	1979	High				5972					
		Medium	(B)			5883	7400	8107			
		Low				5756		7816			
U.S. Bureau of the Census	1979	High		4134	4548	6797					
		Medium		4090	4470	6350					
		Low		4043(B)	4384	5921					
World Bank	1990				4416(B)	6015				9868 (stationary)	
United Nations	1980	High			4443	6340	9140				
		Medium	4067(B)	4434	6121	8199					
		Low		4422	5838	7171					
		<u>NRR=1.0 in:</u>									
Frejka-Mauldin	1980	2040				6357	9264	11648	13039	13427	
		2020				4412(B)	8407	9902	10527	10639	
		2000					5930	7386	8214	8477	8539
		1980					5333	6323	6743	6942	6986
Actual population ⁺			2513	3027	3677	4033	4415				

*B stands for "base year of projection."

⁺According to UN, footnote 21.

Sources: See footnotes.

lished by Sir William Petty (1623-1687) who stressed the need to measure societal events and change. King had clearly been influenced by Petty's ideas, particularly in the field of population,¹ but he did not adopt Petty's findings and conjectures blindly. Petty adopted an estimate of 320 million for the world population, but King considered that figure much too small. King's own estimates of the contemporary size of the world population were almost all of the order of 600 to 700 million.² The data base available to King was very thin--he used estimates of land area of continents and of climatic zones, and estimates of population density in the various countries ["That There is no Country in the World besides Holland and China so populous as to have but 4 Acres per head" (p. 165)]--but his estimates of the total world population of the late seventeenth century (although not its distribution) were as good as any made since.

Unfortunately, King's notions of the mechanics of population change were rather farfetched and consequently his projections failed to give even a rough indication of possible future developments. In addition to his own estimate of the world population for the year A.D. 1695, the building blocks of King's calculations were derived from the Bible. King noted the population data given in the Bible and this led him to believe that population doubled at successively longer intervals. King constructed several schemes of "Computation(s) of the Number of People in the World from the Flood to the present times, and thence for the time to come . . ." (p. 3). King's projection of the world population for the year 1980 was about 750 million people. As it happens, these projections were not published until 1973; thus they were probably seen only by archivists, and, more importantly, they appear not to have elicited any scholarly debate or critical commentary.

Both Petty and King were also concerned with the carrying capacity of the world and inquired as to the timing of when a population matching that capacity might be achieved. Petty opined that "the present 320 Millions . . . will within the next 2000 years . . . increase . . . to give one Head for every two Acres of Land in the Habitable part of the Earth" (p. 19) and will then "exceed . . . Twenty Thousand Millions" (p. 42). King computed that "if fully Peopled . . . (the World) . . . would sustain 6257'000,000 which is Ten times the number of People now in being, and it is not possible to maintain more than double that Number or 20 times more than the number of People now in being" (638 million). "And if it were possible to sustain 20 times the number of People now in being, it could not encrease to that number till about the year of Christ 10'000, which is above 8000 years to come" (p. 2).

Despite continuing debates among social scientists on the nature of population growth, particularly since the end of the eighteenth century, there appears not to have been a single subsequent attempt to project the global population until the 1920s. It was in the 1920s that the theme of the world's carrying capacity was again picked up as a dominant, and at times the sole, stimulus for concern about future population change. In 1924 Edward M. East,³ a plant geneticist turned social scientist, claimed to "have made a rather extended study" and concluded "that a reasonable maximum for the world's future population is one person for each 2.5 acres on 40 percent of the land area of the globe. This gives a figure of 5,200 millions, a population which at the present rate of increase would be reached in just a little over a century" (p. 69). East's estimate of the rate of global population growth (doubling in about 60 years) was taken from a noted demographer of the early twentieth century, George H. Knibbs.

Knibbs⁴ in 1928 summarized his views on future population growth:

It is when we realise how extraordinarily slow Man's average rate of numerical increase has been in the past, that we grasp the true significance of his rate of increase during the last century and during the century on which we have entered. For the latter rate would have given the world its existing population in about 2000 years. With such a fact in view, and remembering that we start now with, say, 1950 millions, we cannot escape seeing that the world's future is ominous. Thus suppose that the rate of increase was, as mentioned, about 0.864 per cent. It would double its population every 80.54 years, and thus we should have, were such increase possible, the following astonishing figures for the earth's population, at the date-years indicated, viz.:-

Date-years	1928	2008	2089	2169	2250	2330
Millions -	1950	3900	7800	15,600*	31,200*	62,400*

It will be shown later that the figures marked with asterisks are not possible populations for this earth; . . ." (p. 12).

The crux of the Knibbs and East global population projections was an application of the current estimated growth rate to the estimated size of the world population. This is much the same method as applied over two centuries earlier by Petty and King.

Research by Raymond Pearl in the 1920s and 1930s led him to believe that there is a law according to which growth of populations (not only human) takes place, that this law is in principle shaped by biological forces, and that it can be expressed mathematically in various forms of the stretched out S-shaped logistic curve. Future population growth can be predicted by extrapolation as long as actual or potential resources for growth remain unchanged. If and when growth conditions change the population enters a new curve and the projections need to be revised.

In addition to fitting numerous national populations to curves, Pearl⁵ in 1924 calculated the growth curve for the world population, which he and S. Gould⁶ later revised upward. These growth curves projected, respect

ively, a world population of over 2 billion to be reached after 2050, and over 2.6 billion to be approached in the year 2100. According to Pearl and Gould "(T)he case demonstrates with great clarity the necessity for frequent revision of human population logistics as new data become available, a point upon which one of us has always insisted from his first work with these curves" (p. 409). Pearl's effort was directed at providing an understanding of the general mechanism of population change, but in reality his projection method -- like that of Knibbs -- was still very similar to the method used by King: extrapolation of total population based on past trends.

II. The Emergence of Modern Global Projections

Modern projections of the world population reflect a more sophisticated understanding of the dynamics of world population growth. They are made possible by the continuing advancement of demographic knowledge, and are characterized by (1) aggregation of independent national or regional projections; and (2) the application of component computations (age structure, fertility, and mortality). Global projections of this sort require an explicit theoretical framework, relevant statistical data, and appropriate computational methods.

These prerequisites to modern projections were evolving at a time when the need for worldwide projections was identified by the League of Nations. In January 1939 the Council of the League of Nations "appointed a committee to study demographic problems in their economic, financial and social setting, and to submit a report on the subject which might be of practical value to governments in the determination of their policies" (Notestein 1944, p. 3).

The outbreak of World War II disrupted research activities that had barely begun; however, they were soon revived, in 1941, when the League of Nations requested the Office of Population Research of Princeton University to undertake an extensive program of analysis of world population trends and problems. The first volume of an intended series⁷ was published early in 1944.

Although this study does not contain global population projections in the strict sense of the term, it contains theoretical, empirical, and methodological ingredients deemed indispensable to such projections. And, indeed, the basic approach and results of The Future Population of Europe and the Soviet Union were apparently utilized by Frank Notestein to prepare what could be labeled as the embryo of modern global projections. In 1945 in "Population - the long view,"⁸ Notestein reviews past population trends of countries and continents; he succinctly discusses his understanding of the mechanisms of population change, distinguishing three main demographic types of populations corresponding to different stages of the "demographic evolution" -- "incipient decline," "transitional growth," and "high growth potential" (p. 41); and finally, he discusses prospects for growth and provides estimates separately by continent from which he concludes that "(S)umming the hypothetical figures for the year 2000, we have a world total of 3.3 billion people. On the assumption of general order and the spread of modern techniques of production the figure is probably conservative" (p. 57). The actual size of the world population in the year 2000 will--barring catastrophe--certainly be much larger than the then-projected 3.3 billion; but the ideas, approach, and methods Notestein applied provided a valuable base for a generation of world projections to follow.

In 1950 Notestein again discussed the mechanisms shaping population growth and described expected population growth trends throughout the remainder of the twentieth century. In doing so Notestein stressed the point "that the size of the population by the end of the century is much less important than the process by which the population of that date is reached" (p. 335).⁹

III. Modern Global Projections

Almost all global population projections since the early 1950s have not been extrapolations of total population numbers, but rather, relatively complex operations involving, in varying modifications, the following features and steps:

- a theoretical framework of the mechanism of population change, which guides the formulation of assumptions about future changes in demographic trends;
- a wealth of accumulated demographic information, which serves as the empirical base for the framework and makes possible a disaggregated approach;
- separate assessment and projection of national and/or regional populations, which, when aggregated, yield global projections or which provide a check on separately computed global projections; and
- separate assessment of an initial age structure and separate projection of the two motor forces of demographic dynamics in a closed population: mortality and fertility. Combination of these elements yields the so-called "component" projection of a population.

While the above properties have characterized global projections since the early 1950s, a continuous evolution is taking place as will be evident from the review of various global projections over the past 30 years.

1. The First Generation of UN Global Projections: The Refinement of Methods and Data

During the 1950s and the early 1960s the sole producer of world population projections was the Population Division of the United Nations. During this period, four successive sets of projections were prepared in 1951, 1954, 1957, and 1963.

In the United Nations 1951¹⁰ projections, the demographic situation in the late 1940s was assessed for 11 regions of the world which were then assembled into three groups. Group I (North America, Oceania, most of Europe) containing about 20 percent of the world's population had already reached low mortality and fertility. Group II countries (Latin America, Japan, Eastern Europe and Asiatic USSR) had experienced substantial mortality decline and some fertility decline. In Group III (Africa and most of Asia) fertility and mortality were high. The dominant element in the projection exercise was speculation on future fertility and mortality trends in the three groups of countries, based on past demographic trends and on assumptions about economic and social development. The ideas about the societal interrelations generating the assumed demographic trends were an elaboration of Notestein's earlier work. High, medium, and low assumptions of average growth rates for the 1950-1980 period provided a range of hypothetical populations for 1980 (Table 2).

TABLE 2: UNITED NATIONS 1951 POPULATION ESTIMATES AND PROJECTIONS
 COMPARED TO 1978 POPULATION ESTIMATES AND PROJECTIONS

	1951 UN Estimates and Projections					1978 UN Estimates and Projections		
	Estimated 1950 Population (millions)	Projected 1980 Popu- lation (millions)			Projected Average Annual Growth Rate (in percent) 1950-1980	Estimated 1950 Population (millions)	Projected 1980 (millions) Medium Variant	Annual Growth Rate 1950-1980 (in percent)
		"Low"	"Medium"	"High"				
World Total	2406	2976	3277	3636	0.7-1.3	2513	4415	1.9
Group I (Northern America north-west-central and Southern Europe Oceania)	486	548	599	655	0.4-1.0	483	635	0.9
Group II (Latin America Japan Eastern Europe Asiatic USSR)	533	718	809	938	1.0-1.9	536	915	1.8
Group III (Africa Near East south-central Asia remaining Far East)	1387	1710	1869	2043	0.7-1.3	1494	2865	2.2

Source: Footnotes 10 and 21.

The authors anticipated that economic and social development together with "techniques for the reduction of mortality may at some future time lead to a spectacular lowering of the death rate in group III" (p. 5) but "a moderate reduction is the most that can be expected . . . over the next thirty years" (p. 10). The failure to anticipate significant mortality declines in group III countries was the major reason why, in retrospect, the UN 1951 projections for 1980 turned out to be a considerable underestimate.

Authors of the 1954 United Nations projections¹¹ believed that ". . . despite temporary setbacks, it appears that the epoch of accelerating world population growth, which can be traced back for 300 years, has not yet reached its climax" (p. 272). Nevertheless, the medium projection prepared for the period 1950-1980 still turned out to be an underestimate by about one fifth of the actual 1980 population.

A major reason why the 1954 global projections for 1950-1980 were below actual trends was poor statistical information about the contemporary state of large proportions of the populations of Africa and Asia. In particular, the dimensions of mortality decline in Africa and Asia after World War II were greatly underestimated. The authors of the projections believed the population growth rates in the early 1950s to be much lower than they actually were. For the world population the perceived growth rate in the early 1950s was 1.2 percent per year, whereas in reality it was around 1.8 percent per year (Table 3). The assumed changes in the population growth rates for the future (1950-1980) were in the right direction, but the projections were lower than actual trends, chiefly because the exercise started out with growth rates which were lower than the real ones. Note that both in the 1951 and in the 1954 UN projections past and expected fertility and mortality trends were

TABLE 3: UNITED NATIONS 1954 POPULATION ESTIMATES AND PROJECTIONS
 COMPARED TO 1978 POPULATION ESTIMATES AND PROJECTIONS

	Annual Growth Rate in Early 1950s		1954 UN Estimates and Projections					1978 UN Estimates and Projections		
	1954 UN Estimate	1978 UN Estimate	Estimated 1950 Population (millions)	Projected 1980 Popu- lation (millions)			Projected Average Annual Growth Rate (in percent) 1950-1980	Estimated 1978 Population (millions)	Projected 1980 (millions) Medium Variant	Annual Growth Rate 1950-1980 (in percent)
World	1.2	1.8	2454	3295	3628	3990	1.0-1.6	2513	4415	1.9
Africa	1.2	2.2	198	255	289	327	0.8-1.7	219	469	2.5
America	1.8	2.3	330	487	535	577	1.3-1.9	330	615	2.1
Northern	1.4	1.8	168	207	223	240	0.7-1.2	166	247	1.3
Latin	2.2	2.7	162	280	312	337	1.8-2.4	164	368	2.7
Asia (excluding USSR)	1.0	1.9	1320	1816	2011	2227	1.1-1.7	1380	2558	2.1
Europe (including USSR)	1.1	1.1	593	721	776	840	0.7-1.2	572	750	0.9
Oceania	1.4	2.3	13	16	18	19	0.7-1.3	12	23	2.2

Source: Footnotes 11 and 21.

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taken into account, but computations were performed with the population growth rates.

In the next round of UN global projections in 1957,¹² the annual growth rate of the world population in the early 1950s was estimated at 1.6 percent. In these projections considerable use was made of sophisticated demographic methods, both in estimating demographic parameters and in the projection computations. For this occasion the United Nations prepared a set of model life tables,¹³ as well as models of fertility trends.

In the 1957 UN projections, growth trends for the world population were again augmented as a consequence of the assumed fertility and mortality trends. The global population range projected for 1980 was 3.9 to 4.3 billion compared to the earlier projections of 3.3 to 4.0 billion (1954) and 3.0 to 3.6 billion (1951). This was the first UN projection extended to the year 2000, for which time a global population of 4.9 to 6.9 billion was projected. In general it was presumed that the growth rate in the last quarter of the twentieth century would be larger than in the 1950-1975 period. It is of interest to note that for the first time regions were divided into "technologically developed and under-developed" (p. 22).

In the 1963 UN global projections¹⁴ for the first time future fertility and mortality assumptions were specified separately for each region, and, wherever available, country projections made by national or regional institutions outside the UN Population Division were taken into account. Not only was the differentiation of countries as developed and developing maintained, but it was observed that "(N)o other criterion, be it per capita income, urbanization, literacy, industrialization, etc., defines this

dichotomy so sharply as the level of fertility" (p. 3), the dividing point being a gross reproduction rate of 2.

The 1963 projections recorded a further upgrading of the projected trajectories of the world population, but differed relatively little from the 1957 set. As established by hindsight, the actual 1980 population was bracketed by the projected low and high variants, 4.1 and 4.6 billion. For the year 2000 a range of 5.4 to 7.0 billion, somewhat narrower and slightly higher than the 1957 range, was projected.

An "auxiliary" variant assuming constant fertility was calculated because during the 1950s fertility was near constant and significant rises in life expectancy occurred everywhere. This variant was considered "an unrealistic high" (p. 125) and it was to serve as a benchmark for comparison with the other variants.

2. Diverse Theoretical Approaches in the Global Projections of the 1960s

In the mid-1960s two global projections were prepared by authors other than the United Nations, one by A.Y. Boyarsky, the other by Donald J. Bogue. In the theoretical framework providing arguments about the direction of future demographic trends, these projections differed from those of the United Nations and from each other. The data requirements and the computational procedures were considerably less elaborate than those of the United Nations, even more so in Bogue's than in Boyarsky's projections, as far as can be judged from published documents.

In 1965 A.Y. Boyarsky¹⁵ divided the world into 12 areas distinguished by social system and by stage of economic development. He then estimated growth coefficients for the 1960-2000 period for each area assuming that

mortality and fertility trends would be determined by socioeconomic conditions. Future growth was estimated to be smallest in the advanced capitalist countries, somewhat larger in socialist countries, due to more favorable conditions for mortality decline and relatively high fertility, and greatest in the developing countries, due to a considerable potential for mortality decline and a likely slow fertility decline. Boyarsky projected a world population between 4.2 and 5.0 billion for the year 2000, significantly less than projected by the preceding two UN sets of projections.

In 1966 D.J. Bogue¹⁶ based his projections on the general argument that the mechanisms determining fertility in the developing countries would change rapidly. Bogue argued that the majority of people in the developing countries desired small families; that political elites would support fertility control efforts increasingly; that professionals would endorse family planning methods; that these methods would be widely adopted; and that advances in contraceptive technology would occur. In addition, Bogue suggested that further control of mortality would be increasingly difficult. As a result of such developments, wrote Bogue, the rate of population growth will slacken "at such a pace that it will be zero or near zero by the year 2000, so that population growth will not be regarded as a major social problem except in isolated and small 'retarded' areas" (1967, p. 19). The size of the world population in the year 2000 was projected at 4.5 billion; again, as in the Boyarsky projection, significantly less than projected by the United Nations in its 1963 global projections.

While both these projections attracted attention and were discussed in the literature,¹⁷ the authors of the next round of UN projections in 1968¹⁸ were not convinced by Boyarsky's or Bogue's arguments. As in

previous UN projections the objective of the 1968 round was defined as "an attempt to project population changes into the future as accurately as possible with available information to provide basic data on population size and characteristics for future planning" (p. 1), but stressing that "(L)ike all projections, these will require revision as new information becomes available" (p. iii). Contrary to Boyarsky and Bogue, the authors of the 1968 UN projections specified mortality and fertility assumptions in such a way that the projected trajectories of future global population growth were increased further, although the difference between the 1963 and the 1968 projections of the global population to the year 2000 was rather inconsequential: the low-high range of the 1968 projections was between 6.0 and 7.1 billion. It is of interest to note that the "actual" 1980 world population was within one percent of the population projected by the medium variant in 1968 for the year 1980: 4457 million.

While the general approach and the basic features of the 1968 UN global projections were similar to those of the 1963 projections, a number of innovations and modifications were introduced. For instance, developments in estimating techniques and increased data availability improved the estimates of demographic measures in many developing countries; age-specific fertility rates were used universally, as well as models of changing age patterns of fertility by level of fertility; and the computation of the projections was greatly facilitated through the use of electronic computers.

3. Recent Global Projections

In the early 1970s another set of global projections was prepared outside the United Nations system, this time by T. Frejka.¹⁹ An approach that differed from previous projections was devised in order to explore certain issues of future population dynamics not covered by standard projections.

Whereas previous projections aimed at "an assessment of plausible prospects" (UN 1963, p. iii), Frejka's projections also contained calculations illustrating the population growth consequences of implausible, mainly low and high, fertility trends. Further, a set of general rules about assumed alternative fertility trends was defined, which could be applied to all populations, namely, that fertility would change from its present level to the replacement level at specified future dates and that it would remain constant thereafter. Given the nature of the approach, it was necessary to project populations further into the future than had been customary in other modern projections. This approach also made possible the exploration of issues that had not been raised earlier, such as: What kind of demographic trends would be needed to reach a stationary population at a particular future date? What would be the long-term population growth implications of particular fertility trends? How large would the eventually stabilized population be, given particular fertility (and mortality) trends? How long are the necessary time periods to arrive at a particular stationary population? How large is the population growth momentum inherent in present demographic features (vital measures and age structure) and as shaped by possible future trends? Last but not least, these projections, by illustrating both plausible and implausible future population growth alternatives, provided the users with an opportunity to make informed judgments of their own, and suggested the plausible trends

more forcefully.

These global projections were based on data of the late 1960s, many of which were provided by the UN for this project. They demonstrated that considerable future population growth should be expected during the next several decades and well into the twenty-first century as a result of the interaction of the assumed mortality and fertility trends and the youthful age structure of the world population. It became evident that the global population growth rate around the turn of the twenty-first century was likely to be significantly higher than 1 percent per year and that in the year 2000 the world population was not likely to be smaller than 5 billion, contrary to the Boyarsky and Bogue projections. These projections indicated it was unlikely that the world population could approach a stationary state before the middle of the twenty-first century. The world population was likely to increase to at least double its 1970 size of about 3.6 billion, but it could realistically increase to about four times its 1970 size before stabilizing toward the end of the twenty-first century if fertility were to decline in the developing countries at a rate comparable to the fertility decline of the developed countries in the late nineteenth and early twentieth centuries.

These projections provided insights and information that did not contradict but complemented the existing UN global projections. In addition to illustrating the orders of magnitude of the global long-term population growth momentum at that time, the long-term implications of the 1968 UN projections were illustrated: "One can speculate that if the world population were to develop according to the United Nations medium projection . . . a leveling off of the world population in the order of 10 billion inhabitants seems more

consistent with the growth trend than a leveling off around, for instance, 8 billion" (p. 192).

In recent years the Population Division of the United Nations has prepared several sets of global projections: "regular" sets in 1973,²⁰ 1978²¹ and 1980,²² a long-range set in 1974,²³ which is basically an extension of the 1973 set; and a 1978 long-range set.²⁴

In the "regular" UN global projections there is relatively little change from one revision to the next. The low-high range for the year 2000 has narrowed slightly, from 5.84-6.64 billion (UN 1973) to 5.85-6.37 billion (UN 1980), and the medium projection has remained on the order of 6.2 billion in all the regular sets of projections. It is worth recalling that the medium projection for the year 2000 in the 1957 UN set was 6.3 billion. This close agreement does not mean that there were no changes in projections for individual countries or regions, but merely that country or regional deviations tended to cancel out.

The 1974 long-range set centers on a medium projection of about 12 billion for the second half of the twenty-first century with a high projection of almost 16 billion and a low of 9.5 billion; the 1978 long-range set centers on a medium projection of about 10.5 billion, with a low-high range of 8.0-14.2 billion. The 1980 UN projections are extended only to the year 2025 with a low-high range for that year of 7.2-9.1 billion.

Each consecutive set of the UN projections has been a further attempt to fine-tune the methodology applied in making them. In the 1973 set, for example, models for the future course of fertility in both developed and developing countries were adjusted, and the reverse logistic curve (a

stretched out reverse S) was introduced with specified time points at which replacement level fertility will be reached and, beyond it, sustained.

As more is learned about the dimensions of demographic measures of the past, these are also being revised. The UN 1973 set projected a peak in the world growth rate in the 1975-1980 period, with global annual growth rates from 1960 through 1990 all in the narrow range of 1.84 to 1.95 percent per year. According to the 1978 set, "the rate of increase of total population for the world appears to have peaked in the early 1960s . . . the current (1980) annual rate of global population increase is estimated to be 1.8 percent; it was less than 2.0 percent in the 1960-1965 period" (p. 9).

During the late 1970s institutions other than the UN and several individual authors prepared short-term and long-term projections (World Bank,²⁵ United States Bureau of the Census,²⁶ Littman and Keyfitz²⁷). As none of them contains results or methodological features fundamentally different from those projections that have already been discussed, they will not be reviewed here.

Population projections published in the early 1970s that originated from studies associated with The Club of Rome, in contrast, reflected an effort to introduce ambitious methodological innovations. These projections attempted to link population projections more tightly to social, economic, environmental, resource and political trends. In 1972 Meadows et al.²⁸ and in 1974 Mesarovic and Pestel²⁹ defined global dynamic systems analysis models that contained population as one of several basic components. Projections of those systems were carried into the twenty-first century to demonstrate possible disastrous or harmonious long-term consequences inherent in global societal trends. According to these projections, the likely trends of popula-

tion growth (as well as trends in industrialization, resource depletion, etc.) will lead to a collapse of the world system in the twenty-first century—which will include an increase in mortality and a consequent rapid population decline. The authors conclude that if such a global collapse is to be avoided, inter alia, rapid fertility declines, significantly faster than those of the UN low projections, would have to be generated. While these projections were innovative in their holistic approach, numerous critics questioned the validity of employed assumptions.³⁰

During the late 1970s one other set of projections was prepared, and their authors, D.J. Bogue and Amy Ong Tsui,³¹ claimed the population figures implied by these projections were exceptionally low. Bogue and Tsui wrote that "the magnitude and pace of the (1965-1975 fertility) decline is greater than many demographers had expected" and that

this development makes it necessary for demographers to review and re-examine their projections for the future. We predict that by the year 2025 the world will have nearly achieved zero population growth. It is estimated that this equilibrium will be achieved with a world population of about 7.4 billion . . . primarily because of the worldwide drive by Third World countries to introduce family planning as a part of their national social-development services (pp. 99-100).

The Bogue-Tsui projections elicited considerable public attention and generated some controversy.³² At least one comment related to the proclaimed novelty of the projections is warranted in the context of the main focus of the present paper. The Bogue-Tsui 1978-1979 global projections are very close to the UN low projections of the 1970s. Since 1973 the UN low projections have been on the order of 5.8-5.9 billion for the year 2000 and the Bogue and Tsui low-high range for that year is 5.8-6.0 billion. The same

observation applies for the year 2025, for which Bogue and Tsui "predict" 7.4 billion, and the UN low variant projects 7.2 billion.

The most recent set of global projections, prepared in 1980 by T. Frejka and W.P. Mauldin³³, are similar in form to the 1973 Frejka projections. They suggest a narrowing in the still broad range of likely trajectories for global population growth: toward the end of the next century the world population is likely to be between 7 and 13 billion, rather than between 6 and 15 billion as it appeared a decade ago. Further, the world population as of the late 1970s continues to contain a vigorous growth momentum. As a plausible low alternative, an increase of another 80 percent of the world's 1980 population of 4.4 billion can be expected; it seems reasonable to assume that the world population will be over 8 billion before stabilizing; a doubling of the world's 1980 population is a realistic possibility. Calculations and considerations exploring a plausible high alternative of world population trends in the twenty-first century in light of the present vigorous growth momentum point to a stabilized population of about 12 billion. While higher population trajectories--such as an eventual tripling of the present world population --are not very likely, they remain a realistic possibility.

4. Concluding Reflections

Demographers appear to be increasingly capable of providing meaningful information on expected future global population growth trends. This state of affairs is intricately linked to progress in the social sciences in general, and in demography and statistics in particular. These related fields are likely to continue to develop, and, therefore, the methods of population projections are likely to improve further. But does this mean that we are

now, or will be at some point in the future, capable of preparing a population prediction, i.e., a single projection that will outline the exact path that will be followed by population change?

In my view the answer is no. Population is a component of the complex societal dynamic system in which we are never likely to understand all the existing and developing interrelations, and even if we did, it is unlikely that we could predict all the future economic, political, environmental, and other developments that interact to shape future population growth. In other words, while both short-term and long-term population projections do have the potential for further improvement for a variety of uses, such improvement will not result in an ability to accurately predict a single path of future population growth.

A somewhat related issue is the role population projections may play in shaping future population change. The presentation and analysis of population projections in specific societal contexts, indicating possible desirable and/or less desirable consequences, may stimulate efforts to modify population trends in directions that are considered more desirable than currently expected trends. A range of population projections can be perceived as options for society, and if a given society feels strongly enough that the likely outcome could have deleterious consequences, it will be moved to design measures to alter the undesired trends.

One other aspect of the history of global population projections warrants note: revisions. What is their function? Do they rectify "erroneous" projections?

To consider revisions only as an instrument that corrects errors in a preceding set of projections appears to be a simplistic notion. Even when a

set of projections is found to have been correct for a certain time period, i.e., when actual population change occurred within the projected range, there are good reasons for preparing a new set of projections after a certain passage of time. The population under study will have followed a particular path and it will have reached one of the many possible projected points. The size and structure of the population at that point can then serve as the base for a new set of projections. In addition, other developments may justify a new projection exercise: a better understanding of the mechanism of population change; a new methodological tool; more and better data. Last but not least, one should realize that important insights can be gained by comparing a set of projections to an earlier set. Such a comparison may demonstrate changes in the population growth prospects that resulted from demographic developments that took place between the two sets of projections.

This overview of the history of world population projections might give the impression that in the three areas needed for projections--theory, methods, data--a continuous and cumulative process of refinement has been under way. Such a perception is reasonably correct as far as methods and data are concerned, but developments in the theoretical base needed in making projections are more complex. This complexity presents itself in at least three different ways.

(1) As knowledge about societal dynamics in general, and about the mechanisms shaping population dynamics in particular, accumulates, it can be utilized in theories providing the framework for population projections. The understanding of mechanisms of population change has indeed improved over time; nevertheless, utilizing and applying appropriate knowledge for projections is likely to remain a difficult process.

(2) Given its amount and complexity, existing knowledge is open to varying interpretations when theories of population change are constructed. Any given interpretation is likely to be colored by a certain weltanschauung. This is at least part of the reason for the diversity of theoretical frameworks that were applied during the 1960s, and similar diversity is likely to characterize future population projections as well.

(3) Given the complexity of interrelations in the dynamics of social systems and the difficulties in quantifying many of the interacting components, authors of population projections are frequently poorly placed to estimate the quantitative impact of various factors on population growth. Often, the theory governing the formulation of fertility and mortality assumptions can be stated only in qualitative general terms, that is, the ties between the theory and the formulation of assumptions are necessarily loose and somewhat arbitrary. In such situations the intuition of the authors of projections—based, of course, on their professional experience—may be the dominating influence in the calculation of future demographic trends. Typically, the authors will be most experienced in demography, and this is then likely to be reflected in the projections—as was the case to varying extents with the more recent projections of the United Nations, the United States Bureau of the Census, the World Bank, and Littman and Keyfitz. Such a blending of knowledge and intuition is likely to persist in the making of future projections: indeed it is an unavoidable ingredient in them.

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