Population growth and economic development.

James Robert. Allen

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POPULATION GROWTH

AND

ECONOMIC DEVELOPMENT

by

James Robert Allen

A Thesis
submitted to the Faculty of
Graduate Studies
through the Department of Economics
in Partial Fulfillment
of the requirements for the Degree of
Master of Arts at the
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Windsor, Ontario, Canada

1976
ABSTRACT

It can be stated with certainty, that a truly revolutionary change in the reproductive balance of the human species has taken place in modern times. The word revolutionary is used here with the connotation of radical change. The changing reproductive balance, furthermore, is not an isolated event, but associated with equally radical changes in the economic and social spheres, all of these having repercussions upon each other. Never in history had it been possible to reduce human mortality to such an extent as it was in the past hundred years or so. During that period, however, a very sharp distinction has emerged in economic, social and demographic conditions among these areas now regarded as more developed, semi-developed and less developed. The revolutionary change attained major importance in the more developed areas from the middle of the nineteenth century onward. More suddenly, and with greater magnitude, it came into prominence in the semi-developed areas, only in the middle of the present century. The purpose of this study is to investigate this revolutionary change and to develop a dynamic model which illustrates population growth as a function of economic development. The dynamic model will
be referred to as the RNI-Yd per capita model for population change and economic development. The hypothesis may be expressed as follows; during the process of economic development natural rate of increase tends to increase, then become stable and then decrease. This hypothesis can be empirically generalized by regressing a measure of population growth, the natural rate of increase, RNI, on a measure of economic development, national disposable income per capita, Yd. According to the above hypothesis the shape of the curve which might best describe the empirical relationship between (RNI) and (Yd) is given by a positively skewed frequency polygon.

The study also investigates various factors which will alter the future trend in the natural rate of population change.
ACKNOWLEDGMENT

I would like to express my sincere gratitude to Dr. B. S. Meyer and to Dr. P. A. Della Valle for the help and advice which they freely gave me during the preparation of this thesis.
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CHAPTER I

INTRODUCTION
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INTRODUCTION

My main purpose in what follows is to trace the effects of population growth (Birth rate per 1,000 less Death rate per 1,000) due to the process of economic development, as measured by changes in per capita disposable income.¹

"Nothing is ... gained ... by pretending that Nature's action is simple."² The relationships between the population factor and other variables making up the societal universe can be treated in terms of one-at-a-time analysis, but not with as much completeness as one would like.

The population factor is only one of the many factors which the process of economic development affects; but it is one of the most important.

To discuss economic development meaningfully, we must choose an index suitable to reflect its course. Of the indices available, the most satisfactory appears to be

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¹The data used for a per capita income measure of economic development is disposable income per capita. For the individual, this gives the best measure of the amount available for expenditure on consumption and saving according to United Nations Department of Economic and Social Affairs.

annual income per capita, for this index is both a summary measure of many elements after which man aspires and an end result of that process of technological and industrial change which has transformed the economies of at least a quarter of the world's population and raised its levels of living far above the poorer style found almost everywhere two centuries ago.

I shall make use of this index, therefore, without implying that it is, of necessity, highly correlated with an inner state known as physiopsychic well being.

This thesis attempts firstly, to review and appraise the history of population theories; secondly, to develop a theoretical framework to be used in the economic analysis linking the natural rate of population change and economic betterment; and thirdly, to suggest various factors which will alter the future trend in the natural rate of population change.
CHAPTER II

HISTORY OF POPULATION

THEORIES
CHAPTER II
HISTORY OF POPULATION THEORIES

The publication of Malthus' Essay at the end of the eighteenth century brought, for the first time, the question of population into a prominent position in the literature on economics and related subjects.\(^1\) The works on population theory published since that time are far more numerous than the earlier writings in the field, and more relevant to the problems of the present day. An effort has been made, therefore, in the present summary to indicate their contents. Even with reference to the writings of the nineteenth and twentieth century, however, the summary is selective and compressed. In selecting the material to be included, the aim has been not only to indicate the trends in the development of modern thought on population questions, but also to present a summary of the theories of certain representative writers.

Seeds of certain ideas which have figured prominently in recent theoretical works on population can be found in

very ancient writings. The idea that excessive growth of population may reduce output per worker, and depress the level of living of the masses is of great antiquity.² It appears in the works of Confucius and in the works of other schools of ancient Chinese philosophers. These ancient Chinese writers observed that mortality increases when the food supply is insufficient; that premature marriage makes for high infant mortality rates; and that war checks population growth. They did not attempt to show how the variations of mortality and fertility affect the balance between population and resources.

Plato and Aristotle³ considered the question of optimum size of population in their discussions of the ideal conditions of a city-state in which man's potentialities could be fully developed. They suggested that population size should be large enough to be economically self-sufficient and capable of defending itself, but not too large to prevent constitutional government. However, neither Plato nor Aristotle inquired explicitly into the relationship between population density and per capita output.

The Romans,⁴ like the Chinese, viewed population questions in perspective of a great empire rather than a

³ Ibid., page 369.
⁴ Ibid., page 370.
small city-state. Roman writers were concerned with the practical problem of stimulating population increase. They were concerned with checks to population growth—floods, epidemics, famines, war and revolution—but did not attempt to state a general theory of the determinants of population increase or decrease.

Medieval Christian writers considered questions of population almost entirely from a moral and ethical standpoint. Their prevailing tendency, however, was to favour maintenance of a high birth rate.  

The Mercantilist schools of political economy, which flourished in Europe during much of the seventeenth and eighteenth centuries, emphasized the economic, political and military advantages of a large and growing population. Their aim was not to raise per capita income but to increase the aggregate national income. Population growth would augment national income and at the same time depress the hourly wage rate, giving the workers an incentive to work longer hours and widening the margin between national income and wage costs.

Few Mercantilist writers attempted a systematic explanation of population changes, but they did discuss


a number of constraints to population growth, such as plagues, wars and emigration.

During the last half of the eighteenth century, more and more writers on economic and social grounds rejected Mercantilist doctrine and, with it, the idea that population growth was advantageous and should be actively encouraged by the state. Certain writers, including Cantillon and his followers, developed the idea that population growth was dependent upon the scale of living and upon how much of the subsistence produced was available for the support of the people. 7

It was in this period of reaction against the Mercantilist doctrine that Malthus wrote the first edition of his essay on the "principle of population". 8 Malthus' argument rested upon the supposition that man's capacity to increase his means of subsistence was much less than his capacity to multiply; he asserted that man could increase his subsistence only in arithmetical progression, whereas his numbers tended to increase in geometrical progression. The history of mankind demonstrated, he said, that population always tended toward the limit set by subsistence and was contained within that limit by the operation of positive and preventive restraints. These restraints are want, famine, pestilence and premature mortality.


8 Ibid., pages 53 to 59.
In the second and later editions of his Essay, Malthus examined what he regarded as the principle cause of mass poverty, namely, population pressure and the diversion of too large an amount of productive resources to population growth. In opposition to the assertion that an indefinite increase of population could be supported, since in agriculture returns were at least in proportion to the labour bestowed upon the land, Malthus suggested the law of diminishing returns in agriculture. He argued that fertile land was limited in amount and not capable of continuous and sufficient improvement. Therefore, the practice of moral restraint appeared as the only practicable and satisfactory alternative to unrestrained population growth.  

The development of population theory from the early part of the nineteenth century up to about 1870 was dominated by two schools of thought; first, the classical school of political economy, and second, the writers in the socialist and Marxian traditions.

The theorists of the "classical school" were concerned with the causes and consequences of population changes, in their efforts to discover the laws governing

---


10 Adam Smith, Jeremy Bentham, James Mill, David Ricardo and T. R. Malthus contributed to the formation of the classical school of thought.
the levels and trends of production, wages, interest, rent and profits.

Classicalists believed that the cost of production of agricultural commodities tended to rise as a result of increases in population and consequent increases in demand and output, while the cost of producing manufactured goods tended to fall. Decreasing costs (i.e. "increasing returns") in manufacturing occurred because of the possibilities of increasing division of labour and continuing technical improvements, while increasing costs in agriculture were expected, at least in the long run. It followed that, as population increased and more labour was employed in agriculture and manufactures, the increase in agricultural output would be less than proportional. Thus depending on the relative strength of the opposing tendencies in manufacturing and in agriculture, population growth would be accompanied either by an increase or by a decrease in per capita output.

The relationships of population growth to wages and capital formation were incorporated into the classical theory of the stationary state, a theory designed to explain how the forces making for economic growth became equilibrated.11 According to this theory, continuing increases in capital and labour would eventually reduce the rate of returns on

capital to a level where the stock of capital was constant, while the level of wages would reach a point exactly equal with the standard of living. The growth of both capital and population would then cease, and the stationary state would be present.

The classical school also called attention to the importance of the distribution of income as a major factor affecting population growth.

Most early nineteenth-century authors fundamentally disagreed with Malthus and with the writers in the tradition of the classical school, regarding population questions. They contended either than an increase in population density made for an increase in productivity, or that, irrespective of the rate of population growth, there was a tendency for productivity to increase, thus insuring a steady rise in per capita income.

Socialist and Marxist writers, 12 since the early part of the nineteenth century, have either denied the existence of a population problem or maintained that it would be solved through reorganization of society. They have generally attributed human misery, not to excessive population growth, but to the unequal distribution of income and other defects in the existing capitalist social order. They have held that under the new form of society which

they advocate, adequate restraints on population growth would operate, and that the productive resources of the people would increase more rapidly than their numbers.

Marx held that there could be no universal law of population and that the source of existing overpopulation was found in the prevailing capitalist mode of production.

Marx's explanation implied that relative overpopulation of the sort associated with the capitalist mode of production would disappear when capitalism was replaced by a collective mode of production. He had little to say explicitly about the manner in which population would grow thereafter. His analysis of reproductive behaviour under capitalism suggested, however, that the increase of income, the reduction of inequalities in income distribution, and the improvements in the living conditions of the masses, which he expected to result from the reorganization of society, would bring about a decline in the death rate. The birth rate also would presumably decline because of the rise in living standards.

Socialist writers in the 1920's and 1930's continued to assert that relative overpopulation, though characteristic of the capitalist mode of production, is avoided under socialism.

During the period since about 1870, non-socialist writings on population have been affected by several important changes in circumstances. First, statistical information relevant to population has been greatly extended
and the methods of analysing demographic statistics have been much improved. Second, after about 1870 the birth rate and the rate of natural increase began to decline in many of the economically advanced countries. Third, significant improvements continued to be made in both manufacturing and primary product industries, with the result that living conditions improved. Fourth, writers devoted to the developing science of sociology had taken an increasing role in the study of population questions.

In England, Germany, Holland, the United States and France a significant number of writers in the late nineteenth century and into the twentieth continued to emphasize that, unless population growth slowed down, the economic condition of the people would be adversely affected.

Writers in the eighteenth and the early nineteenth centuries generally thought that the increase of food supply regulated the growth of population. In more recent literature the idea has been developed that certain requirements other than food, which cannot readily be replaced by substitutes, may become population limiting factors. More and more the growth of population has been treated as a function of increasing income; thus the pertinence of Malthusian theory regarding the increase of subsistence and its relation to population growth has diminished.

There has, moreover, been an increasing recognition of the

complexity of the factors affecting the rate of population growth.\textsuperscript{14}

The reasons for the declining birth rates and natural increase rates in various advanced countries were a subject of considerable conjecture among writers of the late nineteenth and early twentieth centuries. Certain writers sought to demonstrate that a decline in the birth rate was inevitable in view of the processes of social change and the limits of economic expansion. Other writers argued that advances in income produced various cultural effects which in turn made for family limitation.

In general, the majority of writers toward the end of the nineteenth century and early in the twentieth century were more optimistic than the earlier nineteenth-century writers in their estimates of man's ability to control his numbers. Their optimism had its origin in the spread of contraceptive practices and the decline of birth rates in economically advanced countries, and was reinforced by the view that the birth rate tends to decline with the advance of civilization.\textsuperscript{15} Many writers hold that the decline of the birth rate in Europe and England was associated with industrialization, urbanization and accompanying changes in modes of living and attitudes of the various classes within

\textsuperscript{14} Thomlinson, R., Population Dynamics. (New York: Random House, 1965), page 379.

these societies. They emphasize that as some of the changes characteristic of countries experiencing declines in the birth rate are spread to areas where the birth rate is still high, it is to be expected that birth and death rates will decline, thus resulting in less rapid population increase and less pressure upon resources.

Several theorists have tried to formulate a general law of population development which would not be based upon oversimplified hypotheses and predominantly biological analogies, and which would take account of various influences, particularly those within the economic sphere. They have argued that what is needed is a dynamic scheme of analysis of population growth. Modern theorists like Blalock, Thompson and Landry have attempted to develop a dynamic scheme of analysis of population growth. They have assumed that populations tend to evolve through certain stages, having characteristic tendencies of growth, and have subsequently classified given populations according to their position in this sequence of stages.

Blalock and Thompson have identified five stages in population growth: (1) the high stationary, marked by high natality and high mortality; (2) the early expanding, with high natality and high but declining mortality; (3) the late expanding, with declining natality but with mortality declining more rapidly; (4) the low stationary, with low natality balanced by equally low mortality, and an excess of
deaths over births.\textsuperscript{16}

Another such classification has been presented by Landry, who has identified three demographic regimes, based in large part upon the observations of Cantillon, on the relationship between production and consumers' preferences in determining population growth.\textsuperscript{17} The three regimes are as follows: (1) A primitive regime exists during the period when population growth is controlled by the means of subsistence. The maximum population may rise or fall with changes in the conditions of production. (2) An intermediate demographic regime continues for the period in which the interests of individuals and of societies in the maintenance of a standard of living affect the growth of population by influencing marriage. Economic production tends to determine the size of population, but only indirectly and in relation to certain standards of living. (3) A modern demographic regime is characterized by general decline in fertility. Population changes no longer conform to any population law and economic influences no longer determine the trend of population. Under the first two demographic regimes, technological advances are the prime source of increase of population. In the modern society, technology progresses at an accelerated rate but ceases to have the same direct relationship with population changes.


\textsuperscript{17} Ibid.
This summary has attempted to indicate the trends in the development of modern thought on population questions and to present an overview of the theories of certain representative writers.
CHAPTER III

THE DEVELOPMENT OF A DYNAMIC MODEL:

NATURAL RATE OF POPULATION

CHANGE AND ECONOMIC BETTERMENT
CHAPTER III

THE DEVELOPMENT OF A DYNAMIC MODEL:

NATURAL RATE OF POPULATION

CHANGE AND ECONOMIC BETTERMENT

A "theory of population" is understood as an attempt to elucidate the major factor or factors determining population growth.¹

A theory of population should be able to explain not only historically observed changes in the natural rate of population growth patterns, but also should provide the basis for predicting with some accuracy the future natural rate of population growth pattern of a country or group of countries, given the stage of economic development and type of social organization.

At first inspection, the unparalleled rate of increase in population growth might be attributed to rising birth rates. However, no proof exists of increased births continuing for a century or longer during modern times, in any sizeable section of the world. On the contrary, considerable evidence points to a decline in the birth rate.

Migration obviously cannot be a factor in world population change. Therefore, the third demographic variable, the death rate, must be responsible for this explosive population increase.²

The cause of the rapidly mounting rate of population growth is the reduction of the death rate,³ made possible by recent medical discoveries. In earlier centuries other forces were at work to lower mortality. A rising standard of living resulted from improvements in agricultural and industrial production, and also in the ability to distribute these goods quickly, widely and inexpensively.

Credit for the decreased mortality is commonly given to medicine, but in fact, scientific medicine and sanitation did not have a strong effect on mortality until the late nineteenth century. A more important factor was the gradual adoption of improved industrial and agricultural production techniques, whereby food and other scarce goods began to be available to most people in large and regular quantity. This decline in the death rate probably began in Europe and then spread to other countries.

Paradoxically, a reduction of the birth rate occurred during this period of modernization and population expansion.

²The three demographic variables are the birth rate, the death rate and the migration rate. The first two are combined to form a composite variable: the natural increase rate of the excess (or deficit) of births over deaths.

³Chapter Seven discusses the decline in the death rate in greater detail.
The tremendous population growth resulted from the lag between the decreasing death rate and the decreasing birth rate.\(^4\)

At the same time as men were receptive to techniques which would minimize mortality, they were attempting to maximize fertility. In the struggle against the adversities of nature, a high birth rate was essential to counterbalance the high death rate. Value systems encouraged people to have as many children as they could and to keep them alive as long as possible.

When methods became available for saving people from disease and starvation, they were adopted quickly because they conformed to existing beliefs. In contrast, lowering the birth rate was generally opposed because it contradicted the prevailing value system. Under such conditions, if mortality control reaches a high level of efficiency, natural increase is substantial.

In contrast, economic changes encouraged lowering the birth rate.\(^5\) People became aware of the financial liability of too many children in a competitive, individualistic, nonagricultural society. The large family became a heavy burden, especially for the bourgeoisie. Children were no longer assets. Children did not produce income for the


\(^5\) Chapter Six discusses the factors in the decline of the birth rate in greater detail.
parents as they did in an agrarian economy. They were now liabilities and cost money to bring into the world and raise.

As a result, in many countries, the birth rate declined to approximately the same level as mortality.

A new kind of demographic stability was first reached in Western Europe. Instead of high births balancing against a high level of mortality, countries like France, England and Sweden maintained their population through low births and low mortality. These two conditions are called the old balance and the new balance respectively.

Figure 1 is a schematic diagram of the shift from the old to the new balance. Specific dates and rates are omitted so that the graph may have general applicability rather than being descriptive of only one country. Different nations enter periods A, B and C at different times. Period A represents the old balance, period C the new. The transitional period B occurs when the death rate has declined or is declining rapidly and the birth rate is declining slowly. The shaded area represents natural increase – the growth of population due to the surplus of births over deaths.

The old balance is normal to mankind. Indeed, throughout almost all of human existence, man’s control over his environment was negligible. The result was a high death rate. Consequently, a large number of births was necessary if society were to offset the large number of deaths – a very inefficient way to maintain the population.
Figure 1. The Demographic Transition Model

In contrast, the new balance represents an improved condition of human efficiency and health, a level of well-being never before achieved by any society. This novel equilibrium is accompanied by relative freedom from health worries. This modern state is not possible, however, for all types of societies. Western countries did not achieve it until after the industrial revolution, and it is unlikely that any region can reach this high standard of living without industrialization.

In the interval between abandonment of the old balance and achievement of the new, rapid natural increase results from the discrepancy between the still high birth rate and the newly lowered death rate. This growth is helpful for underpopulated nations, supplying larger markets, more productive manpower and greater military potential. But for countries already overcrowded, population increase impedes improvement in the standard of living.

These world changes, suggested to demographers that a typology might be constructed which would describe the historical transition already made by some countries and perhaps permit us to predict what will happen in those countries just beginning to abandon the old balance. Let us consider three possibilities: (1) high birth rate, high death rate; (2) high birth rate, low death rate; (3) low birth rate, low death rate. These three possibilities have been grouped into a widely accepted typology known as the
Transition Theory. In the order given above, the types are customarily labeled: (1) high potential growth, (2) transitional growth, and (3) incipient decline.

This first stage describes the old balance commonly found in agrarian cultures with traditional tribal or peasant social organizations, largely unaffected by industrialization, secularization and urbanization. Both the birth and death rates are very high. The former is rooted in well entrenched marriage customs and reproductive norms; the latter maintained by endemic disease and chronic undernourishment. The resulting condition of growth is near-static.

The label for stage one is derived from the high rate of growth that is latent in the old balance. The decisive reduction of the death rate customarily attendant upon a rising standard of living might cause the population to enlarge rapidly. Also, the low life expectancy produces a concentration of people in the age groups having the greatest likelihood of becoming parents. Thus the age distribution favors continuing high natality.

Many people are now living under conditions of a high birth rate and a high death rate (most of Africa, Asia and a few countries in South America). Lowering their death rates will probably result in rapid and possibly lengthy

population increase.

When the potential for natural increase of the first stage is released, stage two is reached - B in Figure 1. Transitional growth nations have achieved considerable control over their death rates, but their slender control over birth rates makes for erratic but high natural increase. Countries which have attained greater control over death but have not decreased their number of births - Latin America, South America and South Africa - are now under rapid growth. Transitional growth accompanies the first steps toward industrialization and urbanization.

For those countries now in the first stage it is generally assumed that they will soon reach the second level, as preventive medicine, sanitation and improved food supply make inroads on the death rate. With modern medical discoveries available, these now underdeveloped areas should require far less time for the passage into the transitional stage - providing their standard of living may be raised permanently and not temporarily - than was necessary for the nations of Western Europe, who pioneered this movement.

Completion of the move toward modernization - C in Figure - is coupled with a lowered birth rate, bringing the new balance. Most of Europe, North America and Australia are in this category.

Demographers expect countries now in the high potential and transitional growth stages to enter the third stage in the future. The rapidity with which they pass through the
transitional growth period to stage three will depend heavily on their readiness and ability to limit their birth rate.

In Figure 1, period A corresponds to the High Potential Growth Type, period B to the Transitional Growth Type and period C to the Stage of Incipient Decline. This tripartite scheme may be regarded from four points of view: (1) as a simple historical description of what happened in the past, (2) as a classification system, (3) as a theoretical explanation of the forces impelling demographic changes, and (4) as a prediction of the sequence through which the country will progress.  

These three stages have distinguishing economic properties. The third stage has a productive economy, with high efficiency and a high standard of living. The intermediate stage is characterized by a less productive economy in which industrialization is spreading and agricultural production is increasing. Technological backwardness is being abandoned in favour of western economic standards. The earliest period is characterized by a low level of productivity, primitive energy sources, and dim immediate prospects of a rising standard of living. These people often lack necessary surplus capital for investment in education, social welfare, and the production of equipment.


8 Ibid., page 24.
Many, however, have raised living standards, improved health conditions and moved into stage two.

My dynamic model is developed by combining the demographic transition model, in Figure 1, with the process of economic development, as indicated by the distinguishing economic properties in each of the three stages in the demographic transition model. The theoretical and empirical analysis will deal with the natural rate of population increase - the dependent variable - as a function of the process of economic development - the independent variable. The result is what I shall call the RNI-Yd per capita model of population change and economic development.  

The RNI-Yd per capita model of population change and economic development is developed in Chapter Four and empirically analyzed in Chapter Five.

The abbreviation RNI is defined as the rate of natural increase (birth rate per 1000 minus death rate per 1000) and Yd per capita is defined as disposable income per capita measured in terms of United States dollars.
CHAPTER IV

THE ECONOMETRIC FORM

FOR THIS DYNAMIC MODEL
CHAPTER IV

THE ECONOMETRIC FORM

FOR THIS DYNAMIC MODEL.

In principle, long-run relationships between demographic and socioeconomic factors can be investigated statistically from two points of view. One possibility is to study one or more geographical units over time and determine the variations in natural rate of increase which are associated with changes in the per capita disposable income. To draw conclusions of general validity from this approach, a similar analysis must be repeated for several countries over long periods of time.

Alternatively, a number of geographical units can be investigated at the same point in time.¹ The influence of per capita disposable income, as a measure of economic development, coupled with the natural rate of increase, can then be established quantitatively. There is a fundamental difficulty inherent in this cross-sectional technique: in order to draw any conclusions from the data it must be assumed that, regardless of any differences in environmental

and historical conditions, each human population, from a demographic point of view, responds to a small number of more or less quantifiable socioeconomic variables, as if it were drawn from a homogeneous environment. In view of the tremendous variations in values, outlook, and other socio-cultural features throughout the world, this condition is an important one.

However, since satisfactory time series for birth and death rates are unavailable even for the modern industrialized countries, the time-series approach cannot be effectively used. The present study must therefore rely upon cross-sectional analysis to investigate long-term effects of the natural rate of increase due to changes in per capita disposable income.

In using cross-sectional analysis, the RNI-Yd per capita model for population change and economic development may be divided into three distinct classifications, as summarized in Table 1. Similarly, each classification in the RNI-Yd per capita model exhibits particular characteristics of demography and economic development, as summarized in Table 2.

If we combine the information given in Tables 1 and 2, the resulting hypothesis may be expressed: with economic development, natural rate of increase tends to increase, then become stable and then decrease. This hypothesis can be empirically generalized by regressing a measure of population growth, the natural rate of increase, RNI, on a measure of economic development, national disposable income per capita, Yd. According to the above hypothesis,
Table 1
The RNI-Yd per capita Cross-Sectional Model Classifications

<table>
<thead>
<tr>
<th>Developmental Level</th>
<th>Rate of Natural Population Increase Level</th>
<th>Per capita Disposable Income Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Underdeveloped</td>
<td>Low</td>
<td>high B.R.(^a)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>high D.R.(^b)</td>
</tr>
<tr>
<td>(B) Semi-Industrialized</td>
<td>High</td>
<td>high B.R.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>low D.R.</td>
</tr>
<tr>
<td>(C) Industrialized</td>
<td>Low</td>
<td>low B.R.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>low D.R.</td>
</tr>
</tbody>
</table>

\(^a\) B.R. = Birth Rate
\(^b\) D.R. = Death Rate
Table 2

The RNI-Yd per capita Cross-Sectional Model Characteristics of Demography and Economic Development

Movement from (A) to (B) characterized by a declining mortality rate coupled with a high birth rate

(A) Underdeveloped

Semi-Industrialized

(B) Industrialized

Movement from (B) to (C) characterized by a declining birth rate coupled with a low mortality rate

(C) Industrialized

Process of Economic Development

(A) Period of High Growth Potential:
- high mortality and birth rates
- agrarian cultures with traditional tribal or peasant social organizations, unaffected by industrialization or urbanization

(B) Transitional Growth:
- achievement of control over mortality rates coupled with high birth rates resulting in a high natural increase
- first steps to industrialization and urbanization

(C) Incipient Decline:
- achievement of the move toward modernization coupled with low birth and mortality rates
the shape of the curve which might best describe the empirical relationship between (RNI) and (Yd) is given by a positively skewed frequency polygon, as described in equation (1) and Figure 2 below.

\[ RNI = ae^{b(lnYd - c)^2} \]  

(1)

where RNI is the natural rate of population increase per 1000, Yd = National Disposable Income per capita measured in terms of United States dollars and a, b and c are constants.

Taking logarithms of equation (1) we have

\[ \ln RNI = \ln a + b(\ln Yd - c)^2 \]

\[ = \ln a + b(\ln Yd)^2 - 2bc \ln Yd + bc^2 \]  

(2)

Therefore, we can regress RNI on Yd in the form given in Figure 2 using

\[ \ln RNI = \beta_0 + \beta_1 (\ln Yd) + \beta_2 (\ln Yd)^2 \]  

(3)

where:

\[ \beta_0 = \ln a + bc^2 \]  

(3a)

\[ \beta_1 = -2bc \]  

(3b)

\[ ^2 \text{In addition, a further justification of using a positively skewed frequency polygon form will be dealt with in Chapter Five.} \]

\[ ^3 \text{The econometric form for this RNI-Yd per capita model of population change and economic development was first suggested to me by Dr. P. A. Della Valle from his article: Income Distribution and Economic Development, Discussion Paper number 26, Department of Economics, University of Windsor.} \]
Figure 2. The RNI-Yd per capita Cross-Sectional Model

Rate of Natural Increase per 1000

High

Low

(A) Underdeveloped range of Yd

(B) Semi-industrialized range of Yd

(C) Industrialized range Yd

Yd per capita
and $\beta_2 = b$ \hspace{1cm} (3c)

Therefore, equation (3) will be used as the econometric form for the RNI-Yd per capita model for population change and economic development.
CHAPTER V

THE REGRESSION RESULTS,

INTERPRETATION AND LIMITATION

OF THIS DYNAMIC MODEL
CHAPTER V

THE REGRESSION RESULTS, INTERPRETATION AND LIMITATION OF THIS DYNAMIC MODEL

The data upon which this study is based include a number of countries, for which roughly comparable demographic and economic data were available, at some date in the period from 1961 to 1963 and in the period from 1969 to 1971.

The geographic distribution of the observations is also wide; where a total of 40 countries was used in the 1969 to 1971 study and a total of 30 countries was used in the 1961 to 1963 study.¹ A list of these countries is presented in Table 3.

For each country in both samples, the natural rate of population increase per 1000 was determined, and the value of the independent variable - National Disposable Income per capita as a measure of economic betterment - was centered on, or around, that date of the dependent variable in both samples.

¹For the more recent study (1969 to 1971) credible data was calculated for 40 countries, however for the earlier study (1961 to 1963) credible data was calculated for only 30 of these 40 countries. The reason being that 10 countries were rejected, was due to the fact that this data was totally unreliable or unavailable.
Table 3

Countries Under Study

<table>
<thead>
<tr>
<th>Australia</th>
<th>Jordan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia</td>
<td>Mexico</td>
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<td>Canada</td>
<td>Netherlands</td>
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<td>Haiti</td>
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<td>Iceland</td>
<td>Tanzania</td>
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<tr>
<td>India</td>
<td>Togo</td>
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<td>Iraq</td>
<td>Tunisia</td>
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<tr>
<td>Ireland</td>
<td>Uganda</td>
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<td>Italy</td>
<td>Uruguay</td>
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<tr>
<td>Jamaica</td>
<td>Zaire</td>
</tr>
<tr>
<td>Japan</td>
<td>Zambia</td>
</tr>
</tbody>
</table>
According to the hypothesis presented in Chapter IV, the shape of the curve which might best describe the empirical relationship between (RNI) and (Yd) is given by a positively skewed frequency polygon. The non-linear relationship as described by equation (1),

\[ \text{RNI} = \alpha e^{b(\ln Yd - c)^2} \]  

is justified since the mean of (Yd) is significantly greater than its median. For the 1969 to 1971 study, the mean of (Yd), 1108, is significantly greater than its median, 466. (See Figure 3 below.) Similarly, for the 1961 to 1963 study, the mean of (Yd), 547, is significantly greater than its median, 322. (See Figure 4 below.)

We can regress (RNI) on (Yd) in the form given in Figure 3 or 4 using the equation

\[ \ln \text{RNI} = \beta_0 + \beta_1 (\ln Yd) + \beta_2 (\ln Yd)^2 \]  

Using the 1969 to 1971 data for forty countries, the empirical results of (3) are as follows:

\[ \ln \text{RNI} = -1.25 + 2.30 (\ln Yd) - 0.483 (\ln Yd)^2 \]  

\[ (0.298) \quad (0.053) \]

Number of observations .................. 40
R square ............................... 0.88
Adjusted R square ....................... 0.87

The numbers in parentheses below the estimated coefficients are the respective standard errors.

The "F" test is used to determine whether there exists
Figure 3. Statistical Justification of a Positively Skewed Frequency Polygon Form - 1969 to 1971 Study

RNI per 1000

median (466) mean (1108) Yd per capita
Figure 4. Statistical Justification of a Positively Skewed Frequency Polygon Form - 1961 to 1963 Study

\[ P''I \quad \text{per capita} \]

median (322)  mean (547)
a functional relationship between the dependent variable and all the independent variables.

From the estimated regression equation (4)

\[ F \text{ statistic } = 139.244 \]

\[ F \text{ critical } = F_{0.01, K-1, N-K-1} = 7.370 \]

so \( 139.244 > 7.370 \) and the \( F \) statistic is statistically significant at the 99% level.

The "t" test is used to determine the significance of each estimated regression coefficient. From the estimated regression equation (4)

\[ t \text{ statistic for } \beta_1 = \frac{\hat{\beta}_1}{SE} \]

\[ = \frac{2.30}{0.298} \]

\[ = 7.71 \]

\[ t \text{ critical } = t_{\alpha/2} (N-K-1), \text{ where } \alpha = 1\% \]

\[ = 2.71 \]

so \( 7.71 > 2.71 \)

\[ t \text{ statistic for } \beta_2 = \frac{\hat{\beta}_2}{SE} \]

\[ = \frac{-0.483}{0.053} \]

\[ = -9.11 \]

\[ t \text{ critical } = t_{\alpha/2} (N-K-1), \text{ where } \alpha = 1\% \]

\[ = -2.71 \]

so \( -9.11 < -2.71 \)

The estimated beta coefficients (\( \beta_1 \) and \( \beta_2 \)) are statistically
significant at the 99% level of confidence.

The $R^2$ is 0.88 and the adjusted $R^2$ is 0.87. Given the large number of cross-sectional observations and an F value of 139.244, the $R^2$ is significantly greater than zero at the 0.01 level.

In some cases, even though a theory clearly indicates the independent variables in explaining movements in a dependent variable, it may not be possible to interpret some of the parameters of the regression equation. This problem arises whenever there is a fixed relationship between independent variables. The problem is known as multicollinearity.

In many empirical problems the basic of interconnection may not be so conspicuous. Whatever the source of the fixed relationship, the problem can be averted by redefining the variables in such a way as to make the parameters subject to interpretation. For example, in equation (3)

$$\ln RNT = \beta_0 + \beta_1 (\ln Yd) + \beta_2 (\ln Yd)^2$$ (3)

the independent variable $(\ln Yd)^2$ was defined as, first taking the log $Yd$, and then squaring it. If this specification was not followed, $\beta_2$ would be twice as large as $\beta_1$, and the problem of multicollinearity would be present.\(^2\)

By substituting the coefficients given in equation (4)


\(^3\)This would occur if the log of $(Yd^2)$ was taken, creating a fixed relationship between the parameters $\beta_1$ and $\beta_2$.\(^3\)
into equation (3a), (3b) and (3c) we are able to solve for the original coefficients of equation (1).

\[ RNI = ae^{b(\ln Yd - c)^2} \]  

(1)

The empirical estimate of (1)\(^4\) can then be reported as follows:

\[ RNI = 1.48e^{-0.483(\ln Yd - 2.38)^2} \]  

(5)

The above result would seem to offer empirical evidence to the previously stated hypothesis relating natural rate of population change and economic development. A scattergram of (RNI) with (Yd) for the 1969 to 1971 data is illustrated in Figure 5. More specifically, the relationship between natural rate of population change and economic development is shown to be in the general form of a positively skewed frequency polygon for the 1969 to 1971 study.

A further investigation into the data is required in order to reveal the credibility of the RNI-Yd per capita model for population change and economic development. The typologies and classifications created in Table 1 and Table 2 must be analyzed.

The concept of demographic and economic types combines birth-rate, death-rate and disposable income values, as illustrated in Tables 1 and 2. As a re-statement, the demo-

\(^4\)See Appendix One for the mathematical calculation of equation (1), using the 1969 to 1971 cross-section regression results.
Figure 5. Scattergram of (RNI) with (Yd) - 1969 to 1971 Study
Figure 5 continued. Numerical List of Countries Corresponding to Scattergram

<table>
<thead>
<tr>
<th></th>
<th>Country</th>
<th></th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ethiopia</td>
<td>21</td>
<td>Mexico</td>
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<tr>
<td>2</td>
<td>Zaire</td>
<td>22</td>
<td>Panama</td>
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<td>Tanzania</td>
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<td>Jamaica</td>
</tr>
<tr>
<td>4</td>
<td>Dahomey</td>
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<td>South Africa</td>
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<td>Greece</td>
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<td>11</td>
<td>Ghana</td>
<td>31</td>
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<td>12</td>
<td>Zambia</td>
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<td>Iceland</td>
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<td>13</td>
<td>Tunisia</td>
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<td>Netherlands</td>
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<tr>
<td>14</td>
<td>Philippines</td>
<td>34</td>
<td>Australia</td>
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<td>15</td>
<td>Fiji</td>
<td>35</td>
<td>Canada</td>
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<td>16</td>
<td>Guyana</td>
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<td>Italy</td>
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<td>17</td>
<td>Jordan</td>
<td>37</td>
<td>Norway</td>
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<td>18</td>
<td>Iraq</td>
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<td>France</td>
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<td>Colombia</td>
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<td>Switzerland</td>
</tr>
<tr>
<td>20</td>
<td>Costa Rica</td>
<td>40</td>
<td>Sweden</td>
</tr>
</tbody>
</table>
graphic-economic transition model assumes that a country, in
the process of its economic development, experiences a
succession of changes in its birth rates, death rates and
consequently in its natural rates of increase. In Stage A,
preceding semi-industrialization, there is a fairly stable
balance involving high birth rates, high death rates, and a
resulting slow natural growth of population. This passes
over into a second or intermediate semi-industrialized stage
characterized by an imbalance between a continuing high
birth rate and a declining, often rapid, death rate. The
consequence is a sustained and usually fast growth of
population. Early in Stage B there is a divergence of the
profiles of birth and death rates. Later in this stage
births begin to fall off and the decline in deaths slows.
Thus, convergence of the birth and death rate profiles
gradually comes to replace divergence, and the gap between
births and deaths narrows, resulting in a slowing of natural
population increase.

Finally, in Stage C or the industrialized stage of
economic development, a new balance is reached between low
birth rates and low death rates. Slow population growth is
the result.

In applying the RNI-Yd per capita model to the 40
countries, the levels of 35 per 1000 for births and 27 to
11 per 1000 for deaths, with a per capita disposable income
of less than $310, represents Stage A. The levels of 31 to
19 per 1000 for births and 11 per 1000 for deaths, with a
per capita disposable income of between $310 to $1050, represent Stage B. The levels of 19 per 1000 for births and 7 to 11 per 1000 for deaths, with a per capita disposable income of greater than $1050, represent Stage C.\(^5\)

**Type A. Underdeveloped.** Included are those countries characterized by birth rates of 35 per 1000 or above and death rates of 27 to 11 per 1000. Such countries are either on the threshold of, or have recently entered, the period of declining death rates and accelerated population growth. These countries have abnormally low per capita incomes which reflect intense and widespread poverty. Type A is especially representative of tropical Africa and Asia. The first 14 countries listed in Figure 5 may be classified as Type A. The data for these countries is found in Table 4.

**Type B. Semi-Industrialized.** This more advanced semi-industrialized stage includes the countries in which birth rates still remain high, although it is beginning to come under control, and death rates are 11 per 1000. The declining birth rates have started to narrow the demographic gap caused by an earlier and sharper decline of mortality. Thirteen countries fall within this type, as illustrated in Table 5. South America best represents Type B, because it is in South America that natural growth rates of population

---

\(^5\) These estimated levels used in this study were developed by G. T. Trewartha in her book, *The Less Developed Realm: A Geography of Its Population* and by United Nations in the study, *The World Population in 1970.*
Table 4

Type A - Underdeveloped Countries; 1969 to 1971 (Yd per capita < $310 for each of these countries)

<table>
<thead>
<tr>
<th>#</th>
<th>Country</th>
<th>Demographic Variables&lt;sup&gt;a&lt;/sup&gt;)</th>
<th>Birth Rate b)</th>
<th>Death Rate b)</th>
<th>Rate of Natural Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ethiopia</td>
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<td>45.6</td>
<td>25.0</td>
<td>20.6</td>
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<tr>
<td>2</td>
<td>Zaire</td>
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<td>44.4</td>
<td>22.7</td>
<td>21.7</td>
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<td>25.0</td>
</tr>
<tr>
<td>4</td>
<td>Dahomey</td>
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<td>India</td>
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<sup>a</sup>) Rates per 1000

<sup>b</sup>) Predominate factors for Type A countries are the high Birth Rate and the high Death Rate.

<table>
<thead>
<tr>
<th>#</th>
<th>Country</th>
<th>Demographic Variables</th>
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<td>Rate of Natural Increase</td>
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<td>22.4</td>
<td>9.2</td>
<td>13.2</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Singapore</td>
<td>27.8</td>
<td>10.4</td>
<td>17.4</td>
<td></td>
</tr>
</tbody>
</table>

a) Rates per 1000

b) Predominate factor for Type B countries is the high Birth Rate.

are the highest, on the average, for the world. In other areas, such as South Africa, natural growth rates are slowing.

**Type C. Industrialized.** In the more developed or industrialized regions of the world, the birth rate is less than 19 per 1000 and the death rate ranges from 7 to 11 per 1000. The last 13 countries listed in Figure 5 may be classified as Type C. The data for these countries is found in Table 6.

On the basis of the 1969 to 1971 cross-sectional study, the data seems to conform to the RNI-Yd per capita model for population change and economic development.

A comparable analysis is also completed for the 1961 to 1963 data, where thirty countries are studied.

Similarly, equation (1) is used to describe the relationship between population change and economic development, as illustrated previously in Figure 2. Likewise, equation (3) is used as the regression equation:

\[ \ln RNI = \beta_0 + \beta_1 (\ln Yd) + \beta_2 (\ln Yd)^2. \] (3)

The empirical results of equation (3) for the 1961 to 1963 data are as follows:

\[ \ln RNI = -1.78 + 2.90 (\ln Yd) - 0.646 (\ln Yd)^2 \] (6)

(0.440) \hspace{1cm} (0.086)

---

Table 6

Type C - Industrialized Countries; 1969 to 1971 (Yd per capita > $1050 for each of these countries)

<table>
<thead>
<tr>
<th>#</th>
<th>Country</th>
<th>Demographic Variables</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Birth Rate b)</td>
<td>Death Rate b)</td>
<td>Rate of Natural Increase</td>
</tr>
<tr>
<td>28</td>
<td>Ireland</td>
<td>22.8</td>
<td>10.6</td>
<td>12.2</td>
</tr>
<tr>
<td>29</td>
<td>Spain</td>
<td>19.6</td>
<td>8.1</td>
<td>11.5</td>
</tr>
<tr>
<td>30</td>
<td>Greece</td>
<td>16.3</td>
<td>8.3</td>
<td>8.0</td>
</tr>
<tr>
<td>31</td>
<td>Japan</td>
<td>19.2</td>
<td>6.6</td>
<td>12.6</td>
</tr>
<tr>
<td>32</td>
<td>Iceland</td>
<td>19.5</td>
<td>7.1</td>
<td>12.4</td>
</tr>
<tr>
<td>33</td>
<td>Netherlands</td>
<td>18.8</td>
<td>8.4</td>
<td>10.4</td>
</tr>
<tr>
<td>34</td>
<td>Australia</td>
<td>20.7</td>
<td>8.7</td>
<td>12.0</td>
</tr>
<tr>
<td>35</td>
<td>Canada</td>
<td>17.0</td>
<td>7.3</td>
<td>9.7</td>
</tr>
<tr>
<td>36</td>
<td>Italy</td>
<td>16.8</td>
<td>9.6</td>
<td>7.2</td>
</tr>
<tr>
<td>37</td>
<td>Norway</td>
<td>16.9</td>
<td>9.9</td>
<td>7.0</td>
</tr>
<tr>
<td>38</td>
<td>France</td>
<td>17.1</td>
<td>10.7</td>
<td>6.4</td>
</tr>
<tr>
<td>39</td>
<td>Switzerland</td>
<td>15.2</td>
<td>9.2</td>
<td>6.0</td>
</tr>
<tr>
<td>40</td>
<td>Sweden</td>
<td>14.1</td>
<td>10.2</td>
<td>3.9</td>
</tr>
</tbody>
</table>

a) Rates per 1000

b) Predominate factors for Type C countries are the low Birth Rate and the low Death Rate.

Number of observations ...................... 30
R square ........................................ 0.85
Adjusted R square ............................. 0.85

The numbers in parentheses below the estimated coefficients are the respective standard errors.

The F statistic is statistically significant at the 99\% level of confidence.
Since \( F \) statistic = 82.532
and \( F \) critical = \( F_{(K-1, N-K-1)}^{0.01} = 7.680 \)
therefore, 82.532 > 7.680

The estimated regression coefficients are statistically significant at the 99\% level of confidence.
For \( \hat{\beta}_1 \) the t statistic = \( \frac{\hat{\beta}_1}{se} \)
\[ = \frac{2.90}{0.440} \]
\[ = 6.59 \]
while the t critical = \( t_{a/2}(N-K-1) \), where \( a = 1\% \)
\[ = 2.77 \]
so 6.59 > 2.77.

Similarly, for \( \hat{\beta}_2 \) the t statistic = \( \frac{\hat{\beta}_2}{se} \)
\[ = \frac{0.646}{0.086} \]
\[ = -7.51 \]
while the t critical = \( t_{a/2}(N-K-1) \), where \( a = 1\% \)
\[ = -2.77 \]
so -7.51 < -2.77.

The \( R^2 \) of 0.85 is significantly greater than zero at
the 99% level, given the large number of cross-sectional observations and an F value of 82.532.

Similarly, substituting the coefficients given in equation (6) into equation (3a), (3b) and (3c) we are able to solve for the original coefficients of equation (1).

\[ RNI = ae^{b(\ln Yd - c)^2} \]  \hspace{1cm} (1)

The empirical estimate of (1)\(^7\) can then be reported as follows:

\[ RNI - 1560.0 \times 0.646(\ln Yd - 2.24)^2 \]  \hspace{1cm} (7)

Similarly, the cross-sectional results for the 1961 to 1963 study would seem to offer further empirical evidence for the relationship between natural rate of population change and economic development. A scattergram of (RNI) with (Yd) for the 1961 to 1963 data, again illustrates this relationship to be in the general form of a positively skewed frequency polygon. See Figure 6.

The RNI-Yd per capita model is used to analyze the 1961 to 1963 data for the 30 countries. The demographic projection levels already discussed are used in this study. It is assumed that these annual average levels will continue from 1960 to 2000.\(^8\) However, there are many speculative

\(^7\)See Appendix Two for the mathematical calculation of equation (1), using the 1961 to 1963 cross-section regression results.

Figure 6. Scattergram of (RNI) with (Yd) - 1961 to 263 Study
Figure 6 continued. Numerical List of Countries Corresponding to Scattergram

1 Uganda  
2 Tunisia  
3 Bolivia  
4 Ghana   
5 Haiti   
6 India   
7 Togo    
8 Dahomey 
9 Republic of Korea  
10 Jordan  
11 Columbia 
12 Guyana  
13 Fiji    
14 Zambia  
15 Nicaragua  
16 Costa Rica  
17 Mexico  
18 Jamaica 
19 Panama  
20 Singapore  
21 Japan   
22 Spain   
23 Ireland 
24 Italy   
25 Netherlands  
26 Norway  
27 Australia  
28 France  
29 Switzerland  
30 Sweden
elements affecting this estimate which must be stressed.

Type A. Underdeveloped. The first 14 countries listed in Figure 6 may be classified as Type A during the period of 1961 to 1963. The data for these countries is found in Table 7. Again, the predominant factors for Type A are the high birth rate and the high death rate for the various countries.

Type B. Semi-Industrialized. As shown in Table 8, ten countries may be classified as Type B, in which the birth rate still remains high, although it is beginning to come under control as the process of economic development takes place.

Type C. Industrialized. The last 6 countries listed in Figure 6 may be classified as Type C. The data for these countries is found in Table 9, where the predominant demographic factors are, again, low birth rates and low death rates.

Similarly, on the basis of the 1961 to 1963 cross-sectional study, the data seems to conform to the RNI-Yd per capita model for population change and economic development. As the process of economic development takes place, the model states that the natural rate of population change tends to increase, then become stable and then decrease according to the theoretical format developed in Chapter IV.

Today the developing or semi-industrialized world is in a somewhat similar stage of demographic transition, as European peoples were a century earlier. In Europe, however,
<table>
<thead>
<tr>
<th>#</th>
<th>Country</th>
<th>Birth Rate</th>
<th>Death Rate</th>
<th>Rate of Natural Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Uganda</td>
<td>42.0</td>
<td>20.0</td>
<td>22.0</td>
</tr>
<tr>
<td>2</td>
<td>Tunisia</td>
<td>47.0</td>
<td>26.0</td>
<td>21.0</td>
</tr>
<tr>
<td>3</td>
<td>Bolivia</td>
<td>43.0</td>
<td>20.0</td>
<td>23.0</td>
</tr>
<tr>
<td>4</td>
<td>Ghana</td>
<td>47.0</td>
<td>24.0</td>
<td>23.0</td>
</tr>
<tr>
<td>5</td>
<td>Haiti</td>
<td>45.0</td>
<td>20.0</td>
<td>25.0</td>
</tr>
<tr>
<td>6</td>
<td>India</td>
<td>41.7</td>
<td>16.2</td>
<td>25.5</td>
</tr>
<tr>
<td>7</td>
<td>Togo</td>
<td>55.0</td>
<td>29.0</td>
<td>26.0</td>
</tr>
<tr>
<td>8</td>
<td>Dahomey</td>
<td>54.0</td>
<td>26.0</td>
<td>28.0</td>
</tr>
<tr>
<td>9</td>
<td>Republic of Korea</td>
<td>44.7</td>
<td>16.0</td>
<td>28.7</td>
</tr>
<tr>
<td>10</td>
<td>Jordan</td>
<td>47.0</td>
<td>16.0</td>
<td>31.0</td>
</tr>
<tr>
<td>11</td>
<td>Columbia</td>
<td>44.0</td>
<td>14.0</td>
<td>30.0</td>
</tr>
<tr>
<td>12</td>
<td>Guyana</td>
<td>41.0</td>
<td>10.0</td>
<td>31.0</td>
</tr>
<tr>
<td>13</td>
<td>Fiji</td>
<td>37.8</td>
<td>6.1</td>
<td>31.7</td>
</tr>
<tr>
<td>14</td>
<td>Zambia</td>
<td>51.4</td>
<td>19.4</td>
<td>32.0</td>
</tr>
</tbody>
</table>

a) Rates per 1000

Table 8

Type B - Semi-Industrialized Countries; 1961 to 1963 (Yd per capita > $310 but < $1050 for each of these countries)

<table>
<thead>
<tr>
<th>#</th>
<th>Country</th>
<th>Demographic Variables a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Birth Rate</td>
</tr>
<tr>
<td>15</td>
<td>Nicaragua</td>
<td>50.0</td>
</tr>
<tr>
<td>16</td>
<td>Costa Rica</td>
<td>46.0</td>
</tr>
<tr>
<td>17</td>
<td>Mexico</td>
<td>45.0</td>
</tr>
<tr>
<td>18</td>
<td>Jamaica</td>
<td>40.0</td>
</tr>
<tr>
<td>19</td>
<td>Panama</td>
<td>42.0</td>
</tr>
<tr>
<td>20</td>
<td>Singapore</td>
<td>32.1</td>
</tr>
<tr>
<td>21</td>
<td>Japan</td>
<td>22.7</td>
</tr>
<tr>
<td>22</td>
<td>Spain</td>
<td>22.2</td>
</tr>
<tr>
<td>23</td>
<td>Ireland</td>
<td>22.5</td>
</tr>
<tr>
<td>24</td>
<td>Italy</td>
<td>20.0</td>
</tr>
</tbody>
</table>

a) Rates per 1000

Table 9

Type C - Industrialized Countries; 1961 to 1963 (Yd per capita $1050 for each of these countries)

<table>
<thead>
<tr>
<th>#</th>
<th>Country</th>
<th>Demographic Variables&lt;sup&gt;a)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Birth Rate</td>
</tr>
<tr>
<td>25</td>
<td>Netherlands</td>
<td>20.7</td>
</tr>
<tr>
<td>26</td>
<td>Norway</td>
<td>17.5</td>
</tr>
<tr>
<td>27</td>
<td>Australia</td>
<td>19.3</td>
</tr>
<tr>
<td>28</td>
<td>France</td>
<td>18.1</td>
</tr>
<tr>
<td>29</td>
<td>Switzerland</td>
<td>18.0</td>
</tr>
<tr>
<td>30</td>
<td>Sweden</td>
<td>16.0</td>
</tr>
</tbody>
</table>

<sup>a</sup> Rates per 1000

the modernization process evolved slowly over a period of centuries. But most of the present developing countries lack this long and gradual period of preparation for, and acquisition of, modernization. Often the most backwardly traditional societies are the ones most eager for immediate and direct contact with the industrial culture. Moreover, the modernizing western peoples of a century back were fairly homogeneous, being essentially European in origin and institutions. In contrast, the evolving semi-industrial world today represents the greatest heterogeneity of races, languages, religions and general cultural complexes. As a consequence, much of the traditional way of life still prevails among the semi-industrialized peoples, particularly among the rural element.

It should be stressed that modernization is usually accompanied first by changes in the techniques of production. A backward country will often add a significant veneer of imposed foreign technology without having widespread cultural change in the general population. Yet, sooner or later the foreign technology will break the traditional societal structure and bring about comprehensive cultural change. The speed of the modernization process depends on a number of variables, most decisive of which, is whether increased production is used to improve the living conditions of the whole population, or instead, is converted to expensive and unneeded luxuries for the government.

In the case of an underdeveloped society, this western
imposed internal disharmony is in no way better exemplified than by the fact that, while an underdeveloped society may well remain backward in most other respects, it can rapidly lower its death rate to a point which may even approach that of the advanced industrial countries. A plummeting death rate in conjunction with a persistently high birth rate can only result in a soaring population growth, which in turn adds its effects as a brake on economic growth.  

However, the results of this study suggest that there is a systematic dependence of the natural rate of population change (RNI) upon the process of economic development (Yd). For economic development, the implications of this study on population change are therefore rather encouraging. Furthermore, if developmental programs were accompanied by an effective educational effort in Stage B, the rate of population expansion might be limited. All in all, it would seem that the influence of economic development on the demographic features of a society is more widespread than conventionally thought.

CHAPTER VI

FACTORS IN THE DECLINE OF

THE BIRTH RATE
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FACTORS IN THE DECLINE OF

THE BIRTH RATE

The decline of the birth rate in Western Europe and in North America during the last half-century stands out as the most significant demographic change of our time. The reasons for this decline, therefore, merit the closest study, for unless we comprehend them we are not likely to appreciate the significance of this movement. In general, it may be stated that the present decline in the birth rate represents a more or less conscious effort to adapt the rate of births to the changed conditions of modern life, on the part of a vast section of mankind.¹

It is often said that the decline in the birth rate is due primarily to the use of contraceptive measures by an increasing proportion of the European and North American population. It should be obvious that this is not an explanation of the why of this great movement; it is merely a statement of the means used to accomplish an end. What we really need to know is why people should want to make

use of contraception. It is more important to know why people want a smaller number of children, if we are to arrive at a truly rational control of the growth of population.\(^2\)

There is no reason to believe that there has been any fundamental hereditary change in man. It seems that the explanation of the fewer births per woman must lie in the environmental conditions which have developed in Western Europe and North America in recent decades. I shall discuss here only a few of those social and psychological factors which appear to be of prime importance in helping to determine the size of the family desired in modern industrial societies.

In the first place, I would call attention to the great decline in the death rate (Chapter VII) which has taken place in the industrialized countries since approximately 1850. This decline in the death rate has unquestionably been an important factor leading many people in the more industrialized countries, to undertake the voluntary control of the size of their families.

Abortion has always been and still is a significant factor in determining the birth rate.\(^3\) It is discussed here


\(^3\) In medical jargon, abortion includes spontaneous miscarriage as well as induced abortion.
as a social factor of importance because, the extent to which it is used in any society depends upon the cultural values of that society.

It is not possible to estimate the total number of abortions in any western population with accuracy, but if 15 percent of all pregnancies end in abortion in the United States, for example, this means approximately 18 abortions per 100 live births. Therefore, with about 4,285,000 live births in 1970, there would have been over 766,000 abortions. It is not known how many of the spontaneous abortions, which constitute much of the largest class, are preventable or how many of the illegal and therapeutic abortions prevented a normal live birth. But there can be no doubt that the number of live births would be significantly larger if all preventable spontaneous abortions were eliminated and if there were no illegal abortions. At a guess, there might be an increase of between 300,000 and 500,000 more live births in the United States annually. I would not minimize the importance of abortion in reducing the birth rate or its injurious effects on the health of women, but I feel we can be reasonably certain that abortion has only a small effect in reducing the birth rate as compared with the practice of contraception. Moreover, abortion is probably becoming less and less important as the effective use of

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contraception increases.

The decline in the birth rate has been preceded and accompanied in all countries by a great shift of the population from rural areas to the city. Without necessarily emphasizing urbanization, most writers concerned with the causes of the decline in family size believe that modern large cities have provided a favourable environment for the development of the attitudes motivating family limitation. Many writers have regarded the urban environment as an essential condition for this development.

Many factors are believed to limit urban family size relative to that of rural areas.\(^5\) First, it has been pointed out that family life in the city is less cohesive, because family members participate in other institutions and have a broader range of contacts outside the family. Second, children are not regarded as an economic asset in the city as they are in the country. Only a small proportion of children, especially young children, contribute to the family income in the city, and those who contribute do so on a small scale. Third, status aspirations, the achievement of which may be handicapped where support of a large family is mandatory, are probably more prominent in the cities, as are the opportunities to gratify such ambitions.

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The desire to improve one's social position has been stressed as an important motive for family limitation. The argument is particularly associated with the name of Francais Dumont who in the last half of the nineteenth century devoted an extensive series of studies to this phenomenon, which he termed social capillarity. He argued that during the period when family size declined, the mobility between social classes increased greatly, and new attitudes toward social mobility developed. The effect of social mobility on desired family size appears to be attributed in general to the fact that rearing children costs money, time and effort which could otherwise be used to move up the social ladder. Social mobility is more feasible with one or two children rather than with a larger family.

Changes in both the status and the role of women have been advanced as a reason for the decline in family size. Factors frequently mentioned as contributing to the changing attitude among women are the increased education, equality for women in many areas of public life, the emphasis upon the woman's role as a companion with equality in marriage, and the opportunity for personal development and independence.

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Attention has been devoted not only to employment itself but to the type of employment in which women engage, as a factor tending to reduce family size. Such discussions have frequently been related to the growth of urbanization and industrialization. In an agrarian economy, women participated in the economic activities around home which were easily combined with that of bearing and rearing children. However, with industrialization, economic activities which took the women outside the home made homemaking, child-bearing and child-rearing activities more difficult. Today it is widely believed that in industrialized societies, women avoid child bearing or restrict the number of children in order to maintain employment outside the home.

That women work to maintain or achieve a higher standard of living may account for the smaller families of married women employed. Both the gainful employment of married women and their abstention from child bearing may result in a standard of living otherwise unobtainable. Such views I feel tend to reflect changes in the concept of the function of the family from that primarily of child-bearing and child-rearing. The changing pattern of family organization has been stressed as being responsible for the decline in the birth rate and in family size.

It is also often argued that a decline of religious interest has been conducive to the limitation of family size. Certain attempts have been made to measure the association between attitudes towards religion and family
size. In general, the findings do not indicate that religious interest is of great importance in explaining variations in reproductive behaviour.

Other causes suggested for explaining the decline in the birth rate are housing shortages, poverty, unemployment and fear of war. Objections to such causes have been advanced on the grounds that there has been no intensification of such factors in most countries, during the 1960's, where the birth rate has declined.

The most general conclusion one can draw from the many studies of the birth rate that have been made during the past seven decades is as follows: Once the traditional cultural patterns of reproductive behaviour in preindustrial societies begin to give way under the stress of adjusting family life to the social and economic changes involved in developing an industrial and commercial society, a great multiplicity of new social and psychological factors come into play in determining the size of families.\footnote{Thompson, W. S. and Lewis, D. T., Population Problems. (New York: McGraw-Hill Book Company Inc., 1965), page 332.}

As the people in any society come to believe, it is desirable to keep families rather small if they are to assure a decent level of living for their families and good opportunities for their children. They will adopt the measures to achieve this end which are most compatible, perhaps we should say the least incompatible, with their cultural values and with the existing practices that have
been used to achieve these values. There are probably many ways to achieve the aim of adjusting the size of a population to its economic bases of support and at the same time to assure as far as is possible the continuous cultural and personal development that appear desirable in modern societies. It appears, however, that keeping population within the bounds determined by the ability of the society to ensure a decent living to all its people is now, or gradually become, one of the greatest values in all
CHAPTER VII

THE DEATH RATE
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THE DEATH RATE

Apart from the fluctuations which may be readily explained - for example, those caused by epidemics, wars and starvation - it is clear that the death rate has been declining in much the same manner as the birth rate declined during the last few decades. In some countries, indeed, it has been declining for more than a century, and on the whole, prior to World War II it had been declining somewhat faster than the birth rate in many western countries.¹ Indeed, there has been a very large and general decline in the death rate during the last half century in all parts of the world where sanitary practices have been improved and where even a small amount of medical service has become available. The decline of the death rate in the industrialized west has prevailed for so long that we have almost come to the point of regarding a falling death rate as the normal condition of modern society.²

What has happened in the more advanced countries is


that modern medicine and sanitation are making it possible for a larger proportion of the people to live longer. Of this there can be no doubt, but we should be careful not to assume that medical science has done more than it really has.

The lowering of infant mortality since about the turn of the century has been one of the greatest achievements of modern times and is one of the brightest spots in the development of modern science. The causes for this improvement are fourfold: (1) the improvement in the methods and sanitation of infant feeding; (2) the decline in the number of births per family, which allows mothers to give their children better care both before and after birth; (3) the more expert medical care of children; and (4) the generally more comfortable circumstances in which a large part of the people in the more advanced nations now live.

With regard to the first of these four factors little need be said. There is clear evidence that cleanliness and health are closely associated, especially in the lives of young children.

It is also easy to understand how the mother with a small family can generally give better care to her children than can the mother with a large family, so that the decline in the birth rate may be a cause of the decline in


4 Ibid., page 181.
child mortality.

The third important factor in reducing infant mortality is the improvement in the medical care available to children at the present time, as compared with that of a few generations ago. We need mention only that smallpox has been virtually wiped out by vaccination, that diphtheria has yielded to serum treatment, that scarlet fever and whooping cough have yielded to somewhat similar treatment, and that most of the other diseases of infancy and early childhood do not take the toll that they formerly took. Certainly, medicine has done a great deal for children in recent years.

The fourth factor mentioned above is probably of more importance than any of the others. The relatively easy economic conditions under which many people are living today are favourable to a low general death rate but especially to a low death rate for infants and young children. Many studies of infant mortality have shown this beyond question, but even rather casual observation of the differences in living conditions between peoples having widely different standards of living is sufficient to convince anyone that harsh economic conditions bear very heavily on children and raise their death rate.

Numerous other aspects of the death rate are of interest but only the more important of them will be considered here. The sex constitution of a population is an important factor in determining its death rate. Women have lower death

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rates than men. A comparison of death rates of different populations without a knowledge of their sex constitution may, and often does, result in misconception of their actual mortality conditions.

In addition to knowing the sex composition of a population, we must also know its age composition. Death rates which take account of these two factors - age and sex - are called corrected or adjusted rates and are more useful for comparing different populations or the same population at different times, than are the crude rates.°

Beginning in the mid-nineteenth century, large scale measures were taken to improve living and working conditions in cities. Similarly, measures directed towards the eradication of slums and the improvement of housing conditions were first adopted in the second half of the

°The adjusted or true death rates differ from the crude death rates only insofar as the crude rates are influenced by temporary changes or irregularities in the age and sex composition of any population. True rates are, therefore, more useful than crude rates in studying mortality trends of various countries. Unfortunately, true rates in this technical sense may not be true rates in the ordinary sense of this word, because of imperfections in the source data on which they are based. A further adjustment is often needed if proper allowance is to be made for inaccuracies in official death reports, and this further adjustment may involve many uncertainties in the resulting statistics.

The method of obtaining true rates of natural increase per year is expensive; moreover, proper data of the requisite kinds are lacking for many groups. Fortunately, however, there are several alternative methods of obtaining approximate true rates of natural increase per year. For this study the vital statistics - birth rate, death rate, and natural rate of increase - were obtained from the Demographic Yearbook, published by the Statistics Office of United Nations, Department of Economic and Social Affairs. These vital statistics have been adjusted or corrected, so that they exhibit the most credible magnitude overall.
nineteenth century, in most of the industrial advanced societies.\footnote{These included the following countries: United Kingdom, France, Germany, Belgium, United States and Holland.}

The nineteenth century also witnessed a great expansion of public utilities for the improvement of environmental sanitation.

The purification of the water supply began early in the nineteenth century, when filters were introduced on a small scale in Paris. However, the chlorination of water supplies began to be practical after the turn of the century. Thus, by the beginning of the twentieth century, most of the cities of the western world had introduced systems of sanitary water supply and refuse removal, leading to generally improved public health conditions.\footnote{Thomlinson, R., Population Dynamics. (New York: Random House, 1965), page 92.} As a result of improvements in sanitation, mortality declined to a small fraction of its former levels.

It is by no means easy to assess the roles played by the various factors which have been at work in the reduction of mortality. It is clear, however, that the lowering of the mortality rate of the western industrialized nations during the eighteenth and the first part of the nineteenth centuries was due to a rising standard of living, as indicated by better working conditions, and broad social reforms rather than to the development of scientific methods.
for the control of individual diseases. In the twentieth century, the general improvements in social and economic conditions have continued in western countries, supplemented by more and more effective medical knowledge and public health methods for combating particular diseases.  

With regard to the causes of the recent decreases in mortality in underdeveloped countries, three important points should be mentioned. First, unlike western industrialized countries where a decline in mortality has been dependent upon economic and scientific development and the diffusion of knowledge, the underdeveloped countries have had the benefit of techniques and knowledge which have evolved gradually in more advanced countries. Second, it has been possible to achieve a reduction in mortality rates in underdeveloped countries at relatively low costs. Frequently, personnel and facilities, and sometimes financial aid, have been provided from abroad with relatively little cost to the recipient country. Because mortality rates have been extremely high, large reductions have been possible with the application of simple and relatively inexpensive techniques. Third, the decline in mortality cannot always be attributed to improvement of the economic condition of


the population. It appears that public health and medical
techniques have provided for the maintenance and extension
of human life without an accompanying improvement in
economic conditions.

Since the principal causes of death are not the same
in countries of high and of low mortality, any attempt to
evaluate the possibility of reducing mortality in the
future must take these differences into account.

In the highly-developed countries, great improvements
in medical and health services and in the social and economic
conditions have already resulted in low mortality rates,
particularly within the upper social and economic classes.
As a result of these advances, it is unlikely that future
mortality reductions will significantly affect the younger
age groups in the upper classes. Future declines may come
about in two ways. First, and perhaps most important, the
discovery and utilization of new methods of reducing deaths
from terminal diseases may lengthen the life expectancy
at advanced ages. Second, the relatively high mortality
rates of the lower social and economic classes of all
ages may be reduced at least to the present level of the
upper-class groups.

In the least-developed countries high death rates are
mainly caused by infectious and epidemic diseases which
occur most frequently within the young population. The
experiences of developing nations have shown that infant
and child mortality, particularly in some underdeveloped
areas account for as much as 40 to 50 percent of the total deaths, and respond readily to measures of epidemic control. Although considerable progress has been achieved through the aid of medical techniques, much remains to be done through the improvement of existing economic and social conditions.

To what extent the gains already achieved will be permanent, if they are not accompanied by more fundamental changes in the economic and social setting, is a question which has not been clearly answered by the studies made to date. Any improvements in health conditions which make it possible for the people to live longer and healthier lives, increase the potential productivity of the labour force, and to that extent at least provide a better material basis for maintaining health improvements in the long run. Nonetheless, it is apparent that it is no easy matter for the underdeveloped countries to provide the health facilities and personnel, the food supplies, the public sanitation, and the other amenities which would help to lower the death rates to the level of the more developed countries. Insufficient financial resources for the support of large-scale public health programmes, high illiteracy rates and poor facilities for the training of personnel, low agricultural yields per unit of labour, and unsanitary housing are some of the obstacles to mortality.

reduction which are prevalent in these areas. To a certain extent some of the basic needs can be supplied in the form of loans and personnel from foreign governments or international organizations, but assistance from the outside can hardly substitute for the most effective utilization of a nation's own resources and manpower.

In most underdeveloped countries, it is likely that with major improvements in the social and economic well-being of the people the future mortality trends may follow the pattern established by the more highly developed countries of the world. It is likely that substantial reductions in the mortality rates are to be expected during the next few years in most, if not all, of the underdeveloped countries. It is desirable that this should be so, for the reduction of mortality is everywhere taken as a primary goal of social policy.

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CHAPTER VIII

NATURAL INCREASE AND ITS
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The influence of economic and social factors affecting future population trends is manifested, indirectly, through changes in the determinants of population levels - births and deaths - which have been discussed in Chapter VI and Chapter VII. Population projections, based upon different assumptions about future trends in these components, represent the result of the interplay among the determinants and illustrate the effects of changes in each.

In this chapter the principles and methods of population prediction are discussed. In the following three sections the forecasts of future population trends in areas of low birth rates and low death rates, in areas of incipient decline in birth rates, and in areas of high birth rates and high death rates are discussed. In the final section, estimates of the future population of the world are presented.

Prediction in demography, as in other branches of social science, is a hazardous undertaking. It has been amply demonstrated that population trends, although they are more stable than many other attributes of human societies, are subject to considerable change within periods of a few
decades or even a few years. Absolute confidence in prediction of future population trends would be possible if: (1) universal laws of population had been established, and (2) the relevant future social and economic circumstances influencing population change could be known in advance. Neither of these conditions is fulfilled for the analyst who attempts to make such estimates. Nevertheless it is possible to make some calculations regarding possible future population trends, which have relevance as a basis for studying prospective economic and social problems.

Many different methods have been used for such calculations. The simplest consists of a classification of populations by types, with reference to the present levels and trends of their birth and death rates, or to their social and economic characteristics. On the basis of available information about the growth of populations conforming to each type in the past, inferences are drawn from these classifications about prospects for future growth of various population groups. Among the classifications used for this purpose are Landry’s demographic regimes, and various stages of the demographic transition, identified by Thompson, Davis and Blacker.¹ Predictions based on such classifications are commonly stated in non-numerical terms, though they are sometimes accompanied by rough estimates.

based on past experience, of the magnitude of population increase expected within a given number of years or generations.

In some cases, population forecasts are based on assessments of the prospective capacity of an area to support population at a given time in the future, taking into account expected economic and social developments. Predictions of this type relate to areas with very low living standards, where the quantity of the means of subsistence is considered to be the principal factor controlling the future population.²

Methods such as those described in the two preceding paragraphs are virtually the only practical means of analysing population prospects in those areas where little reliable data are available on the present population and its past trends. However, where adequate data are available, more refined methods of population projection can be employed. These methods are of two types: (1) projection of growth curves and (2) component projections, in which prospective trends of births and deaths are analysed separately.³

Projections of growth curves involve the assumption that the size of the population or its rate of increase


conforms to a simple mathematical function of time. Several
types of growth curves have been used, the most common
being linear and geometric. The constants of the linear
and geometric functions are usually determined empirically
from available data on population growth in the past.

Component projections require more data than projections
of growth curves, and are usually attempted only with
reference to areas that have reliable vital statistics
calculated in enough detail and for a long enough period of
time to permit a comprehensive analysis of birth and death
trends. The result being, that births and deaths are pro-
jected in terms of crude rates in order to project future
rates of change in population. Projections are then simply
indications of future population trends.

It seems to be generally agreed that the conditions
affecting prospective population changes during the next
few decades, in countries where both birth and death rates
are now relatively low, differ from those in areas where
either birth or death rates are now high. The countries of
low birth and death rates include Western Europe, United
States, Canada, Australia and New Zealand. On the average,
these countries have more adequate data than the remainder
of the world, and more work has been done on future
population projections than elsewhere.

As indicated in Chapter VII, further gains in life
expectancy are likely to be smaller and to be won with much
more difficulty than those of the last few decades. The
future trend of the birth rate is much more dubious. There is some disagreement as to whether the long-range trend will stabilize, or continue to decline, or begin to rise. The aging of the population will be an important factor tending to retard the rate of growth in many of these countries during the next few decades. The result will be not only to dampen the birth rate, even on the assumption of undiminished age-specific birth rates, but also to push up the death rate.

On the basis of the findings in Chapter V, the rate of natural increase in most of Western Europe, United States, Canada and Australia will probably be distinctly lower, on the average, during the second half of the twentieth century. These findings are consistent with the set of growth curve projections by the United Nations, which indicate that the average rate of increase in this group of countries, between 1950 and 1980, is unlikely to exceed 1 percent per annum, and that the total population of the group is likely to rise from about 486 million in 1950 to a figure of approximately 600 million in 1980. The dates when population is expected to cease growing have been pushed further into the future,

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though in many cases a reduction is still expected during the last quarter of the twentieth century, if not before.

There are areas where births are still high but where it has recently shown a tendency to decline. These areas include nearly all of South America. In all of them, great reductions of mortality have been achieved during recent decades, which, with the still high birth rates, mean rapid population growth.

In these areas further reductions in mortality are expected. Their prospects for further industrial development and a rising per capita income are favourable and vigorous campaigns in public health and education can be expected to bring substantial savings of life.

Birth rates also may be expected to continue their decline in these areas, if they follow the path of demographic evolution charted by the peoples of Western Europe, Canada, United States, Australia and New Zealand. The future trend of their populations, in that event, will depend on the relative decline in the birth and death rates as economic and social development takes place. If the history of other regions just mentioned is repeated, their births will eventually reach a near balance with their deaths. In any event, the present wide gap between birth rates and death rates in these areas makes an intervening period of rapid population growth appear almost inevitable.\footnote{United Nations, The World Population Situation in 1970 - Number 48. (New York: Department of Economic and Social Affairs, United Nations, 1971), pages 10 to 12.}
In a United Nations study, prospective population trends are analysed for a group of countries which includes Eastern Europe, South America and Latin America. It was considered probable that the rate of natural increase for the group during the period 1950 to 1980 would average 1.5 to 2.0 percent per annum. The aggregate population of the group would rise from 533 million in 1950 to a figure of approximately 800 million by 1980. This group of countries will have an increase in the proportion of the world's population.

As shown in Chapter V, the birth rate is generally high throughout Asia, Africa and some countries of South America. According to the data available on mortality in these regions, the death rates in some of these countries have been reduced during recent decades, so that the population has been growing at an accelerating rate. In other countries within these regions, the reductions in mortality rates up to the present time have been smaller. Thus, so far as it is known, the picture of recent trends of population in these regions is a mixed one - of rapidly increasing numbers in some areas and of a slowly growing or stationary population in other areas.

In view of the lack of data on past population trends and the uncertainties regarding the future economic develop-

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ments in most of the countries of these regions, hypotheses with respect to their future population growth are necessarily speculative.

The discussion in Chapter VII implies that further reductions in mortality are feasible where less progress has been achieved in the control of epidemics and diseases. But the extent to which these gains will be lasting ones, unless accompanied by improvements in the living conditions of the people affected, remains uncertain.

It is possible that economic development and associated social changes, in these countries where the prevailing death rates have begun to fall, will bring about a decline of birth rates similar to that which has occurred in other parts of the world. Among the reasons which have been given to support predictions that this would happen is the hypothesis that the reduction of mortality rates is likely to lead to the reduction of birth rates, as various social and economic factors occur in these countries. Even if it is accepted that the eventual result of economic development and related social changes will be a reduction in births, there is a question as to the length of time that may elapse before this effect becomes evident.

A few estimates of future population in these regions of high birth rates and high death rates have been made. A recent United Nations study states, for the combined regions of Asia and Africa – the population figure for 1950 is 1,387 million, while the estimate for 1980 is between
1,710 million and 2,043 million. The higher figure was derived on the assumption of increasing reductions in the death rate and little change in the birth rate. The lower figure was based on the assumption of the maintenance of a high death rate and no change in the birth rate.

Future population estimates for a number of countries in Asia and Africa, where progress in public health work has been made, indicate that large increases will result from the rapidly declining mortality accompanied by little or no immediate decline in births.

A number of estimates of future population growth in the world as a whole have been made recently on the basis of studies of past trends, all indicating substantial increases during the next few decades. Notestein obtained a total of 3,300 million for the year 2000 A.D. by summing component projections for the major regions of the world. A United Nations study suggests that the world's people will increase by at least 1,200 million and perhaps by as much as 2,000 million during the period 1950 to 1980. On

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this basis, the world population will rise from 2,400 million in 1950 to between 3,632 million and 4,457 million in 1980.

Prospects for future population growth have been considered with reference to three groups of areas - those where births and deaths are now relatively low; those where births, though still relatively high, have begun to decline; and those where births and deaths remain high with little or no evidence of decline.

The first group includes most of the countries in Western Europe, Canada, United States, Australia and New Zealand. In these countries the rates of population increase at present are low, and there seems to be little prospect of rapid growth in the next few decades.

The second group includes the semi-industrialized countries of Latin America, South America and South Africa. These countries are now experiencing rapid population growth as a result of past reductions in mortality, although their birth rates still remain high. It seems probable that further declines in mortality will be achieved so that the death rates in these countries generally will be as low as those of the most highly industrialized and economically advanced nations. Births also are likely to begin to decline as industrialization and urbanization proceed, but the birth rates will probably, for some time in the future, exceed the death rates.

The third group, consisting of countries where both births and deaths are still high and are not declining,
includes most of the countries of Asia and Africa. In general, it encompasses the economically least developed areas of the world. The future trend of world population depends very heavily on developments in these countries which contain the majority of the world's peoples at present. The rates of population growth in this group vary widely at the present time. Growth is very rapid in those areas where mortality has begun to decline, with births remaining high. In other areas, where progress in the fight against disease and death has been less spectacular up to the present, rates of population growth are moderate or low. It is to be expected that in the future, reductions in mortality can be expected to be extended among the countries in this group, resulting in a general acceleration of the rate of population growth, if the birth rates remain high and if the means can be found to supply food to the growing populations through a process of semi-industrialization.

The potential for population expansion in many underdeveloped countries is greater than it was among western industrialized countries at the early stages of their industrialization, largely because of the speed with which mortality is being reduced through the application of knowledge acquired in the advanced nations. It is also possible that the social customs and attitudes of industrialized countries may also spread rather quickly to the less developed countries, and that the small family pattern may be adopted without a very great time lag, particularly if
government policy directed toward encouraging family planning is adopted.

At what pace industrial development will proceed, and at what pace it will have any effect upon the high birth rates of different countries, especially in the second and third group, is not known. The basic research has not been done whereby even the past influences of changed economic conditions upon natural increase rates could be established, so that there is little upon which to base views as to the future. 11

This study, which has been presented here, illustrates a definite relationship between the natural rate of population growth and economic development. The process of economic development, as measured by increases in per capita disposable income, is initially associated with a rapidly rising natural rate of increase, a peaking, and finally a gradual decline in the natural rate of increase. More specifically, the relationship between the natural rate of population increase and the process of economic development is shown to be in the general form of a positively skewed frequency polygon.

In every part of the world, researchers are seeking to discover more precisely the factors that affect demographic change, while administrators and technicians are seeking to initiate or sponsor those medical and industrial changes

that are favourable to a better life for the poor, on continents where poverty has been the norm. It is not known how soon, or even whether, an increased standard of living will result in a more controlled birth rate, but it is known that without such an increase, the natural rate of increase will remain uncontrolled.\textsuperscript{12}

APPENDIX ONE

The mathematical calculation of equation (1), using the 1969 to 1971 cross-section regression results, are as follows:

\[ RNI = ae^{b(lnYd - c)^2} \]  \hspace{1cm} (1)

\[ \ln RNI = \beta_0 + \beta_1 (lnYd) + \beta_2 (lnYd)^2 \]  \hspace{1cm} (3)

where \( \beta_0 = lna + bc^2 \)  \hspace{1cm} (3a)

\( \beta_1 = -2bc \)  \hspace{1cm} (3b)

\( \beta_2 = b \)  \hspace{1cm} (3c)

\[ \ln RNI = -1.25 + 2.30 (lnYd) - 0.483 (lnYd)^2 \]  \hspace{1cm} (4)

\[ . \cdot \cdot \text{using (3c) } b = -0.483 \]

using (3b) \( -2bc = 2.30 \)

\[ -2(-0.483)c = 2.30 \]

\[ .966c = 2.30 \]

\[ c = 2.38 \]

using (3a) \( lna + bc^2 = -1.25 \)

\[ lna + (-0.483)(2.38)^2 = -1.25 \]

\[ lna - 2.735 = -1.25 \]

\[ lna = 1.485 \]

Substituting the above results into equation (1) yields

\[ RNI = 1.48e^{-0.483(lnYd - 2.38)^2} \]  \hspace{1cm} (5)
APPENDIX TWO

The mathematical calculation of equation (1), using the 1961 to 1963 cross-section regression results are as follows:

\[ RNI = a e^{b (\ln Yd - c)^2} \]  \hspace{1cm} (1)

\[ \ln RNI = \beta_0 + \beta_1 (\ln Yd) + \beta_2 (\ln Yd)^2 \] \hspace{1cm} (3)

where \( \beta_0 = \ln a + bc^2 \) \hspace{1cm} (3a)

\( \beta_1 = -2bc \) \hspace{1cm} (3b)

\( \beta_2 = b \) \hspace{1cm} (3c)

\[ \ln RNI = -1.78 + 2.90 (\ln Yd) - 0.646 (\ln Yd)^2 \] \hspace{1cm} (6)

\[ \therefore \text{using (3c) } b = -0.646 \]

\[ \text{using (3b) } -2bc = 2.90 \]

\[ -2(-0.646)c = 2.90 \]

\[ 1.292c = 2.90 \]

\[ c = 2.24 \]

\[ \text{using (3a) } \ln a + bc^2 = -1.78 \]

\[ \ln a + (-0.646)(2.24)^2 = -1.78 \]

\[ \ln a - 3.241 = -1.78 \]

\[ \ln a = -1.561 \]

Substituting the above results into equation (1) yields

\[ RNI = 1.56e^{-0.646(\ln Yd - 2.24)^2} \] \hspace{1cm} (7)
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