A DISAGGREGATE POPULATION MODEL OF CHINA

Dr. Qifan Wang
Shanghai Institute of Mechanical Engineering
People's Republic of China
and
Visiting Scholar
Sloan School of Management
Massachusetts Institute of Technology

John D. Sterman
Assistant Professor
Sloan School of Management
Massachusetts Institute of Technology
Cambridge MA 02139

May 1983

A DISAGGREGATE POPULATION MODEL OF CHINA

Dr. Qifan Wang
Shanghai Institute of Mechanical Engineering
and
Visiting Scholar, M.I.T.

John D. Sterman
Assistant Professor
Sloan School of Management
Massachusetts Institute of Technology

ABSTRACT

A disaggregate population model of China is presented. The age structure is represented by one-year cohorts. Urban and rural populations are distinguished. Birth and death rates, family size, life expectancy, and other demographic variables are determined endogenously. The model can be used to analyze population problems and to project population size, the age structure, the adult labor force, the elderly population, and so on. The model can be used in two modes. It can be used to project the consequences of various exogenous fertility levels. Alternatively, birth rates and fertility can be determined endogenously by economic inputs such as food supply, GDP, and services. The model incorporates socioeconomic factors important in the demographic transition, such as the effect of perceived life expectancy on fertility, the effects of traditional values, and the ability of government to influence family fertility choices. The model can be used to evaluate policies and programs designed to control population growth, such as delayed marriage age, improved contraception, and restrictions on family size.

The model requires industrial, service, and food output per worker as inputs, and also the level of pollution. The model should be thought of as a component of a comprehensive planning model which generates these inputs endogenously.

Based on the system dynamics approach to modeling complex systems, the model is implemented in the DYNAMO simulation language.

The population of China now exceeds one billion persons. In the past thirty-three years, the population of China has virtually doubled. Despite the immense strides towards population control China has taken since 1949, overpopulation remains the most serious problem facing the Chinese nation. Between 1952 and 1978, the means of living increased by 5.4% per year. In the same period the population increased 67%, so output per capita increased only 3.4% per year (Coale 1981). Although Chinese production of products such as coal, cloth, and grain are among the highest levels in the world, per capita production lags behind.

Overpopulation has reduced arable land per capita. Arable land per capita was 2 mu in the early 1950s, and averages 1.57 mu at present (Chen 1981), with less than 1 mu in Jiangsy and Zhegian provinces and just 0.3 mu in Sandon and Guangdon provinces (Xu 1981). There are more than six mu per acre. Besides restraining material improvement, population growth also conflicts with the improvement of the quality of life of the population because of insufficient education and public services.

The causes of overpopulation in China are closely related to the social background and political developments of the country. As in many third-world countries, the health of the population has improved dramatically in the past three decades. Medical services and modern health care have become widely available. As a consequence, the crude death rate dropped sharply. But at the same time, feudal ideas remain strong. Traditional beliefs such as the idea that happiness springs from

having many children and that the gravest unfilial act is to die without offspring still have a strong influence, especially in rural areas. It was common for a family to have five or six children, and some families had ten or twelve. Political developments also play a large role. For example, during the first decade of the People's Republic government policy reinforced the traditional norms.

Analysis of the population problem and especially of policies to control population must not only account for the technical aspects of life expectancy, age structure, etc., but consider the social traditions and political realities that govern desired family size and fertility. Further, population studies should integrate population with economic and environmental development. All too often population projections fail to account for the relationships between the population and the availability of food, the material standard of living, health services, and the quality of the environment.[1]

One exception is represented by the CHINA1 model (Brinton et al. 1974, Wolfe 1975). Based on the WORLD3 global model (Meadows et al. 1974), CHINA1 endogenously determines both population and economic development. Life expectancy, desired family size, and birth rate are endogenously determined by the availability of food, the material standard of living, and other economic and social factors. These, in turn, are endogenously determined by the interaction of population with capital investment, resources, soil fertility, arable land, and pollution. The advantage of the CHINA1 approach is the integrated treatment of population, technology, and the physical environment. However, such models have been attacked for their highly aggregate treatment of the system.

This paper presents an extension of the CHINA1 approach focusing on a disaggregate representation of the population sector. In particular, the age structure is represented by annual cohorts, and urban and rural populations are distinguished.

The purpose of the model is twofold. First, it shows the integrated approach to population and development planning demonstrated by the CHINA1 model can be extended to include the level of detail common in traditional demographic studies. Second, the model provides a tool to assess the development of China's population. The model can examine issues such as the shifting balance of children, workers, child-bearing, and elderly persons, the effects of delayed marriage age, incentives for small families, and the growing disparity between urban and rural fertility.

The model presented below treats only the population and takes economic development as exogenous. However, the interactions between population growth and economic development are most important in determining the long-run path of development. The results must, therefore, be viewed as a demonstration of the capability to endogenously model the age structure of the population. The model should be viewed as a component of a larger model in which the economy is endogenously determined.

Distinctive Features of the Chinese Population

The population of China has four main characteristics. (Birth Planning Group 1981, Xu 1981, Xinhua 1980):

1. Life expectancy increased from 35 in 1948 to 68 in 1965, and is more than 68 now.

2. The population of child-bearing age is large and growing. If the net growth rate were just 1 percent per year, it would mean an increase of ten million persons each year. If total fertility for each couple remained at the 1981 level of 2.4 children, the population would exceed 1.2 billion by 1995.[2]

3. Over sixty percent of the population, about 600 million people, are under the age of 32. The high proportion of young people means larger numbers of births in the future, especially before the year 2000. The percentage of the population of reproductive age is likely to increase from 45% in 1981 to over 50% in 1987, and will remain above 50% through 2000.

4. The age structure has three distinct peaks (Figure 1). In 1978 there were about 27.2 million people of age 10 (born in 1968), about 28.9 million people of age 15 (born in 1963), and about 19.5 million people of age 24 (born in 1954).

The Model

The model (called TW-CH) is based on CHINA1 and the 15 cohort population model developed as part of the WORLD3 project (Meadows et al. 1974, Ch. 2). Like the population sector of CHINA1, the model is divided into four major subsectors: the age structure, mortality, fertility, and the economic inputs. Unless otherwise noted, all units are the same as in WORLD3. A complete listing of the model is available from the authors.

Age Structure

$PO_{t+1} = PO_t + (DT)(B_t - DO_t - MATO_t)$
$Pi_{t+1} = Pi_t + (DT)(MATi\text{-}1_t - Di_t - MATi_t)$ $i = 1,\ldots,64$
$P65_{t+1} = P65_t + (DT)(MAT64_t - D65_t)$
$MATi_t = Pi_t/YPC$
$YPC = 1$
$Di_t = Pi_t * f_1(LE_t)$ $f_1' < 0$
where

PO	=	Population, age 0-1 (people)
Pi	=	Population, age i, i+1 (people)
P65	=	Population, age 65+ (people)
B	=	Births (people/year)
DO	=	Deaths, age 0-1 (people/year)
Di	=	Deaths, age i, i+1 (people/year)
D65	=	Deaths, age 65+ (people/year)
MATO	=	Maturation rate, age 0-1 (people/year)
MATi	=	Maturation rate, age i, i+1 (people/year)
YPC	=	Years per cohort (years)
LE	=	Life expectancy (years)
DT	=	Solution interval for model (years)

The major difference between the present model and CHINA1 is the disaggregation of the age structure. Sixty-six cohorts are portrayed, one each for persons 0-65 years of age and one for all persons over 65. Mortality as a function of life expectancy for each cohort was derived by interpolation based on the life tables used in the construction of WORLD3 (Meadows et al. 1974, 141-146).

Urban Population

$FPU_t = PU_t/POP_t$
$PU_{t+1} = PU_t + (DT)(NBU_t + NMU_t)$
$NMU_t = 0$
$NBU_t = (B_t(TFU_t/TF_t) - D_t)*FPU_t$
where

FPU	=	Fraction of population urban (dimensionless)
PU	=	Urban population (people)
NBU	=	Net urban births (people/year)
NMU	=	Net migration to urban areas (people/year)
TFU	=	Total urban fertility (dimensionless)
TF	=	Total fertility (dimensionless)

The urban and rural population have been distinguished. Fertility in urban areas of China has fallen substantially since 1949, while rural fertility has not responded as well to the incentives that have been offered. Because about 80 percent of the population reside in rural areas, the model distinguishes between urban and rural fertility. For simplicity, however, the average death rate is assumed equal for rural and urban populations. Net migration is set to zero since migration is regulated by the government.

Life Expectancy

$LE_t = LEN*LMF_t*LMHS_t*LMP_t*LMC_t$
$LEN = 28$
$LMF_t = f_2(FPC_t)$ $f_2' \geq 0$
$LMHS_t = f_3(EHSPC_t)$ $f_3' \geq 0$
$EHSPC_t = SMOOTH(HSAPC_t, HSID)$
$HSID = 10$
$HSAPC_t = f_4(SOPC_t)$ $f_4' \geq 0$
$LMP_t = f_5(PPOLX_t)$ $f_5' \leq 0$
$LMC_t = 1-(CMI_t*FPU_t)$
$CMI_t = f_6(IOPC_t)$
where

LEN	=	Life expectancy reference (years)
LMF	=	Lifetime multiplier from food (dimensionless)
FPC	=	Food per capita (vegetable equivalent calories/person/year)
LMHS	=	Lifetime multiplier from health services (dimensionless)
EHSPC	=	Effective health services per capita ($/person/year)
SMOOTH	=	First order exponential smoothing
HSAPC	=	Health services allocations per capita ($/person/year)
HSID	=	Health services impact delay (years)
SOPC	=	Service output per capita ($/person/year)
LMP	=	Lifetime multiplier from pollution (dimensionless)
PPOLX	=	Index of persistent pollution (dimensionless)

LMC = Lifetime multiplier from crowding (dimenisonless)
CMI = Crowding multiplier from industrialization (dimensionless)
IOPC = Industrial output per capita ($/person/year)

Life expectancy is influenced by food per capita, health services per capita, exposure to persistent pollution, and crowding. As in CHINA1 and WORLD3, the effects of these inputs are multiplied to capture interactions: if no food is available, life expectancy approaches zero even though health services or pollution may be acceptable. The relationships assumed between the inputs and their effect on life expectancy are shown in Figure 2, compared against the original values used in WORLD3.

The impact of health services on life expectancy is delayed by an average of ten years to capture the time required for medical knowledge and services to be disseminated, for improved medical technology to influence life expectancy, and for health care infrastructure to be built up. Health services per capita are determined as a function of total service output per capita (Figure 3).

The effect of crowding depends on the fraction of the population living in urban areas and the level of industrialization. When industrialization is low, crowding reduces life expectancy, primarily through the spread of infectious disease. As industrialization proceeds, improvements in sanitation and access to health care increase life expectancy. Further industrialization produces social stresses and local pollution that reduce life expectancy slightly. As in WORLD3, pollution is assumed to have a weak effect of life expectancy.

Birth rate and fertility

$B_t = TF_t * \sum r_i * Pi \qquad 16 \le i \le 45, \quad \sum r_i = 1$

$TF_t = TFR_t*(1-FPU_t) + TFU_t*FPU_t$

$TFj_t = MIN(MTFj_t, MTFj_t*(1-FCEj_t)+DTFj_t*FCEj_t) \qquad j = R,U$

$MTFj_t = MTFN*FM_t*MARFj$

$MTFN = 12$

$FM_t = f_7(LE_t) \quad f_7' \ge 0$

$MARFj = (45-MARAj)/(45-15)$

$MARAR = 22$

$MARAU = 24$

where

TFR = Total fertility, rural areas (dimensionless)
TFU = Total fertility, urban areas (dimensionless)
MTF = Maximum total fertility (dimensionless)
FCE = Fertility control effectiveness (dimensionless)
DTF = Desired total fertility (dimensionless)
MTFN = Maximum total fertility normal (dimensionless)
FM = Fecundity multiplier (dimensionless)
MARF = Marriage age fraction (dimensionless)
MARA = Marriage age (year)

Total births are given by total fertility TF, distributed over the population in the child-bearing years as shown in Figure 4. The child-bearing years are assumed to be ages 15 to 45. The majority of births are assumed to occur between years 25 and 30.

Total fertility is a weighted average of urban and rural fertility. Fertility in urban and rural areas is determined as in WORLD3: fertility is a weighted average of the biologically determined level and the desired level, where the weight is given by the effectiveness of fertility controls. In the absence of any fertility control, the biological maximum determines fertility. When fertility control is perfect, actual fertility equals the desired level.

Total fertility can never exceed the biological maximum. Maximum total fertility in urban and rural areas is determined by the health of the population and by the fraction of the child-bearing years (ages 15 to 45) in which women are married. The average marriage age in urban areas is assumed to be 24, while in rural areas, the average age at marriage is assumed to be 22. The health of the population is measured by life expectancy, and its influence on total fecundity is shown in Figure 5.

Desired Total Fertility

$DTFj_t = DCFSj_t * CMPLE_t \qquad j=R,U$
$CMPLE_t = f_8(PLE_t) \quad f_8'<0$
$PLE_t = DLINF3(LE_t, LPD)$
$LPD = 15$
$DCFSj_t = SDF_t + ETTj_t*(TTFj-SDF_t)$
$SDF_t = f_9(t)$
$ETTj_t = f_{10j}(t)$
$TTFR = 3$
$TTFU = 2$

where

DCFS = Desired completed family size (dimensionless)
CMPLE = Compensatory multiplier from perceived life expectancy (dimensionless)
PLE = Perceived life expectancy (years)
DLINF3 = Third order information delay
LPD = Lifetime perception delay (years)
SDF = Social desired fertility (dimensionless)
ETT = Effect of traditional thought (dimensionless)
TTFj = Traditional total fertility (j = R,U)

Desired total fertility depends on desired completed family size and on the expected life expectancy of children. When life expectancy is perceived to be low, women must give birth to more children than ultimately desired to compensate for the children who are not expected to live to maturity. The compensatory

multiplier from life expectancy is assumed to be the same as in WORLD3 (Figure 6).

Like CHINA1, desired completed family size is influenced by government policy. Social desired fertility represents government population goals and is the chief channel through which the policies of the government are portrayed in the model (marriage age and fertility control effectiveness are the others). The model does not assume that government goals are necessarily realized, however. The impact of government goals on family size also depends on traditional family size norms. Traditional family size norms are assumed to be two children per family in urban areas and three in rural areas. Note that these figures refer to completed family size. The number of births required to attain these goals will also depend on the compensatory multiplier from life expectancy and historically has been higher due to low life expectancy. The strength of traditional norms in urban and rural areas is assumed to be exogenous (Figure 7). The strength of traditional family size goals has declined since 1949, and can be expected to continue to decline in the future. Traditional norms are, however, assumed to be much stronger in rural areas.

Fertility control

$FCEj_t = f_{11j}(FCFPC_t) \quad f_{11j}' \geq 0 \qquad j=R,U$
$FCFPC_t = DLINF3(FCAPC_t, HSID)$
$FCAPC_t = FSAFC_t * SOPC_t$
$FSAFC_t = f_{12}(NFC_t) \quad f_{12}' \geq 0$
$NFC_t = MTF_t / SDF_t$
$MTF_t = MTFR_t*(1-FPU_t) + MTFU_t*FPU_t$

where

FCFPC = Fertility control facilities per capita ($/person/year)
FCAPC = Fertility control allocations per capita ($/person/year)
FSAFC = Fraction of services allocated to fertility control (dimensionless)
NFC = Need for fertility control (dimensionless)
MTF = Maximum total fertility (dimensionless)

Fertility control effectiveness is modeled as in WORLD3, but with rural and urban fertility control distinguished. Access to and use of contraception is assumed to be higher in urban areas (Figure 8). Fertility control effectiveness depends on the services allocated to contraception, abortion, reproductive education, etc. Like the formulation for the effect of health service on life expectancy, an average delay of ten years is assumed between a change in the resources allocated to fertility control and the resulting impact on fertility control effectiveness. The delay represents the time required to develop and disseminate new fertility control methods. The resources devoted to fertility control depend on the total service output of the economy per capita and the perceived need for fertility control, as measured by the ratio of maximum total fertility to the government fertility goal (social desired fertility).

Economic Inputs

$$IOPC_t = IO_t/POP_t$$
$$IO_t = IOPW_t*PL_t$$
$$IOPW_t = f_{13}(t)$$
$$SOPC_t = SO_t/POP_t$$
$$SO_t = f_{14}(t)*IO_t$$
$$FPC_t = F_t/POP_t$$
$$F_t = FPW_t*PL_t$$
$$FPW_t = f_{15}(t)$$
$$PL_t = \sum_k P_{kt} + \sum_l FEWF*P_{lt} \quad 16\leq k \leq 45,\ 46\leq l \leq 65$$

where

IO = Industrial output ($/year)
IOPW = Industrial output per worker ($/person/year)
SO = Service output ($/year)
F = Food production (veg. eq. calories/year)
FPW = Food per worker (veg. eq. calories/person/year)
PL = Labor force (persons)
FEWF = Fraction of elderly in workforce (dimensionless)

The model requires industrial output, service output, food production, and pollution as inputs. For comprehensive planning purposes, these should be modeled endogenously, as in CHINA1. The interactions of population with economic growth, food production, land development, and pollution will determine the actual path of development. In the model, industrial output, services, and food production are endogenous, and depend on the workforce and the output per worker. In the absence of a complete economic model, however, industrial output, services, and food per worker are specified exogenously. The exogenous economic inputs are presented in Figure 9. The economic inputs presume China meets her development goals. Industrial output per worker is assumed to rise at five percent per year until about 2000. After 2000, the growth rate gradually diminishes. Service output is assumed to be a rising fraction of industrial output. Food per worker is assumed to grow at one percent per year. Pollution is assumed to be zero.

An example: The Consequences of Various Future Fertility Levels

One use of the model is to assess the consequences of various levels of total fertility in the future. In this mode, total fertility is specifed exogenously. Life expectancy, however, is determined endogenously, as described above. The results are presented in Table 1, compared to similar projections made by Chinese demographers (Xinhua 1980). The Chinese projections suggested that the population of China would range from 4.26 billion to 370 million in 2080 as total fertility varied from three children per woman to one child per woman, respectively. The model results match the Chinese results fairly closely. It is not possible to explain the discrepancies, as the assumptions behind the Chinese projections were not published. Nevertheless, the test shows that the model results are broadly consistent with the state of demographic analysis in China.

Population Policy Under Constraints

It is currently Chinese policy to encourage one child families. Yet, especially in rural areas, the policy goal is not being realized. A second use of the model is to project population assuming traditional values change only slowly and that government goals have only limited effectiveness, as described above.

The model presumes industrial, service, and food output per worker are exogenous, and until these are modeled endogenously cannot be used to assess the ability of the Chinese economy to sustain the population. It can, however, be used to assess the likely population that would have to be sustained. In addition, a rapid transition from a growing to a stable or declining population may create imbalances in the age structure

such as a high proportion of elderly persons or an inadequate workforce. The model can be used to assess these issues.

In the simulation, it is assumed that the government target for fertility remains at the current one child level until about 2000. After 2000, the fertility target rises to 1.7 by about 2020 and remains at that level thereafter (Figure 10). The results (Figure 11) show total population reaches 1190 million by 2000 and peaks at about 1270 million in 2024. While it takes about forty years for population to rise from one billion to its peak, the decline is more gentle, with population dropping to about 1020 million by about 2080.

During this period, industrial and service output per capita rise substantially. Food per capita rises as well, although there is a period between 2000 and 2030 in which food output per capita is stagnant, the result of a shrinking workforce and growing elderly population.

The improvement in output per capita is primarily the result of the assumed trends in output per worker. As a result, life expectancy rises to 75 years by 2078. The population becomes slightly more rural, a consequence of higher fertility in rural areas and the assumption that there is no migration to the cities.

The most striking feature of the results is the large degree of inertia in the population. Though total fertility drops below two children per family by the mid 1980s, population continues to rise until the mid 2020s. The inertia is the direct consequence of the large number of children born before the 1980s who reach their child-bearing years between now and 2020.

The source of the population inertia is highlighted in figure 12, which shows the evolution of the age distribution over time. In 1978 there was a large "hump" of persons under the age of 15. The population hump of persons born between 1960 and 1980 will create special strains on the Chinese economy. Between 1960 and the present, the burgeoning number of children created strains on the medical and educational systems. The fraction of the population under the age of 15 reached nearly forty percent in 1978. The strain on educational infrastructure, particularly higher education, will continue as these people mature over the next decade.

By the year 2000, these people are in the prime child-bearing years. The years through the first decade of the next centory are thus the critical years for Chinese population control. The large size of the cohorts who will reach child-bearing age in the next thirty years implies fertility control during this time is imperative. For this reason it is assumed in the simulation that the goal of one child per family is maintained through the year 2000, gradually approaching 1.7 children per couple by about 2020. Yet the simulation suggests that despite the continuing restraint and the assumption of continuing erosion of traditional values favoring large families, the population increases more than twenty percent over the next forty years.

During the next thirty years, the people in the population hump will also be entering the workforce. The Chinese economy will have to be able to generate a large number of new

jobs during this time. The simulation shows the labor force expanding from about 52 percent of population in 1978 to nearly 67 percent by the first decade of the next century. The expansion in the fraction accompanies an absolute growth in total population to over 1.2 billion. Generating adequate and suitable employment will be a major problem for the economy.

By 2024, the year simulated population reaches it peak value, the oldest people in the population hump are beginning to leave the workforce. During this time, the fraction of elderly (persons over 65) in the population begins to rise substantially. In 1978, less than five percent of the population were over 65 years of age. By 2024, this fraction has risen to more than 15 percent, and it reaches a peak of more than one quarter of the population by 2050.

The more than five-fold increase in elderly persons will be a particular strain after 2020. During this time, the fraction of the population in the labor force will be shrinking just when the elderly population will be growing most rapidly. After 2050, the age structure reaches a fairly steady state of near equilibrium, and population declines slowly.

Conclusions

The model has been used to explore alternative government fertility policies and other policies such as further restrictions on marriage age. Though these policies can have a significant impact on the size of the population in the future, the basic conclusions demonstrated above remain unaltered. In particular, the large hump of young persons will cause strains on the Chinese economy as they reach child-bearing age and enter the workforce, and as they age and leave the workforce.

The next thirty years are the crucial ones for Chinese population policy becuase of the large size of the cohorts who will reach child-bearing age in these years. The ability to restrict fertility during this time will make the difference between a peak population around 1.2 billion and a peak around 1.5 billion persons. After the first two decades of the next century, the dominant issue will shift to one of accommodating an increasingly elderly population with a shrinking workforce.

China must tread a narrow path. A slower decline in fertility will dramatically swell the population to be supported in the difficult years of the early twenty-first century. A faster decline in fertility, however, will exacerbate the imbalance between the workforce and the elderly population in the middle and later years of the next century.

Finally, the model shows how the system dynamics methodology can be used to study the evolution of a population at the level of detail commonly expected in demographic studies. The major strength of system dynamics, however, is not the ability to portray the population in great detail, but to integrate population growth and the age structure with economic development. The next step is to extend the model to endogenously include the determinants of economic output. The resulting model would be a substantial step forward towards the goal of an integrated tool for development planning.

NOTES

1. The Global 2000 report to the President (Council on Environmental Quality 1980) demonstrated that comprehensive, coordinated and consistent foresight capabilities in the executive branch of the U.S. government simply do not exist. Projections of population, economic growth, resource availability, agriculture, and so on are made by each agency largely without regard to the assumptions and projections used by other agencies, and without considering the interactions.

2. Calculated by the TW-CH model.

REFERENCES

Birth Planning Group, 1981, "An Outline of Propaganda for Controlling Population in China," Population Research. 2, 1-4 (in Chinese).

Brinton, W. et al., 1974, "CHINA1: A Model of Growth for the People's Republic of China," Simulation. 23, 5.

Chen, Mu Hua, 1981, "Developing Population Science and Making it Serve the Goal of Controlling Population Growth," Population Research. 3, 1-7 (in Chinese).

Coale, A., 1981, "Population Trends, Population Policy, and Population Studies in China," Population and Development Review, 7, 1 (March).

Council on Environmental Quality, 1980, The Global 2000 Report to the President. 3 vols., Washington, D.C.

Meadows, D. et al., 1974, The Dynamics of Growth in a Finite World. Cambridge, MA: The MIT Press.

Wolfe, J., 1975, "A Technical Report of CHINA1: A Model of Growth for the People's Republic of China," Hanover NH: Dartmouth System Dynamics Group, Dartmouth College.

Xinhua News Service, 1980, "On China's Future Population Growth: Projections and Targets," Population and Development Review. 6, 2, 343-348.

Xu, Dixin, 1981, "Questions Related to Population Science," Economic Research. 4 (in Chinese).

Table 1. Comparison of Chinese and TW-CH projections assuming constant fertility levels.

Scenario	Chinese Projection[a]		TW-CH Projection	
1. Total Fertility = 3	2000	1410	2000	1440
	2050	2920	2050	2760
	2080	4260	2080	3970
2. Total Fertility = 2.3	2000	1280	2000	1310
	2050	NA	2050	1760
	2080	2120	2080	1940
3. Total Fertility = 2	2000	1220	2000	1250
	2052[b]	1540	2033[b]	1460
	2080	1470	2080	1360
4. Total Fertility = 1.5	2000	1130	2000	1160
	2027[b]	1170	2010[b]	1190
	2080	777	2080	710
5. Total Fertility = 1	2004[b]	1050	2004	1070
	2028	960	2028	920
	2060	613	2060	520
	2080	370	2080	330

[a] Source: Xinhua 1980
[b] Peak year

Figure 1. Age structure of the Chinese population, 1978

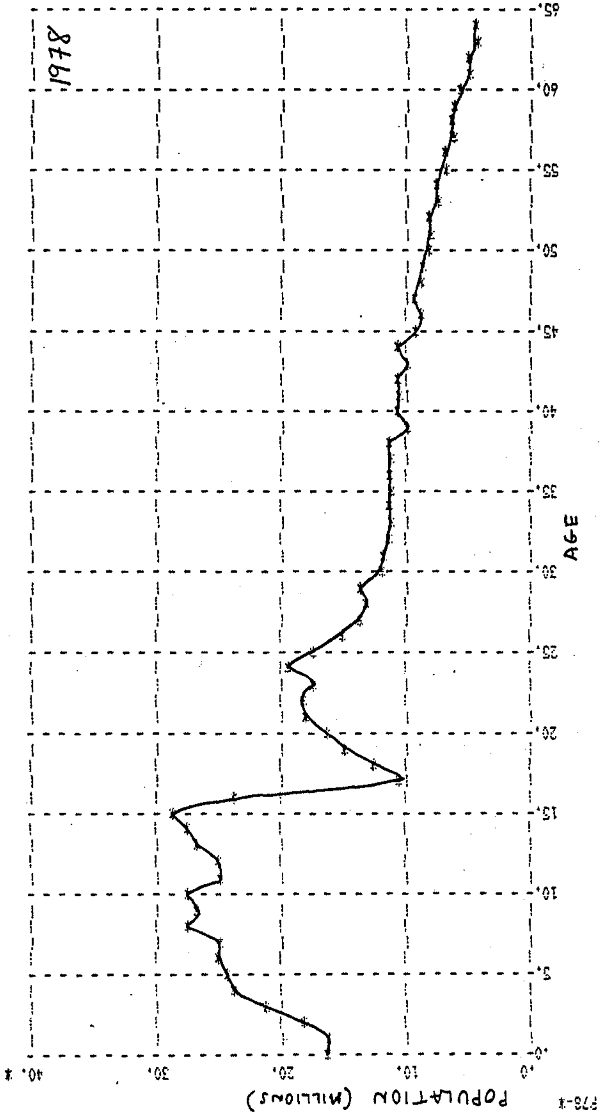
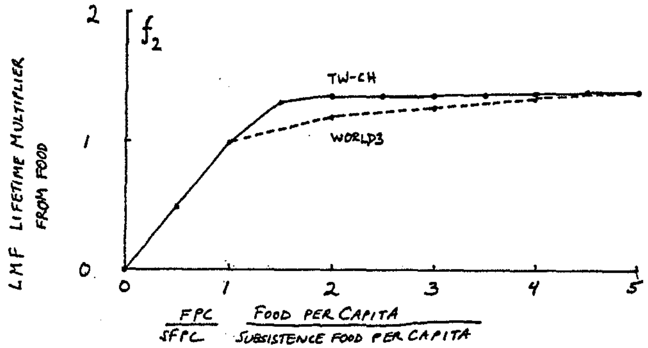


Figure 2a. Determinants of life expectancy: food and health services per capita



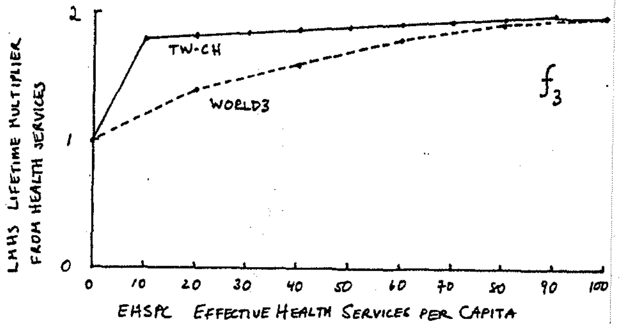
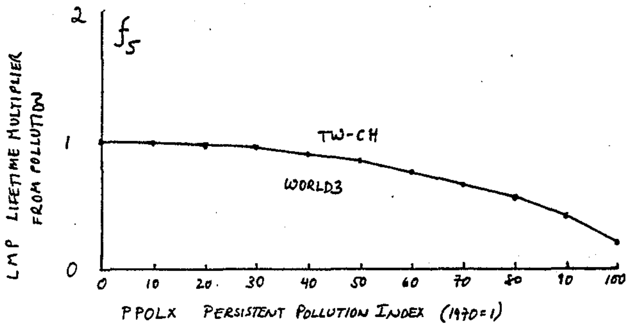


Figure 2b. Determinants of life expectancy: pollution and crowding



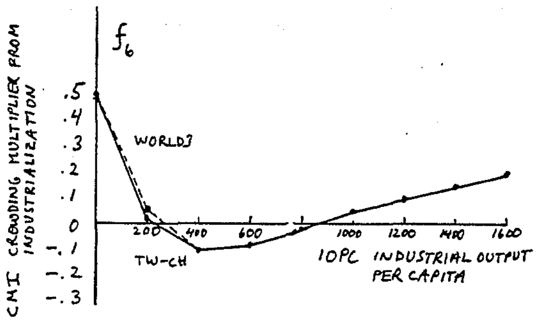


Figure 3. Health services allocated per capita

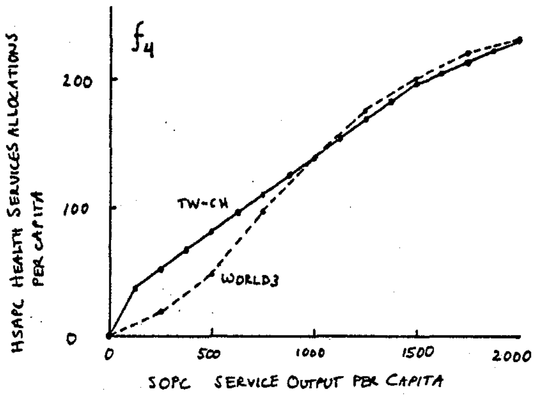


Figure 4. Age distribution of child-bearing

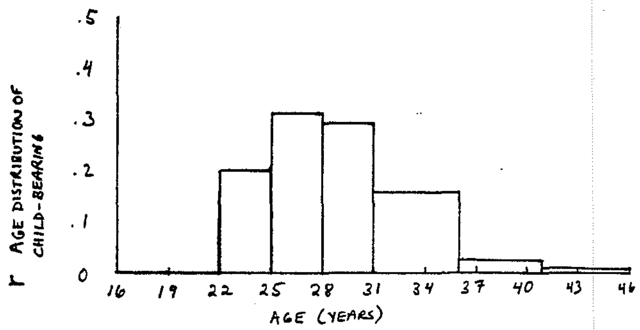


Figure 5. Effect of life expectancy on fecundity

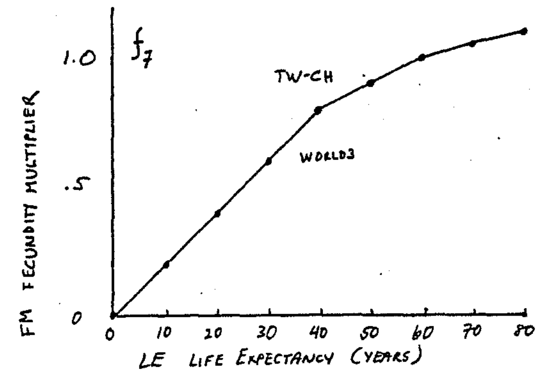


Figure 6. Effect of perceived life expectancy on fertility

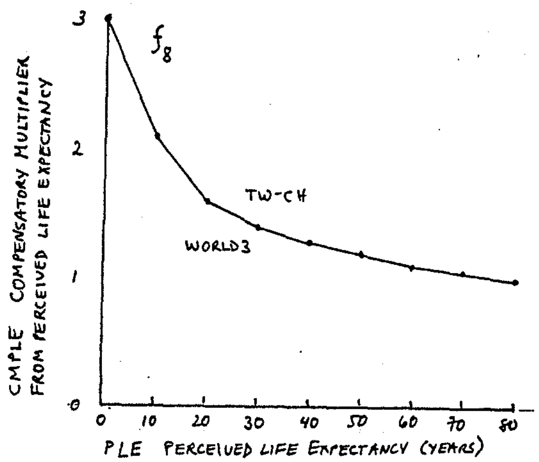


Figure 7. Assumed strength of traditional values

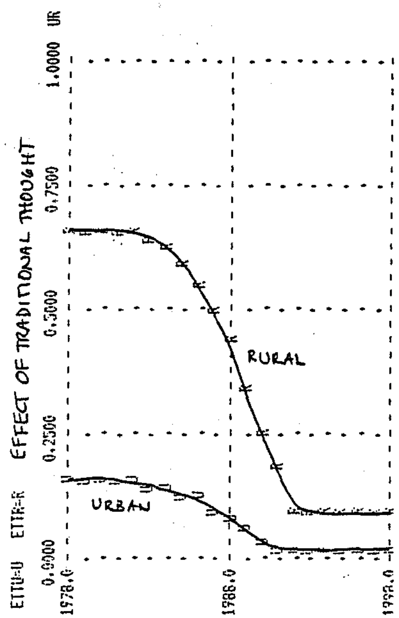


Figure 8. Fertility control effectiveness and health services allocated to fertility control

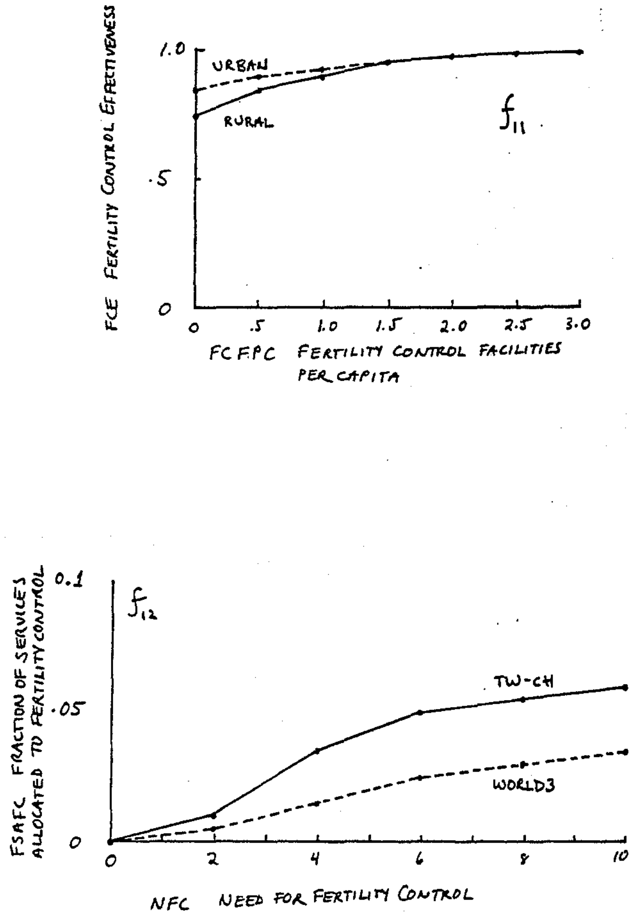


Figure 9a. Assumed industrial output per worker

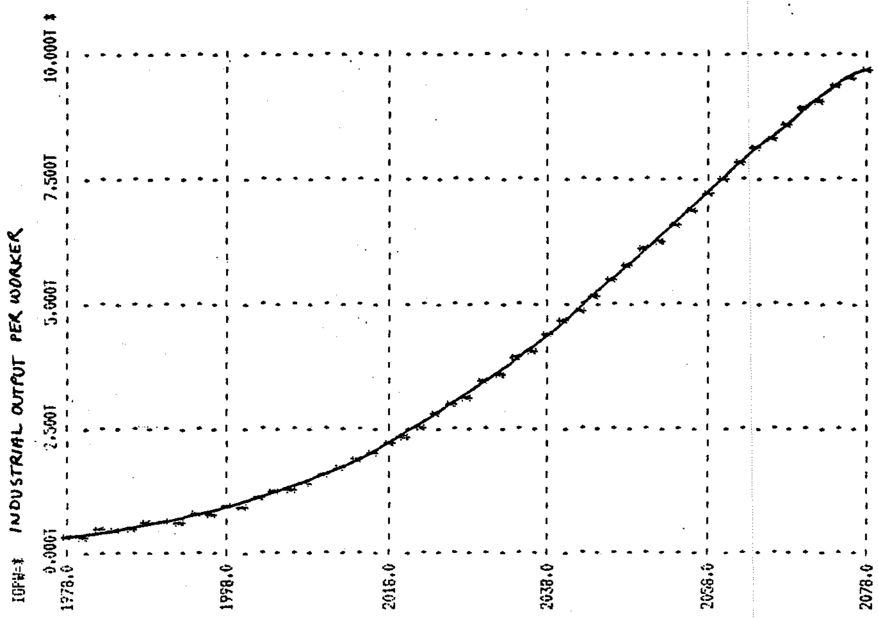


Figure 9b. Assumed service output fraction

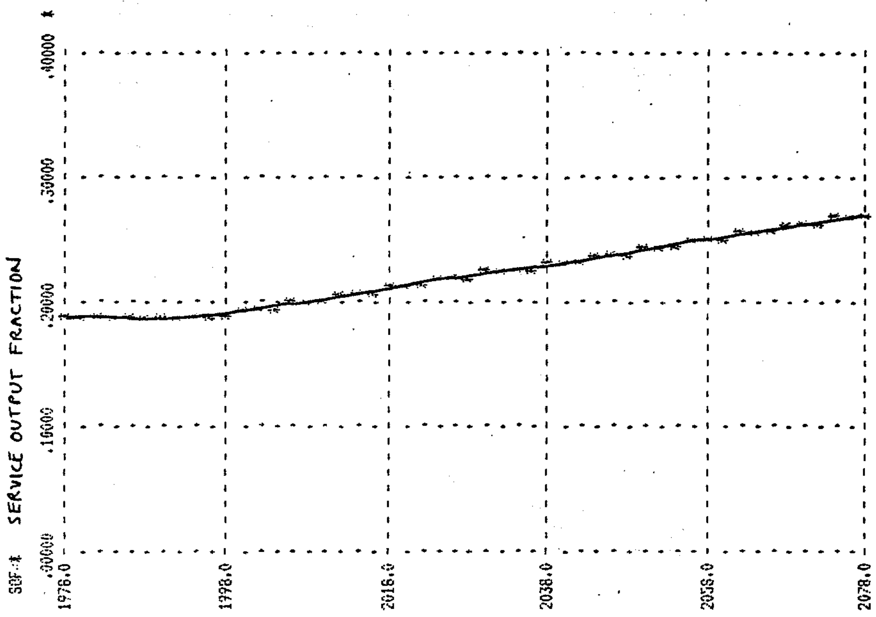


Figure 9c. Assumed food output per worker

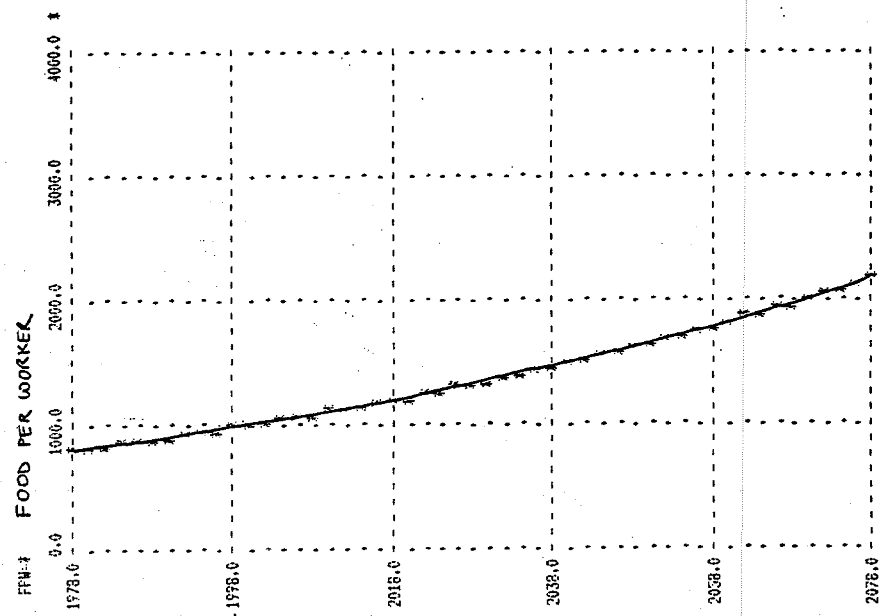


Figure 10. Assumed government goal for total fertility

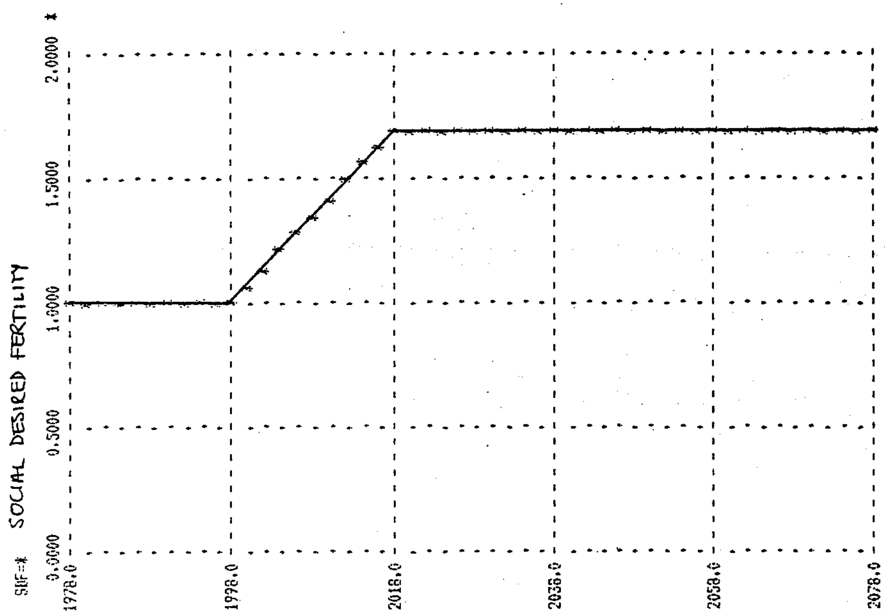


Figure 11a. Simulated population, crude birth and death rates

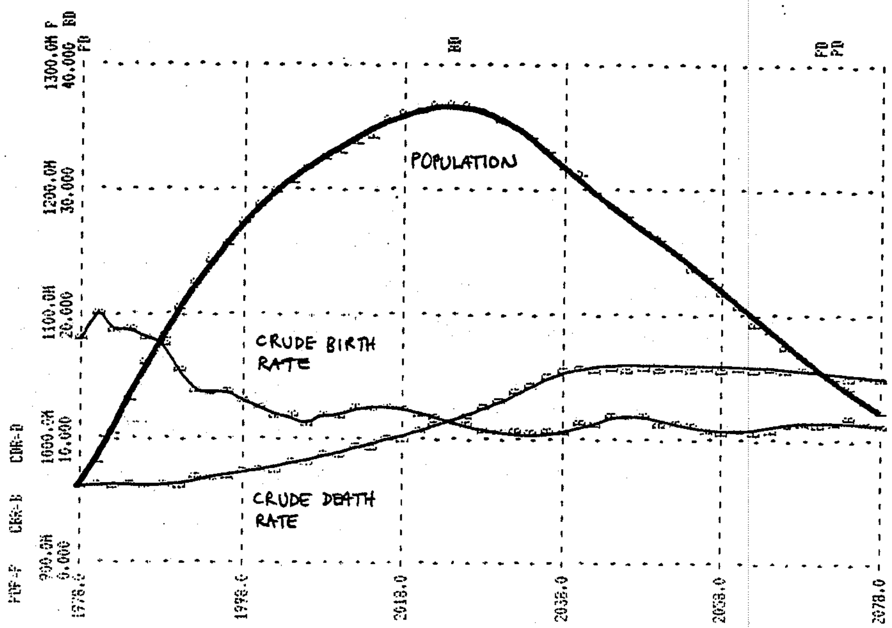


Figure 11b. Simulated life expectancy, total fertility, and fraction of population in urban areas

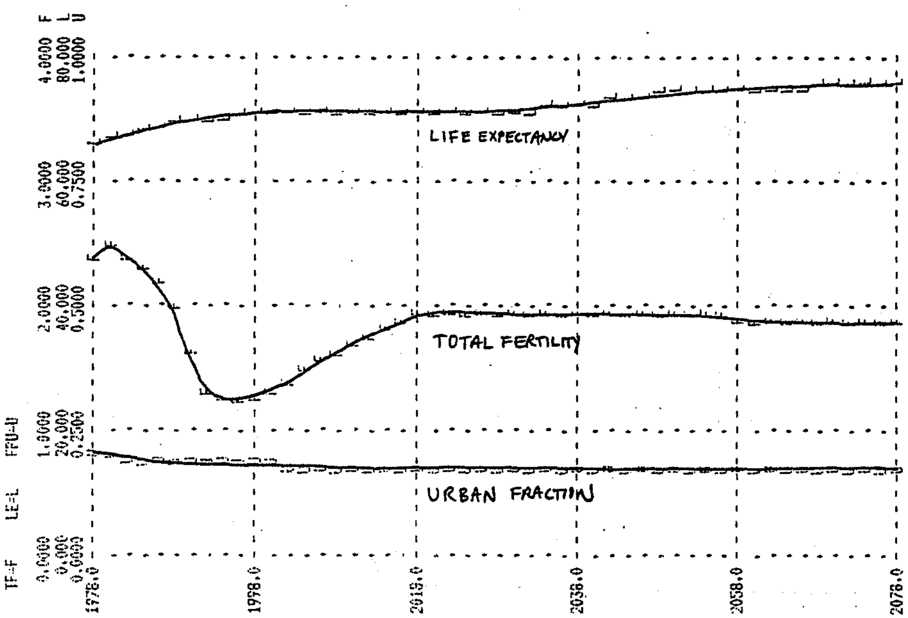


Figure 11c. Simulated fraction of population in labor force, of child-bearing age, elderly, and children

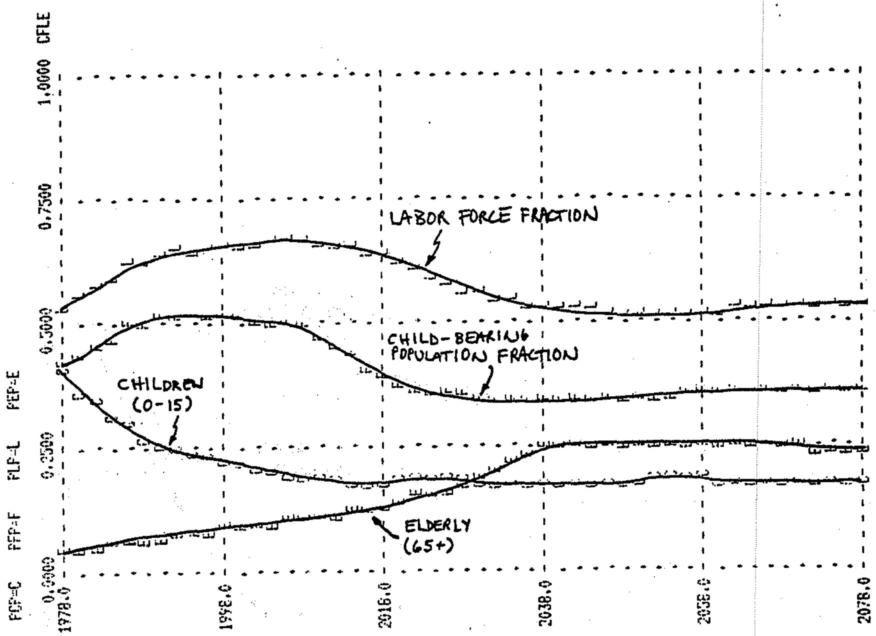


Figure 11d. Simulated industrial, service, and food output

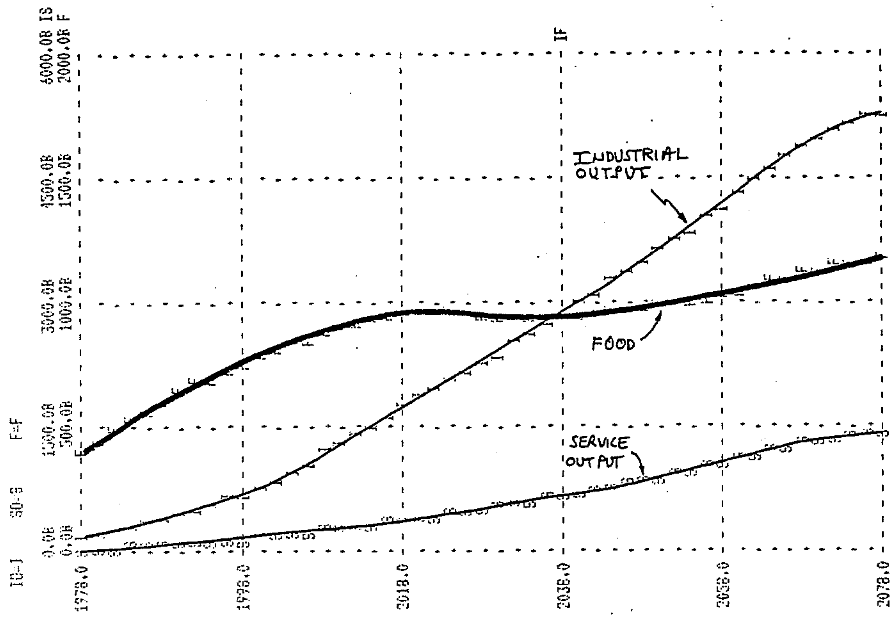


Figure 11e. Simulated industrial, service, and food output per capita

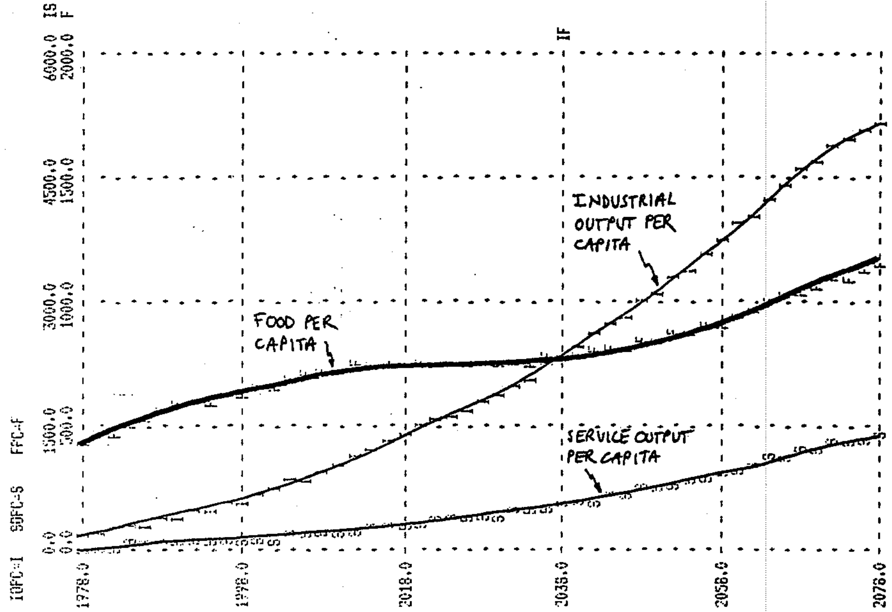


Figure 12a. Simulated age structure, 2000

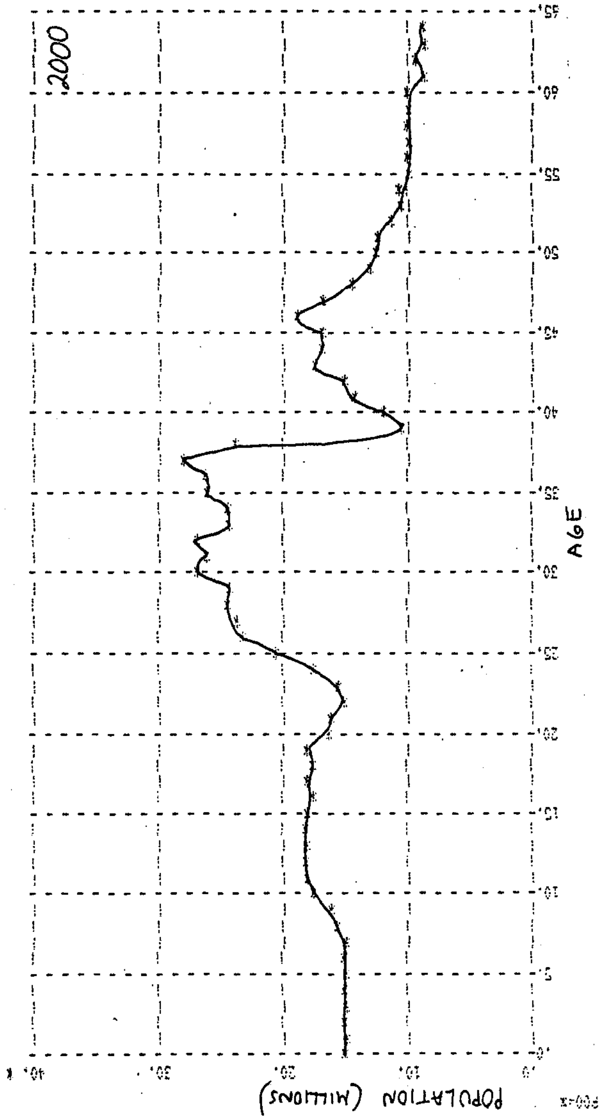


Figure 12b. Simulated age structure, 2024

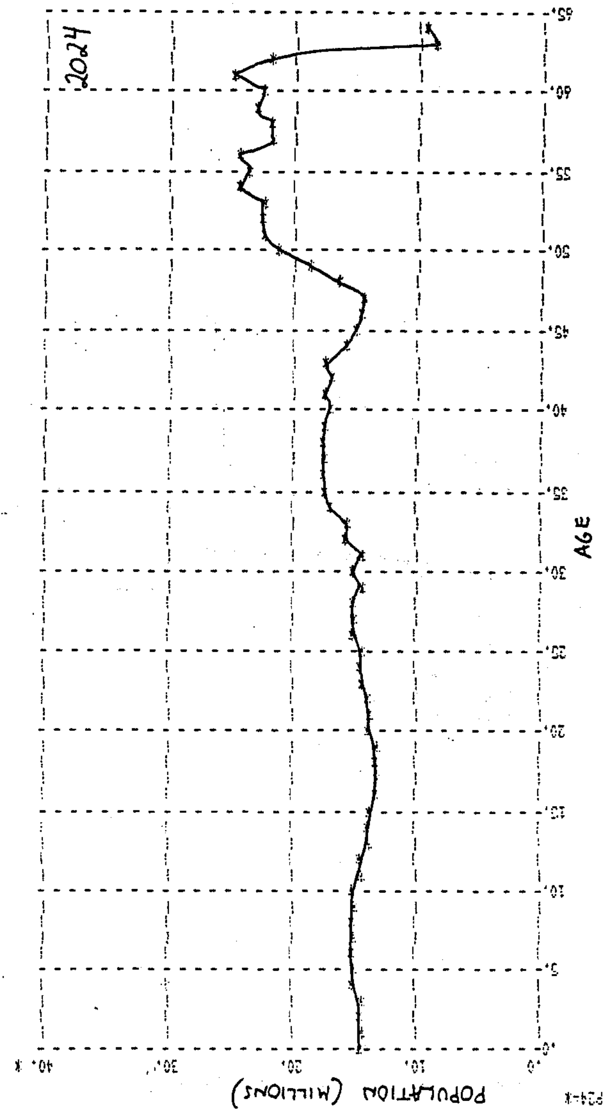


Figure 12c. Simulated age structure, 2050

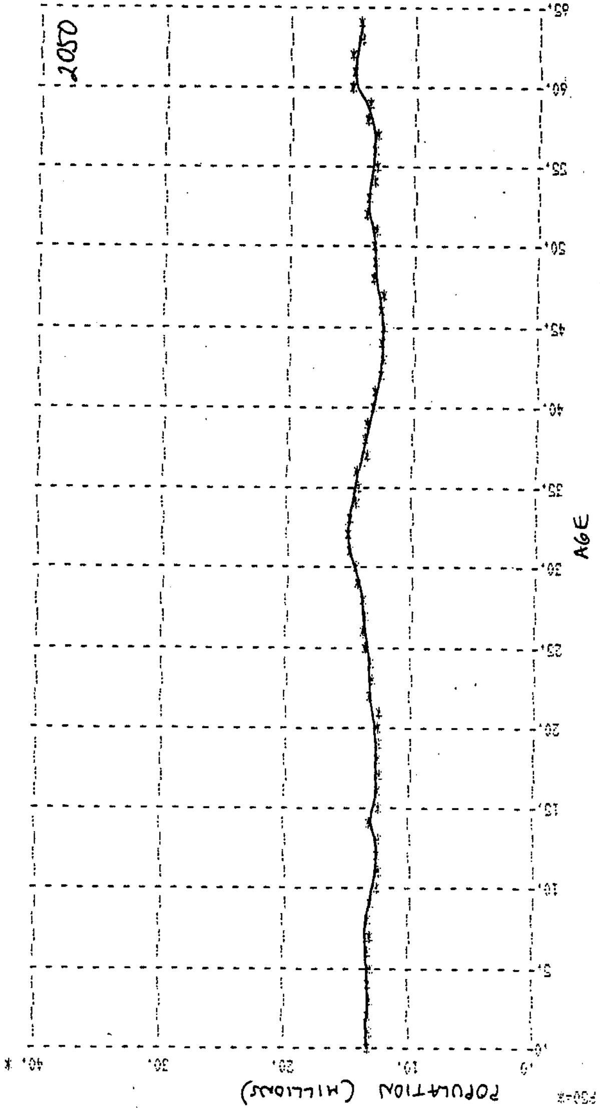


Figure 12d. Simulated age structure, 2078