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Pension Benefit and Hours Worked*

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Abstract

This paper clarifies the effects of pension benefit systems on aggregate hours worked. By incorporating the labor income taxes and the social security taxes into a representative agent model, previous studies successfully explain the long term decline in the hours worked in some continental European countries, and the differences between these European countries and the U.S. in recent years. However, their model underpredicts the hours worked in Japan and Sweden. We measure the marginal pension benefit rates of the labor supply, which the previous studies do not take into account, and incorporate them into previous studies. We find that the marginal pension benefit can explain much of the discrepancy between the actual hours worked and the predictions of the previous studies. This result also implies that the pension benefit might offset the effect of the unemployment insurance that is thought to make the prediction worse in some continental European countries.

JEL classification: E2, E6, H2, J2, O5
Key words: Hours worked, Pension benefit, Taxation, Japan, Sweden

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1 Introduction

It is generally considered that the development of social security conflicts with economic performance. For example, Friedman and Friedman (1980) mentioned that "[welfare policies] weaken the family; reduce the incentive to work, save, and innovate; reduce the accumulation of capital; and limit our freedom" (pp. 127). What can economic theory tell us on this issue?

In particular, Prescott (2004) finds that taxation can explain the difference between the hours worked in the U.S. and in major European countries and the decline in hours worked in these European countries in the 1970s and 1980s, by incorporating social security taxes, labor income taxes, and consumption taxes into a representative agent model. However, his model underpredicts the hours worked in Japan and Sweden. The hours worked in Japan, which is the one of the longest for OECD countries, is much longer than those in the U.S., although its tax burden is close to that of the U.S. The hours worked in Sweden is not so much different from those in the U.S. in the 1970s and the 1980s, although the tax burden in Sweden, which is the one of the highest in OECD countries, is markedly heavier than that in the U.S.

The purpose of this study is to show the extent that the pension benefit can explain this discrepancy between the actual hours worked and the theory, and demonstrate the importance of a pension benefit system on the hours worked in the macro economy. Prescott (2004) does not take into account the pension benefits because their scheme is highly regressive in the U.S.; however, they are not in Japan and Sweden. In addition to the regressivity, there are other reasons to take into account the pension benefits. First, the life expectancies in Japan and Sweden are longer than that in the U.S..[1] Second, the age of entitlement in Japan was 60 before 1994, and that in Sweden is 65 after 1977, while that in the U.S. is 67 for people born after 1960. We measure the marginal pension benefit rates of the labor supply, and incorporate them with other taxes into the Prescott (2004) model. We calculate the pension benefits that were not realized but expected for each year, because there were some changes in the pension benefit systems, which were not expected; therefore the agents make decisions under the pension system at each point.

We find that the marginal pension benefit rates in Japan and Sweden reach five percent and higher. The marginal pension benefit rates can explain much of the discrepancy between the actual hours worked and the theory in Japan and Sweden. These results imply that the pension benefit system could have a great impact on worker behavior.

These results for Japan and Sweden have an implications for other countries. Ljungqvist and Sargent (2006) incorporate the unemployment insurance into the Prescott (2004) model, and demonstrate that their model underpredicts the actual hours worked in some continental European countries. They paradoxically discuss "Why do French people work so much?" In France, Germany, and Italy, the pension benefit amount relates to the labor income; therefore, the pension benefit can increase the predicted hours worked, as it does in Japan and Sweden.

This study also has an important implication for the literature on optimal social security system and pension system reform from not funding (pay-as-you-go) to fully funding or privatization.[2] As many studies find that the reduction in the U.S. pension system

[1] At 2005, the male (female) life expectancies in Japan, Sweden, and U.S. are 78.7 (85.7), 78.3 (82.7), and 75.2 (80.4), respectively.

[2] See Feldstein (1985), Auerbach and Kotlikoff (1987), Hubbard and Judd (1987), Imrohoroglu, Imrohoroglu, and Joines (1995), Huang, Imrohoroglu, and Sargent (1997), De Nardi,Imrohoroglu, and Sargent(1999), Conesa and Krueger (1999), Kotlikoff, Smetters, and Walliser (1999), Nishiyama and

increases the labor supply if it is variable,[3] similarly Prescott (2004) also emphasizes, it is possible to convert a not funded pension system into a fully funded one in a way that makes every generation better off. However, this theory might not be correct for the countries where the pension benefits are not regressive.

The remainder of this paper is divided into four sections. Section 2 is a literature review. Section 3 and section 4 measures the marginal pension benefit rates and analyze the hours worked in Japan and Sweden, respectively. Section 5 contains concluding remarks.

2 Taxes and Hours Worked

Prescott (2004) demonstrated that taxation can explain many of the variations in the hours worked in G7 countries, by using a simple representative agent model and the taxes measurement. We explain his methodology in this section.

First, the model used is as follows. The preferences of a stand-in household are

$$E\left\{\sum_{t=0}^{\infty}\beta^t\left[\log c_t+\alpha\,\frac{(\bar{l}-l_t)^{1-\gamma}-1}{1-\gamma}\right]\right\}, \tag{1}$$

where c_t and l_t are consumption and working hours, respectively. The household's budget constraint is

$$(1+\tau_{ct})\;c_t+(1+\tau_{xt})x_t\le(1-\tau_{lt})\;\omega_t l_t+(1-\tau_{kt})(r_t-\delta)k_t+\delta k_t+T_t\;, \tag{2}$$

where $x_t, k_t, \omega_t, r_t, \tau_{ct}, \tau_{xt}, \tau_{kt}, T_t,$ and δ are the investment, the capital stock, the real wage rate, the rental price of capital, the consumption tax rate, the investment tax rate, the capital income tax rate, the lump-sum transfer, and depreciation rate of the capital stock, respectively.

The representative firm maximizes the profit:

$$y_t-\omega_t l_t-r_t k_t, \tag{3}$$

where y_t is the output, and the production function is Cobb-Douglas as follows:

$$y_t=A_t k_t^{\theta} l_t^{1-\theta}. \tag{4}$$

From the first order conditions for c_t and l_t of the household,

$$\alpha\frac{c_t}{(\bar{l}-l_t)^{\gamma}}=\frac{1-\tau_{lt}}{1+\tau_{ct}}w_t=(1-\tau_t)w_t\;, \tag{5}$$

where

$$\tau_t=\frac{\tau_{lt}+\tau_{ct}}{1+\tau_{ct}}\;. \tag{6}$$

From the first order condition for l_t of the firm,

$$w_t=(1-\theta)\frac{y_t}{l_t}\;. \tag{7}$$

Smetters (2007), and Nishiyama (2008).

[3]In the case of Imrohoroglu and Kitao (2009), the simulated labor supply changes little because the substitution effects and the income effects, which are due to the loosening of the no borrowing constraint, cancel each other out.

From these equations,

$$\frac{l_t}{(\bar{l}-l_t)^\gamma} = \frac{1-\theta}{\alpha}(1-\tau_t)\frac{y_t}{c_t} \ . \tag{8}$$

This equation implies that we can predict the aggregate hours worked from output, consumption, tax rates, and calibrated parameters.

Second, the tax measurement is as follows. The net indirect taxes on consumption are

$$IT_{ct} = \left[\psi + (1-\psi)\frac{C_t}{C_t+I_t}\right] IT_t \ , \tag{9}$$

where $C_t, I_t,$ and IT_t are SNA private consumption expenditures, SNA private investment, and net indirect taxes, respectively[4] The model economy's consumption and output are

$$c_t = C_t + G_t - G_{mil,t} - IT_{ct} \ , \tag{10}$$

$$y_t = GDP - IT \ , \tag{11}$$

where $G_t, G_{mil,t},$ and GDP are public consumption, military expenditures, and gross domestic product, respectively. The consumption tax rate is

$$\tau_{ct} = \frac{IT_{ct}}{C_t - IT_{ct}} \ . \tag{12}$$

The labor income tax rate is calculated from[5] [6] [7]

$$\tau_{lt} = \tau_{ss,t} + 1.6 \ \bar{\tau}_{inc,t} \ , \tag{14}$$

$$\tau_{ss,t} = \frac{\text{Social Security Taxes}}{(1-\theta)(GDP-IT)} \ , \tag{15}$$

$$\bar{\tau}_{inc,t} = \frac{\text{Direct Taxes paid by Households}}{GDP - IT - Depreciation} \ . \tag{16}$$

Third, the calibration is as follows. The value of the capital cost share, θ, is set to 0.3224, which is the average for G7 countries, and the values of the individual countries are close to each other. The utility of leisure parameter, α, is 1.54, which is chosen so

[4]Prescott (2004) assumes that ψ equals 2/3 in each country. McDaniel (2007) measures ψ in OECD countries from *OECD Revenue Statistics*, and she finds that those in Japan and Sweden are 0.702 and 0.372, respectively. Furthermore, McDaniel (2007) points out that the net indirect taxes contain property taxes that are not imposed on the consumption and investment goods, and she reports that 10.5 percents of the Japan's net indirect taxes are property taxes. However, these measurement problems do not have substantial impacts on the prediction.

[5]This definition of labor income tax rates is based upon comprehensive taxation. However, dual income tax was adopted in Sweden in 1991. See Sorensen (1998). The progressivity of labor income tax, 1.6, is based upon the empirical study on the U.S. We check the progressivity of Japan in appendix B.

[6]In the case of Sweden, we add "Employers' contribution to private pension insurance" to the numerator in equation (15), because the private pensions in Sweden have characteristics similar to public pensions. Details are discussed in section 4.

[7]McDaniel (2007) calculates the average tax rates from

$$\bar{\tau}_{inc,t} = \frac{\text{Direct Taxes paid by Households}}{GDP - IT} \ . \tag{13}$$

that the average labor supply is close to the data except for the two outliers. Prescott (2004) assumes the same values of α and θ for the all countries. This assumption enables us to compare the hours worked for each country from a unified viewpoint.[8] Prescott (2004) employs a log-log utility function, $\gamma = 1$.

Table 1 shows the data and the prediction results that incorporate the measured variables into equation (8)[9]. This model fits the data reasonably well except for Italy, Japan, and Sweden. Figures 1 and 2 illustrate the data and the prediction of hours worked in Japan and Sweden, respectively (baseline (gamma=1)).[10] Both in Japan and Sweden, this model consistently greatly underpredicts the data; the discrepancies reach at most 5.5 hours in Japan and 12.8 hours in Sweden. The cause of this gap is due to some unknown factors rather than the dynamic property of this simple model, such as the lack of adjustment cost. Alesina, Glaeser, and Sacerdote (2006) point out that the elasticity of labor supply assumed by Prescott (2004) might not be consistent with the empirical studies. However, the results for Japan and Sweden discussed above do not basically change, even if we employ different values for the elasticity. Figures 1 and 2 illustrate the predictions that the values of γ are .5 and 2.[11]

3 The Case of Japan

3.1 The Pension System and Its Evolution[12]

There are many public old-age pension systems in Japan. However, the main systems are the *Employees' Pension Insurance* (EPI; Kousei Nenkin), the *Mutual Pension Insurance* (MPI; Kyousai Nenkin), and the *National Pension* (NP; Kokumin Nenkin). The EPI compulsorily covers full-time employees in the private sector that are under 70 years of age and work for a corporatio or a company with five or more employees. The MPI

[8] Ohanian, Raffo, and Rogerson (2006) also analyze the hours worked in OECD countries by using the average tax rates measured by McDaniel (2007) and a model similar to Prescott's (2004) model. However, they set the values of the utility of leisure parameter for each country such that the prediction equals to the data at the initial year. Therefore, we can not analyze the cross country differences in the hours worked in the manner of Ohanian et al. (2006).

[9] The data of hours worked is calculated from

$$(\text{hours per worker}) \times (\#\text{ of employment})/(\#\text{ of 15-64 population}) . \tag{17}$$

[10] It is pointed out that the long working hours of the Japanese include a considerable amount of unpaid work. Mizunoya (2002) measured the hours of unpaid work from the difference between the household survey data, *the Japan's Labor Force Survey* (LFS), and the establishment survey data, *the Monthly Labor Survey* (MLS), and demonstrated that the unpaid work of the male workers in 1993 were as many as 270 hours.

Many statistics on hours worked do not take into account the unpaid work in Japan. The datasets of the Organization for Economic Co-operation and Development (OECD) and the Groningen Growth and Development Centre (GGDC), which are frequently used for cross country analysis, are basically based upon the MLS (Figure 3). On the other hand, the data of many other industrialized countries do take unpaid work into account. The OECD's data for Canada, France, Italy, and the U.K. are based on the household survey. Although the data for the U.S. are sourced from the establishment survey, the data is adjusted to the hours actually worked. As a result, the data is close to the Current Population Survey, which is a household survey. Although the data for Germany do not consider unpaid work because the hours for full-time workers comes from the wage agreement data on the negotiated hours, Bell, Gaj, and Hart (2001) and Mizunoya (2002) point out that the hours of unpaid work in Germany is very short.

[11] We calibrate α for each value of γ, such that the average values of the predicted hours worked in G7 countries, except for Japan in the early 70s and the mid 90s, equal to actual values.

[12] We refer to Ihori and Tachibanaki (2002) and Kaizuka and Krueger (2006) in this subsection.

compulsorily covers full-time employees in the public sector that are under 70 years of age. The MPI has many subsystems, but they are basically similar to EPI.[13] Hereafter, the term "EPI" includes both the EPI and the MPI. The NP compulsorily covers other persons, such as self-employed, family workers, part-time employees, and the unemployed. In 2005, EPI, MPI, and NP covered 33.0, 4.6, and 21.9 million persons, respectively.

The histories of the EPI and the NP go back to 1942 and 1961, respectively. Their benefit amount began to automatically relate to the inflation rate and the wage growth rate in 1973, and the EPI's replacement rate increased to over 35% in 1976.[14][15] The EPI's tax is basically a constant rate of the labor income, and the NP's tax is a constant amount.

We define $EPIB_{jv}(t)$ as the EPI's old age pension benefit amount, such that the cohort born at year j expects at year t that they will receive at year v. During 1973–1985, $EPIB_{jv}(t)$ is as follows:

$$EPIB_{jv}(t) = \eta_v \times \min\left(T_j^{EPI}, 35\right) + .01 \times AR_{jv}(t) \times T_j^{EPI} + o_v. \tag{18}$$

T_j is the coverage years. η_{jv} is the parameter of the portion that is related only to the coverage years. o_{jv} is the portion that is related to neither the coverage years nor the average remuneration. η_{jv} and o_{jv} automatically change with the inflation rate and the wage growth rate after 1973. The so-called *Average Remuneration*, AR_{jv}, is a kind of averaged present value of life time wage, and is calculated from

$$AR_{jv}(t) = \frac{1}{T_j} \sum_{s=\underline{s}_j}^{\bar{s}_j} RAR_{sv}(t) W_{js} \ , \tag{19}$$

where $\underline{s}_j$ is the initial year coved by the EPI, $\bar{s}_j$ is the last year covered by the EPI, $RAR_{sv}(t)$ is the reassessment rate that takes into account the inflation rate and the wage growth rate, and W_{js} is the annual wage.

During 1973–1985, employees could receive the EPI's benefit only when they were covered by the EPI for 20 years or more. This restriction was based upon the policy makers' assumptions that the male employees worked during their prime age and that their wives did not work or worked as part time employees. However, this assumption had become unrealistic because more women had begun to work as the full-time.[16] Therefore, the minimum coverage years were shortened to 1 from 20 in 1985. At the same time, the magnitude of the second term in equation (18) was determined to gradually decline to 7.5×10^{-3} from 10×10^{-3}. These evolutions implied that the benefit amounts of employees who work fewer than 20 years increased; on the other hand, the total benefit amounts of employees who work 20 years or more decreased.

After 1985, the benefit systems are different regarding the ages of recipients. From 60 to 64 years old, the benefit during 1986–1993 is as follows:

$$EPIB_{jv}(t) = \kappa_v \times \mu_j \times \min\left(T_j^{EPI}, \bar{T}_j^{EPI}\right) + \lambda_j \times AR_{jv}(t) \times T_j^{EPI} + o_v, \tag{20}$$

and after 65 years old,

$$EPIB_{jv}(t) = \iota_j \times BP_v \times \min\left(1, \frac{T_j^{EPI}}{\bar{T}_j^{NP}}\right) + \lambda_j \times AR_{jv}(t) \times T_j^{EPI} + o_v. \tag{21}$$

[13]Therefore, we assume that the benefit schemes of the MPI are same as that of the EPI.

[14]See Oshio and Yashiro (1997).

[15]For these reasons, we start the analysis after 1973.

[16]In 1986, the Japanese government ratified *the Convention on the Elimination of All Forms of Discrimination against Women*, and enforced *the Equal Employment Law for Women*.

There are two parameters that depend on the receipt year: BP_v, which is the benefit amount of *the Basic Pension*, and o_v (Table 2). There are four parameters that depend on the cohort: $\bar{T}_j^{EPI}$, which is the maximum coverage years of the portion proportionate only to coverage years, $\bar{T}_j^{NP}$, which is the maximum coverage years of the basic pension, μ_j, and λ_j. Index ι_j equals to 1 if the spouse is independently covered by a public pension system, and equals to 2 if the spouse is not covered.[17]

The NP's old age pension benefit, $NPB_{jv}(t)$, was as follows:

$$NPB_{jv}(t) = \begin{cases} BP_v \times \min\left(1, \frac{T_j^{NP}}{25}\right), t < 1986, \\ BP_v \times \min\left(1, \frac{T_j^{NP}}{\bar{T}_j^{NP}}\right), t \geq 1986. \end{cases} \quad (22)$$

As in the case of the EPI, the maximum coverage years were prolonged in 1985. The parameters BP_v and $\bar{T}_j^{NP}$ are same as in equation (21), and are displayed in Table 2 and Table 3.

Because the deterioration of the pension system finances were revealed in the 1990s, the pension benefits began to be reduced simultaneously with the increase in the tax rates. The first term in equation (20) was decided to be gradually reduced and then abolished in 1994, and the second term was also abolished in 1999.[18] Tables 4 and 5 display the ages at which each cohort begins to receive them. In addition, the time varing parameters such as κ_v, RAR_{sv}, and BP_v were targeted to change with the after-taxed labor income in 1994; however this method was abolished in 1999, and in 2004 they were reduced by 0.9 percents and will remain at that rate until 2023.

3.2 Methodology

The measurement procedure for the pension benefit rates is as follows. First, we calculate the discounted sum of the marginal pension benefits generation by generation because the benefit schemes are different for each generation. In the calculation, we assume that people expect the current benefit system to continue until a new law is announced. We simplify the calculation by using the relationship between the wage growth rate, the real interest rate, and the discount factor in the Euler equation.[19] Then, we take averages of each generation's benefit using the number of employees as the weight. Finally, we incorporate the measured marginal pension benefit rates into equation (8).

As equations in the last subsection indicate, the marginal benefits are differ between the coverage years and the Average Remuneration— in other words, between the extensive margin and the intensive margin. We measure the return rates of the coverage years for the following two reasons. (1) Kuroda and Yamamoto (2008) estimate the Frisch elasticity in Japan by using yearly data, and find that the elasticity of only the intensive margin is very low, however, the elasticity both of the intensive margin and the extensive margin is high.[20] and (2) as Hayashi and Prescott (2002) describe, the hours per worker decreased after the revision of *the Labor Standards Law* in 1988; therefore, we think that the law has had a considerable effect on the hours per worker. Additionally, in order to deal with

[17]In the measurement, we use the value of ι_j that is calculated from data.

[18]The persons insured by the EPI can receive the decreased (increased) first term before (after) 65, and those insured by the NP can also recieve the decreased (increased) pension benefit before (after) 65. We assume that all persons receive the pension benefit at its standard age.

[19]See appendix A for more details on this point.

[20]Braun, Esteban-Pretel, Okada, and Sudou (2006) find that the elasticity of intensive margin is higher than that of extensive margin by using a quarterly data. We interpret that this difference is due to the period of the data.

two pension systems, we assume that households choose the employment rate given the probability that they are covered by EPI or NP, that is, χ_{js} and $(1-\chi_{js})$.

The discounted sum of the EPI's benefit amounts, Z_{jt}^{EPI}, is defined as follows:

$$Z_{jt}^{EPI} = \sum_{v}^{\bar{v}_{jt}^{J}} \left(\prod_{u=t}^{v} \frac{1}{1+i_u} \right) EPIB_{jv}(t), \tag{23}$$

where $\bar{v}_{jt}^{J}$ is the life expectancy of generation j, and i_u is the nominal interest rate.[21] Then, the discounted sum of marginal benefit amounts is

$$\zeta_{jt}^{EPI} = \frac{\partial Z_{jt}^{EPI}}{\partial e_{jt}} = \sum_{v=v_j}^{\bar{v}_{j}^{J}} \left(\prod_{u=t}^{v} \frac{1}{1+i_u} \right) \frac{\partial EPIB_{jv}(t)}{\partial T_j^{EPI}} \frac{\partial T_j^{EPI}}{\partial e_{jt}}, \tag{24}$$

where e_{jt} is the employment rate, therefore, $T_j^{EPI} = \sum_{s=\underline{s}_j}^{\bar{s}_j} \chi_{js} e_{js}$. The derivation of $EPIB_{jv}(t)$ with respect to T_j^{EPI}, namely $epib_{jv}(t)$, varies depending on t. We employ a simplified definition of $epib_{jv}(t)$ as follows: during 1973–1984,

$$epib_{jv}(t) = \eta_v + .01 \times AR_{jv}, \qquad (60 \le v \le \bar{v}_{jt}^{J}), \tag{25}$$

during 1985–1992,

$$epib_{jv}(t) = \begin{cases} \kappa_v \times \mu_j + \lambda_j \times AR_{jv}(t), & (60 \le v < 65), \\ \iota_j \times BP_v \div \bar{T}_j^{NP} + \lambda_j \times AR_{jv}(t), & (65 \le v \le \bar{v}_{jt}^{J}), \end{cases} \tag{26}$$

during 1993–1997,

$$epib_{jv}(t) = \begin{cases} \lambda_j \times AR_{jv}(t), & (60 \le v < \underline{v}_j), \\ \kappa_v \times \mu_j + \lambda_j \times AR_{jv}(t), & (\underline{v}_j \le v < 65), \\ \iota_j \times BP_v \div \bar{T}_j^{NP} + \lambda_j \times AR_{jv}(t), & (65 \le v \le \bar{v}_{jt}^{J}), \end{cases} \tag{27}$$

thereafter,

$$epib_{jv}(t) = \begin{cases} \lambda_j \times AR_{jv}(t), & (\underline{v}'_j \le v < \underline{v}_j), \\ \kappa_v \times \mu_j + \lambda_j \times AR_{jv}(t), & (\underline{v}_j \le v < 65), \\ \iota_j \times BP_v \div \bar{T}_j^{NP} + \lambda_j \times AR_{jv}(t), & (65 \le v \le \bar{v}_{jt}^{J}), \end{cases} \tag{28}$$

where $\underline{v}_j$ and $\underline{v}'_j$ are the ages that the cohort j begins receiving the first term and the second term, respectively (Tables 4 and 5).[22] We ignore the case where $T_j^{EPI} > T_j$

[21] We do not take into account the income taxes on pension benefit, because the measured income tax rates in equation (16) contain them. In order to isolate the effects of the pension benefits, we have to measure the marginal income tax rates on the pension benefit, and exclude the taxes on the pension benefits in equation (16). However, we can not do so because there is no data about the taxes on the pension benefits. Specifically, in Japan after late 1980s, a large part of the pension benefits is not taxed, because there were three important changesin the law that affected taxation of the pension benefit. First, the uncovered spouse was granted the right of the pension benefit in 1985, which corresponds to $BP_t\min(1, T_j/\bar{T}_j^{NP})$ in equation (21). Because the unit of taxation in Japan is the individual, this change implies the decline of taxable income. Second, the marital special deduction and the pension benefit deduction of *the Income Tax* and *the Residential Tax* began in 1987 and 1988, respectively. *The Pension Finance* show that a large percentage of the beneficiaries receives a pension benefit amount less than minimum taxable income after 1988.

[22] We assume that the new law is announced in the year before it is implemented.

and $T_j^{EPI} > T_j'$ because the authority sets T_j and T_j' such that the EPI covers ordinary full-time employees for the most.

The procedure for the NP is as follows. The discounted sum of the NP's benefit amount, Z_{jt}^{NP}, is

$$Z_{jt}^{NP} = \sum_{v}^{\bar{v}_{jt}^J} \left(\prod_{u=t}^{v} \frac{1}{1+i_u} \right) NPB_{jv}(t), \tag{29}$$

then, the discounted sum of marginal benefit amounts is

$$\zeta_{jt}^{NP} = \sum_{v}^{\bar{v}_{jt}^J} \left(\prod_{u=t}^{v} \frac{1}{1+i_u} \right) \frac{\partial NPB_{jv}(t)}{\partial T_j^{NP}} \frac{\partial T_j^{NP}}{\partial e_{jt}} = \sum_{v}^{\bar{v}_{jt}^J} \left(\prod_{u=t}^{v} \frac{1}{1+i_u} \right) npb_{jv}(t) \frac{\partial T_j^{NP}}{\partial e_{jt}}, \tag{30}$$

where

$$npb_{jv}(t) = \begin{cases} BP_v \div 25, & (t < 1985), \\ BP_v \div \bar{T}_j^{NP}, & (t \geq 1985), \end{cases} \tag{31}$$

$$T_j^{NP} = \sum_{s=\underline{s}_j}^{\bar{s}_j} (1-\chi_{js}) e_{js}. \tag{32}$$

We calculate the average of the marginal pension benefit amount, ζ_t^J, by taking the weighted average of ζ_{jt}^{EPI} and ζ_{jt}^{NP}:

$$\zeta_t^J = \frac{1}{(1-\theta)(GDP_t^J - IT_t^J)} \sum_j E_{jt}^J (\zeta_{jt}^{EPI} + \zeta_{jt}^{NP}) \ , \tag{33}$$

where E_{jt}^J is the number of workers.

Finally, we incorporate ζ_t^J into equation (8) as follows:[23]

$$\frac{l_t^J}{1-l_t^J} = \frac{1-\theta}{\alpha} \frac{1-\tau_{lt}^J + \zeta_t^J}{1+\tau_{ct}^J} \frac{y_t^J}{c_t^J} \ . \tag{36}$$

3.3 Data

The dataset is annual, and its period is from 1973–2006. The data of the GNP, private consumption expenditure, private investment, government expenditure, salary and wages, and taxes are sourced from 68SNA and 93SNA published by *the Cabinet Office, Government of Japan*. The parameters of the benefit, $\eta_v, W_s, \kappa_v, \mu_j, \lambda_j, \iota_j, BP_{jt}, \bar{T}_j^{EPI},$ and $\bar{T}_j^{NP}$ are sourced from the Ministry of Health and Welfare (1998, 1999) and the website of the

[23] Equation (33) can be transformed as follows:

$$\zeta_t^J = \frac{1}{(1-\theta)(GDP_t^J - IT_t^J)/E_t^J} \sum_j \frac{E_{jt}^J}{E_t^J} (\zeta_{jt}^{EPI} + \zeta_{jt}^{NP}) = \frac{1}{\omega_t^J h_t^J} \sum_j \frac{E_{jt}^J}{E_t^J} (\zeta_{jt}^{EPI} + \zeta_{jt}^{NP}) = \frac{x_t}{\omega_t^J h_t^J}, \tag{34}$$

where E_t^J denotes the aggregate number of workers in Japan, and x_t is the average of marginal pension benefits. Because we employ the extensive margin, the intratemporal optimization condition is as follows:

$$\alpha \frac{h_t}{1-l_t} (1+\tau_{ct}) c_t = (1-\tau_{lt}) \omega_t h_t + x_t = \left(1 - \tau_{lt} + \frac{x_t}{\omega_t h_t} \right) \omega_t h_t = (1-\tau_{lt} + \zeta_t) \omega_t h_t. \tag{35}$$

Ministry of Health and Welfare.[24] The life expectancy data, $\bar{v}_{jt}$ are sourced from the *Abridged Life Table*.

Because there is no data on the number of people covered by the EPI and the NP generation by generation, we measure $E^J_{jt}\chi_{jt}$ and $E^J_{jt}(1-\chi_{jt})$ from

$$E^J_{jt}\chi_{jt} = (\text{ratio of cohort j in EPI}) \times (\text{total \# of covered by EPI}), \tag{37}$$

$$E^J_{jt}(1-\chi_{jt}) = (\text{ratio of cohort j in NP}) \times (\text{total \# of covered by NP}). \tag{38}$$

The ratio of cohort j in the EPI are sourced from *the Wage Census*, whose coverage is close to that of the EPI. The ratio of cohort j in the NP comes from *the Labor Force Survey*, whose number of workers in the agricultural industry, self-employed, family workers, temporary employees, and day labourers are in the non-agricultural industries.

In order to deal with the shortening of the EPI's minimum coverage years in 1985, we employ the following setting:

$$E^J_{jt}\chi_{jt} = \begin{cases} \text{\# of covered male}, & t < 1985, \\ \text{\# of all covered employee}, & t \geq 1985, \end{cases} \tag{39}$$

$$W_t = \begin{cases} \text{average wage of covered male}, & t < 1985, \\ \text{average wage of all covered employee}, & t \geq 1985. \end{cases} \tag{40}$$

3.4 Result

Figure 4 displays the marginal pension benefit rates. It rises in 1985 because the effect of the decrease in the minimum coverage years overcomes that of the increase in the maximum coverage years. The sudden drops in 1993, 1998, and 2003 are caused by the delays of the benefit starting age and other factors. Because the arrears in the NP becomes an issue of public concern, we measure the pension benefit rates without the NP. The pension benefit rates of the NP are not large, especially after 1985, because the number of those covered and the benefit amount per person of the NP are smaller than those of the EPI. Figure 5 illustrates the gross and the net tax rates of the entirety of the social security and pension systems. The social security tax rates have increased since the 1970s, which is the most important factor in the taxes that cause a decrease in the predicted hours worked. However, if we take into account the pension benefit rates, a large portion of social security taxes are set off. Note that the pension's net tax rates were negative before 1993, and they remain under three percent even after 1993.

Figure 6 illustrates the prediction that takes into account the pension benefits. The pension benefit can explain a large part of discrepancy between the data and prediction. It increases the prediction by 1.6–2.3 per-week hours. However, as the pension benefit rates have declined, their positive effect on the hours worked has become weak. This implies that Japan's hours worked continues to decline if the pension benefit is reduced due to the deterioration of the pension system's finances. The prediction worsens in the mid-1970s, which we interpret as follows. While the EPI's expected benefit amount was largely increased in 1973, its contribution temporarily remained at a low level until 1976, because of the depression due to the oil shock. Although the model employed does not take into account any frictions in the labor supply, they seem to exist in reality. Because the increase in the tax rate after the oil shock was announced, workers might not have increased their labor inputs, in anticipation of the rise in the tax rate in the near future.

[24] `http://www.mhlw.go.jp/topics/nenkin/zaisei/zaisei/index.html` (in Japanese).

4 The Case of Sweden

4.1 The Pension System and Its Evolution[25]

The history of the old-age public pension system in Sweden began in 1913, when *the Pension Insurance Law* was passed. In 1946, *the National Pension Law* was established, which is a prototype of today's *Basic Pension* (Allmän Folkpension, AFP). The benefit amount of the AFP did not relate to the contribution or the income of the covered person.[26]

The supplementary pension (Allmän tilläggs pension, ATP) began in 1960. ATP compulsorily covered all workers in Sweden agede 16 years or older, and whose annual labor income is more than *the Base Amount*. The ATP's benefit scheme of cohort j at year v is as follows:

$$ATPB_{jv} = 0.6 \times BA_v \times APP_j \times \min\left(1, \frac{T_j^{ATP}}{\bar{T}_j^{ATP}}\right). \tag{41}$$

BA_s is *the Base Amount*, on which the amounts of the social security benefits are calculated. Although it was fully linked to the inflation rate, it is linked only to 60 percent of the inflation rate after 1995. Furthermore, 98 percent of the Base Amount is used in the calculation of the social security benefits after 1993. $\bar{T}_j^{ATP}$ is the maximum coverage years depending on the cohort (Table 6). APP_j is *the Average Pension Point*, which is the average of the 15 highest *Pension Point*.[27] The Pension Point for each year s, PP_{js}, is calculated from

$$PP_{js} = \min\left(\frac{w_{js}h_{js} - BA_s}{BA_s}, 6.5\right). \tag{42}$$

PP_{js} is a growing variable because BA_s does not relate to the real economic growth rate. At the beginning, people could receive the benefit beginning at age 67. That was reduced to 65 in 1977.

In addition to AFP and ATP, there are several occupational pension systems. *The Industrins Tilläggspension* (ITP), which covers the white-collar workers, was founded in 1960, and *the Särskild tilläggspension* (STP) was agreed to be established in 1971 to cover the blue-collar workers. Other occupational pension systems cover workers in the public sector, with benefit schemes similar to the ITP.[28] Until the age of entitlement of AFP and ATP was declined to 65 from 67 in 1977, the ITP and STP paid large amounts between 67 and the retirement age, which was basically 65, although it was 62 for female white-collar workers in private sector before 1971. The benefit schemes of the ITP and STP before 1977 are

$$\begin{aligned} ITPB_{jv} =& \left(\prod_{u=s_j}^{v}(1+\pi_u)\right) \times \min\left(1, \frac{T_j^{ITP}}{30}\right) \times \qquad (43) \\ & \left[\psi \times \min(w_{js_j}h_{js_j}, 7.5 \times BA_{s_j}) + .325 \times \max\left(0, (w_{js_j}h_{js_j} - 7.5 \times BA_s)\right)\right], \end{aligned}$$

$$STPB_{jv} = \left(\prod_{u=s_j}^{v}(1+\pi_u)\right) \times \min\left(1, \frac{T_j^{STP}}{30}\right) \times \left[\psi \times PW_j^{STP}\right]. \tag{44}$$

[25] We refer to Wadensjö (1997) on this subsection.

[26] Therefore, we do not take into account the AFP in the measurement of the marginal benefit rates.

[27] If the coverage years are less than 15, the APP is the average of these years.

[28] For this reason, we assume that these benefit schemes are the same as that of the ITP. See Wadensjö (1997).

s_j is the year before retirement. PW_j^{STP} is the STP's "Pension Wage" that is the average of a portion below the 7.5 Base Amount of the three highest annual wages between the ages of 55 and 59. ψ equals to .65 for aged 65 or 66, and .1 thereafter. Then, the benefit schemes of the ITP and STP after 1977 are

$$\begin{aligned} ITPB_{jv} = & \left(\prod_{u=s_j}^{v} (1+\pi_u) \right) \times \min\left(1, \frac{T_j^{ITP}}{30}\right) \times \\ & \Big[.1 \times \min(w_{js_j} h_{js_j}, 7.5 \times BA_s) + \\ & .65 \times \max\Big(0, \min(w_{js_j} h_{js_j} - 7.5 \times BA_s, 12.5 \times BA_s)\Big) + \\ & .325 \times \max\Big(0, \min(w_{js_j} h_{js_j} - 20 \times BA_s, 10 \times BA_s)\Big) \Big], \end{aligned} \tag{45}$$

$$STPB_{jv} = \left(\prod_{u=s_j}^{v} (1+\pi_u) \right) \times \min\left(1, \frac{T_j}{30}\right) \times \left[.1 \times PW_j^{STP} \right]. \tag{46}$$

As equation (42) describes, the ATP's marginal benefit of additional annual labor income for workers that earn more than 7.5 times the BA_s is zero. However, as a substitute for the ATP, the ITP pays 65 percent of the labor income before retirement of the portion between 7.5 times and 20 times the BA_s. In addition, the calculation considers the limitation of PP_{js} is non-bindingin the case of blue-collar workers, because their labor income is low.[29]

There were drastic changes in the pension system in the 1990s.[30] The pension system was converted from the defined benefit to the defined contribution, and a part of the pension tax was moved to reserve financing.[31]

4.2 Methodology

During 1960–1999, the pension benefit amounts of generation j at year s are generally described as follows:

$$PB_{js} = AFPB_{js} + APTB_{js} + OPB_{js}, \tag{47}$$

where $AFPB_{js}$ is the benefit amount of the AFP, and OPB_{js} is the occupational pension benefit.

The discounted sum of pension benefit at year t is

$$Z_{jt}^S = \sum_{v}^{\bar{v}_j^S} \left(\prod_{u=t}^{v} \frac{1}{1+i_u} \right) PB_{jv}. \tag{48}$$

[29]For these reasons, we ignore the limitation of PP_{js} and assume the occupational pension systems pay 10 percent of the labor income before retirement in the measurement of pension benefits.

[30]The new law was enacted in 1994, and enforced in 1999.

[31]For these reasons, we stop the measurement of the marginal pension benefit in 1993.

Then, the marginal pension benefit rates are

$$\zeta_{jt}^{S} = \frac{\partial Z_{jt}^{S}}{\partial e_{jt}} = \sum_{v}^{\bar{v}_j^S} \left(\prod_{u=t}^{v} \frac{1}{1+i_u} \right) \frac{\partial PB_{jv}}{\partial e_{jt}} \tag{49}$$

$$= \sum_{v}^{\bar{v}_j^S} \left(\prod_{u=t}^{v} \frac{1}{1+i_u} \right) \left[\frac{\partial AFPB_{jv}}{\partial e_{jt}} + \frac{\partial APTB_{jv}}{\partial T_j^{ATP}} \frac{\partial T_j^{ATP}}{\partial e_{jt}} + \frac{\partial OPB_{jv}}{\partial T_j^{OPB}} \frac{\partial T_j^{OPB}}{\partial e_{jt}} \right],$$

where

$$\frac{\partial AFPB_{jv}}{\partial e_{jt}} = 0 \tag{50}$$

$$\frac{\partial APTB_{jv}}{\partial T_j^{APT}} = \begin{cases} .6 \times BA_v \times APP_j \div \bar{T}_j^{ATP} \ , \ \text{if } 30 \leq (t-j) < 60 \\ 0 \ , \ \text{otherwise} \end{cases} \tag{51}$$

$$T_j^{ATP} = \sum_{s=\underline{s}_j}^{\bar{s}_j} e_{js} \qquad \Rightarrow \qquad \frac{\partial T_j^{ATP}}{\partial e_{jt}} = 1, \tag{52}$$

$$T_j^{OPB} = \sum q_{js} e_{js} \qquad \Rightarrow \qquad \frac{\partial T_j^{OPB}}{\partial e_{jt}} = q_{jt}. \tag{53}$$

The derivation of OPB_{jv} before 1977 is

$$\frac{\partial OPB_{jv}}{\partial T_j^{OPB}} = \begin{cases} .65 \times \left(\prod_{u=s_j}^{v} (1+\pi_u) \right) \times w_{s_j} \div 30 \times h_{s_j} \ , \\ \qquad \text{if } 30 \leq (t-j) < 60 \text{ and } (v-j) = 65, 66, \\ .1 \times \left(\prod_{u=s_j}^{v} (1+\pi_u) \right) \times w_{s_j} \times h_{s_j} \div 30 \ , \\ \qquad \text{if } 30 \leq (t-j) < 60 \text{ and } (v-j) \geq 67, \\ 0 \ , \ \text{otherwise,} \end{cases} \tag{54}$$

and that after 1977 is

$$\frac{\partial OPB_{jv}}{\partial T_j^{OPB}} = \begin{cases} .1 \times \left(\prod_{u=s_j}^{v} (1+\pi_u) \right) \times w_{s_j} \times h_{s_j} \div 30 \ , \ \text{if } 30 \leq (t-j) < 60 \\ 0 \ , \ \text{otherwise.} \end{cases} \tag{55}$$

q_{jt} is the ratio of workers covered by the occupational pension. The retirement year s_j is assumed to be the year when the cohort j reaches the age of 64. We assume that the marginal pension benefit of the APT becomes positive at the ages over 30–59, because PP_{js} is a growing variable; therefore, these ages include the period of the 15 highest Pension Points. With respect to OPB_{jv}, we employ the same age setting because the occupational pension systems count coverage years after the age of 28, and assume that the annual labor income at the year before retirement equals to the average labor income, that is, $w_{js_j} h_{js_j} = w_{s_j} h_{s_j}$.

The calculation of APP_j is as follows. First, we assume the entire cohort's wages at year v are equal as follows:

$$w_{js} h_{js} = w_s h_s. \tag{56}$$

Then, because the Swedish National Accounts do not distinguish "the Owner-Occupied Dwellings" and "the Other" in "the Enterpreneurial Income of Unincorporated Enterprises," we can not calculate the self-employees' income, and we calculate the average wage by assuming the self-employees' income equals to the employees' wage:[32]

$$w_s h_s = \frac{\text{Wages and Salaries}}{(\text{\# of total emp.}) \text{ - } (\text{\# of self emp.})}. \tag{57}$$

With this assumption,

$$PP_{js} = PP_s. \tag{58}$$

In the calculation of APP_j, we use PP_s at ages over 45–59 because PP_s is a growing variable:

$$APP_j = \frac{1}{15} \sum_{s=j+45}^{j+59} PP_s = \frac{1}{15} \sum_{s=j+45}^{j+59} \frac{w_s h_s - BA_v}{BA_v}. \tag{59}$$

Because there is no data on the future Pension Points, we assume that the Pension Points grow at the constant rate $g_{pp} = 0.025$, which is the average growth rate of PP_v during 1963–2006:

$$PP_s = (1 + g_{pp})^{s-2006} \; PP_{2006}, \text{ if } s > 2006. \tag{60}$$

Finally, we take the average of the marginal pension benefit as follows:

$$\zeta_t^S = \frac{1}{(1-\theta)(GDP_t^S - IT_t^S)} \sum_j E_{jt}^S \zeta_{jt}^S \; , \tag{61}$$

where N_{jt}^S is the number of generation j employees. By incorporating ζ_t^S into equation (8), we predicted the hours worked.

4.3 Data

Data of the GNP, private consumption expenditure, private investment, government expenditure, salary and wages, and taxes are sourced from *the OECD's National Accounts Detailed Tables.* The total number of employees, the number of employees in the industrialized sector, and hours per worker are sourced from *the OECD's Labor Force Statistics.* The Base Amount is published by *Statistics Sweden.* The life expectancy is published by *the Statistiska Centralbyran.* The real interest rate is calculated from the Government bond yields (10 years) and *the Consumer Price Index.* These data are sourced from *the SCB.* We use the average of real interest rate during 1997–2008 because the interest rates in Sweden before the mid 1990s were unstable, such that the short term interest rate became higher than the long term rate at some times.

4.4 Result and Discussion

Figure 9 displays the marginal pension benefit rates (baseline), which are between 5 and 10 percent. There are two factors that cause the growth of marginal pension benefit rates

[32]The calculated wages are close to the wage of the "Average Production Worker" published by the OECD.

after 1980: the increase in life expectancy and the change in the demographic structure of employees. If the life expectancy had remained at the 1963 level, the marginal pension benefit rate in 1993 would decrease by approximately 1.7 percent (const. life exp.).[33] Similarly, if the demographic structure had remained at the 1963 level, the marginal pension benefit rate in 1993 would decrease by approximately one percent, as a result, the growing trend would nearly disappear (const. life exp. & stable demo. str.). Figure 10 shows the gross and net tax rates of the entirety of the social security and pension systems. The gross tax rates on the social security are quite high, especially after 1978. However, if we take into account the pension benefits, a large portion of taxes are offset.

Figure 11 illustrates the prediction that takes into account the pension benefits. The pension benefit can explain 24–55 percent of the discrepancy between the data and the prediction during 1970–1993, and it increases the prediction by 2.5–4.0 hours. Compared with the case of Japan, there remains a large discrepancy between the data and the prediction. One possible element of this remaining discrepancy is the other social security benefits. Rogerson (2007) and Olovsson (2009) point out that a some portion of the Swedish government expenditure substitute for the leisure or the home production; therefore, the hours worked in Sweden is longer than the prediction that ignores this category of government expenditure. Our pension benefit story and theirs are not exclusive of each other. It is possible that the combination of these two factors can explain the hours worked in Sweden. Of course, there could be other causes. Gustafsson (1992) and Gustafsson and Jacobsson (1985) demonstrate that the introduction of separate taxation in 1971 increased the female employment rates in Sweden. Although we assume the same progressivity of labor income tax for all countries, it might not be relevant.

5 Conclusion

The purpose of this study was to show what degree the pension benefit can elucidate the discrepancy between the actual hours worked and the Prescott (2004) model in Japan and Sweden, and demonstrate the impact of the pension benefit system on the hours worked in the macro economy. To this end, we measured the pension benefit rates, and incorporated them into the previous studies. We found that the marginal pension benefit rates reach five percent and higher in both countries, and the marginal pension benefit rates can explain much of the discrepancy between the actual hours worked and those predicted by the theory.

These results implied that the pension benefit systems could have significant impacts on the economic activities. In Japan, since the social security finances have deteriorated, the pension benefit amounts have been reduced and might be reduced further in the future. This means that the hours worked in Japan might continue to decline. Because the main cause of the deterioration of the social security finances is the growth of the aging populace, there might be a decline in hours worked due to similar financial deterioration in other aging countrites.

Furthermore, pension benefits might be able to answer the question that Ljungqvist and Sargent (2006) raised— why the Prescott (2004) model is consistent with the data in the continental European countries in spite of its ignoring the unemployment insurance. As in Japan and Sweden, the increase in social security tax rates is the main cause of the decline in predicted hours worked in France and Germany (Figure 14). The pension

[33] To deal with the increase in life expectancy, the pension benefit amount of each cohort changes with its life expectancy in the new Swedish pension system.

benefit systems in these countries are similar to those in Japan and Sweden; therefore, the pension benefits could offset the effect of the unemployment insurance.

As demonstrated above, pension benefits could act as an incentive for work; in other words, they could offset the negative impact of the pension tax. We think, therefore, that the development of social security, at least as a pension system, does not necessarily conflict with the economic growth.

A Details in the Calculation of the Pension Benefit

The EPI's benefit of cohort j at year v is generally described as follows:

$$EPIB_{jv}(t) = \left[D_{jv}(t) T_j^{EPI} + \lambda_j(t) AR_{jv}(t) T_j^{EPI} + o_v \right], \tag{62}$$

$$AR_{jv} = \frac{1}{T_j} \sum_{s=\underline{s}_j}^{\bar{s}_j} RAR_{vs}(t) W_{js}. \tag{63}$$

Then, the discounted sum of $EPIB_{jv}(t)$ is

$$Z_{jt}^{EPI} = \sum_{v=v_j}^{\bar{v}_j^J} \left(\prod_{u=t}^{v} \frac{1}{1+i_u} \right) EPIB_{jv}(t) \tag{64}$$

$$= \sum_{v=v_j}^{\bar{v}_j^J} \left(\prod_{u=t}^{v} \frac{1}{1+i_u} \right) \left[D_{jv}(t) + \lambda_j(t) AR_{jv}(t) T_j^{EPI} + o_v \right], \tag{65}$$

and that of NP_{jv} is

$$Z_{jt}^{NP} = \sum_{v}^{\bar{v}_{jt}^J} \left(\prod_{u=t}^{v} \frac{1}{1+i_u} \right) NPB_{jv}(t) \tag{66}$$

$$= \begin{cases} \sum_v^{\bar{v}_{jt}^J} \left(\prod_{u=t}^v \frac{1}{1+i_u} \right) BP_v(t) \div 25, & (t < 1985), \\ \sum_v^{\bar{v}_{jt}^J} \left(\prod_{u=t}^v \frac{1}{1+i_u} \right) BP_v(t) \div \bar{T}_j^{NP}, & (t \geq 1985). \end{cases} \tag{67}$$

In the calculation, we employ the assumptions below:

$$W_{jt} = \rho_j W_t, \tag{68}$$

$$\frac{1}{T_j} \sum_{s=\underline{s}_j}^{\bar{s}_j} \rho_j = 1, \tag{69}$$

where ρ_j and W_t denote the time-invariant efficiency of a cohort j worker and the average wage of workers covered by EPI, respectively. Because $D_{jv}(t)$, $AR_{jv}(t)$ and $BP_v(t)$ were expected to grow with the inflation and the wage before 1993, we can easily calculate them as follows:

$$\left(\prod_{u=t}^{v}\frac{1}{1+i_u}\right)D_{jv}(t)=\left(\prod_{u=t}^{v}\frac{(1+g_u)(1+\pi_u)}{1+i_u}\right)D_{jt}(t), \tag{70}$$

$$\begin{aligned}\left(\prod_{u=t}^{v}\frac{1}{1+i_u}\right)AR_{jv}(t)&=\left(\prod_{u=t}^{v}\frac{1}{1+i_u}\right)\frac{1}{T_j}\sum_{s=\underline{s}_j}^{\bar{s}_j}\left(\prod_{k=s}^{v}(1+g_k)(1+\pi_k)\right)\rho_j W_s\\&=\left(\frac{1}{T_j}\sum_{s=\underline{s}_j}^{\bar{s}_j}\rho_j\right)\left(\prod_{u=t}^{v}\frac{1}{1+i_u}\right)W_v \qquad (71)\\&=\left(\prod_{u=t}^{v}\frac{(1+g_u)(1+\pi_u)}{1+i_u}\right)W_t,\end{aligned}$$

$$\left(\prod_{u=t}^{v}\frac{1}{1+i_u}\right)NP_{jv}(t)=\left(\prod_{u=t}^{v}\frac{(1+g_u)(1+\pi_u)}{1+i_u}\right)NP_{jt}(t), \tag{72}$$

then, during 1993–1997,

$$\left(\prod_{u=t}^{v}\frac{1}{1+i_u}\right)D_{jv}(t)=\left(\prod_{u=t}^{v}\frac{(1+g_u)(1+\pi_u)}{1+i_u}-g_\tau\right)D_{jt}(t), \tag{73}$$

$$\left(\prod_{u=t}^{v}\frac{1}{1+i_u}\right)AR_{jv}(t)=\left(\prod_{u=t}^{v}\frac{(1+g_u)(1+\pi_u)}{1+i_u}-g_\tau\right)W_t, \tag{74}$$

$$\left(\prod_{u=t}^{v}\frac{1}{1+i_u}\right)NP_{jv}(t)=\left(\prod_{u=t}^{v}\frac{(1+g_u)(1+\pi_u)}{1+i_u}-g_\tau\right)NP_{jt}(t), \tag{75}$$

during 1998–2002,

$$\left(\prod_{u=t}^{v}\frac{1}{1+i_u}\right)D_{jv}(t)=\left(\prod_{u=t}^{64}\frac{(1+g_u)(1+\pi_u)}{1+i_u}\right)\left(\prod_{u=65}^{v}\frac{1+\pi_u}{1+i_u}\right)D_{jt}(t), \tag{76}$$

$$\left(\prod_{u=t}^{v}\frac{1}{1+i_u}\right)AR_{jv}(t)=\left(\prod_{u=t}^{64}\frac{(1+g_u)(1+\pi_u)}{1+i_u}\right)\left(\prod_{u=65}^{v}\frac{1+\pi_u}{1+i_u}\right)W_t, \tag{77}$$

$$\left(\prod_{u=t}^{v}\frac{1}{1+i_u}\right)NP_{jv}(t)=\left(\prod_{u=t}^{64}\frac{(1+g_u)(1+\pi_u)}{1+i_u}\right)\left(\prod_{u=65}^{v}\frac{1+\pi_u}{1+i_u}\right)NP_{jt}(t), \tag{78}$$

after 2003,

$$\left(\prod_{u=t}^{64}\frac{1}{1+i_u}\right)D_{jv}(t)=\left(\prod_{u=t}^{v}\frac{(1+g_u)(1+\pi_u)}{1+i_u}-ms_u\right)\left(\prod_{u=65}^{v}\frac{1+\pi_u}{1+i_u}-ms_u\right)D_{jt}(t), \tag{79}$$

$$\left(\prod_{u=t}^{64}\frac{1}{1+i_u}\right)AR_{jv}(t)=\left(\prod_{u=t}^{v}\frac{(1+g_u)(1+\pi_u)}{1+i_u}-ms_u\right)\left(\prod_{u=65}^{v}\frac{1+\pi_u}{1+i_u}-ms_u\right)W_{jt}, \tag{80}$$

$$\left(\prod_{u=t}^{64}\frac{1}{1+i_u}\right)NP_{jv}(t)=\left(\prod_{u=t}^{v}\frac{(1+g_u)(1+\pi_u)}{1+i_u}-ms_u\right)\left(\prod_{u=65}^{v}\frac{1+\pi_u}{1+i_u}-ms_u\right)NP_{jt}(t), \tag{81}$$

$$ms_u=\begin{cases}.009, & \text{if } 2004\le u\le 2023,\\ 0, & \text{otherwise,}\end{cases} \tag{82}$$

where g_u is the wage growth rate, π_u is the inflation rate, and g_τ is the growth rate of the labor income tax rate imposed on employees.

In the steady state, from a Euler equation,

$$\frac{(1+g)(1+\pi)}{1+i}=\beta. \tag{83}$$

We set the value of β, which is 0.977, from Braun, Ikeda, and Joines (2008). In addition, we assume that the wage growth rate, g_u, is .02. The value of g_τ, 0.0048, is calibrated from the Ministry of Health and Welfare (1997), which stated that the proportion of the social security taxes in the national income was expected to increase from 18.5 percent in 1995 to 35.5 percent in 2025.

B Average Marginal Tax Rate of Labor Income Tax

In this appendix, we measure the labor income's *average marginal tax rate* (AMTR) following Joines (1981), Seater (1982), and Stephenson (1998), and then we check the progressivity of the labor income tax in Japan by comparing the AMTR with the average tax rate (ATR). When we measure the labor income's AMTR in Japan, there are two problems. First, there are two income taxes: the income tax of the central government (*National Income Tax*) and that of the local governments (*Residential Income Tax*). There are statistics of the income and tax amount for income classes for the former, but not for the latter. Therefore, we measure the hypothetical tax amounts of the Residential Tax, which come from the data on the taxation and deductions. Second, there are two statistics: one for the employees of the private sector, and the other for the self-employees. Therefore, we measure the AMTRs of each employee, and then we take the average.

B.1 Methodology

The methodology is as follows. First, we measure the marginal tax rate of the National Income Tax. The marginal tax rate for income class j, $MTRN_j$, is

$$MTRN_j^i=\frac{TN_{j,t}^i-TN_{j-1,t}^i}{Z_{j,t}^i-Z_{j-1,t}^i}\ ,\ (i=E,S), \tag{84}$$

where $TN^i_{j,t}$ and $Z^i_{j,t}$ are the average tax amount of the National Income Tax and the average income amount of income class j, respectively. The super subscript i denotes the employees of the private sector and the self-employees. The average marginal tax rate is

$$AMTRN^i_t = \sum_j \frac{X^i_{j,t}}{X^i_t} MTRN^i_{j,t} \ , \tag{85}$$

where $X_{j,t}$ is the labor income of income class j, and X_t is the aggregate labor income.

Second, we measure the hypothetical marginal tax rate of the Residential Income Tax. Employing the data on the income and tax deduction, we calculate the average Residential Income Tax amount for each income class, $\widetilde{TR}^i_{j,t}$. The data on the income deductions are summarized in Tables 7 and 8. Then, the marginal tax rate of the Residential Income Tax is as follows:

$$MTRR^i_j = \frac{\widetilde{TR}^i_{j,t} - \widetilde{TR}^i_{j-1,t}}{Z^i_{j,t} - Z^i_{j-1,t}} \ , \ (i = E, S). \tag{86}$$

The average marginal tax rate is

$$AMTRR^i_t = \sum_j \frac{X^i_{j,t}}{X^i_t} MTRR^i_{j,t} \ . \tag{87}$$

B.2 The Dawning of the Residential Income Tax

Before 1961, there were three taxation systems in the per-income levy (Shotoku Wari) of the municipal inhabitant tax (Shi-Cho-Son Min Zei), which local government could choose.[34] The first, second, and third system levied a part of the national income tax, the taxable income of national income tax, and the taxable income minus national income tax, respectively. The Ministry of Finance (1960, 1962, 1963a) report that the first system covered the largest part of the per-income levy of the municipal inhabitant tax.[35] Therefore, we measure the municipal tax amount from the first system during this period. In 1962 and 1963, there were two taxation systems, the formula in the main text (Honbun Houshiki) and the formula in the proviso (Tadashigaki Houshiki). Ministry of Finance (1963a, 1964, 1965) report that the former covered a greater tax amount than the latter. Therefore, we employ the former formula for the measurement. In 1964, the tax system was unified.

B.3 The 'Ku-Ro-Yon' Problem

There were (and are) severe tax evasions by self-employed in Japan. This problem is crucial to measuring the marginal tax rates because it means that data do not capture the real income. Ishi (2001, pp. 64–70) reports that approximately 20 % of self-employed income was untaxed due to deductions and 30–40 % due to unreported or underreported incomes during 1970–1990.[36] We can assume that a large portion of tax erosion is due

[34]The second and the third system had two subsystems, the formula in the main text (Honbun Houshiki) and the formula in the proviso (Tadashigaki Houshiki), respectively.

[35]The most local governments employed the second system. However, the large part of these were small governments (Cho or Son), therefore the coverage of the tax amount were low.

[36]Ohta, Tsubouchi, and Tsuji (2003). However, Arai (2005) criticize Ohta et al. (2003) on their measurement procedure.

to reported incomes below minimum taxable level because approximately 60–80 % of the self-employed does not pay the income tax. These figures are calculated from the difference between the number of self-employed tax payers in the tax statistics and the number of self-employed in the Labor Force Survey.[37] Here, we assume that all tax erosion is due to the income below minimum taxable level.

B.4 Data

We employ two statistics: *the Results of the Statistical Survey of Actual Status for Salary in the Private Sector* (SASP) and *the Results of the Sample Survey for Self-assessment Income Tax* (SSIT). When the latter is employed to measure the tax rates of the self-employed, $Z_{j,t}$ and $X_{j,t}$ are different because $Z_{j,t}$ includes capital income. Finally, the total average marginal tax rates are calculated from the average of these two result.

B.5 Results

Figures 15, 16, and 17 display the measurement results for the employees, the self-employed, and the weighted average of both, respectively. The ratio between AMTR and ATR employees is stable, and its average, 1.74, is close to the 1.6 assumed by Prescott (2004), that is, 1.6. However, the ratio for self-employed is different. It falls below 1.3 after 1969, except for 1994. This phenomenon is due to the skew distribution of tax payments. A large portion of the income of self-employed is not taxed; therefore, the marginal tax rate for them is zero. As a result, the AMTR falls close to the average tax rate.

The ratio between the AMTR and the ATR of the weight average is stable, and stays between 1.4 and 1.7, except for 1954–1961 and 1994 (Figure 17). The decline of this ratio around the late 1950s and 1960s is due to the development of the income deductions: the establishment of the marital deduction and the expansion of the employment income deduction. In 1994 there was a large cut in the tax rate in order to ease the depression after the "bubble economy." The ratio decreased in 2006 because the residential tax rate uniformly became 10 percents for all tax payers.

Finally, we compare our ATR with the average income tax rate measured by Prescott's (2004) procedure, based on the SNA (Figure 18). These are close; however, tax rates based on the SNA are higher than ours, except for 1960, 2006, and 2007. This difference is due to the definition of taxes. The former is the total income tax rate, while the latter is the labor income tax rate. Therefore, the gap becomes larger when the capital income relatively increases; in the mid-70s when the inflation rate was high due to the oil shock, and around 1990 during "bubble economy."

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[37]There might be a difference in the definitions of "self-employed" between the tax statistics and the Labor Force Survey. The definition in the tax statistics is clearly based upon the tax law; therefore, the tax statistics does not cover legal corporations. On the other hand, that of the Labor Force Survey might cover small corporations because the Labor Force Survey is a household survey and the presidents of small corporations recognize themselves as self-employed.

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Table 1: Actual and Predicted Labor Supply

Period	Country	Labor Supply Actual	Labor Supply Predicted	Difference	Prediction Factors Tax Rate (τ)	Prediction Factors Cons./Output (c/y)
1993-96	Germany	19.3	19.5	.2	.59	.74
	France	17.5	19.5	2.0	.59	.74
	Italy	16.5	18.8	2.3	.64	.69
	Canada	22.9	21.3	-1.6	.52	.77
	U.K.	22.8	22.8	0	.44	.83
	U.S.	25.9	24.6	-1.3	.40	.81
	Japan	32.2	29.0	-3.2	.37	.68
	Sweden	21.8	15.2	-6.6	.69	.76
1970-74	Germany	24.6	24.6	0	.52	.66
	France	24.4	25.4	1.0	.49	.66
	Italy	19.2	28.3	9.1	.41	.66
	Canada	22.2	25.6	3.4	.44	.72
	U.K.	25.9	24.0	-1.9	.45	.77
	U.S.	23.5	26.4	2.9	.40	.74
	Japan	33.9	35.8	1.9	.25	.60
	Sweden	23.7	19.1	-4.6	.62	.71

Note: The actual hours worked from Germany to the U.S. and the predictions from Germany to Japan are sourced from Table 2 of Prescott (2004). The actual hours worked in Japan and Sweden are sourced from *Japan's Labor Force Survey* and OECD Labour Database, respectively. The predictions of Sweden are our own calculation.

Table 2: Time Varying Parameter of Pension Benefits in Japan (yen per year)

Year	BP_t
1973	240,000
1974	278,640
1975	339,600
1976	390,000
1977	426,696
1978	455,100
1979	470,700
1980	504,000
1981	507,931
1982	528,248
1983	528,248
1984	538,813
1985	600,000
1986	622,800
1987	626,500
1988	627,200
1989	666,000
1990	681,300
1991	702,000
1992	725,300
1993	737,300
1994	763,650
1995	785,500
1996	785,500
1997	785,500
1998	799,500
1999	804,200
2000	804,200
2001	804,200
2002	804,200
2003	797,000
2004	794,500
2005	794,500
2006	792,100

Table 3: Cohort Parameter of Pension Benefits in Japan (1986–1993)

birth year	$\bar{T}_j^{EPI}$	$\bar{T}_j^{NP}$	p_j	$m_j \times 10^3$
–1926	35	25	1.875	10
1927	35	26	1.817	9.86
1928	35	27	1.761	9.72
1929	36	28	1.707	9.58
1930	36	29	1.654	9.44
1931	36	30	1.603	9.31
1932	36	31	1.553	9.17
1933	36	32	1.505	9.04
1934	37	33	1.458	8.91
1935	37	34	1.413	8.79
1936	37	35	1.369	8.66
1937	37	36	1.327	8.54
1938	37	37	1.286	8.41
1939	37	38	1.246	8.29
1940	37	39	1.208	8.18
1941	37	40	1.17	8.06
1942	37	40	1.134	7.94
1943	37	40	1.099	7.83
1944	37	40	1.065	7.72
1945	37	40	1.032	7.61
1946–	37	40	1	7.5

Table 4: Entitlement Age of EPI's "Fixed Amount Portion" (from 1994)

birth year	male	female
–1940	60	60
1941	61	60
1942	61	60
1943	62	60
1944	62	60
1945	63	60
1946	63	61
1947	64	61
1948	64	62
1949	- - -	62
1950	- - -	63
1951	- - -	63
1952	- - -	64
1953	- - -	64
1954–	- - -	- - -

Table 5: Entitlement Age of EPI's "Remuneration-related Portion" (from 1999)

birth year	male	female
–1952	60	60
1953	61	60
1954	61	60
1955	62	60
1956	62	60
1957	63	60
1958	63	61
1959	64	61
1960	64	62
1961	- - -	62
1962	- - -	63
1963	- - -	63
1964	- - -	64
1965	- - -	64
1966–	- - -	- - -

Table 6: Cohort Parameter in APT (Sweden)

birth year	$\bar{T}_j^{ATP}$
–1914	20
1915	21
1916	22
1917	23
1918	24
1919	25
1920	26
1921	27
1922	28
1923	29
1924–	30

Table 7: Income Deductions of the Residentail Tax after 1962

index	Income Deductions	establishment	this paper
1	Basic Deduction	—	
	Marital Deduction		
2	general	1966	
3	special disabled	1983	from 1990
4	old	1981	
5	special disabled	1990	
6	Special Marital Deduction	1988	
	Dependent Deduction		
7	general	—	
8	special disabled	1983	from 1990
9	old	1973	lack, 1975–77
10	special disabled	1990	
11	old parents	1980	
12	special disabled	1990	
13	specifit	1990	
14	special disabled	1990	
15	Employment Income Deduction	—	
16	Employees' Specifit Expenditure Deduction	1989	no data
17	Public Pension Deduction	1989	
	Family Employee Deduction		
18	blue return	—	
19	white return	—	
20	spouse	1988	no data
21	Blue Retun Deduction	1973	no data
22	Disabled, Old, Widow, Widower, Student Dedution	1968	
23	special disabled	1970	from 1977
24	old	1987	lack, 1980–88
25	special widow	1990	
	Other Deductions		
26	casualty losses	—	
27	medical treatment	—	
28	life insurance	—	
29	private pension type	1985	from 1990
30	non-life insurance	1991	
31	social insurance	—	
32	small enterprise mutual relief projects	1968	
33	donation	1990	ignore

Note: The last column indicates the treatment of each deduction by this paper. If this column is blank, we take into account that deduction from its deduction. Depending on the taxation systems, deductions varied before 1962. Deductions in 1962 and 1963 are based upon the formula in the main text. "casualty losses" (index 26) are permitted of a portion in that excess of 10 percents of income. "social insurance" (31) and "small enterprise mutual relief projects" (32) are permitted 100 percents deduction.

Table 8: Income Deduction Amount of the Residential Tax

index	1	2	3	4	5	6	7	8	9	10	11	12	13	14	22	23	24	25	28	29	30
unit	10,000 yen / person																		max (yen)		
1950	1.5																				
1951	2.5						1.2														
1952	3.8						1.7														
1953	5						2														
1954	6						3.5														
1955	6.75						3.88														
1956	7.5						4														
1957	8						4														
1958	8.75						4.75														
1959	9						5														
1960	9						6.5														
1961	9						7														
1962	9						7												2.25		
1963	9						7												2.25		
1964	9						7												2.25		
1965	9						7												2.25		
1966	10	8					4												2.25		
1967	10	8					4												2.25		
1968	11	9					5								6		6		2.5		
1969	12	10					6								7		7		2.5		
1970	13	11					8								8	10	8		2.5		
1971	14	13					10								9	11	9		2.75		
1972	15	14					11								10	12	10		2.75		
1973	16	15					12		14						12	14	14		2.75		
1974	18	18					14		16						13	16	13		2.75		
1975	19	19					17		19						16	19	16		3.5		
1976	19	19					17		19						16	19	16		3.5		
1977	20	20					19		20						18	20	18		3.5		
1978	21	20					19		20						18	20	18		3.5		
1979	22	21					19		20						19	21	19		3.5		
1980	22	22					22		23		26				21	23	21		3.5		
1981	22	22		23			22		23		26				21	23	21		3.5		
1982	22	22		23			22		23		26				21	23	21		3.5		
1983	22	22	25	23			22	25	23		26				21	23	21		3.5		
1984	25.3	25.3	29.3	26.3			25.3	29.3	26.3		30.3				24	26	24		3.5		
1985	26	26	30	27			26	30	27		31				24	26	24		3.5	0.35	
1986	26	26	34	27			26	34	27		31				24	26	24		3.5	0.35	
1987	26	26	34	27			26	34	27		31				24	26	24		3.5	0.35	
1988	28	28	36	29		14	28	36	29		33				24	26	24		3.5	0.35	
1989	28	28	36	29		14	28	36	29		33				24	26	48		3.5	0.35	
1990	30	30	51	35	56	30	30	51	35	56	42	63	35	56	26	28	48	30	3.5	0.35	
1991	31	31	52	36	57	31	31	52	36	57	43	64	36	57	26	28	48	30	3.5	3.5	1
1992	31	31	52	36	57	31	31	52	36	57	43	64	36	57	26	28	48	30	3.5	3.5	1
1993	31	31	52	36	57	31	31	52	36	57	43	64	36	57	26	28	48	30	3.5	3.5	1
1994	31	31	52	36	57	31	31	52	36	57	43	64	39	60	26	28	48	30	3.5	3.5	1
1995	33	33	54	38	59	33	33	54	38	59	45	66	41	62	26	28	48	30	3.5	3.5	1
1996	33	33	54	38	59	33	33	54	38	59	45	66	41	62	26	28	48	30	3.5	3.5	1
1997	33	33	54	38	59	33	33	54	38	59	45	66	41	62	26	28	48	30	3.5	3.5	1
1998	33	33	54	38	59	33	33	54	38	59	45	66	41	62	26	28	48	30	3.5	3.5	1
1999	33	33	56	38	61	33	33	56	38	61	45	68	43	66	26	30	48	30	3.5	3.5	1
2000	33	33	56	38	61	33	33	56	38	61	45	68	45	66	26	30	48	30	3.5	3.5	1
2001	33	33	56	38	61	33	33	56	38	61	45	68	45	66	26	30	48	30	3.5	3.5	1
2002	33	33	56	38	61	33	33	56	38	61	45	68	45	66	26	30	48	30	3.5	3.5	1
2003	33	33	56	38	61	33	33	56	38	61	45	68	45	66	26	30	48	30	3.5	3.5	1
2004	33	33	56	38	61	33	33	56	38	61	45	68	45	66	26	30	48	30	3.5	3.5	1
2005	33	33	56	38	61	33	33	56	38	61	45	68	45	66	26	30	48	30	3.5	3.5	1
2006	33	33	56	38	61	33	33	56	38	61	45	68	45	66	26	30	48	30	3.5	3.5	1
2007	33	33	56	38	61	33	33	56	38	61	45	68	45	66	26	30	48	30	3.5	3.5	1
2008	33	33	56	38	61	33	33	56	38	61	45	68	45	66	26	30	48	30	3.5	3.5	1

Note: The index in the first row correspond to the index in Table 7.

Figure 1: Hours per Person (Japan, per week)

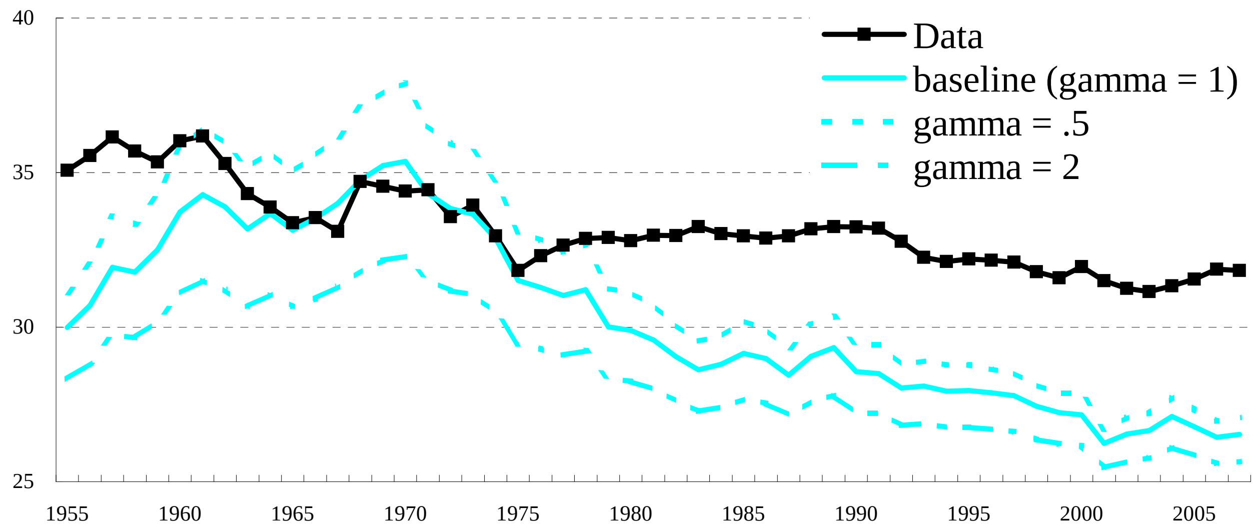


Figure 2: Hours per Person (Sweden, per week)

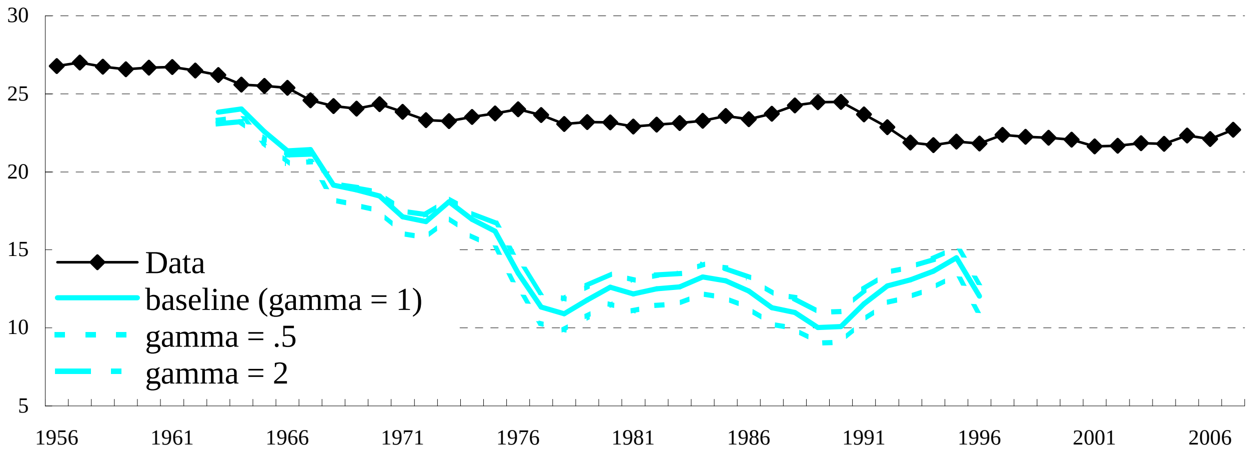


Figure 3: Hours per Worker (Japan, per week)

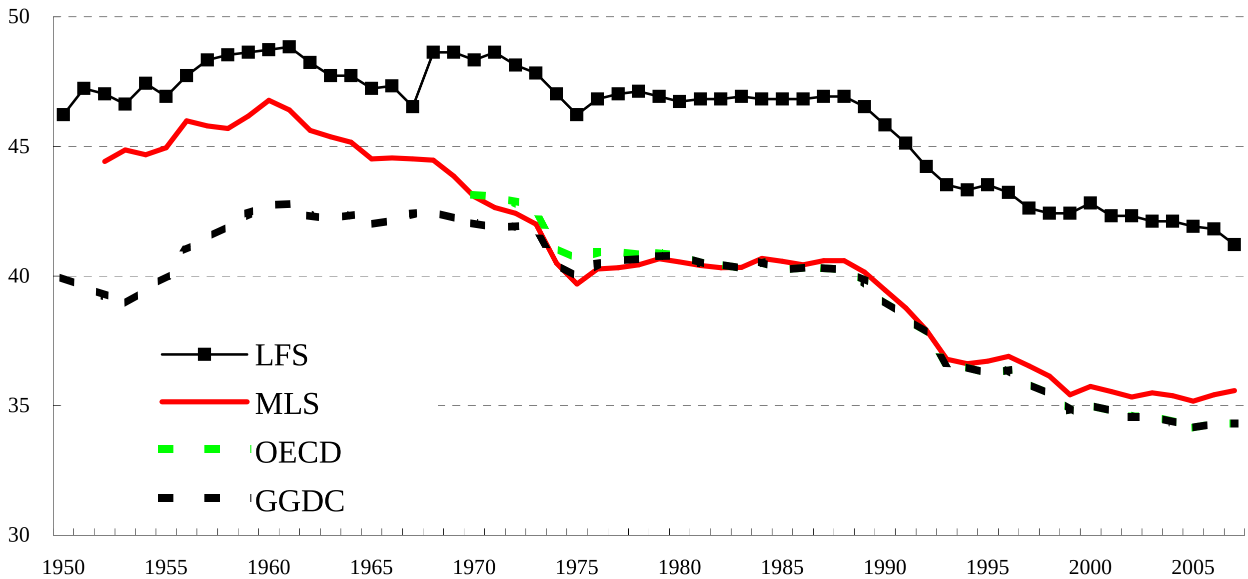


Figure 4: Marginal Pension Benefit Rate (Japan)

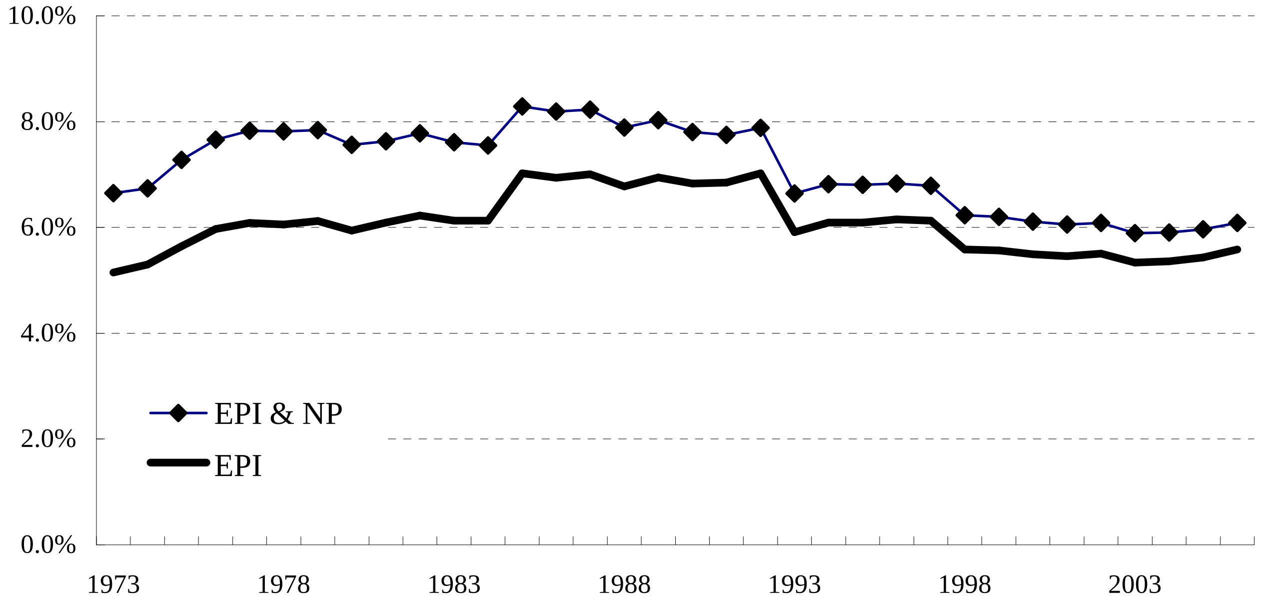
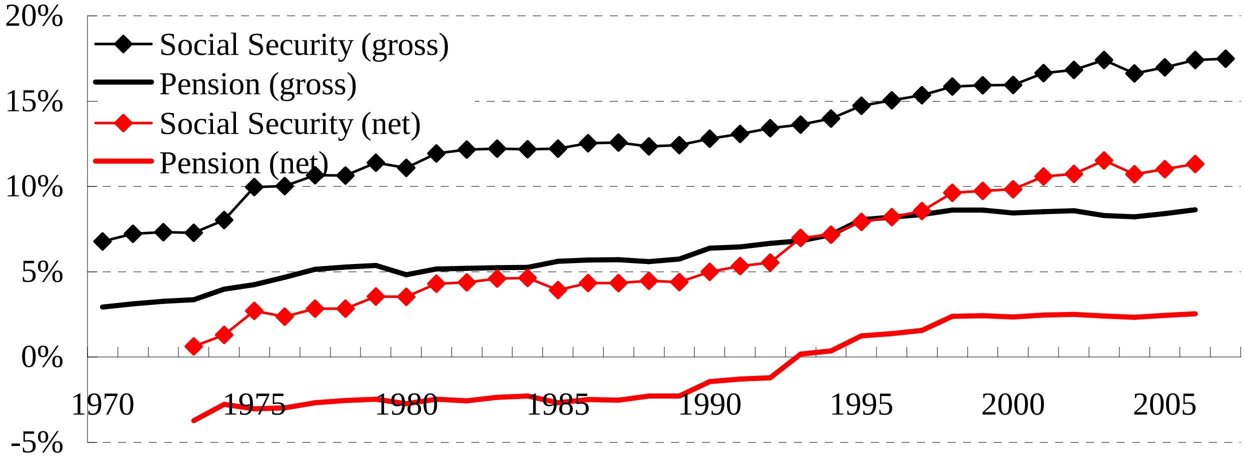


Figure 5: Gross & Net Tax Rates (Japan)



Note: "Social Security (gross)" $= \tau_{ss}$,

"Pension (gross)" $= \dfrac{\text{(Pension Taxes)}}{(1-\theta)(GDP - IT)}$,

"Pension Taxes" are sourced from SNA,

"Social Security (net)" $= \tau_{ss} - \zeta_t^J$,

"Pension (gross)" = "Pension (gross)" $- \zeta_t^J$.

Figure 6: Weekly Hours per Person in Japan (baseline: gamma = 1)

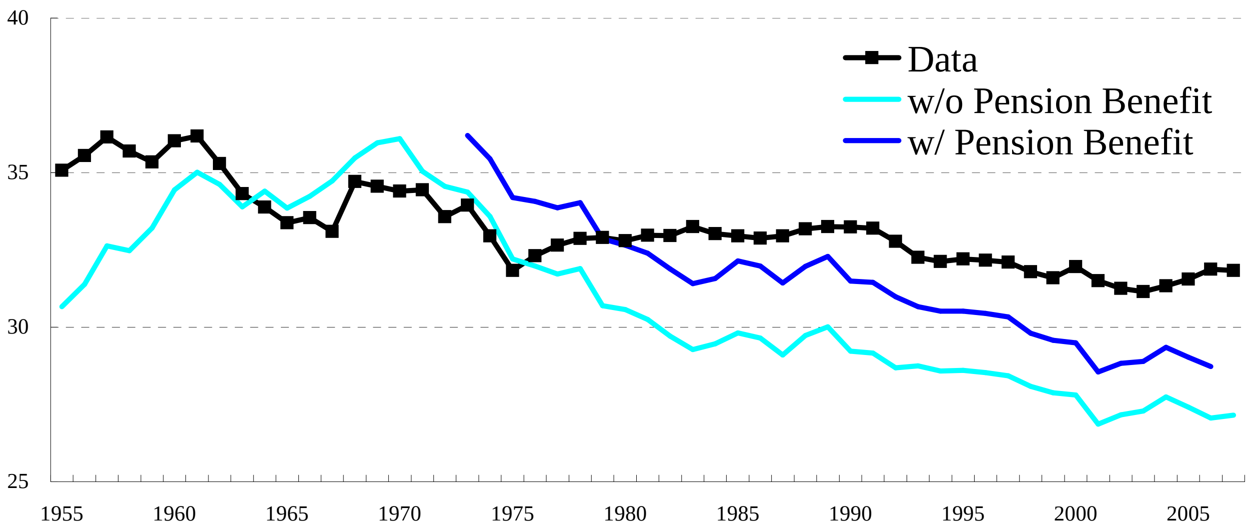


Figure 7: Weekly Hours per Person in Japan (gamma = .5)

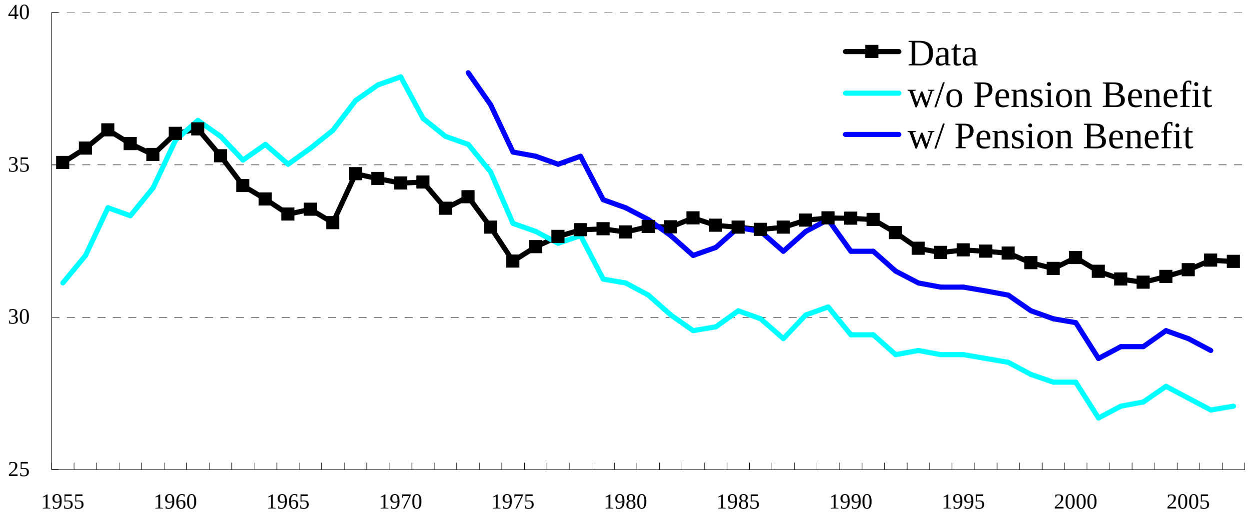


Figure 8: Weekly Hours per Person in Japan (gamma = 2)

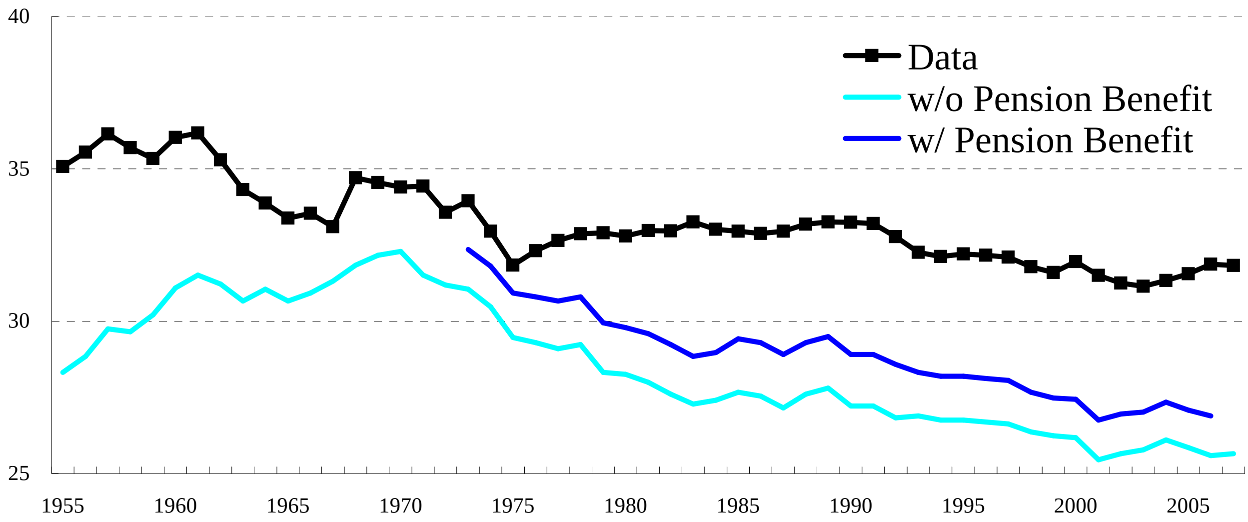
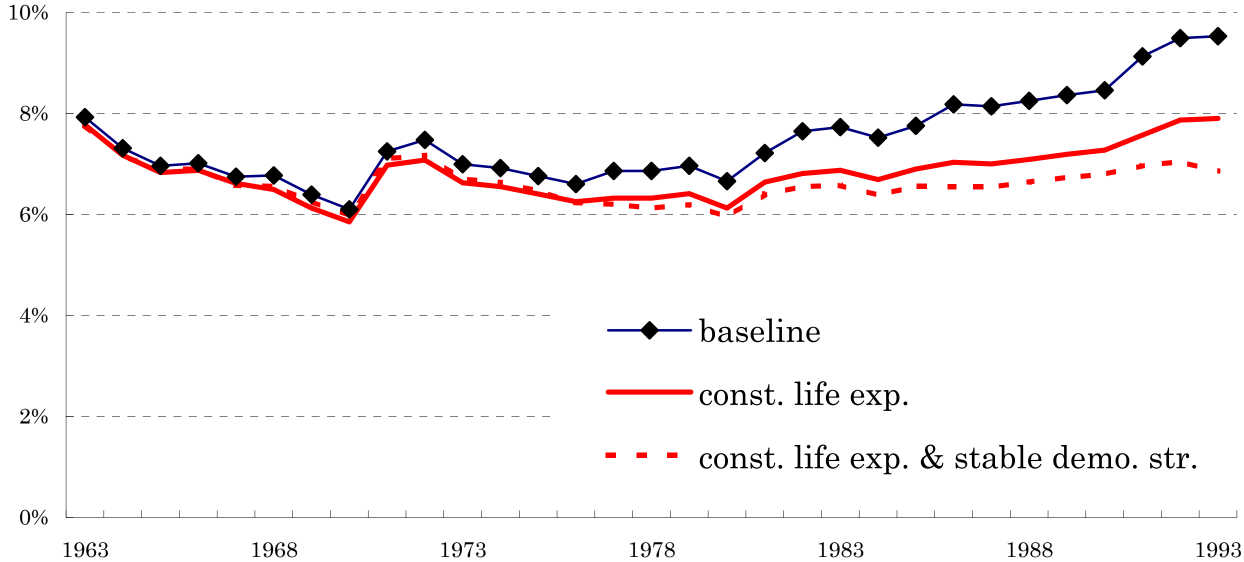
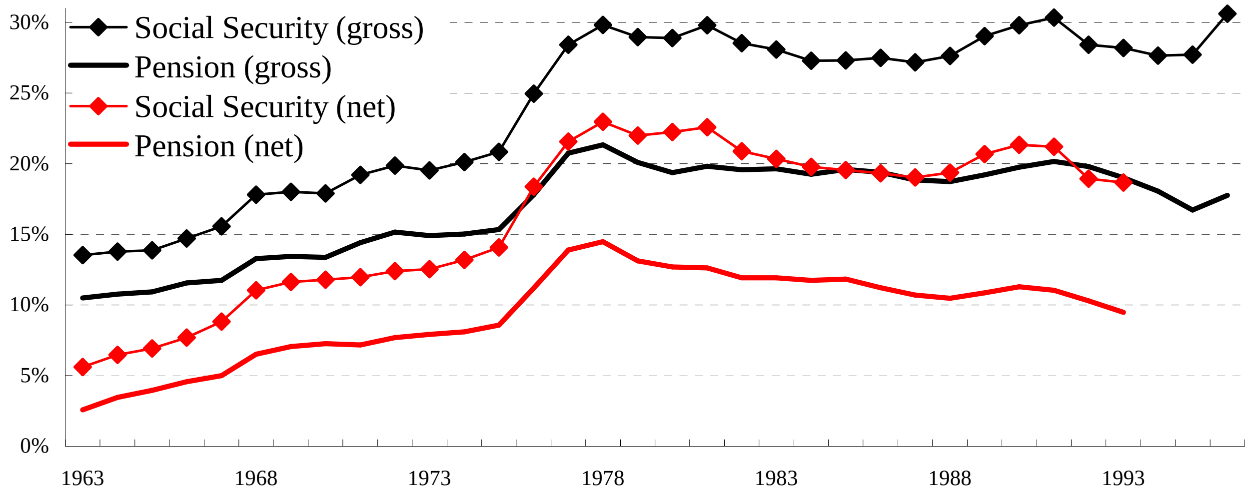


Figure 9: Marginal Pension Benefit Rate (Sweden)



Note : "const. life exp." is the marginal pension benefit rates in the case that the life expectancies are unchanged at the 1963 level. "const. life exp. & stable demo. str." are those in the case that the demographic structure of workers is unchanged from that of 1963 in addition to "const. life exp.".

Figure 10: Gross & Net Tax Rates (Sweden)



Note: "Social Security (gross)" $= \tau_{ss}$,

$$\text{“Pension (gross)”} = \frac{(\text{Taxes of AFP \& ATP}) + X}{(1-\theta)(GDP - IT)},$$

"Taxes of AFP and ATP," SCB.

X : "Employers' contribution to private pension insurance," SNA

"Social Security (net)" $= \tau_{ss} - \zeta_t^S$,

"Pension (gross)" = "Pension (gross)" $- \zeta_t^S$.

Figure 11: Weekly Hours per Person in Sweden (baseline: gamma = 1)

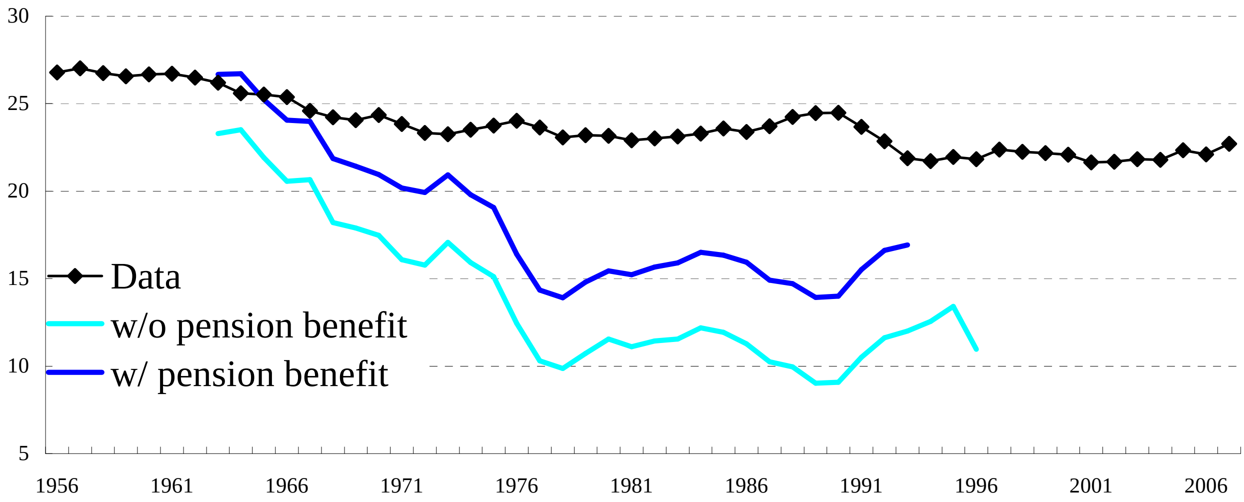


Figure 12: Weekly Hours per Person in Sweden (gamma = .5)

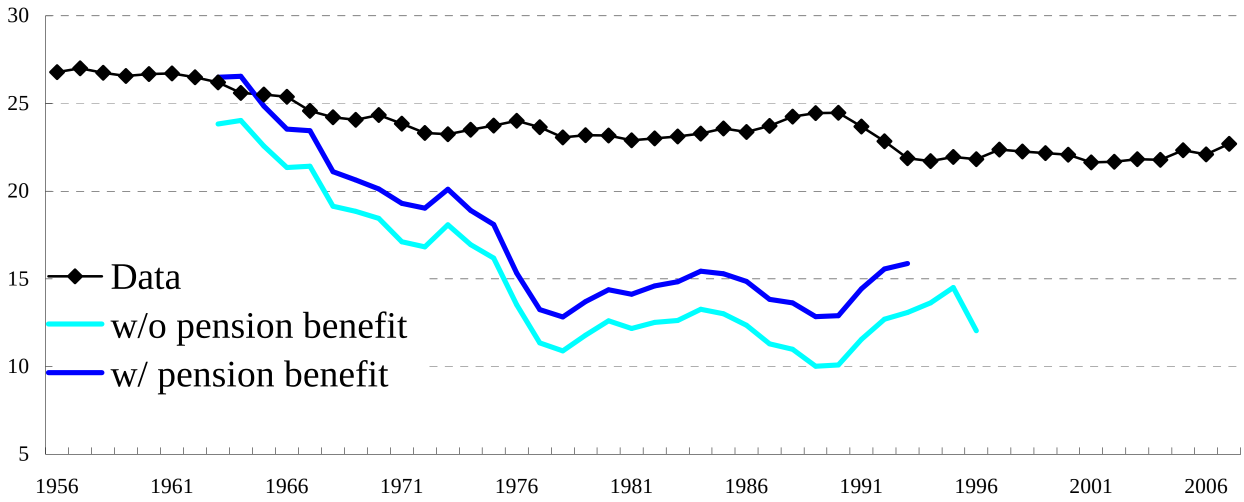


Figure 13: Weekly Hours per Person in Sweden (gamma = 2)

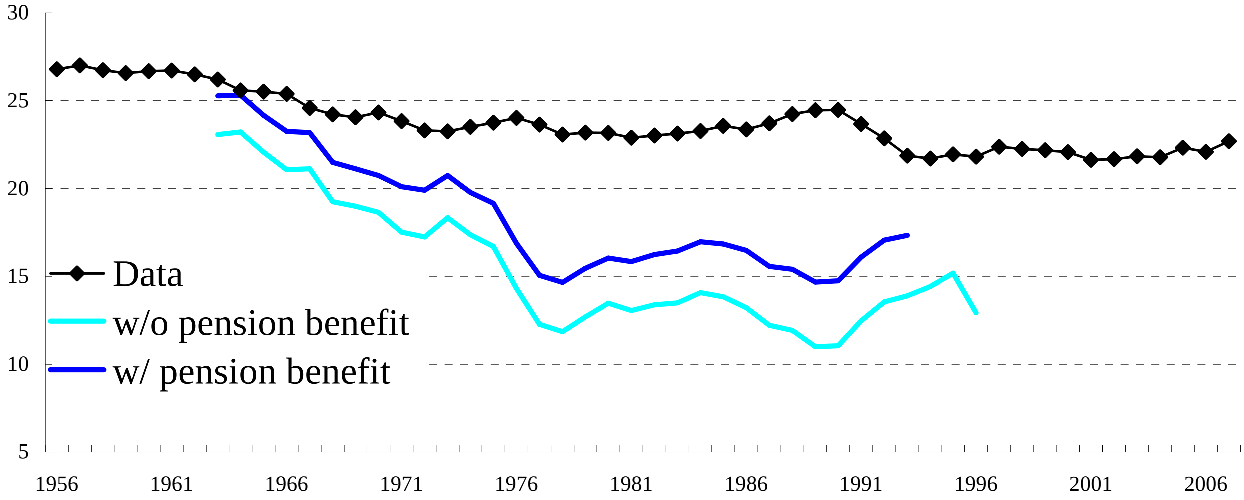


Figure 14: Gross Social Security Tax Rates

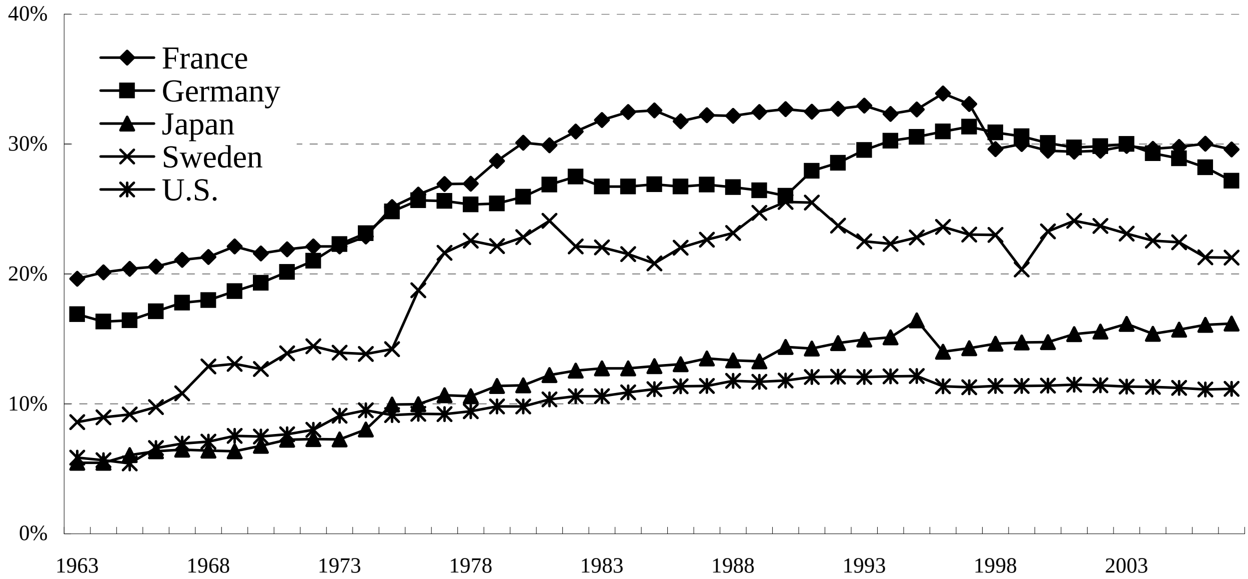
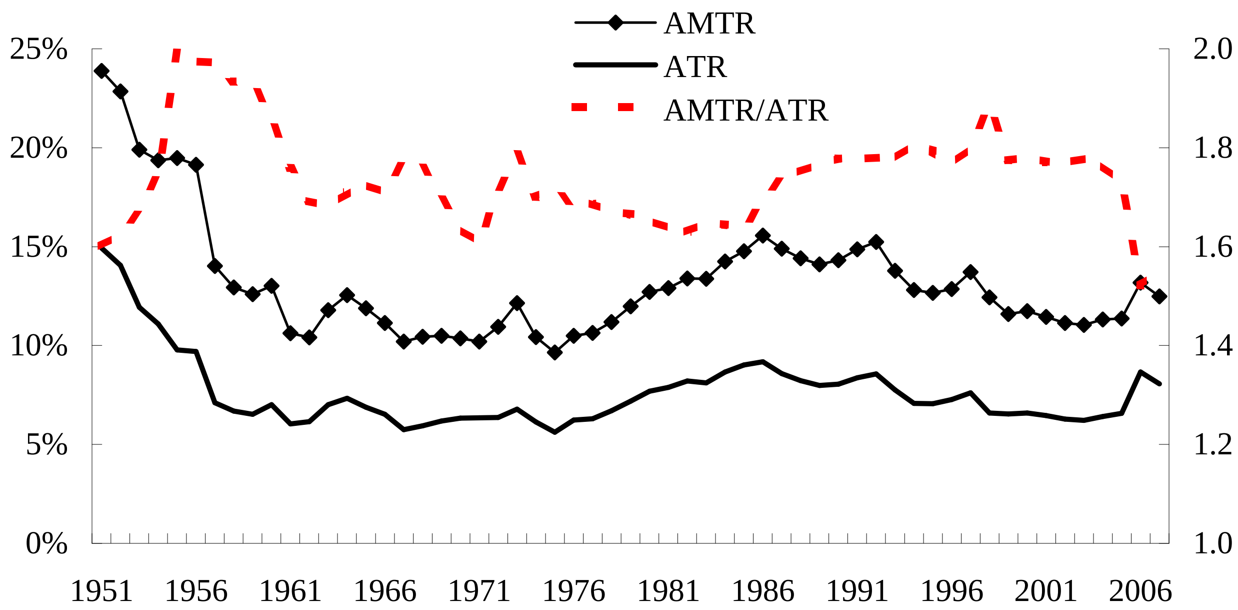


Figure 15: Average Marginal Tax Rate (Employee)



Note: "AMTR" denotes the average marginal tax rates (left-hand scale). "ATR" is the average tax rates (left-hand scale). "AMTR/ATR" is the right-hand scale.

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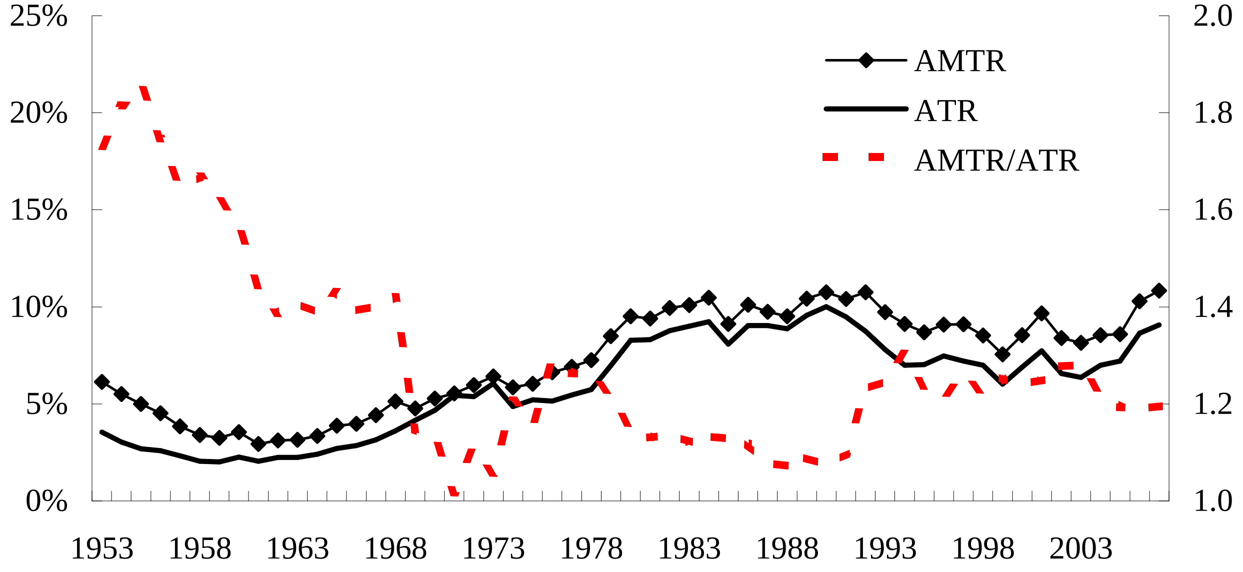
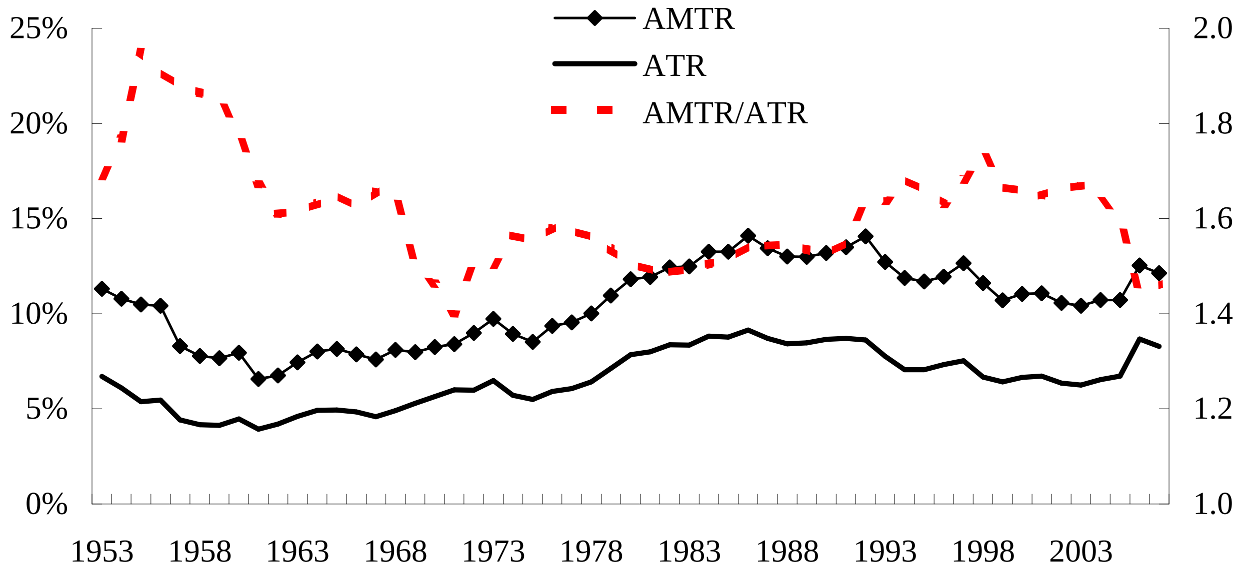
Figure 16: Average Marginal Tax Rate (Self-employee)



Note: "AMTR" denotes the average marginal tax rates (left-hand scale). "ATR" is the average tax rates (left-hand scale). "AMTR/ATR" is the right-hand scale.

Figure 17: Average Marginal Tax Rate (Average)



Note: “AMTR” denotes the average marginal tax rates (left-hand scale). “ATR” is the average tax rates (left-hand scale). These values are the weighted average between that of employees and that of self-employees. “AMTR/ATR” is the right-hand scale.

Figure 18: Average (Labor) Income Tax Rate