THE IMPACT OF POPULATION AGING ON OUR ECONOMIC WELL-BEING

by

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Thesis

submitted in partial fulfillment of the

requirements for the degree of

Bachelor of Arts with

Honours in Economics

Acadia University

(April, 1986)

This thesis by Leon Maurice Teal
is accepted in its present form by the
Department of Economics
as satisfying the thesis requirements for the degree of
Bachelor of Arts with Honours

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ACKNOWLEDGEMENTS

The author wishes to extend thanks to those who helped in the completion of this study. First I would like to thank Dr. Peter Townley. Without his encouragement this project would never have been attempted, and his assistance throughout the past year was invaluable and greatly appreciated.

Lynn Connors and the staff at the Computer Center are thanked for curing many seemingly unsolvable problems, frequently on short notice and always with great speed.

Thanks to Norm Couturier and Ken Stewart (and a list of vocalists too long to mention) for giving me six continuous hours each week during which I did not worry about work that had to be done.

I would also like to extend thanks to this year's residents of 6th floor Crowell Tower. Your mature behaviour, for the most part, made my job as a Residence Assistant much easier, and allowed me to spend more time studying and pursuing other interests.

Finally I thank Mr. Y. Jack for providing additional motivation.

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ABSTRACT

This thesis is a response to a gap in our economic knowledge. The Canadian population is expected to age dramatically over the next several decades and the impact of this phenomenon on our overall level of economic activity has not been previously examined.

We develop an empirical relationship between economic welfare and demographic structure using standard econometric techniques. We then couple this estimated relationship with a variety of population forecasts and calculate possible time paths of per capita output in Canada to the year 2031. We conclude that a higher level of economic welfare could be attained if the current aging trend were to be slowed or arrested.

INTRODUCTION

Decreasing fertility rates and longer life expectancies have caused the proportion of the Canadian population defined as 'elderly' to double in the past sixty-three years.[1] This increase is reflected in the median age of Canadians which has risen from 24.0 to 30.8 years in the same period.[2] This phenomenon is called "population aging." If current fertility trends continue, this aging process is expected to accelerate over the next several decades.

As population growth slows, a country's demographic structure changes: There will be proportionately more older people and fewer younger people. Just as individuals change as they age, so do economies. Certainly we expect 'young' economies to differ from 'old' economies. Given that the aging of the Canadian economy seems inevitable, we would appreciate some forewarning of the changes which are likely to occur.

The purpose of this thesis is to gain as much insight into the effects of this phenomenon as possible using standard econometric analysis. The study is exploratory in nature. We will search for a relationship between population growth and our economic well-being. Immediately we encounter a problem: In a macroeconomy, everything depends on everything else. For instance, we expect consumption patterns to change as a population changes. We may expect the demand for rattles to decrease and the demand for dentures to increase. Moreover, not only are we interested in how the composition of aggregate demand changes, we are interested in whether the level of aggregate demand will change. However, if the level of aggregate demand changes, the level of national income will change thus causing the level of aggregate demand and its composition to change. We have travelled a circuitous route back to the beginning of our example: A change in aggregate demand will cause other variables to change which will cause aggregate demand to change again.

In Chapter I we suggest some other variables which may also change because of population aging. Like aggregate demand, a priori, we will not be able to identify the impact of population aging on them unambiguously. This is not a useless process because it will help us to define the question central to our discussion: Will the economic welfare of the average person increase or decrease as the Canadian population ages?

Thus, in Chapter II, we shall define our measure of economic well-being and the demographic variables we expect to influence it. After modelling the relationship, we will use data from 1926 to 1984 to estimate this relationship in a multiple regression model.

In Chapter III we shall incorporate three population growth scenarios into our model in order to forecast the effects of population aging on our level of economic welfare. We offer our conclusions in Chapter IV.

Chapter I

POPULATION AGING AND THE ECONOMY

As a population ages, the elderly play a progressively larger role in determining the characteristics of our society while the role of the young diminishes. This change in the relative importance of each age group will affect several economic variables. Four variables that come to mind immediately are aggregate consumption, aggregate savings, average labour productivity and government expenditures. Our level of output is both dependent upon and determined by these variables. Therefore, because population aging influences these variables, it will also affect output and, when output changes, these variables will be further affected.

In this chapter we shall investigate the relationship between these variables and population aging. These relationships are fairly complicated as each involves a number of simultaneously changing variables. Our discussion will be simplified by examining each of these four economic variables separately. We will find that population aging does influence these variables, but we will not be able to determine, a priori, if their combined effect on national income will be positive or negative.

People of different ages consume different goods in different quantities. Therefore, as a population ages, we will observe changes in the composition of goods and services demanded; less demand for youth-oriented goods, such as diapers, and more demand for goods that the elderly usually buy. This necessitates a shift in the production decisions of firms and, in turn, forces the transfer of factors of production out of industries manufacturing goods for the young and into those producing goods for the elderly. Firms affected by this reallocation face a period of adjustment during which time they will utilize a suboptimal combination and number of inputs in production processes. That is to say, adjustment costs will be incurred. Thus population aging might be expected to have a negative effect on output. However, the changing demand for goods might be compensated for through trade. In this way, the need to reallocate resources from the production of one good into the production of another good might be delayed or possibly eliminated. International trade would thus help to cushion the impact of shifts in the demand for goods.

As opposed to commodities, shifts in the demand for services generally have to be satisfied domestically. As the population ages, we will experience a movement away from youth-oriented services toward those services catering to the elderly. Therefore, domestic factors of production of services will be reallocated. This shift will result in a movement of labour into expanding service industries. Labourers who find that the demand for their services is decreasing must find new employment and, in some cases, this may require retraining. Once again, adjustment costs will be incurred as factors of production (in this case labour) are reallocated. Again these costs will be at the expense of our level of output.

The negative effect of adjustment costs on our level of output could, however, be offset by shifts in aggregate demand. As the relative size of the elderly population increases, demand for food, clothing, and services tends to increase while the reverse is true for housing and durables.[3] Thus aggregate demand overall may decrease or increase. An increase in aggregate demand stimulates factor markets as firms try to produce an increasing number and quantity of goods and services. As the size of factor markets increases, higher levels of output and consumption are attained. However, the opposite is true for a contraction of aggregate demand.

We cannot be sure of the direction of this shift. Therefore we cannot determine if the overall effect of a change in aggregate demand associated with population aging influences output positively or negatively. Thus we cannot predict the effect of population aging on consumption without examining a general equilibrium model. For our purposes it is sufficient to note that as the population ages, the composition of consumption changes and in response to this, firms will adjust output. While the net effect may be positive or negative, demographic changes will clearly have some influence on our level of output.

Population aging also influences our level of aggregate savings. This occurs because accumulated savings differ for people of different ages. According to the life-cycle hypothesis, in a household's early years, as it is being formed, it is quite probable that income will not exceed and, in many cases, will fall short of spending. In the middle years, planned consumption will normally be less than income as savings are accumulated. In the later years, income probably falls significantly particularly following retirement. Consumption will then exceed income, and savings will be decumulated.[4] Thus, as the proportion of elderly people increases, we can expect the level of aggregate savings to be affected.

Unfortunately, it is difficult to predict whether the effect of population aging on aggregate savings will be positive or negative. Recent analyses using models of varying degrees of complexity have produced different results. A simple model based on the life-cycle hypothesis indicates that aggregate savings increases as a population ages. However, a more complicated model, which considers the decumulation of savings in the middle years as mortgages are paid and the education of offspring is financed, predicts a negative relationship between aging and savings.[5] Thus we cannot ascertain the impact of population aging on savings unambiguously.

If we can find a relationship between demographic factors and output (real income), we will be able to predict how population aging affects savings . If population aging causes an increase in income, we would expect savings to rise since the marginal propensity to save is positive with respect to income. However, while this implies that population aging will influence savings, we cannot be certain if the net effect is positive or negative unless we know its net effect on output. Once again the relationship between output and our population's age-profile is not known and we can make no unambiguous predictions about the effect of population aging on this variable.

Population aging and the resultant aging of the labour force will affect labour productivity. A younger person might be expected to work with a great deal of speed, but he might lack experience and thus much of his effort could be wasted. The opposite might be expected for an older person. Therefore, different levels of productivity will be associated with each age group. Because of these differences the average productivity of the labour force changes as a population ages. To assess the impact of this change, we must compare the relative contribution to output--the value of the marginal product--of workers of different ages. Theoretically, this could be accomplished by observing that the value of the marginal product of a unit of labour is equal to its wage in competitive markets. Relative productivity of labourers of different ages could thus be expressed as the ratio of their wages.

Unfortunately productivity is not the sole determinant of wages in Canada: Seniority and inter-firm relationships are also considered when wages are determined. As seniority is related to age, we would expect elderly labourers to be paid more not necessarily because they are more productive, but merely because of their age. This biasing of wages in favor of the elderly makes it difficult to determine relative productivity based on wages. Thus we cannot determine if an older labour force is more productive than a younger labour force. We can only say that population aging influences productivity, and this, in turn, affects output.

The composition of government expenditures must also be altered as demographic changes occur. With proportionately more elderly members, funds must be shifted into programs such as medical insurance and public pension plans and out of youth-oriented programs such as education. The total costs of programs for the young as opposed to the costs of those for the elderly must be considered when assessing the consequences of this shift. It is estimated that the expenditure dependency ratio is approximately 2.5 in Canada.[6] This means it costs the government (and thus society) two and a half times as much to provide for an elderly person annually as it does to provide for a younger person in the same period.

Therefore, as the population ages, the cost of supporting its non-productive members--the old and the young--increases even if the percentage of non-productive members remains the same. Thus the same level of services can be maintained only if productivity gains are sufficient to meet the increased demand for goods. Without such gains, we would have to make a choice. We could increase taxes so that the same level of social programs could be maintained. However, higher taxes leave the taxpayer with less disposable income. This results in lower consumption and thus lower output. Alternatively, we could maintain taxes at their current level while reducing social programs. Either way, at least part of the population (taxpayers or the young and old or some combination of the two) becomes worse off because of the increasing cost of providing public services to greater numbers of elderly people.

A problem arises in determining how to divide this burden among the population. Those who have retired, having spent their working lives supporting programs for the elderly, will no doubt be strongly opposed to cutting them back as they have contributed to them in the past and now expect to benefit. However, if programs are not cut back, a greater tax burden falls on the entire population. This leads to a decline in the standard of living for all members of society. This problem becomes more acute as the proportion of the population that is elderly grows. Thus, as the population ages, we can expect to observe an overall increase in the demand for government programs resulting in a greater burden on all of society. This leads to a lower standard of living and would thus be a negative effect of population aging.

We have not yet determined if the effect of population aging on output is positive or negative. While we can predict the negative impact of increasing government expenditures on programs for the elderly, this could potentially be offset by changing savings, consumption and productivity as discussed above. Because all of these changes occur simultaneously, we cannot conclusively argue that the impact of population aging on output will be positive or negative. However, we have shown that there is some relationship between output and a population's age-profile. The specification of this relationship will be the object of this study. Furthermore, if this relationship can be found, we will be able to estimate how other economic variables will be influenced by population aging.

In the next chapter we examine the relationship between population aging and output empirically. Two models are developed and, from these, a series of hypotheses are tested. The equation which best describes the relationship between demographics and output will later be used to predict how future population aging can be expected to influence our level of economic welfare.

Chapter II

THE RELATIONSHIP BETWEEN OUTPUT AND DEMOGRAPHY

In this chapter we empirically examine the effects of demographic makeup on our level of output. The structural relationships discussed in Chapter I are redefined as reduced form equations for estimation. This enables us to negate any simultaneous equation bias which would arise if we had tried to estimate relationships in which some variables are both dependent and explanatory. An example of this would be aggregate consumption which is both dependent on and a determinant of output. Using reduced form equations allows us to calculate output strictly in terms of demographic variables. Thus our models are as follows:

Y = f(MP, VP, CTP),

CY = g(MP, VP, CTP), where

Real Gross National Product per Capita is denoted by Y,

Economic Growth is denoted by CY,

the median age of the population is denoted by MP,

the variance across the population is denoted by VP, and

the rate of population growth is denoted by CTP.

The endogenous (dependent) variables were calculated from Statistics Canada population estimates and GNE statistics. Recent GNE statistics are from "The

Bank of Canada Review" (see Appendix A).

Real Gross National Product per capita is denoted by Y. It was calculated by dividing figures for Real Gross National Expenditure by those for total population. Thus defined, the variable Y gives us the average value of output of each member of society in a given year measured in thousands of 1971 dollars. It is assumed that the more we produce, the more we will be able to consume and that the more we consume, the better off we are. We recognize that growth in output will not necessarily benefit every member of society equally. However, we are interested in effects on the population as a whole.

GNP per capita, our measure of the average level of output for each member of society, thus fits the requirements of our study and, as defined, is indicative of our average level of economic well-being. This statistic may show a tendency to be autocorrelated. This problem arises because, until the year 1971, censi were performed only once every ten years. Population estimates for the years between censi are based on interpolation which has the effect of averaging the true variations in population growth over time. This reduction in variance can result in autocorrelation.[7] However, imperfect as they may be, Statistics Canada population estimates are the best available to us.

The annual change in Real GNP per capita is denoted by CY. It was calculated as follows:

$$CY_i = (Y_i - Y_{i-1})100/Y_{i-1}, \quad i = 1926, 1927, \ldots, 1984.$$

Thus defined, CY is the rate of per capita economic growth. Since it is dependent on Real GNP per capita, our discussion of the variable Y is applicable to CY.

The exogenous (explanatory) variables in our models were all calculated from Statistics Canada population estimates (see Appendix B), and, like Y, are susceptible to autocorrelation.

MP denotes the median age of the population. This is the age which divides the population into two equally sized halves by age and is used to indicate the relative age of the population. An increasing median age will thus be indicative of an aging population. Given our discussion from Chapter I, we cannot predict, a priori, how a change in the median age of the population will affect output or the rate of economic growth.

VP denotes variance of the age distribution of the population. This statistic will describe the dispersion from the median of the ages of individuals within the population. We have created a variable which indicates if the ages of individuals within the population tend to cluster around the median or if they tend to be more widely dispersed. This variable was constructed by taking population data grouped into five-year intervals.[8] The midpoint of each grouping (x_j) was squared, and then multiplied by the number of people in that age group (f_j). These were then summed and the result divided by the total population (P). Finally the square of the median was subtracted. Our variance term is thus defined as:

$$VP_i = ((f_j x_j^2)_i / P_i) - (MP_i)^2, \text{ where}$$

$$i = 1926, 1927, \ldots 1984, \; j = 2.5, 7.5, \ldots, 92.5.$$

A wider dispersion implies a more heterogeneous population and thus a more heterogeneous work force. This means that a greater variety of labor skills will be available which might enable us to reach higher levels of output through increased specialization. However, a wider dispersion will also result in an increase in the size of our dependent population and thus will have a negative effect on per capita output. Thus we cannot predict, a priori, how changes in variance will affect either output or economic growth.

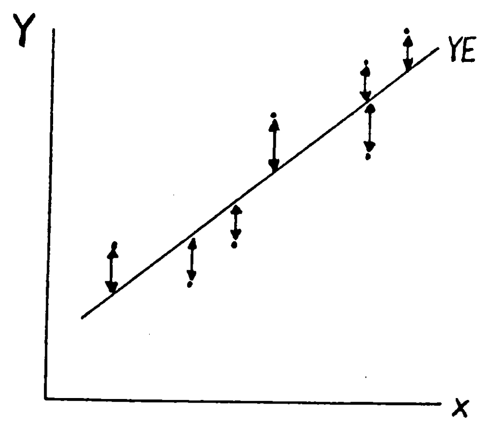
CTP denotes the annual rate of population growth. It was calculated as follows:

$$CTP_i = (P_i - P_{i-1})100/P_{i-1}, \quad i = 1926, 1927, \ldots, 1984.$$

As the population grows, adjustments must be made in the allocation of resources. The costs of these adjustments might be expected to have a negative impact on our economy. However, because these changes are somewhat predictable from one year to the next, we expect the influence of changes in the rate of population growth to be fairly small.

Having defined our variables, several different equations using data from a variety of different time periods were examined using Ordinary Least Squares (OLS) estimation techniques. This technique compares the observed values of the dependent and independent variables and estimates a linear relationship by minimizing the sum of the squared differences between the observed and estimated values of the dependent variable. For example, in Figure I, "the dots represent actual observations on the dependent variable Y and the independent variable X. Each observation is a certain vertical distance away from the estimated line, as pictured by the double-ended arrows. The lengths of these double-ended arrows measure the errors."[9] The estimator

Figure I



which minimizes the sum of the squared residuals is referred to as the OLS estimator.

Econometric analysis was applied to the estimated equations to determine which time period was most suitable for our study. In the analysis that follows, a number of frequently used statistical terms appear. These include R^2, F-statistic and t-statistic. The following is a general description of each of these terms.

R^2 refers to the "proportion of the variation in the dependent variable 'explained' by variation in the independent variables."[10] Its is formally defined as,

$R^2 = (YE_i - YM)^2 / SSE$, where

YE_i = the estimated value of Y at each observation, i.

YM = the mean value of the observed Y.[11]

Thus the R^2 statistic takes on values between 0 and 1. A low R^2 indicates that the variation of the dependent variable is not explained well by our independent variables while a model with high explanatrory power will have a high R^2. Thus we will place more confidence in estimated equations with high R^2 statistics than in those having low R^2's.

F-statistics and t-statistics are used for joint and single hypothesis testing respectively. A critical region is developed outside of which a hypothesis will be rejected. For a t-statistic, the bounds of this region are determined by first calculating the degrees of freedom of our model by subtracting the number of independent variables from the number of observations. Having calculated the degrees of freedom, we can refer to a table of critical values of the t-distribution to find the critical region. For an F-statistic, we must refer to both the number of explanatory variables and the degrees of freedom. These statistics are used to determine the critical region through reference to a table of the F-distribution.[12]

The availability of GNP statistics dictated that our initial data set span the years 1926 to 1984. However, it was found that the use of Depression-era data

(1930-38) resulted in low R^2 and t-statistics. That is, neither the estimated equations nor the explanatory variables conveyed much information. This led us to believe that the unusual economic conditions of the Depression detracted from our model's explanatory power. These observations were thus omitted, leaving us with a regression spanning 1926 to 1929 and 1939 to 1984. As the initial four observations would add little to our regression, they were also dropped. Also, it was noted that the addition of Newfoundland to Canada in 1949 resulted in an unusually high rate of population growth (4.87%) for that year. The values for the year 1949 were thus eliminated from the model, which now spanned the years 1939 to 1948 and 1950 to 1984. Logarithmic transformations were applied to both the exogenous and endogenous variables and several regressions with different combinations of transformed and raw variables were tested. The highest levels of explanatory power were found in the following two equations:

$$Y = a_0 + a_1 \log MP + a_2 \log VP + a_3 \log CTP$$

$$CY = b_0 + b_1 MP + b_2 VP + b_3 CTP$$

The initial regression on CY yielded a plot of residuals showing highly erratic errors from one year to the next over the period 1939 to 1956. This led to the hypothesis that a structural shift had occurred in our relationship about 1956. A 'Chow' test[13] for this shift was performed for each of 1955-56, 1956-57, 1957-1958, and 1958-59. To perform this test, separate regressions were generated for the period prior to the hypothesized shift and for the period following the shift. The sum of squared residuals (SSE) of each of these two equations were added to form the term SSE_{ur}. An F-statistic was then formulated as follows:

$F_{k,n-2k} = ((SSE_r - SSE_{ur})/k)/(SSE_{ur}/(n-k))$, where

k = number of explanatory variables in model = 4,

n = total observations = 45.

SSE_r = SSE of our equation regressed over the period 1939 to 1948 and 1950 to 1984.

Equivalently:

$$F_{4,41} = ((SSE_r - SSE_{ur})/4)/(SSE_{ur}/41).$$

The highest value for this F-statistic (3.82) was associated with the test for a break between 1956 and 1957. We require an F-statistic less than 2.61, the critical F-value, to accept with 95% confidence that no structural shift occurred. Since our calculated F-statistic (3.82) is greater than our critical F-value, we concluded that a structural shift in this equation occurred between 1956 and 1957.

Having found a structural shift in our regression for economic growth, we then searched for a similar result in our regression on output. Testing the breaks for each of the years from 1953 to 1958 gave a maximum calculated F-statistic of 3.85 for the break between 1956 and 1957, which also allowed us to reject with 95% certainty, the hypothesis of no structural shift. Thus, between 1956 and 1957, both relationships changed because of structural shifts in the economy.

The shifts in our two relationships were most likely caused by the unusual fertility patterns associated with World War II. From 1939 to 1945 the number of pregnancies decreased as men enlisted in the Armed Forces. When the war ended, men returned home and a sharp increase in the number of children born followed. This trend continued into the 1950's and was still observable in the 1960's. This resulted in an unusually high rate of population growth and a sudden increase in the relative number of young people. We believe that these unusual circumstances led to the observed shifts. This means that the relationship between output and our demographic structure is not consistent throughout the period 1926-1984. Thus our pre-shift period observations were eliminated and we based our estimates on data from the years 1957 to 1984.

The equation,

$$Y = a_0 + a_1 \log MP + a_2 \log VP + a_3 \log CTP,$$

was estimated for the years 1957 to 1984 and resulted in an R^2 of .9711 indicating that approximately 97% of the variance of Y around its mean value is explained by our independent variables. The F-statistic, F = 268.44 was well above the 3.01 necessary to reject the null hypothesis H_0: $a_0 = a_1 = a_2 = a_3 = 0$ with 99% confidence. The coefficients of the exogenous variables, with corresponding t-statistics in brackets, were estimated as follows (where L denotes log):

$$\underset{(10.48)}{Y = -135.91} + \underset{(13.09)}{15.73(LMP)} + \underset{(9.29)}{13.63(LVP)} + \underset{(0.03)}{.0073(LCTP)}$$

For twenty-four degrees of freedom, we require t-statistics less than -1.711 or greater than 1.711 to reject the null hypotheses H_0: $a_i = 0, i = 0,1,2,3$ at a significance level of five percent. Because the t-statistic associated with LCTP is within this bound, we accept that a_3 is not significantly different from zero. Because of its insignificance, the variable LCTP was eliminated and the equation,

$$Y = a_0 + a_1LMP + a_2LVP,$$

was tested. This new relationship yielded the same R^2 (.9711) as the original equation and a higher F-statistic (419.42). The new equation was estimated as follows:

$$Y = -135.54 + 15.70(LMP) + 13.59(LVP)$$
$$(-23.48) \quad (26.59) \quad (17.70)$$

By eliminating a variable we gained a degree of freedom. Thus t-statistics beyond the ranges -1.708 to 1.708, and -2.485 to 2.485 are required at the five percent and one percent levels of significance respectively to reject the null hypotheses, H_0: $a_i = 0, i = 0,1,2$. Our t-statistics all lie well beyond these levels and thus we accept, with 99% certainty, that a_0, a_1, and a_2 are each significantly different from zero.

Our equation was now checked for heteroscedasticity, a condition which occurs when the variance of errors associated with each observation differ in scale and thus results in an inefficient estimator. In our context this might be caused by differences in the variances of our explanatory variables over time. A Goldfield and Quandt test[14] for heteroscedasticity was performed by the following procedure. First, the six central observations were dropped from our model. Separate equations were then regressed over the periods 1957-1967 and 1974-1984. For both regressions, we obtained a sum of squared errors. An F-statistic (3.68) was then calculated by dividing the bigger SSE by the smaller SSE. Our critical region for this test is defined as,

$$F_{7,7} < 3.79$$

Since 3.68 is less than our critical F-value at a 5% level of significance, the Goldfield and Quandt test confirms that we can dismiss the existence of heteroscedasticity in this equation with 95% certainty.

Another potential problem with our estimated equation is multicollinearity. Multicollinearity occurs when an approximate linear relationship exists between any of our independent variables. If this arises, our estimates will be unbiased but roughly equal amounts of explanatory power will be associated with each of our estimated parameters. Our estimated equation will thus be unreliable. Because no formal tests for multicollinearity exist,[15] we must resolve this problem through informal tests. One of these involves entering an additional explanatory variable in the regression and checking to see if the estimated parameter values are changed significantly.[16] If we re-introduce our population growth variable (LCTP) our parameters remain almost unchanged (see Table I). Another informal test indicating that

Table I

PARAMETER	regression containing LCTP	regression not containing LCTP
a_0	-135.91	-135.54
a_1	15.73	15.70
a_2	13.63	13.59

multicollinearity is not a problem is if the absolute values of the t-statistics for the coefficients of our explanatory variables are all significantly different from zero.[16] Our minimum t-statistic is 17.70 (associated with the population's variance). As the critical t-statistic is 2.48, this requirement is met. Based on the results of our two informal tests, we conclude that multicollinearity is not present in our regression on Gross National Product per capita.

The equation was now checked for autocorrelation, a problem which arises when the errors associated with the observations are not independent of each other. As noted, Statistics Canada population estimates tend to be autocorrelated because interpolation between census years tends to smooth the true variations in the data. Each variable in our equation has been calculated (at least in part) from these statistics. Therefore, we might expect to have an error structure which exhibits autocorrelation. A Durbin-Watson test for autocorrelation was performed. The Durbin-Watson statistic associated with this regression was 0.443, well beyond the bounds ($0.97 < dw < 3.03$) required to reject autocorrelation with 99% confidence. Thus, as predicted, our estimate is autocorrelated. A cursory examination of our plot of residuals indicated that this arose because of the influence of the business cycle. Thus there is little we can do about this problem. However, for forecasting purposes, autocorrelation does not pose a problem.

We examined our regression for heteroscedasticity, autocorrelation and multicollinearity. Only autocorrelation poses a potential problem in terms of the efficiency of our estimator although this will not diminish our equation's forecasting power. We thus predict that the influence of demographic factors on our level of economic well-being is best estimated by the following equation:

$$Y = -135.54 + 15.70(LMP) + 13.59(LVP).$$

The positive coefficients associated with the variables logMP and logVP indicate that an increase in either the median age or the variance of the age distribution of the population will have a positive effect on Real GNP per capita and thus will lead to a higher average level of economic well-being. Because our relationship is log-linear, each successive increase in our independent variables will have a progressively smaller effect on output. For example, Real GNP per capita rises by 766 dollars if the median age of the population increases from 20 to 21 years. However, while a further increase to a median age of 22 still results in an increase in Real GNP per capita, the change is now only 730 dollars. The positive effects of population aging will continue to decline. When the median age rises from 40 to 41 years, GNP per capita rises by 388 dollars. A similar effect is observed for the variance of the age distribution of the population. Unit increases in variance have a progressively smaller impact on Real GNP per capita.

We now turn to our second model,

$$CY = b_0 + b_1MP + b_2VP + b_3CTP,$$

which was used to estimate economic growth as a function of demographic variables. The initial regression on CY resulted in an R^2 of .4251. That is, only 42.5% of the variance of CY around its mean is explained by this equation. However, the F-statistic, F = 5.91, is sufficiently large to enable us to reject the null joint hypothesis H_0: $b_0 = b_1 = b_2 = b_3 = 0$ with 99% confidence. Our equation was estimated as follows (t-statistics in brackets):

$$CY = 59.01 - 1.37(MP) - 0.021(VP) - 3.63(CTP)$$
$$(1.69) \quad (-2.72) \quad (-0.68) \quad (-2.13)$$

The t-statistics associated with variance VP and our constant (59.01) indicate b_2 and b_0 are not significantly different from zero. Thus the variable VP was eliminated from the equation which was then re-estimated as,

$$CY = b_0 + b_1MP + b_3CTP.$$

For this relationship, our explanatory power dropped slightly (R^2= .4141) while our F-statistic rose to 8.84. Our new equation was estimated as follows:

$$CY = 36.11 - 1.09(MP) - 2.61(CTP)$$
$$(4.34) \quad (-3.89) \quad (-3.35)$$

With twenty-five degrees of freedom, our t-statistics are sufficiently large to allow us to reject the individual null hypotheses, H_0: b_i = 0, i=0,1,3, with 99% confidence.

Our informal tests for multicollinearity indicate that our estimated equation may be unreliable. This is based on the change in our parameter values caused by the addition of an extra independent variable (in this case our variance statistic). Both our coefficient for population growth and our constant are significantly affected (see table II) by the removal of the variance statistic from our equation. Thus multicollinearity may

Table II

PARAMETER	regression containing VP	regression not containing VP
b^0	59.01	36.11
b^1	-1.37	-1.07
b^3	-3.63	-2.61

present a problem in this case.

Our regression was also tested for the presence of autocorrelation, a problem which, we have noted, could arise due to the nature of our data (particularly our population data). The Durbin-Watson statistic for this regression was 2.32. We require a Durbin-Watson statistic between 1.65 and 2.35 in order to reject autocorrelation with 95% confidence. Since 2.32 falls within these bounds, we can conclude that autocorrelated errors do not present a problem.

A Goldfield and Quandt test for heteroscedasticity was now applied to this regression. The resultant F-

Figure II

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=========================================================
        YEAR                  PLOT OF ERRORS

        1957                          .   . O .
        1958                          .   O   .
        1959                          .   .O  .
        1960                          . O .   .
        1961                          .O  .   .
        1962                          .   .   O
        1963                          .    O  .
        1964                          .   .  O.
        1965                          .   . O .
        1966                          .   .  O.
        1967                          O   .   .
        1968                          .   O   .
        1969                          .  O.   .
        1970                        O .   .   .
        1971                          .   . O .
        1972                          .   .O  .
        1973                          .   .   .O
        1974                          .  O.   .
        1975                         O.   .   .
        1976                          .   .  O.
        1977                          .O  .   .
        1978                          .   O   .
        1979                          .   O   .
        1980                          .  O.   .
        1981                          .   .  O.
        1982                O         .   .   .
        1983                          .   .   O
        1984                          .   .   .  O
=========================================================
```

statistic (3.92) is greater than our critical F-value of 3.79 at the five percent level of significance. Thus we cannot reject heteroscedasticity with 95% certainty. This leaves us with estimated parameters which are most likely inefficient. This hypothesis is supported by our plot of errors (see Figure II) which shows several unusually large residuals for certain years (most notably 1970, 1973, 1975, 1982 and 1984).

The presence of both heteroscedasticity and multicollinearity leads us to believe that our regression on economic growth is highly suspect. We thus judge our estimated equation to be unreliable. These problems are most likely the result of either specification error (the exclusion of a relevant explanatory variable), or the possibility that the relationship between economic growth and the population's age-profile is neither linear nor log-linear. This regression on economic growth is, however, the best we can produce. Unfortunately, because it contains so many potential problems, its usefulness is limited. Therefore, the remainder of this study will be based on our estimated equation of Real GNP per capita as a function of demographic variables.

In summary, the effect of demographic changes on our level of output per capita is best estimated by the following equation:

$$Y = -135.54 + 15.70(LMP) + 13.59(LVP)$$

This equation indicates that unit increases in either the median age or the variance of the population will exert a progressively decreasing positive effect on our level of output per capita. In the following chapter we will forecast Real GNP per capita using Statistics Canada population projections and this equation to produce annual expected values of output per capita for the years 1986-2006 and quinquennial estimates for the period 2006 to 2031. Our results will be used to forecast the time path of per capita output in several possible future growth scenarios. Based on the projected time path of output for each of these scenarios, we hope to determine if a continuation of our population's aging trend will enhance or diminish our economic well-being.

Chapter III

POPULATION AGING AND FUTURE PER CAPITA OUTPUT

In the previous two chapters we have described and estimated how demographic factors play a role in the determination of our economic well-being. We will now use our estimated equation to predict the future effects of population aging on Real Gross National Product per capita. Four possible growth scenarios and the assumptions upon which they are based are examined. We shall then combine these projections with the equation developed in Chapter II in order to predict the effects of future demographic changes on our economic well-being as measured by Real Gross National Product per capita.

Our population projections span the period 1986-2031, and are taken from the publication "Population Projections For Canada, Provinces and Territories (1984-2006)," the most recently released set of population projections from Statistics Canada. A total of eighteen growth scenarios were formulated based on all possible combinations of three different fertility assumptions, two international migration assumptions and three interprovincial migration assumptions. We will examine each set of assumptions separately.

The fertility rate--the average number of births per woman--is the most important factor in determining population growth. Although it is currently at a Record low of 1.66,[18] over 80% of population growth is still accounted for by natural increase (births minus deaths).[19] Therefore, we can expect changes in the fertility rate to greatly influence population growth. The three fertility assumptions (low, medium, high) are as follows:

LOW: Under this assumption the fertility rate drops to 1.4 by the year 1995 and remains constant thereafter. It is based on the hypothesis that, in the future, an increasing number of women will enter the work force and either delay or forgo childbearing. It is also speculated that declining marriage rates and increasing divorce rates will continue, thus resulting in a lower incidence of marital pregnancy. Improved contraceptive methods may also be expected in the future.[20]

MEDIUM: Under this assumption, fertility rates remain constant at 1.66 throughout the projection period. While it is useful as a bridge between our high and low fertility assumptions, it should be noted that the fertility rate has not changed significantly over the past six or seven years. It is not known if this stabilization is permanent or transitory. If we assume that it is permanent, the medium fertility scenario will result.[21]

HIGH: This assumption is that the fertility rate will rise above the long term replacement level(2.1)--the level necessary for the population to just replace itself in the long run[22]--reaching 2.2 by 1995 and remaining constant thereafter. This assumption can be supported if one notes that those born in the 'baby-bust'--the period following the 'baby-boom' of the 1950's and 1960's--will reach working age in the early 1990's. It is believed that, because of their small numbers, they might have access to better jobs and thus should be able to attain a higher standard of living. There would be less financial need for women to go to work thus enabling them to begin childbearing at an early age and thus to bear more children. We might also expect corporations to formulate policies which would make it easier for a working woman to become a working mother. This might also encourage more births and thus an increase in the fertility rate.[23]

Each of these three fertility assumptions has been combined with a single mortality assumption to give us three possible rates of natural increase. This mortality assumption is that life expectancy will increase to 81.6 years for females and to 74.9 years for males by the year 1996 and remain constant thereafter.[24]

The second component of population growth, net immigration, is determined by subtracting emigration from immigration. Because little is known about the determination of emigration patterns, a single assumption placing its level at 50,000 people per annum was used.[25] Two immigration assumptions were developed as follows:

LOW: In the long run it is not expected that immigration levels can fall below 100,000 per year. The low projection assumes immigration stabilizes at this, its current level, throughout the projection period.[26]

HIGH: Under this assumption, immigration reaches 150,000 by 1996 then stabilizes. This is seen as the result of an increasing demand for labour brought about by economic development.[27]

By subtracting international emmigration from each of our international immigration figures we arrive at our two net immigration assumptions; a high of 100,000 people by 1996 and a low of 50,000 people throughout the projection period.

A third component of population growth is interprovincial migration. The three assumptions developed result in a wide range of growth possibilities for the individual provinces. However, they do not significantly alter the growth and age structure of Canada as a whole. Therefore, because our study examines Canada in aggregate, we will not consider separate interprovincial migration assumptions. This results in a reduction, from eighteen to six, in the the number of possible growth scenarios to be studied. These six consist of all combinations of our three fertility assumptions and our two international migration assumptions. Statistics Canada has published detailed projections for four of these six. These are summarized in Table III below:

Table III

PROJECTION	FERTILITY RATE Children/woman by 1996	INTERNATIONAL MIGRATION Net immigration in 1000's by 1996
1	1.4	50
2	1.66	50
3	1.66	100
4	2.2	100

We thus have one low growth scenario (Projection 1), two medium growth scenarios (Projections 2 and 3) and a high growth scenario (Projection 4).

For each of the low, medium, and high fertility assumptions, we observe differences in the growth rate of the young population (those aged 0-17 years) throughout the entire projection period. After the year 2000, the young age groups of the 1980's join the labour force, and its growth is also altered. Up until this point, the relative size and composition of the labour force is virtually unaffected by different fertility assumptions.

The growth of the older aged groups (65 years and over) is consistent for each set of assumptions. This was expected since our projection period spanning 1986-2031, only runs for forty-five years. If our projection period spanned more than sixty-five years, the older age groups would be affected. International migration appears to have a slight effect on the size of the younger half of the labour force. Because this group accounts for most of our births, the younger age groups are also affected. The differences between our scenarios result in different values for the exogenous variables contained in the equations estimated in Chapter II. These differences are summarized as follows (see Appendix C):

PROJECTION 1: In our low growth scenario, the fertility rate is well below the replacement level of 2.1. As a result, the total population of Canada grows at a progressively slower rate, peaking at about 28,250,000 people in the early 2010's and declining thereafter. Population aging accelerates with the median age rising from its current level of 31.6 to 35.0 years in the year 1994 to 40.4 years by 2005. By the year 2031 (the limit of our projection period) the median age reaches 47.9 years. The variance of the age distribution of the population decreases rapidly as the number of young people falls.

PROJECTION 2: With a constant fertility rate and low net immigration, population aging continues at a steady pace until the turn of the century after which it declines slowly. The median age reaches 40 years by the year 2008 and 44.2 years by 2031. Total population peaks at just over 30,000,000 people in the early 2020's. The variance of the age distribution of the population declines at a slower rate than that observed in Projection 1. This happens because the number of young people is not reduced as drastically as in Projection 2. Towards the end of the projection period, the variance of the age distribution stabilizes and then increases in response to the discrepancy between the relative age of our population and that of our immigrants who will have become our principal source of population growth.

PROJECTION 3: Our alternative medium growth scenario is a demonstration of the effect of increasing net immigration to 100,000 people by the year 1996. Population aging still occurs throughout the projection period but at a slower rate than forecast in either Projection 1 or 2. The population does not reach a median age of 40 years until the year 2012, and, by 2031, the median age will only increase to 42.8. Variance of the age distribution of the population closely follows the pattern observed in Projection 2 but at slightly higher levels. The size of the population increases at a diminishing rate until about 2030, when we shall number near 32,700,000.

PROJECTION 4: The high growth projection results in a population totalling 30,000,000 people at the turn of the century and over 38,000,000 people by the year 2031. The variance of the age distribution of the population is quite stable throughout the projection period declining slowly until the year 2006 before starting on a slow secular climb. Population aging is slowed and then arrested as births increase. In the year 2006, the median age of the population will be 37.05 years, a figure which changes little by 2031. High growth will thus be associated with a low rate of population aging.

We now combine each of our growth scenarios with the estimated equation for real GNP per capita developed in Chapter II. This will produce annual projections to the year 2006 and quinquennial projections to 2031 for real GNP per capita based on our population's age-profile. When we employ our four population projections with our estimated equation,

$$Y = -135.543 + 15.6968(LMP) + 13.5868(LVP),$$

we obtain results as listed in Table IV:

Table IV

YEAR	Y = Real GNP per capita in 1971 dollars: PROJECTION 1	2	3	4
1986	5847.02	5867.09	5864.39	5860.36
1987	5927.18	5913.64	5899.01	5900.61
1988	5969.22	5952.72	5941.31	5925.83
1989	6005.15	5969.07	5956.10	5929.21
1990	6043.41	5991.84	5972.82	5941.27
1991	6076.25	6014.91	5985.89	5937.12
1992	6102.65	6036.56	5990.16	5923.35
1993	6042.10	6029.81	5983.03	5897.29
1994	6107.59	6022.00	5958.31	5856.99
1995	6065.22	5991.62	5943.40	5818.22
1996	6012.49	5923.57	5881.18	5761.49
1997	5964.07	5873.60	5826.31	5699.12
1998	5875.60	5790.35	5738.22	5614.40
1999	5786.60	5692.58	5641.01	5511.23
2000	5695.85	5612.97	5578.06	5463.46
2001	5604.92	5575.32	5542.30	5463.18
2002	5518.53	5539.98	5544.61	5534.05
2003	5320.54	5446.77	5495.11	5595.63
2004	5015.33	5301.95	5401.80	5627.41
2005	4817.68	5094.10	5292.03	5668.39
2006	4738.51	5077.10	5252.01	5728.26
2011	4372.98	5269.76	5550.95	6564.37
2016	4455.54	6089.96	6386.67	7697.79
2021	5039.36	7083.21	7275.51	8776.20
2026	5531.81	7951.11	8002.99	9547.47
2031	5678.96	8484.82	8494.15	9914.49

In each case, GNP per capita increases until a peak is reached in the early 1990's. This peak is highest for the low population growth scenario ($6108 in the year

1994), and lowest for the high population growth scenario ($5941 in the year 1990). For every year in the period from 1987 to 2002, the low population growth projection leads to the most favorable level of economic well-being while high population growth leads to the least favorable level. This occurs because, initially, a lower fertility rate results in a relatively smaller young population, and therefore a relatively smaller dependent population. Output is thus increasing at a relatively faster rate than population, causing the population to be better off than they would be with higher population growth. Thus, under the low population growth scenario, we maximize our economic well-being in the short run. The largest difference between the high and low population growth scenarios in this period occurs in the year 1998 when GNP per capita is 4.7% higher in the low population growth scenario than under the high population growth scenario. This difference diminishes over time and, by the year 2002, all four projections predict similar levels of economic well-being.

After the year 2002, our results are reversed. The high population growth projection now leads to the highest level of economic well-being while low population growth leads to the lowest level. This occurs because, as the young reach working age, the relative sizes of both the young aged groups and the labour force stabilize under high growth. In the other projections, most notably Projection 1, the relative size of both of these groups declines while the percentage of elderly people increases rapidly. This places a greater burden on the labour force who must support a relatively larger dependent population. The average member of society would be worse off in the low growth scenario than they would be if the high population growth assumption held.

We noted that Real GNP per capita is highest from 1987 to 2002 in our low growth scenario, reaching a peak of $6108 in the year 1994. The decline that follows this peak continues until about the year 2013 when Real GNP per capita is near $4300. By the year 2031 Real GNP per capita appears to be levelling off, having reached a level of only $5679, well below its 1994 peak. This contrasts sharply with the high growth scenario in which Real GNP per capita peaks at $5941 in the year 1990 then declines slightly to $5463 by the turn of the century. After the year 2001 we have a secular increase in Real GNP per capita which reaches $9914 by the year 2031, a level much greater than what would be obtained under the low growth assumption. Thus, a continuation of population aging results in lower levels of GNP per capita in the long run than those possible if the population aging trend were to be reversed.

From this analysis we can conclude that a continuation of the phenomenon of population aging, as projected in the low population growth scenario, will lead to a slightly higher level of economic well-being in the short run than that experienced if population aging is slowed or arrested. However, in the long run, if our population continues to age, we can expect our level of Real GNP per capita to be substantially lower than the level of GNP per capita that would be attained if population aging were slowed or arrested. Thus, when assessing the impact of population aging on our economic well-being (as measured by Real GNP per capita), we must weigh the short-term gains against the long-term losses. We have noted that a continuation of the population aging phenomenon will be beneficial in the short run. The benefits, however, are minimal. In the short run, output will not be greatly affected by population aging. However, in the long run, the impact of population aging on output could be quite large. Thus the results of our projections for GNP per capita for a series of population growth scenarios indicate that a continuation of the phenomenon of population aging will result in a level of economic well-being lower than that possible if population growth were to be stimulated.

Chapter IV

CONCLUSIONS

The purpose of this thesis was to answer a question: Does our level of economic well-being depend on the age structure of our economy? Using a standard econometric analysis of time series data, this question was answered. It is an important answer because we know that the Canadian population is aging, and in many ways, this process is inevitable. By applying independent population forecasts to our estimated equation linking real per capita output and demographic variables, we were able to forecast how our level of well-being would change over the next several decades depending on the population growth scenario. With a great deal of certainty we can say that if current population trends continue, we can expect the welfare of the average Canadian to increase by some extent in the short term, but in the long run avarage welfare will be less than that possible if population aging is slowed or arrested.

Although population aging is regarded as inevitable, our forecast pattern of real per capita output need not be inevitable as well. We should keep in mind that our estimated relation and thus our forecasts are, in part, based on past behaviour. While the aging trend will likely continue, behaviour may change. Indeed, if agents in the economy are aware of our forecast, we would expect them to react. For example, firms who plan now for the future using the information we have generated can be expected to respond in such a manner as to minimize the adjustment costs associated with population aging. Because of this, we are confident that our forecast somewhat overestimates the long term negative impacts of population aging.

We have established a functional relationship between output and age structure and this opens up new avenues. In Chapter I, we noted that little could be said about the impact of population aging on aggregate consumption, aggregate saving, labour productivity and government expenditures on social programmes until we knew how output would be affected. We now know and further research into these matters can proceed with the central issue resolved.

APPENDIX A

Table A I

Endogenous Variables

Y=REAL GROSS NATIONAL PRODUCT PER CAPITA (1971 dollars)
CY=RATE OF ECONOMIC GROWTH (%)
TP=TOTAL POPULATION (1000's)
GNE=REAL GROSS NATIONAL PRODUCT (1000's of 1971 dollars)

YEAR	Y[a]	CY[b]	TP[c]	GNE[d]
1926	1490	----	9451	14086
1927	1600	7.38	9637	15423
1928	1711	6.93	9835	16831
1929	1685	-1.57	10029	16894
1930	1584	-5.94	10208	16174
1931	1361	-14.13	10377	14118
1932	1204	-11.50	10510	12654
1933	1111	-7.74	10633	11811
1934	1233	11.01	10741	13245
1935	1317	6.77	10845	14279
1936	1362	3.43	10950	14912
1937	1486	9.10	11045	16410
1938	1484	-0.14	11152	16545
1939	1578	6.33	11267	17774
1940	1782	12.93	11381	20277
1941	2016	13.13	11507	23194
1942	2359	17.06	11654	27497
1943	2425	2.78	11795	28604
1944	2489	2.64	11946	29736
1945	2408	-3.26	12072	29071
1946	2302	-4.42	12292	28292
1947	2350	2.11	12551	29498
1948	2358	0.31	12823	30231
1949	2334	-0.99	13447	31388
1950	2462	5.48	13712	33762
1951	2531	2.77	14009	35450
1952	2671	5.54	14459	38617
1953	2735	2.41	14845	40605
1954	2624	-4.08	15287	40106
1955	2796	6.57	15698	43891
1956	2960	5.87	16081	47599
1957	2933	-0.91	16610	48718
1958	2918	-0.50	17080	49844
1959	2959	1.41	17483	51737
1960	2979	0.66	17870	53231
1961	3001	0.76	18238	54741

Endogenous Variables (con't)

YEAR	Y^a	CY^b	TP^c	GNE^d
1961	3001	0.76	18238	54741
1962	3147	4.84	18583	58475
1963	3248	3.22	18931	61487
1964	3401	4.71	19291	65610
1965	3562	4.73	19644	69981
1966	3739	4.96	20015	74841
1967	3795	1.50	20378	77344
1968	3955	4.19	20701	81864
1969	4106	3.82	21001	86225
1970	4150	1.07	21297	88390
1971	4379	5.51	21568	94450
1972	4592	4.86	21830	100248
1973	4879	6.26	22095	107812
1974	4975	1.97	22446	111678
1975	4957	-0.38	22799	113005
1976	5202	4.95	22993	119612
1977	5245	0.82	23258	121988
1978	5382	2.61	23476	126347
1979	5501	2.28	23681	130362
1980	5481	-0.44	24042	131765
1981	5585	1.90	24372	136108
1982	5280	-5.46	24634	130065
1983	5398	2.24	24889	134353
1984	5596	3.66	25128	140614

[a] $Y_i = GNP_i/TP_i$, $i = 1926,\dots,1984$.

[b] $CY_i = 100(Y_i - Y_{i-1})/Y_{i-1}$, $i = 1926,\dots,1984$.

[c] Population estimates are from the following Statistics Canada publications: <u>Population 1921-1971, Revised Annual Estimates of Population By Sex and Age Group.</u>, for the years 1921-1971; <u>Population of Canada By Sex and Age Group.</u>, for the years 1972-1975; <u>Estimates of Population By Marital Status, Age and Sex Group.</u>, for the years 1976-1984.

[d] Figures for Real GNE were taken from <u>Historical Statistics of Canada</u>, for the years 1926-1975, and from <u>The Bank of Canada Review</u>, (April 1985), for the years 1976-1984.

APPENDIX B

Table B I

Exogenous Variables

MP=MEDIAN AGE OF THE POPULATION (years)
VP=VARIANCE ACROSS THE POPULATION
CTP=RATE OF POPULATION GROWTH (%)

YEAR	MP[a]	VP[b]	CTP[c]
1926	24.40	557.85	----
1927	24.52	559.69	1.97
1928	24.61	562.47	2.05
1929	24.67	566.29	1.97
1930	24.71	570.11	1.78
1931	24.75	574.78	1.66
1932	24.93	577.04	1.28
1933	25.14	578.39	1.17
1934	25.37	580.83	1.02
1935	25.60	583.11	0.97
1936	25.82	585.44	0.97
1937	26.08	585.53	0.87
1938	26.39	583.34	0.97
1939	26.66	581.46	1.03
1940	26.93	579.79	1.01
1941	27.08	581.16	1.11
1942	27.24	581.41	1.28
1943	27.37	581.73	1.21
1944	27.50	581.14	1.28
1945	27.61	579.38	1.05
1946	27.72	575.70	1.82
1947	27.74	579.49	2.11
1948	27.74	582.33	2.17
1949	27.65	583.12	4.87
1950	27.70	581.58	1.97
1951	27.69	579.22	2.17
1952	27.60	578.89	3.21
1953	27.54	579.03	2.67
1954	27.44	579.83	2.98
1955	27.31	581.23	2.69
1956	27.19	583.29	2.44
1957	26.95	587.78	3.29
1958	26.69	593.80	2.83
1959	26.61	600.37	2.36
1960	26.45	608.70	2.21
1961	26.29	618.77	2.06
1962	26.05	632.43	1.89

Exogenous Variables (con't)

YEAR	MP[a]	VP[b]	CTP[c]
1962	26.05	632.43	1.89
1963	25.78	647.35	1.87
1964	25.58	659.71	1.90
1965	25.48	668.66	1.83
1966	25.47	674.15	1.89
1967	25.53	678.53	1.81
1968	25.64	681.75	1.59
1969	25.82	683.62	1.45
1969	25.82	683.62	1.45
1970	26.02	683.90	1.41
1971	26.26	684.05	1.27
1972	26.52	681.82	1.21
1973	26.92	673.38	1.21
1974	27.20	668.75	1.59
1975	27.47	665.33	1.57
1976	27.81	666.21	0.85
1977	28.17	661.07	1.15
1978	28.52	657.13	0.94
1979	28.87	654.10	0.87
1980	29.30	646.49	1.52
1981	29.66	642.70	1.37
1982	30.01	639.45	1.08
1983	30.41	634.23	1.04
1984	30.80	627.12	0.96

[a,b,c]These figures were calculated by the author based on population statistics contained in the following Statistics Canada publications: Population 1921-1971, Revised Annual Estimates of Population By Sex and Age Group., for the years 1921-1971; Population of Canada By Sex and Age Group., for the years 1972-1975; Estimates of Population By Marital Status, Age and Sex Group., for the years 1976-1984.

APPENDIX C

Population Variables From Population Projections

TP=TOTAL POPULATION (1000's)[a]
MP=MEDIAN AGE OF THE POPULATION (years)[b]
VP=VARIANCE ACROSS THE POPULATION[c]
TP=RATE OF POPULATION GROWTH (%)[d]

Table C I

Projection 1

YEAR	TP	MP	VP	CTP
1986	25610	31.61	611.94	---
1987	25808	32.01	606.68	.77
1988	26024	32.42	599.68	.84
1989	26232	32.83	592.60	.80
1990	26428	33.26	585.41	.75
1991	26615	33.69	578.18	.71
1992	26785	34.13	570.68	.64
1993	26945	34.64	558.49	.59
1994	27092	35.04	553.80	.55
1995	27226	35.54	543.11	.50
1996	27349	36.04	532.34	.45
1997	27462	36.53	522.24	.41
1998	27564	37.03	510.76	.37
1999	27657	37.51	499.94	.34
2000	27741	37.99	489.37	.30
2001	27817	38.45	479.55	.27
2002	27884	38.90	469.99	.24
2003	27945	39.39	456.54	.22
2004	27999	39.91	439.69	.19
2005	28047	40.37	427.64	.17
2006	28089	40.76	420.46	.15
2011	28217	42.57	389.25	.10
2016	28180	44.08	376.17	0.00
2021	27938	45.39	379.62	-.20
2026	27474	46.69	381.00	-.30
2031	26796	47.93	373.66	-.50

Table C II

Projection 2

YEAR	TP	MP	VP	CTP
1986	25607	31.58	613.52	---
1987	25851	31.96	607.18	.95
1988	26091	32.34	600.67	.93
1989	26327	32.73	593.12	.90
1990	26558	33.13	585.83	.88
1991	26781	33.52	578.95	.84
1992	26997	33.91	572.17	.81
1993	27204	34.32	564.00	.77
1994	27403	34.72	556.18	.73
1995	27592	35.15	547.11	.69
1996	27772	35.60	536.43	.65
1997	27944	36.03	527.10	.62
1998	28105	36.47	516.58	.58
1999	28256	36.90	505.98	.54
2000	28397	37.32	496.49	.50
2001	28529	37.70	489.36	.47
2002	28654	38.07	482.61	.44
2003	28771	38.46	473.70	.41
2004	28882	38.86	463.11	.38
2005	28987	39.29	450.31	.36
2006	29038	39.66	444.91	.17
2011	29526	40.95	434.88	.30
2016	29852	41.87	450.23	.20
2021	30025	42.65	474.16	.10
2026	30004	43.42	495.10	0.00
2031	29779	44.17	504.84	0.00

Table C III

Projection 3

YEAR	TP	MP	VP	CTP
1986	25622	31.57	613.62	---
1987	25876	31.95	606.74	.99
1988	26133	32.31	600.80	.99
1989	26390	32.68	593.60	.98
1990	26648	33.06	586.45	.98
1991	26904	33.43	579.51	.96
1992	27158	33.80	572.37	.94
1993	27410	34.17	564.92	.93
1994	27659	34.54	556.92	.91
1995	27905	34.91	549.50	.89
1996	28144	35.31	539.84	.86
1997	28375	35.70	530.88	.82
1998	28596	36.10	520.70	.78
1999	28808	36.49	510.61	.74
2000	29011	36.86	502.36	.71
2001	29207	37.20	495.76	.68
2002	29396	37.51	491.11	.65
2003	29578	37.84	484.40	.62
2004	29755	38.18	476.14	.60
2005	29927	38.53	467.35	.58
2006	30095	38.83	461.82	.56
2011	30880	39.97	456.57	.50
2016	31573	40.73	475.09	.40
2021	32132	41.42	497.46	.40
2026	32511	42.14	514.47	.20
2031	32693	42.82	523.64	.10

Table C IV

Projection 4

YEAR	TP	MP	VP	CTP
1986	25625	31.57	613.44	---
1987	25889	31.93	607.25	1.03
1988	26165	32.28	600.77	1.07
1989	26452	32.62	593.68	1.09
1990	26749	32.95	587.34	1.13
1991	27057	33.27	580.64	1.15
1992	27372	33.58	573.87	1.17
1993	27695	33.88	566.92	1.18
1994	28025	34.17	559.70	1.19
1995	28359	34.46	552.68	1.19
1996	28695	34.75	545.10	1.18
1997	29029	35.04	537.40	1.16
1998	29351	35.34	528.82	1.11
1999	29663	35.64	519.72	1.06
2000	29966	35.91	513.40	1.02
2001	30261	36.14	509.62	.98
2002	30547	36.32	509.35	.95
2003	30828	36.50	508.75	.92
2004	31102	36.69	506.89	.89
2005	31373	36.88	505.40	.87
2006	31639	37.05	504.94	.85
2011	32952	37.47	530.04	.80
2016	34279	37.50	575.62	.80
2021	35628	37.38	625.48	.80
2026	36916	37.36	662.43	.70
2031	38063	37.52	677.21	.60

[a]These figures are from the Statistics Canada publication Population Projections For Canada, Provinces and Territories, 1984-2006.

[b,c]These figures were calculated by the author, based on Statistics Canada population projections.

[d]For each projection, the rate of population growth was calculated by the author based on Statistics Canada population projections for the years 1986-2006. Our quinquennial rates from 2011-2031 are actual Statistics Canada estimates taken from Population Projections For Canada, Provinces and Territories, 1984-2006.

FOOTNOTES

[1]Statistics Canada, Estimates of Population By Marital Status, Age and Sex Group, (Ottawa: Statistics Canada, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985). Population of Canada By Sex and Age Group, (Ottawa: Statistics Canada, 1973, 1974, 1975, 1976). Population 1921-1971, Revised Annual Estimates of Population By Sex and Age Group, Canada and the Provinces, (Ottawa: Statistics Canada, 1972).

[2]Ibid.

[3]Clark, Kreps and Spengler, "Economics of Aging," Journal of Economic Literature, Volume XVI, (September, 1978), p. 938.

[4]R.A.Shearer, J.F.Chant and D.E.Bond, The Economics Of The Canadian Financial System, (Scarbourough: Prentice-Hall, 1984), pp. 68-69.

[5]David K. Foot, Canada's Population Outlook, (Toronto: James Lorimar and Co., 1982), p. 227.

[6]Ibid., p. 137.

[7]Peter Kennedy, A Guide To Econometrics, (Oxford: Martin Robertson and Co., 1979), p. 80.

[8]Persons over 95 years of age were included in the age group 90-95.

[9]Peter Kennedy, op.cit., p. 11.

[10]Ibid., p. 12.

[11]Leland Blank, Statistical Procedures For Engineering, Management, and Science, (New York: McGraw-Hill, 1980), p. 523.

[12]We have used tables from J. Johnston, Econometric Methods, (New York: McGraw-Hill, 1972).

[13]Peter Kennedy, op.cit., p. 70.

[14]J. Johnston, Econometric Methods, (New York: McGraw-Hill, 1972), pp. 218-219.

[15]Peter Kennedy, op.cit., p. 131.

[16] Ibid.

[17] Ibid., p. 132.

[18] Statistics Canada, Population Projections For Canada, Provinces and Territories, 1984-2006, (Ottawa: Statistics Canada, 1984), p. 46.

[19] Ibid.

[20] Ibid., p. 19.

[21] Ibid., p. 21.

[22] F. T. Denton and B. G. Spencer, "Population Aging and the Economy: Some Issues in Resource Allocation," QESP Research Report No. 105, (Hamilton: McMaster University), p. 6.

[23] Statistics Canada, Population Projections For Canada, Provinces and Territories, 1984-2006, (Ottawa: Statistics Canada, 1984), p. 20.

[24] Ibid., pp. 28-29.

[25] Ibid., p. 31.

[26] Ibid.

[27] Ibid.

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