



**THE IMPACT OF DEMOGRAPHIC CHANGE  
ON PENSION SCHEME FINANCING  
IN THE CARIBBEAN**

by

Alywn Jordan  
Economist

&

Adrian Carter  
Research Officer  
Research Department  
Central Bank of Barbados

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**Abstract**

The paper utilizes a simple social security projection model to analyse the implications of population aging on financing social security pensions in the long-term. Four Caribbean nations are examined namely Barbados, St. Lucia, Jamaica and Trinidad and Tobago and indications are that without significant reforms, the existing social security programs would imply a substantial increase in social security tax rates to finance pensioners. A number of reforms strategies were investigated which could enhance the sustainability of the nations' social security programs.

## The Impact of Demographic Change on Pension Scheme Financing in the Caribbean

### Introduction

The social security<sup>1</sup> programs in the Caribbean as in most other countries are based on a pay-as-you-go financing scheme, which means that contributions paid by current workers are used to pay the benefits of today's retirees. However, demographic projections suggest that as the baby-boom generation heads into retirement, the generation that will replace them in the workforce will be far smaller in proportion to the number of retirees, raising fears about the sustainability of social security scheme in their present form.

In this light the paper utilizes a simple projection model to examine the relationship between population aging and social security financing in the context of four Caribbean countries namely Barbados, Jamaica, Trinidad and Tobago and St. Lucia and suggests a number of reform possibilities which can aid in the sustainability of these countries' public pensions. This paper is structured as follows: section two provides a brief perspective on the development of the social security programs in the countries under study. The next section presents and analyses the implications of the projected demographic developments on existing social security schemes. In section four, the components of the country specific social security programs are incorporated into a simple model and the results presented. Section five presents some reform possibilities and their implications on the basis of the model and the paper concludes with a brief summary in section six.

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<sup>1</sup> "Social security" throughout this paper refers only to public retirement pensions.

### 2. Caribbean Social Security

The provision of public retirement benefits as administered by government is based on a long-term contract between workers and retirees. This provides a measure of security against economic and social distresses that would otherwise be caused by the stoppage of earnings due to ageing. This concept of protecting the elderly dates back to the time when active members of an extended family supported their relatives, in the expectation that they in turn will be supported by the younger members of the family. However, aware that this informal nuclear system could break down, as is the case with families where no one is economically active, Caribbean governments took the initiative to put formal institutional arrangements in place to protect the elderly.

The first of the English-speaking Caribbean nations to institute such arrangements was Jamaica, which enacted social security legislation in 1965. Barbados followed in 1966 with its National Insurance and Social Security Act and Trinidad and Tobago in 1971. The last of the four countries to adopt Social security legislation was St. Lucia in 1979 (LaFoucade, 1992). The schemes covered all formally employed persons, with the only exception being St. Lucia where public servants were not covered. Financing of the schemes comes mainly from the compulsory contributions of employees and employers as well as investment income. Investments funds are limited to fixed deposits, government securities and loans to provide some of the resources necessary for the payment of benefits.

The normal age to qualify for benefits under the schemes is generally between sixty and sixty-five years. St. Lucia and Trinidad and Tobago retirement age stands at sixty, while that of Barbados is sixty-five and

Jamaica is sixty for females and sixty-five for males. St. Lucia and Trinidad and Tobago provides some provisions for persons who wish to defer retirement to age sixty-five. In addition to achieving the retirement age, retirees need to obtain a minimum number of contributions paid or credited to their account to qualify for pension-benefits. This minimum requirement varies across countries from 312 contributions for Jamaica, 13 of which must be in a single year to 750 for Trinidad and Tobago. Contributions of 500 and 520 are required in Barbados and St. Lucia.

During the early years of the schemes no attempt was made to match increased benefits with a rise in contributions, since contribution income substantially exceeded benefit payments. However, in Barbados like most of the other Caribbean countries the contribution income was initially over four hundred percent of benefit payments, this rate has however fallen to an average of under one percent over the last decades (New Insight). The main factor contributing to the decline has been the rise in the number of persons over the pensionable age relative to the working population, a trend which is forecasted to continue in the future.

### 3. A Demographics Description

In the four countries under study, the number of persons over the pensionable age is expected to double from eight percent of the population to sixteen percent over the next twenty-five years<sup>2</sup>. With the exception of Barbados the 1995 fertility rates were above the replacement rate of 2.1 in the countries included in this study (Table 1). However, the rates for Jamaica and Trinidad and Tobago are expected to decline below

<sup>2</sup>For data consistency, projections from the World Bank (1995) were utilized instead of those derived by the country specific methodologies of individual countries.

the rate of replacement by 2005 and St. Lucia's by 2015. In addition, life expectancy at birth is projected to increase for all of the countries from an average of 73.7 years in 1995 to 79.2 years in 2030 (Table 2).

Table 1. Fertility Rates, 1995-2030

Country	1995	2005	2015	2025	2030
Barbados	1.8	1.85	1.92	2.05	2.07
Jamaica	2.24	2.07	2.06	2.06	2.05
St. Lucia	2.79	2.19	2.09	2.08	2.08
Trinidad & Tobago	2.25	2.07	2.07	2.06	2.06

Source: World Population Projections 1994-95

Barbados is expected to maintain the highest level of life expectancy throughout the period, while further improvements of 6.4, 5.9 and 5 years are expected for St. Lucia, Trinidad and Tobago and Jamaica respectively. The projected decline in the fertility rates below the replacement rates and an increase in longevity, point to significant changes in demographic structure of the four countries through to 2030.

Table 2. Life Expectancy, 1995-2030

Country	1995	2005	2015	2025	2030
Barbados	76.4	78.5	79.4	80.4	80.9
Jamaica	74.6	76.7	77.8	79.0	79.6
St. Lucia	71.3	74.2	75.5	77.0	77.7
Trinidad & Tobago	72.6	75.1	76.4	77.8	78.5

Source: World Population Projections 1994-95

Based on the demographic projections the population in all four Caribbean nations are expected to increase

(Table 3). The largest increase in total population is expected for St. Lucia, which will be 61.3% higher by 2030 than in 1995. Trinidad and Tobago's, total population is projected to rise by 21.6% between 1995 and 2015 and 13.9% over the 2015 to 2030 period. Population projections for Jamaica indicate there will be an overall increase of 24.8% in its population by 2030. In Barbados, the low fertility rate coupled with a growth in life expectancy will result in a small expansion of 17.6% relative to the other Caribbean countries.

Table 3. Demographic Structure, 1995-2030

Population Index	1995	2005	2015	2025	2030
Barbados	100	104.2	109.6	115.3	117.6
Jamaica	100	104.7	111.3	120	124.8
St. Lucia	100	117.1	134.9	152.7	161.3
Trinidad & Tobago	100	108.7	121.6	133.8	138.6
% of population retired					
Barbados	11.5	10.0	11.5	16.6	19.8
Jamaica	7.6	8.3	9.9	9.6	16.4
St. Lucia	7.4	6.8	6.8	8.4	11.0
Trinidad & Tobago	8.1	9.3	12.0	16.3	17.8

Source: World Population Projections 1994-95

The proportion of persons over the pensionable age in these countries on average stood at 8.6% in 1995 and is projected to increase to 16.2% by 2030 (Table 3). In Barbados despite the fall in the number of persons over the retirement age to 10% in 2005, this trend is expected to be reversed by 2015 resulting in 20% of the total population at retirement age by 2030. Jamaica and Trinidad and Tobago's retired

population are projected to more than double to 16.4% and 17.8% respectively, while that of St. Lucia is expected to remain relatively stable registering a 3.6% growth over the period.

The demographic projections suggest strongly that the elderly will become a larger proportion of the Caribbean's population, thus resulting in an increase in the number of pension payments. This will occur against the background of a decline in the fertility rates, which will transmit into fewer contributions to fund the retirees. The implications of these developments on the way the social security pensions are financed is now analysed in the context of a simple social security projection model as proposed by Halter and Hemming (1987).

#### 4. Methodology

The model assumes that the average social security pension and the average social security tax payment are a fixed proportion of the same average earnings base,  $\gamma$ . If there are  $R$  retirement pensioners and the average pension is  $\rho = \beta\gamma$ , then total pension expenditure is  $R\beta\gamma$ , where  $\beta$  is the average replacement rate<sup>3</sup>. The pension programmes in the Caribbean nations are financed on a pay-as-you-go basis, so that a social security tax is levied on the population at a rate  $\alpha$  to meet concurrent pension expenditure. If there are  $W$  workers, then total social security tax revenue is  $W\alpha\gamma$ , with the pay-as-you-go rule requiring that the tax rate be given by,

$$\alpha = \beta R / W \quad (1)$$

<sup>3</sup>This is the ratio of the average pension to average earnings at the same point in time.

Given that the ratio  $W/R$  is the support ratio  $S$ , that is the number of employed workers per pensioner, then equation 1 can be rewritten as,

$$\alpha = \beta/S \quad (2)$$

The replacement rate is assumed to be fixed since contributory pensions — which make up the largest proportion of long term benefits— in the Caribbean nations are tied to earnings hence the social security tax rate is inversely proportional to the support ratio. Thus, if projected demographic shifts can be transformed into changes in the support ratio, the implications of these shifts for social security tax rates will follow directly. Thus by taking 1995 as the base year, we incorporate the number of retirement pensioners  $R$ , workers  $W$  and contribution rate  $\alpha$  into equation 2 to obtain a base year value for the replacement rate  $\beta$  (Table 4).

Table 4. Social Security Tax Rates, Replacement Rates and Support Ratios, 1995

Country	Contribution Rate ( $\alpha$ )	Replacement Rate ( $\beta$ )	Support Ratio ( $S$ )
Barbados	9.2 <sup>a</sup>	33.6	3.7
Jamaica	5.0 <sup>b</sup>	25.5	5.1
St. Lucia	5.8	26.4	4.5
Trinidad & Tobago	7.5 <sup>c</sup>	29.5	3.9

a Average long term benefit rate excluding non-contributory pensions<sup>4</sup>  
b Due to lack of data the total contribution rate was used  
c Authors' estimates

<sup>4</sup>Non-contributory pension rates are excluded because this type of pension is expected to decline in the coming decades, hence the contribution rates needed to sustain it cannot be expected to increase.

We are interested in obtaining projections of  $\alpha$  which given that  $\beta$  is fixed are obtained from incorporating projections of the support ratios into equation 2. These ratios were obtained by utilising the population projections given in Bos et al (1994-95) to find both the number of persons estimated to be at retirement age in the future, and the number of persons projected to be in the labour force<sup>5</sup>.

Table 5. Support Ratios, 1995-2030

Country	1995	2005	2015	2025	2030
Barbados	3.7	4.3	3.8	2.5	1.9
Jamaica	5.1	5.0	4.3	4.2	2.5
St. Lucia	4.5	5.7	6.9	5.0	3.8
Trinidad & Tobago	3.9	3.8	2.9	2.0	1.8

Given the traditionally high unemployment rates prevalent in the Caribbean, the number of employed persons who are supporting the retired is relatively small and is projected to get much smaller (Table 5). In Barbados the support ratio is expected to increase slightly by 2005 however, in the next twenty-five years the ratio is projected to decline to approximately two workers supporting each pensioner. A similar picture exists for Jamaica and Trinidad and Tobago, where by the year 2030, both support ratios are projected to decline steadily in the thirty-five year period to less than half their value, as the proportion of retired persons to employed persons increases. St. Lucia is estimated to maintain a relatively high support ratio over the period, due mainly to its comparatively youthful population.

<sup>5</sup> Estimates of the number of employed persons were obtained by finding the proportion of persons in the labour force as a percentage of the persons in the working age category for the base year 1995. Next the average percentage of persons employed in relation to the total labour force was found for a seven year period in each country. Finally the average percentage of the population which is employed as a percentage of the total working age population was found, and this average was used for successive projections.

Two assumptions were made in computing the projected tax rates needed to finance future pension payments. Firstly the ratio of pension benefits to other benefits was assumed to remain constant over the period. Secondly, all the pension schemes were assumed to be at a mature stage since only a short time is required to become eligible for a long term benefit<sup>6</sup>.

Table 6. Social Security Tax Rates, 1995-2030

Country	1995	2005	2015	2025	2030
Barbados	9.2	7.8	8.9	13.7	17.2
Jamaica	5.0	5.2	5.9	6.1	10.4
St.Lucia	5.8	4.7	3.8	5.3	7.0
Trinidad & Tobago	7.5	7.8	10	14.4	15.8

### Results

The contribution rates required to finance the pensions are expected to double by 2030 for all of the countries except St.Lucia (Table 6). In Barbados the rate required to support pension benefits is estimated to decline in the first ten years as the population becomes more youthful, however, the increase in the number of retired persons is then projected to lead to progressively higher contribution rates. These rates are projected to almost double between 2015 and 2030. In the case of Trinidad and Tobago, the rate required to cover long term benefits is projected to increase marginally in the first ten years, however, for the remaining period the contribution rate is estimated to increase by an average of 2.6 percentage points to reach 15.8 percent at the end of the period. Jamaica's contribution rate is projected to increase marginally by an average of 0.4 percentage points up to 2025 and rises by 4.3 percentage points thereafter.

<sup>6</sup>On average a person only needs to contribute to one of these pension schemes for ten years in order to be eligible for a long term benefit.

The rate required in St. Lucia is projected to decline initially but after 2015 the rate is projected to increase by an average of 1.6 percentage points as the population becomes older.

The above analyses suggests that the rise in longevity and the fall in fertility rates that will exemplify the demographics of Caribbean nations will lead to fewer workers paying contributions to support the growing elderly population. This suggest that the working population may be called upon to pay substantially higher taxes if the retirees' pensions is to be guaranteed . However, these tax hikes may be strongly resisted because of the excessive burden which the working population may face. The impact on employers may serve to compound the problem, since a rise in contribution rates represents an additional cost to businesses, which in turn may attempt to maintain their level of profitability by possibly reducing their permanent staff and employing casual workers (as they are not covered under national insurance schemes). Hence even though increases in tax rates of this nature, might in theory allow these pension schemes to be sustainable, they could have the opposite effect and lead to declining contribution revenues. The implications therefor are that unless some urgent reforms are instituted to the social security schemes in the Caribbean and their pay-as-you-go system of financing, collision of these schemes with financial insolvency is likely.

### 5.Pension Reforms

The problems that characterize the Caribbean nations' social security programs are not peculiar to them, many other developed and developing countries have found themselves in a similar dilemma and have adopted a number of reform strategies to address the situation. In this section a number of those reform strategies proposed for other countries are examined within the context of the Caribbean.

### *Increasing the Pension Age*

One of the reform options available within the existing pay-as-you-go programs, to limit the growth of tax rates is to increase the age at which a person is eligible for a pension. Under this reform strategy the retirement age has been increased by five years by 2005 for all of the countries. The pensionable age was increased to sixty-five for St. Lucia, Trinidad and Tobago and for women in Jamaica while men in Barbados would become eligible for retirement benefits at age seventy.

Table 8. Social Security Support Ratios and Tax Rates for a Five Year Increase in Pension Age, 1995-2030

Support Ratios	1995	2005	2015	2025	2030
Barbados	3.6	4.9	4.7	3.2	2.4
Jamaica	5.1	6.1	5.6	5.3	3.2
St. Lucia	4.5	8.4	11.6	7.8	6.5
Trinidad & Tobago	3.9	5.8	4.6	3.3	2.7
<hr/>					
Tax Rates					
Barbados	9.2	6.8	7.0	10.7	13.7
Jamaica	5.0	4.2	4.6	4.8	8.0
St. Lucia	5.8	3.1	2.3	3.4	4.1
Trinidad & Tobago	7.5	5.1	6.4	8.9	10.8

Incorporating the increase in pension age into the model outlined above generated improvements in the support ratios and contribution rates required to finance the elderly in the long-term (Table 8). In the case of St. Lucia, the results indicate that the required contribution rates would actually fall if the pension age was increased while those of Jamaica, Barbados and Trinidad and Tobago appear to decline initially in 2005, and then gradually rise through to 2030. By 2030 the contribution rates required to finance retirement

pensions would have fallen by about four percentage points in St. Lucia and Barbados relative to those shown in Table 6. Trinidad and Tobago's tax rate would be approximately five percentage points lower while that of Jamaica would fall by about two percentage points.

An increase in pension age tends to have the effect of easing the burden of paying for long term benefits on future generations in all four of the Caribbean nations, as the time frame for receiving benefits would implicitly be reduced and hence from an annuity perspective the present value of future payments is reduced. However a number of other issues would be raised by this change. Firstly it would be in direct conflict with the trend in individuals' preferences toward an earlier rather than a later retirement, thus some incentive program such as a larger retirement benefit might be needed to encourage workers to defer retirement. The larger pension benefit could be financed by the returns from the investment of the deferred benefits. Secondly, some tax incentives might be required to encourage firms to keep workers for the additional years since older workers might lower the productivity of the firm.

### *Changing the Pension Contract*

Pensions and benefits in the Caribbean are currently calculated from gross earnings; this type of contract contains a built-in potential for collapse. This is related to the point that under the PAYE system, the rules determining pensions tend to be fixed, and the tax rate is adjusted to guarantee that income matches expenditure. Therefore as the proportion of retired persons rises, the ensuing increase in tax rates will result in a decrease in the relative net income of workers. To avoid this an alternative contract which would calculate the pension benefits on the basis of net rather than gross earnings could be employed to reduce

the level of pension benefits, thus containing the growth in contribution rates.

Table 9. Social Security Tax Rates, Fixed Relative to Average Net Earnings 1995-2030

Country	1995	2005	2015	2025	2030
Barbados	9.2	7.8	8.9	13.1	15.9
Jamaica	5.8	4.7	3.8	5.3	6.9
St.Lucia	5.0	5.1	5.8	6.0	9.8
Trinidad & Tobago	7.5	7.6	9.6	13.1	14.2

By modifying equation 2, the impact of linking pension benefits to net earnings on the contribution rates required to finance pensions in the Caribbean can be derived<sup>7</sup> (Table 9). A switch in pension contract would result in a reduction in contribution rates between 1 and 2 percentage points by 2030 in Trinidad and Tobago and Barbados and by less than one percentage point by 2030 in Jamaica and St.Lucia. The marginal effects on the contribution rates suggests that although such a switch may be desirable it is not enough to contain the growth in social security tax rates.

A more effective change to the pension contract might be achieved by taxing any benefits which retirees receive beyond what they have contributed to the social security scheme. In addition, the period over which retirees' benefits are computed could be based on average lifetime earnings rather than on the average of the best years. Although in theory these changes would serve to reduce benefit payments and in turn the level of contribution rates required to fund the schemes, the analysis needed to evaluate these options is beyond

<sup>7</sup>See Appendix I for the derivation of the tax rates required when pensions are linked to average net earnings.

the scope of this paper.

#### *Funded Scheme*

One option which has become popular in Latin America has been the partial or complete replacement of the pay-as-you-go system with a funded pension scheme. Chile adopted this approach in 1981, where workers were given the option of either continuing with the government social security programme or contributing between ten and twenty percent of their wages to any of several private investment funds that would contract to deliver retirement benefits in place of the social security programme. Workers could choose among a number of competing Pension Fund Administration companies (AFPs). Each AFP is a management firm whose investment and operating policies are regulated by the government in such a way that if an AFP were to go bankrupt, funds would still be available to finance retirees' benefits.

Proponents of the funding system tend to highlight both the political and economic advantages of the funded system. Firstly the claim is made that private investment accounts sensitise workers to financial issues and enterprise performance, thus reducing the dichotomy between capital and labour (Piñera, 1991). Secondly the system establishes a close link between contributions and benefits, thus reducing the labour market distortions with which traditional unfunded programmes are considered to be fraught. Thirdly the reform approach furthers and accelerates financial market developments and thus efficiency of resource allocation. Finally it is claimed that funded systems positively affect national savings and capital accumulation and hence, contributes to economic growth (Holzmann, 1997).

Despite these advantages a switch from the pay-as-you-go to a funded system would be difficult due to structure of Caribbean economies. The persistent budget deficits that characterize these economies would make it extremely difficult for their governments to fund the transition and since the capital markets in the region are in their infancy, they are unable to offer workers the level and volume of investment opportunities that are required under a funded system. Also due to the limited levels of foreign exchange in these nations, significant investments in foreign capital markets would be difficult.

#### *A Three Tiered Structure*

Another option available for pension reformers in the Caribbean is to change the existing pay-as-you go structure to a three tiered system. This can be done by desegregating national pension funds into the following three separate tiers:

1. a basic tier, which provides flat rate benefits at subsistence level on a universal pay-as-you go basis from taxation;
2. a mandatory, defined-benefit tier, financed mainly through contributions and operating on a partially funded basis;
3. a complementary tier, based on individual or collective private initiative, and operating on a fully funded basis.

The first tier will provide the means of subsistence for all those persons who have not made the contributions necessary to receive a contributory pension. This would effectively replace the old age non contributory pensions and old age contributory grants present in many of the pension schemes in the Caribbean. The

second mandatory tier, would allow all those who are able to contribute towards their protection to do so. The benefits received would be based on the average earnings received over the working life of the individual. In addition persons who defer their retirement would receive increased benefits when they retired. A privately managed pension plan would constitute the second tier. In this tier, government would need to encourage employers to provide pension plans to their employees. This could be accomplished by exempting the employers' and employees' contributions as well as the investment income on the reserve fund from taxation. Government involvement would also be required to issue extensive, detailed regulations in connection with the development of complementary schemes and to supervise their application (Iyer, 1993).

The three tier structure raises a number of issues , the first relates to determining the percentage of contributions which would go to financing the individual tiers. Secondly, if contributions made to the national insurance schemes are reduced as a result of the tiered system how will the existing pensions due to those who are already eligible to receive retirement benefits be financed.

#### **6. Conclusion**

The preceding discussion has served to underscore the myriad of problems facing Caribbean pension schemes in the future as the proportion of retired persons to workers increases. Indications are that with the exception of St.Lucia whose population is projected to remain relatively youthful, the social security schemes of the other Caribbean nations are in need of significant restructuring if they are to be sustainable in the future. Some possible reform ingredients within the existing scheme might be to increase the retirement age or adjust the pension contract so as to contain the growth in the contribution rates. Also a more radical

change to a funded or three tier system of financing could prove beneficial once the necessary mechanisms are put in place.

It must be clear however that any attempt at pension reform within the Caribbean must be accompanied by economic reform. Caribbean governments therefore need to practise fiscal discipline so as to reduce the use of their national insurance schemes as a cheap source of financing budget deficits. Also public and private pension schemes should be allowed to invest a significant portion of their assets in foreign markets to generate returns necessary to make them financially viable.

#### References

- Bos, Eduard et al.**, 1994-95. *World Population Projections, Estimates and Projections with related Demographic Statistics*. World Bank Book.
- Central Bank of Barbados.**, *Annual Statistical Digest*. Various Issues.
- Eastern Caribbean Central Bank.**, *Report and Statement of Accounts*. Various Issues.
- Halter, W. and Hemming, R.**, 1987. *The Impact of Demographic Change on Social Security Financing*. IMF Staff Papers, Vol. 34, No. 3, pp. 471-502.
- Holzmann, R.**, 1997. *Pension Reform, Financial Market Development and Economic Growth: Preliminary Evidence from Chile*. IMF Staff Papers, Vol. 44, No. 2, pp. 149-178.
- Iyer, S.**, 1993. *Pension Reform in Developing Countries*. International Labour Review, Vol. 132, No.2, pp. 187-207.
- LaFoucade, A.**, 1992. *A Review of The Evolution and Performance of Social Security Schemes in the English-Speaking Caribbean*. Inter-American Conference of Social Security.
- National Insurance Scheme of Barbados.**, *New Insight Magazine*. Various Issues.
- Statistical Institute of Jamaica.**, *Statistical Abstract*. Various Issues.
- Trinidad and Tobago Central Statistical Office.**, *Annual Statistical Digest*. Various Issues.

Appendix

In order to derive an equation linking net earnings to contribution rates, an expression for net earnings must first be derived. The average net earnings is given by,

$$n = (1 - \tau - \hat{\alpha}) \gamma$$

where,  $\tau$  = average personal tax rates and  $\hat{\alpha}$  = Contribution rate. The average pension is then,

$$p = \hat{\beta} n = \hat{\beta} (1 - \tau - \hat{\alpha}) \gamma$$

Since average personal tax rates are assumed to remain fixed over the projection period the expression  $1 - \tau$  will be constant and can hence be replaced by the constant term  $\nu$ . Therefore the average replacement rate defined relative to net earnings, and total pension expenditure is,

$$R \hat{\beta} (\nu - \hat{\alpha}) \gamma$$

The social security tax revenue is given as,  $W \hat{\alpha} \gamma$ , since the social security tax rate is equal to the total pension expenditure divided by total revenue given by,

$$\hat{\alpha} = \frac{R (\nu - \hat{\alpha}) \gamma \hat{\beta}}{W \hat{\alpha} \gamma} \quad (3)$$

Equation 3 solves to become,

$$\frac{\hat{\alpha}}{(\nu - \hat{\alpha})} = \hat{\beta} \frac{R}{W} \quad (4)$$

where,  $\frac{R}{W} = S$ .

The social security tax rate,  $\hat{\alpha}$  is therefore inversely related to the support ratio, average net earnings and the average pension change in the same proportion, reflecting the change in the retention rate  $(\nu - \hat{\alpha})$  as the support ratio worsens, making cost sharing is equitable. Taking the time period into account,  $\hat{\alpha}_0$  = the contribution rate at time 0 and  $\hat{\alpha}_t$  = the contribution rate at time  $t$ , then,

$$\hat{\alpha}_t = \frac{\hat{\beta}_t}{S_t} \quad (5)$$

Where,

$$\hat{\beta}_t = \frac{\hat{\alpha}_0 S_0}{(\nu - \hat{\alpha}_0)}$$

Note that since the average pension and the base used to determine the pension decline by the same proportion the replacement rate remains the same. Therefore,

$$\hat{\beta}_0 = \beta_0 = \alpha_0 S_0 / (v - \alpha_0)$$

and since the replacement rate remains constant,  $\hat{\beta}_t = \beta_0$

Therefore equation 5 becomes,

$$\hat{\alpha} / (v - \hat{\alpha}) = \alpha_0 S_0 / (v - \alpha_0) S, \quad (6)$$

This equation then further reduces to one which relates the after-tax contribution rate to the before tax contribution rate and the average tax rates as shown in equation 7 below.

$$\hat{\alpha}_t = v \alpha_t / (v - \alpha_0 - \alpha_t) \quad (7)$$