

A SIMULATION MODEL OF POPULATION AND AGRICULTURAL  
GROWTH IN A DEVELOPING COUNTRY

A CASE STUDY OF PAKISTAN

by

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Submitted in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

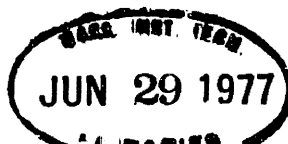
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Submitted to the Operations Research Interdepartmental Program of the Massachusetts Institute of Technology on February 17, 1977 in partial fulfillment of the requirements for the degree of Master of Science in Operations Research.

Abstract

In recent years the population issue has been the subject of much debate and discussion. The World Population Conference at Bucharest (1974) highlighted the different views on the subject of population, particularly the population of the developing countries of the Third World.

Although the views expressed were very diverse and, at times, diametrically opposed, there was a general consensus that the population issue could not be studied in isolation from the socio-economic conditions. This work will try to study the interrelationship of population and development and will concentrate primarily on agricultural growth in a developing country.

The analysis shows that unless the standard of living of the rural people in a developing country is increased many times the present, it may not be possible to bring down the population growth rate in the rural areas.

In an agrarian economy unless a just, equitable distribution of wealth is realized, unless labor intensive techniques are employed to harness the energy of the masses, and unless a restructuring of the socio-economic structure through massive land reforms takes place, there is not much hope that birth rate and death rates can be lowered by agricultural development alone.

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ACKNOWLEDGEMENTS

The author wishes to thank her thesis supervisor Professor Glen Urban, whose constant encouragement and guidance led to the final shape of the study. Professor Nazli Choucri of the Political Science Department, M.I.T., introduced me to the subject of population and development and the faculty of the Operations Research Center, M.I.T., provided me with skills to undertake this study. I would also like to add a note of thanks to my fellow students at the Operations Research Center for their encouragement. Special thanks to Ms. Annie Cooper who typed the manuscript with a great deal of patience.

My deepest gratitude to my family in Pakistan whose support made it possible for me to study at M.I.T.

Finally a very special "thank you" to my husband Nesar, for his encouragement, suggestions and forbearance that enabled me to complete this work.

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## INTRODUCTION

Demographers, social scientists, economists politicians, all seem to be interested in the issue of population growth. A wide range of multi-disciplinary subjects have evolved which attempt to study various aspects of the population issue.

Social scientists are interested in the historical perspective, economists in modeling the relationship of socio-economic-demographic variables, politicians and governments are trying to politicize the issue. In short it is being increasingly realized that the issue of population growth cannot be studied in isolation from other problems of development.

There is a wide variety of topics that can be discussed under issues of population and development in the developing countries. Studies have been undertaken both at the macro-economic and the micro-economic levels.

These studies attempt to examine the historical and socio-economic conditions that have led to present day demographic patterns. Some try to establish correlates of fertility, while others concentrate on determining the impact of rapid population growth on the economy.

### Objective of the study

The objectives of this paper can be summarized as:

1. a) To discuss the population issue and socio-economic factors affecting population growth in developing countries,  
b) To examine typical socio-economic demographic models.
2. To construct a model relating population and agricultural growth in an agrarian, developing society and

- a) To examine whether the population growth can be slowed by expanding investment in the agriculture sector,
- b) whether the lag between population growth and development is so large that even if the standard of living of the people is raised, the population does not stop growing.

The analysis will use population trends from a typical developing country with rapid growth patterns and whose economy is primarily agrarian. Pakistan has been chosen to represent a such a country.

In this study various aspects of the population issue will be presented. Chapter One described the historically different trends of population in the developed and developing countries and the possible factors relating these trends and socio-economic conditions. The second chapter presents the issue of population control vs. development, the diversity of views at the Bucharest Conference (1974) and the experience of the People's Republic of China with population planning programs.

In chapter three a critical survey will be made of Economic- Demographic models. This is followed by an introduction to the issue of population growth and agricultural development, (Pakistan as a case study in chapter four.

In the next chapter the heart of this study is presented. Here a population and agricultural production model is constructed. Data from Pakistan, whenever available has been used.

A discussion of the results and recommendations for further study are presented in the concluding chapter.

CHAPTER ONE

The Population Issue: A Historical Perspective

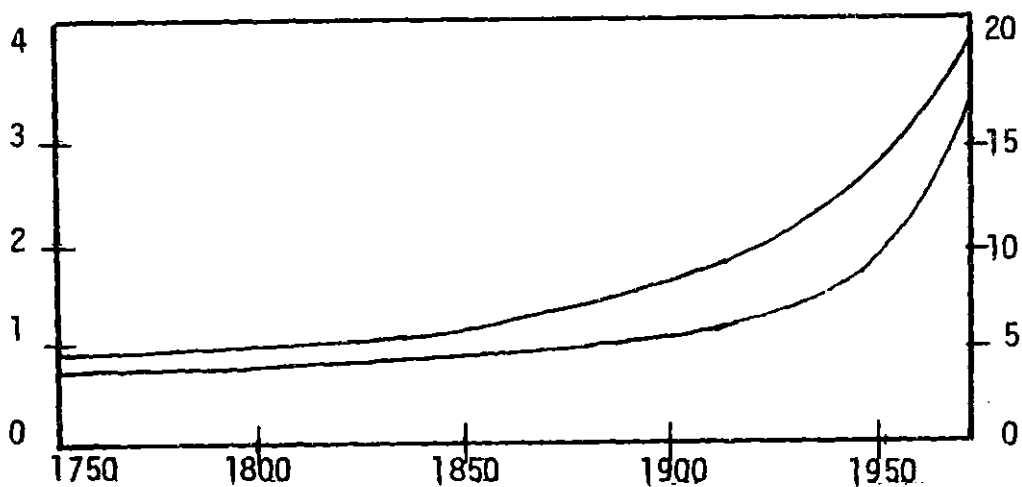
Differences between the population trends in the developed and developing countries of the world

Despite the long history of mankind, most of the human population growth has occurred during the past three hundred years or so. "[The] Period since 1750 is characterized by rapid and rapidly accelerating growth in the size of the world population. This period represents only about .02 percent of man's history, yet 80 percent of the increase in human numbers has occurred during it. Moreover, within this period, the rate of increase has climbed drastically in very recent times: it has doubled in the past 25 years"<sup>1</sup>

The change in the demographic structure has affected both the developed and the developing countries. However, the two depict significantly different demographic trends. As far as the situation in the more developed countries (MDC's) goes; "These populations, a little more than a fourth of the human species, may be well on the way to long term numerical stability... the average life expectancy at birth has climbed to more than 70 years... (with population growth) rates that not only are low (less than 1 percent) but also are still falling."<sup>2</sup>

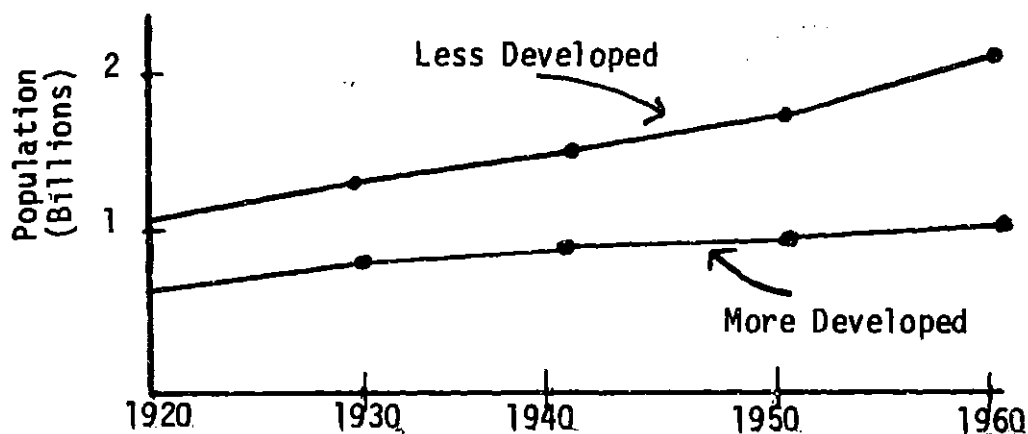
The situation in the less developed countries (LDC's) is however quite different. "The principal impetus to world population growth comes today from the underdeveloped countries where nearly three-fourths of

Figure 1.1: The History of the Human Population



Source: Ansley J. Coale, "The History of the Human Population," Scientific American, September, 1974, Vol. 231, No. 3, p. 42

Figure 1.2: The Population of the Less Developed and More Developed Countries



Source: Kenneth F. Smith, "Population Dynamics: A Computerized Simulation for Policy Analysis, Unpublished Master's Thesis, Political Science Department, M.I.T., 1970, p. 19

mankind dwell. Death rates in those countries have been falling over the past 25 years toward the low levels of the developed countries. Birth rates, however, remain twice as high as they are in the developed countries. The result is a population increase averaging 2.5 percent and in many countries exceeding 3 percent."<sup>3</sup>

Among the popular causes cited for the differences in demographic trends is the theory of Demographic Transition. In explaining population trends in the MDC's Westoff states that

"The balancing of [these] vital rates at very low levels can be viewed as the end of a major demographic transition, a process involving the entire economic development and accompanying transformation of social institutions..."<sup>4</sup>

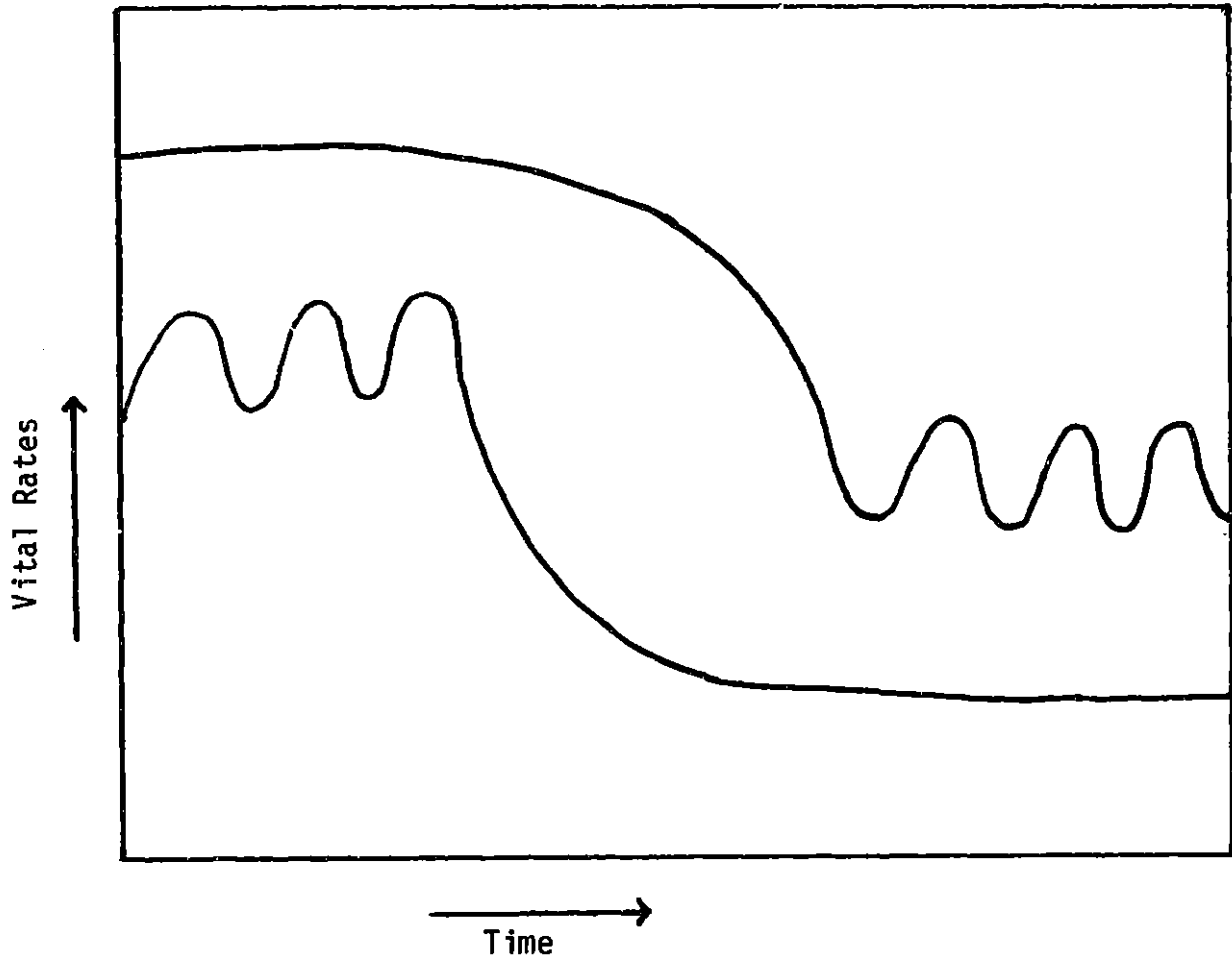
#### The Demographic Transition Theory

The ideas of this theory are summarized in Fig. (1.3).

"The demographic transition, (represented schematically) is the central event in the recent history of the human population. It begins with a decline in the death rate, precipitated by advances in medicine (particularly in public health), nutrition or both. Some years later the birth rate also declines, primarily because of changes in the perceived value of having children. Before the transition the birth rate is constant but the death rate varies; afterward the



Figure 1.3: The Demographic Transition



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Source: Ronald Freedman and Bernard Berelson, "The Human Population" in Scientific American, September, 1974, Vol. 23, No. 3, p. 49.

death rate is constant but the birth rate fluctuates. The demographic transition usually accompanies the modernization of nations; it began in Europe and the U.S. late in the 18th century and early in the 19th, but in the underdeveloped nations it began only much later, often in the 20th century. In the developed countries the transition is now substantially complete, but in much of the rest of the world only mortality has been reduced; the fertility rate remains high. In the interim between the drop in mortality and fertility population has increased rapidly."<sup>5</sup>

Factors contributing to decline in natality in the developed countries of the world.

The decline in natality in the developed countries of the world has been brought about by changes in the economic, social and cultural set up. Guzevatyi<sup>6</sup> has noted that some of the factors contributing to this decline are

- i) The considerable decline in infant mortality.
- ii) The disintegration of the patriarchal peasant family and disappearance of the economic importance of children for the family economy.
- iii) The legislative prohibition of child labor and introduction of compulsory schooling and increased expenses of child rearing.
- iv) The development of the system of social security for old age.
- v) The emancipation of women, their growing involvement in social production, education, political and cultural life.
- vi) The increase in the social mobility of youth, its growing desire to acquire a higher education and the resulting higher age at marriage.
- vii) The growing material and cultural demands of spouses as a result of the general improvement in the condition of life.

viii) The technical-scientific revolution in the modern world which makes society more interested in qualitative than in quantitative characteristics of population and which considerably complicates the task of childrearing, places new responsibility on parents and finally contributes to the formation of families with fewer children as the standard of modern demographic behaviour.

Thus economic and cultural progress and the level of development determines, through numerous factors and relationships, the demographic patterns of low mortality and low natality in the developed countries of the world.

Developing countries: Factors relating population trends and socio-economic conditions

Studies at a micro-economic level

The studies on population and economic growth at a micro-economic level have mainly focused on the consequences of rapid population growth.

Topics such as the Age Structure dependency effect have been analyzed in detail by Coale and Hoover.<sup>7</sup> Other topics studied are the sib number effect, which considers the consequences of the number of children per family; the sib-spacing effect; parent mortality effect, effects of one or both parents being absent during nurture or schooling period and the replacement effect.

Some experiments have been conducted to study the relationship between intelligence and family size (Anne Anastasi, and J.A. Scott).<sup>8</sup>

Paul Schultz<sup>9</sup> has built a model of family behavior to study the 'value' of children. He sees children as a source of satisfaction to their parents; the value of these satisfaction depending on psychological, social and economic needs. Schultz criticizes Enke's<sup>10</sup> work where children are treated only as commodities and appear to be poor social investments. Schultz points out that there are both pecuniary and non-pecuniary returns from children; and that to parents children represent more than just consumer goods.

Robert Cassen<sup>11</sup> has studied the economics of family formation in India. He comments that there is very little systematic information on

what parents spend on their children or on how soon and how much net positive contributions are made by children. He adds that it is for economic reasons that the families in less developed regions have more children, for children are the poor man's greatest asset, the more children a peasant has the better his chances of improving the family's economic status.

One of the most interesting studies done on a micro-level to study the family formation patterns is by Mahmud Mamdani<sup>12</sup> who has presented a detailed analysis of families in a Punjab village in India. He shows that people from different occupational groups and income levels want more children for economic reasons: the better off want larger families so as to provide educational and professional careers for younger sons; the middle level cultivators hope that sons will earn enough to buy more lands or save them from hiring labor and for people in the lowest rungs of the economic ladder, children are their only assets.

Mamdani's work illustrates that this need for more children is linked to two other factors

- a) The need for old age security: In the present day socio-economic structure of the developing countries, children (specially sons) are still the chief means of old age security. It is therefore in the interest of parents to ensure a certain number of surviving children in order to ensure old age security.

b) The role of women: Women in most of the developing countries play a traditional secondary role. Although the rural woman works on the fields and farms she is still an economic liability in a traditional society. Most of the urban women are housewives and are not actively involved in the economic processes of production.

Their economic dependence on men enforces the preferences for sons. Many families will continue to have children unless a desired number of sons are born.

Although it seems plausible that tradition plays an important part in determining birth patterns, particularly at a micro level, the socio-economic necessity for people in developing countries to desire large families cannot be ignored; "the outdated social structure inherited from the epoch of colonialism characterized by widespread vestiges of archaic production relations, by the absolute prevalence of the poor, illiterate peasant population... by the lack of rights for women... by the absence of any social guarantees for old people and so on. In such conditions children constitute an economic necessity for the overwhelming majority of families..."<sup>13</sup>

Are the present day demographic patterns in the developing countries temporary?

Guzvatyi has suggested that the present day demographic patterns in the developing countries are temporary. The demographic experience of the developed countries has shown that economic and cultural construction on a wide scale lays down the material and psychological preconditions for a gradual decline in natality. He states that the transition from one type of population reproduction to another does not occur simultaneously and, so just as the developed countries have undergone the 'demographic transition' due to the richer socio-economic and political conditions so also will the developing countries. "...thus the demographic changes currently taking place in the developing countries represent a temporary stage in the transition of those countries from the pre-industrial type of population reproduction with its high natality and high mortality to the type of population reproduction that is prevalent in the industrially developed countries, with its low natality and low mortality."<sup>14</sup> This view, of course, presupposes that the underdeveloped countries will succeed in following the western policy toward social and economic reconstruction.

If social and economic factors play such an important role in shaping demographic patterns, what can be said about the importance or otherwise of the family planning programs? Should such programs be scrapped in favor of efforts towards industrialization? These questions are discussed in the next section.



The importance of family planning programs

Family planning programs are a way of providing information to the population about the methods of consciously planning the number of children desired. Their importance in the social structure cannot be ignored. They are necessary for the improvement in the welfare of mothers and children.

Governments of many developing countries are spending heavily on various family planning programs in an attempt to reduce fertility. However, the programs in most countries have not been successful.

Some of the possible reasons for this lack of success have been illustrated by Guzevatyi,<sup>15</sup> who states that measures in the field of birth limitation can be successful only if they are based on the general socio-economic and cultural transformation. Otherwise, they will not have any demographic effect, because no propaganda for having fewer children can reach its objective in the condition of the traditional peasant society, languishing in want -- feeling no real change in it's life, and thus having no motivation to change its customs with regard to family relations.

Among the main reasons for the failure of family planning programs in many developing countries the one that stands out most is the need for children for economic reasons, as labor and old age security.

Mahmood Mamdani<sup>16</sup> has reviewed the Khanna study carried out in the Punjab in India to evaluate the success of a controlled family planning program. He has criticized the KAP (Knowledge, Aptitude and Practice of

Birth Control) studies because the findings of these studies that "whenever asked, substantial proportions of married couples, approve family planning in principle, express interest in learning how to control their own fertility and say they would do something if they had appropriate means..."<sup>17</sup>

The vagueness of these findings only confirms the failure of that birth control program. Mamdani emphasizes that the failure of the program was a failure in understanding the social realities of rural life in developing countries. He interviewed people in the village and in his book cites examples to show that birth control contradicted the vital interests of the majority of the villagers. To them practising contraception meant courting disaster, for children were an essential economic need. Mamdani points out that people are not poor because they have large families, they have large families because they are poor. "Labor costs are the only variable part of a farmer's production costs, and they can be significantly lowered only by a large family. Every farmer knows that the cost of each child declines the more children he has. The benefits, on the other hand increase."<sup>18</sup>

One can conclude that the family planning programs are an important method of bringing about population control. But to insure their success, we must not ignore the kind of socio-economic factors which impede the implementation of these programs. In other words, efforts should be directed toward the elimination of those conditions which create the need and desire for more children. Alongside such efforts, the attempts

to implement family planning programs should continue, so that parents in the developing countries are made aware of the methods of consciously planning the number of children, when they desire to do so.

The preceding brief examination of different studies on population patterns in developed and developing countries indicates a general concern about the rapid population growth. However, the present day demographers, social scientists, economists and governments, are trying to relate the phenomenon to the socio-economic state of affairs.

Such an attitude was adopted at the World Population Conference at Bucharest (1974) where one of the main resolutions supported by all attending member states, was to view the problem in a socio-economic context. More of this in the next chapter.

CHAPTER TWO

Population vs. Development

Section 2.1: The World Population Conference at Bucharest (1974)

The United Nations World Population Conference held in Buchrest in August 1974, was the first conference of government representatives to consider the relationship of demographic problems and socio-economic development. It was attended by 136 member states of the U.N. and dealt with population policies and action programs needed to promote human welfare and development.

The principal emphasis at the conference and in the plan of action was on the need for economic and social development and for a more equitable distribution of wealth. The conference emphasized the need for viewing the population issue in a socio-economic frame work for development. It is evident for the statement of the principles of the Plan of Action.

"Population and Development are interrelated: population variables influence development variables and are also influenced by them; thus the formulation of a World Population Plan of Action reflects the international community's awareness of the importance of population trends for socio-economic development, and the socio-economic nature of the recommendations contained in this Plan of Action reflects its awareness of the crucial role that development plays in affecting population trends."<sup>19</sup>

Major viewpoints at Bucharest<sup>20</sup>

The two major opposing viewpoints that came to light were: the first regarding population as a priority and the second regarding development as a priority. The former represented the views of the developed countries (led by U.S.), while the latter represented views of most of the developing countries.

Among the Third World delegations, there were differences in viewpoints too. The majority of them, however, believed that demographic trends are defined by general socio-economic development. This viewpoint was based on two historical experiences.

- i) The European demographic transition.
- ii) The experience of the People's Republic of China.

These two very different historical experiences "were employed implicitly as models"<sup>21</sup> supporting the developmentalist viewpoint. The European demographic transition was used to show that fertility declines are a result of socio-economic transformation, even in the absence of any government support or policy. The success of the Chinese in reducing fertility was viewed to be the result of fundamental social and economic transformation after the Revolution.

Section 2.2: The Experience of the People's Republic of China<sup>22</sup>

The Chinese proclaim themselves as following the Marxist ideology. In this ideology "over-population" is never considered as a fundamental

problem or a hinderance to development. Other socio-economic factors such as maldistribution of income, exploitation of the laboring masses, etc. are blamed for proverty and underdevelopment. In other words, those who subscribe to this ideology prefer the "developmentalist viewpoint."

Despite the above ideological stance, the Chinese are making positive efforts to control their population. The experience of the Chinese is specially interesting because of the fact that it is a giant nation of about 800 million people, and it is instructive to see how population policies are carried out on such a vast scale.

In the People's Republic of China the term "planned birth" includes the practice of delayed marriage and contraception and, therefore, has a broader meaning than the term 'family planning' as used elsewhere.

Ever since the Cultural Revolution in China, the leaders have been confident that they could solve the "population problem" - if one existed. The Chinese do not view population in itself to be a problem and emphasize more the utilization of manpower to better the socio-economic conditions of the masses.

In the summer of 1953, the government initiated the first nationwide enumeration. The results became known in 1954 and the government announced in mid 1956 that it favored birth limitations. The programs ran into difficulty during the 'Great Leap Forward' due to drought and food problem and during the Cultural Revolution when a number of programs including birth planning had to be suspended while other more pressing political

and socio-economic matters were being handled. However, since early 1970's the programs have been resumed, expanded and intensified (Aird, Chen, Tein).<sup>23</sup>

The Policy of the People's Republic of China on the Population Issue

At the World Population Conference (Bucharest 1974), China took the position that 'overpopulation' alone is never the root cause of unemployment, poverty, starvation, a high mortality rate, etc. Nor has it alone been the cause of war. These problems were seen as being associated with imperialism, colonialism, neo-colonialism and hegemonism.

In China's view, economic development is necessary for a country to emerge from poverty and solve its population problems. It did not rule out the need for population policies and programs, or census taking and publication of statistics.

China insisted that all matters regarding population were internal affairs that "must be decided by each government in the light of the specific conditions of its own country. Some countries need to lower, and others to raise the rate of population growth to a proper extent. No uniformity should be imposed since conditions vary from country to country."<sup>24</sup>

The Chinese did not assert that rapid population growth posed no hinderance to socio-economic development but emphasized the combating of imperialism and hegemonism and developing the national economy and culture as the primary way of solving the population problems.

At the conference Dr. Huang made the following remarks. "On the basis of energetically developing production and raising the living standards of the people, China has developed medical and health services throughout the cities and country side and strengthened the maternity and childcare facilities, thus reducing mortality on the one hand and regulating the birth rate through birth planning on the other. Our birth planning is not merely birth control, as some people understand it to be, it comprises different measures for different circumstances. In densely populated areas, late marriage and birth control are encouraged on the basis of voluntariness, while active treatment is given in cases of sterility. In national minority areas and other sparsely-populated areas, appropriate measures are taken to facilitate population growth, while birth control advice and help are given to those parents who have too many children and desire birth control. Such a policy of planned population growth is in the interest of the thorough emancipation of women and the proper upbringing of future generations as well as of national construction and prosperity."<sup>25</sup>

#### Reasons for the need of population planning<sup>26</sup>

The government asserts that birth planning is important and is needed to:

- 1) Reduce the burdens of childbearing and household chores and allow more time to study Marxism-Leninism and Mao's teachings, as well as to acquire and improve job-related



skills and knowledge.

- 2) Release the energy of the young and masses for production, construction and defense, rather than diverting all their efforts into building families.
- 3) Regulate population growth to facilitate national development, raise living standards, and continue the Socialist revolution.
- 4) Protect the health of women and children and achieve better health and prosperity for the nation;
- 5) Insure and improve the welfare and quality of the next generation by permitting better education, health care and upbringing of the young; parents can provide better care for fewer children, while the state can provide better education, health care and employment for fewer youths.

The government motivates people by contrasting the pre-1949 living and health conditions with the present ones to show that under socialism it is no longer necessary to have many children in order to ensure the survival of a few and have security in old age.

#### Group Planning of Births<sup>27</sup>

The tactic used in birth planning is to "let the masses draw up their birth plans and follow them through." Suggested targets are transmitted through the organizational networks to local small groups who draw up their own plans to meet the target.

The local people plan for production, income distribution, reinvestment and social welfare and know the relationship between child rearing and costs to the local community. If the ward or commune leadership suggests that crude birth rate be brought down a few points from that of previous year the target is passed down to eligible couples in their production teams, residents' group or factory to plan how to meet such targets. Taking into account their population size, they calculate the number of births that would yield the proposed birth rate and then proceed to 'allocate' the birth among themselves (to decide who should have a child next year). Priority is given first to newly married couples, second to couples with only one or two children and third to couples whose youngest child is closet to age five. Adjustments are made throughout the next year if target cannot be met.

The system of birth planning was first developed in Shanghai in 1971-1972 and has spread rapidly to other cities.

#### Institutional and Social Changes Conducive to Birth Planning

Reduction in the need for sons as old age security<sup>28</sup>: The Chinese government has drastically reorganized the society and economy to create a classless society in China.

Since 1956 the means of production (land and assets) have been socialized turning every person into a wage owner. In the urban industrial sectors a generous retirement pension has been provided for the majority of retired workers. In the rural areas the commune provides, "five

guarantees" (food, clothing, shelter, medical care and burial) for childless old people. These steps taken by the government has established relatively equitable income distribution and has helped reduce the needs for sons as old-age security.

#### Removal of traditional parental dominance

The marriage law promulgated in 1950 prohibits arranged marriages and gives young people the right to choose their own partners. Further, the abolition of private property and land holdings (except small plot) which was a means of subordinating the young, has helped remove traditional parental dominance.

#### Emancipation of women

The government has worked for emancipation of women from their traditional subordinate dependent status through legislation and campaigns. It has encouraged women to work outside the home and called for equal pay for equal work. It has provided widespread childcare facilities, especially in the urban industrial sectors.

#### Education

The country's educational system has been expanded greatly. In the urban areas there is universal education up to junior middle school and in the rural areas there is universal schooling for at least four years.

TABLE 2-1

Demographic data of Selected Communes China 1972.

Commune	No. of house- holds	Population	Number of production brigades	Number of production teams	Crude birth rate	Crude death rate	Crude rate of natural increase	Number of married women of reproductive age
Sha-chiao, Sun-te Hsien, Kwangtung	15,200	66,000	22	296	27	7.32	19.68	6,577
Ch'i-yi, Shanghai	4,122	16,965	11	88	13.2	5.2	8	2,496
Tung-ting, Wu Hsien, Kiangsu		45,000	30	237	17.6	5	(13)	6,000
Nan-wan, Peking	9,473	39,000	16	135	25			
Nan-ying, Shanghai	6,800	27,000	17	164	14	4	(10)	3,500
Pa-yi, Shenyang, Liaoning	4,400	20,853	15	73			17	
Sze-chi-ching, Hangchow, Chekiang	4,656	21,890	10	105	16	2	14	3,328

Source: Pi-Chao Chen and Ann Elizabeth Miller, "Lessons from the Chinese Expensive: China's Planned Birth Program and its Transferability" in Studies in Family Planning, Vol. 6, No. 10, October 1975, p. 360.

### Reduction of Mortality

Health and sanitation programs along with improved living standards and more egalitarian distribution of food have reduced mortality, (Salaff The government's efforts to improve the socio-economic conditions of the masses, have created a social environment more conducive to the spread of contraceptive practices and small-family norms.

### Transferability of the Chinese Experience<sup>30</sup>

China's planned birth program is still in the experimental stage and there are certain points that have to be considered if one intends to apply Chinese methods elsewhere.

- i) China's planned birth organizational arrangements are integrated in a thorough political, economic and social restructuring of society.
- ii) The commitment of Chinese leadership to health and birth planning and the influence of administration and personnel down to the lowest levels seems to be unique.
- iii) Other countries do not have similar organizational capabilities or may not choose to use similar methods.

Chen and Ann Miller have analyzed the Chinese program to determine which measures might serve as models for action elsewhere. The recommendations emphasize the need for local adaptation before any

transfer of technique can take place.

The success of the program is attributed to the decentralization of family planning problems and the presence of a socio-economic structure conducive to widespread dissemination of population planning programs.

Chen and Miller have suggested some aspects of the program for services and delivery systems educational and motivational work which might be adopted by developing countries. However, they admit that the success is due to organizational capabilities and socio-economic system, other developing countries may not have similar economic structures or may not choose to use similar methods.

Factors that have been conducive to the implementation of birth planning programs such as reduced mortality, increase in literacy and emancipation of women have yet to be realized in many of the developing countries.

### Section 2.3: Achievements at Bucharest

To summarize the discussion on the World Population Conference at Bucharest, one can say that it's major impact was to synthesize varying viewpoints.

"The major theme that emerges from the Bucharest meeting is that population policies and programs must be pursued in the context of development and that population growth and development are integrated. Although this proposition has long been accepted by those in the field of population, it was evident that many delegates at the conference,

especially those from the developing world, felt that to date population and development had been treated as an either/or proposition and that a focus on the population problem was an attempt to deflect attention from development problems... Bucharest exposed and high-lighted two misunderstandings about panaceas in population that were seriously consequential for the discourse and beyond: 'population control is no panacea for development or for social problems; family planning is no panacea for population problems'...'<sup>31</sup>

### CHAPTER III

#### Economic-Demographic Models

Economic Demographic Models can be interpreted as an expression, in a systematic manner, of a set of interlinking relationships between economic and demographic variables. Such an expression need not necessarily be expressed formally in symbolic form or as a set of equations. The models in the literature are often not complete economic-demographic models, which include causal relationships in both directions i.e. expressing the impact of economic variables on demographic variables, as well as that of demographic on economic variables. Many are partial models; they are restricted to explaining only some part of the economic-demographic system.

The macro models consider the relationships between aggregate variables representing the whole economy, discussing the interrelationships between economy-wide aggregate economic and demographic variables. Micro-models relate to the behavior at the economic unit level. (e.g. Micro models of fertility discuss the fertility behavior at the household level).

A review of the literature on economic-demographic models reveals that there are three major types of models; purely analytical economic growth models, models describing income effects of fertility reduction, numerical simulation models which try to determine complex links between economic and demographic processes which cannot be solved by analytic tools. Other models are; investment oriented - trying to study investment patterns in industrialization, urbanization and agricultural expansion and



their possible relationship with demographic valuables. Cost benefit analysis to evaluate profitability of public investment projects under different demographic assumption; studies of trends in per capita under alternative population trends, fertility models, (studies at micro level), which are theoretical models of fertility behavior based on economic models of consumer theory.

Section 3.1: Introducing Demographic Variables into the Macro-Economic Framework<sup>32</sup>

One method for evaluating the economic impact of demographic change is by using economic growth models. The objective being to estimate the impact of a fertility decline on the future per capita income of the country. Comparison is made of results from a decline in fertility with the per capita income for a specified date, and the expected future per capita income with no decline in fertility. In this methodology demographic variables are introduced endogenously into a macro-economic framework. Schematically this process is described in Fig.

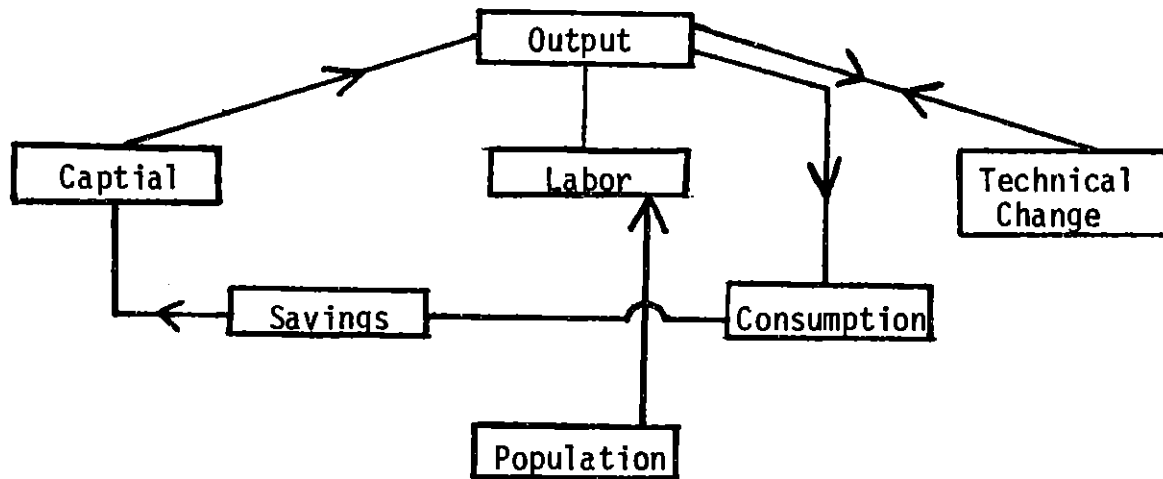
- 1) The total output of goods and services is determined by three factors of production:

Capital K, labor N and technical progress T

$$y = F(T,K,N)$$

Different models have different forms of this function. It could be a simple capital output ratio relating output only to income

Figure 3.1: Introducing Demographic Variables into the Macro-Economic Framework



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Source: U.N. Secretariat, "Economic-Demographic Models," in The Population Debate: Dimensions and Perspectives, Papers of the World Population Conference, Bucharest 1974, Vol. 1, (New York 1975).

or Cobb-Douglas functions with autonomous technical progress. The supply of capital arises through domestic savings. Savings is that part of income which is not consumed.

- 2) Population and its components influence these models through capital and labor. The influence of population on capital occurs through the consumption function

$$C = aY + bP^*$$

The consumption function is a function of income and  $P^*$  the "equivalent consumer population" (This function is usually linear).

- 3) Savings:  $S = Y - C$

Increment to capital formation:  $\Delta K = I = S$

- 4) Some of the models incorporate labor as an explicit determinant of output. The supply of labor is associated to the age-sex specific labor force participation of the form

$$L = \sum_i (p_{mi} P_{mi} + p_{fi} P_{fi})$$

where  $p_{mi}$ ,  $p_{fi}$  are the male and female labor force participation ratio of the  $i^{\text{th}}$  cohorts  $P_{mi}$  and  $P_{fi}$  respectively. It is argued that labor would always be available given the supply of capital and therefore it should not be incorporated in the production function.

Examples of this type of models are the Coale-Hoover,<sup>33</sup> Demeny<sup>34</sup> and Enke<sup>35</sup> models. The Coale-Hoover model had fertility decline as an exogenous variable and then studied the impacts on per capita income in India. Demeny treated fertility decline as an endogenous variable and argued that reduction of fertility requires demographic investments. He used a model similar to Coale-Hoover with two trends of fertility, one where GRR reduced from 3.0 to 1.5 over 25 years and the other where fertility remains unchanged.

Enke has developed a similar model with two population trends. The main difference from the Coale-Hoover model is the production function. In addition to capital, labor and a constant rate of technological change are introduced into this function. The labor input is specified in two ways:

- i. The economically active labor force is determined by using constant age-sex specific participation rates.
- ii. The rate of growth of employment is assumed to be proportional to the rate of growth of capital. This proportionality is related to the employment rate. The relationships between labor force, capital stock and unemployment being,

$$\frac{\Delta N_t}{N_t} \div \frac{\Delta K_t}{K_t} = h \frac{U_t}{U_0}$$

where

$N_t$  = employment

$K_t$  = capital stock

$U_t$  = unemployment rate in period  $t$

$h$  = constant.

### Section 3.2: Fertility Models

These are micro-economic demographic models which are intended to explain fertility behavior at the family unit level, rather than at the economy-wide level. Mincer and Easterlin<sup>36</sup> developed early empirical models in this area. Mincer studied the determinants of fertility at a micro level. The relationship used was

$$x_0 = b_1x_1 + b_2x_2 + b_3x_3$$

where

$x_0$  = fertility

$x_1$  = sum of husband and wife's earnings

$x_2$  = wife's opportunity costs

$x_3$  = number of years of husband's schooling

(used as a measure of his knowledge of  
contraception)

For a sample of 400 employed urban white families he found the income effect on fertility to be positive, the wife's opportunity costs as well as the education effect to be negative.

The theoretical models of fertility behavior have evolved around the economic models of consumer behavior. They postulate that households maximize some 'utility function', where children with other consumer goods appear as arguments.

Leibenstein<sup>37</sup> has identified three types of utilities generated by children

- Utility as a consumer good, personal satisfaction and psychic pleasure of parents
- Utility as a productive agent, the child's contribution to the family income after entering the labor force and
- Utility as a potential source of security either in the old age of parents or otherwise.

These classification of utilities is useful for the analysis of fertility behavior in developing countries, however any theory relating to the behavior in developing countries must also incorporate other social factors which may represent tradition and customs particular to a country.

### Section 3.3: Example of Neoclassical Economic Growth Model

Solow and Swan<sup>38</sup> suggest models of economic growth which considered population growth as constant and exogenous.

The production function for output was a linearly homogenous function of capital and labor

$$y = F(K,L)$$

$$Y = \text{output}$$

K = capital

L = labor

The labor growth was assumed to be exponential and exogenous

$$L = e^{nt} L_0$$

where

L = labor

n = rate of growth of population

$L_0$  = initial population

By assuming that the savings rate was constant and that there were constant returns to scale, they demonstrated that the equilibrium growth of capital and of income would be the same as the rate of growth of the labor force. Out put could increase indefinitely as the labor force grew if there were no diminishing returns, and a constant per capita income would be maintained. The level of this per capita income depended on the rate of growth of the labor force.

The slower the rate of growth of the labor force, the greater the equilibrium level of income per capita, whatever the absolute size of the population maybe. Possibilities of higher per capita income through greater savings rate, technological change, or sufficient economies of scale were not considered within this analytical framework.

Section 3.4 Example of Macro-Economic Simulation Models

Classical Model

Coale-Hoover Model<sup>39</sup>: This was a pioneering work in the field of Macro-Economic Simulation Models. It was the first study which demonstrated the relative magnitude of the differences which would be expected in per capita income under alternative "fertility paths."

Their model is a simple Keynesian accelerator model with two equations and two unknowns. Their fundamental income equation was

$$Y_t = Y_{t-1} + \frac{I_{t-1}}{R_{t-1}} \quad (1)$$

where

- $Y_t$  = income in period t
- $I_{t-1}$  = lagged investment
- $R_{t-1}$  = lagged marginal capital-output ratio.

The savings function is based upon savings per equivalent consumer and income per equivalent consumer.

$$S_t = C_t \left[ \frac{S_0}{C_0} + a \left( \frac{Y_t}{C_t} - \frac{Y_0}{C_0} \right) \right] \quad (2)$$

where

- $C_t$  = number of adult equivalent consumer
- $a$  = marginal propensity to save out of  
relative income increases per consumer



Zero subscripted variables refer to initial conditions.

Eqn (2) can be rewritten as

$$S_t = aY_t - \left( \frac{aY_0 - S_0}{C_0} \right) C_t \quad (2')$$

It is clearer in this form that the rate of savings is assumed to be always lower if the number of equivalent consumers is greater. Thus size of population and savings rate are inversely related. This is an assumption and not a conclusion of the model.

Coale and Hoover used Indian data to calculate the parameters for the second term of the right hand side of (2') under an assumption that the marginal propensity to save would use to average .3 over the planning period. Their calculated form of the savings function was

$$S_t = .3Y_t - 49.27C_t \quad (2'')$$

The demand for investment and supply of investment both were a function of income. They divided investment into two components;

- a) "welfare" investment for education, housing and other social services and
- b) directly productive investment welfare (demographic) investment depended on sheer population size and rate of growth and was divided into investment for current expenses on population (maintenance) and investment to equip new additions to the population.

The investment equation

$$I_t = D_t + (e_c W_{ct} + e_t W_{it})L_t + (e_c W_{ct-15} + e_i W_{it-15})(1-L_t) \quad (3)$$

where

- $D_t$  = directly productive investment - (residual)
- $W_{it}$  = welfare investment for incremental expenses
- $W_{ct}$  = welfare investment for current expenses
- $L_t$  = size of the labor force
- $e_c$  &  $e_i$  = growth contribution weights of current  
and incremental welfare investment respectively.

Assumption:

$$W_{ct} = .0725I_t$$
$$W_{it} = 10w_{ct}$$

Coale and Hoover recognized that productivity of investments lagged by significantly different periods depending on whether they were made for children or working age population. They therefore, specified coefficients ( $e_c$  and  $e_i$ ) which would give each class of investment its relative weight it contributing to income growth, a species of relative growth elasticity of investment.

Thus  $e_c$  and  $e_i$  were given the following arbitrary values

$$e_c = 5.0$$

$$e_i = 0$$

This is a highly questionable assumption for it implies that investments in additional schools to meet growing school age has zero productivity for the economy.

Eqn (3) can be viewed as stating that productive contribution of available investment will depend upon its allocation among directly productive investments, demographic investments for the labor force and lagged demographic investments for the remainder of the population.

The Unknown Variables of the System: Since welfare investments were simple functions of income and the population size and since the population size is determined exogenously, the only two unknowns of the system are income and investment.

Coale and Hoover implicitly equated savings and investment as noted by Conroy and Folbre.<sup>40</sup>

Assumption:

$$S_t = I_t$$

Substituting eqn (2') into (1)

$$Y_t = Y_{t-1} \frac{aY_{t-1} - \left( \frac{aY_0 - S_0}{C_0} \right)}{R_{t-1}} C_{t-1}$$

Let

$$b = \frac{aY_0 - S_0}{C_0}$$

Then

$$Y_t = \left(1 - \frac{a}{R_{t-1}}\right) y_{t-1} - \left(\frac{b}{R_{t-1}}\right) C_{t-1} \quad (4)$$

As long as  $b > 0$  (Coale and Hoover used  $b > 0$ ) eqn (4) implies that the larger the value of  $C_{t-1}$ , the smaller is  $Y_t$ .

The model assumes that the larger number of adult-equivalent consumers will always be associated with a slower rate of growth in either total income or per capita income.

The model as specified by Coale and Hoover could not have produced the result that the faster growing populations had higher incomes.

### Section 3.5: A More Recent Example of Macro-Economic Simulation Models

The Enke Bennett TEMPO Model<sup>41</sup>: A number of studies of this type have been undertaken in the General Electric TEMPO Center for Advanced Studies. The models of TEMPO type are generally used in Coale-Hoover manner to show the differences in per capita income, capital stock, unemployment etc., in high fertility and low fertility populations.

The Basic (Original) TEMPO Model: "An initial proportion of the labor force is assumed to be employed. The initial values of employed labor and the stock of capital, determines the GNP the total domestic production of the economy during the first year of the projection. A standard Cobb-Douglas production function determines the GNP associated with given amounts of capital and employed labor. Technological progress is

introduced by increasing the GNP by a fixed percentage each year. The yearly GNP is divided between total consumption and net investment... The size of consumption is determined by the level of GNP, plus the size and age of composition of the population. The effect of the age composition on consumption is taken into account by "equivalent consumers" as the population term in the consumption function. In the computation of equivalent consumers, each member of the work-age population is considered a full equivalent consumer. The old and the young are given smaller weights. The proportion of GNP not consumed represents net investment. The sum of the stock of capital available at the beginning of the year and net investment during the year gives the stock of capital at the beginning of the next year. The growth of the capital stock and the labor force determines the growth in employed labor. The available capital and employed labor determine the economy's GNP during the following year. The process is repeated each year for the duration of the projection."<sup>42</sup>

The Enke and Bennett Model uses a production function which is a lagged Cobb Douglas production function

$$Y_t = z(1 + q)^t K_{t-1}^u N_{t-1}^v$$

where

Y = real gross national product

z = scale constant

q = rate of technological change

K = real value of capital stock

N = employed labor

u,v = respective output elasticities

(Variables are in upper case and parameters in lower case letters)

Parameters      q = .015

                  u = .3

                  v = .6

Thus the model assumes that India would encounter significant diminishing returns to output over the 40 years simulation.

The employed labor

$$N_t = 1 + g \left( \frac{K_t - K_{t-1}}{K_{t-1}} \right) N_{t-1}$$

where

$$g = h \left( \frac{1 - \frac{N}{L} t-1}{1 - \frac{N}{L} t} \right)$$

where

h = measure of factor substitution

h = .9

Setting h=19 the authors tried to reflect "the intention of the Indian development policy that capital stock grows faster than employed labor."

Capital stock

$$K_t = K_{t-1} + I_t + FI_t$$

where

$I_t$  = instantaneously realized domestic  
investment

$FI_t$  = instantaneously realized foreign  
investment

There was no specification given for foreign investment.

Net investment expenditure

Net investment = savings  
= output-consumption

$$I_t = Y_t - C_t$$

The consumption function

$$C_t = aY_t + b \sum_{i=1}^{16} P_{it} e_i$$

where

a = marginal propensity to consume out  
of income.

b = marginal additional share of income  
attributable to each weighted consumer.

$e_i$  = consumption weights for each  
age and sex group.

The parameters a and b were assigned arbitrary values

$$a = .85$$

$$b = 19$$

Enke and Bennett did two comparable simulations one in which gross reproduction rate remained constant at 2.69 and the other in which GRR declines exogenously to 1.50. They came to the following conclusions.

The simulated fertility decline would produce a population in 2001 with 29.6% fewer persons, with 31.7% fewer persons in urban areas, a 66% smaller ratio of children to working age population, and a 21.1% increase in the proportion of the total population in the labor force.

- i) Total output per person in 2001 would be 34% higher under the simulated decline than it would have been under constant fertility levels.
- ii) Each employed person would be complemented by 16 percent more capital in the smaller population.
- iii) By 2001 the population below an arbitrarily chosen poverty line of 160 rupees per person would fall under fertility decline from 110 million to 34 million, rather than to just 88 million under constant fertility.



Section 3.6: A Re-Specification and Re-Estimation of a TEMPO-like Model based on Enke and Bennett Model

Conroy and Folbre<sup>43</sup> have attempted to recreate the Enke and Bennett model by removing some of the inherent biases in the Enke-Bennett model against population growth. They encountered "difficulty due to typographical errors and absence of parameter specifications in the TEMPO models."

In the production function of the Enke Bennett model

$$Y_t = z(1 + q) K_{t-1}^u N_{t-1}^v \quad (1)$$

$q=.015$ ,  $u=.3$  and  $v=.6$  were specified but there was no lagged initial conditions for (real value of stock)  $K_{t-1}$  or (employed labor)  $N_{t-1}$  assigned. Also no value was specified for the scale constant  $Z$ . The initial conditions for  $t_0$  (1961) were given. The authors assumed  $K_{-1}$  and  $N_{-1}$  equal to  $K_0$  and  $N_0$  and estimated the value of  $Z$ .

$$Z = 6.28.56$$

In the equation for employed labor

$$N_t = 1 + g \left( \frac{K_t - K_{t-1}}{K_{t-1}} \right) N_{t-1}$$

The Enke Bennett article suggested a value of  $g$

$$g = h \left( \frac{(1-N/L)_{t-1}}{(1-N/L)_t} \right)$$

The authors Conroy and Folbre point out that this would require simultaneous rather than sequential solution and is at variance with all other descriptions of the TEMPO model. They set a value of

$$g = h \left( \frac{1 - \frac{N_{t-1}}{L_{t-1}}}{1 - \frac{N_0}{L_0}} \right) \quad (2)$$

(This was based on the TEMPO document "Description of the Economic-Demographic Model" 68TMP-120 revised pg. 27). The parameter  $h=.9$  (measure of factor substitution) in the Enke-Bennett model. Conroy and Folbre point out this parameter specification is confused on two accounts for

- i) it is  $g$ , not  $h$  in eqn (2) which relates the growth of capital to unemployment generated 'h' merely relates the relative rate of unemployment to the employment coefficient.
- ii) Setting initial value of  $h=.9$

$$\text{i.e. } \frac{N_{t-1}}{L_{t-1}} = \frac{N_0}{L_0}$$

suggests that the government will seek to introduce capital intensive techniques irrespective of the rate of unemployment. This is a bias against possible labor intensive technology available from a growing population.

A further bias against population is introduced in the consumption function. It is assumed that two countries with equal GNP but different population size are such that the country with the larger population will necessarily consume more

$$c_t = aY_t + b \sum_{i=1}^{16} P_{it} e_i \quad (3)$$

Enke-Bennett set  $a=.85$  and  $b=19$  without discussion. A range of value of  $e_i$  (consumption weights for each age and sex group) were discussed but no specific value was given in the reported results.

Conroy and Folbre set  $e_i=.75$  for all women and for male children and elderly and  $e_i=1.0$  for all working age males.

The authors assumed the same values of the size of the labor force as Enke and Bennett. They started with the same populations and birth and survival rates of the Enke-Bennett model, to obtain the same intermediate and terminal gross reproduction rates. The absolute and relative size of the authors' alternative populations differ from Enke and Bennett Model. The proportions in the labor force and the ratios of children to working-age population are similar. The Conroy-Folbre model with these specifications, generated much lower absolute levels of output but similar ratios of most of the common economic variables as Enke-Bennett. The results of the author's basic model had similar specifications as Enke and Bennett. Conroy and Folbre then introduced a population-neutral consumption function by setting  $b=0$  in eqn. (5), thus consumption becomes a simple function of income. Conroy and Folbre took into account the possibility of

introducing labor-intensive technology to alleviate unemployment by setting the initial value of the 'employment coefficient'  $g=1.1$ . They also introduced a lagged endogenous fertility decline, reducing all age specific birth rates by .2% for each 1% by which per capita income rose during the preceding five years.

A comparison of the results of the Enke-Bennett and Conroy-Folbre model indicates that if either the population-neutral consumption specification or the labor-intensive specification are introduced the endogenous fertility declines generate per capita income in 2001 which are from .4% to 4.3% greater than those associated with exogenous decline. In each of the three alternative specifications, the population which experienced endogenous decline in fertility completed the 40 year period with 2.2% larger NNP, larger populations, higher income per capita and almost identical capital stock. In the population-neutral, labor intensive specification the GRR reaches 1.5 nearly five years earlier than the date called for by exogenous decline.

The authors concluded that simulation of income growth under alternative fertility regimes which omit the possibility of endogenous fertility decline are misspecified. The magnitude of endogenous fertility decline likely under conditions comparable to those of some of the presently poorest nations may be considerably greater than has been suggested to date.

The Coale-Hoover model has been specified with the savings rate declining as the population grows and with the capital-output ratio rising at the same time. This is a double bias against the contribution of

population. The constant high fertility assumption has also been used in the TEMPO models, which also uses a savings function which is biased against population growth. A respecification of some parameters and equations in the Enke-Bennet model by Conroy and Folbre have produced very different and optimistic results.

The Conroy-Folbre study is specially useful for it illustrates that many assumptions inherent in economic growth and simulation models are biased against increasing numbers. Possibilities of labor intensive techniques are not taken into account. It is assumed that the larger the population the lesser the savings; these assumptions may not necessarily be true in many situations.

### Section 3.7: Birth Cohort Analysis

"Tracing the history of a cohort from birth, through marriage and childbearing to death, has proved to be a fruitful way of looking at demographic processes -- the cohort approach can also be applied to capital stock formation. A cohort orientation toward the human stock or population may have, as a natural counterpart, a similar orientation toward the capital stock in models of demographic-economic system."<sup>44</sup>

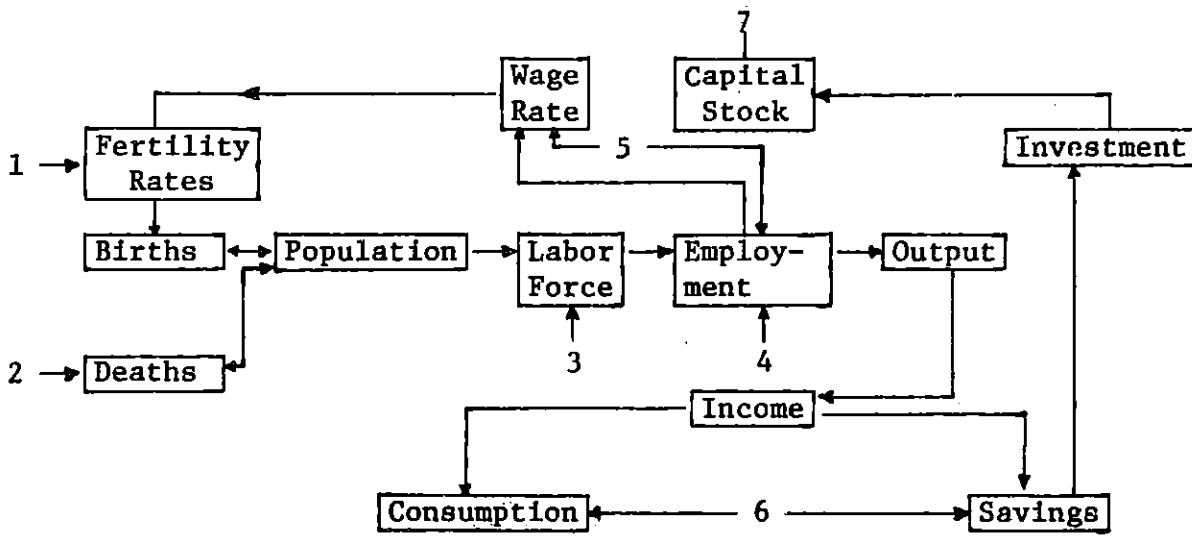
Denton and Spencer<sup>45</sup> have constructed a model of the Economic-Demographic Macro system. The basic concept is the 'birth cohort' defined as a group of persons born in a given time period.

1. General characteristics of the Denton-Spencer Model

The model consists of demographic and economic sub-models, both of which are of a macro variety and both of which are non-stochastic. The demographic submodel receives exogenously specified values for the total fertility rate and the rate of net immigration and generates values for population, by age and sex.

The population variables are fed into the economic submodel and values for labor and capital inputs, output, investment, consumption and other economic aggregates are generated. In the first phase the model does not allow for any feed backs from economic to demographic variables. Simulation is done for various patterns of fertility and immigration change. The model is then modified to allow the level and distribution of income to affect the fertility rates of women of different ages, and hence affect the rate of population growth.

Fig. 3.2: The Denton Spencer Model.



Source: Frank T. Denton and Byron G. Spencer, Population and the Economy, (Lexington, MA, 1975).

Description of Fig. 3.2.

1. Death rates
2. Parameters of fertility function
3. Labor force participation rates
4. Employment rates
5. Parameters of production function

## 2. Fertility and Wages

The influence of economic factors on population takes place by making fertility rates (annual births per woman) as functions of male wage rates.

$$f_{jt} = f_j^* \left( \frac{w_{1,j+2,t}}{w_{1,j+2}^*} \right)^\xi \quad j = 15, 16 \dots 49$$

$$f_{jt} = 0 \quad j < 15$$

$$j > 49$$

The fertility rate for women of age  $j$  is related to the wage rate for males of age  $j+2$ , because of the tendency for husbands to be somewhat older than wives.

$w_{1,j+2,t}$  = actual male wage rate, expressed as a ratio to the wage rate in the stationary state ( $w_{1,j+2}^*$ )

$f_j^*$  = multiplicative constant, equal to the stationary-state value of the fertility rate for women of age  $j$ .

$\xi$  = parameter representing the elasticity of the fertility rate with respect to changes in the husband's wage rate (assumed to be the same for all ages of women within the childbearing range.)



### 3. The Production Function

It is specified as a generalized Cobb-Douglas function of the form

$$Q_t = a \left( \prod_{i=1}^2 \prod_{j=14}^{79} E_{ijt}^{\beta_{ij}} \right) K_t^{1-\beta}$$

where

$$\beta = \frac{\sum_{i=1}^2 \sum_{j=14}^{79} \beta_{ij}}{\sum_{i=1}^2 \sum_{j=14}^{79} \beta_{ij}}$$

The labor force consists of people of ages 14 to 79.

$\beta_{ij}$  = proportion of total output received as wages by workers of sex  $i$  and age  $j$ .

$\beta$  = over all fraction of output assumed to go to labor.

$K_t$  = capital stock at beginning of year  $t$ .

$E_{ijt}$  = number of persons of sex  $i$ , age  $j$  employed at midyear of time  $t$ .

$a$  = parameter of the production function (possibly variable over time)

### 4. Wage Rate

The annual wage rate for individuals of each age sex is then determined by

$$w_{ijt} = \beta_{ij} \left( \frac{Q_t}{E_{ijt}} \right) \quad \begin{array}{l} i = 1, 2 \\ j = 14, 15 \dots 79 \end{array}$$

$Q_t$  = Total output during year  $t$ .

### 5. Basic relationships of the model

- i) The fertility rates are influenced by the wage rates, and are the parameters of the fertility function. The number of births is then determined by the population size and composition and fertility rates. The number of deaths is determined by the population and the fixed mortality rates. The population is last year's population adjusted for births and deaths (no migration allowed).
- ii) The labor force is determined by the participation rates of the population and the number employed (influenced by employment rates of the labor force).
- iii) The level of output is determined by inputs of labor and capital according to the specified production function.
- iv) Capital stock is the accumulation of undepreciated investment in each period is the amount of output not consumed.
- v) Wage rates are determined by the number of persons employed, level of output and parameters of the production function.

### 6. The simulation experiments and conclusions of the model

- i) The model is first put into a stationary condition by specifying an initial population, fertility rates to maintain this

population and setting capital stock such that gross investment equals depreciation.

- ii. All other variables are determined internally by the model given these initial conditions.
- iii. A variety of shocks are then introduced by means of different fertility patterns.

As the authors point out, the most noteworthy result is that the elasticity of fertility rates with respect to wage rates must be greater than 2 in order for the system to generate regular, self perpetuating cycles -- this implies that a one-fifth increase in the wage rate experienced by a given cohort would increase the fertility rate by about half.

The basic lead-lag structure of the cycles is not affected by parameter changes: labor force, output and capital stock all lag behind population and in that order. The relative magnitudes of the lags are influenced to some extent by the particular parameters specified.

Although the model tries to incorporate affect of economic factors on demographic trends, it still suffers from the general problems inherent in growth models which use the Cobb-Douglas production function (Refer to section 3.9). Also the lags specified imply that at most an increase in wages would increase fertility but would not be able to produce a decreasing affect.

### Section 3.8: Some Comments on Economic-Demographic Models

In the majority of the developing countries the first phase of demographic transition is being experienced with low mortality and high fertility. In the absence of Malthusian assumptions there is need for better socio-economic indicators than simple per capita income. Such indices of modernization as levels of literacy and basic infra structure of the society must be incorporated in the economic demographic models. Recent developments of micro models of fertility behavior treats children as 'durable consumer goods'. Also attempts have been made to evaluate 'cost of time' of parents in these models. Yet it is not clear how useful they are in explaining the behavior in developing countries.

### Growth Models of Developing Countries

Conventional theory of growth identifies four main sources of growth land, labor, capital and technical progress. Land is not considered a sufficiently important source of growth in modern economic theory (unlike it's importance in classical analysis). The recent growth models of developing countries concentrate only on capital. The role of labor and technical progress has not been adequately explained. Even though it can be argued that labor is not a contraining force of production in developing countries the technical progress factor cannot be ignored.

Nonconventional sources of growth such as education and health must be incorporated in economic demographic models.

Conroy and Folbre in a critical survey of economic demographic models, list some questionable assumptions generally found in most of a) Malthusian growth assumptions; b) arbitrary growth assumptions; c) the assumption that widespread dissemination of contraceptives is sufficient to reduce birth rates; d) simplistic definitions of costs and benefits e.g. definitions focused solely on income.<sup>46</sup>

In most of the analytical models the assumed effects of population growth are Malthusian i.e., increases in income per capita generates increases in population growth which tend to wipe out the former. In those studies in which population remains an exogenous variable, the assumed relationships deny, neglect or ignore recent studies that economic growth in recent years have had significant anti-Malthusian effects (i.e. fertility falls as income rises).

There is growing evidence that fertility has been falling significantly in response to increases in income and these trends could have significant sustaining impacts upon population growth by the end of the century. These studies partially confirm the theory of 'demographic transition.' Kirk<sup>47</sup> has noted that evidence accumulated within the last five years suggest that for a relatively small group of formerly high fertility countries, birth rates were coming down with increasing velocity. Hicks<sup>48</sup> found that in Mexico, increases in per capita income had a pronounced effect on fertility.

Repetto<sup>49</sup> found for a cross-section of 64 MDCs and LDCs that each 1% increase in per capita income is associated with .18% to .20% reduction

in fertility. In a cross-section analysis he found decreases in the Gini coefficient of inequality associated with significant decreases in fertility. Thus redistribution would amplify the effects of increases in income.

Beaver<sup>50</sup> found for a group of 24 Latin American Nations that economic expansion has a small positive immediate effect on fertility, but increases in income per capita lagged seven and a half, years had strong negative effects.

#### Population as exogenous

Most of the cost-benefit analysis treat population as an endogenous variable. Endogenous declines in fertility due to changing socio-economic conditions confound the cost benefit analysis of family planning investments and defeats the constant high fertility assumptions of Coale-Hoover and TEMPO models (refer to sections 3.5 and 3.6).

#### Capital as the prime source of growth

In analytical models the assumptions with respect to growth processes are often arbitrary. The assumption that income per capita is solely a function of the quantity of capital per capita is convenient but misleading. For it places undue emphasis on capital accumulation as prime source of growth.

#### Other sources of growth ignored

These models ignore other sources of growth such as the use of labor intensive technology and changing quality of the labor force.

The savings assumption

The traditional view is that faster population growth affects savings negatively. Large families and age structure (dependency) effects of high fertility depresses the rate of savings at the individual and aggregate level. Gupta<sup>51</sup> and Adams<sup>52</sup> demonstrated that such results were questionable. IBRD<sup>53</sup> reports that little is known about household savings habits in developing countries and even if data was available these savings have only a small share of total savings. Models with traditional savings view have another questionable assumption that any reduction in population growth will automatically result in additional consumption for the smaller population.

Alternative development patterns ignored

The assumption of constant or slowly rising capital-output ratios: Models with such assumptions assume that development will continue in a distorted capital intensive heavy industry oriented manner. They do not acknowledge that there are alternative development patterns based on re-organization of wealth, redistribution of income and wealth. They also neglect the fact that appropriate locally-oriented technology would induce substitution of labor for capital and absorb larger number of a growing population into a more productive labor force.

The Cobb-Douglas production function

Use of the Cobb-Douglas production function precluded the possibility of labor augmented technological change. Also the change it does permit increases the efficiency of capital and labor identically. Models with only one sector and two homogenous inputs do not permit any analysis of structural change.

Arthur and McNicoll<sup>54</sup> noted that the assumed production fn. is such that "the derivative of per capita output with respect to labor is always negative. An increase in population can therefore never pay it's way."

The Cobb-Douglas production function

$$y = AK^{\alpha}L^{\beta}$$

where

y = output

K = capital

L = labor

A,  $\alpha$  and  $\beta$  are constants       $\alpha > 0$  and  $\beta < 1$

If  $\alpha + \beta = 1$ . We have a homogenous eqn of degree 1. This is a special case of the Cobb-Douglas production function for which constant returns to scale and two inputs capital and labor.

$$\alpha + \beta = 1 \quad \beta = 1 - \alpha$$



$$\begin{aligned}\text{per capita output} &= \frac{Y}{L} = AK^\alpha \frac{L^{1-\alpha}}{L} \\ &= AK^\alpha L^{-\alpha}\end{aligned}$$

Taking the derivative of per capita output w.r.t. labor

$$\begin{aligned}\frac{d}{dL} \left( \frac{Y}{L} \right) &= AK^\alpha (-\alpha L^{-\alpha-1}) \\ &= -\alpha AK^\alpha L^{-(\alpha+1)}\end{aligned}$$

since  $\alpha > 0$ , this derivative is always negative.

Derivative of per capita output w.r.t. labor is always  $< 0$ .

An increase in population can never pay it's way.

Hence those demographic economic models that use the Cobb-Douglas production function have an implicit assumption that increases in population function can never pay its way by increased production.

### The choice of welfare function

The choice of welfare function is more complex than simple changes in income per capita, as is done in the cost benefit models. The implicit welfare function behind the per capita income measure neglects the non-monetary satisfaction of families who continue to have children despite their 'apparent negative present value.'

The choice of utility function

Simon's<sup>55</sup> critique of the cost benefit literature has emphasized that welfare economics of additional children depends critically upon the specific criterion of social welfare. The 'utility' function for development may also be conceived in terms of more equal distribution of wealth and more even agricultural development rather than simple increases in income per capita.

Assumptions which imply that widespread dissemination of contraceptives is sufficient to lower the birth rate

These assumptions are questionable for they assume that the people (in the developing countries) are ready and willing to accept birth control. An A.I.D. funded study by McGreevey et.al.<sup>56</sup> appraised 32 evaluations of family planning programs. They found lack of 'strong methodology' and that those studies which concluded that family planning programs reduce fertility all pertain to Taiwan, which is a special case since fertility decline in Taiwan had started before the introduction of these programs.

Mamdani's critique of family planning programs in India (refer to Chapter One), outlines the difficulties of evaluating these programs and the effectiveness of contraceptives in reducing birth rates. Pradevand<sup>57</sup>, Hofsten<sup>58</sup> and others have also suggested that high fertility is a rational response to prevailing socio-economic conditions in many developing countries. The family is an important productive unit, as well

as a source of old age security.

As a solution policy makers are suggesting economic incentives to create the demand for contraceptives or for sterilization. Blandy<sup>59</sup> had explained that such schemes and others such as pension plans, sterilization bonuses and graduated taxes on additional children is bound to fail. Recent riots in India against forced sterilization have also proved the failure of such programs.

Section 3.9: New Considerations and Long Term Projections for the World:  
Recent Neo-Malthusian models of population and development

In recent years there has been a revival of Malthusian<sup>60</sup> concepts of population growth. These models emphasize the fast pace of population growth and how this growth is outpacing economic growth.

Meadows<sup>61</sup> 'Limits to Growth' model and Forrester's World Dynamics<sup>62</sup> model all emphasize the ultimate catastrophe that would occur as a result of exponential growth of population (in the developing countries) of the world. In the World Dynamics model five principle variables are interacting; population, capital investment, natural resources, fraction of capital devoted to agriculture and pollution. The model attempts to show that resource shortage, pollution, crowding, food failure or some equally powerful force will limit population and industrialization. These forces are similar to the positive checks proposed by Malthus.

As Forrester points out "the combination of expanding population with shrinking environment is a general phenomenon with broader implication that for food supply alone -- population will eventually be suppressed by shortage of natural resources, by pollution, crowding and consequent social strife or by insufficient food ---Malthus dealt only with the latter, but it is possible for civilization to fall victim to other pressures before the food shortage."<sup>63</sup>

Forrester claims that Malthus, by identifying the supply of food as "one ultimate barrier to unending population growth... (was) not erroneous; (he was) merely incomplete."<sup>64</sup>

Denton and Spencer (refer to section 3.7) comment on the model of Forrester and assert that Forrester is not speaking of the renewable natural resources when emphasizing their finiteness.

Denton and Spencer emphasized man's ability to adopt and respond to supply of resources and the continued search for substitutes and suggest that in general, the Forrester argument would seem to involve approaching a problem of long run equilibrium with an assumption about resource availability, that is more appropriate in a short run context.

The World Dynamics model views the world as lifeboat, dumping the developed and developing countries together. Situations vary from country to country and hence the population issue is different depending on the socio-economic structure in a particular country. Also many of the aspects used in the model do not apply to a developing country (for e.g. problem of pollution).

The main theme of the systems approach of Meadows 'Limits to Growth' model states that "one of the most commonly accepted myths in our present society is the promise that a continuation of our present patterns of growth will lead to human equality. We have demonstrated... that present patterns of population and capital growth are actually increasing the gap between the rich and the poor on a world wide basis, and that ultimate result of a continued attempt to grow according to the present pattern will be a disastrous collapse. The greatest possible impediment to more equal distribution of the world's resources is population growth. It sums to be a universal observation, regrettable but understandable, that as the

number of people over whom a fixed resource must be distributed increases, the equality of distribution decreases."<sup>65</sup> Josef Pajestka<sup>66</sup> has discussed this approach. He feels that the main issues of the model are

- 1) Economic growth leads to inequalities - It has not been demonstrated as yet that growth leads to inequalities. The two options available are: to stop growth; or to change it's "current pattern" in a way to enhance human equality. This option is available to the world as a whole. For the poor countries, the only alternative is to grow and it cannot be said that their economic growth leads to inequalities.
- 2) World population as an aggregate - Global models have to operate with aggregates but they should not contain implied conclusions with respect to the component parts of the aggregate. This rule is violated by the models at present for they contain statements such as the population of the poor countries is growing faster than that of the rich countries. This statement is true but its implied content is incorrect when the argument is based on the limitation of natural resources and of environmental capacities. It cannot be forgotten that the use of natural resources (including environmental aspects) per person is 10 to 20 times higher in the rich countries than in poor ones.
- 3) Justification of inequalities - Due to the existence of limited resources there can no 'universal' justification

of inequalities. It cannot be taken for granted that injustice is a 'natural' consequence of limited resources.

- 4) The relevant time-horizon - The world models are all based on exponential growth of population. The continuation of exponential growth leads to absurdity. The relevance of this fact for policy issues is that an appropriate assessment of the world's resources and of the potential technological changes should take place. Unless this assessment is done satisfactorily, the exponential growth argument is a 'gimmick' which can be applied at any time to serve the desired purposes.

Josef Pajestka has criticized the world models of Meadows type. He points out that although it is necessary to look at world problems and policies in the 1970s for a longer time horizon and with a systems approach a number of flaws exist in these models. These models do not put forward any of the evidence necessary for changing the outlook of the world's prospects or for reappraising the International Development strategy for the 1970s.

This is because the ideas of the models reflect the authors' own philosophy (with respect to important issues mentioned earlier) rather than disclosing the world's real options and tendencies. "It should be recalled that it is not the first time in the history of human thinking that powerful intellectual tools have been used in this way." ---Pajestka.

Basic Feedbacks and certain Conclusions of the Limits to Growth Model

The long-term diagnosis of the world's prospects as viewed by the limits to growth models can be viewed as in fig. 3.3. The policy conclusions drawn from them are:

- stop economic growth (zero capital growth)
- stop population growth (zero population growth)
- redirect human priorities

Pajestka has pointed out that the above diagnosis of development inter-relationships with respect to the world's prospects can and should be challenged. In his opinion there is sufficient evidence to support the existence of a feedback interrelation as shown in fig. 3.4 which depicts a vicious circle of poverty and population growth.

Ways of breaking through the vicious circle of poverty and population growth can be achieved through socio-economic progress as is being demonstrated by a growing number of countries.

Pajestka states that the causes of fertility decline are very complex. "They include such influences as high levels of living, urbanization, education, using equality for women, the spread of old age pension system and the prohibition of child labor. All of them, however, have one common theme-economic and social progress of the broad strata of population... the same set of factors do not operate alike in all societies. Therefore the loop (of fig. 3.4) may change its direction: social and economic progress brings about a decline in fertility and eventually in the population



Fig. 3.3: Long-term diagnosis of world's prospects.

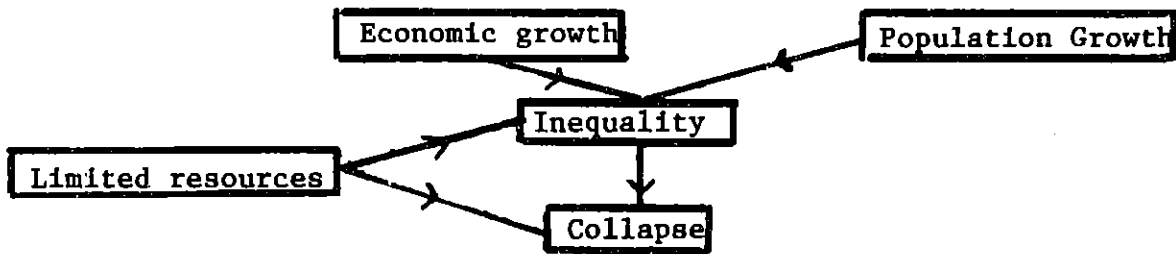


Fig. 3.4: Feedback loop showing interrelation between population growth and inequalities.



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Source: Josef Pajestka, "Population and Development in Perspective, With Particular Reference to the Second United Nations Development Decade," in The Population Debate, op. cit., p. 461.

growth rate, which again give use to positive influences on further socio-economic progress. This feedback can be strengthened by appropriate policy measures, including provision of family-planning services."<sup>67</sup>

Within the broad world framework, mass poverty can be said to be a result of world inequalities. Limitation of natural resources does not result in world inequalities. By diminishing world economic and social discrepancies, one can contribute to slowing down world population growth. Some policies which can help are better international division of labor elimination of exploitation, economic aid, transfer of technology, etc. They can also be found in the International Development Strategy for the 1970s.

Pajestka fully sympathizes with the demand for a profound change in human priorities and patterns of behavior, within both the international and national frameworks. He points out that in all considerations on long term prospects of the world (including the population issue), particular attention should be given to the general 'philosophical or ideological' approach.

### Section 3.10: Ascertaining the Relationship between Socio-Economic Factors and Population Growth Using Regression Analysis and Factor Analysis

J.A. Lim<sup>68</sup> has studied how economic and social conditions are related to fertility patterns and trends of population growth. Factor analysis and regression analysis was done on data from 39 developing countries. An attempt was also made to see how family planning measures relate to

fertility and to what degree. The variables used in Lim's study were

- 1) Measures of fertility - Fertility rate (number of births per married women of reproductive age) and short run fall in birth rate.
- 2) Economic-socio-demo variables: Measures of economic development and growth - GNP per capita and GNP growth rate used as measures of income and its growth.  
Measure of Urbanization - used was the urbanization ratio or fraction of the population living in urban areas.  
Degree of Industrialization - was measured by per capita energy consumption.
- 3) Socio-welfare indicators:
  - a. measures of mortality - death rate, life expectancy and infant mortality.
  - b. measures of literacy - literacy rate, school enrollment rate of children and daily newspaper circulation.
  - c. measures of nutrition and health - food supply per capita and the ratio of total population to the number of physicians. Food supply/capita is measured by total vegetable calories per day.
- 4) Demographic variables besides birth rate:
  - a. population density
  - b. dependency burden
  - c. long run population growth

5) Family planning measures:

- a. acceptance rate - cumulative users rate i.e. fraction of all cumulative acceptors of the program who have continued to practice family planning relative to the total married women of fertile age.
- b. years in family planning

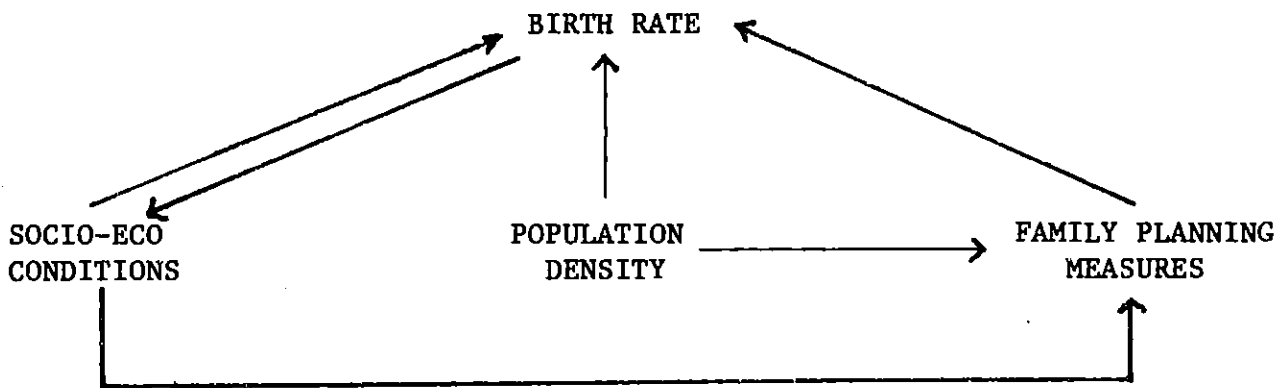
6) The regression analysis and factor analysis results - The techniques of regression analysis and factor analysis were applied to several developing countries and following the conclusion were drawn.

- a. The dimension more correlated with birth rate seems to be variables of a more 'social' nature as opposed to 'economic'.
- b. Mortality and literacy measures may be more representative of income distribution and the degree of poverty implying that simple economic growth may not be sufficient in affecting birth rate.
- c. Population density seems to be an important determinant of fertility.
- d. Acceptance rate is very highly related to GNP growth rate and school enrollment rate implying a definite relationship between family planning program effectiveness and socio-economic development. Good family planning program depends on an improved economic and social development.

- e. Lack of correlation of family planning measures with fertility.
- f. No significant relationship between population growth and socio-welfare indicators, confirming that the time lag of the effect of population growth on the welfare of the people is quite long.

Lim recommends the need to ascertain the causal effects of each arc and the time lags associated of models of the type in the figure below.

Figure 3.5: A Recommendation for Studying Causal Relationships



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Source: J. A. Lim, "The Effects of Socio-Eco-Demographic Factors and Family Planning Programs on Fertility," unpublished Masters of Science Thesis, M.I.T., January 1974.

From Lim's statistical analysis it was confirmed that socio-economic conditions do account for birth rates and population patterns. Also the fact that GNP does not turn up as a good indicator of birth rates implies that per capita income alone may not be such a good measure of birth rates.

Irma Adelman<sup>69</sup> did a similar study on data from 37 countries from different geographic locations and a wide range of income per capita to examine the relationships of fertility and socio-economic factors.

The determinants of fertility were income per capita (Y), urbanization (represented by a non-agricultural employment index (I)), the mothers level of education (represented by an average literacy index and an index of newspaper circulation per capita (E)), population density (P) and infant mortality.

The equation tested was

$$\log_e b_i = a_{0i} + a_{1i} \log_e y + a_{2i} \log_e I + a_{3i} \log_e E + a_{4i} \log_e P$$

where  $b_i$  is the number of live births per thousand to females in the age group. The lograthimic form implies that the coefficients may be interpreted as elasticities.

Age specific mortality rates were also determined by the equation.

$$\log m_i = C_{0i} + C_{1i} \log Y + C_{2i} \frac{\Delta Y}{Y} + C_{3i} \log I + C_{4i} \log H$$

where

$m_i$  = number of deaths per thousands in the  $i$ th age group.

Y = per capita income.

I = non agricultural employment index

= rate of share of per capita real income.

H = health index (measure by number of physicians per capita).

It was found that the education index and population density were the most significant determinants of fertility. Both Lim's and Adelman's works established out the relationship of socio-economic factors and fertility. Their works point out that some literacy measure is a significant determinant of fertility. An attempt will be made to incorporate this fact in the present study. Lim's and Adelman's study confirms the need of incorporating some sort of social or welfare indicator in all economic-demographic models.

### Summary

A survey of economic demographic models has revealed many questionable assumptions found in these models. A respecification of inherent assumptions, which are biased against population growth produces significantly different results (refer to section 3.6).

Since rapid population growth is being experienced in many developing countries, it seems appropriate to chose one such country, and study the interrelationships of population and development in it. A mathematical model constructed to study such relationships must try to avoid the pitfalls of standard economic demographic models discussed in this chapter.

The need for incorporating socio-economic indicators in any study of population patterns is evident. Causal relationships, their strengths and magnitudes should be also be included.

The chapters that follow will concentrate on selecting a developing country, and will focus on a particular aspect of development namely,

agricultural development. An attempt is made to build a model to study the links between population and agricultural development, incorporating some pertinent causal relationships.



## CHAPTER FOUR

### Population Growth and Agricultural Development

#### Pakistan as a Case Study

For developing countries whose economy is agrarain based, any economic development means an improvement in the agricultural sector. The importance of improving the agricultural sector was noted at the Bucharest conference in the World Population Plan of Action. "More attention should be given to food production and agricultural development, including land reform, use of appropriate technology, adequate employment opportunities and rural development through agriculturally based industries."<sup>70</sup>

#### Section 4.1: Classic Model Relating Food and Population

Any population needs food to survive. As early as Malthus<sup>71</sup> the links between food and population have been studied. One of the earliest theories trying to relate population with food was proposed by Reverend Thomas Malthus (1798) of England, who stated that population if unchecked, grows at a rate outpacing the food supply necessary to keep the population alive. Malthus claimed that the production of food from limited land must obey the law of diminishing returns. As more and more land was cultivated to feed the rising number of people, the extra food grown would probably diminish. Food production can increase at most in arithmetic progression while population grows geometrically.

In order to curb the population growth Malthus presented the notion of 'population checks', which were either 'preventive' or 'positive.' Preventive checks lowered the birth rate and positive checks increases the death rate and through these checks population growth could be curbed.

Preventive checks represented moral restraint to lower birth rates. If man did not consciously check the rate of growth of his numbers by lowering the birth rate, then as population outpaced food production, the positive checks would limit his population growth by raising the death rate. Some positive checks mentioned were increase of death rate by war, diseases, epidemics, lack of sanitation and medical care and by starvation.

If the food supply could not increase in step with population, it was clear that the rise in human numbers would be limited. The only question was how this limitation would occur. According to Malthus, starvation was the ultimate check to population growth. "By the laws of nature man cannot live without food. Whatever may be the rate at which population would increase if unchecked, it never can actually increase in any country beyond the food necessary to support it."<sup>72</sup>

The Reverend Malthus however did not foresee the process of increasing agricultural productivity through technological advances.

According to a 6 January 1970 report by FAO. "FAO indicates that fears of a world famine had been rendered groundless by new strains of crops, fertilizers, irrigation and pesticides as among the new developments, and said food production has increased faster than the population."<sup>73</sup>

Inspite of impressive gains in agricultural production in the developing countries, high malnutrition and undernourishment are still there.

The race between food and population in these countries have encouraged recent day neo-Malthusians to predict catastrophe for the world in the near future. As seen earlier, the Forrester-Meadows argument is based on this assumption, (refer to section 3.8).

#### Section 4.2: Some Recent Models Relating Food and Population

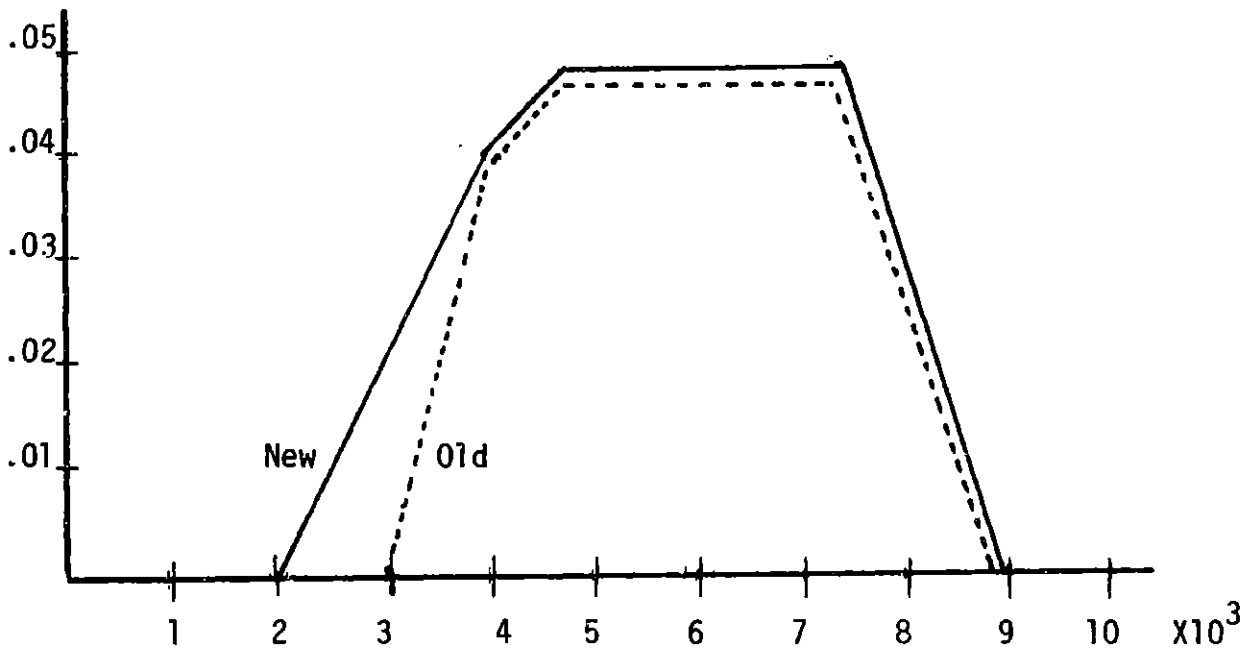
Runge has attempted to study the interactions between food and population in a developing country. The paper "attempts to analyze the ethics of humanitarian food relief from a dynamic perspective, and to consider the ethical dilemma posed by such a program."<sup>74</sup> The country under consideration has a subsistence agrarian economy. "The interactions between population and food production in this kind of society yield an equilibrium value of population as the food production reaches the ultimate capacity of the area."<sup>75</sup> The model studies the impact of external food relief on the interactions between population and food. Food relief is first sent to this agrarian country and then withdrawn by the donor country. Runge describes the 'ethical dilemma' of a food relief program, for withdrawal of food relief causes even greater misery than before. "...In the long term, the short term goal of preventing starvation through a food relief program produces greater suffering for a greater number of people."<sup>76</sup> The Runge model assumes that an increased food per capita increases the life expectancy and lowers the death rate to increase the size of the population. However, the possible effects of increased food per capita on birth rates has not been incorporated in this model.

Khilnani and Agarwal<sup>77</sup> have specified a similar model to study interactions between food, population and food relief. However, the model constructed in this study incorporates the possible effects of food per capita on birth rates and the productivity of the people. Criticizing the Runge model, the authors stated that "...while it is important to recognize that providing more food might lower the death rate and, therefore, increase the rate of growth of population, this need not be the only effect. A properly fed population is generally more capable of feeding itself, further an increased life expectancy resulting from better food intake may also lead to a lower birth rate so that the entire constellation of forces is changed."<sup>78</sup>

The three main interactions studied in the Khilnani-Agarwal model are between life expectancy and food per capita; food per capita and productivity of the population; the birth rate and life expectancy. The authors state that although life expectancy is a function of many variables, primary amongst these is the health of the population. Health in turn being primarily related to the nutritional level of the population. Citing Berg and Meadows,<sup>79</sup> the authors have constructed a relationship between food per capita and life expectancy; increasing the food per capita, increases the life expectancy, following a pattern of diminishing returns.

Admitting that the relationship between food per capita and productivity are more difficult to determine, Khilnani and Agarwal state a well fed population has a better capacity to work and produce more. The model determines the increased productivity fraction as a function of food per

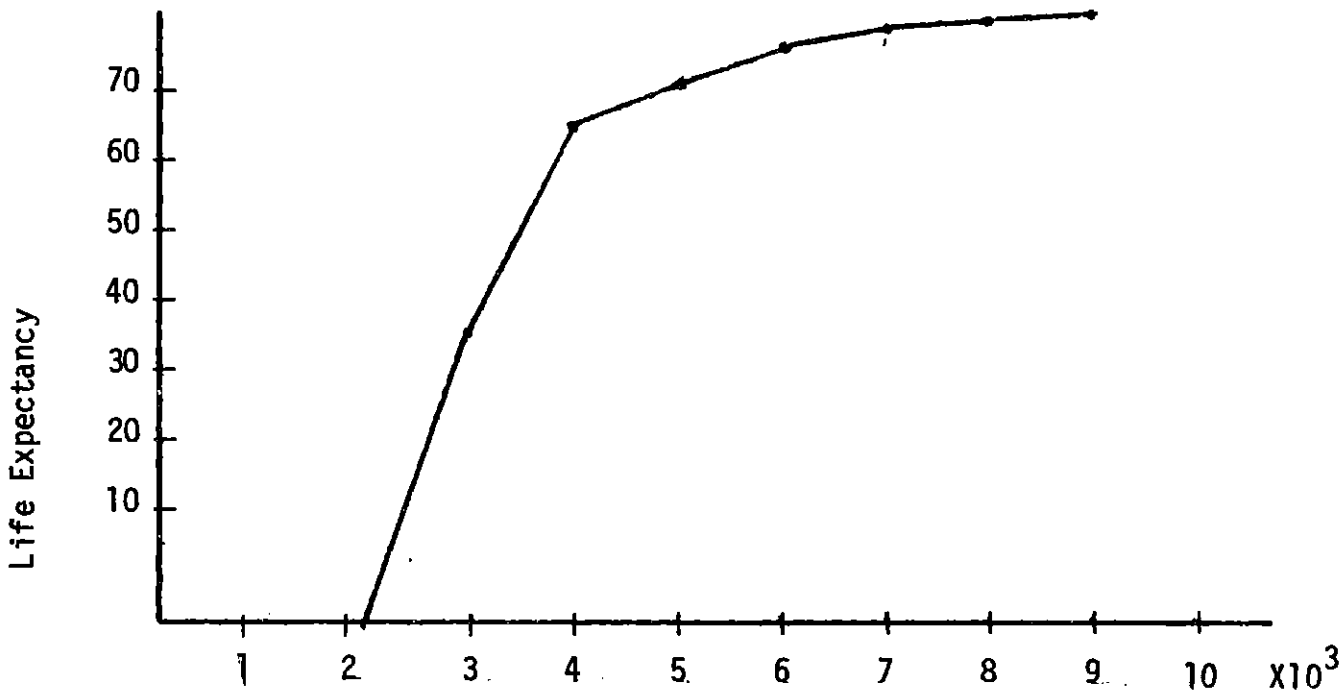
Figure 4.1 Increased Food Productivity as a Function of Food Per Capita



Source: Arvind Khilnani and Mohan Agarwal,  
"A Reappraisal of the Simple Food and  
Population Model, M.I.T.

Food per capita  
(vegetable calories  
per person-day)

Figure 4.2 Life Expectancy as a Function of Food Per Capita



Source: Meadows, cited by Khilnani-Agarwal.

Food per capita  
(vegetable calories  
per person-day)

capita. (See fig. 4.1).

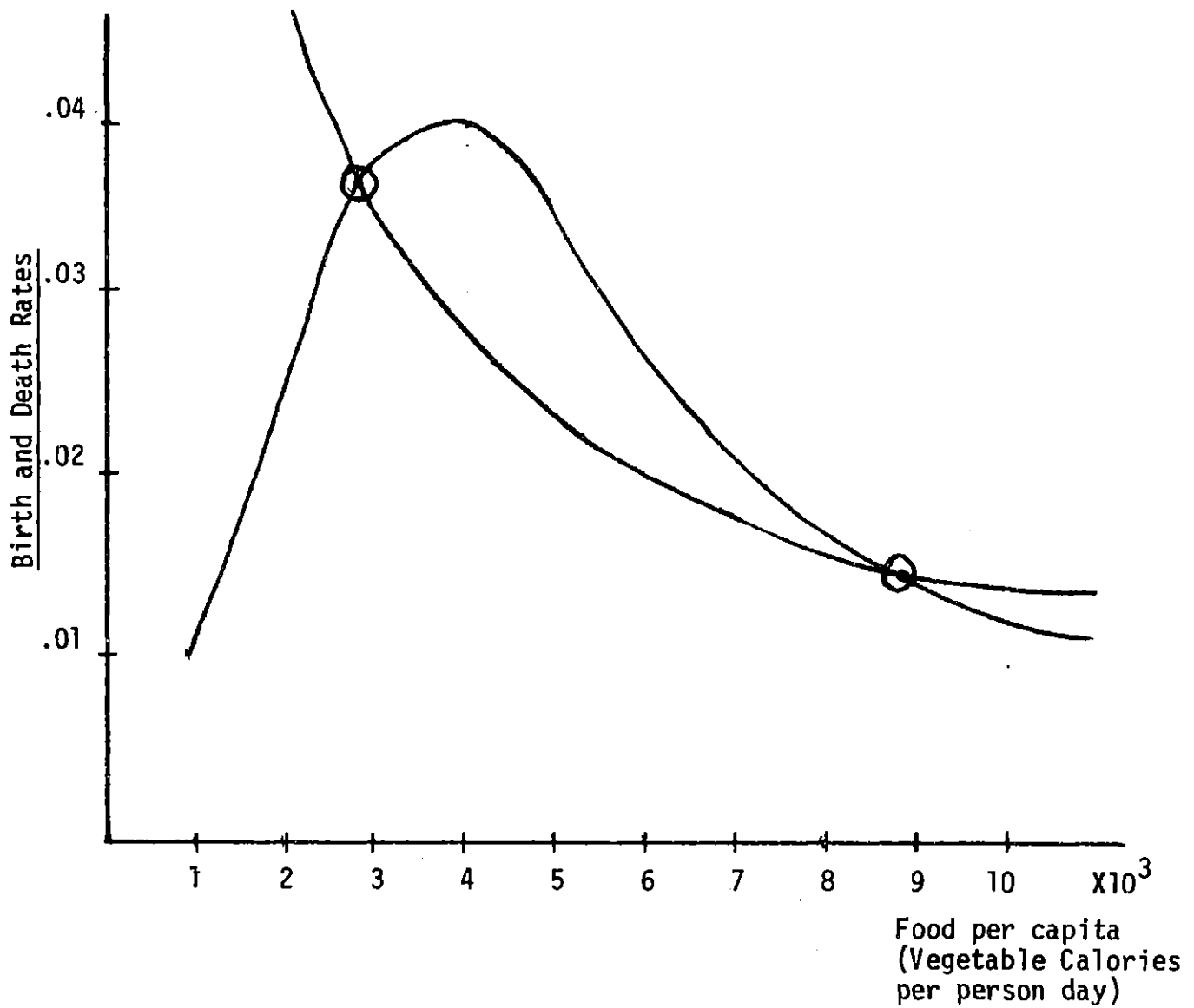
At 3000 vegetable calories per day, society is at a subsistence level. Increasing the food per capita increased the productivity fraction. Once the per capita reaches around 9000 vegetable calories per person-day "there would be no reason to want to increase production beyond this figure."<sup>80</sup> This increased productivity fraction then drops to zero.

The model is set up so that the increase in life expectancy has two effects: a) decreases the death rate; b) first increases and then decreases the birth rates. Although the first effect can be substantiated, no evidence has been given of the second. One cause cited for the second effect is that people perceived the rising life expectancy of their children and thus do not desire to have more children to compensate for the death of some.

The interaction of food relief, food production and population are studied under different productivity functions. A desirable equilibrium for the population (low birth and death rates) is reached with and without external assistance with an increased productivity function. The authors conclude that "...food assistance can only help a country seek an appropriate goal, such assistance cannot be the crucial link between achievement and non-achievement, increased productivity is the link. Any debate on the food population issue which focuses on assistance only detracts from the most crucial aspects of the relationship."<sup>81</sup>

For the purpose of the present study, the interactions of food relief have not been considered, but the setting is the same as in the Runge

Figure 4.3: Birth and Death Rates as a Function of Food Per Capita



Source: Khilnani, Arvind and Agarwal, Mohan in "A Re-Examination of the Simple Food and Population Model." Unpublished paper, M.I.T. Systems Dynamics Group, April 1975.

and Khilnani-Agarwal models. The country under consideration is a developing country whose economy is primarily agrarian. Increasing the standard of living through increases in food per capita, income per capita, and literacy ratio will effect both the death rates and birth rates.



### Section 4.3: Pakistan as a Case Study

#### Introduction

The Islamic Republic of Pakistan is a country in Southern Asia on the Northwestern border of India. It came into existence on the 14th of August 1947. With the separation of its former eastern wing, known as East Pakistan, in 1971, the present Pakistan consists wholly of what was formerly known as West Pakistan. The total area of the country is 307,374<sup>82</sup> square miles with a population of 64.89 million people. (Refer to table 4-1).

Politically, it is divided into four provinces viz Punjab, Sind, N.W. N.W.F.P. (North West Frontier Province) and Baluchistan. Of the total population, it is estimated that some 47.99 million people live in the rural areas. (Refer to table 4-1).

#### The geo-climatic conditions in Pakistan

Pakistan includes a dry plateau (Baluchistan) which lies outside the influence of the monsoon. The climate is subject to extremes of heat and cold and the rainfall is uncertain and scanty. Only a small fraction of Baluchistan is under cultivation because of lack of water. Principal crops are millets, wheat, fodder, cotton and fruits.

In the dry hilly region of North West frontier province rainfall does not exceed 20 inches. The monsoon does not reach this region. There is some irrigation in the Peshawar Valley and Bannu plain where most of the population is concentrated.

Important crops are wheat, grain and millets. Through the plains of Punjab flows the river Indus and its tributaries. This is the most fertile region of Pakistan. The area south of the river Sutlej and the eastern portion of Sind are mostly desert.

The population growth in Pakistan

The historical growth of population since 1901 in Pakistan is shown in the table below.

TABLE 4-1  
Population Growth in Pakistan 1901-1972

Census Year	Population (in thousands)	Intercensal Growth Percentage Growth	Annual Rate of Growth (Percent) <sup>a</sup>
1901	16,576 <sup>b</sup>	-	-
1911	19,382	16.9 (7.1) <sup>c</sup>	1.6 (0.7) <sup>c</sup>
1921	21,109	8.9	0.8
1931	23,542	11.5	1.1
1941	28,282	20.1	1.9
1951	33,740	19.4	1.8
1961	42,880	27.0	2.4
1972 <sup>d</sup>	64,890 <sup>e</sup>	51.2	3.6

Source: 1) "Census of Pakistan" 1961 vol. 3 (West Pakistan)  
Census Organization Pakistan.

2) "Population CENSUS OF PAKISTAN 1972" - Provisional Tables  
Census Organization Pakistan. Census Bulletin No. 1  
Islamabad 1973.

Description of Table 4-1.

- a. Geometric rate
  - b. Excluding population of frontier regions
  - c. Excluding 1,622,000 persons of frontier region in 1911.
  - d. 1961-72 intercensal period was 11.7 years
  - e. Includes non-Pakistanis
- 

Since 1921 the population of Pakistan has been showing increasing intercensal rate of growth. The lower increase during the decade 1911-21 reflects the impact of decimation of population due to influenza epidemic of 1918. The next decade 1921-31 shows a higher increase of 11.5 percent with annual rate of increase 1.1 percent. This increase is attributed partly to immigration from other parts of the subcontinent due to extension of irrigation system and large-scale colonization. Between 1931 and 1941 the population increased by 20.1 percent which was considerably higher than during the previous decades. The chief reasons for this increase were the elimination of famines and considerable control over epidemics which lowered the death rate and increased life expectancy. The 1941-51 decade again showed a high increase of 19.4% mainly due to natural increase but also due to excess of immigration from India following the partition of the subcontinent.

The exceptional increase of 27.0 percent in the 1951-61 decade is attributed mainly to the excess of births over deaths resulting from a sharp fall in the death rate due to improved environmental conditions and health facilities... the average annual rate of growth on the basis of

population census of 1961 and 1972 amounts to 3.6 percent. This growth, however, may be a resultant of an estimated undercount of about seven percent in the 1961 census and a continuous high rate of natural increase. If the population of 1961 is adjusted for the estimated underenumeration, the average rate of growth during the intercensal period comes down to the level of 2.9 percent. This, however, assumes no underenumeration in the 1972 census.<sup>83</sup>

### The rural population of Pakistan

For the purpose of this study we will be concentrating on the rural population of Pakistan. The rural population represents more than 70 percent of the population as is seen from table

### Population policies in Pakistan

The government of Pakistan is very concerned about the population problem. "The shadow of overpopulation looms over our country, indeed over our part of the world. It darkens the prospects of our economic advance. It nullifies our efforts towards social progress. No objective, is therefore, more vital than that of population planning."<sup>84</sup> ---Zulfiqar Ali Bhutto, Prime Minister of Pakistan.

The Pakistan government's efforts to reduce the population growth rate are at a level of effort equal to any in the world."<sup>85</sup> In all the development plans, large sums of money have been allocated to family planning. The first Five Year Plan for 1955-1960 included a grant of

TABLE 4-2

Urban-Rural Distribution and Intercensal Growth  
in Population of Pakistan: 1901 to 1972

Census year	Population (in thousands)			Percentage distribution Intercensal percentage increase					
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
1901	16,576	14,957	1,619	100	90.2	9.8	-	-	-
1911	19,382	17,693	1,689	100	91.3	8.7	16.9	18.3	43
1921	21,109	19,051	2,058	100	90.3	9.8	8.9	7.7	21.9
1931	23,542	20,773	2,769	100	88.2	11.8	11.5	9.0	34.6
1941	28,282	24,267	4,015	100	58.8	14.2	20.1	16.8	45.0
1951	33,780	27,761	6,019	100	82.2	17.8	19.4	14.4	49.1
1961	42,880	33,226	9,654	100	77.5	22.5	29.9	19.7	60.4
1972	64,892	47,994	16,898	100	74.0	26.0	51.3	43.8	75.0

-101-

Source: Mohammad Afzal, The Population of Pakistan, CICRED Series (Pakistan Institute of Development Studies, Islamabad, Pakistan 1974).

Rs500,000 to private agencies for family planning. Spending on the family planning programs is described in the following table.<sup>86</sup>

TABLE 4-3

Family Planning Programs

<u>Time</u>	<u>Funding</u>		<u>Administration</u>
	in Rs	in US\$	
1st plan 1955-1960	500,000	105,000	private agencies
2nd plan 1960-1965	30,500,000	6,400,000	Ministry of Health & Social Welfare
3rd plan 1965-1970	365,000,000	7,665,000	Independent Family Planning Division
For West Pakistan	158,000,000	3,318,000	Independent Family Planning Division
1973-1975 (2 year scheme)	247,500,000	25,000,000	Independent within Ministry of Health

Inspite of these massive spending on family planning programs, Pakistan has a population of above 70 million people, a growth rate of 2.9% at the time of the 1972 census and projected population figure for 1990 stands at 103.4 millions.<sup>87</sup>

According to the National Impact Survey (1968-69) of the Government of Pakistan only 4% of married women surveyed were practicing birth control at the time of the survey. The survey also showed that 70% of the married women knew of at least four methods of birth control.

Shahid Javed Burki, World Bank economist and former government official discussed the failures of the programs of the 1960 in a paper for a conference on population planning in Pakistan (1975).

"Poor distribution of supplies, the lack of field workers, and other material problems were among the many causes cited by (Hardee and Satterwaite 1970) but the basic flaw was conceptual in nature. The underlying assumption of the family planning program was that family size was the accidental outcome of sexual activity, that it was necessary to convince fertile couples of the benefits that would result from family limitation, and that the state could transform the family from a large and, therefore, uneconomic to a smaller economic unit with the help of specially trained agents who would help parents empute both costs and benefits to the production of children. It was believed that, as a result, parents would surely have smaller families."<sup>89</sup>

According to the 1972 Household Income and Expenditure Survey of the government of Pakistan, rural family size averages 5.8 persons and the urban 5.9 persons.

Thus it is safe to say that inspite of the massive government spendings, propaganda on T.V. and radio, posters and clinics even in remote villages of Pakistan, the family planning program has not been successful.

Land availability in Pakistan<sup>90</sup>

The total land area in Pakistan is estimated at 196.7 million acres. Of this, 67 percent has been surveyed = 132.41 million acres.

During 1970-1971, out of the surveyed area 38% was not available for cultivation. The land available for cultivation was equal to 71.71 million acres. Out of this land only 35.7 million acres were sown, so that land available but not in use is equal to 36.11 million acres. This figure does not include land which undergoes multiple cropping. An estimated 6.1 million acres are sown more than once a year.

Income from the agricultural sector<sup>91</sup>

Agriculture is the largest sector of the economy of Pakistan. This sector contributed 33.83% to G.N.P. during 1975-76. The total value added in agriculture has been estimated at Rs1360.1 crore during 1975-76 compared to Rs1308.5 crore in 1974-75 showing an increase of 3.9%.

The major crops rendered Rs779.0 crore on 57.28 percent of the total value added in agriculture, while the minor crops and other sub-sectors claimed 12.70 percent and 30.02 percent of agriculture's contribution to G.N.P. during 1975-76.

An examination of the table on structural changes in G.N.P. shows that agriculture has been in the past and continues to be the main contributor to G.N.P.



TABLE 4-4

Structural Changes in GNP at Constant Factor Cost of 1959-60

Sectors	1969-70	70-71	71-72	72-73	73-74	74-75	75-76
1. Agriculture	38.88	37.74	38.51	36.47	35.98	34.16	33.83
2. Mining and Quarrying	.49	.48	.49	.46	.48	.53	.51
3. Manufacturing	16.04	16.31	15.35	15.69	15.81	15.23	14.72
4. Construction Services	4.20	4.30	3.55	3.83	4.01	4.94	5.42
5. Other Services	40.38	41.39	41.88	43.04	43.22	44.47	44.72
6. Gross Domestic Product	99.99	100.22	99.78	99.49	99.50	99.33	99.20
7. Net Factor income from/to rest of the world	+0.01	-.22	+0.22	+0.57	+0.50	+0.67	+0.80
8. Gross National Product	100	100	100	100	100	100	100

Source: Statistics Division, cited in Pakistan Economic Survey 75-76, Table 2.2, pg. 9.

This table shows that for all practical purposes, in order to determine the economic growth in the rural areas, we can concentrate on the agricultural sector. It is the largest contributor to the national income, and almost all the people in the rural areas depend on it for their livelihoods.

Income in the rural areas

The average monthly income of a household in rural areas was Rs234.43 compared to Rs360.54 in the urban areas in 1971-72.<sup>92</sup> Statistics regarding income distribution further highlight the poverty in rural area, as is clear from the following table.

TABLE 4-5

Income Distribution in Rural and Urban  
Areas During 1971-1972

Monthly income per Household	Percent of Households	
	<u>Rural</u>	<u>Urban</u>
Less than Rs200	52.4	28.4
Rs200 to Rs399	38.6	46.8
Rs400 to Rs499	4.3	8.9
Rs500 to Rs794	3.1	8.9
Over Rs750	1.6	7.0

Source: Statistics Division, Household Income & Expenditure Survey 1971-72, cited in Pakistan Economic Survey 1974-75 (Govt. of Pakistan, Finance Division Economic Adviser's Wing Islamabad), Table No. 4.3. pg. 28.

A household being defined as consisting of a single person living alone or a group of persons who normally live and eat together. The average number of members in a rural household was 5.8 in 1971-72. This government data suggests that on the average a person would have a

monthly income of Rs40.4 (i.e. an annual income of Rs484.8) in the rural areas. However, a recent study by S.M. Naseem (June 1976) has estimated that even this may be a very optimistic figure.

The extent of rural poverty in Pakistan

"Agriculture has been the mainstay of Pakistan's economy, besides providing sustenance to three fourths of the population, it has also provided the life-blood to its industrial sector (where textiles and food processing account for the major share in value added) and has earned most of the foreign exchange for the country. Like most Asian countries, the development strategy in Pakistan has tended to be urban-biased and the improvement of conditions in the rural areas has been on a rather low scale of priority."<sup>93</sup>

Based on the IBRD Survey in 1966, which estimated an average subsistence for an average family in the Punjab to be 5 acres of land holdings, Naseem has estimated the number of households below the poverty line in the rural areas<sup>94</sup> as given below

Total farm households	2,854,000
Landless labor households	609,125
Nonfarm households	<u>517,500</u>
	3,980,625

Thus out of a total of 6.5 million households about 3.98 or 61 percent of the households were below the poverty line.

TABLE 4-6

Households and Population below the Poverty Line  
in Rural Pakistan

Poverty Line	Average House- hold Size	Percentage of Households	No. of House- holds (millions)	Percentage of Popula- tion	Number of persons (millions)
<b>Income expendi- ture equivalent of 90% calorie intake</b>					
1963-64	5.5	50.56	4.325	31.1	15.646
1966-67	5.6	-	-	-	-
1968-69	5.4	62.77	6.742	60.14	34.881
1969-70	5.3	57.95	6.528	46.33	27.659
1970-71	5.2	64.11	7.581	59.86	36.808
1971-72	5.8	72.41	7.906	70.48	44.181
<b>Rs300 per capita per annum</b>					
1963-64	5.5	64.05	5.359	58.57	29.467
1966-67	5.6	68.42	6.694	60.77	33.296
1968-69	5.4	65.24	7.007	63.45	36.801
1969-70	5.3	61.67	6.947	56.25	33.581
1970-71	5.2	62.00	7.331	54.07	33.248
1971-72	5.8	61.00	7.317	59.01	36.991

TABLE 4-6 (continued)

Poverty Line	Average House- hold Size	Percentage of Households	No. of House- holds (millions)	Percentage of Popula- tion	Number of Persons (millions)
Rs250 per capita per annum					
1963-64	5.5	54.13	4.951	42.73	21.498
1966-67	5.6	56.24	5.503	34.44	18.870
1968-69	5.4	54.11	5.812	26.00	15.080
1969-70	5.3	52.30	5.891	26.01	15.522
1970-71	5.2	48.71	5.780	26.69	16.412
1971-72	5.8	54.25	5.825	21.27	13.473

-109

Source: S.M. Naseem, "Rural Poverty and Landlessness in Pakistan: Dimensions and Trends (1960-75)," Table 1.5, (June 1976), to be published in Landlessness and Poverty in Rural Asia, edited by Keith Griffin and A.R. Khan, World Employment Programme I.L.O. Geneva).

Naseem defines three poverty lines:

Poverty Line 1 : Income expenditure equivalent of 90% calorie intake.

Poverty Line 2 : Rs300 per capita per annum.

Poverty Line 3 : Rs250 per capita per annum.

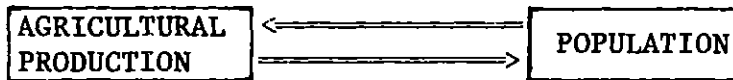
Looking at Table from 1963 to 1972 the percentage of households below the poverty line ranges from 48.71 to 72.41 percent of the rural population depending on the definition of the poverty line. This gives a picture of the misery of the majority of the rural population in Pakistan.

CHAPTER FIVE

The Population and Agricultural Production Model

Section 5.1: Introduction to the Model

The model will attempt to study some of the interactions between population and agricultural development in a developing country whose economy is agrarian based. The basic relationship to be studied are between population and agricultural production.



The population is determined by the birth and death rates and grows according to the population growth rate. Similarly, the agricultural sector grows according to the inputs to the agricultural production process. Thus, at any point in time there is a per capita agricultural product.

Population influences agricultural production through the labor force. The agricultural production process results in income and food which, in per capita terms, manifests itself as a standard of living of the population. This standard of living affects the population by influencing the birth and death rates. It is possible to increase the level of agricultural production by increasing the inputs (eg. labor and capital).

It is also possible that population growth outpaces the increase in agricultural production so that even though after a period of time the per capita indices are higher than before, population is still growing but at a

slower pace.

This is the phenomenon that the model will attempt to study, namely, the effect of different increases in the agricultural inputs on the standard of living and, hence, on the population. In subsequent runs the effect of education will also be incorporated.

### The population sector

- 1) The population to be considered is that of a developing country experiencing rapid population growth. Migration has not been considered in this model. The population is being altered simply by births and deaths. Population here is measured in millions of people per year.
- 2) The birth and death rates denote the number of people who are born and who die each year respectively measured in millions of people per year. The birth rate depends on the population in the previous time period, the normal birth rate and a birth rate multiplier. Similarly, the death rate depends on the previous time period, the normal death rate and a death rate multiplier.
- 3) The normal birth and death rates correspond to the demographic crude birth and death rates and represents the fraction of the population, which is born and which dies respectively.
- 4) The multipliers are used to change the values of the normal birth and death rates. They will be discussed in detail later. For the time being, it is sufficient to say that multipliers will



try to reflect the socio-economic conditions of the population under consideration.

The link between the population sector and the agricultural sector

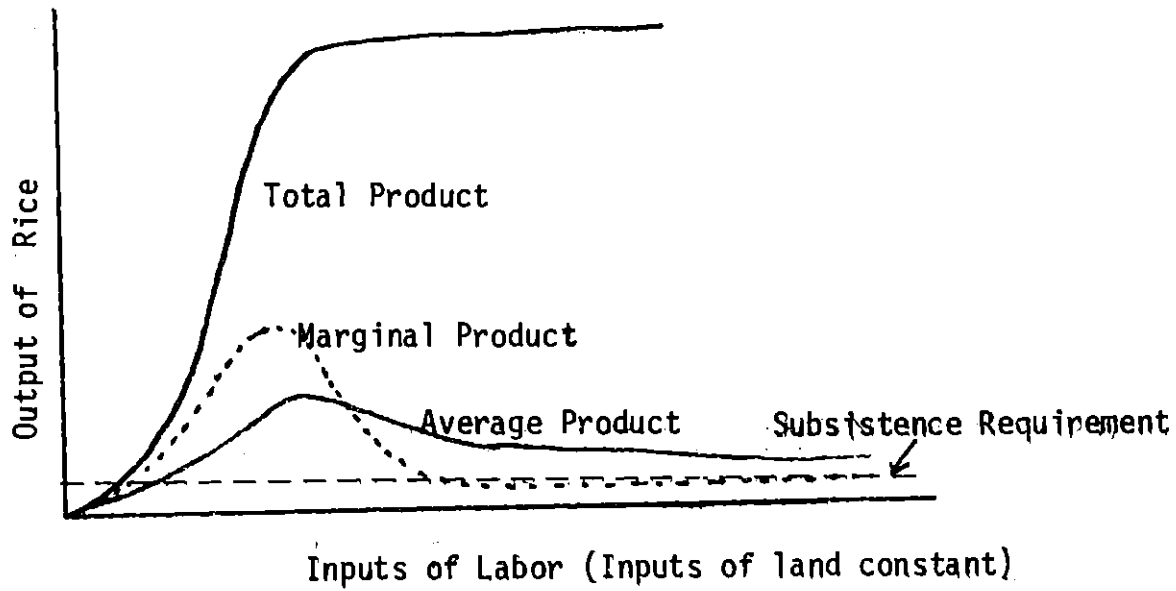
The population is linked to the agricultural sector via the labor force. A certain percentage of the population forms the labor force. The fraction of people in the labor force will be chosen to reflect a realistic number for a developing country, where the dependency burden is large, i.e. a large number of the population are minors and are not part of the labor force.

Labor is one of the inputs to the agricultural production process. An increase in labor increases the agricultural output. However, this process does not go on indefinitely. The model assumes that agricultural output is a function of labor and follows a pattern of diminishing returns.

Such an assumption is realistic, for with no technological advance in the production process it does not seem likely that the output can be increased indefinitely.

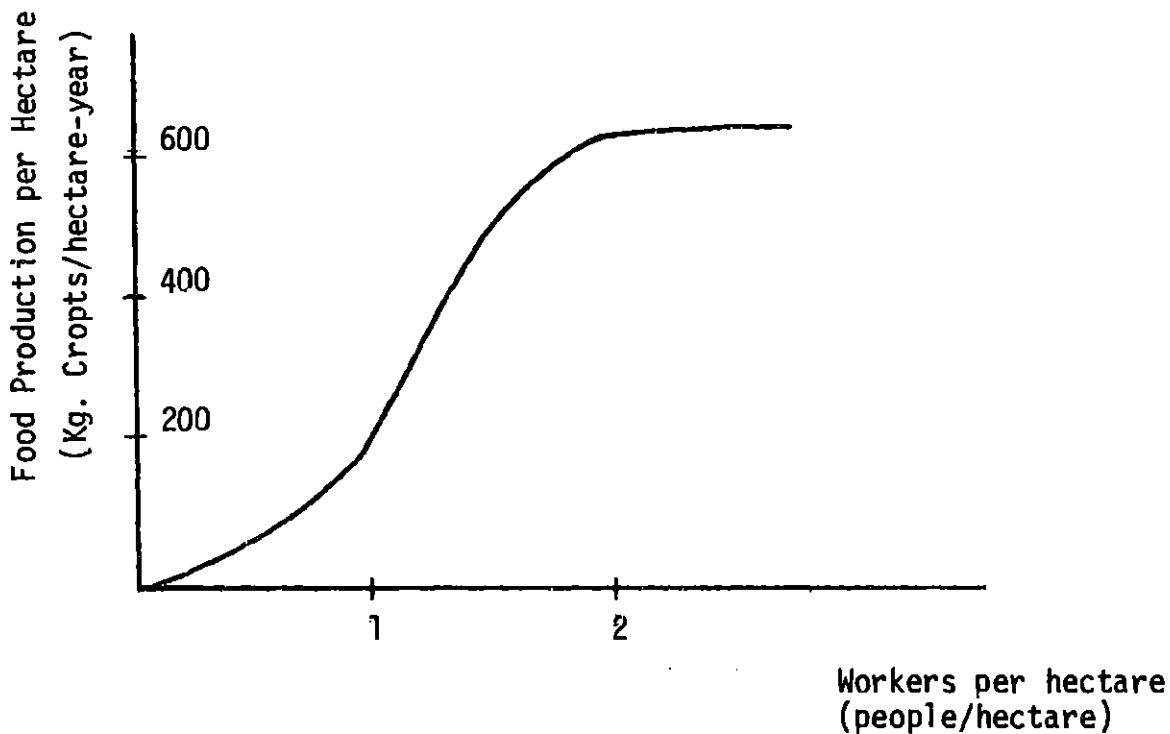
The motivation for this assumption is derived from Mellor,<sup>95</sup> who defines a hypothetical relation between the number of labors and the amount of rice harvested from a given area of land. (See fig. 5.1).

Fig. 5.1: Hypothetical Labor Production Function in High Productivity Soils.



Source: Dale Runge, "The Ethics of Humanitarian Food Relief," Systems Dynamics Group, M.I.T., May 1974, p. 46.

Fig. 5.2: Food Production per Hectare as a Function of Workers per Hectare.

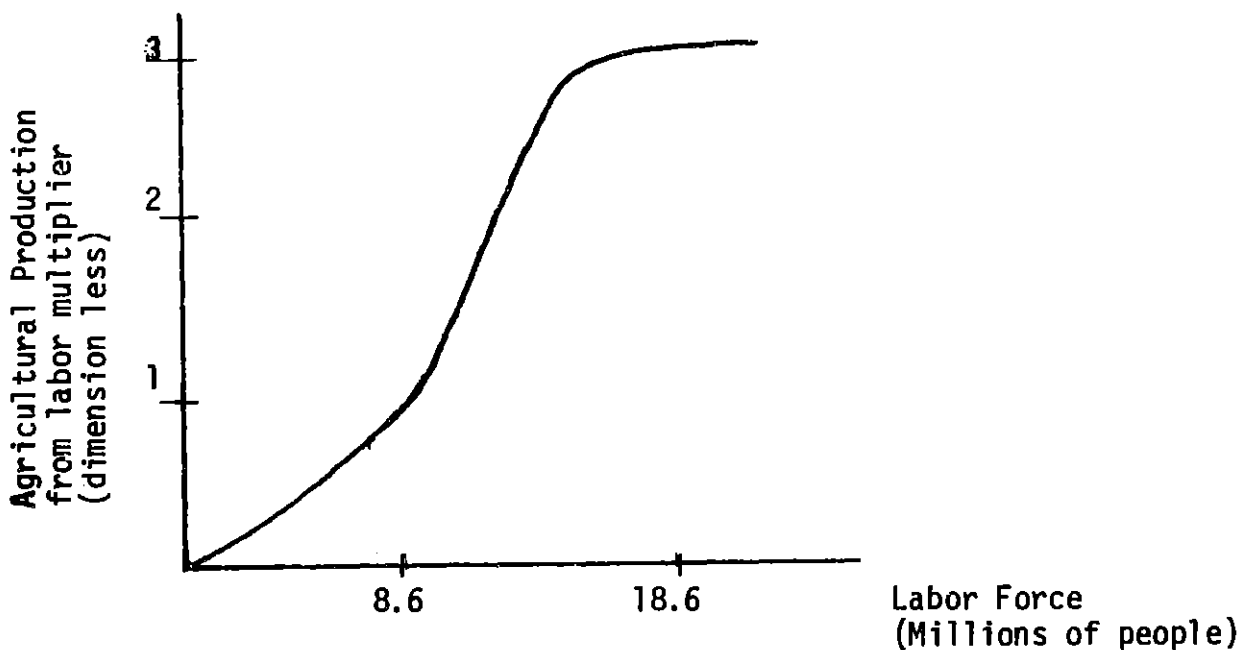


Source: Runge, op. cit., p. 47.

Runge<sup>96</sup> has proposed a similar relationship between workers/hectare and food production/hectare (see fig. 5.2). Food production being measured in terms of kilogram crops per hectare. The maximum yield per hectare is equal to 600kg crops/hectare/year when there are two workers per hectare (neglecting the effect of capital investment). When labor force doubles, the production increases from 280 to 600kg crops/year, an increase of more than double.

For the purpose of our work here, the model is set up so that doubling the labor force can at most triple the normal agricultural output. This is an optimistic assumption to make, but a realistic one, if the agriculture section continues to function as it does at present in many agrarian developing countries. Different shapes of the curve (fig. 5.3) can be experimented with.

Fig. 5.3: Agricultural Output and the Labor Force.



### The agricultural sector

The agricultural production process will attempt to represent the situation in a developing country, namely, the abundance of labor and absence of technical innovation. As far as the input of land is concerned, the situation varies from country to country. For this model we assume that land is not a constraining factor.

The other input to the agricultural production process is capital. The base runs assumes no capital investment i.e. labor being the input. In subsequent trials capital is introduced exogenously, to double or triple the output. The agricultural output will be measured in terms of index units (dimensionless) of agricultural product.

### Food from agriculture

From the agricultural production process is obtained food and income. It is assumed that all the food that is available is an output of the agricultural process and that no food relief or imports take place.

The agriculture may consist of both food as well as non-food crops (cash crops or fibre crops). For the base sum it is assumed that the agricultural sector only produces food crops. A change in this can readily be made to set food at 90% or 80% etc. of the total agricultural output.

### Income from agriculture

The model considers an agrarian developing country, where the prime source of income is the agricultural sector. It cannot be denied that in some developing countries industries and imports are also sources of income, but their contribution to national wealth may be negligible or small compared to agriculture. The model is set up so that income is generated only from the agricultural production process.

It is also assumed that costs and prices remain constant during the period under consideration, so that income is a function of output alone. The function is set up to represent a linear relationship between agricultural output and income.

### Food per capita and income per capita

Depending on the population at any time, the food and income obtained from the agricultural sector define a food per capita and income per capita respectively.

Food per capita and income per capita will be used as two of the indicators of welfare and development. The third, literacy level, will be incorporated also in later trials of the model. Although these indications fail to capture the skewed distribution of the standard of living of the people, income per capita is used as an indicator of economic development for lack of a better indicator, and food per capita is used to represent social conditions, for it represents the most basic of the basic needs of a population. As Naseem states when describing indicators of poverty:

"A basic step in determining the trends and extents of poverty is the selection of an income or consumption norm for the individual or the household, which is considered to be a minimum below which existence would become intolerable. The selection of such a poverty line is to a considerable extent arbitrary. In most such exercises relating to developing countries, the poverty lines are anchored to the fulfilment of a minimum diet based on nutritional considerations... The logic of such exercise is that since food is the most basic of the 'basic needs,' their adequate satisfaction commands priority over other needs."<sup>97</sup>

Food per capita will be measured in terms of index of agricultural production per million people as one indicator of the welfare of the population. It is being assumed here (and this assumption may not be valid for most developing countries), that there is equitable distribution of food and income among the population.

#### Standard of living and food

Food is the most basic of man's needs. There can be no survival without it and thus the question of development here is to be viewed in terms of whether this basic need of the population is being fulfilled or not.

The health and life expectancy of a population is primarily related to the nutritional level of a population which depends on the food per capita available. Berg has shown the relationships between life expectancy, health and nutrition (refer to section 4.2). Also Cepede et al<sup>98</sup> have shown the correlation between nutritional level and male life expectancy in

some countries. Indicating a strong relationship between food per capita and food productivity Khilnani states that "when a society is at the subsistence level, each person is helping to produce, just as much as he or she consumes... However, as the food consumption and standard of living of a population increases, health and life expectancy improve and so does the ability to work harder and produce more. As food production goes up due to productivity increases, so do savings and the level of technology. This results in even greater productivity."<sup>99</sup>

Khilnani has cited a quantitative study by Dema,<sup>100</sup> showing a strong interrelationship between nutrition and agricultural production. Meadows<sup>101</sup> has also computed the relationship between life expectancy and vegetable calories per person-day, using data from over seventy countries. (Refer to section 4.2).

Thus an increase in per capita food results in an increase in the standard of living in terms of better health, nutrition and life expectancy. This in turn could lead to reduced mortality, general well being of the population, and increased productivity of the labor force.

#### Standard of living and income

Despite the inherent flaw of per capita economic indications (viz not being able to incorporate the distribution patterns), income per capita is a convenient, much used indicator of economic growth.

A higher income per capita means an increase in the standard of living in terms of budgetary position of household, consumption and increased

saving patterns, ability to afford the basic amenities, such as food, clothing, shelter, medicine etc. In fact, an increased income per capita may mean an increase in the welfare of the people.

An examination of the Household Income and Expenditure Survey of Pakistan in 1972,<sup>102</sup> reveals that people in the higher income groups are well off in terms of budgetary position and food consumption, a situation which is true of any country where income disparities exist.

Fig. 5.5 indicates that people in highest income groups consumes almost twenty times more food than those in the lowest income group. Fig. 5.6 indicates that the budgetary position improves from a deficit of almost 85% to a surplus of almost 34% as income increases from the lowest to the highest income groups. Similarly, consumption of non-food in terms, access of better living conditions, and general well being are accessible only if per capita income increases. Thus, per capita income defines a certain standard of living, and increasing the per capita income increases the standard of living.

#### Literacy level and the standard of living

Education defines a standard of living of a population in terms of its ability to adopt new ideas and innovations and participation in development process. In examining possible correlates of low fertility, Robert Repetto<sup>103</sup> observed that functional literacy may be the most important influence. The spread of education, particularly education, and particularly education for women, was also seen to be correlated with low fertility rates.



Education (measured in terms of literary rates) will be introduced in subsequent runs of the model as a factor motivating a reduction in birth rates.

The standard of living and its influence on birth and death rates

In a subsistence agrarian economy, the standard of living of the people can be measured best in terms of food per capita and income per capita. These two per capita measures are used in the initial stages of the model to represent the socio-economic condition or standard of living of the people. In later runs another indicator, the literary rate and its contribution to the standard of living, is introduced.

When food per capita, income per capita and literary rates are at their normal values, the corresponding standard of living in terms of food, income and education, is at a normal value of one. Increases in these socio-economic indicators increases the corresponding standard of living. These increases are measured in terms of multiples of the normal value and the effects introduced by way of dimensionless multipliers.

A low standard of living depicts a high death rate, high mortality and poor health. A low standard of living demands the need of children as labor, particularly in an agrarian setting. In order to have a desired number of children at old age, the high infant mortality rates compels people to compensate by having more children. Children provide economic benefits and old age security in the rural sector of an agrarian developing country. (Refer to Chapter One).

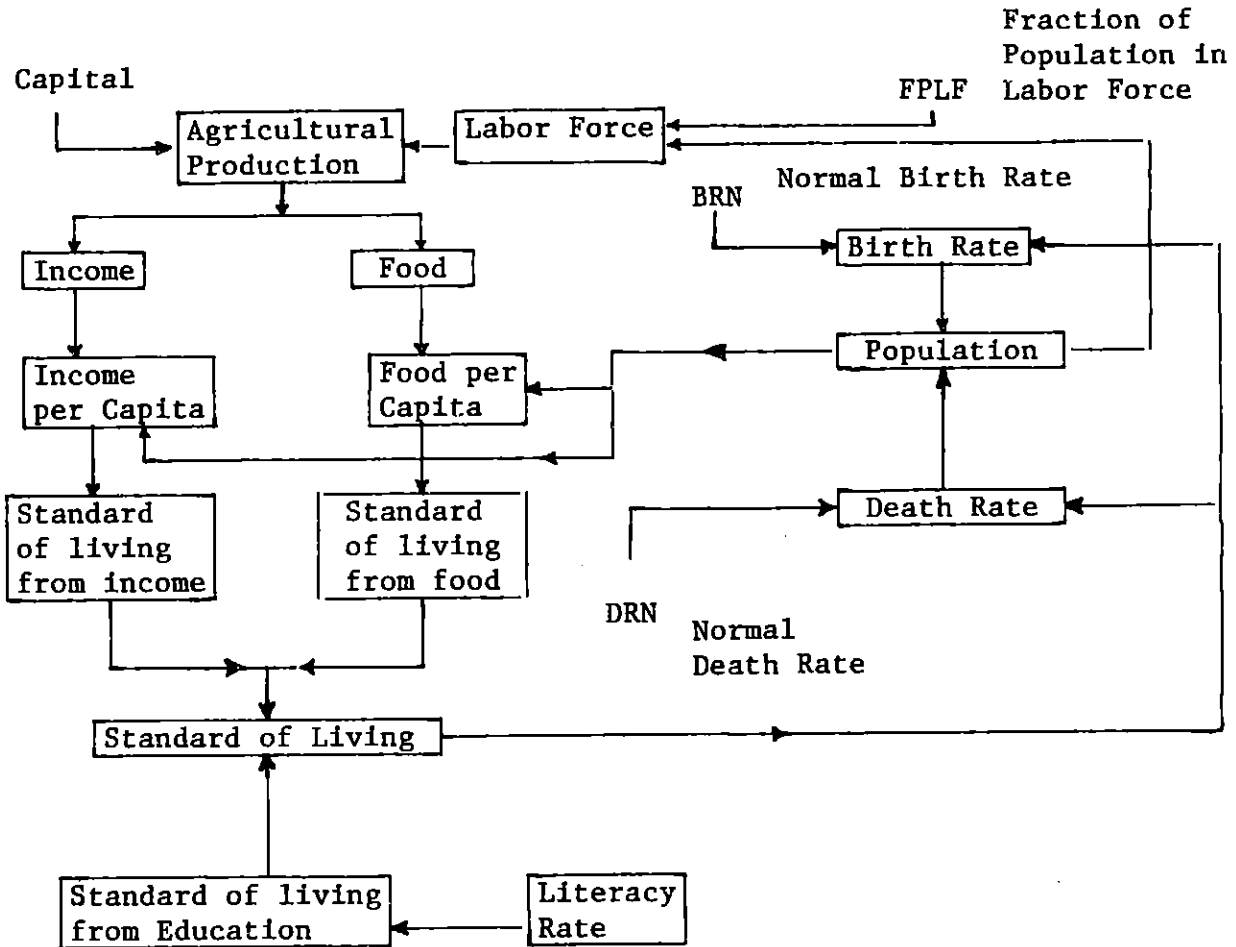
The socio-economic state of the population is an important correlate of fertility rates. Lim's work using regression and factor analysis confirms that socio-economic conditions account for birth rates and population trends. (Refer to section 3.10).

Repetto has shown that a reduced infant mortality rate results in a short term increase in birth rates but later on the birth rates fall. A higher standard of living also means better opportunities for women and their emancipation from traditional roles, another factor cited by Repetto as a correlate of lower fertility. Khilnani uses a relationship depicting decreases in birth rates with increased income. (Refer to section 4.2). Irma Adelman has correlated low birth rates with increased income. (Refer to section 3.10).

The socio-economic state of the population is an important determinant of fertility and birth rates, the model uses the standard of living variable to represent the socio-economic state. The standard of living being defined by the additive contributions of income per capita, food per capita and literacy level.

The model assumes that continued increase in the standard of living decreases the birth rate. The effect of the standard of living on birth and death rates is introduced through the birth rate multiplier and death rate multiplier respectively.

Fig. 5.4: The Population and Agricultural Production Model; A Flow Diagram.



Variables of the model

The complete model is schematically represented in fig. 5.4.

- 1) Population is altered by the birth rate and the death rate. Population defines a labor force depending on the fraction of the population in the labor force.
- 2) Labor Force is one of the inputs to agricultural production, the other being capital, which is an exogenous variable.
- 3) From agricultural production is generated income and food. Depending on the population at that time, income per capita and food per capita are defined.
- 4) The income per capita and food per capita define the standard of living in terms of multipliers from food.
- 5) The standard of living will be measured in dimension less units which are multiples of the normal value of the standard of living. It is also influenced by the literary ratio via the standard of education multiplier a factor incorporated in the later runs of the model.
- 6) The standard of living affects the birth and death rates via the birth rate multiplier (BRM) and death rate multiplier (DRM).
- 7) The birth rate and death rate are influenced by the respective multipliers and the normal crude birth rate (BRN) and normal crude death rate (DRN).

## Section 5.2: Choice of Technique

A survey of economic demographic models in chapter three has revealed a number of short comings and inherent flaws in these models. A majority of them are based on assumptions, which are not valid in the present day situation of a developing country.

The analytical models suffer generally from the use of the Cobb-Douglas production function, and thus contain the inherent characteristics viz being biased against the growth of population. Other models rely on Malthusians assumption which, as seen earlier, may not be true in many developing countries. (Refer to section 3.8).

Very little empirical work has been done particularly on a micro level to ascertain the causal relationships between population and development. An attempt was made in the summer of 1976 to collect as much statistics as possible on population and development in Pakistan. An extensive trip to Pakistan and numerous visits to government sources and offices revealed that the 1972 population census conducted by the government of Pakistan had not been released. Some crude estimates were available. For socio-economic conditions too, there is a lack of data available. The data that is available suffers from the same problems as data from most Third World countries, namely inaccuracy, missing data and unreliability.

Most important of all, causal relationships of the type under consideration have as yet not been determined analytically. Though past experience of other countries and historical patterns can give ideas about the general trends of such interactions, the exact magnitude of these relationships is

not defined. In view of all these considerations, the only choice left was to use simulation techniques. Wherever available, data from Pakistan, based on government sources, have been used.

#### Duration of simulation

Most of the data on Pakistan is available from 1960 onwards. For the purpose of this study, the simulation time is from 1960 to 1990, a period of thirty years. Time is set equal to zero at the start of the simulation. After 30 years when time reaches the value 30, simulation stops. Values of the variables are calculated after every half year.

In the base run the only input to the agricultural process is labor. Subsequent trials will be made with increasing capital investment. Effect of social conditions like literacy rate are also incorporated in later runs.

Section 5.3: The Model Inputs

Wherever possible, model inputs will be based on statistics and data from Pakistan. As seen earlier, Pakistan fits well as the type of country our model is trying to represent. It is a developing country, whose economy is agrarian; majority of the population lives in the rural areas and is experiencing rapid population growth. Birth rates are high and agriculture is the main contributor to the national income.

As with most developing countries, in Pakistan statistics on many important issues are either not available or are unreliable. The population census of 1972 has not been released as yet, although crude estimates are available.

Population

The population under consideration is the rural population of Pakistan. The initial value of population used in this model is the rural population of Pakistan in 1960, which is  $33.23^{104}$  million people. The normal birth and death rate figures correspond to the crude birth and death rates for Pakistan.

The initial values are chosen to correspond to the 1962 values of the variables. The Population Growth Survey 1971<sup>105</sup> has estimated these values from 1962 to 1971. Again, some values are missing. By 1971, the crude birth rate had dropped from .037 to .035 and the crude death rate fell from .012 to .011. The model incorporates this by changing the normal birth and death rates in 1972 to correspond to the figures for 1972.

### The labor force

According to the Labor Force Survey<sup>106</sup> 1971-72, conducted by the Government of Pakistan, only 30.97 percent of the total rural population were in the civilian labor force. Out of this 30.47 percent were employed, and .5 percent were found unemployed.

The figures on employed persons by major occupation groups reveals that 70.44 percent of the total employed people in the rural areas were in Agriculture and related occupations (such as animal husbandary and forestry workers, fishermen and hunters.)

Thus the fraction of population in the agricultural labor force (FPLF) is set equal to .26, taking into account the above statistics. This is the figure for 1971-1972 period.

Different values of this variable will be tried indicating possible changes in age structure or labor intensive techniques, capable of employing larger number of people.

### The agricultural sector

The initial value of agricultural production is the index of agricultural output for 1960 in Pakistan. This is a dimensionless index of the quantity of agricultural product, including all crops. To simplify the model, it is assumed that the crops being produced are all food crops.

If the fact that a number of crops are cash crops, such as tobacco or fibers, is to be taken into account, then the value of the constant in the equation relating food and agricultural production can be changed to a fractional value instead of the initial value of one. The index is set equal to 100 at the start of the simulation.



### Income from Agricultural Production

As described earlier, if prices and costs are assumed constant during the simulation, then income can be expressed as a function of output alone, the model assumes this function is linear so that

$$\text{Income} = \text{Constant} \times \text{Agricultural Production}$$

In determining the value of this constant we will try to incorporate the income and income per capita figures for Pakistan.

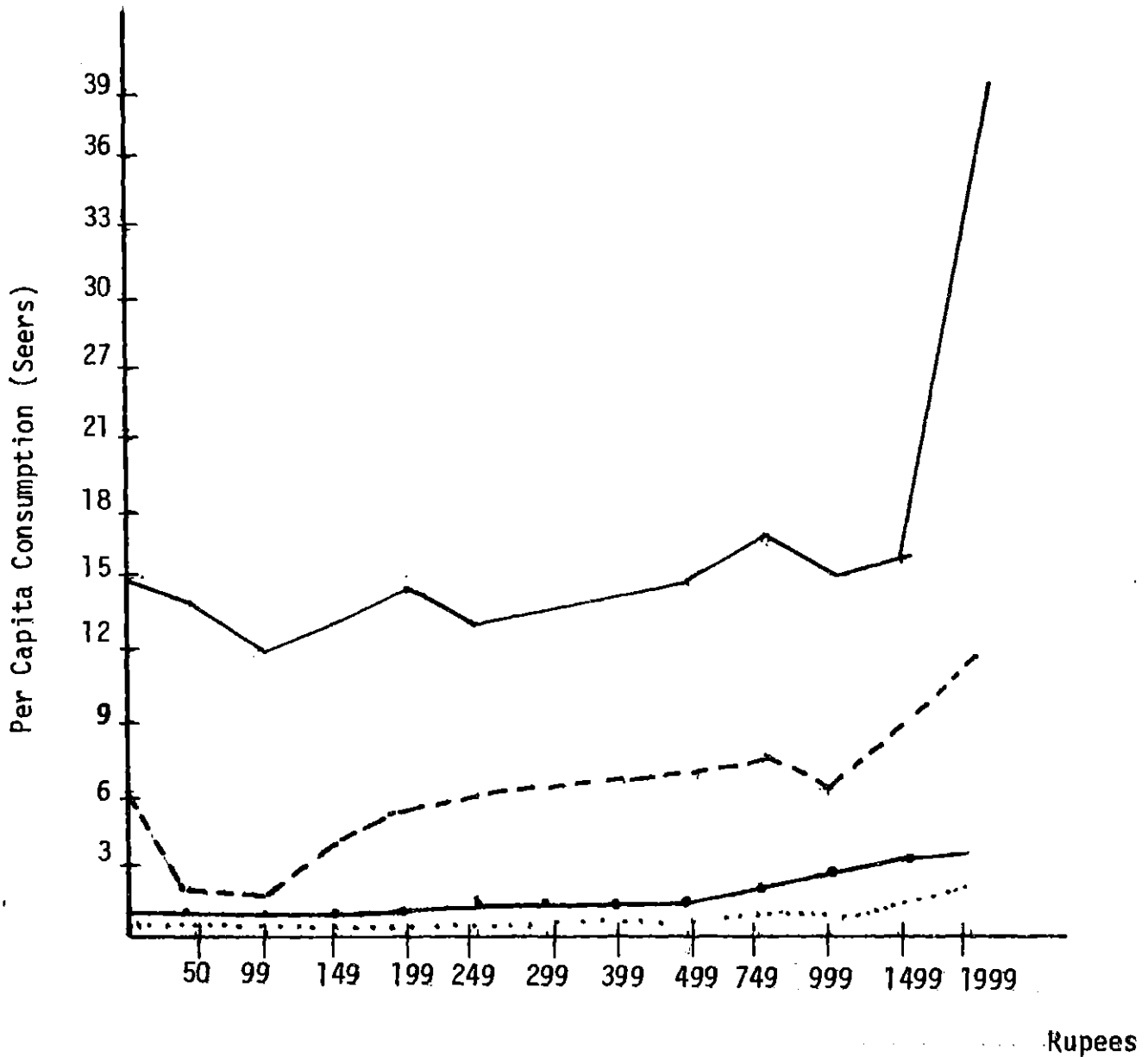
The initial population is 33.23 million and the per capita income is approximately Rs 200 in 1960.<sup>107</sup> This gives a figure for initial income as 6646 million Rupees. The initial agricultural output is 100. Which gives a value for the constant in the above equation equal to 66 million Rs.

In successive runs of the model different values of this constant will be used to reflect changes in the value of the agricultural output, which may take place by exogenous changes, such as in the procurement prices, etc.

### Standard of Living and Income in Pakistan

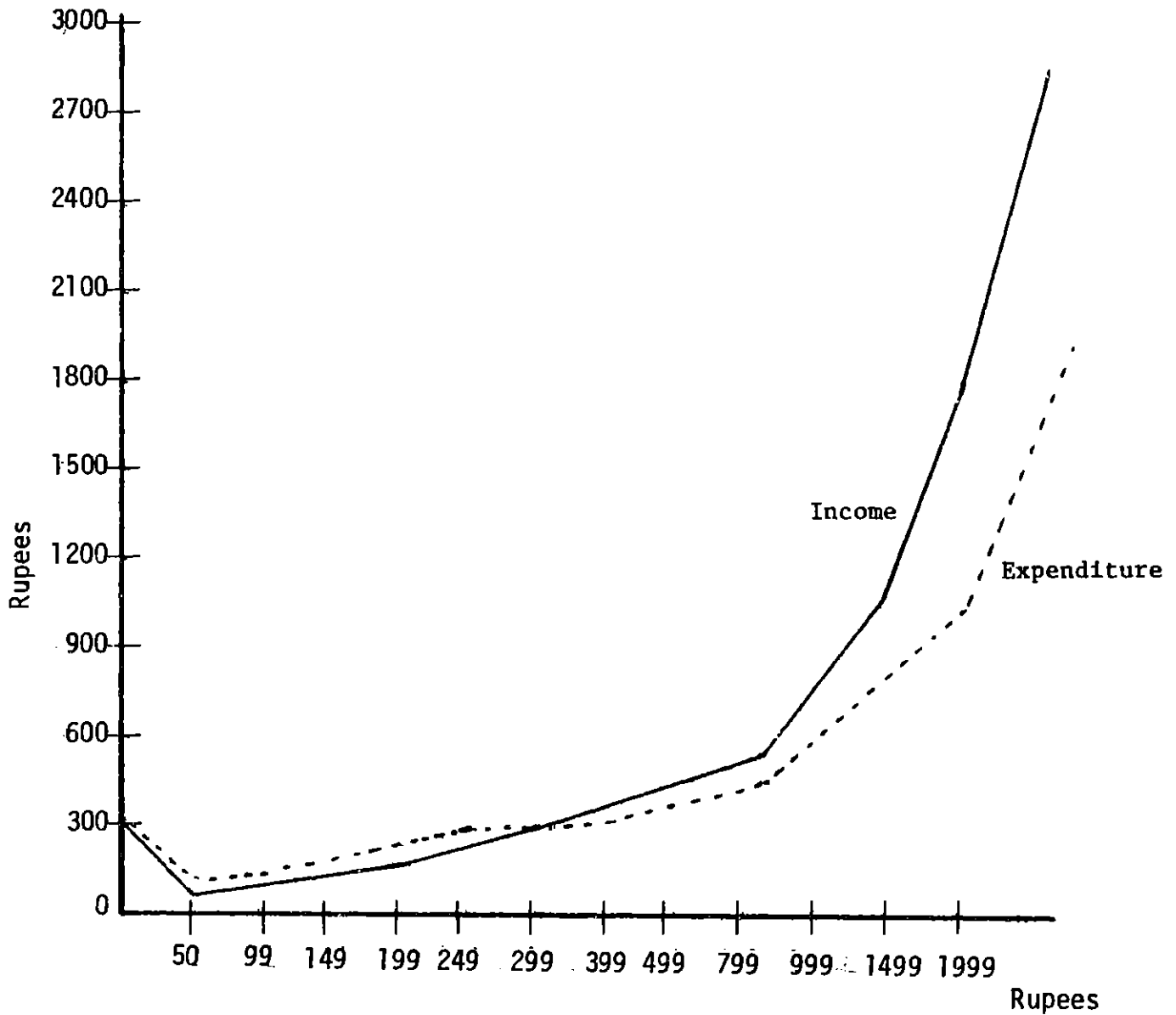
In order to get an idea of the standard of living of different income groups we examine the Monthly Per Capita Consumption of Major Food Items by Income Group Fig. 5.5 and the Budgetary position of Households by Monthly income groups Fig. 5.6. As income increases, per capita food consumption increases, which people with income Rs 50 consume 15 seers of food grains those with income Rs 2000 consume 39 seers. Milk consumption increases from 3 seers to 12 seers i.e. 4 times as much, while sugar and meat and fish consumption increases from 0 to 3 seers per person per month. (Refer to glossary).

Figure 5.5: Monthly Per Capita Consumption of Major Food Items  
by Income.



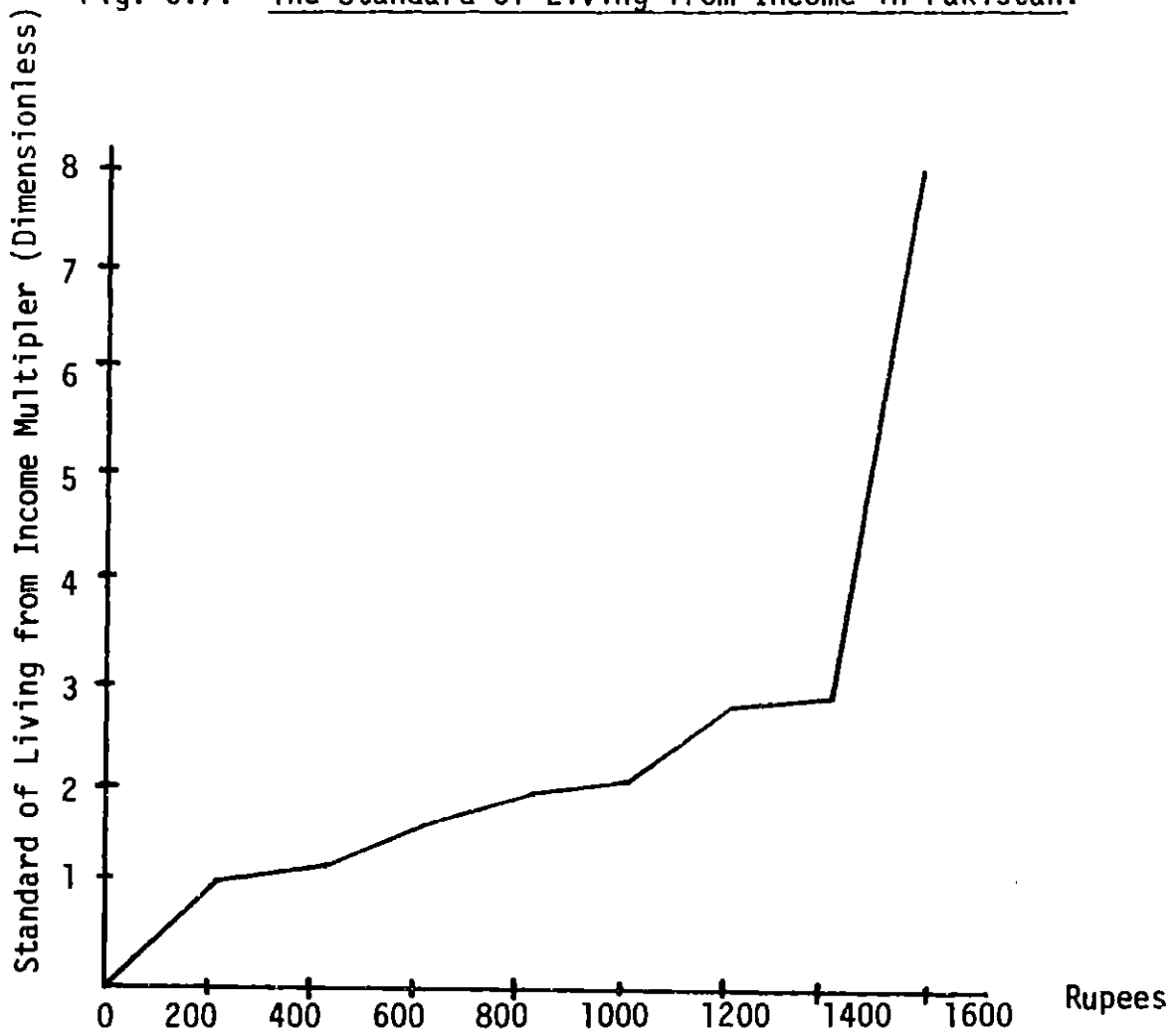
Source: Statistical Division, Government of Pakistan, Household Income and Expenditure Survey 1971-72, pg. 35.

Figure 5.6: Budgetary Position of Households by Monthly Income in Pakistan.



Source: Statistical Division, Government of Pakistan, Household Income and Expenditure Survey, 1971-72, pg. 37.

Fig. 5.7: The Standard of Living from Income in Pakistan.



The budgetary position of people in the highest income is six times better than people in the lowest income bracket.

Thus it is safe to say that people in the high income groups have a far higher standard of living. This helps in formulating a relationship as shown in figure 5.7.

As income per capita increases from a normal value of Rs 200, the standard of living multiplier increases from its normal value of one. On one extreme, with no income per capita, standard of living from income is zero and, on the other, with an income per capita of Rupees 1600 or above, the standard of living is eight times the normal value. (Fig. 5.7). The standard of living increases steadily from Rs 0 to Rs 1400. After this point there is a sudden increase, a fact substantiated by figures 5.5 and 5.6.

#### Income Effects on Birth Rates in Pakistan

There has been no work done on how income affects birth rates in Pakistan. In order to ascertain possible relationships of per capita income and birth rate, we use this table on size of an average family by income groups.

TABLE 5-1

#### SIZE OF AN AVERAGE HOUSEHOLD BY MONTHLY INCOME GROUPS

Monthly income rupees	Percent of households	Average No. of family members per household
1) Less than 200	52.4%	3.8
2) 200-400	38.6%	6.6
3) 400-1000	8.2%	9.7
4) 1000-1500	.5%	10.0
5) 1500 and above	.3%	8.0

Source: The Household Income and Expenditure Survey 1972, Government of Pakistan,

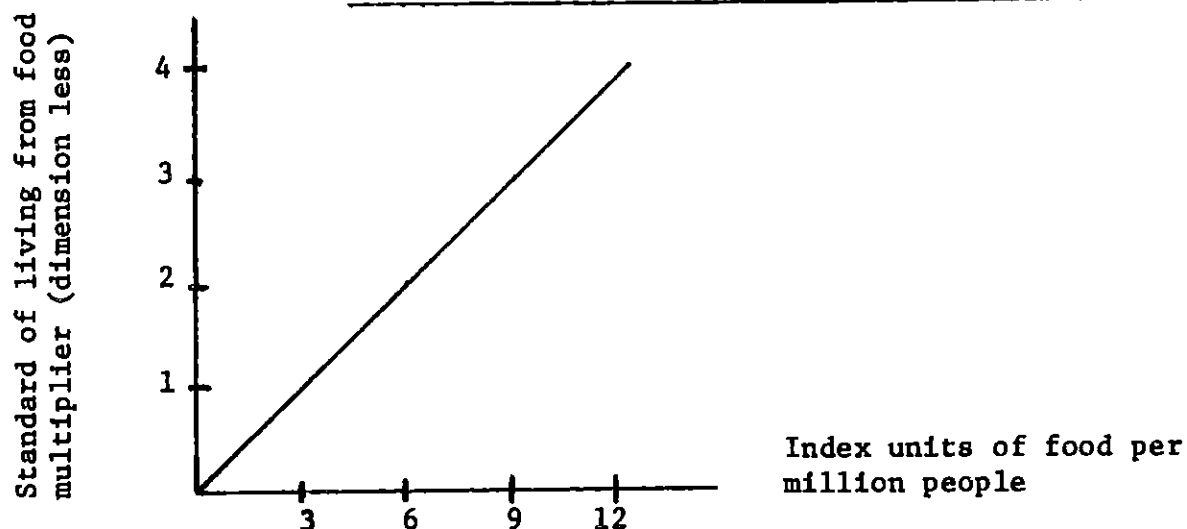
Thus an increase in income is accompanied by an increase in family members from income group one to income group four. Only when monthly income increases to Rs 1500 that family size falls. One can hardly state that income is the only determinant of family size but works cited earlier have shown correlation between incomes and birth rates. One reason that family size is low in the lowest income groups is because of high infant mortality, malnutrition, undernourishment and general ill health of the people in that income group.

As the income increases, monthly budgetary position and food consumption increases. This results in a higher standard of living and a decrease in the need for children for economic reasons. This could be one of the reasons that people in the highest income groups have fewer children. Also, it is people in these income groups who are exposed to the processes of modernization, who can afford an education, who are more willing to accept family planning, factors which have positive effect on lowering birth rate.

The standard of living and food in Pakistan

At the start of the model run the population stands at 33.23 million and the agricultural production index at 100, giving a measure of food per capita in terms of food index per million people = 3. At this level of food per million people, the standard of living from food is set at a normal value of one. Increases in this index will increase the standard of living.

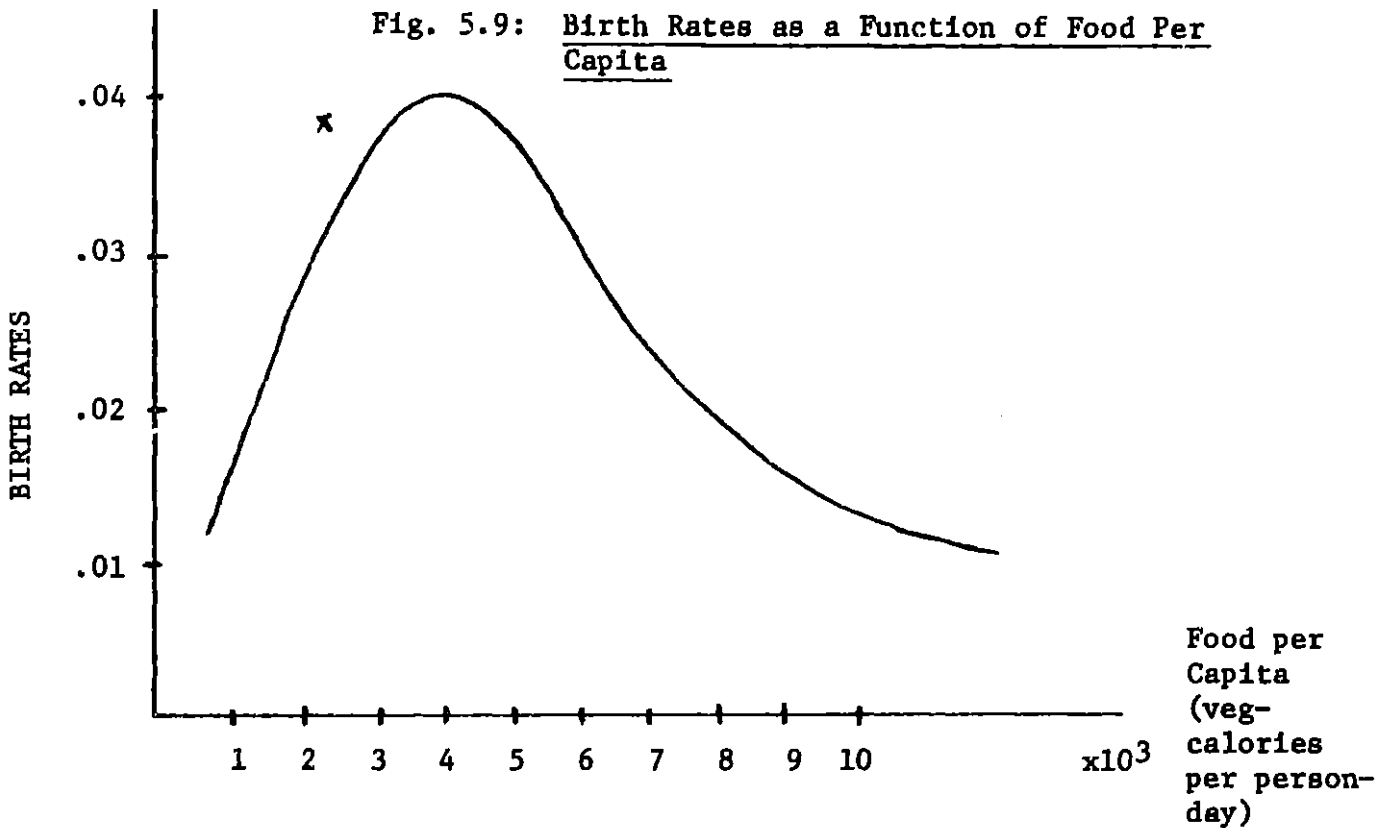
Fig. 5.8: The Standard of Living and Food in Pakistan



In the initial runs the relationship between food per million people and standard of living is assumed to be linear. However, since there is no data available in Pakistan on such a relationship, different forms of this relationship can be tried with the general assumption that increases in food per capita increases the standard of living from food.

Birth and Death Rate as a Function of Food Per Capita

The Khilnani-Agarwal Model uses a relationships shown in the Fig. 5.9 below (same as Fig. 4.3)



As far as the situation in Pakistan goes, the Calorie Intake for all Income Groups stands at 1988 =  $1.988 \times 10^3$ , and a birth rate of .037 puts the country at position marked 'x' on the graph. So that food per capita intake would have to be increased to four times or more than the present intake to decrease the birth rate to half of the present.

Increases in the standard of living due to the increase in the supply of food will increase the birth rates initially, and then lower it. The effect on the death rate is that increases in standard of living due to increase in the supply of food decreases the death rate.

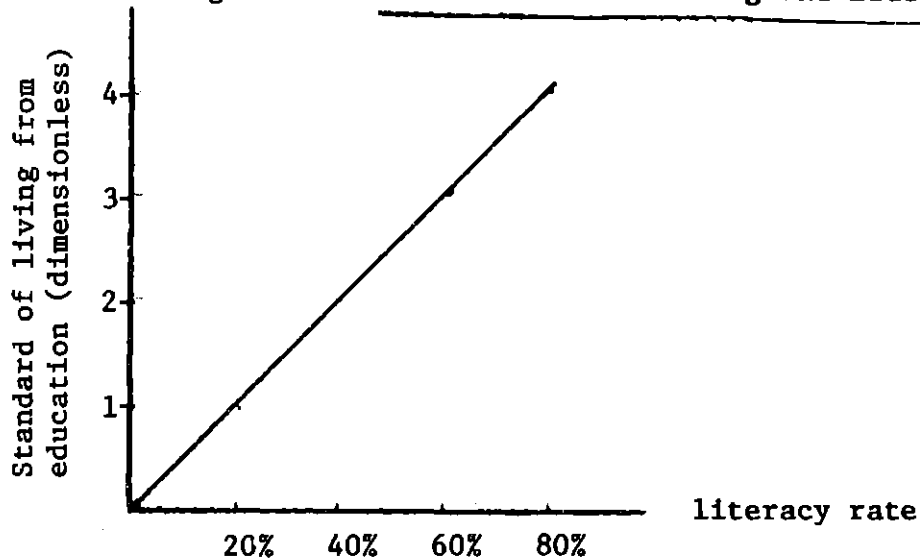
The Literacy Rate in Pakistan

The 1972 census showed a literacy rate of 20% in Pakistan. Corresponding to this level of literacy, the standard of living in terms of



education is set at one. Increasing ~~the~~ literacy rate increases the standard of living in terms of education. (Refer to Chapter 3).

Fig. 5.10: The Standard of Living and Education



The birth and death rate multipliers and the standard of living

The birth and death rate multipliers are functions of the standard of living. The relationship is to quite an extent arbitrary but realistic and is based on works (discussed earlier) by Khilnani, Irma Adelman, Lim, etc. (Refer to sections 4.2, 3.10).

The way the model is set up, different functions relating the standard of living and the multipliers will be tried, the standard of living being the sum of the standard of living in terms of the effects of food, income and education. (Figs. 5.11 and 5.12)

Fig. 5.11: The Death Rate as a Function of the Standard of Living

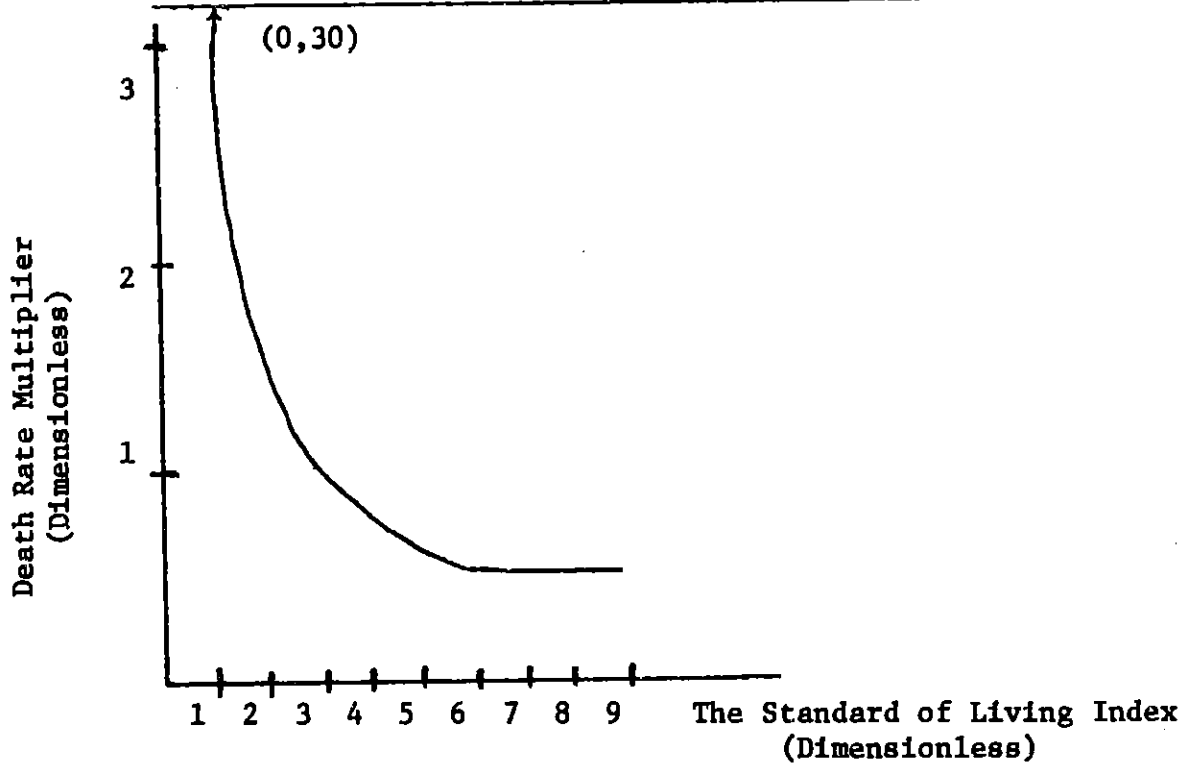
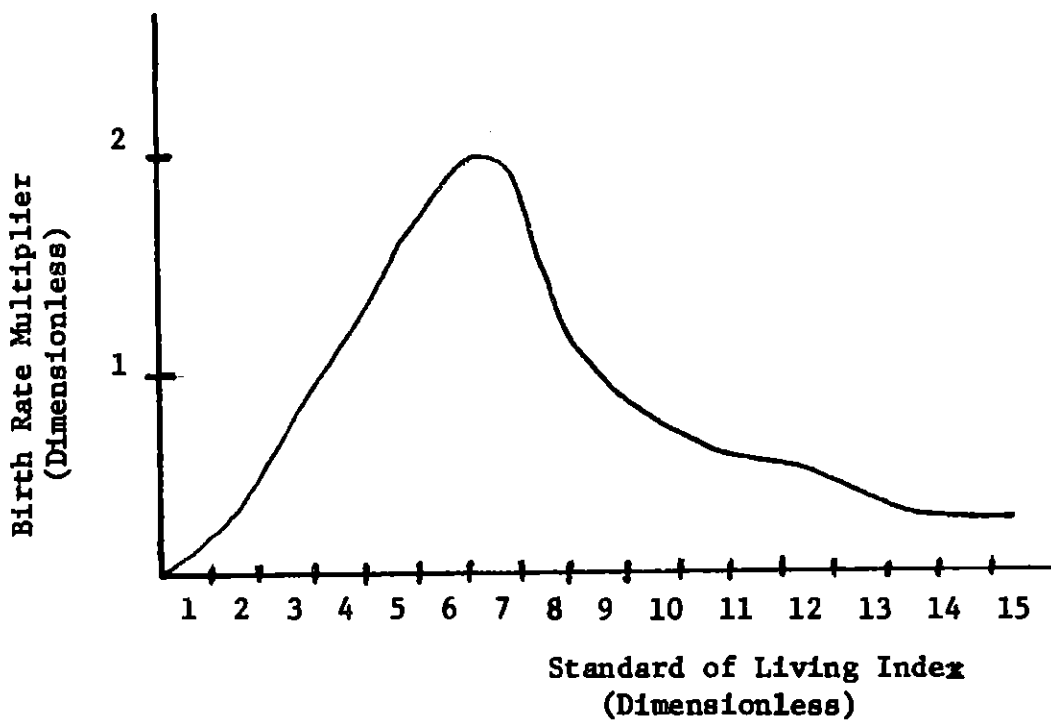


Fig. 5.12: The Birth Rate as a Function of the Standard of Living



Section 5.4: The Equations of the Model

Population Sector

Population (P)

$$P_t = P_{t-1} + BR_t - DR_t$$

$P_t$  = Population at time t (millions of people)

$P_{t-1}$  = Population at time t-1 (millions of people)

$B_t$  = Number of people born at time t (millions of people)

$D_t$  = Number of people who die at time t (millions of people)

The initial values

$$P_0 = 33.23 \text{ million}$$

$$B_0 = .037 \text{ million}$$

$$D_0 = .012 \text{ million}$$

The initial values correspond to the values of the variables in 1960 in the rural population of Pakistan.

The Birth Rate (B)

Birth rate is defined as the total number of people born each year.

$$BR_{t+1} = P_t * BRN_t * BRM_t$$

$BR_{t+1}$  = number of people born at time t+1 (millions of people)

$P_t$  = population at time t

$BRN_t$  = normal birth rate, corresponds to the crude birth rate at time t

$BRM_t$  = birth rate multiplier at time t

### The Death Rate (D)

Death rate refers to the total number of people who die each year.

$$DR_{t+1} = P_t * DRN_t * DRM_t$$

$DR_{t+1}$  = total number of people who die at time t+1  
(millions of people)

$P_t$  = population at time t

$DRN_t$  = normal death rate, corresponds to the demographic  
crude death rate.

$DM_t$  = death rate multiplier at time t.

### The Birth Rate and Death Rate Multipliers

The birth rate multiplier ( $BRM_t$ ) and death rate multiplier ( $DRM_t$ ) influence the birth and death rates respectively.

The multipliers are function of the standard of living

$$BRM_t = u(s_t) \text{ (Refer to fig. 5.12)}$$

$$DRM_t = v(s_t) \text{ (Refer to fig. 5.11)}$$

where  $s_t$  is the standard of living at time t.

### The Agricultural Sector

#### The agricultural production (A)

$$A_t = A_o * A_{L,t} * A_{K,t}$$

$$A_o = 100$$

$A_t$  = agricultural production at time t (index of  
agricultural production-dimensionless)

$A_0$  = initial value of agricultural production which is set at 100 to correspond to the value of agricultural production in 1960 in Pakistan.

$A_{L,t}$  = agricultural production from labor at time t

$A_{K,t}$  = agricultural production from capital investment in agriculture at time t.

$A_{L,t}$  is a function of the labor force at time t

$$A_{L,t} = f_1(L_t)$$

where  $L_t$  is the labor force at time t.

$f_1$  reflects a pattern of diminishing returns to labor. (Refer to fig. 5.3)

$A_{K,t}$  is a function of the capital investment at time t.

$$A_{K,t} = f_2(K_t)$$

$A_{K,t}$  will act as a multiplier e.g.  $A_{K,t} = 2$  will mean that capital investment in agriculture has increased from a normal value to double the normal value.

(In the base run  $A_{K,t} = 1$ , implying no capital investment.)

The function  $f_2$  is exogenously determined and represents the capital investment in agriculture.

### Labor Force (L)

The function  $f_1$  will be determined by the labor force  $L_t$

$$L_t = FPLF_t * P_t$$

$L_t$  = labor force at time t

$FPLF_t$  = fraction of population in the labor force  
at time t.

$P_t$  = population at time t.

For the base run FPLF is set equal to .26 to correspond to the figure for the rural population's work force in agriculture in Pakistan.

#### Food from Agricultural Production (F)

$$F_t = C1 * A_t$$

$F_t$  = Food production at time t

$C1$  = Constant of proportionality

$A_t$  = Agricultural production at  
time t.

It is assumed that the food production is a constant proportion of agricultural production.

In the model  $C1$  is set equal to 1 implying that only food crops are being grown in the agricultural sector.

#### Income from Agriculture (I)

Assuming that prices remain constant, income is expressed as a linear function of production. It is measured in million rupees.

$$I_t = C2 * A_t$$

$I_t$  = Income from agriculture at time t

$C2$  = constant of proportionality

$A_t$  = agricultural production at time t

The constant C2 is chosen to conform to the situation of per capita income in the rural areas of Pakistan.

Income per capita (IPC)

$$IPC_t = \frac{I_t}{P_t}$$

$IPC_t$  = income per capita at time t (rupees)

$I_t$  = income at time t (million rupees)

$P_t$  = population at time t (millions of people)

Food per capita (FPC)

Food per capita will be measured by the index, food per million people

$$FPC_t = FMP_t = \frac{F_t}{P_t}$$

$FMP_t$  = food per million people at time t (Food index/  
million people)

$F_t$  = food at time t (Index, dimensionless)

$P_t$  = population at time t (millions of people)

Standard of living from food per capita

$$S_{F,t} = f(FPC_t)$$

$S_{F,t}$  = standard of living from food per capita at time t

$FPC_t$  = Food per capita

Standard of living from income per capita

$$S_{I,t} = g(IPC_t)$$

$S_{I,t}$  = standard of living from income per capita, at time t.

$IPC_t$  = income per capita at time t

The function f and g will be set up to reflect the trends in Pakistan, but are, to quite an extent, arbitrary, and variations in f and g are experimented with in this model.

The standard of living from education

$$S_{E,t} = h(LR_t)$$

$S_{E,t}$  = standard of living from education at time t

$LR_t$  = literacy rate at time t

The standard of living from education is a function (h) of literacy rate. The function h is somewhat arbitrary, but uses again literacy rates from Pakistan.

The standard of living (S)

$$S_t = S_{F,t} + S_{I,t} + S_{E,t}$$

$S_t$  = standard of living at time t

$S_{F,t}$  = standard of living from food per capita

$S_{I,t}$  = standard of living from income per capita.

$S_{E,t}$  = standard of living from education



It is an assumption of the model that the effects of food, income and education are additive. The standard of living  $S_t$ , determines the multipliers  $BRM_t$  and  $DRM_t$ , affecting the birth and death rates, respectively.

Section 5.5: Definition of Terms Used in the Model

The model has been implemented in DYNAMO.<sup>108</sup> Since subscript notations were not possible, a complete list of variables and parameters used in the computer model is as follows:

P	Population, measured in millions of people per year.
P1	Initial population.
BR	Birth rate, measured by millions of people born each year.
DR	Death rate, measured by millions of people born each year.
BRN	Normal birth rate, measured by fraction of people born per year represents crude birth rate.
BRN1	New value of BRN.
SWT1	Switch time number 1 for BRN (years).
BRM	Birth rate multiplier (dimensionless).
DRN	Normal death rate (represents crude death rate) measured by fraction of population who die each year.
DRN1	New value of DRN.
DRM	Death rate multiplier (dimensionless).
SWT2	Switch time number 2 for DRN (years).
AP	Agricultural production measured in index units of agricultural product (dimensionless).

APN	Normal agricultural production (dimensionless index), (initial base value).
APLM	Agricultural production from labor multiplier.
APKM	Agricultural production from capital multiplier.
APKM1	New value of APKM.
SWT3	Switch time number 3 for APKM.
APLMT	Agricultural production from labor multiplier table.
FPLF	Fraction of population in the labor force.
FPLF1	New value of FPLF.
SWT4	Switch time number 4 for FPLF
F	Food from agricultural production (index units, dimensionless).
C1	Constant of proportionality.
FMP	(Food per capita indicator) food per million people measured by food index per million people).
SLFM	Standard of living from food multiplier (dimensionless).
SLFMT	Standard of living from food multiplier table.
I	Income from agricultural production measured in million rupees.
C2 and C3	Constant of proportionality, relating agricultural production and income.
SWT5	switch time number 5 for C2.
IPC	Income per capita measured by rupees per person.
SLIM	Standard of living from income multiplier (dimensionless).
SLIMT	Standard of living from income multiplier table.
LR	literacy ratio, percentage of people who are literate.
L1, L2	Values of the literacy ratio.

SWT6                    Switch time number 6 for literacy ratio L.

SLEM                    Standard of living from education multiplier  
(dimensionless)

SLEMT                   Standard of living from education multiplier table.

SL                      Standard of living (dimensionless).

DRMT                    Death rate multiplier table.

BRMT                    Birth rate multiplier table.

CLIP                    A logical function used as a time switch to change  
parameter values. When time reaches the value de-  
noted by SWT.

TABHL                   Logical function, table look up and interpolation.

TIME                    Calender time (years).

CHAPTER SIX

Conclusions and Recommendations

Section 6.1: The Result of Different Trials of the Model

The Base Run

In the base run, no change has been made in the capital investment in agriculture or in the literacy ratio. Labor is the only input to the production process. The fraction of population in the labor force has been increased from .26 to .32 by 1978 to represent the possibilities of employing more labor. Only food is being produced in the agricultural production process.

Starting with a population of 33.23 million people by 1972, the population has increased to 46.97 million. This compares favorably with the figures for the rural population for Pakistan (provided by the Census Organization of Pakistan), which stand at 47.99 million in 1972. At the end of the thirty year period, the population is 82.33 million and continues to increase.

The birth rate has increased from 1.24 million to 3.10 million and the death rate from .40 million to .86 million and both depict increasing trends. The agricultural production index in 1973 stands at 220, which is higher than the index (190) in government data.

Although the agricultural product has tripled during this time, the food per million people does not show any substantial change. Starting from an initial value of 3.0, it increases to a maximum of 3.87 in eighteen and half years with a corresponding population figure of 57.82 million people. However, the population outpaces this increasing trend and the indicator of food per million people drops to a value of 3.64.

The income per capita is set at Rupees 200 at the start of the simulation by 1972 the figure is 292.78. Naseem's estimate of rural poverty in Pakistan has shown that from 1963 to 1972 about 48.71 to 72.41 percent of the rural population had an income below Rupees 300 per capita per annum. (Refer to section 4.3). Thus the simulated value of income per capita is fairly representative of the situation in the rural areas of Pakistan. The income per capita reaches a maximum of Rupees 341.32 after eighteen and a half years with a corresponding population of 57.82 million people. At the end of the thirty year simulation, the income per capita has dropped down to Rupees 240.5.

The normal value of the standard of living is three, which corresponds to the situation in 1960. This is because the normal value of the standard of living in terms of , the standard of living in terms of income and in terms of education, each is set at a value of one. This corresponds to the normal values of food per million people of 3.0, income per capita of Rupees 200 and literacy ratio of 20%.

The standard of living is 3.87 better after eighteen and half years, but this figure drops to 3.26 at the end of the run. The labor force has increased from an initial value of 8.64 to 26.35 million people.

#### Trials with increased capital investment in agriculture

Increasing the capital investment in agriculture is incorporated by increasing the value of the agricultural product from capital multiplier (APKM) from one, to a new value (APKMI) equal to two or three, the effect

of this change is to increase the agricultural product to twice or thrice the normal value.

With APKMI equal to 2, agricultural product increases from 101.19 to 600 in eighteen and a half years and remains at this figure till the end of the run. The labor force stands at 33.49 million people which is larger than the base run. The birth rate stands at 4.89 million people (higher than base run) and the death rate at .90 million people (higher than the base run). The income per capita increases to 378.39 Rupees (higher than the base run), and the standard of living stands at 4.09 compared to 3.26 in the base run. The population in this run, however, is far greater than the base run and stands at 104.64 million people with the labor force at 33.49 million (higher than the base run).

Further increasing the capital investment by setting  $APKMI = 3$ , increases the agricultural output from 101.19 to 900 index units, the labor force increases to 35.25, the food per million people 8.17, income per capita 539.2 Rupees, and the standard of living (5.27) are better in this run compared to when the agricultural production multiplier from capital AKMI is doubled. Also the death rate is lower (.69 million people per year). However, the population is higher than the previous two runs now standing at 110.16 million people and the birth rate too is larger (6.87 million people).

Thus, it seems that although this run does better in general than the previous two runs, we end up with a fairly large population and a high birth rate. If the casual relationships assumed in the model are correct,

then it seems that a better strategy is to keep the capital investment at par with the second run and increase the value of the agricultural output.

#### Increasing the income from agricultural production

In the model income is proportional to the output. The value of the constant of proportionality had been chosen to represent income per capita, in rural Pakistan. In the base and second run C2 was equal to 66 (refer to section 5.5). In the latter runs the value of this constant is increased. C2 equals C3 with a value of 100 or 200. This reflects increasing the value of the output (maybe by increasing procurement prices).

In run four with  $APKMI = 2$  and  $C3 = 100$  the agricultural output stands at 600, the labor force 34.86 the income per capita has increased to 550.8 Rupees. Compared to run three the standard of living has dropped, so has the population, the birth rate and the labor force. However, the death rate has increased (.86 million). So that a policy desiring increased standard of living would prefer run three, while one desiring lower population would prefer run four.

In run five a further increase is made in the income from agricultural output, C3 is set equal to 200. This run is far better than run three or four. The agricultural product is 600, a lower labor force 20.87 million people, significantly lower birth rate than any of the previous runs (1.13 million), a significantly higher income per capita, food per million people and standard of living. Also, the population stands at a much lower figure (65.23 million) than any of the previous runs.

Thus increasing the value of the agricultural output and the income from the agricultural sector (assuming that equitable distribution is possible) has a more significant impact on increasing the standard of living and lowering the population growth rate than increasing capital investment in agriculture to merely double or triple the output. Subsequent runs of the model assume that  $C3 = 200$  and  $APKMI = 2$ .

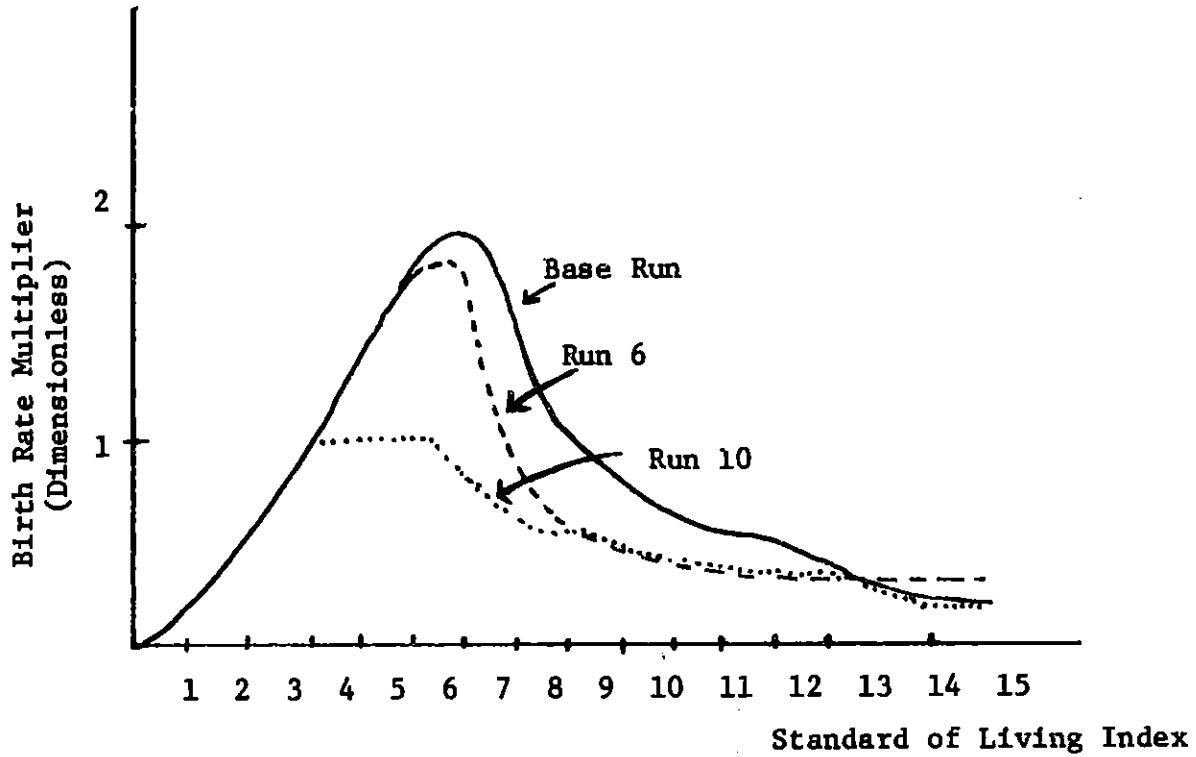
#### Trial with a new birth rate multiplier

The birth rate multiplier is a function of the standard of living. Recall that  $BRM_t = U(S_t)$  (refer to section 5.4). As discussed earlier, this function is, to quite an extent, arbitrary and, therefore, different shapes of this curve can be tried to reflect possible impacts of family planning. It may be possible that introduction of birth planning programs (which are acceptable to the people) helps in lowering the peak of the birth rate curve.

Run 6 incorporates this relationship as shown in fig. 6.1 (with  $APKMI=2$  and  $C3 = 200$ ). Compared to the base run, run 6 shows a lower population 63.33 million, smaller birth rate (.89 million) and death rate (.35 million). Compared to run 5, however, the population is lower (66.33 million) the income higher 1894.7 Rupees and the standard of living more or less the same.



Fig. 6.1: Trials with the Birth Rate Multiplier



Family Planning (Run 6)

Small Family Norms and Family Planning (Run 10)

The effects of increasing the literacy ratio

With an increase in the literacy from 20 percent to 40 percent and the same birth rate multiplier table as in the base run, population stands at 63.26 million people, a figure lower than all other runs with this birth rate multiplier. The labor force is lower than other runs (20.24 million people) so is the birth rate (.87 million people). The food per million people is 9.48 and the income per capita, 1896.8. The standard of living is also higher than any other run and stands at 13.2.

Increasing the literacy ratio to 60% or 80% (by the year 1980) produces even better results. The results with 80% literacy rate show a population of 61.45 million, a labor force 19.66 million, birth rate .65 million and death rate .34 million. The food indicator, income per capita and the standard of living have the highest values compared to all other runs.

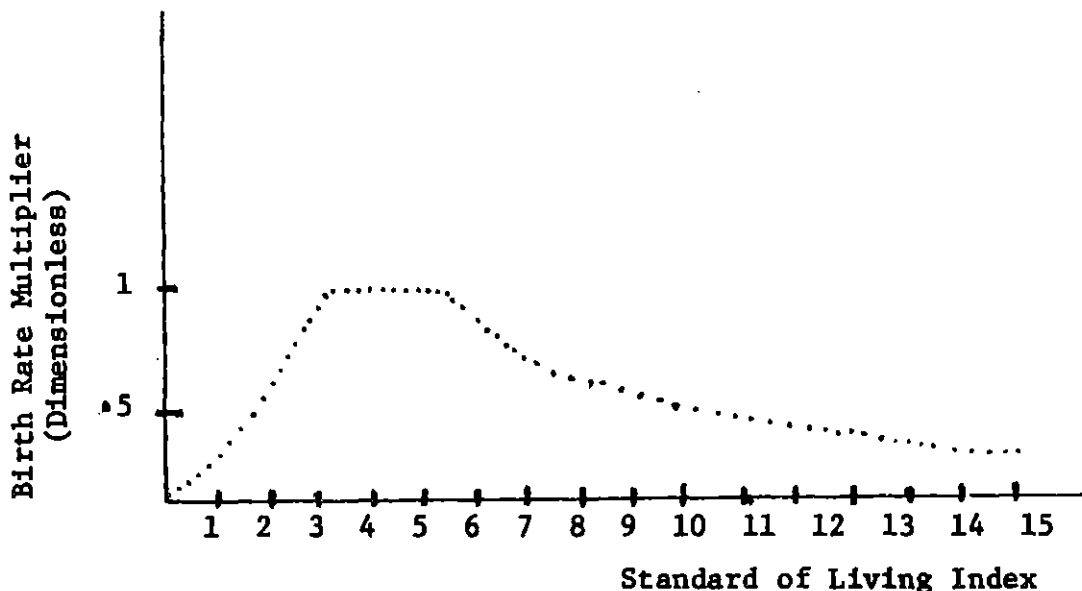
However, an important aspect here is that even though increasing the literacy ratio affects the standard of living favorably for 10 to 12 years, the slow but steady growth of population starts reducing this effect of increases in the standard of living.

A significant factor that must not be overlooked is that it does not seem realistic that a developing country such as Pakistan could increase the literacy ratio to 80%. This would involve massive capital investments on the part of the government, expenses which a poor country may not be able to afford.

Inculcation of small family norms

It may be possible to reduce the present high birth rate patterns if the people consciously and willingly adopt small family norms. This can be done by introducing birth planning programs in a radically different socio-economic structure of society. It must be emphasized that unless the family planning programs are acceptable to the majority of the people, there is not much chance of their success. The last run assumes a favorable environment for the implementation of birth planning programs and/or a conscious desire on the part of the rural family to limit their numbers. This hypothesis is introduced in the model by a new birth rate multiplier which assumes that as the standard of living increases, the present birth rates will prevail for some time, followed by a gradual decrease in the birth rates (see fig. 6.2).

Fig. 6.2: Successful Family Planning and Inculcation of Small Family Norms, a New Birth Rate Function.



At the end of thirty years of simulation, the population is 58.44 million people; birth rate .82 million and death rates .32 million, figures lower than any of the previous runs. The food index is 10.3 and the income per capita Rupees 2053, figures higher than other runs. No change has been made in the literacy level in this run so that the standard of living index (12.42) is lower than when changes in literacy levels are made.

The model is very sensitive to changes in this function and the implications of this run is significant for policy issues. It seems necessary to create an environment for the possibilities of such relationship to exist, if population patterns are to be changed in the developing countries.

#### Section 6.2: Major Findings of the Study

One of the major findings of this study is that even if it were possible to reduce birth rates by increasing the standard of living of the people, the population does not stop growing. This is because of the lag between implementation of development schemes (the capital investment in agriculture, increasing the literacy ratio) and population growth is large.

Increases in food per capita, income per capita and the literacy ratio do help in increasing the standard of living of the population for 10 to 15 years or so, but the slow yet steadily growing population has a tendency to negate this growth of standard of living.

The model has assumed very favorable development conditions, chances of heavy investment in agriculture, increasing the value of the output,

TABLE 6-1

Result of Different Runs of the Model

Run No.	Description of Run		P	AP	LF	BR	DR	FMP	IPC	LR	SL
1	Base Run	I.V.	33.23	101.19	8.6	1.24	.40	3.05	200.0	20	3.02
		E.V.	82.33	300	26.35	3.10	.86	3.6	240.0	20	3.26
2	Doubling the capital investment in agriculture. APKM1=2	I.V.	Same as Base Run								
		E.V.	104.64	600	33.49	4.89	.90	5.73	378.4	20	4.09
3	Triple the capital investment in agriculture. APKM1=3	I.V.	33.23	101.19	8.6	1.24	.40	3.05	201.0	20	3.02
		E.V.	110.16	900	35.23	6.87	.69	8.17	539.2	20	5.27
4	Increasing the value of the agricultural output, i.e., income from agriculture. Capital C3=100 Invest double APKM1=2	I.V.	Same as Run 3								
		E.V.	108.92	600	34.86	5.59	.86	5.51	550.8	20	4.4
5	Futher increasing income from agriculture C3=200 and SPKM1=2	I.V.	Same as Run 3								
		E.V.	65.23	600	20.87	1.13	.36	9.20	1839.6	20	12.02
6	Introduction of family planning, a new birth rate multiplier	I.V.	Same as Run 3								
		E.V.	63.33	600	20.27	.89	.35	9.47	189.7	20	12.16
7	Increasing the literacy from 20 to 40 percent	I.V.	Same as Run 3								
		E.V.	63.26	600	20.24	.87	.35	9.48	1896.8	40	13.16

TABLE 6-1 (continued)

Run No.	Description of Run		P	AP	LF	BR	DR	FMP	IPC	LR	SL
8	Increasing the literacy to 60 percent	I.V.	Same as Run 3								
		E.V.	62.17	600	19.89	.74	.34	9.65	1930.3	60	14.22
9	Increasing the literacy to 80 percent	I.V.	Same as Run 3								
		E.V.	61.45	600	19.66	.65	.34	9.76	1952.8	80	15.26
10	Inculcation of small family norms and/or widespread family planning programs; a new birth rate multiplier.	I.V.	Same as Run 3								
		E.V.	58.44	600	18.7	.8	.32	10.27	2053	20	12.42

Abbreviations Used:

- I.V. → Initial Value (1960)  
 E.V. → End Value (1990)  
 P → Population (millions of people)  
 AP → Agricultural Production (Index Units)  
 LF → Labor Force (millions of people)  
 BR → Birth Rate (millions of people born each year)  
 DR → Death Rate (millions of people who die each year)  
 FMP → Food per million people (Food index/million people)  
 IPC → Income per capita (Rupees)  
 LR → Literacy Ratio (Percentage)  
 SL → Standard of Living (Dimensionless Index)

possibility of wide scale educational reforms. Initially, the casual relationship between development and population growth has been set up so that increases in the standard of living up to five times the present should enable birth rates and death rates to drop by more than 60 percent.

The trial that does best in terms of lowest growth rates is the one in which radical changes in the socio-economic structure, successful family planning programs and inculcation of small family norms are assumed. The population in this trial stands at 58.44 million in 1990 compared to 33.23 million (less than double) at the start of the simulation and is growing at the rate of .82 million people per year.

### Section 6.3: Recommendations for Future Work

This study presses on the necessity of finding the determinants of causal relationships of the kind assumed in the model here. Work should be done on an in-country basis and on a micro-level to determine why and how families are motivated to have more children. Issues to be investigated should include how the socio-economic structure and political organizations are influencing decisions of families in developing countries to have many children.

No one can deny the importance of family planning programs in developing countries, but as we have seen, not many of them succeed. Certainly, in the case of Pakistan, the performance of these programs leaves much to be desired. Countries which lack the organizational and political structure of a country such as China cannot motivate people to accept family planning

programs.

So far as mathematical tools like model building are concerned, there exists an urgent need to develop better socio-economic indicators and incorporating them in economic demographic analysis. The nature and extent of causal relationships must be determined, if model building is to be a guide in development policies.

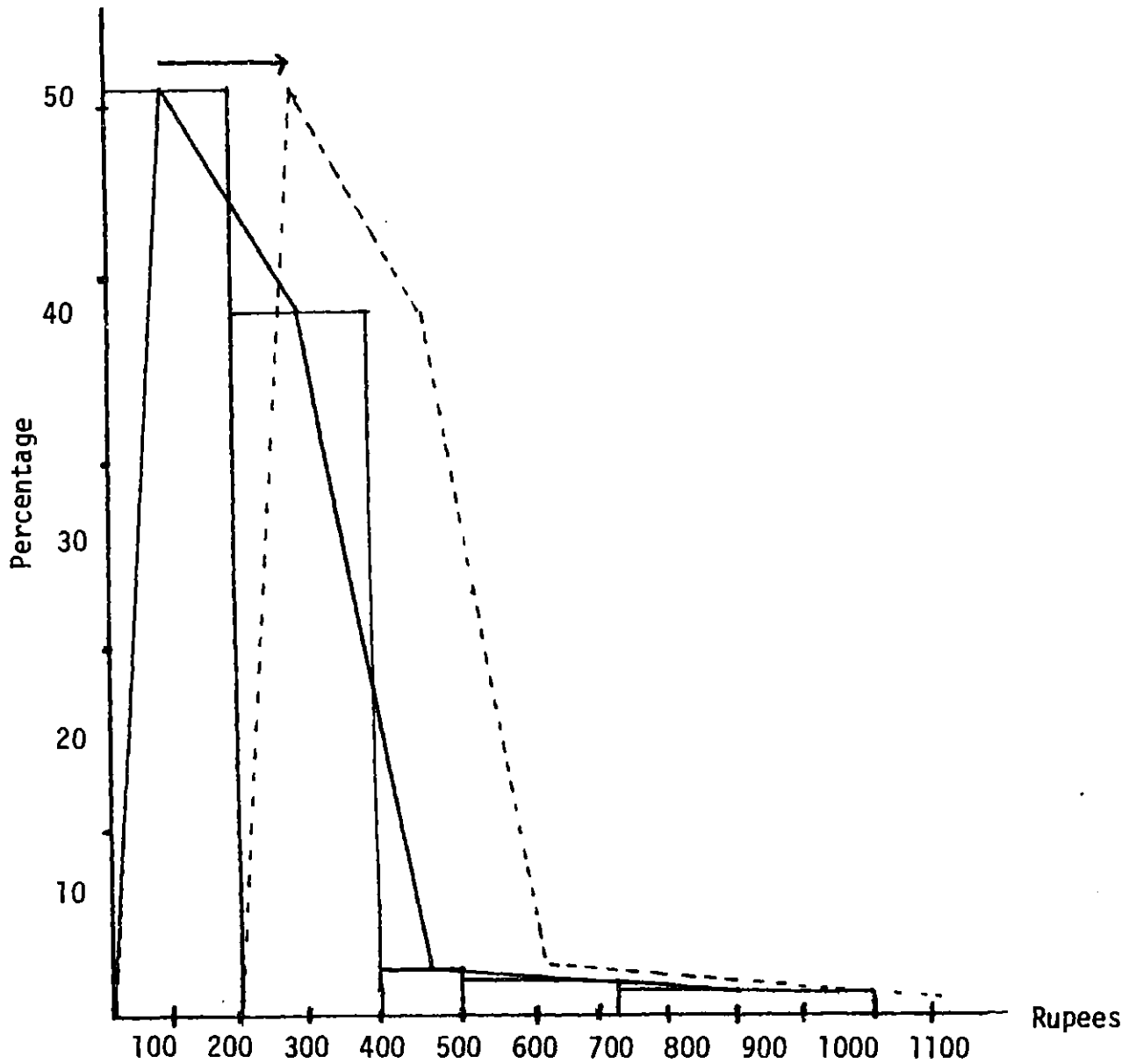
Micro-level analysis within particular countries is necessary. Even within a country, different income groups depict varying population patterns. The skewed distribution of income should be incorporated in models of this type. So far as the situation in Pakistan goes, the income distribution portrays an extremely skewed distribution. (See fig. 6.3). Assuming that the variance of this distribution remains the same, effects of shifting the curve to the right (increasing the income) need to be studied. Average per capita income is not a good indicator of socio-economic conditions.

Family formation in Pakistan at different income levels must be studied. This can be achieved only by extensive field work and data gathering. It has been assumed in the model that the standard of living is the additive effect of food, income and literacy. Different forms of this function need to be studied. Extensive field work could help in determining what weights should be attached to these socio-economic indicators and how they interact with each other to form a certain standard of living.

The importance of such studies for policy issues cannot be overemphasized. Such studies could indicate the extent of the influence of a higher standard of living on lower birth rates. As seen in the different trials



Fig. 6.3: Skewed distribution of Income in rural Pakistan 1971-72.



Source: Statistics Division, Government of Pakistan, Household Income and Expenditure Survey 1971-72.

of the model, the crucial functions are the ones relating the standard of living to the birth and death rates. Quantifying such relationships in terms of meaningful indicators, has important implications for any development plans which incorporate population considerations.

### Conclusion

The issue of population growth must be viewed in a socio-economic context. Massive development and restructuring of society may be needed before people in developing countries like Pakistan can be motivated to change their attitudes towards family planning. Tradition and culture may play some part in the desire of large families, but the impact of economic and political structures cannot be denied.

Studies should be initiated to incorporate those socio-economic aspects which are difficult to quantify. The necessity and urgency of such studies must be realized if the population issue is to be resolved in the interests of the common people in the Third World Countries.

APPENDIX

PAGE 1 POPULATION AGRIC PROD MODEL 2/14/77 20:37

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* POPULATION AGRIC PROD MODEL
L P.K=P.J*(DT)*(BR,JK-DR,JK)
N P=P1
C P1=33.23
R BR.KL=(P.K)*(CLIP(BRN,BRN1,SWT1,TIME.K))*(BRM.K)
C BRN=.037
C BRN1=.035
C SWT1=12
R DR.KL=(P.K)*(CLIP(DRN,DRN1,SWT2,TIME.K))*(DRM.K)
C DRN=.012
C DRN1=.011
C SWT2=12
NOTE AGRICULTURAL SECTOR
A AP.K=APN*APLM.K*(CLIP(APKM,APKM1,SWT3,TIME.K))
C APN=100
A APLM.K=TARHL(APLMT,LF.K,8.6,18.6 2)
T APLMT=1/1.6/2.2/2.6/2.8/3
C APKM=1
C APKM1=1
C SWT3=18
A LF.K=(CLIP(FPLF,FPLF1,SWT4,TIME.K))*P.K
C FPLF=.26
C FPLF1=.32
C SWT4=18
NOTE FOOD FROM AP
A F.K=C1*AP.K
C C1=1
A FMP.K=F.K/P.K
NOTE STANDARD OF LIVING FROM FOOD
A SLFM.K=TARHL(SLFMT,FMP.K,0,12,3)
T SLFMT=0/1/2/3/4
NOTE INCOME FROM AP
A I.K=(CLIP(C2,C3,SWT5,TIME.K))*AP.K
C C2=66
C C3=66
C SWT5=18
A IPC.K=I.K/P.K
NOTE STANDARD OF LIVING FROM INCOME
A SLIM.K=TARHL(SLIMT,IPC.K,0,1600,200)
T SLIMT=0/1/1.2/1.7/1.8/2/2.9/3/8
NOTE LITERACY RATIO
A LR.K=(CLIP(L1,L2,SWT6,TIME.K))
C L1=20
C L2=20
C SWT6=20
NOTE STANDARD OF LIVING FROM EDUCATION
A SLEM.K=TARHL(SLEMT,LR.K,0,80,20)
T SLEMT=0/1/2/3/4
NOTE THE STANDARD OF LIVING
A SL.K=SLFM.K+SLIM.K+SLEM.K
NOTE THE DEATH RATE MULTIPLIER
A DRM.K=TARHL(DRMT,SL.K,0,9,1)
T DRMT=30/3/2/1/.8/.6/.5/.5/.5
NOTE THE BIRTH RATE MULTIPLIER
A BRM.K=TARHL(BRMT,SL.K,0,15,1)
T BRMT=0/.2/.5/[1/.3/1.7/2/1.6/1.3/.8/.6/.5/.5/.4/.35/.3
PRINT 1)P,2)AP,3)LF,4)BR,5)DR,6)FMP,7)IPC,8)BRM,9)DRM,10)SL,11)LR
SPEC LENGTH=30/PLTPER=.5/DT=.25/PRTPER=.5

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Information Processing Center

Information Processing Center

RUN 1

Information Processing Center

Information Processing Center

TIME	P		AP		LF		RR		DR		FMP		IPC		BRM		DRM		SL		LR	
	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00
.C	33.230	101.19	8.640	1.2354	.39746	3.0453	200.99	1.0048	.99679	3.0161	20.000											
.5	33.652	104.48	8.749	1.2600	.40060	3.1048	204.92	1.0120	.99203	3.0399	20.000											
1.	34.084	107.86	8.862	1.2852	.40380	3.1644	208.85	1.0191	.98727	3.0636	20.000											
1.5	34.528	111.31	8.977	1.3110	.40709	3.2239	212.78	1.0262	.98252	3.0874	20.000											
2.	34.982	114.86	9.095	1.3375	.41045	3.2834	216.71	1.0334	.97776	3.1112	20.000											
2.5	35.449	118.50	9.217	1.3647	.41391	3.3429	220.63	1.0405	.97302	3.1349	20.000											
3.	35.927	122.23	9.341	1.3926	.41745	3.4022	224.55	1.0476	.96828	3.1586	20.000											
3.5	36.418	126.06	9.469	1.4211	.42108	3.4615	228.46	1.0547	.96354	3.1823	20.000											
4.	36.921	129.98	9.599	1.4505	.42481	3.5206	232.36	1.0618	.95882	3.2059	20.000											
4.5	37.437	134.01	9.734	1.4805	.42863	3.5796	236.25	1.0688	.95411	3.2294	20.000											
5.	37.966	138.14	9.871	1.5114	.43255	3.6384	240.14	1.0759	.94941	3.2529	20.000											
5.5	38.509	142.37	10.012	1.5430	.43657	3.6971	244.01	1.0829	.94473	3.2764	20.000											
6.	39.066	146.71	10.157	1.5754	.44069	3.7556	247.87	1.0899	.94006	3.2997	20.000											
6.5	39.637	151.17	10.306	1.6087	.44492	3.8138	251.71	1.0969	.93540	3.3230	20.000											
7.	40.222	155.73	10.458	1.6428	.44925	3.8718	255.54	1.1038	.93077	3.3462	20.000											
7.5	40.823	160.42	10.614	1.6778	.45370	3.9296	259.36	1.1108	.92615	3.3692	20.000											
8.	41.439	165.22	10.774	1.7136	.45826	3.9872	263.15	1.1177	.92156	3.3922	20.000											
8.5	42.071	170.15	10.938	1.7504	.46294	4.0444	266.93	1.1245	.91699	3.4151	20.000											
9.	42.718	175.20	11.107	1.7882	.46773	4.1014	270.69	1.1313	.91244	3.4378	20.000											
9.5	43.383	180.39	11.280	1.8269	.47265	4.1580	274.43	1.1381	.90791	3.4604	20.000											
10.	44.064	185.70	11.457	1.8666	.47770	4.2143	278.14	1.1449	.90342	3.4829	20.000											
10.5	44.763	191.15	11.638	1.9073	.48287	4.2703	281.84	1.1516	.89895	3.5053	20.000											
11.	45.480	196.74	11.825	1.9470	.48818	4.3259	285.51	1.1582	.89450	3.5275	20.000											
11.5	46.215	202.48	12.016	1.9919	.49362	4.3812	289.16	1.1649	.89009	3.5495	20.000											
12.	46.969	208.36	12.212	2.0358	.49921	4.4360	292.78	1.1714	.88571	3.5715	20.000											
12.5	47.724	214.25	12.408	1.9674	.46273	4.4893	296.30	1.1778	.88145	3.5927	20.000											
13.	48.481	220.10	12.605	2.0087	.46792	4.5399	299.64	1.1839	.87741	3.6130	20.000											
13.5	49.255	224.13	12.806	2.0431	.47494	4.5503	300.32	1.1851	.87658	3.6171	20.000											
14.	50.043	228.22	13.011	2.0779	.48208	4.5605	301.00	1.1864	.87577	3.6212	20.000											
14.5	50.844	232.39	13.219	2.1133	.48935	4.5706	301.66	1.1876	.87496	3.6252	20.000											
15.	51.660	236.63	13.431	2.1494	.49675	4.5806	302.32	1.1887	.87417	3.6292	20.000											
15.5	52.489	240.95	13.647	2.1860	.50428	4.5904	302.96	1.1899	.87338	3.6331	20.000											
16.	53.334	245.34	13.867	2.2234	.51194	4.6000	303.60	1.1911	.87261	3.6369	20.000											
16.5	54.194	249.81	14.090	2.2614	.51974	4.6095	304.23	1.1922	.87185	3.6407	20.000											
17.	55.068	254.35	14.318	2.3000	.52767	4.6189	304.85	1.1933	.87110	3.6445	20.000											
17.5	55.958	258.98	14.549	2.3394	.53574	4.6281	305.46	1.1944	.87037	3.6482	20.000											
18.	56.863	261.84	14.784	2.3716	.54557	4.6048	303.92	1.1917	.87223	3.6389	20.000											
18.5	57.822	299.03	18.503	2.5491	.52599	5.1716	341.32	1.2596	.92697	3.8652	20.000											
19.	58.836	300.00	18.828	2.5758	.53896	5.0999	336.53	1.2508	.83277	3.8362	20.000											
19.5	59.856	300.00	19.154	2.5907	.55287	5.0121	330.80	1.2404	.83970	3.8015	20.000											
20.	60.880	300.00	19.481	2.6216	.56684	4.9278	325.23	1.2303	.84644	3.7678	20.000											
20.5	61.908	300.00	19.811	2.6446	.58087	4.8459	319.83	1.2205	.85298	3.7351	20.000											
21.	62.941	300.00	20.141	2.6678	.59496	4.7664	314.58	1.2110	.85933	3.7034	20.000											
21.5	63.979	300.00	20.473	2.6910	.60911	4.6891	309.48	1.2017	.86550	3.6725	20.000											
22.	65.021	300.00	20.807	2.7144	.62332	4.6139	304.52	1.1927	.87150	3.6425	20.000											
22.5	66.067	300.00	21.142	2.7378	.63760	4.5408	299.69	1.1840	.87734	3.6133	20.000											
23.	67.119	300.00	21.478	2.7614	.65194	4.4697	295.00	1.1755	.88302	3.5849	20.000											
23.5	68.174	300.00	21.816	2.7850	.66634	4.4005	290.43	1.1672	.88855	3.5573	20.000											
24.	69.235	300.00	22.155	2.8088	.68090	4.3311	285.98	1.1591	.89393	3.5303	20.000											
24.5	70.300	300.00	22.496	2.8326	.69533	4.2674	281.65	1.1512	.89918	3.5041	20.000											
25.	71.370	300.00	22.838	2.8566	.70992	4.2035	277.43	1.1436	.90428	3.4786	20.000											
25.5	72.444	300.00	23.182	2.8806	.72458	4.1411	273.31	1.1361	.90926	3.4537	20.000											
26.	73.524	300.00	23.528	2.9048	.73930	4.0803	269.30	1.1288	.91412	3.4294	20.000											
26.5	74.607	300.00	23.874	2.9291	.75409	4.0210	265.39	1.1217	.91885	3.4057	20.000											
27.	75.696	300.00	24.223	2.9535	.76894	3.9632	261.57	1.1148	.92347	3.3826	20.000											
27.5	76.790	300.00	24.573	2.9780	.78385	3.9068	257.85	1.1080	.92798	3.3601	20.000											

TIME	P	AP	LF	BR	DR	FMP	IPC	BRM	DRM	SL	LR
28.	77.888	300.00	24.924	3.0026	.79883	3.8517	254.21	1.1014	.93238	3.3381	20.000
28.5	78.991	300.00	25.277	3.0273	.81388	3.7979	250.66	1.0950	.93667	3.3166	20.000
29.	80.099	300.00	25.632	3.0521	.82899	3.7454	247.19	1.0887	.94087	3.2957	20.000
29.5	81.212	300.00	25.988	3.0770	.84417	3.6941	243.81	1.0825	.94497	3.2752	20.000
30.	82.329	300.00	26.345	3.1021	.85941	3.6439	240.50	1.0765	.94897	3.2551	20.000

Information Processing Center

Information Processing Center

PAGE 5

POPULATION AGRIC PRODD MODEL

2/14/77 20:37

C. APKM1=2  
RUN 2

PRESENT  
ORIGINAL

APKM1  
2.000  
1.000

Information Processing Center

Information Processing Center

TIME	P	AP	LF	BR	DR	FMP	IPC	BRM	DRM	SL	LR
E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00
.0	33.23	101.19	8.640	1.2354	.39748	2.045	200.99	1.0048	.99679	3.0161	20.000
.5	33.65	104.49	8.749	1.2600	.40060	3.105	206.92	1.0120	.99203	3.0399	20.000
1.	34.08	107.86	8.862	1.2852	.40380	3.164	208.85	1.0191	.98727	3.0636	20.000
1.5	34.53	111.31	8.977	1.3110	.40709	3.224	212.78	1.0262	.98252	3.0974	20.000
2.	34.98	114.86	9.095	1.3375	.41045	3.283	216.71	1.0334	.97776	3.1112	20.000
2.5	35.45	118.50	9.217	1.3647	.41391	3.343	220.63	1.0405	.97302	3.1349	20.000
3.	35.93	122.23	9.341	1.3926	.41745	3.402	224.55	1.0476	.96828	3.1586	20.000
3.5	36.42	126.06	9.469	1.4211	.42108	3.461	228.46	1.0547	.96354	3.1823	20.000
4.	36.92	129.98	9.599	1.4505	.42481	3.521	232.36	1.0618	.95882	3.2059	20.000
4.5	37.44	134.01	9.734	1.4805	.42863	3.580	236.25	1.0688	.95411	3.2294	20.000
5.	37.97	138.14	9.871	1.5114	.43255	3.638	240.14	1.0759	.94941	3.2529	20.000
5.5	38.51	142.37	10.012	1.5430	.43657	3.697	244.01	1.0829	.94473	3.2764	20.000
6.	39.07	146.71	10.157	1.5754	.44069	3.756	247.87	1.0899	.94006	3.2997	20.000
6.5	39.64	151.17	10.306	1.6087	.44492	3.814	251.71	1.0969	.93540	3.3230	20.000
7.	40.22	155.73	10.458	1.6428	.44925	3.872	255.54	1.1038	.93077	3.3462	20.000
7.5	40.82	160.42	10.614	1.6778	.45370	3.930	259.36	1.1108	.92615	3.3692	20.000
8.	41.44	165.22	10.774	1.7136	.45826	3.987	263.15	1.1177	.92156	3.3922	20.000
8.5	42.07	170.15	10.938	1.7504	.46294	4.044	266.93	1.1245	.91699	3.4151	20.000
9.	42.72	175.20	11.107	1.7882	.46773	4.101	270.69	1.1313	.91244	3.4378	20.000
9.5	43.38	180.39	11.280	1.8269	.47265	4.158	274.43	1.1381	.90791	3.4604	20.000
10.	44.06	185.70	11.457	1.8666	.47770	4.214	278.14	1.1449	.90342	3.4829	20.000
10.5	44.76	191.15	11.638	1.9073	.48287	4.270	281.84	1.1516	.89895	3.5053	20.000
11.	45.48	196.74	11.825	1.9490	.48818	4.326	285.51	1.1582	.89450	3.5275	20.000
11.5	46.21	202.48	12.016	1.9919	.49362	4.381	289.16	1.1649	.89009	3.5495	20.000
12.	46.97	208.36	12.212	2.0358	.49921	4.436	292.78	1.1714	.88571	3.5715	20.000
12.5	47.72	214.25	12.408	1.9674	.46273	4.489	296.30	1.1778	.88145	3.5927	20.000
13.	48.48	220.10	12.605	2.0089	.46792	4.540	299.64	1.1839	.87741	3.6130	20.000
13.5	49.26	224.13	12.806	2.0431	.47494	4.590	300.32	1.1851	.87658	3.6171	20.000
14.	50.04	228.22	13.011	2.0779	.48208	4.561	311.00	1.1864	.87577	3.6212	20.000
14.5	50.84	232.39	13.219	2.1133	.48935	4.571	301.66	1.1876	.87496	3.6252	20.000
15.	51.66	236.63	13.431	2.1494	.49575	4.581	302.32	1.1887	.87417	3.6292	20.000
15.5	52.49	240.95	13.647	2.1860	.50248	4.590	302.96	1.1899	.87338	3.6331	20.000
16.	53.33	245.34	13.867	2.2234	.51194	4.600	303.60	1.1911	.87261	3.6369	20.000
16.5	54.19	249.81	14.090	2.2614	.51974	4.610	304.23	1.1922	.87185	3.6407	20.000
17.	55.07	254.35	14.318	2.3000	.52767	4.619	304.85	1.1933	.87110	3.6445	20.000
17.5	55.96	258.98	14.549	2.3394	.53574	4.628	305.46	1.1944	.87037	3.6482	20.000
18.	56.86	261.84	14.784	2.3716	.54557	4.605	303.92	1.1917	.87223	3.6389	20.000
18.5	58.20	600.00	18.625	3.9305	.32012	10.309	680.37	1.9294	.50000	6.1764	20.000
19.	60.03	600.00	19.711	4.1510	.33019	9.994	659.62	1.9755	.50000	6.0612	20.000
19.5	61.97	600.00	19.831	4.3034	.34448	9.682	638.99	1.9840	.50533	5.9467	20.000
20.	63.96	600.00	20.466	4.3673	.36326	9.381	619.16	1.9510	.51633	5.8367	20.000
20.5	65.97	600.00	21.109	4.4320	.38225	9.096	600.32	1.9198	.52679	5.7321	20.000
21.	67.99	600.00	21.758	4.4721	.40006	8.825	582.42	1.8793	.54024	5.5976	20.000
21.5	70.03	600.00	22.409	4.5121	.42601	8.568	565.48	1.8409	.55303	5.4697	20.000
22.	72.07	600.00	23.064	4.5521	.44806	8.325	549.44	1.8046	.56515	5.3485	20.000
22.5	74.13	600.00	23.721	4.5924	.47020	8.094	534.21	1.7701	.57664	5.2336	20.000
23.	76.19	600.00	24.381	4.6328	.49244	7.875	519.74	1.7373	.58757	5.1243	20.000
23.5	78.26	600.00	25.044	4.6735	.51479	7.666	505.98	1.7061	.59796	5.0204	20.000
24.	80.34	600.00	25.710	4.6922	.54413	7.468	492.89	1.6686	.61569	4.9215	20.000
24.5	82.41	600.00	26.373	4.7052	.57512	7.280	480.50	1.6312	.63440	4.8280	20.000
25.	84.48	600.00	27.033	4.7182	.60598	7.102	468.76	1.5958	.65212	4.7394	20.000
25.5	86.53	600.00	27.690	4.7311	.63671	6.934	457.64	1.5622	.66892	4.6554	20.000
26.	88.58	600.00	28.344	4.7440	.66710	6.774	447.07	1.5302	.68488	4.5756	20.000
26.5	90.61	600.00	28.996	4.7569	.69776	6.622	437.03	1.4999	.70005	4.4998	20.000
27.	92.64	600.00	29.645	4.7696	.72809	6.477	427.46	1.4710	.71449	4.4276	20.000
27.5	94.66	600.00	30.291	4.7823	.75829	6.339	418.35	1.4435	.72825	4.3587	20.000

Information Processing Center

Information Processing Center



TIME	P	AP	LF	BR	DR	FMP	IPC	BRM	DRM	SL	LR
28.	96.67	600.00	30.934	4.7950	.78836	6.207	409.65	1.4172	.74139	4.2931	20.000
28.5	98.67	600.00	31.574	4.8076	.81829	6.091	401.34	1.3921	.75394	4.2303	20.000
29.	100.66	600.00	32.712	4.8341	.84593	5.960	393.39	1.3721	.76396	4.1802	20.000
29.5	102.66	600.00	32.850	4.8635	.87313	5.845	385.75	1.3536	.77321	4.1340	20.000
30.	104.65	600.00	33.489	4.8928	.90035	5.733	378.39	1.3358	.78211	4.0895	20.000

Information Processing Center

Information Processing Center

C APKM1=3  
RUN 3

PRESENT 3.000  
ORIGINAL 1.000

TIME	P	AP	LF	RR	DR	FMP	IPC	ARM	DRM	SL	LR
E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00
.0	33.23	101.19	8.640	1.2354	.39748	3.045	201.0	1.0048	.99679	3.0161	20.000
.5	33.65	104.48	8.749	1.2600	.40060	3.105	204.9	1.0120	.99203	3.0399	20.000
1.	34.08	107.86	8.862	1.2852	.40380	3.164	208.9	1.0191	.98727	3.0636	20.000
1.5	34.53	111.31	8.977	1.3110	.40709	3.224	212.8	1.0262	.98252	3.0874	20.000
2.	34.98	114.86	9.095	1.3375	.41045	3.283	216.7	1.0334	.97776	3.1112	20.000
2.5	35.45	118.50	9.217	1.3647	.41391	3.343	220.6	1.0405	.97302	3.1349	20.000
3.	35.93	122.23	9.341	1.3926	.41745	3.402	224.5	1.0476	.96828	3.1586	20.000
3.5	36.42	126.06	9.469	1.4211	.42108	3.461	228.5	1.0547	.96354	3.1823	20.000
4.	36.92	129.98	9.599	1.4505	.42481	3.521	232.4	1.0618	.95882	3.2059	20.000
4.5	37.44	134.01	9.734	1.4805	.42863	3.580	236.3	1.0688	.95411	3.2294	20.000
5.	37.97	138.14	9.871	1.5114	.43255	3.638	240.1	1.0759	.94941	3.2529	20.000
5.5	38.51	142.37	10.012	1.5430	.43657	3.697	244.0	1.0829	.94473	3.2764	20.000
6.	39.07	146.71	10.157	1.5754	.44069	3.756	247.9	1.0899	.94006	3.2997	20.000
6.5	39.64	151.17	10.306	1.6087	.44492	3.814	251.7	1.0969	.93540	3.3230	20.000
7.	40.22	155.73	10.458	1.6428	.44925	3.872	255.5	1.1038	.93077	3.3462	20.000
7.5	40.82	160.42	10.614	1.6778	.45370	3.930	259.4	1.1108	.92615	3.3692	20.000
8.	41.44	165.22	10.774	1.7136	.45826	3.987	263.2	1.1177	.92156	3.3922	20.000
8.5	42.07	170.15	10.938	1.7504	.46294	4.044	266.9	1.1245	.91699	3.4151	20.000
9.	42.72	175.20	11.107	1.7882	.46773	4.101	270.7	1.1313	.91244	3.4378	20.000
9.5	43.38	180.39	11.280	1.8269	.47265	4.158	274.4	1.1381	.90791	3.4604	20.000
10.	44.06	185.70	11.457	1.8666	.47770	4.214	278.1	1.1449	.90342	3.4829	20.000
10.5	44.76	191.15	11.638	1.9073	.48287	4.270	281.8	1.1516	.89895	3.5053	20.000
11.	45.48	196.74	11.825	1.9490	.48818	4.326	285.5	1.1582	.89450	3.5275	20.000
11.5	46.21	202.48	12.016	1.9919	.49362	4.381	289.2	1.1649	.89009	3.5495	20.000
12.	46.97	208.36	12.212	2.0358	.49921	4.436	292.8	1.1714	.88571	3.5715	20.000
12.5	47.72	214.25	12.408	1.9674	.46273	4.489	296.3	1.1778	.88145	3.5927	20.000
13.	48.48	220.10	12.605	2.0009	.46792	4.540	299.6	1.1839	.87741	3.6130	20.000
13.5	49.26	224.13	12.806	2.0431	.47494	4.550	300.3	1.1851	.87658	3.6171	20.000
14.	50.04	228.22	13.011	2.0779	.48208	4.561	301.0	1.1864	.87577	3.6212	20.000
14.5	50.84	232.39	13.219	2.1133	.48935	4.571	301.7	1.1876	.87496	3.6252	20.000
15.	51.66	236.63	13.431	2.1494	.49675	4.581	302.3	1.1887	.87417	3.6292	20.000
15.5	52.49	240.95	13.647	2.1860	.50428	4.590	303.0	1.1899	.87338	3.6331	20.000
16.	53.33	245.34	13.867	2.2234	.51194	4.600	303.6	1.1911	.87261	3.6369	20.000
16.5	54.19	249.81	14.090	2.2614	.51974	4.610	304.2	1.1922	.87185	3.6407	20.000
17.	55.07	254.35	14.318	2.3000	.52767	4.619	304.8	1.1933	.87110	3.6445	20.000
17.5	55.96	258.98	14.549	2.3394	.53574	4.628	305.5	1.1944	.87037	3.6482	20.000
18.	56.86	261.84	14.784	2.3716	.54557	4.605	303.9	1.1917	.87223	3.6389	20.000
18.5	58.02	269.04	18.568	3.1874	.31914	15.494	1022.6	1.5695	.50000	7.1017	20.000
19.	59.48	900.00	19.032	3.3317	.32712	15.132	998.7	1.6005	.50000	6.9987	20.000
19.5	60.99	900.00	19.517	3.4377	.33544	14.757	973.9	1.6104	.50000	6.9739	20.000
20.	62.55	900.00	20.017	3.5472	.34404	14.388	949.6	1.6202	.50000	6.9496	20.000
20.5	64.17	900.00	20.534	3.6602	.35292	14.026	925.7	1.6297	.50000	6.9257	20.000
21.	65.83	900.00	21.067	3.7768	.36209	13.671	902.3	1.6391	.50000	6.9023	20.000
21.5	67.56	900.00	21.618	3.8973	.37156	13.322	879.3	1.6483	.50000	6.8793	20.000
22.	69.33	900.00	22.187	4.0217	.38133	12.981	856.7	1.6573	.50000	6.8567	20.000
22.5	71.17	900.00	22.774	4.1502	.39142	12.646	834.6	1.6661	.50000	6.8346	20.000
23.	73.06	900.00	23.380	4.2878	.40184	12.318	813.0	1.6748	.50000	6.8130	20.000
23.5	75.02	900.00	24.006	4.4164	.41260	11.997	791.8	1.6820	.50000	6.7949	20.000
24.	77.05	900.00	24.656	4.6609	.42377	11.681	770.9	1.7284	.50000	6.6791	20.000
24.5	79.20	900.00	25.343	4.9197	.43559	11.364	750.0	1.7748	.50000	6.5630	20.000
25.	81.47	900.00	26.071	5.1935	.44810	11.047	729.1	1.8213	.50000	6.4468	20.000
25.5	83.88	900.00	26.841	5.4833	.46134	10.730	708.2	1.8677	.50000	6.3306	20.000
26.	86.43	900.00	27.656	5.7899	.47534	10.413	687.3	1.9141	.50000	6.2148	20.000
26.5	89.12	900.00	28.519	6.1145	.49017	10.099	666.5	1.9602	.50000	6.0994	20.000
27.	91.97	900.00	29.432	6.4234	.50741	9.785	645.8	1.9954	.50153	5.9847	20.000
27.5	94.94	900.00	30.381	6.5189	.53547	9.480	625.7	1.9618	.51273	5.8727	20.000

Information Processing Center

Information Processing Center

TIME	P	AP	LF	BR	DR	FMP	IPC	BRM	DRM	SL	LR
28.	97.94	900.00	31.341	6.6155	.56385	9.189	606.5	1.9299	.52337	5.7663	20.000
28.5	100.97	900.00	32.312	6.6883	.59515	9.913	588.3	1.8925	.53583	5.6417	20.000
29.	104.02	900.00	33.288	6.7481	.62802	8.652	571.0	1.8535	.54885	5.5115	20.000
29.5	107.09	900.00	34.268	6.8082	.66105	8.404	554.7	1.8165	.56118	5.3882	20.000
30.	110.16	900.00	35.252	6.8685	.69422	8.170	539.2	1.7814	.57288	5.2712	20.000

Information Processing Center

Information Processing Center

C C3=100  
CP APKM1=2  
RUN 4

	C3	APKM1
PRESENT	100.0	2.000
ORIGINAL	66.00	1.000

Information Processing Center

Information Processing Center

TIME	P	AP	LF	BR	DR	FMP	IPC	BRM	DRM	SL	LR
E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00
.0	33.23	101.19	8.640	1.2354	.39748	3.045	201.0	1.0048	.99679	3.0161	20.000
.5	33.65	104.48	8.749	1.2600	.40060	3.105	204.9	1.0120	.99203	3.0399	20.000
1.	34.08	107.86	8.862	1.2852	.40380	3.164	208.9	1.0191	.98727	3.0636	20.000
1.5	34.53	111.31	8.977	1.3110	.40709	3.224	212.8	1.0262	.98252	3.0874	20.000
2.	34.98	114.86	9.095	1.3375	.41045	3.283	216.7	1.0334	.97776	3.1112	20.000
2.5	35.45	118.50	9.217	1.3647	.41391	3.343	220.6	1.0405	.97302	3.1349	20.000
3.	35.93	122.23	9.341	1.3926	.41745	3.402	224.5	1.0476	.96828	3.1586	20.000
3.5	36.42	126.06	9.469	1.4211	.42108	3.461	228.5	1.0547	.96354	3.1823	20.000
4.	36.92	129.98	9.599	1.4505	.42481	3.521	232.4	1.0618	.95882	3.2059	20.000
4.5	37.44	134.01	9.734	1.4805	.42863	3.580	236.3	1.0688	.95411	3.2294	20.000
5.	37.97	138.14	9.871	1.5114	.43255	3.638	240.1	1.0759	.94941	3.2529	20.000
5.5	38.51	142.37	10.012	1.5430	.43657	3.697	244.0	1.0829	.94473	3.2764	20.000
6.	39.07	146.71	10.157	1.5754	.44069	3.756	247.9	1.0899	.94006	3.2997	20.000
6.5	39.64	151.17	10.306	1.6087	.44492	3.814	251.7	1.0969	.93540	3.3230	20.000
7.	40.22	155.73	10.458	1.6428	.44925	3.872	255.5	1.1038	.93077	3.3462	20.000
7.5	40.82	160.42	10.614	1.6778	.45370	3.930	259.4	1.1108	.92615	3.3692	20.000
8.	41.44	165.22	10.774	1.7136	.45826	3.987	263.2	1.1177	.92156	3.3922	20.000
8.5	42.07	170.15	10.938	1.7504	.46294	4.044	266.9	1.1245	.91699	3.4151	20.000
9.	42.72	175.20	11.107	1.7882	.46773	4.101	270.7	1.1313	.91244	3.4378	20.000
9.5	43.38	180.39	11.280	1.8269	.47265	4.158	274.4	1.1381	.90791	3.4604	20.000
10.	44.06	185.70	11.457	1.8666	.47770	4.214	278.1	1.1449	.90342	3.4829	20.000
10.5	44.76	191.15	11.638	1.9073	.48287	4.270	281.8	1.1516	.89895	3.5053	20.000
11.	45.48	196.74	11.825	1.9490	.48818	4.326	285.5	1.1582	.89450	3.5275	20.000
11.5	46.21	202.48	12.016	1.9919	.49362	4.381	289.2	1.1649	.89009	3.5495	20.000
12.	46.97	208.36	12.212	2.0358	.49921	4.436	292.8	1.1714	.88571	3.5715	20.000
12.5	47.72	214.25	12.408	1.9674	.46273	4.489	296.3	1.1778	.88145	3.5927	20.000
13.	48.48	220.10	12.605	2.0089	.46792	4.540	299.8	1.1839	.87741	3.6130	20.000
13.5	49.26	224.13	12.806	2.0431	.47494	4.550	300.3	1.1851	.87658	3.6171	20.000
14.	50.04	228.22	13.011	2.0779	.48208	4.561	301.0	1.1864	.87577	3.6212	20.000
14.5	50.84	232.39	13.219	2.1133	.48935	4.571	301.7	1.1876	.87496	3.6252	20.000
15.	51.66	236.63	13.431	2.1494	.49675	4.581	302.3	1.1887	.87417	3.6292	20.000
15.5	52.49	240.95	13.647	2.1860	.50420	4.590	303.0	1.1899	.87338	3.6331	20.000
16.	53.33	245.34	13.867	2.2234	.51174	4.600	303.6	1.1911	.87261	3.6369	20.000
16.5	54.19	249.81	14.090	2.2614	.51974	4.610	304.2	1.1922	.87185	3.6407	20.000
17.	55.07	254.35	14.318	2.3000	.52767	4.619	304.8	1.1933	.87110	3.6445	20.000
17.5	55.96	258.98	14.549	2.3394	.53574	4.628	305.5	1.1944	.87037	3.6482	20.000
18.	56.86	261.84	14.784	2.3716	.54557	4.605	303.9	1.1917	.87223	3.6389	20.000
18.5	58.12	259.95	18.598	3.5911	.31965	10.323	1032.3	1.7654	.50000	6.5864	20.000
19.	59.79	600.00	19.132	3.8829	.32883	10.035	1007.5	1.8556	.50000	6.3611	20.000
19.5	61.59	600.00	19.710	4.1209	.33877	9.741	974.1	1.9115	.50000	6.2212	20.000
20.	63.51	600.00	20.324	4.3627	.34933	9.447	944.7	1.9626	.50000	6.0936	20.000
20.5	65.55	600.00	20.976	4.5654	.36295	9.153	915.3	1.9999	.50336	5.9664	20.000
21.	67.66	600.00	21.650	4.6244	.38380	8.868	886.8	1.9529	.51571	5.8429	20.000
21.5	69.78	600.00	22.330	4.6839	.40484	8.598	859.8	1.9173	.52741	5.7259	20.000
22.	71.93	600.00	23.016	4.7439	.42607	8.342	834.2	1.8844	.53052	5.6148	20.000
22.5	74.09	600.00	23.709	4.8045	.44749	8.098	809.8	1.8528	.54908	5.5092	20.000
23.	76.27	600.00	24.408	4.8710	.46855	7.866	786.6	1.8246	.55845	5.4155	20.000
23.5	78.48	600.00	25.114	4.9421	.48943	7.645	764.5	1.7992	.56694	5.3306	20.000
24.	80.71	600.00	25.828	5.0140	.51055	7.434	743.4	1.7749	.57504	5.2496	20.000
24.5	82.97	600.00	26.551	5.0867	.53191	7.231	723.1	1.7516	.58280	5.1720	20.000
25.	85.26	600.00	27.282	5.1602	.55352	7.038	703.8	1.7293	.59022	5.0978	20.000
25.5	87.57	600.00	28.021	5.2346	.57537	6.852	685.2	1.7080	.59734	5.0266	20.000
26.	89.90	600.00	28.768	5.2967	.60158	6.674	667.4	1.6833	.60833	4.9584	20.000
26.5	92.25	600.00	29.521	5.3510	.63054	6.504	650.4	1.6573	.62136	4.8932	20.000
27.	94.62	600.00	30.277	5.4056	.65966	6.341	634.1	1.6324	.63382	4.8309	20.000
27.5	96.99	600.00	31.037	5.4605	.68893	6.186	618.6	1.6085	.64573	4.7713	20.000

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TIME	P	AP	LF	RR	DR	FMP	IPC	BRM	DRM	SL	LR
28.	99.38	600.00	31.802	5.5157	.71836	6.037	603.7	1.5857	.65713	4.7143	20.000
28.5	101.78	600.00	32.569	5.5412	.75262	5.895	589.5	1.5555	.67224	4.6388	20.000
29.	104.17	600.00	33.335	5.5563	.78840	5.760	576.0	1.5239	.68803	4.5599	20.000
29.5	106.55	600.00	34.097	5.5713	.82402	5.631	563.1	1.4939	.70305	4.4848	20.000
30.	108.92	600.00	34.855	5.5862	.85949	5.508	550.8	1.4653	.71735	4.4133	20.000

Information Processing Center

Information Processing Center

CP C3=200  
RUN 5

PRESENT	APKM1	C3
ORIGINAL	2.000	200.0
	1.000	66.00

Information Processing Center

Information Processing Center



TIME	P		AP		LF		BR		DR		GMP		IPC		BRM		DRM		SL		LR	
	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00
.0	33.230	101.19	8.640	1.2354	.39748	2.045	201.0	1.0048	.99679	3.016	20.000											
.5	33.652	104.48	8.749	1.2600	.40060	3.105	204.9	1.0120	.99203	3.040	20.000											
1.	34.084	107.86	8.862	1.2852	.40380	3.164	208.9	1.0191	.98727	3.064	20.000											
1.5	34.528	111.31	8.977	1.3110	.40709	3.224	212.8	1.0262	.98252	3.087	20.000											
2.	34.982	114.86	9.095	1.3375	.41045	3.283	216.7	1.0334	.97776	3.111	20.000											
2.5	35.449	118.50	9.217	1.3647	.41391	3.343	220.6	1.0405	.97302	3.135	20.000											
3.	35.927	122.23	9.341	1.3926	.41745	3.402	224.5	1.0476	.96828	3.159	20.000											
3.5	36.418	126.06	9.469	1.4211	.42108	3.461	228.5	1.0547	.96354	3.182	20.000											
4.	36.921	129.98	9.599	1.4505	.42481	3.521	232.4	1.0618	.95882	3.206	20.000											
4.5	37.437	134.01	9.734	1.4805	.42863	3.580	236.3	1.0688	.95411	3.229	20.000											
5.	37.966	138.14	9.871	1.5114	.43255	3.638	240.1	1.0759	.94941	3.253	20.000											
5.5	38.509	142.37	10.012	1.5430	.43657	3.697	244.0	1.0829	.94473	3.276	20.000											
6.	39.066	146.71	10.157	1.5754	.44069	3.756	247.9	1.0899	.94006	3.300	20.000											
6.5	39.637	151.17	10.306	1.6087	.44492	3.814	251.7	1.0969	.93540	3.323	20.000											
7.	40.222	155.73	10.458	1.6428	.44925	3.872	255.5	1.1038	.93077	3.346	20.000											
7.5	40.823	160.42	10.614	1.6778	.45370	3.930	259.4	1.1108	.92615	3.369	20.000											
8.	41.439	165.22	10.774	1.7136	.45826	3.987	263.2	1.1177	.92156	3.392	20.000											
8.5	42.071	170.15	10.938	1.7504	.46294	4.044	266.9	1.1245	.91699	3.415	20.000											
9.	42.718	175.20	11.107	1.7882	.46773	4.101	270.7	1.1313	.91244	3.438	20.000											
9.5	43.383	180.39	11.280	1.8269	.47265	4.158	274.4	1.1381	.90791	3.460	20.000											
10.	44.064	185.70	11.457	1.8666	.47770	4.214	278.1	1.1449	.90342	3.483	20.000											
10.5	44.763	191.15	11.638	1.9073	.48287	4.270	281.8	1.1516	.89895	3.505	20.000											
11.	45.480	196.74	11.825	1.9490	.48818	4.326	285.5	1.1582	.89450	3.527	20.000											
11.5	46.215	202.48	12.016	1.9919	.49362	4.381	289.2	1.1647	.89009	3.550	20.000											
12.	46.969	208.36	12.212	2.0358	.49921	4.436	292.8	1.1714	.88571	3.571	20.000											
12.5	47.724	214.25	12.408	1.9674	.46273	4.489	296.3	1.1779	.88145	3.593	20.000											
13.	48.481	220.10	12.605	2.0089	.46792	4.540	299.6	1.1839	.87741	3.613	20.000											
13.5	49.255	224.13	12.806	2.0431	.47494	4.550	300.3	1.1851	.87658	3.617	20.000											
14.	50.043	228.22	13.011	2.0779	.48208	4.561	301.0	1.1864	.87577	3.621	20.000											
14.5	50.844	232.39	13.219	2.1133	.48935	4.571	301.7	1.1876	.87496	3.625	20.000											
15.	51.660	236.63	13.431	2.1494	.49675	4.581	302.3	1.1887	.87417	3.629	20.000											
15.5	52.489	240.95	13.647	2.1860	.50428	4.590	303.0	1.1899	.87338	3.633	20.000											
16.	53.334	245.34	13.867	2.2234	.51194	4.600	303.6	1.1911	.87261	3.637	20.000											
16.5	54.194	249.81	14.070	2.2614	.51974	4.610	304.2	1.1922	.87185	3.641	20.000											
17.	55.068	254.35	14.318	2.3000	.52767	4.619	304.8	1.1933	.87110	3.644	20.000											
17.5	55.958	258.98	14.549	2.3394	.53574	4.628	305.5	1.1944	.87037	3.648	20.000											
18.	56.863	261.84	14.784	2.3716	.54557	4.605	303.9	1.1917	.87223	3.639	20.000											
18.5	57.469	595.80	18.390	.9140	.31608	10.367	2073.5	.4544	.50000	12.456	20.000											
19.	57.768	597.77	18.486	.9202	.31772	10.347	2069.4	.4551	.50000	12.449	20.000											
19.5	58.070	599.65	18.582	.9264	.31930	10.326	2065.3	.4558	.50000	12.442	20.000											
20.	58.374	600.00	18.680	.9345	.32106	10.279	2055.7	.4574	.50000	12.426	20.000											
20.5	58.682	600.00	18.778	.9431	.32275	10.225	2044.9	.4592	.50000	12.408	20.000											
21.	58.993	600.00	18.878	.9518	.32446	10.171	2034.2	.4610	.50000	12.390	20.000											
21.5	59.307	600.00	18.978	.9606	.32619	10.117	2023.4	.4628	.50000	12.372	20.000											
22.	59.625	600.00	19.080	.9695	.32794	10.063	2012.6	.4646	.50000	12.354	20.000											
22.5	59.947	600.00	19.183	.9785	.32971	10.009	2001.8	.4664	.50000	12.336	20.000											
23.	60.272	600.00	19.287	.9876	.33150	9.955	1991.0	.4682	.50000	12.318	20.000											
23.5	60.601	600.00	19.392	.9968	.33331	9.901	1980.2	.4700	.50000	12.300	20.000											
24.	60.934	600.00	19.499	1.0061	.33514	9.847	1969.3	.4718	.50000	12.282	20.000											
24.5	61.270	600.00	19.606	1.0156	.33699	9.793	1958.5	.4736	.50000	12.264	20.000											
25.	61.611	600.00	19.715	1.0251	.33886	9.739	1947.7	.4754	.50000	12.246	20.000											
25.5	61.955	600.00	19.825	1.0347	.34075	9.685	1936.9	.4772	.50000	12.228	20.000											
26.	62.303	600.00	19.937	1.0445	.34266	9.630	1926.1	.4790	.50000	12.210	20.000											
26.5	62.654	600.00	20.049	1.0543	.34460	9.576	1915.3	.4808	.50000	12.192	20.000											
27.	63.010	600.00	20.163	1.0643	.34656	9.522	1904.4	.4826	.50000	12.174	20.000											
27.5	63.370	600.00	20.278	1.0744	.34854	9.468	1893.6	.4844	.50000	12.156	20.000											

TIME	P	AP	LF	BR	DR	FMP	IPC	BRM	DRM	SL	LR
28.	63.734	600.00	20.395	1.0846	.35054	9.414	1882.8	.4862	.50000	12.138	20.000
28.5	64.102	600.00	20.513	1.0949	.35256	9.360	1872.0	.4880	.50000	12.120	20.000
29.	64.474	600.00	20.632	1.1053	.35461	9.306	1861.2	.4898	.50000	12.102	20.000
29.5	64.851	600.00	20.752	1.1158	.35668	9.252	1850.4	.4916	.50000	12.084	20.000
30.	65.231	600.00	20.874	1.1265	.35877	9.198	1839.6	.4934	.50000	12.066	20.000

Information Processing Center

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Information Processing Center

T BRMT=0/.2/.5/1/1.3/1.7/1.5/.8/.6/.5/.4/.4/.4/.4/.4  
RUN 6

	APKM1	C3	BRMT	. . .	. . .	. . .	. . .	. . .
PRESENT	2.000	200.0	0.	.2000	.5000	1.000	1.300	1.700
ORIGINAL	1.000	66.00	0.	.2000	.5000	1.000	1.300	1.700

PRESENT	.500	.8000	.6000	.5000	.4000	.4000	.4000	.4000
ORIGINAL	2.000	1.600	1.300	.8000	.6000	.5000	.5000	.4000

PRESENT	.4000	.4000
ORIGINAL	.3500	.3000

Information Processing Center

Information Processing Center

TIME	P		AP		LF		BR		DR		FMP		IPC		ARM		DRM		SL		LR	
	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00
.0	33.230	101.19	8.640	1.2354	.39748	3.045	201.0	1.0048	.99679	3.316	20.000											
.5	33.652	104.48	8.749	1.2600	.40060	3.105	204.9	1.0120	.99203	3.340	20.000											
1.	34.084	107.86	8.862	1.2852	.40380	3.164	208.9	1.0191	.98727	3.064	20.000											
1.5	34.528	111.31	8.977	1.3110	.40709	3.224	212.8	1.0262	.98252	3.087	20.000											
2.	34.982	114.86	9.095	1.3375	.41045	3.283	216.7	1.0334	.97776	3.111	20.000											
2.5	35.449	118.50	9.217	1.3647	.41391	3.343	220.6	1.0405	.97302	3.135	20.000											
3.	35.927	122.23	9.341	1.3926	.41745	3.402	224.5	1.0476	.96828	3.159	20.000											
3.5	36.418	126.06	9.469	1.4211	.42108	3.461	228.5	1.0547	.96354	3.182	20.000											
4.	36.921	129.98	9.599	1.4505	.42481	3.521	232.4	1.0618	.95882	3.206	20.000											
4.5	37.437	134.01	9.734	1.4805	.42863	3.580	236.3	1.0688	.95411	3.229	20.000											
5.	37.966	138.14	9.871	1.5114	.43255	3.638	240.1	1.0759	.94941	3.253	20.000											
5.5	38.509	142.37	10.012	1.5430	.43657	3.697	244.0	1.0829	.94473	3.276	20.000											
6.	39.066	146.71	10.157	1.5754	.44069	3.756	247.9	1.0899	.94006	3.300	20.000											
6.5	39.637	151.17	10.306	1.6097	.44492	3.814	251.7	1.0969	.93540	3.323	20.000											
7.	40.222	155.73	10.458	1.6428	.44925	3.872	255.5	1.1038	.93077	3.346	20.000											
7.5	40.823	160.42	10.614	1.6778	.45370	3.930	259.4	1.1108	.92615	3.369	20.000											
8.	41.439	165.22	10.774	1.7136	.45826	3.987	263.2	1.1177	.92156	3.392	20.000											
8.5	42.071	170.15	10.938	1.7504	.46294	4.044	266.9	1.1245	.91699	3.415	20.000											
9.	42.718	175.20	11.107	1.7882	.46773	4.101	270.7	1.1313	.91244	3.438	20.000											
9.5	43.383	180.39	11.280	1.8269	.47265	4.158	274.4	1.1381	.90791	3.460	20.000											
10.	44.064	185.70	11.457	1.8665	.47770	4.214	278.1	1.1449	.90342	3.483	20.000											
10.5	44.763	191.15	11.638	1.9073	.48287	4.270	281.8	1.1516	.89895	3.505	20.000											
11.	45.480	196.74	11.825	1.9490	.48818	4.326	285.5	1.1582	.89450	3.527	20.000											
11.5	46.215	202.48	12.015	1.9919	.49362	4.381	289.2	1.1649	.89009	3.550	20.000											
12.	46.969	208.36	12.212	2.0358	.49921	4.436	292.8	1.1714	.88571	3.571	20.000											
12.5	47.724	214.25	12.408	1.9674	.46273	4.489	296.3	1.1778	.88145	3.593	20.000											
13.	48.481	220.10	12.605	2.0089	.46792	4.540	299.6	1.1839	.87741	3.613	20.000											
13.5	49.255	226.13	12.806	2.0431	.47494	4.590	303.3	1.1851	.87658	3.617	20.000											
14.	50.043	228.22	13.011	2.0779	.48208	4.561	301.0	1.1864	.87577	3.621	20.000											
14.5	50.844	232.39	13.219	2.1133	.48935	4.571	301.7	1.1876	.87496	3.625	20.000											
15.	51.660	236.63	13.431	2.1494	.49675	4.581	302.3	1.1887	.87417	3.629	20.000											
15.5	52.489	240.95	13.647	2.1860	.50428	4.590	303.0	1.1899	.87338	3.633	20.000											
16.	53.334	245.34	13.867	2.2234	.51194	4.600	303.6	1.1911	.87261	3.637	20.000											
16.5	54.194	249.81	14.090	2.2614	.51974	4.610	304.2	1.1922	.87185	3.641	20.000											
17.	55.068	254.35	14.318	2.3000	.52767	4.619	304.8	1.1933	.87110	3.644	20.000											
17.5	55.958	258.98	14.549	2.3394	.53574	4.628	305.5	1.1944	.87037	3.648	20.000											
18.	56.863	261.84	14.784	2.3716	.54557	4.605	303.9	1.1917	.87223	3.639	20.000											
18.5	57.441	259.62	18.381	.8042	.31593	10.369	2073.8	.4000	.50000	12.456	20.000											
19.	57.686	597.19	18.459	.8076	.31727	10.352	2070.5	.4000	.50000	12.451	20.000											
19.5	57.931	598.76	18.538	.8110	.31862	10.336	2067.1	.4000	.50000	12.445	20.000											
20.	58.178	600.00	18.617	.8145	.31998	10.313	2062.6	.4000	.50000	12.438	20.000											
20.5	58.425	600.00	18.696	.8180	.32134	10.270	2053.9	.4000	.50000	12.423	20.000											
21.	58.674	600.00	18.776	.8214	.32271	10.226	2045.2	.4000	.50000	12.409	20.000											
21.5	58.923	600.00	18.855	.8249	.32408	10.183	2036.5	.4000	.50000	12.394	20.000											
22.	59.174	600.00	18.936	.8284	.32546	10.140	2027.9	.4000	.50000	12.380	20.000											
22.5	59.426	600.00	19.016	.8320	.32684	10.097	2019.3	.4000	.50000	12.366	20.000											
23.	59.679	600.00	19.097	.8355	.32823	10.054	2010.8	.4000	.50000	12.351	20.000											
23.5	59.932	600.00	19.178	.8391	.32963	10.011	2002.3	.4000	.50000	12.337	20.000											
24.	60.187	600.00	19.260	.8426	.33103	9.969	1993.8	.4000	.50000	12.323	20.000											
24.5	60.443	600.00	19.342	.8462	.33244	9.927	1985.3	.4000	.50000	12.309	20.000											
25.	60.701	600.00	19.424	.8498	.33385	9.885	1976.9	.4000	.50000	12.295	20.000											
25.5	60.959	600.00	19.507	.8534	.33527	9.843	1968.5	.4000	.50000	12.281	20.000											
26.	61.218	600.00	19.590	.8571	.33670	9.801	1960.2	.4000	.50000	12.267	20.000											
26.5	61.479	600.00	19.673	.8607	.33813	9.759	1951.9	.4000	.50000	12.253	20.000											
27.	61.740	600.00	19.757	.8644	.33957	9.718	1943.6	.4000	.50000	12.239	20.000											
27.5	62.003	600.00	19.841	.8680	.34102	9.677	1935.4	.4000	.50000	12.226	20.000											

TIME	P	AP	LF	BR	DR	FMP	IPC	BRM	DRM	SL	LR
28.	62.267	600.00	19.925	.8717	.34247	9.636	1927.2	.4000	.50000	12.212	20.000
28.5	62.531	600.00	20.010	.8754	.34392	7.595	1919.0	.4000	.50000	12.198	20.000
29.	62.798	600.00	20.095	.8792	.34539	9.555	1910.9	.4000	.50000	12.185	20.000
29.5	63.065	600.00	20.181	.8829	.34686	9.514	1902.8	.4000	.50000	12.171	20.000
30.	63.333	600.00	20.267	.8867	.34833	9.474	1894.7	.4000	.50000	12.158	20.000

Information Processing Center

Information Processing Center

C L2=40  
RUN 7

	APKM1	C3	L2
PRESENT	2.000	200.0	40.00
ORIGINAL	1.000	66.00	20.00

Information Processing Center

Information Processing Center

Information Processing Center

Information Processing Center

	TIME	P	AP	LF	BR	DR	FMP	IPC	BRM	DRM	SL	LR
	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00
	.0	33.230	101.19	8.640	1.2354	.39748	3.045	201.0	1.0048	.99679	3.016	20.000
	.5	33.652	104.48	8.749	1.2600	.40060	3.105	204.9	1.0120	.99203	3.040	20.000
	1.	34.084	107.86	8.862	1.2852	.40380	3.164	208.9	1.0191	.98727	3.064	20.000
	1.5	34.528	111.31	8.977	1.3110	.40709	3.224	212.8	1.0262	.98752	3.087	20.000
	2.	34.982	114.86	9.095	1.3375	.41045	3.283	216.7	1.0334	.97776	3.111	20.000
	2.5	35.449	118.50	9.217	1.3647	.41391	3.343	220.6	1.0405	.97302	3.135	20.000
	3.	35.927	122.23	9.341	1.3926	.41745	3.402	224.5	1.0476	.96828	3.159	20.000
	3.5	36.418	126.06	9.469	1.4211	.42108	3.461	228.5	1.0547	.96354	3.182	20.000
	4.	36.921	129.98	9.599	1.4505	.42481	3.521	232.4	1.0618	.95882	3.206	20.000
	4.5	37.437	134.01	9.734	1.4805	.42863	3.580	236.3	1.0689	.95411	3.229	20.000
	5.	37.966	138.14	9.871	1.5114	.43255	3.638	240.1	1.0759	.94941	3.253	20.000
	5.5	38.509	142.37	10.012	1.5430	.43657	3.697	244.0	1.0829	.94473	3.276	20.000
	6.	39.066	146.71	10.157	1.5754	.44069	3.756	247.9	1.0899	.94006	3.300	20.000
	6.5	39.637	151.17	10.306	1.6087	.44492	3.814	251.7	1.0969	.93540	3.323	20.000
	7.	40.222	155.73	10.458	1.6428	.44925	3.872	255.5	1.1038	.93077	3.346	20.000
	7.5	40.823	160.42	10.614	1.6778	.45370	3.930	259.4	1.1108	.92615	3.369	20.000
	8.	41.439	165.22	10.774	1.7136	.45826	3.987	263.2	1.1177	.92156	3.392	20.000
	8.5	42.071	170.15	10.938	1.7504	.46294	4.044	266.9	1.1245	.91699	3.415	20.000
	9.	42.718	175.20	11.107	1.7882	.46773	4.101	270.7	1.1313	.91244	3.438	20.000
	9.5	43.383	180.39	11.280	1.8269	.47265	4.158	274.4	1.1381	.90791	3.460	20.000
	10.	44.064	185.70	11.457	1.8666	.47770	4.214	278.1	1.1449	.90342	3.483	20.000
	10.5	44.763	191.15	11.638	1.9073	.48287	4.270	281.8	1.1516	.89895	3.505	20.000
	11.	45.480	196.74	11.825	1.9490	.48818	4.326	285.5	1.1582	.89450	3.527	20.000
	11.5	46.215	202.48	12.016	1.9919	.49362	4.381	289.2	1.1649	.89009	3.550	20.000
	12.	46.969	208.36	12.212	2.0358	.49921	4.436	292.8	1.1714	.88571	3.571	20.000
	12.5	47.724	214.25	12.408	1.9674	.46273	4.489	296.3	1.1779	.88145	3.593	20.000
	13.	48.481	220.10	12.605	2.0089	.46792	4.540	299.6	1.1839	.87741	3.613	20.000
	13.5	49.255	224.13	12.806	2.0431	.47494	4.550	300.3	1.1851	.87658	3.617	20.000
	14.	50.043	228.22	13.011	2.0779	.48208	4.561	301.0	1.1864	.87577	3.621	20.000
	14.5	50.844	232.39	13.219	2.1133	.48935	4.571	301.7	1.1876	.87496	3.625	20.000
	15.	51.660	236.63	13.431	2.1494	.49675	4.581	302.3	1.1887	.87417	3.629	20.000
	15.5	52.489	240.95	13.647	2.1860	.50428	4.590	303.0	1.1899	.87338	3.633	20.000
	16.	53.334	245.34	13.867	2.2234	.51194	4.600	303.6	1.1911	.87261	3.637	20.000
	16.5	54.194	249.81	14.090	2.2614	.51974	4.610	304.2	1.1922	.87185	3.641	20.000
	17.	55.068	254.35	14.318	2.3000	.52767	4.619	304.8	1.1933	.87110	3.644	20.000
	17.5	55.958	258.98	14.549	2.3394	.53574	4.628	305.5	1.1944	.87037	3.648	20.000
	18.	56.863	261.84	14.784	2.3716	.54557	4.605	303.9	1.1917	.87223	3.639	20.000
	18.5	57.469	259.80	18.390	.9140	.31608	10.367	2073.5	.4544	.50000	12.456	20.000
	19.	57.768	597.72	18.486	.9202	.31772	10.347	2069.4	.4551	.50000	12.449	20.000
	19.5	58.070	599.65	18.582	.9264	.31938	10.326	2065.3	.4558	.50000	12.442	20.000
	20.	58.374	600.00	18.680	.9345	.32106	10.279	2055.7	.4574	.50000	12.426	20.000
	20.5	58.641	600.00	18.765	.7788	.32253	10.232	2046.3	.4795	.50000	13.411	40.000
	21.	58.870	600.00	18.838	.7832	.32378	10.192	2038.4	.3801	.50000	13.397	40.000
	21.5	59.100	600.00	18.912	.7877	.32505	10.152	2030.5	.3808	.50000	13.384	40.000
	22.	59.331	600.00	18.986	.7921	.32632	10.113	2022.5	.3815	.50000	13.371	40.000
	22.5	59.565	600.00	19.061	.7966	.32761	10.073	2014.6	.3821	.50000	13.358	40.000
	23.	59.800	600.00	19.136	.8011	.32890	10.034	2006.7	.3828	.50000	13.345	40.000
	23.5	60.036	600.00	19.212	.8057	.33020	9.994	1998.8	.3834	.50000	13.331	40.000
	24.	60.274	600.00	19.288	.8103	.33151	9.954	1990.9	.3841	.50000	13.318	40.000
	24.5	60.514	600.00	19.364	.8147	.33283	9.915	1983.0	.3847	.50000	13.305	40.000
	25.	60.756	600.00	19.442	.8195	.33415	9.876	1975.1	.3854	.50000	13.292	40.000
	25.5	60.999	600.00	19.520	.8242	.33549	9.836	1967.3	.3861	.50000	13.279	40.000
	26.	61.243	600.00	19.598	.8289	.33684	9.797	1959.4	.3867	.50000	13.266	40.000
	26.5	61.490	600.00	19.677	.8337	.33819	9.758	1951.5	.3874	.50000	13.253	40.000
	27.	61.738	600.00	19.756	.8385	.33956	9.718	1943.7	.3880	.50000	13.239	40.000
	27.5	61.988	600.00	19.836	.8433	.34093	9.679	1935.9	.3887	.50000	13.226	40.000

TIME	P	AP	LF	BR	DR	FMP	IPC	ARM	DRM	SL	LR
28.	62.239	600.00	19.917	.8481	.34232	9.640	1928.0	.3893	.50000	13.213	40.000
28.5	62.493	600.00	19.998	.8530	.34371	9.601	1920.2	.3900	.50000	13.200	40.000
29.	62.748	600.00	20.079	.8579	.34511	9.562	1912.4	.3906	.50000	13.187	40.000
29.5	63.005	600.00	20.161	.8628	.34652	9.523	1904.6	.3913	.50000	13.174	40.000
30.	63.263	600.00	20.244	.8678	.34795	9.484	1896.8	.3919	.50000	13.161	40.000

Information Processing Center

Information Processing Center



C L2=60  
RUN 8

	APKM1	C3	L2
PRESENT	2.000	200.0	60.00
ORIGINAL	1.000	66.00	20.00

Information Processing Center

Information Processing Center

	TIME	P	AP	LF	BR	DR	FMP	IPC	ARM	DRM	SL	LR
	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00
	.0	33.230	101.19	8.640	1.2354	.39748	5.045	201.0	1.0048	.99679	3.016	20.000
	.5	33.652	104.48	8.749	1.2600	.40060	3.105	204.9	1.0120	.99203	3.040	20.000
	1.	34.084	107.86	8.862	1.2852	.40390	3.164	208.9	1.0191	.98727	3.064	20.000
	1.5	34.528	111.31	8.977	1.3110	.40709	3.224	212.8	1.0262	.98252	3.087	20.000
	2.	34.982	114.86	9.095	1.3375	.41045	3.283	216.7	1.0334	.97776	3.111	20.000
	2.5	35.449	118.50	9.217	1.3647	.41391	3.343	220.6	1.0405	.97302	3.135	20.000
	3.	35.927	122.23	9.341	1.3926	.41745	3.402	224.5	1.0476	.96828	3.159	20.000
	3.5	36.418	126.06	9.469	1.4211	.42108	3.461	228.5	1.0547	.96354	3.182	20.000
	4.	36.921	129.98	9.599	1.4505	.42481	3.521	232.4	1.0618	.95882	3.206	20.000
	4.5	37.437	134.01	9.734	1.4805	.42863	3.580	236.3	1.0689	.95411	3.229	20.000
	5.	37.964	138.14	9.871	1.5114	.43255	3.638	240.1	1.0759	.94941	3.253	20.000
	5.5	38.509	142.37	10.012	1.5430	.43657	3.697	244.0	1.0829	.94473	3.276	20.000
	6.	39.066	146.71	10.157	1.5754	.44069	3.756	247.9	1.0899	.94006	3.300	20.000
	6.5	39.637	151.17	10.306	1.6087	.44492	3.814	251.7	1.0969	.93540	3.323	20.000
	7.	40.222	155.73	10.458	1.6428	.44925	3.872	255.5	1.1038	.93077	3.346	20.000
	7.5	40.823	160.42	10.614	1.6778	.45370	3.930	259.4	1.1108	.92615	3.369	20.000
	8.	41.439	165.22	10.774	1.7136	.45826	3.987	263.2	1.1177	.92156	3.392	20.000
	8.5	42.071	170.15	10.938	1.7504	.46294	4.044	266.9	1.1245	.91699	3.415	20.000
	9.	42.718	175.20	11.107	1.7882	.46773	4.101	270.7	1.1313	.91244	3.438	20.000
	9.5	43.383	180.39	11.280	1.8269	.47265	4.158	274.4	1.1381	.90791	3.460	20.000
	10.	44.064	185.70	11.457	1.8666	.47770	4.214	278.1	1.1449	.90342	3.483	20.000
	10.5	44.763	191.15	11.638	1.9073	.48287	4.270	281.8	1.1516	.89895	3.505	20.000
	11.	45.480	196.74	11.825	1.9490	.48818	4.326	285.5	1.1582	.89450	3.527	20.000
	11.5	46.215	202.48	12.016	1.9919	.49367	4.381	289.2	1.1649	.89009	3.550	20.000
	12.	46.969	208.36	12.212	2.0358	.49921	4.436	292.8	1.1714	.88571	3.571	20.000
	12.5	47.724	214.25	12.408	1.9674	.46273	4.489	296.3	1.1778	.88145	3.593	20.000
	13.	48.481	220.10	12.605	2.0089	.46792	4.540	299.6	1.1839	.87741	3.613	20.000
	13.5	49.255	224.13	12.806	2.0431	.47494	4.590	300.3	1.1851	.87656	3.617	20.000
	14.	50.043	228.22	13.011	2.0779	.48208	4.561	301.0	1.1864	.87577	3.621	20.000
	14.5	50.844	232.39	13.219	2.1133	.48935	4.571	301.7	1.1876	.87496	3.625	20.000
	15.	51.660	236.63	13.431	2.1494	.49675	4.581	302.3	1.1887	.87417	3.629	20.000
	15.5	52.489	240.95	13.647	2.1860	.50428	4.590	303.0	1.1899	.87338	3.633	20.000
	16.	53.334	245.34	13.867	2.2234	.51194	4.600	303.6	1.1911	.87261	3.637	20.000
	16.5	54.194	249.81	14.090	2.2614	.51974	4.610	304.2	1.1922	.87185	3.641	20.000
	17.	55.068	254.35	14.318	2.3000	.52767	4.619	304.8	1.1933	.87110	3.644	20.000
	17.5	55.958	258.98	14.549	2.3394	.53574	4.628	305.5	1.1944	.87037	3.648	20.000
	18.	56.863	261.84	14.784	2.3716	.54557	4.605	303.9	1.1917	.87223	3.639	20.000
	18.5	57.469	265.80	14.990	.9140	.31608	10.367	2073.5	.4544	.50000	12.456	20.000
	19.	57.768	269.72	14.986	.9202	.31772	10.347	2069.4	.4551	.50000	12.449	20.000
	19.5	58.070	269.65	14.982	.9264	.31930	10.326	2065.3	.4558	.50000	12.442	20.000
	20.	58.374	269.60	14.980	.9345	.32106	10.279	2055.7	.4574	.50000	12.426	20.000
	20.5	58.616	269.60	14.975	.6758	.32248	10.236	2047.2	.3294	.50000	14.412	60.000
	21.	58.792	269.60	14.971	.6789	.32336	10.205	2041.1	.3299	.50000	14.402	60.000
	21.5	58.970	269.60	14.971	.6820	.32414	10.175	2034.9	.3304	.50000	14.392	60.000
	22.	59.150	269.60	14.971	.6851	.32532	10.144	2028.8	.3309	.50000	14.381	60.000
	22.5	59.330	269.60	14.971	.6883	.32631	10.113	2022.6	.3315	.50000	14.371	60.000
	23.	59.511	269.60	14.971	.6914	.32731	10.082	2016.4	.3320	.50000	14.361	60.000
	23.5	59.693	269.60	14.971	.6946	.32831	10.051	2010.3	.3325	.50000	14.350	60.000
	24.	59.877	269.60	14.971	.6978	.32932	10.021	2004.1	.3330	.50000	14.340	60.000
	24.5	60.061	269.60	14.971	.7011	.33034	9.990	1998.0	.3335	.50000	14.330	60.000
	25.	60.247	269.60	14.971	.7043	.33136	9.959	1991.8	.3340	.50000	14.320	60.000
	25.5	60.434	269.60	14.971	.7076	.33238	9.928	1985.7	.3345	.50000	14.309	60.000
	26.	60.621	269.60	14.971	.7109	.33342	9.897	1979.5	.3350	.50000	14.299	60.000
	26.5	60.810	269.60	14.971	.7142	.33446	9.867	1973.3	.3356	.50000	14.289	60.000
	27.	61.001	269.60	14.971	.7175	.33550	9.836	1967.2	.3361	.50000	14.279	60.000
	27.5	61.192	269.60	14.971	.7209	.33655	9.805	1961.0	.3366	.50000	14.268	60.000

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TIME	P	AP	LF	RR	DR	FPP	IPC	BRM	DRM	SL	LR
28.	61.384	600.00	19.643	.7242	.33761	9.774	1954.9	.3371	.50000	14.258	60.000
28.5	61.578	600.00	19.705	.7276	.33868	9.744	1948.8	.3376	.50000	14.248	60.000
29.	61.773	600.00	19.767	.7310	.33975	9.713	1942.6	.3381	.50000	14.238	60.000
29.5	61.968	600.00	19.830	.7344	.34083	9.682	1936.5	.3386	.50000	14.227	60.000
30.	62.166	600.00	19.893	.7379	.34191	9.652	1930.3	.3391	.50000	14.217	60.000

Information Processing Center

Information Processing Center

C L2=80  
RUN 9

	APKM1	C3	L2
PRESENT	2.000	200.0	80.00
ORIGINAL	1.000	66.00	20.00

Information Processing Center

Information Processing Center

TIME	P		AP		LF		RR		DR		FMP		IPC		BRM		DRM		SL		LR	
	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00
.0	33.230	101.19	8.640	1.2354	.39748	2.045	201.0	1.0048	.99679	3.016	20.000											
.5	33.657	104.48	8.749	1.2600	.40060	3.105	204.9	1.0120	.99203	3.040	20.000											
1.	34.084	107.86	8.862	1.2852	.40380	3.164	208.9	1.0191	.98727	3.064	20.000											
1.5	34.528	111.31	8.977	1.3110	.40709	3.224	212.8	1.0262	.98252	3.087	20.000											
2.	34.982	114.86	9.095	1.3375	.41045	3.283	216.7	1.0334	.97776	3.111	20.000											
2.5	35.449	118.50	9.217	1.3647	.41391	3.343	220.6	1.0405	.97302	3.135	20.000											
3.	35.927	122.23	9.341	1.3926	.41745	3.402	224.5	1.0476	.96828	3.159	20.000											
3.5	36.418	126.06	9.469	1.4211	.42108	3.461	228.5	1.0547	.96354	3.182	20.000											
4.	36.921	129.98	9.599	1.4505	.42481	3.521	232.4	1.0618	.95882	3.206	20.000											
4.5	37.437	134.01	9.734	1.4805	.42863	3.580	236.3	1.0688	.95411	3.229	20.000											
5.	37.966	138.14	9.871	1.5114	.43255	3.638	240.1	1.0759	.94941	3.253	20.000											
5.5	38.509	142.37	10.012	1.5430	.43657	3.697	244.0	1.0829	.94473	3.276	20.000											
6.	39.066	146.71	10.157	1.5754	.44069	3.756	247.9	1.0899	.94006	3.300	20.000											
6.5	39.637	151.17	10.306	1.6087	.44492	3.814	251.7	1.0969	.93540	3.323	20.000											
7.	40.222	155.73	10.458	1.6428	.44925	3.872	255.5	1.1038	.93077	3.346	20.000											
7.5	40.823	160.42	10.614	1.6778	.45370	3.930	259.4	1.1108	.92615	3.369	20.000											
8.	41.439	165.22	10.774	1.7136	.45826	3.987	263.2	1.1177	.92156	3.392	20.000											
8.5	42.071	170.15	10.938	1.7504	.46294	4.044	266.9	1.1245	.91699	3.415	20.000											
9.	42.718	175.20	11.107	1.7882	.46773	4.101	270.7	1.1313	.91244	3.438	20.000											
9.5	43.383	180.39	11.280	1.8269	.47265	4.158	274.4	1.1381	.90791	3.460	20.000											
10.	44.064	185.70	11.457	1.8666	.47770	4.214	278.1	1.1449	.90342	3.483	20.000											
10.5	44.763	191.15	11.638	1.9073	.48287	4.270	281.8	1.1516	.89895	3.505	20.000											
11.	45.480	196.74	11.825	1.9490	.48819	4.326	285.5	1.1582	.89450	3.527	20.000											
11.5	46.215	202.48	12.016	1.9919	.49362	4.381	289.2	1.1649	.89009	3.550	20.000											
12.	46.969	208.36	12.212	2.0358	.49921	4.436	292.8	1.1714	.88571	3.571	20.000											
12.5	47.724	214.25	12.408	1.9674	.46273	4.489	296.3	1.1778	.88145	3.593	20.000											
13.	48.481	220.10	12.605	2.0089	.46792	4.540	299.6	1.1839	.87741	3.613	20.000											
13.5	49.255	224.13	12.806	2.0431	.47494	4.550	300.3	1.1851	.87658	3.617	20.000											
14.	50.043	228.22	13.011	2.0779	.48208	4.561	301.0	1.1864	.87577	3.621	20.000											
14.5	50.844	232.39	13.219	2.1133	.48935	4.571	301.7	1.1876	.87496	3.625	20.000											
15.	51.660	236.63	13.431	2.1494	.49675	4.581	302.3	1.1887	.87417	3.629	20.000											
15.5	52.489	240.95	13.647	2.1860	.50428	4.590	303.0	1.1899	.87338	3.633	20.000											
16.	53.334	245.34	13.867	2.2234	.51194	4.600	303.6	1.1911	.87261	3.637	20.000											
16.5	54.194	249.81	14.090	2.2614	.51974	4.610	304.2	1.1922	.87185	3.641	20.000											
17.	55.068	254.35	14.318	2.3000	.52767	4.619	304.8	1.1933	.87110	3.644	20.000											
17.5	55.958	258.98	14.549	2.3394	.53574	4.628	305.5	1.1944	.87037	3.648	20.000											
18.	56.863	261.84	14.784	2.3715	.54557	4.605	303.9	1.1917	.87223	3.639	20.000											
18.5	57.469	265.80	14.990	2.4000	.55608	10.367	2073.5	.4544	.50000	12.456	20.000											
19.	57.768	269.77	15.186	2.4252	.56727	10.347	2069.4	.4551	.50000	12.449	20.000											
19.5	58.070	273.75	15.374	2.4500	.57904	10.326	2065.3	.4558	.50000	12.442	20.000											
20.	58.374	277.72	15.554	2.4752	.59138	10.279	2055.7	.4574	.50000	12.426	20.000											
20.5	58.601	281.69	15.728	2.5000	.60428	10.219	2047.8	.3000	.50000	15.413	80.000											
21.	58.747	285.66	15.898	2.5252	.61773	10.213	2042.7	.3000	.50000	15.404	80.000											
21.5	58.894	289.63	16.064	2.5500	.63173	10.188	2037.6	.3000	.50000	15.396	80.000											
22.	59.041	293.60	16.226	2.5752	.64627	10.162	2032.5	.3000	.50000	15.387	80.000											
22.5	59.189	297.57	16.384	2.6000	.66138	10.137	2027.4	.3000	.50000	15.379	80.000											
23.	59.337	301.54	16.538	2.6252	.67704	10.112	2022.3	.3000	.50000	15.371	80.000											
23.5	59.486	305.51	16.689	2.6500	.69325	10.086	2017.3	.3000	.50000	15.362	80.000											
24.	59.634	309.48	16.837	2.6752	.71000	10.061	2012.3	.3000	.50000	15.354	80.000											
24.5	59.784	313.45	16.982	2.7000	.72729	10.036	2007.2	.3000	.50000	15.345	80.000											
25.	59.933	317.42	17.124	2.7252	.74512	10.011	2002.2	.3000	.50000	15.337	80.000											
25.5	60.083	321.39	17.263	2.7500	.76349	9.986	1997.2	.3000	.50000	15.329	80.000											
26.	60.233	325.36	17.400	2.7752	.78240	9.961	1992.3	.3000	.50000	15.320	80.000											
26.5	60.384	329.33	17.534	2.8000	.80184	9.936	1987.3	.3000	.50000	15.312	80.000											
27.	60.535	333.30	17.665	2.8252	.82181	9.912	1982.3	.3000	.50000	15.304	80.000											
27.5	60.686	337.27	17.793	2.8500	.84231	9.887	1977.4	.3000	.50000	15.296	80.000											

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TIME	P	AP	LF	RR	DR	FMP	IPC	BRM	DRM	SL	LR
28.	60.838	600.00	19.468	.6368	.33461	9.862	1972.4	.3000	.50000	15.287	80.000
28.5	60.990	600.00	19.517	.6404	.33545	9.838	1967.5	.3000	.50000	15.279	80.000
29.	61.143	600.00	19.566	.6420	.33629	9.813	1962.6	.3000	.50000	15.271	80.000
29.5	61.296	600.00	19.615	.6436	.33713	9.789	1957.7	.3000	.50000	15.263	80.000
30.	61.449	600.00	19.664	.6452	.33797	9.764	1952.8	.3000	.50000	15.255	80.000

Information Processing Center

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T BRMT=0/.2/.5/1/1/1/.8/.7/.6/.5/.4/.4/.4/.4/.3/.3  
 RUN 10

	APKM1	C3	BRMT					
PRESENT	2.000	200.0	0.	.2000	.5000	1.000	1.000	1.000
ORIGINAL	1.000	66.00	0.	.2000	.5000	1.000	1.300	1.700

PRESENT	.8000	.7000	.6000	.5000	.4000	.4000	.4000	.4000
ORIGINAL	2.000	1.600	1.300	.8000	.6000	.5000	.5000	.4000

PRESENT	.3000	.3000
ORIGINAL	.3500	.3000

Information Processing Center

Information Processing Center

TIME	P		AP		LF		RR		DR		FMP		IPC		ARM		DRM		SL		LR	
	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00	E+00
.0	33.230	101.19	8.640	1.2295	.39748	1.045	201.0	1.0000	.99679	3.016	20.000											
.5	33.648	104.45	8.748	1.2450	.40057	3.104	204.9	1.0000	.99207	3.040	20.000											
1.	34.071	107.76	8.859	1.2606	.40371	3.163	208.7	1.0000	.98741	3.063	20.000											
1.5	34.501	111.11	8.970	1.2765	.40689	3.220	212.6	1.0000	.98279	3.086	20.000											
2.	34.938	114.51	9.084	1.2927	.41012	3.278	216.3	1.0000	.97822	3.109	20.000											
2.5	35.381	117.97	9.199	1.3091	.41340	3.334	220.1	1.0000	.97370	3.131	20.000											
3.	35.830	121.47	9.316	1.3257	.41673	3.390	223.8	1.0000	.96923	3.154	20.000											
3.5	36.286	125.03	9.434	1.3426	.42011	3.446	227.4	1.0000	.96480	3.176	20.000											
4.	36.749	128.64	9.555	1.3597	.42354	3.501	231.0	1.0000	.96042	3.198	20.000											
4.5	37.219	132.31	9.677	1.3771	.42701	3.555	234.6	1.0000	.95609	3.220	20.000											
5.	37.696	136.03	9.801	1.3947	.43054	3.609	238.2	1.0000	.95180	3.241	20.000											
5.5	38.180	139.80	9.927	1.4126	.43413	3.662	241.7	1.0000	.94756	3.262	20.000											
6.	38.671	143.63	10.054	1.4308	.43776	3.714	245.1	1.0000	.94336	3.283	20.000											
6.5	39.169	147.52	10.184	1.4493	.44145	3.766	248.6	1.0000	.93921	3.304	20.000											
7.	39.675	151.46	10.315	1.4680	.44520	3.818	252.0	1.0000	.93510	3.325	20.000											
7.5	40.188	155.47	10.449	1.4870	.44900	3.868	255.3	1.0000	.93104	3.345	20.000											
8.	40.709	159.53	10.584	1.5062	.45286	3.919	258.6	1.0000	.92702	3.365	20.000											
8.5	41.238	163.65	10.722	1.5258	.45677	3.969	261.9	1.0000	.92305	3.385	20.000											
9.	41.774	167.84	10.861	1.5456	.46074	4.018	265.2	1.0000	.91912	3.404	20.000											
9.5	42.318	172.08	11.003	1.5658	.46477	4.066	268.4	1.0000	.91523	3.424	20.000											
10.	42.871	176.39	11.146	1.5862	.46886	4.115	271.6	1.0000	.91139	3.443	20.000											
10.5	43.432	180.77	11.292	1.6070	.47302	4.162	274.8	1.0000	.90759	3.462	20.000											
11.	44.001	185.21	11.440	1.6280	.47723	4.209	277.9	1.0000	.90383	3.481	20.000											
11.5	44.578	189.71	11.590	1.6494	.48151	4.256	281.0	1.0000	.90011	3.499	20.000											
12.	45.164	194.28	11.743	1.6711	.48585	4.302	284.0	1.0000	.89644	3.518	20.000											
12.5	45.747	198.82	11.894	1.6931	.48931	4.346	286.9	1.0000	.89288	3.536	20.000											
13.	46.325	203.33	12.044	1.6214	.49323	4.389	289.7	1.0000	.88944	3.553	20.000											
13.5	46.911	207.90	12.197	1.6419	.49721	4.432	292.5	1.0000	.88604	3.570	20.000											
14.	47.505	212.54	12.351	1.6627	.46125	4.474	295.3	1.0000	.88267	3.587	20.000											
14.5	48.108	217.24	12.508	1.6838	.46534	4.516	298.0	1.0000	.87935	3.603	20.000											
15.	48.719	221.34	12.667	1.7052	.47008	4.543	299.8	1.0000	.87715	3.614	20.000											
15.5	49.339	224.56	12.828	1.7269	.47570	4.551	300.4	1.0000	.87649	3.618	20.000											
16.	49.966	227.82	12.991	1.7488	.48139	4.560	300.9	1.0000	.87584	3.621	20.000											
16.5	50.602	231.13	13.157	1.7711	.48716	4.568	301.5	1.0000	.87520	3.624	20.000											
17.	51.246	234.48	13.324	1.7936	.49300	4.576	302.0	1.0000	.87457	3.627	20.000											
17.5	51.899	237.87	13.494	1.8164	.49892	4.583	302.5	1.0000	.87394	3.630	20.000											
18.	52.559	241.31	13.665	1.8396	.50491	4.591	303.0	1.0000	.87332	3.633	20.000											
18.5	53.005	244.73	13.838	1.8631	.51096	4.598	303.4	1.0000	.87271	3.636	20.000											
19.	53.231	248.14	14.014	1.8868	.51707	4.604	303.7	1.0000	.87211	3.639	20.000											
19.5	53.457	251.53	14.192	1.9107	.52324	4.609	304.0	1.0000	.87151	3.642	20.000											
20.	53.685	254.91	14.372	1.9348	.52947	4.613	304.2	1.0000	.87091	3.645	20.000											
20.5	53.913	258.28	14.554	1.9590	.53576	4.616	304.4	1.0000	.87031	3.648	20.000											
21.	54.143	261.64	14.738	1.9834	.54211	4.618	304.5	1.0000	.86971	3.651	20.000											
21.5	54.373	264.99	14.924	2.0079	.54851	4.619	304.6	1.0000	.86911	3.654	20.000											
22.	54.604	268.33	15.112	2.0326	.55496	4.619	304.6	1.0000	.86851	3.657	20.000											
22.5	54.837	271.66	15.302	2.0574	.56146	4.618	304.5	1.0000	.86791	3.660	20.000											
23.	55.070	274.98	15.494	2.0822	.56801	4.616	304.4	1.0000	.86731	3.663	20.000											
23.5	55.304	278.29	15.688	2.1071	.57461	4.613	304.2	1.0000	.86671	3.666	20.000											
24.	55.539	281.59	15.884	2.1321	.58126	4.609	304.0	1.0000	.86611	3.669	20.000											
24.5	55.776	284.88	16.082	2.1572	.58796	4.604	303.7	1.0000	.86551	3.672	20.000											
25.	56.013	288.16	16.282	2.1824	.59471	4.598	303.4	1.0000	.86491	3.675	20.000											
25.5	56.251	291.43	16.484	2.2077	.60151	4.591	303.0	1.0000	.86431	3.678	20.000											
26.	56.491	294.69	16.688	2.2331	.60836	4.583	302.5	1.0000	.86371	3.681	20.000											
26.5	56.731	297.94	16.894	2.2586	.61526	4.574	302.0	1.0000	.86311	3.684	20.000											
27.	56.971	301.18	17.102	2.2842	.62221	4.564	301.5	1.0000	.86251	3.687	20.000											
27.5	57.215	304.41	17.312	2.3100	.62921	4.553	301.0	1.0000	.86191	3.690	20.000											



Footnotes

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20. Ibid., p. 362.
21. Ibid., p. 362.
22. For a detailed description see, Pi-Chao Chen and Ann Elizabeth Miller, "Lessons from the Chinese Experience: China's Planned Birth Program and It's Transferability," Studies in Family Planning, Vol. 6, No. 10, October 1975.
23. John Aird, "Population Policy and Demographic Prospects in the People's Republic of China," in People's Republic of China: An Economic Assessment, edited by the Joint Economic Committee, Washington, D.C., Government Printing Office pp. 335-370; Pi-Chao Chen, "Prospects of Demographic Transition in a Mobilization System: China," in Research in the Politics of Population, edited by Wegman, Lin and Purcell, New York, Josiah Macy Jr. Foundation, pp. 236-241, and H. Yaun Tien, China's Population Struggle, (Columbus: Ohio State University Press), cited in Chen and Miller, op. cit. p. 354.
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Glossary

Units of Measurement

One acre = 4840 sq. yds = 0.4047 hectare

One hectare = 2.47 acre

One seer = 2.057 lbs. = 0.9331 kg.

Currency Equivalents

Post-devaluation

Upto February 1973: { One Rupee = 0.09 U.S. dollar  
                          { One U.S. dollar = Rs 11.00

After February 1973: One U.S. Dollar = Rs 9.90



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