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Longevity Effects of Public Pensions: The Case of Japan

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Abstract

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Abstract

Philipson and Becker (1998) point out that public annuities without profit motive management have distortion effects that induce excessive health investment, which in turn leads to excessive longevity. They call these longevity effects of annuities "moral hazard effects." This paper demonstrates that it is more relevant to define the moral hazard effects of public annuities as the portion of longevity effects of public annuities that is in excess of the longevity effects of private annuities, and not as the overall longevity effects of public annuities. The existence of longevity effects of public annuities is also investigated empirically by applying cointegration techniques to aggregate time series data in Japan. It is estimated that partial elasticity of health investment to public pension benefit is approximately twice as large as the elasticity to non-annuitized wealth. The difference can be considered to be the outcome of the substitution effect of the public pension program.

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1 Introduction

Philipson and Becker (1998) point out that public annuities without profit motive management have distortion effects that induce individuals to invest in their health excessively. As a result, longevity increases far more than in the case of non-annuitized individuals. Philipson and Becker call these longevity effects of annuities "moral hazard effects" (A brief explanation of their model is in footnote[1]). Depending on the magnitude of these moral hazard effects, the efficiency losses resulting from them might be too large to ignore vis-à-vis the gains from public annuities (i.e., a retired individual can maintain a certain living standard even if his or her life becomes unexpectedly long).

Therefore, attention should be paid in determining a reasonable range of benefit levels of public annuities, so that the losses from moral hazard effects can be considered tolerable vis-à-vis the gains from public annuities. The higher the benefit level, the larger are moral hazard effects. A good place to start is to compare longevity effects of public annuities with those of private annuities. Historically, when private annuity markets were not well developed, many governments introduced public pension programs. They tended to offer excessively high benefit levels to gain voter support. Yet, there is no sufficient evidence that private annuity markets have failed and that the government intervention was necessary[2]. In an optimally functioning annuity market, the equilibrium level of benefits and premiums would be optimized for individuals in the sense that the gain from the marginal purchase of annuities would balance the costs, including the cost of moral hazard effects. This mechanism in private annuity markets, however, is not well addressed in the Philipson-Becker model (PB model).

[1]Philipson and Becker considered a model on two-commodities-choice (longevity vs. consumption level). Under some assumptions, retired individuals choose an optimal point considering trade-offs between the two commodities. In this model, annuities distort their relative prices. Annuity benefits are paid in installments as long as the individuals live, so that they invest in health excessively compared with the case where they are provided the same amount of lifetime wealth at the initial point in time. In fact, the Philipson and Becker Model (PB model) can be viewed as analogous to Pauly's (1967) model of moral hazard in health insurance in the sense that both models focus on ex-post behavior. Note that these moral hazard effects occur in the ex-post situation. Individuals' ex-ante behavior with annuities is explored in Davis and Kuhn (1992) (DK model).

[2]The hasty introduction of public pension programs may have discouraged the development of private annuity markets.

The objective of this study is twofold. First, a model of a private annuity market is built using the same assumptions as the PB model (i.e., a model based on two-commodities-choice, multiple states in the ex-post situation, and so forth) to explain the point that is not well addressed in the PB paper. This exploration leads to a refined measurement of moral hazard effects resulting from public annuities. It is likely that the benefit level of public annuities becomes excessively high compared with that of private annuities because it is determined through political process. Therefore, it will be more relevant to define the moral hazard effects of public annuities as the portion of longevity effects of public annuities that is in excess of the longevity effects of private annuities, and not as the overall longevity effects of public annuities. This theoretical investigation is presented in Section 2. Second, this study investigates empirically the existence of longevity effects of public pensions. In Section 3, recent cointegration techniques are applied to aggregate time series data in Japan. Because only limited data are available in Japan, only the existence of longevity effects was confirmed. It was not possible to estimate the measure of moral hazard effects. Nevertheless, this writer believes that his findings from the empirical study can serve as good material in discussing public pension reform, as there seem to be few empirical analyses of the PB model. Section 4 presents the conclusion of this paper. Finally, corrections of mathematical errors in Philipson and Becker (1998) are made in the Appendix.

2 Theoretical Comment: The Measure of Moral Hazard

In the first half of their paper[3], Philipson and Becker discuss moral hazard effects of annuities using Rosen's " quantity-quality" of life framework (Rosen (1988, 1994)). This moral hazard model can be viewed as analogous to the one of health insurance in Pauly (1967) in the sense both models focus on ex-post moral hazard as a consequence of individuals' rational behavior[4].

[3]There appear to be mathematical errors in the first half of the PB model although they are not critical to its main conclusion. We correct those errors in the Appendix.

[4]As the recent controversy in the Journal of Health Economics regarding Pauly's model shows, the main interest in the field of health insurance is the optimal degree of insurance coverage given the existence of moral hazard as the feature of health insurance (Nyman(1999), Blomqvist(2001a, b), and Manning and Marquis(2001)). Our discussion is

In the PB model, they compare the opportunity curve of annuitized individuals to that of non-annuitized ones (with lump-sum wealth) holding lifetime wealth constant in Figure 1 in page 559. Then, they argue that the difference of life lengths between two optimized points is the distorted length as a consequence of individuals' moral hazard. In other words, the difference of life lengths is brought by substitution effects of annuities.

Although this discussion can be applied to both private annuities and public ones, we can not fully understand the difference between the two cases in the PB framework. Although they compare the two cases in section II of their paper, they are independently explored, and ex-ante aspects are not sufficiently incorporated. To analyze the difference, we have to consider the two cases simultaneously and take both ex-ante and ex-post aspects into consideration. Fortunately, individuals' ex-ante behavior with annuities was explored in Davis and Kuhn (1992) (DK model). Therefore, We can do those operations by bridging the PB model with the DK model.

First, we review the private annuity case of the PB model. There are multiple states in the ex-post situation. These states are denoted by $s = 1, \ldots, S$ and occur with probabilities $(\pi_1, \ldots, \pi_S)$. In each state, each individual chooses the optimal level of health investment to maximize the indirect utility function. The maximization problem is written as follows:

$$\begin{aligned} &\max_{M_s} \quad V_s(W_s, T_s(M_s)) \\ s.t. \quad &W_s = W_0 + YT_s(M_s) - p - M_s \end{aligned} \tag{1}$$

The indirect utility V_s is the function of W_s (wealth) and T_s (life-length). W_0 is an initial lump-sum asset, M_s is a resource to extend life length, T_s. $T_s(M_s)$ is assumed as a weakly increasing and concave function. Y is an annual benefit level and p is a premium already paid for the annuity. They are exogenous variables in this model. First order conditions are as follows:

$$\frac{\partial V_s}{\partial W_s}\frac{\partial W_s}{\partial T_s}\frac{dT_s}{dM_s} + \frac{\partial V_s}{\partial T_s}\frac{dT_s}{dM_s} = \frac{\partial V_s}{\partial W_s} \tag{2}$$

where $\partial W_s/\partial T_s = Y$. The left hand side is the gain of health investment. The first term represents the gain of receiving the additional annuity benefit accompanying with the increased life-length. The second term represents the gain of the increased life-length. The right hand side is the cost of health investment.

related to the controversy of some aspects.

2.1 Endogeneity of Benefit Levels and Premiums

The PB model deals with the ex-post situation given a certain level of annuity benefit and a premium. We consider how they are determined in the ex-ante situation. That is, we endogenize benefit levels and premiums given the assumptions of the PB model.

We consider a private annuity market that is actuarially fair. An insurance company offers a premium considering the longevity effects of annuities in the ex-post situation. That is, the level of a premium is set to pay the annuity payment that includes the excessive payment resulting from the ex-post moral hazard. We consider the optimal health investment function M_s^* that gives the optimal solution for the ex-post maximization problem (1) when a premium and a benefit level are determined in the ex-ante situation. It can be written as $M_s^*(W_0 - p, Y)$. The optimal health investment will increase if an annual benefit level Y increases because the incentive of living longer is stimulated by a increased benefit level. That is, $\partial M_s^*/\partial Y \geq 0$. However, if Y increases, a corresponding actuarially fair premium p increases, so the amount subtracted from an initial asset level increases. This leads to the decrease of the health investment behavior in the ex-post situation. Therefore, $W_0 - p$ appears in the optimal health investment function as $M_s^*(W_0 - p, Y)$. By the above discussion, $D_1 M_s^* \geq 0$. $D_1 M_s^*$ means differentiating the function M_s^* with respect to the first variable $W_0 - p$. The individuals' ex-ante maximization problem is as follows:

$$\begin{aligned} \max_Y \sum_{s=1}^{S} \pi_s V_s \Big(& W_0 + Y T_s(M_s^*(W_0 - p, Y)) - p \\ & - M_s^*(W_0 - p, Y), \quad T_s(M_s^*(W_0 - p, Y)) \Big) \end{aligned} \tag{3}$$

subject to

$$p = \sum_{s=1}^{S} \pi_s Y T_s(M_s^*(W_0 - p, Y)) \tag{4}$$

In the ex-ante situation, each individual does not know which state will occur to him in the ex-post situation, so he maximizes the expected utility as in (3). The indirect utility function of (3) can be obtained by replacing the health investment function of (1), M_s, with the optimal health investment function, $M_s^*(W_0 - p, Y)$. The constraint (4) represents an actuarially fair premium. An actuarially fair premium must equal the expected annuity

payment. Individuals choose the optimal annual benefit level and pay the actuarially fair premium in the ex-ante situation.

It is difficult to solve this maximization problem because the constraint (4) is the recurrence relation of p. To solve this problem, we replace (4) with $p = P(Y)$. $P(Y)$ is the implicit function. By inserting $p = P(Y)$ into (3), we rewrite the maximization problem as follows:

$$\max_{Y} \sum_{s=1}^{S} \pi_s V_s \Big(W_0 + Y T_s(M_s^*(W_0 - P(Y), Y)) - P(Y) \\ - M_s^*(W_0 - P(Y), Y), \quad T_s(M_s^*(W_0 - P(Y), Y)) \Big) \tag{5}$$

The first order conditions are as follows:

$$\sum_{s=1}^{S} \pi_s \Bigg[\underbrace{\frac{\partial V_s}{\partial W_s} \Big\{ T_s(M_s^*(W_0 - P(Y), Y)) + Y \frac{dT_s}{dM_s^*} \Big(\frac{\partial M_s^*}{\partial Y} - D_1 M_s^* \frac{dP}{dY} \Big) \Big\}}_{(A)} \\ + \underbrace{\frac{\partial V_s}{\partial T_s} \frac{dT_s}{dM_s^*} \Big(\frac{\partial M_s^*}{\partial Y} - D_1 M_s^* \frac{dP}{dY} \Big)}_{(B)} \Bigg] \\ = \sum_{s=1}^{S} \pi_s \Bigg[\underbrace{\frac{\partial V_s}{\partial W_s} \Big\{ \frac{dP}{dY} + \Big(\frac{\partial M_s^*}{\partial Y} - D_1 M_s^* \frac{dP}{dY} \Big) \Big\}}_{(C)} \Bigg] \tag{6}$$

The left hand side is the gain of increasing a benefit level and the right hand side is the cost of it. Before interpreting this condition, we rewrite (4) as follows:

$$\sum_{s=1}^{S} \pi_s Y T_s(M_s^*(W_0 - p, Y)) - p \\ = f(p, Y) = f(P(Y), Y) = 0 \tag{7}$$

By the implicit function theorem, $\frac{dP}{dY}$ in (6) can be written as follows:

$$\begin{aligned} \frac{dP(Y)}{dY} &= -\frac{\partial f(p, Y)}{\partial Y} \Big/ \frac{\partial f(p, Y)}{\partial p} \\ &= \frac{\sum_{s=1}^{S} \pi_s \left\{ T_s(M_s^*(W_0 - P(Y), Y)) + Y \frac{dT_s}{dM_s^*} \frac{\partial M_s^*}{\partial Y} \right\}}{1 + \sum_{s=1}^{S} \pi_s Y \frac{dT_s}{dM_s^*} D_1 M_s^*} \end{aligned} \tag{8}$$

The interpretation of (8) is as follows. (8) represents the effect of the marginal increase of a benefit level to a premium. The numerator expresses the direct

increase of the expected annuity benefit payment resulting from the marginal increase of annual benefit level when we hold a premium level constant. The first term of the numerator represents the payment increase caused by the fact that an annual benefit level increases over a life-length. The second term represents the payment increase caused by the longevity increase stimulated by the strengthened incentives of a benefit increase. However, an actuarially fair premium must increase if the expected annuity payment expressed by the numerator increases. If a premuim increases, as we before mentioned, the amount subtracted from an initial retirement wealth increases. Therefore, individuals will decrease the health investment considering this negative effect. Hence, the positive effect of the increased benefit level on the health investment behavior expressed by the numerator must be discounted by the denominator that expresses the negative effect of the increased premium on the health investment behavior. For the extreme case, if the second term of the denominator is zero, that is, if the denominator is unity, a premium will increase by the size represented by the numerator.

Now we turn to the interpretation of the first order conditions (6). The terms underlined (A) represent the gain from the wealth increase brought by the marginal increase of a benefit level. The first term of (A) is the direct annuity asset increase resulting from the increase of an annual benefit level and the second term is the indirect annuity asset increase resulting from the life-length increase caused by the net increase of health investment, $\left(\frac{\partial M_s^*}{\partial Y} - D_1 M_s^* \frac{dP}{dY}\right)$. As we before mentioned, marginal increase of a benefit level increases an actuarially fair premium as well as the incentive of living longer. Therefore, marginal increase of a benefit level has two opposite effects on health investment behavior. The net increase of health investment is obtained by subtracting the negative effect from the positive effect. The terms underlined (B) represent the gain from the life-length increase similarly caused by the net increase of health investment, $\left(\frac{\partial M_s^*}{\partial Y} - D_1 M_s^* \frac{dP}{dY}\right)$. On the other hand, the terms underlined (C) represent the loss from the wealth decrease brought by the marginal increase of a benefit level. The first term of (C) represents the cost of paying the increased premium. The second term is the cost of the net increase of health investment.

From the above discussion, in an actuarially fair private annuity market, a benefit level and a premium are determined so that the marginal gain of increased annuity wealth and increased life-length balances the marginal cost

of paying a premium and the net health investment.

One of the most important points of this subsection is that a benefit level determined in a private annuity market does not become excessively high. For simplicity, we assume that there exist only two states with the same occurrence probabilities. In one state, the individual can live longer if he invests in health, but he can not even if he does it in the other state. If the difference of life-lengths in two states is not so large, the individual may prefer to live with his own lump-sum wealth rather than to purchase annuities in the ex-ante situation. However, if he can live much longer by health investment in one state, that is, if the difference of life-lengths in two states is so large, his annual living standards (i.e. consumption level) in the state of living longer will become too low if he does not purchase annuities in the ex-ante situation. He can keep the annual living standards at a reasonable level by purchasing a private annuity. We have to pay attention to the fact that this can be achieved by allocating wealth from the state with short life-length to the state with long life-length because we consider an actuarially fair annuities.

As seen in (3) and (4), a lifetime amount of annuity receipt exceeds a premium that the individual already paid if he lives longer than the average life-length (i.e. the expected life-length). The reverse is also true. If a benefit level becomes excessively high, a fair premium will become too expensive. As a result, the individual with the state of short life-length has to live with quite a small asset. This decrease of the life-time asset would lead to the reduction of health investment and consumption. Therefore, the life-length would become even shorter and the living standards would become lower in this state. These effects bring a serious utility decrease. Of course, in turn, the individual who can live longer would enjoy both the long life-length and high living standards. However, the degree of the utility decrease in the state with short life-length would exceed the degree of the utility increase in the state with long life-length. For example, usual people would make much of the utility decrease when they can live to the age of 60 years old + α by health investment in comparison with the case of the utility increase of 80 years old + α. Because the life expectancy has grown in many countries, the marginal unit of life-length would have the greater utility for the people whose life-lengths are shorter than the life expectancy than for the people whose life-lengths are longer. Hence, the amount of the wealth allocation between two states is restricted to a certain degree. This means that there exists the pressure to restrict the rise of a benefit level to a certain range in

a private annuity market.

From the above discussion, a benefit level and a premium are determined by the conditions (6), and their levels would not become excessively high because of the existence of the serious utility decrease in the less favorable state. Now we assume a unique solution to the problem (3). In this case, if the government introduces the public annuity program that gives an excessively higher benefit level compared to the level determined by the conditions (6), the welfare decreases. We explore this point in the next subsection.

2.2 The Measure of Moral Hazard

In this subsection, we consider the government introduces a public annuity program that is actuarially fair into the above world. Suppose that the public annuity system provides the same level of benefit as the private annuity market does. If public annuities and private annuities are perfect substitutes, there will be no special effects on people who have been purchasing private annuities. However, the benefit level of public annuities is determined through the political process, and it is often set at a much higher level compared with the benefit level in the private annuity market. In this case, the degree of the moral hazard will become excessive, and the total welfare of individuals will decrease.

The intuition is as follows. Even if there exists some moral hazard, the equilibrium level of a benefit and a premium determined by the private market is optimized for individuals in the sense that the marginal gains from reallocating incomes balance the marginal costs of paying premiums. However, if the government introduces the public annuity program with an excessively high level of benefit, it distorts the opportunity curve in the PB model more seriously, the degree of the moral hazard becomes excessive, and the total welfare of individuals decreases. Considering these aspects, we should compare the opportunity curve of public annuities to that of private ones in the PB model holding lifetime wealth constant. The difference of these two optimized points can be used as the measure of excessive moral hazard produced by public annuities.

Historically, many governments tended to offer excessively high benefit levels of public annuities to win popularity among voters. However, there does not exist sufficient evidence to prove the failure of private annuity markets and to request the intervention by the government. Our measure of moral hazard will be meaningful in evaluating the current public pension

schemes if it is empirically estimated. In addition, although we have focused on substitution effect in making a comparison between private annuities and public ones where the benefit of each individual balances with the contribution in their lifetime, the wealth effect has become bigger and bigger in the real world. In Japan, the government increased the benefit level over and over again when the ratio of the elderly people in the total population was small. At the same time, the ratio of government subsidies in the contribution of the public pension program has increased significantly. Because of these factors, the program has accelerated longevity effects not only through the substitution effect but also through the wealth effect.

Here, we demonstrate the above discussion in mathematical expositions, given the assumptions of the PB model. First, recall the maximization problem (1). In the PB model, each individual chooses the health investment, M_s, to maximize the indirect utility. We transform this problem to the one that each individual chooses the life-length, T_s. We can consider that the relationship between T_s and M_s is bijective from the PB paper's context. Therefore, we can consider the inverse function, $M_s(T_s) = T_s^{-1}(M_s)$, and by using this, the transformation of the maximization problem (1) can be achieved. These transformations are necessary to illustrate the PB paper's Figure 1 in page 559 with mathematical rigorousness. The case of individuals with private annuities is as follows:

$$\max_{T_s} \quad V_s(W_s^{Pr}, T_s) \tag{9}$$
$$s.t. \quad W_s^{Pr} = W_0^{Pr} + Y_{Pr}T_s - p - M_s(T_s)$$

The subscript Pr represents "Private". Also in this subsection, we consider the case of partial annuitization. $Y_{Pr} > 0$ is the annual benefit level of the private annuity. The marginal gains of risk-allocation must balance the marginal costs of ex-post moral hazard in the ex-ante situation when this benefit level and the corresponding premium are determined. This mechanism has already been explained in the previous subsection. A premium p is an exoginous variable throughout this subsection because we have returned to the ex-post model.

Next, we consider the individuals with public annuities that are actuarially fair. We consider the case where the benefit level of public annuity Y_{Pu} is determined politically and exceeds that of private one. That is,

$$Y_{Pu} > Y_{Pr} > 0 \tag{10}$$

The subscript Pu represents "Public". The maximization problem of the case of individuals with public annuities is as follows:

$$\max_{T_s} \quad V_s(W_s^{Pu}, T_s) \tag{11}$$
$$s.t. \quad W_s^{Pu} = W_0^{Pu} + Y_{Pu}T_s - p - M_s(T_s)$$

Finally, the case of individuals with non-annuitized wealth only is as follows:

$$\max_{T_s} \quad V_s(W_s, T_s) \tag{12}$$
$$s.t. \quad W_s = W_0 - M_s(T_s)$$

The relationships between the opportunity curves of private annuities, public annuities and lump-sum wealth when we hold lifetime wealth constant are illustrated in Figure 1. The reason is as follows. The opportunity curves of these three cases are represented by the constraints of (9), (11) and (12). By comparing the slope of three curves, we can know the relationships as in Figure 1. The slopes are obtained by differentiating the constraints of (9), (11) and (12) with respect to T_s,

$$\frac{dW_s^{Pu}}{dT_s}(Ts) = Y_{Pu} - \frac{dM_s}{dT_s} > \frac{dW_s^{Pr}}{dT_s}(Ts) = Y_{Pr} - \frac{dM_s}{dT_s} > \frac{dW_s}{dT_s}(Ts) = -\frac{dM_s}{dT_s} \tag{13}$$

where

$$\frac{dM_s}{dT_s} = \frac{1}{\frac{dT_s}{dM_s}} \geq 0 \tag{14}$$

by the inverse function theorem. Next, suppose that the optimal point of the public annuity case is represented by $Pu(T_s^*, W_s^*)$. We can illustrate three curves intersecting at this optimal point of public annuities because we have already known the slopes of three curves. The fact that three curves intersect at one point means that we hold lifetime wealth constant in comparing these three curves. Figure 1 can be illustrated for each state. Note that there is no guarantee that real opportunity curves intersect at one point in each state. We focus on the substitution effect in this subsection and Figure 1 is illustrated so that we can compare three curves holding lifetime wealth constant. From these reasons, we can know the relationships between the opportunity curves of three cases as in Figure 1.

Now we define the measure of moral hazard. Suppose that the optimal points of the private annuity and the lump-sum wealth are represented

as $Pr(T_{Pr}, W_{Pr})$ and $Sv(T_{Sv}, W_{Sv})$, respectively as in Figure 1. In the PB model, the distorted length by the longevity effects of public annuities is measured as $T_s^* - T_{Sv}$. However, as we mentioned, we can consider $T_s^* - T_{Pr}$ as the measure of "excessive" ex-post moral hazard when there exist excessive public annuities.

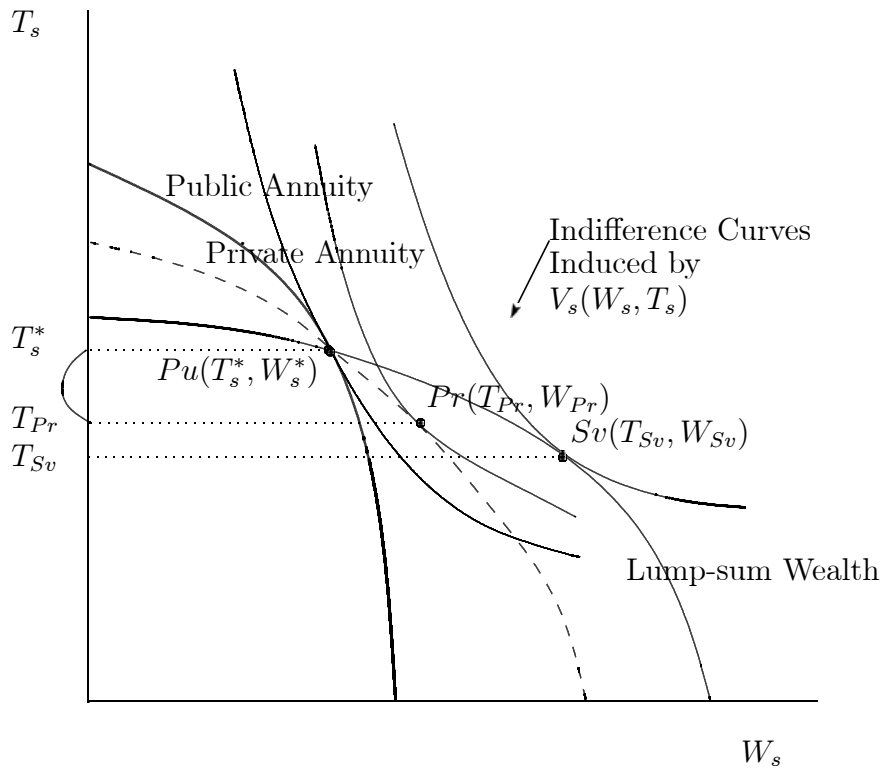

Figure 1: The Measure of Moral Hazard

Note: We illustrate this figure so that three curves intersect at the optimal point of the case of public annuities in order to focus on the substitution effect of annuities. This figure can be always applied even if we consider multiple states or single state in the ex-post situation. However, we have to consider the multiple states model. If there is only one state in the ex-post situation, that means there exist no uncertainties, so there is no need for annuities. Regarding this point, JPE version of the PB model (Philipson and Becker (1998)) has contradiction. They consider multiple states in private annuities, but one state in public annuities. NBER version of the PB model (Philipson and Becker (1996)) considers the one state model first, then they proceed to the multiple states model. The one state model is good for illustration purpose, but not strict in terms of theoretical consideration. Multiple states are necessary when we consider annuities because uncertainty is the reason for the need for annuities.

3 Empirical Analysis

In this section, we investigate empirically the existence of longevity effects of public pensions using Japanese data. To estimate the longevity effects, it may be better to use panel data because we can get more accurate estimates. However, we are in face of limitation of data, so we choose to use aggeregate time series data. We apply sophisticated cointegration techniques to aggregate time series data in Japan.

3.1 Background

First, we review the concept of the longevity effects. In the PB model, the increase of public pension benefit increases the incentives of living longer, so individuals increase the amount of health investment. As a result, life expectancy increases. This mechanism is illustrated in Figure 2. There exist two channels in this mechanism. For the second channel, Lichtenberg (2000) confirms its existence using U.S. aggregate time series data. The result suggests that health investment of individuals accounts for the increase of life expectancy for the period 1960-1997. On the other hand, there is few empirical literature about the first channel. Therefore, if the first channel is empirically confirmed, it will provide support for the PB hypothesis. We investigate this first channel.

$$\text{benefit level} \xrightarrow{①} \text{health investment} \xrightarrow{②} \text{life expectancy}$$

Figure 2: Two Channels

3.2 Model and Data

Next, we specify the econometric model. In the PB model, the health investment of retired individuals is determined by considering the amount of the non-annuitized wealth and the benefit level of public pensions. We add the extra explanatory variables to these two variables using the fruit of the empirical literature of health care expenditure function (see Murthy and Ukpolo (1994) and Hansen and King (1996)). The extra variables are the ratio of public expenditure in national medical expenditure and the relative price of medical care. As the latter half of the PB paper shows, we expect that the

public subsidy for medical care expenditure increases the health investment of individuals. On the other hand, we do not know whether the rise of the relative price of medical care increases it. It depends on whether medical care has a characteristic of necessary goods.

We also pay attention to the definition of health investment. In general, health investment includes various choices in lifestyles as well as direct health care expenditure. However, we consider the latter in this paper because of the difficulties of observation.

We consider the model per household and use the Family Income and Expenditure Survey (FIES hereafter) in Japan. It is better to use the household data on the group with the retired householder. However, it is difficult to get such Japanese data sufficiently, so we use the household data on the group with the 55-59 years old householder. Considering the current Japanese public pension scheme, we may assume the beginning age of receipt of public pension is 60. Hence, the above household has paid the most part of the total premium. Therefore, we can test the PB hypothesis by using this age group. The model is as follows:

$$lnHC = ln\beta_0 + \beta_1 lnW + \beta_2 lnPEN + \beta_3 lnPF + \beta_4 lnRPHC + \mu \qquad (15)$$

where

HC Yearly average of monthly private health care expenditure per household converted by medical care CPI

W Household wealth (savings minus liabilities) at the end of the previous year converted by the current year's general CPI

PEN Yearly average of monthly public pension benefits which the typical household will receive in the future converted by general CPI

PF The ratio of public expenditure in national medical expenditure

RPHC The ratio of medical care CPI to general CPI

μ A mean-zero error term

We use the double-logarithmic model. This model is popular in the literature of health care expenditure function. The coefficients of this model equal the partial elasticities.

HC is obtained from the FIES. This variable corresponds to the concept of health and medical care expenditure in FIES. This item consists of expenditure to medicine, products taken for health maintenance, health and medical equipment and tool, and health and medical care services. HC is "private" health care expenditure and does not include public one. Considering the PB model assumptions, we should define the explained variable as private health care expenditure. Public health care expenditure is strongly influenced by political consideration. W is obtained from the Family Savings Survey (FSS hereafter). As FSS had been a supplemental survey to FIES in order to obtain data on the stock of household economy, we can obtain the household data on the group with the 55-59 years old householder[5]. PEN is obtained from the Annual Report by Social Insurance Agency in Japan[6]. We assume the typical household receiving the public pension benefit consists of employee's pension (*kousei-nenkin*) and national pension (*kokumin-nenkin*). PEN is the sum of employee's pension and national pension benefit. PF is obtained from the National Medical Expenditure in Japan. The some items of health care expenditure in FIES above mentioned are subsidized with the public expenditure because they are classified as national medical expenditure defined by the government. Hence, we expect the ratio of public expenditure in national medical expenditure influences the private health care expenditure. Finally, all price data are obtained from the Consumer Price Index in Japan.

The data used for estimation are annual data. The sample period is 1970-2001 (32 observations). The sample size is almost the same as that of the empirical literature of the usual health expenditure function above mentioned. We expect the signs of the estimated coefficients of the all variables except $lnRPHC$ in equation (15) are positive. In addition, the size of the coefficient of $lnPEN$ (the benefit level of the public pension) would exceed that of lnW (the current non-annuitized household wealth) to a great degree if the PB hypothesis holds. We can consider the coefficient of $lnPEN$ as the sum of the substitution effect and the wealth effect of the public pension and the coefficient of lnW as the wealth effect. Therefore, the difference between two coefficients can be considered as the approximation of the substitution effect of the public pension.

[5]FSS was integrated into FIES in 2002.

[6]Before performing the emprical analysis, the author found that there exist errors in the reported data of the Annual Report. He pointed out the errors to Social Insurance Agency. He got the corrected data from it and used those data in the empirical analysis.

3.3 Unit Root Tests

First, we perform the unit root tests. Table 1 reports the results of the Dickey-Fuller GLS test suggested by Elliott, Rothenberg and Stock (1996). All variables except $lnPEN$ in the intercept model show that they are I(1). We also perform the KPSS test[7] for $lnPEN$ in the intercept model, and the result shows $lnPEN$ is I(1)[8]. Hence, we conclude all variables are I(1) and proceed to the cointegration tests.

3.4 Cointegration Tests

Next, we perform the cointegration tests. To determine the cointegrating rank when there is the possibility of the existence of the multiple cointegrating vectors, the most popular method is the Johansen procedure (Johansen (1991, 1995)). However, the performance of this procedure is sensitive to misspecification. Although several tests have been suggested to allow for more general dependency, the Shintani's nonparametric test (Shintani (2001)) may be better among those in the sense that we do not need to estimate a vector autoregressive model. Hence, we perform both the Johansen procedure and the Shintani's nonparametric test for confirmatory purpose in determining the cointegrating rank, and estimate the cointegrating vector by the Johansen procedure[9][10].

The results are reported in Table 2. The first column shows the null of the cointegrating rank. Λ_{max} and Λ_{trace} are the maximum eigenvalue statistic and the trace statistic of the Johansen test respectively. P_μ and P_μ^* are the first and the second type of the test statistic of the Shintani test respectively. First, we use these tests for the single hypothesis that there exists a single cointegrating vector predicted by the theoretical model. All the four tests do not reject the null at the 1 percent significance level. Next, we use these

[7]This test is suggested by Kwiatkowski, Phillips, Schmidt, and Shin (1992). The null of this test is stationary.

[8]The test statistic shows 0.641 in the level and 0.455 in the first difference.

[9]The author thanks Professor Mototsugu Shintani for providing him with the GAUSS program of the Shintani test.

[10]The Johansen procedure is known as reduced rank regression and based on the idea that the reduced rank of the coefficient matrix in the vector error correction model representaion corresponds to the concept of cointegration. On the other hand, the Shintani test is based on the idea that the degeneracy of the sample moment matrix corresponds to the concept of cointegration.

tests as the sequential procedure to determine the cointegrating rank. This means that we impose a stronger requirement on the model. Λ_{max} and Λ_{trace} select 1 cointegrating rank at the 1 percent significance level while P_μ and P_μ^* select 0 cointegrating rank. Hence, the Johansen test and the Shintani's nonparametric test suggest that there exists a single cointegrating vector with the exception of the Shintani test with a stronger requirement. Therefore, we can conclude that there exists a unique long-run relationship as depicted in equation (15).

Finally, Table 3 reports the normalized cointegrating vector estimated by the Johansen procedure. The result is just like the one the PB model predicts. The signs of the coefficients of lnW and $lnPEN$ are positive. The estimated partial elasticity of the private health expenditure to the public pension benefit is about twice as large as the elasticity to the non-annuitized wealth. This difference of 0.317 can be considered as the outcome of the substitution effect of the public pension program. The two estimated coefficients are also statistically significant at 1 percent level. In addition, the estimated coefficient of $lnPF$ is positive. As the PB model predicts, the public health program as well as the public pension program seems to influence strongly the health investment behavior of the elderly people. Lastly, the estimated coefficient of $lnRPHC$ implies that medical care is the necessary good for the elderly people. Considering all the results, our empirical analysis shows the supportive outcome for the PB hypothesis.

Table 1: DF-GLS Test

Trend and Intercept

Variables	Level	First Difference
lnHC	-3.170(0)	-9.122(0)*
lnW	-2.250(0)	-5.698(0)*
lnPEN	-1.194(4)	-7.696(0)*
lnPF	-1.780(0)	-3.606(0)*
lnRPHC	-1.654(1)	-5.142(0)*

Intercept

Variables	Level	First Difference
lnHC	-1.286(0)	-7.108(0)*
lnW	-0.880(0)	-4.289(0)*
lnPEN	-1.089(0)	-1.841(1)
lnPF	-1.300(0)	-3.271(0)*
lnRPHC	-1.334(1)	-4.191(0)*

Note: * denotes rejection of a unit root hypothesis at 5 % significance level. Lag-adjusted finite sample critical values are computed from response surface equations suggested by Cheung and Lai (1995). Lags selected by SIC in parentheses. An upper bound to the lag length is chosen by the formula: $l_{max} = int(12(T/100)^{1/4})$ where T is the number of samples.

Table 2: Tests for Cointegrating Rank

$\mathcal{H}_0$	Λ_{max}	Λ_{trace}	P_μ	P_μ^*
r=0	52.535**	102.769**	61.817	122.318
r=1	24.778	50.234*	31.739	44.932
r=2	15.205	25.455	9.491	11.314
r=3	7.585	10.250	0.826	0.916
r=4	2.664	2.664	0.000	0.001

Note: * and ** denote rejection of the hypothesis at 5 % and 1 % significance level respectively. Critical values for the Johansen test are taken from Osterwald-Lenum (1992). Those for the Shintani's nonparametric test are taken from Phillips and Ouliaris (1990) and Shintani (2001). The likelihood ratio test, AIC and SIC suggest that the VAR lag length for the Johansen test is two, so we choose it.

Table 3: The Cointegrating Vector by the Johansen Procedure

lnHC	lnW	lnPEN	lnPF	lnRPHC
-1.000	0.274**	0.591**	0.743**	0.016
	(0.071)	(0.085)	(0.269)	(0.316)

Note: Asymptotic standard errors are in parentheses. ** denote significant at 1 % level.

4 Conclusion and Discussion

Philipson and Becker (1998) point out that public annuities without profit motive management have distortion effects that induce excessive longevity. They call these longevity effects of annuities "moral hazard effects". To get a clue to a reasonable range of the benefit levels of public annuities at which the losses from longevity effects can be considered tolerable vis-à-vis the gains from public annuities, this paper endogenizes benefit levels and premiums in private annuity markets using the same assumptions as the PB model. This exploration leads to a refined measure of moral hazard effects resulting from public annuities. That is, it is more relevant to define the moral hazard effects of public annuities as the portion of longevity effects of public annuities that exceeds longevity effects of private annuities, not as the overall longevity effects of public ones. Then, we investigate empirically the existence of longevity effects of public annuities. We apply cointegration techniques to aggregate time series data in Japan. The result suggests that the Japanese public pension program increases health investment of the elderly people by stimulating incentives of living longer. The estimated partial elasticity of health investment to public pension benefit is approximately twice as large as the elasticity to non-annuitized wealth. The difference can be considered to be the outcome of the substitution effect of the public pension program.

However, if we hope more exact evaluation of the current public pension scheme, we should estimate the measure of the moral hazard effects of public annuities suggested in the theoretical part. This estimation needs more detailed data and is our next assignment. Depending on the magnitude of moral hazard effects, we might need to re-design public pension schemes. In addition, under Pay As You Go system, adopted in Japan as well as the U.S., these moral hazard effects would increase the total amount of public pension payments excessively, and this would lead to financial crises of systems. In fact, Japanese PAYG system is facing a serious financial crisis that might partly come from longevity effects of the system. Considering the PB model's implication, this crisis can be eased by switching to a new scheme. For example, the personal account type of public pensions suggested by Kotlikoff (1998) would eliminate these moral hazard effects because the total amount of public pension benefits to each individual is fixed at the retired point. The individuals have no incentives to invest in health to recieve excessive pension benefits.

Appendix: Correction of Mathematical Errors in the PB paper (1998)

1. In page 557, line 17, the mortality-contingent wealth $W(T_s) = YT_s - p$ must be corrected as $W(T_s) = W_0 + YT_s - p$. W_0 is the initial retirement wealth. The former $W(T_s) = YT_s - p$ means only the net increase of wealth. However, because individuals' health investment behaviour is affected by the overall wealth level, not the net increase only, we must define the mortality-contingent wealth as $W(T_s) = W_0 + YT_s - p$.

2. In page 557, line 3 from the bottom, the first order conditions

$$\pi_s \frac{dT_s}{dM_s}(V_W Y + V_T - V_W) = \frac{dp}{dM_s} E[\, V_W \,]$$

must be corrected as

$$\pi_s \left\{ \frac{dT_s}{dM_s}(V_W Y + V_T) - V_W \right\} = \frac{dp}{dM_s} E[\, V_W \,]$$

3. In page 558, line 3 from the bottom, the first order conditions

$$V_W Y + V_T = V_W$$

must be corrected as

$$\frac{dT_s}{dM_s}(V_W Y + V_T) = V_W$$

This error was induced by the above error 2. Because this equation is derived by setting dp/dM_s in the above F.O.C. as zero, the incorrect equation was derived from the incorrect F.O.C..

4. Finally, the model of public annuities case must be corrected as the multiple states model. The model begins from the page 558 is the single-state model (i.e. the deterministic model) because the subscript that represents a state is not used in this subsection. As we mentioned, if there is only one state in the ex-post situation, that means there exist no uncertainties, so there is no need for annuities. Regarding this point, JPE version of the PB model (Philipson and Becker (1998)) has contradiction. They consider multiple states in private annuities,

but one state in public annuities. NBER version of the PB model (Philipson and Becker (1996)) consider the one state model first, then they proceed to the multiple states model. The one state model is good for illustration purpose, but not strict in terms of theoretical consideration. Multiple states are necessary when we consider annuities because uncertainty is the reason for the need for annuities.

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