The point of concern about the implementation of Liability-Driven Investment (LDI) in a pension plan in Japan

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Abstract

The immediate recognition on balance sheet is examined on International Financial Reporting Standards (IFRSs). If it takes place, many companies would like to reduce volatility of funding status in pension plan. Therefore there is a possibility that Liability-Driven Investment (LDI, the invested method to decrease the volatility of the difference (surplus) between the pension asset and the liability on accounting) would become one of the attractive alternatives of the pension investment strategy.

Although examples of application of LDI in frozen pension plans in the United Kingdom and the United States are reported[1], LDI looks uncommon in Japan. The typical reasons are that there are few frozen pension plans, the period of the liability on pension plans is too long to set the bonds corresponding to their period, the current interest rate is too low and the further bond investment does not look like a wise strategy, etc.[1]

If we would implement LDI in an active pension plan, the future accruals might complicate it. In this paper, I discuss the asset allocation method which allows an active pension plan to carry out LDI.

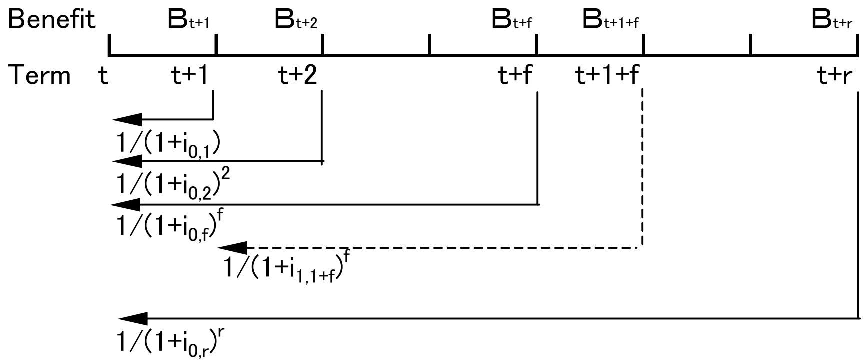
In Japanese GAAP(JGAAP), a single interest rate corresponding to the average remaining benefit period of the pension plan must be used as the discount rate for measuring DBO (Defined Benefit Obligation) other than using the term structure of interest rate, so-called yield curve. The term structure of interest rate is to be considered principally in IAS19, where DBO fits for the bond much better than the single interest rate. As an adoption of IFRSs is anticipated in JGAAP, I discuss DBO measured with yield curve in this paper.

1. DBO and a net cash-flow

In this chapter I confirm that DBO can be written by a present value of the net cash-flow defined in the following.

At first I consider a definition of DBO based on yield curve. "$I_{n,n+f}$" is the interest rate of (n+f)-th year starting from n-th year, and is called "forward-rate". If n=0, it is "spot-rate".[2] DBO can be stated as (eq-1) if "B_{t+1}" is assumed benefit of one year in the "t" year.[3] I discuss based on "a fixed amount per period standard" used generally Japanese accounting standards to simplify an equation this time. I define a net cash-flow(CF) of each year as (eq-3), benefit(B)－service cost(SC). Then DBO becomes the summation of discounted every years' CF shown (eq-7). The period until retirement is "r" years. Because we are unfamiliar with "forward-rate", I mentioned equations slightly in detail. DBO becomes finally the present value of discounted net cash-flow (benefit - SC) of each year at "spot-rate" according

Fig.1



$$DBO_t = \Sigma B_{t+f} \frac{t}{t+f} \frac{1}{(1+i_{0,f})^f} \quad \cdots \text{(eq-1)}$$

$$DBO_t = B_{t+1} \frac{t}{t+1} \frac{1}{1+i_{0,1}} + B_{t+2} \frac{t}{t+2} \frac{1}{(1+i_{0,2})^2} + \cdots\cdots + B_{t+r-1} \frac{t}{t+r-1} \frac{1}{(1+i_{0,r-1})^{r-1}} + B_{t+r} \frac{t}{t+r} \frac{1}{(1+i_{0,r})^r}$$

$$DBO_{t+1} = B_{t+1+1} \frac{t+1}{t+1+1} \frac{1}{1+i_{1,2}} + B_{t+1+2} \frac{t+1}{t+1+2} \frac{1}{(1+i_{1,3})^2} + \cdots\cdot + B_{t+1+r-1} \frac{t+1}{t+1+r-1} \frac{1}{(1+i_{1,r})^{r-1}}$$

$$= B_{t+2} \frac{t+1}{t+2} \frac{1+i_{0,1}}{(1+i_{0,2})^2} + B_{t+3} \frac{t+1}{t+3} \frac{1+i_{0,1}}{(1+i_{0,3})^3} + \cdots\cdots + B_{t+r} \frac{t+1}{t+r} \frac{1+i_{0,1}}{(1+i_{0,r})^r}$$

$$= DBO_t \frac{t+1}{t} (1+i_{0,1}) - B_{t+1}$$

$$= DBO_t (1+i_{0,1}) + DBO_t \frac{1+i_{0,1}}{t} - B_{t+1}$$

$$= DBO_t (1+i_{0,1}) + SC_{t+1} - B_{t+1}$$

$$= DBO_t (1+i_{0,1}) - CF_{t+1} \quad \cdots \text{(eq-2)}$$

$$CF_{t+1} = B_{t+1} - SC_{t+1} \quad \cdots \text{(eq-3)}$$

$$SC_{t+1} = DBO_t \frac{1+i_{0,1}}{t} = \Sigma B_{t+f} \frac{1}{t+f} \frac{1+i_{0,1}}{(1+i_{0,f})^f}$$

$$SC_{t+2} = DBO_{t+1} \frac{1+i_{1,2}}{t+1} = \Sigma B_{t+1+f} \frac{1}{t+1+f} \frac{1+i_{1,2}}{(1+i_{1,1+f})^f} \quad \cdots \text{(eq-4)}$$

$$DBO_t = CF_{t+1}/(1+i_{0,1}) + CF_{t+2}/(1+i_{0,2})^2 + \cdots\cdot + CF_{t+r-1}/(1+i_{0,r-1})^{r-1} + CF_{t+r}/(1+i_{0,r})^r + DBO_{t+r}/(1+i_{0,r})^r \quad \cdots \text{(eq-5)}$$

$$DBO_{t+r} = B_{t+r+1}/(1+i_{r,r+1}) + B_{t+r+2}/(1+i_{r,r+2})^2 + B_{t+r+3}/(1+i_{r,r+3})^3 + \cdots\cdot$$

$$= CF_{t+r+1}/(1+i_{r,r+1}) + CF_{t+r+2}/(1+i_{r,r+2})^2 + CF_{t+r+3}/(1+i_{r,r+3})^3 + \cdots\cdot \quad \cdots \text{(eq-6)}$$

$$DBO_t = \Sigma CF_{t+f}/(1+i_{0,f})^f \quad \cdots\cdots \text{(eq-7)}$$

to (eq-7). It is necessary for us to be careful that SC of each year is calculated by "forward-rate" and SC changes by change in interest rates according to (eq-4). It is important that the bond price is equal to the amount of DBO theoretically if a bond portfolio is made of the net cash-flow of each year. This indicates possibility of the bond investment in the pension plan that is not frozen with SC. The cash-flow of each year is slightly incomprehensible with (eq-1), the net cash-flow which subtracted SC from benefit of each year with (eq-3) is plain on a practical level.

Generally the cash-flow means payment and contribution, but (eq-7) becomes the definition itself of Actuarial reserve in funding if SC is replaced with contribution. The investment is administered with payment and contribution in funding separately from accounting standards in practice. If we use the net cash-flow, a difference of the cash-flow in funding and in accounting is replaced with the difference of the contribution and SC. The purpose of LDI is to match the market value of the bond to DBO. A surplus occurs by the difference of SC and contribution even if I have been able to achieve this purpose. Therefore, if we take this strategy, we should grasp the difference of SC and contribution and we should administer to become “contribution ≧ SC”. Therefore it means that we should balance funding in accounting standards.

2. The characteristic of DBO by the examples

In this chapter, I explain the characteristic of DBO by the examples as follows.

Fig.2 is the result of DBO by discount rates of 1～3% and the yield curve (fig.3). 'DBO' in fig.2 means DBO by person, and the yield curve in fig.3 is modelled at the measurement date of 30^{th} June 2009. The example of the pension plan is as follows; join the plan at the age of 22, the curve of the benefit amount is as fig.2, the withdrawal (retirement) rate including mortality rate is as fig.4, the eligibility requirement for the pension is over 20 years of the enrollment period, the pension benefit starts from at the age of 60 and lasts for 20 years, interest rate during annuitant is 3.0%, interest rate during deferred annuitant is 2.0%, and assuming no one choose lump sum instead of pension.

It shows that the DBO expressed by yield curve is similar to those with discount rate by 2.0%. As it is forward yield curve, let us pay attention to the age of the participants of the pension. We can find out that DBO of young participant is smaller than 2.0%. It is because during the long term till the end of the benefit years, the high interest rate would be applied. Conversely, over the age of 50, DBO becomes larger than 2.0%. It is because the low interest rate would be applied. In addition, as DBO around the age of 60 is large, we can point out the trend that DBO becomes larger when the number of participants over 50-year-old and annuitants are large. We can use the average remaining benefit period as the discount rate. So the pension plans whose withdrawal rate are low, the probability of applying long term discount rate is high. Also, such plans may have many annuitants. In such plans there is a high possibility that DBO would be higher than 2.0%

In fig.5 I compare DBO which discount rate is 2.0% and the actuarial reserves on funding. As for the actuarial reserves, I set three models as follows; setting the contribution each year as a flat rate, setting the contribution slides each year (2 models of sliding). DBO and the actuarial reserve are equal at the age of 60, as the amount of the benefit after 60 years old are the same. Also, every age under 60 years old, the amount of the benefit is the same even if we take any of those three models. This fact shows us that the differences of the amount of the liability between three models are caused by the contribution or SC. As for the model of a flat rate, the accumulation of the contribution brought forward most rapidly. That makes the actuarial reserve large at every age. As for the model which the amount of contribution②(or SC) is small in young age, the amount of the actuarial reserve(or DBO) would be small at every age. The gap between the contribution and SC at slide② in fig.6 is caused by the interest cost in the contribution.

3. DBO with the pension plan

In this chapter, I consider the DBO with the pension plan with participants and annuitants (including deferred annuitants). The distribution of them is as in fig.7. They joined the plan at the age of 22, no participant joins from 0^{th} year, the benefit amount is as fig.2, and the withdrawal rate including mortality rate is as fig.4.

Fig.2 Benefit (curve) vs DBO (per person)

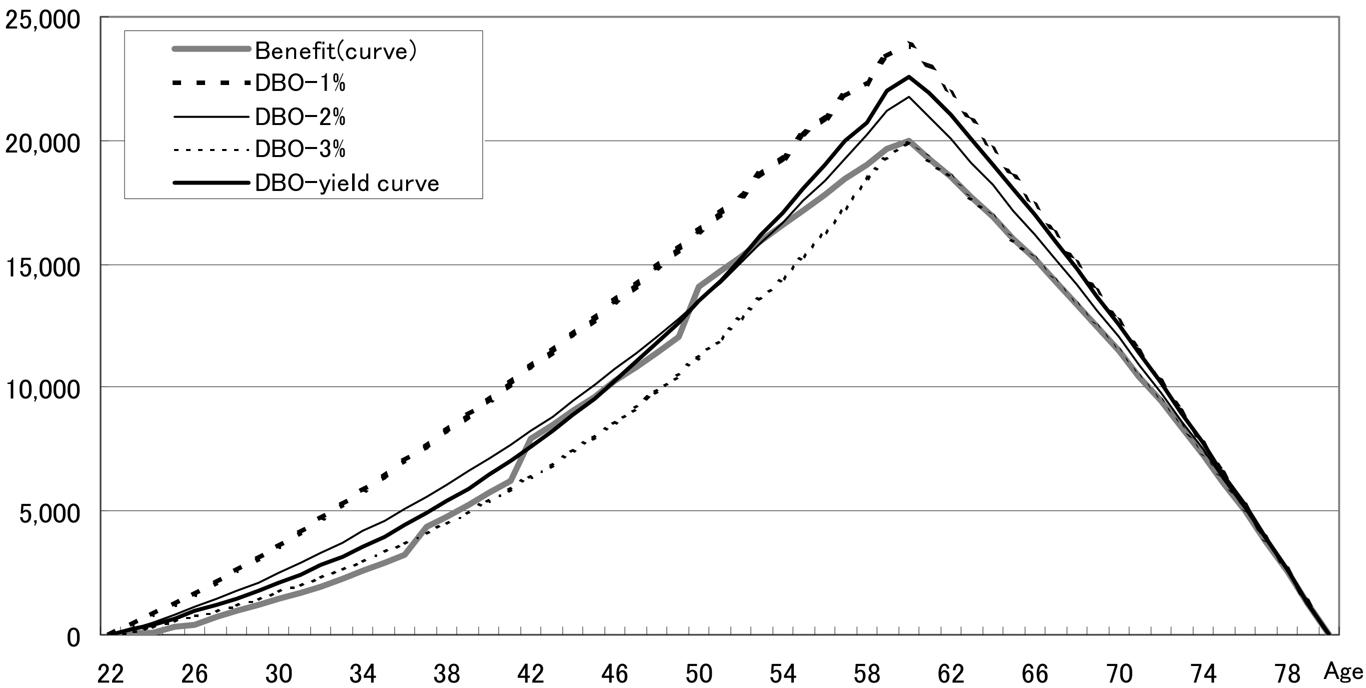


Fig.3 Yield curve

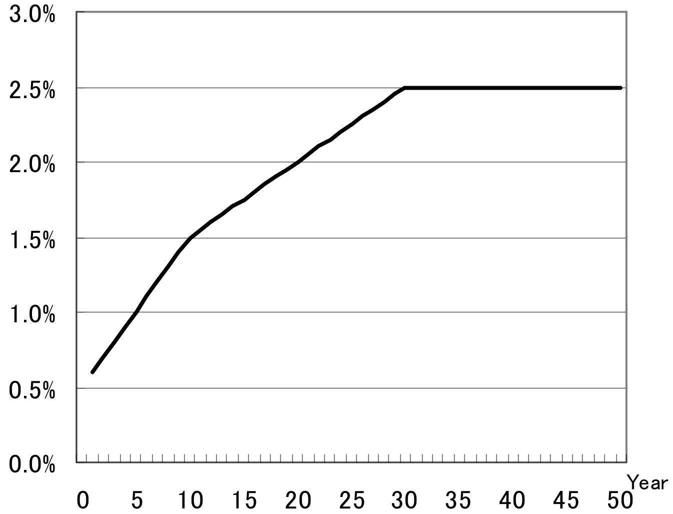


Fig.4 Withdrawal (retirement) rate

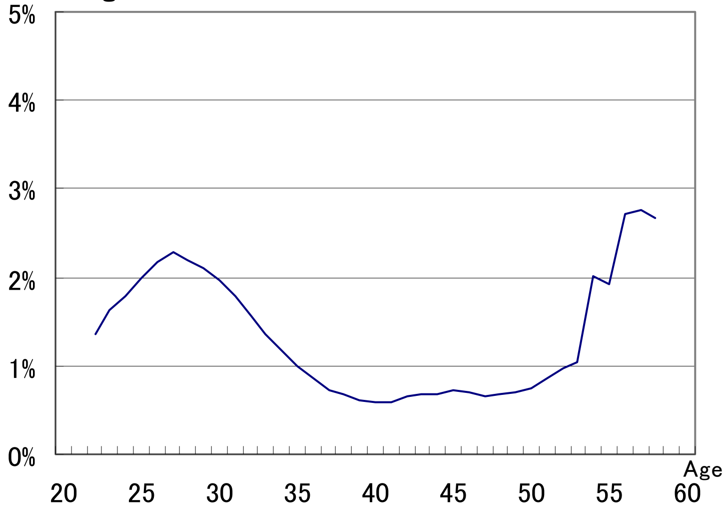


Fig.5 DBO vs actuarial reserve (per person)

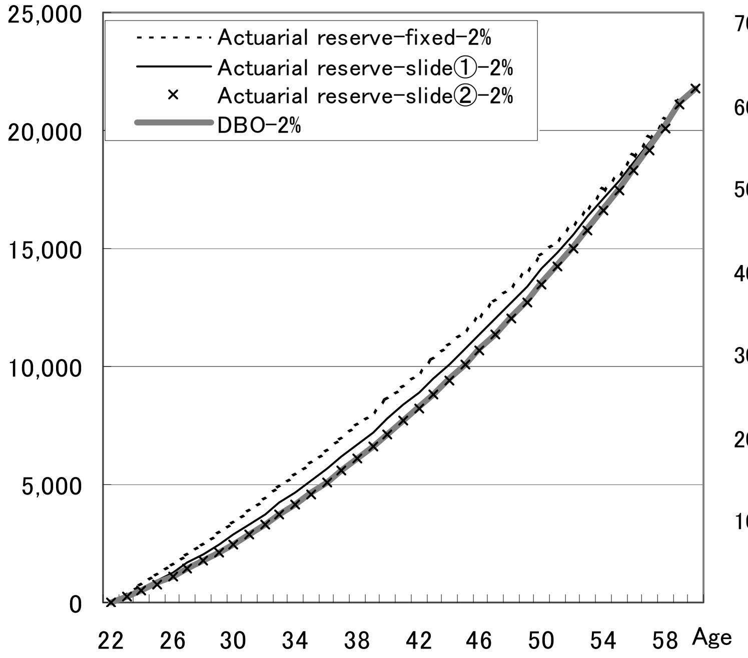
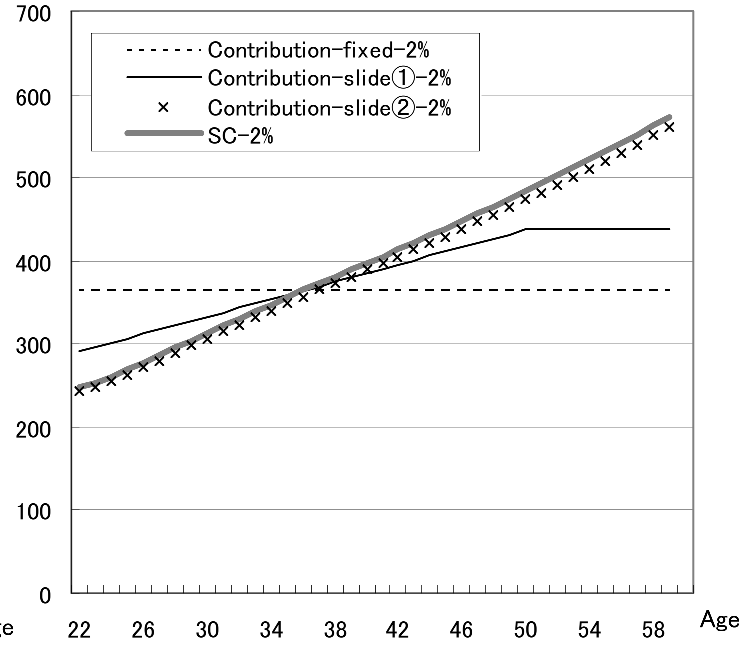


Fig.6 SC vs contribution (per person)



Suppose the yield curve in fig.3 is used for each year (i.e. no change of interest rates).

Fig.8 is the result of simulation of DBO with the single discount rate and DBO with the yield curve. DBO for participants of age 80 at 57th year is zero, because new participants are not assumed in this simulation. The total DBO at 0th year is the multiple of fig.7 by fig.2.

The result of DBO with the yield curve is a little larger than that is with the single discount rate 2.0%, however the number of participants and annuitants over age 50 is large. After 30th year, DBO with the yield curve is about the same as the single discount rate 1.5%. It is because the remaining benefit years gets short as no participant joins from 0th year.

Fig.7 Age distribution (at 0th year)

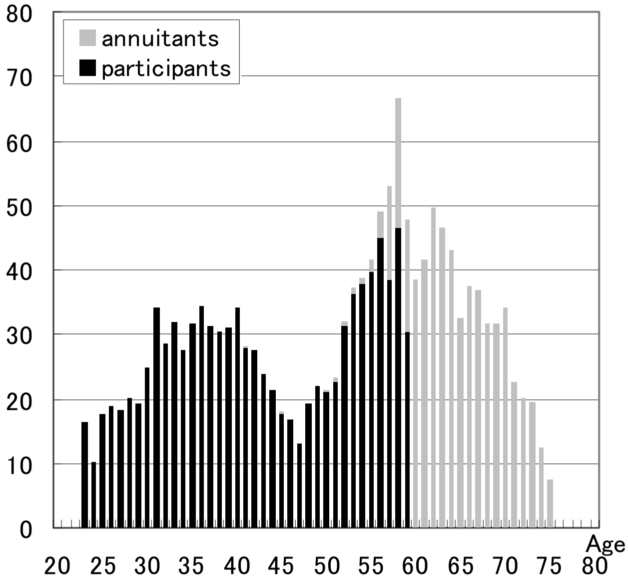


Fig.9 shows the cash flow of benefit and SC. SC with the yield curve is smaller than SC with the single discount rate 2.0% at the beginning. It means DBO with the yield curve is smaller than DBO with the single discount rate if the plan is comprised by participants only.

Fig.8 DBO

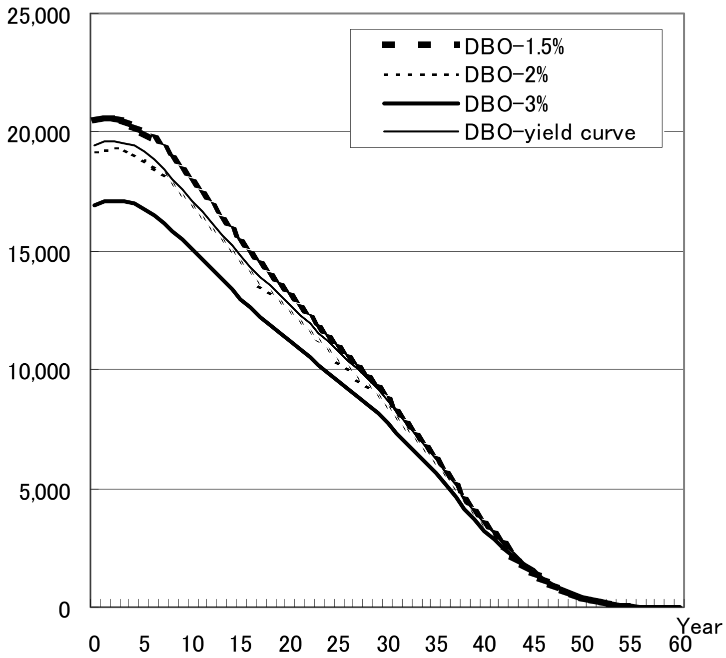
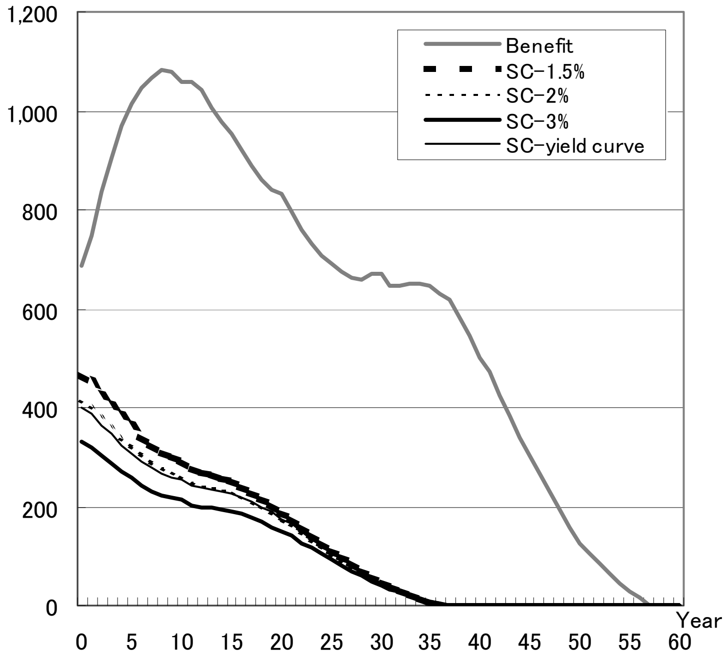


Fig.9 Benefit vs SC

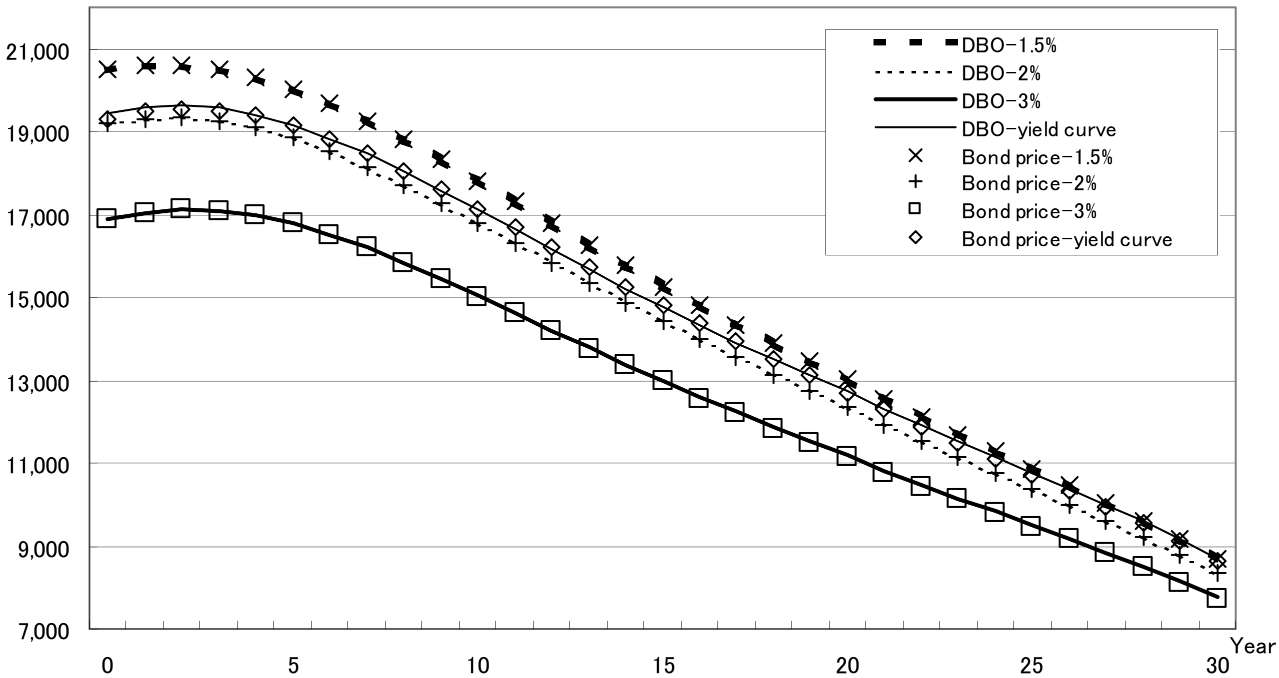


4. LDI by the bond

I consider the effectiveness of LDI by the bond portfolio using the net cash-flow (benefit - SC).

At the beginning, I consider the cash-flow matching by the net cash-flow using the examples in chapters 3. Fig.10 is the simulation result of the bond price making the portfolio of the bond which corresponds to the net cash-flow (benefit - SC) of each year in fig.9. Fig.9 is on the premise that

Fig.10 DBO vs bond price



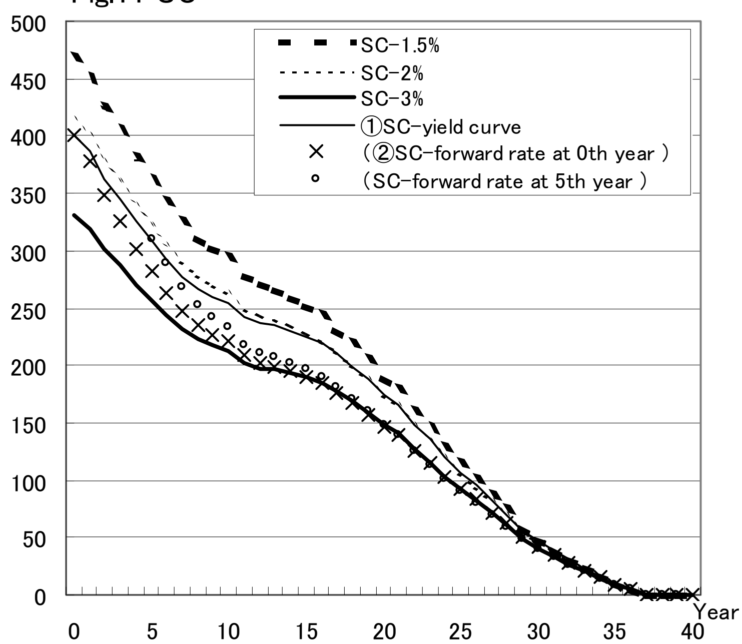
contributions of the same amount of SC are injected in each year. A simulation period is 30 years. And the bond is interest-bearing securities. I decide the face value of each term so that the total amount of a coupon and a repayment of each year corresponds to the net cash-flow in fig.9.

The reason why I use interest-bearing securities is that the long discount bond of the term does not circulate very much in the market. In addition, a bond price is a theory price without a default risk.

As the cash-flow of the bond assumed to corresponds to the cash-flow of DBO in each year, this simulation is on the premise that there is no reinvestment or sale before maturity.

Fig.10 shows us that DBO is equal to a bond price under the same cash-flow for all periods when a single interest rate is 1.5-3%.

Fig.11 SC



Next, I consider the case of the interest rate of yield curve.

SC of ① measured with the yield curve in fig.11 corresponds to SC in fig.9, and it is assumed that the yield curve does not change every year.

② in fig.9 is SC of the calculating each year based on a forward rate at 0th year.

In case of normal yield curve, it is thought that an interest rate rises every year. Therefore SC is smaller than the value of ① under the influence that discount grows large across the ages.

The bond price at 0th year corresponds to DBO according to fig.10 when I calculate based on SC(②) with this forward rate. This is clear from (eq-7). The bond price becomes smaller than

DBO so that the cash-flow (benefit - SC) becomes small when I calculate the bond price in SC of ①. DBO at 1st year is calculated in SC with the forward rate starting from 1st year. I put SC starting at 5^{th} year on fig.11 for reference. The bond price with the yield curve in fig.10 is a result when I use SC of each year calculated at 0^{th} year. When an interest rate and a yield curve do not change every year, it is seemed that there is little influence of the change of SC calculated by a forward rate in each year. It means that in this case I do not have to re-balance the portfolio of the bond every year.

As I mentioned before, in this paper net cash-flow is defined as the benefit which potion of SC is subtracted, and future SC is calculated by a forward rate.

Incidentally, when we use a single interest rate, the forward rate would be the same every year. In other words, we simply assume the flat yield curve.

I consider the duration next.

Fig.12 is the simulation result of DBO and the bond price when an interest rate is 1% higher or 0.5% lower than the assumed yield curve. If an interest rate rises, DBO decreases as the discount becomes large. However, on the other hand, the net cash-flow (benefit - SC) increases as SC decreases. Therefore decrease of DBO will be restrained. This means that the duration of DBO would be smaller than the duration of the bond, if we fix SC (if we fix the cash-flow). This result would be also led from (eq-3) and (eq-4), however, SC in other words net cash-flow would be changes by the change of an interest rate. It means that LDI by the net cash-flow matching can not hedge the risk of the change of an interest rate, which means we should abandon the purpose of LDI to hedge the risk of it. Fig.13 is a simulation result of the duration of DBO and the bond. The duration of DBO is 13% and the duration of the bond is 18% at 0^{th} year. There is a difference of 5% and the difference is comparatively large.

There is a simulation result in fig.12 without changing SC even if an interest rate is higher or lower. If an interest rate is high, the bond price falls largely because of a difference of the duration, and a deficit occurs. Just for the information, the reason of the reduction of the difference is because

Fig.12 DBO vs bond price

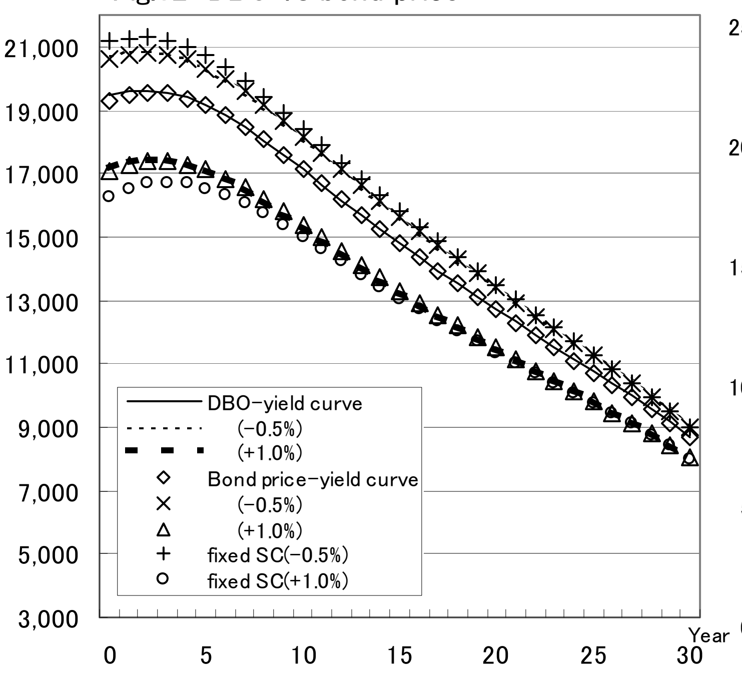
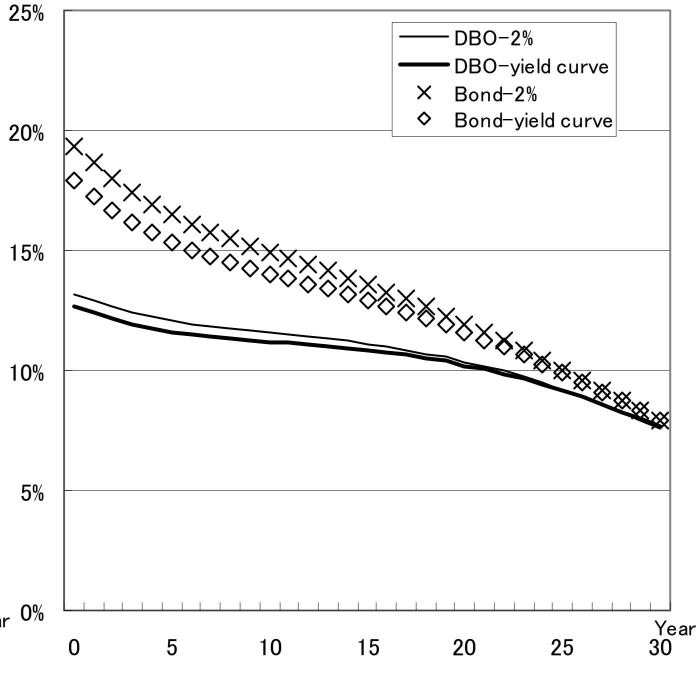


Fig.13 Duration



SC (or contribution) is large. (The result is opposite for that an interest rate is low.) If we could predict the change of an interest rate and change a cash-flow beforehand, we would not have any problems. However, it would be very difficult.

This net cash-flow matching does not lead the duration matching. However, I consider if the duration matching would be made without sacrificing cash-flow matching by devising a bond portfolio.

In fact, there are two merits to make the duration of the bond smaller.

First of all, as the super long-term bond which is beyond 30 years does not circulate very much in the market, it would be a merit to make a bond portfolio without using them.

Secondly, because we can increase short-term bonds, we can make the portfolio to be prepared for a lot of payments by the lump sum choice. These are key points on a practical level.

I have made a bond portfolio for this paper considering next three points.

① Using the interest-bearing securities of a term equal to or less than 30 years

② Increasing the short-term bonds to have payment even if the lump sum choice rate becomes 50% for five years

③ Making the duration of the bond approximately corresponds to the duration of DBO without re-balancing for a period as long as possible

In addition, I assume to reinvest the cash which remains by a coupon and a redemption with 30 years bonds.

I should have a lot of long-term bonds, when I increase short-term bonds to reduce the duration. This action cause the shape of the portfolio so-called barbell-shaped.

I omit the concrete portfolio which I have used for this simulation on this paper. However, this portfolio shows that if I have extremely lots of bonds of a certain maturity, a gap of the duration develops across the ages, and some securities transaction fees by re-balance occur.

Fig.14, 15 are the simulation results when I make the bond portfolio in the condition mentioned above. The duration of the bond is larger than the duration of DBO according to fig.15 at the beginning.

Fig.14 DBO vs bond price (lump sum choice rate 0%)

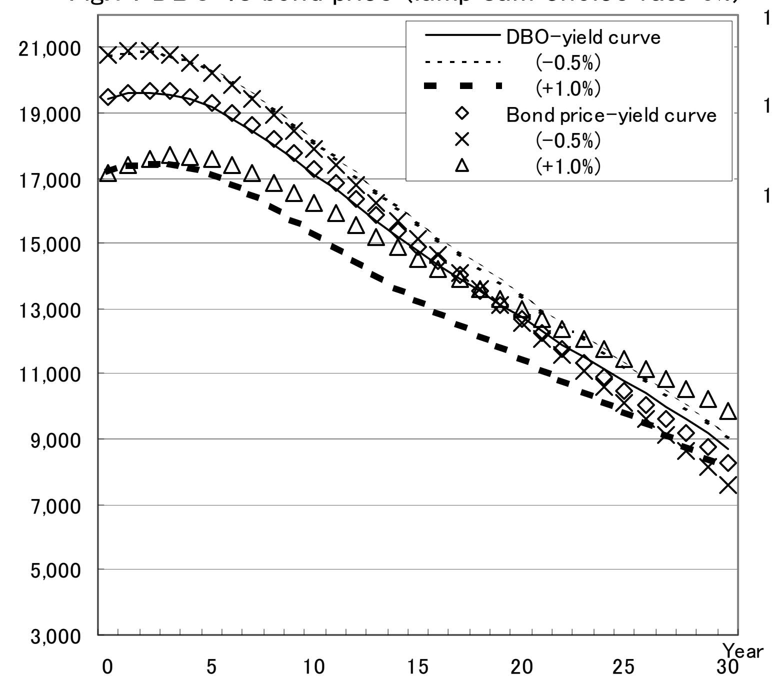
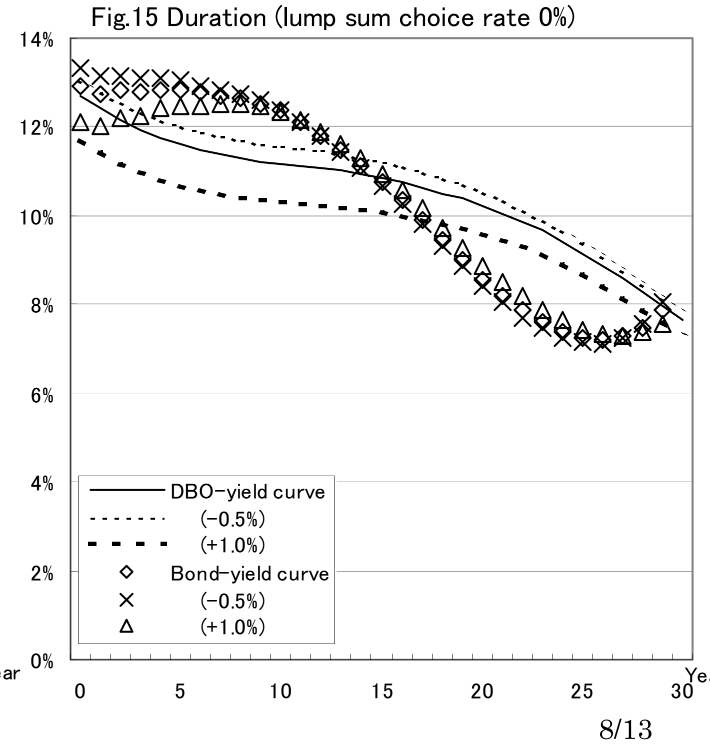


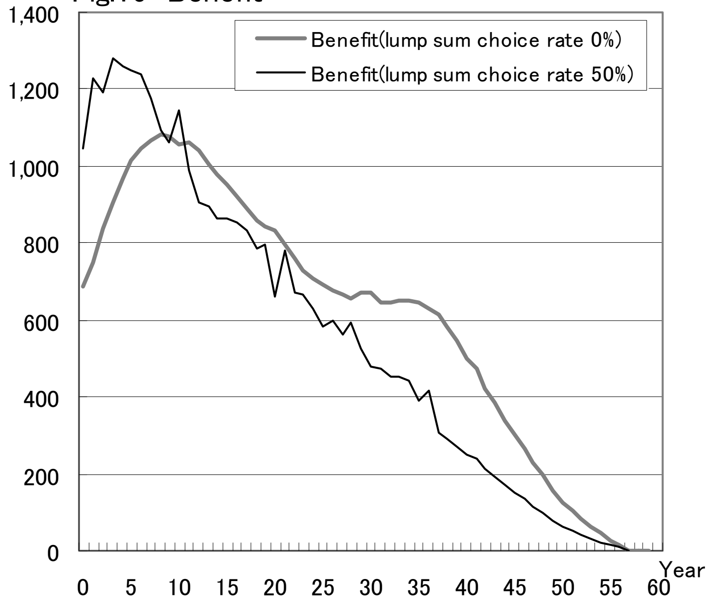
Fig.15 Duration (lump sum choice rate 0%)



This is because the cash remained was reinvested with 30 years bonds, and this reinvestment is caused simulating under lump sum choice rate 0%, while setting up a lot of short-term bonds in a bond portfolio for five years. In addition, when the interest rate falls, the surplus tends to reduce across the ages by the reduction of SC (or contribution). On the contrary, when the interest rate rises, the surplus tends to get larger by SC (or contribution). This mechanism shows us that the duration of the bond had better be slightly larger than the duration of DBO.

Next, fig.17 is a simulation result when lump sum choice rate is 50% (fig.16) with the same bond portfolio, thus there would be much payment for the next 10 years. As I assumed an interest rate during annuitant 3%, it tends to have a surplus by the assumed yield curve influenced by the lump sum choice. When an interest rate is 1% higher, there would be no surplus caused by the lump sum choice. However, there is a tendency that we can recognize the surplus in total, because there would be much SC (or contribution). So we can say that even if a lot of payment occurs by lump sum choice, we do not have any problems in the surplus unless lump sum choice becomes a deficit factor.

Fig.16 Benefit



As for the simulation above, as fig.16 shows, the payment of 50% of the lump of choice is larger than that of 0% of the lump of choice for ten years. However, after 10 years, the positions switch. When there are many lump sum choices, many payments are anticipated at first, but payments decrease in the future so that pension benefits are suppressed across the ages.

Fig.18 shows a transition of the duration. Because most of the reinvestment to 30 years bonds disappears, the duration reduces across the ages in comparison with fig.15. But the duration soars after 20^{th} year. This raise is caused by the reinvestment to 30 years bonds increases by cash reserves, though DBO reduces. If lump sum choice rate is performed in this range from 0% (fig.15) to 50% (fig.18), it is thought that the duration of the bond approaches the duration of DBO in a good way during 10 years.

The bond portfolio which I have made this time is not complete in the duration matching, However, I suggest the possibility of the asset management by the bond that can support a large change of the payment of around 5 years. However, there is a limit in the duration matching naturally for the portfolio made with 30 years bonds. It is thought that an application is difficult in case of the duration of more than 20%.

By the way, re-balance is necessary if the duration reduces across the ages. As a matter of course, a cost depends on re-balance. Thus it is desirable to make the bond portfolio which there is few times of the re-balance as possible. It is good to have a lot of short-term bonds for lump sum choice in general. However, too many bonds require reinvestment by their surplus. It would accrue more cost.

Fig.17 DBO vs bond price (lump sum choice rate 50%)

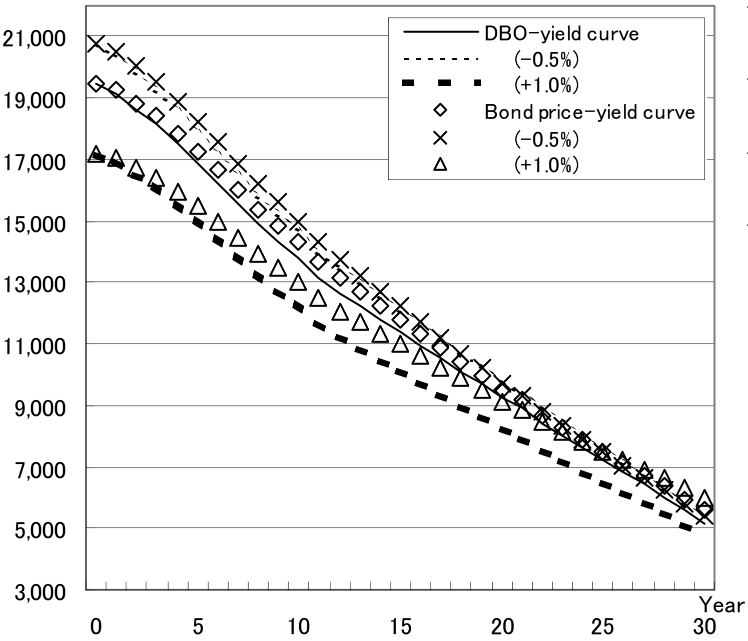


Fig.18 Duration (lump sum choice rate 50%)

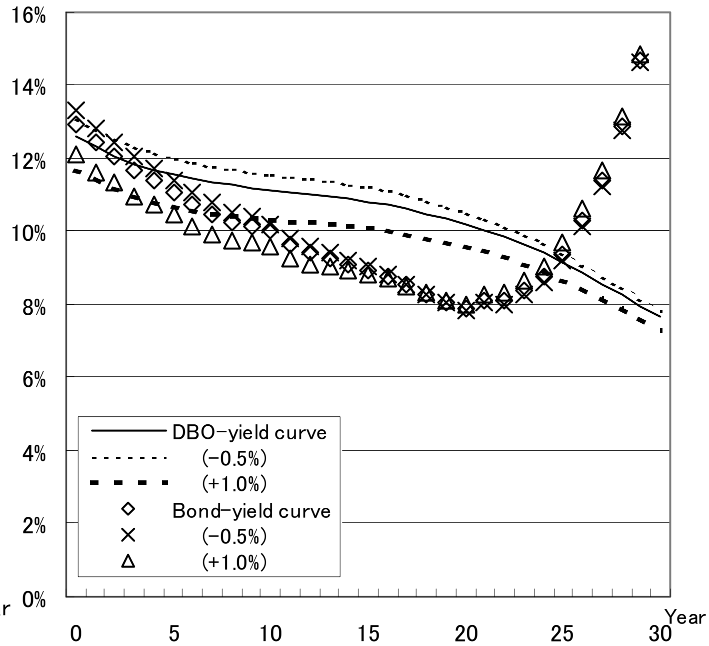


Fig.19DBO vs bond price(lump sum choice rate 0%)re-balance

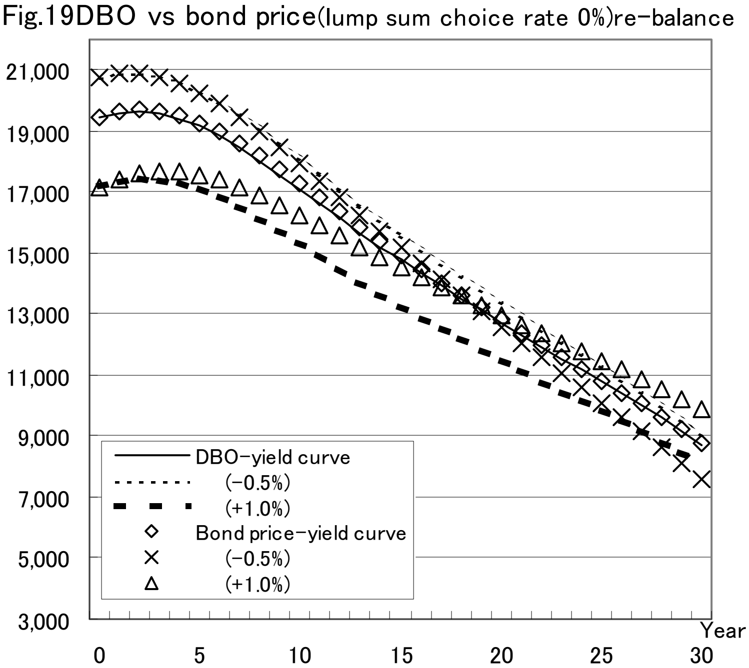


Fig.20 Duration(lump sum choice rate 0%)re-balance

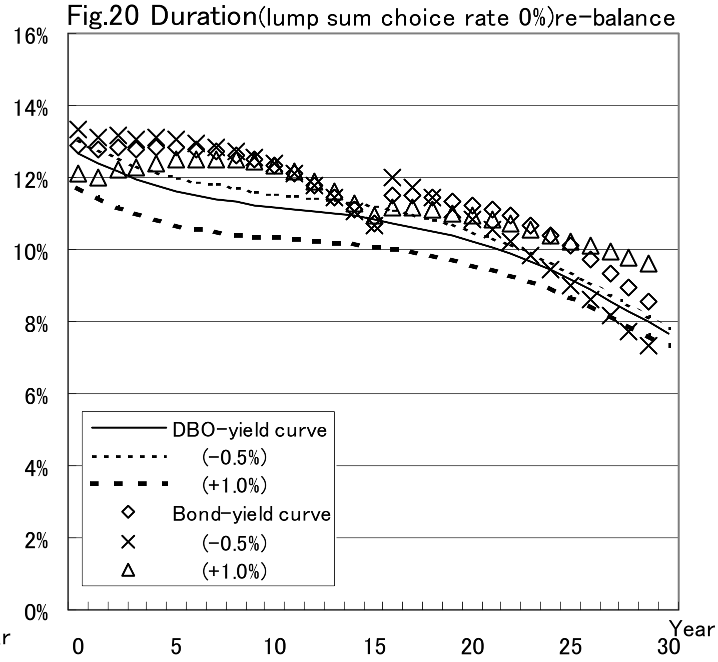


Fig.21DBO vs bond price(lump sum choice rate 50%)re-balance

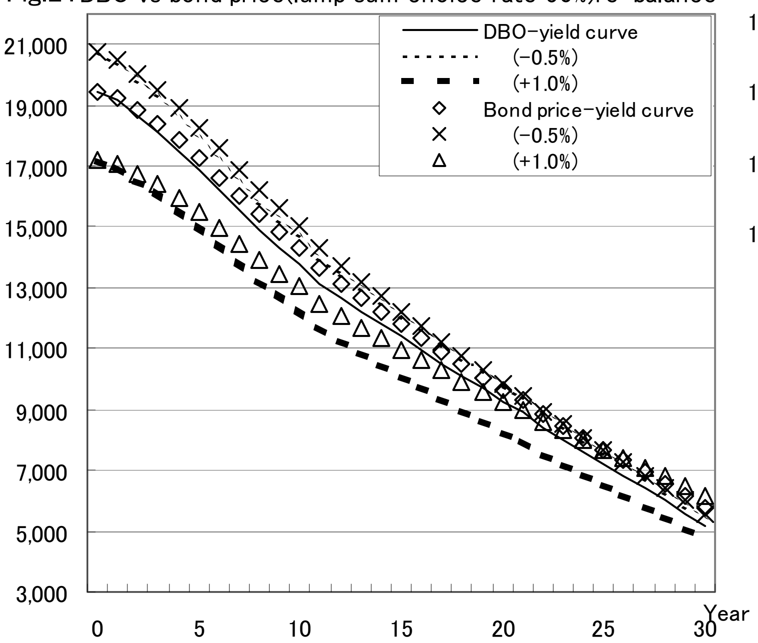
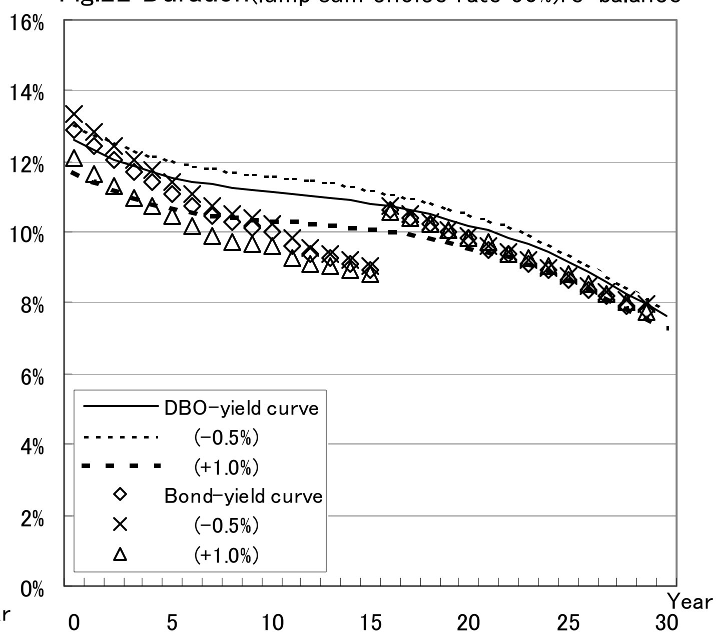


Fig.22 Duration(lump sum choice rate 50%)re-balance



If there are more lump sum payments by halfway withdrawal than an assumption, it is thought that generally the amount of payment itself is smaller than the amount of payment of lump sum choice, and influence is small.

Fig.19, 20 are simulation results when I re-balance the bond portfolio at 15th year under the same premise as fig.14, 15 (lump sum choice rate 0%). According to fig.19, the reduction of the bond price is restrained after re-balance when I make the duration large at 15th year according to fig.20. If I do not re-balance with the assumed yield curve (fig.14), a deficit occurs after 20th year. A deficit would not occur in according to fig.19. Fig.21, 22 are simulation results when I re-balance at lump sum choice rate 50%. The duration of the bond is largely improved to match the duration of DBO after 15th year.

Finally, I consider the influence of the new participants.

Fig.19, 20 are the cases that there are not any new participants. Fig.23, 24 are simulation results when there are new participants (22 years old) so that the whole number of the participants become the same every year. In each year, there is cash-in for the amount of SC of new participants, and it is assumed that I purchase 30 years bonds. DBO of the new participants pile up with SC and interest from scratch little by little every year. Therefore there are not many differences when there are not new participants (fig.19) for the whole DBO in 10 years according to fig.23. However, differences become larger across the ages. The surplus hardly has a difference in case of fig.19. Because the duration of the bond of the new participants is smaller than the duration of DBO, a deficit occurs slightly. However, I can make the duration of bond large by re-balancing at 15th year according to fig.24 and I can improve a deficit factor.

I reinvested the cash remained with 30 years bonds uniformly this time. I can control the duration a little if I devise a portfolio of the reinvestment. For example, it is thought that I reinvest it in the short-term bond if the duration grows large.

Fig.23 DBO vs bond price (new participant)

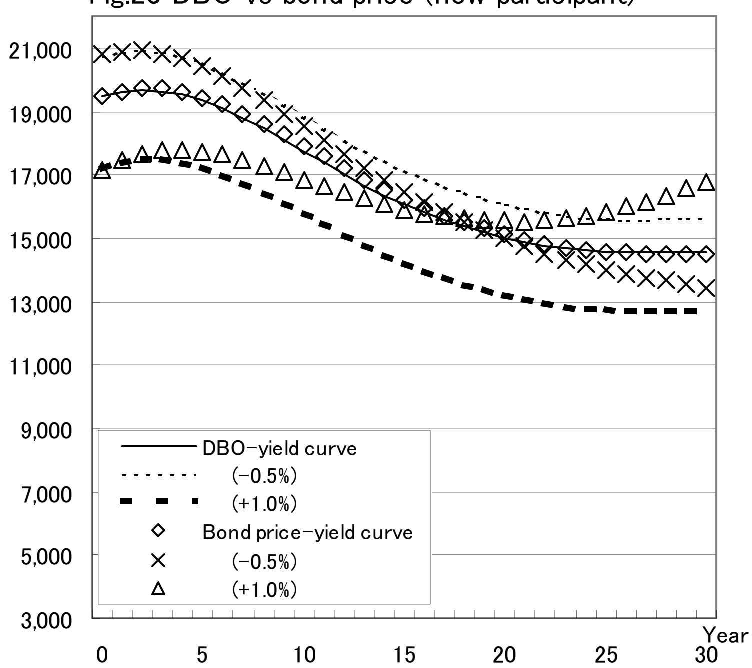
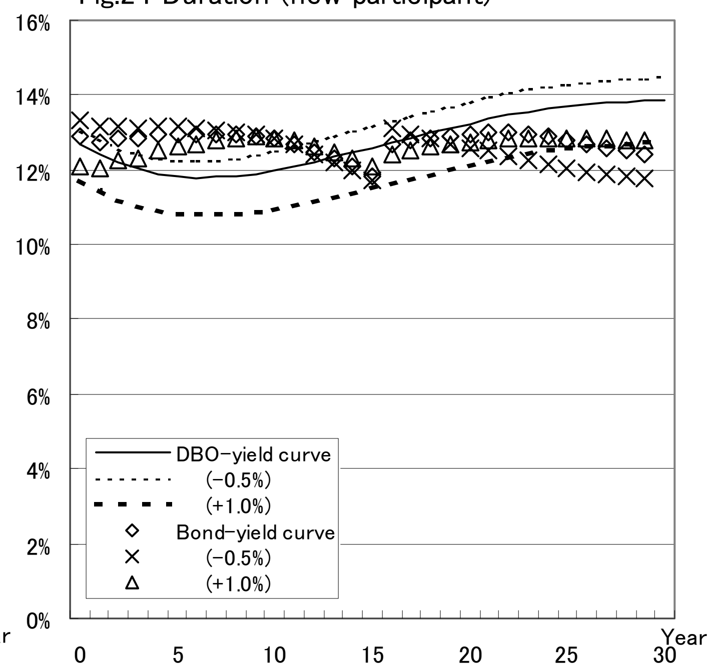


Fig.24 Duration (new participant)



5. Summary

In the following, I enumerate the effectiveness of the bond investment by the net cash-flow that I suggested in this paper.

- A present value of the net cash-flow subtracted SC from benefit of each year corresponds with the amount of DBO in the non-frozen pension plan. Therefore it is possible theoretically to make a bond portfolio by this net cash-flow.
- The duration of the bond becomes larger than the duration of DBO so that SC changes by an interest rate even if I make the net cash-flow matching. Because the difference is comparatively large, the duration matching is necessary at the point of view of the restraint of the surplus risk.
- The payment changes in the non-frozen pension plan. It is possible to make a practical bond portfolio in correspondence with changed payment and the duration follows DBO to some extent for a middle long term under a certain condition.
- I aimed to make the bond portfolio which evaded re-balance as much as possible to hold down a cost this time. Keeping cost down is an important concept in Japan, because the interest rate of the bond is low in Japan currently.
- SC of the net cash-flow is replaced with a contribution in funding by the real administration every year. When I perform the bond investment like this time, the administration becoming "contribution ≧ SC" is demanded. In other words, it is necessary to balance the funding in accounting standards.
- It is necessary to inspect the estrangement of a theory price and the market price of the bond separately from this paper.
- I do not consider a buying and selling cost (securities transaction fee) and the management cost of the bond in this simulation. However, additional cost would occur by the deficit by the fee and the deficit by the difference of a theory price and the market price of the bond. It is necessary for these deficits to support by a special contribution in funding as a practical matter.

Though I had thought that LDI in the active pension plan was difficult, I confirm that it is possible enough for business by the bond investment. Because the simulation in this paper shows us it could support the fluctuating payment and it could match the duration of DBO almost in the long term, besides this strategy reduced a cost. However, full-scale LDI by the bond investment seems not to be carried out often by the reasons as follows in Japan currently.

① Few for DBO in full funding.
② The expected interest rate in funding is high, and it is "contribution <SC", and we do not balance the funding administration in accounting standards.
③ Primarily a standard of DBO is relatively small for an owned capital unlike the United Kingdom and the United States, and influence of account is not large. [1]
④ A current interest rate is too low, and for fear of a future interest rate rise, the company do not permit the reduction of the price by the bond investment

① and ② may not be conscious of by the reason of ③. Or LDI may not be carried out by the reason of ③ and ④ in the company satisfying both ① and ②. LDI is possible enough if a pension plan satisfies a necessary condition in funding of ① and ②, at least. The interest to accounting standards should be high in the company where DBO is large for an owned capital, and the attention degree to LDI may rise in Japan. In addition, there is the possibility that LDI by the bond investment attracts attention when an interest rate rises and the concerning about the interest rate rise decreases.

Both ③ and ④ are the problem of the consciousness of the company. When the consciousness of the company would be changed by "immediate recognition" in accounts in Japan, companies' attention to LDI would thought to be increased.

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