Economics Bulletin

Volume 42, Issue 4

Stationary parameterization of GARCH processes

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Abstract

We propose using the multivariate logistic transform to re-parameterize the Autoregressive Conditionally Heteroscedastic model such that the necessary stationarity constraints are automatically imposed, thereby allowing for unconstrained optimization when computing quasi-maximum likelihood estimates. A few simulations and a standard R data set of daily closing prices (Germany DAX) provide illustrations of the re-parameterization. We offer some numerical comparisons to available R packages (fgarch and rugarch), and comment on the potential advantages of the new technique.

Citation: Tucker S McElroy, (2022) "Stationary parameterization of GARCH processes", *Economics Bulletin*, Volume 42, Issue 4, pages 1908-1930
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Submitted: December 28, 2021. **Published:** December 30, 2022.

1 Introduction

The aim of this paper is to clarify how the most recent change in the earnings test rule for pensions enacted in 2005-which eliminated the 20% cut to pensions for workers aged 60–64 who are required to make Employee Pension Insurance contributions-affected the Japanese elderly labor supply. The cost of this change in the rule was not negligible because the average pension benefit was 185,020 yen (about 1700 US dollars) per month and, in 2004, there were about 3 million eligible persons aged 60–64 in Japan.

To achieve this aim, the paper follows the work of Baker and Benjamin (1999) and Haider and Loughran (2008) and uses a difference-in-differences (DID) framework to estimate the work-status-choice and labor supply functions using data from the 2004 and 2007 editions of Comprehensive Survey of Living Conditions. (CSLC).

The empirical results are summarized as follows. First, there is no evidence that the 2005 change affected the choice of the elderly to work. Second, the change affected work-status-choice decisions by increasing the probability of choosing regular workers (workers who are required to pay Employee's Pension Insurance) and decreasing the probability of choosing non-regular worker (workers not required to pay Employee's Pension Insurance). Finally, the change appeared not to affect overall work hours.

This paper has the following features compared with other studies on the effects of a change in the earnings test rules, such as Disney and Smith (2002) in the United Kingdom (UK), Friedberg (2000), Song and Manchester (2007) in the United States (US), Hernæs and Jia (2013) in Norway, Higuchi and Yamamoto (2002) and Ishii and Kurosawa (2009) in Japan, and Baker and Benjamin (1999) in Canada. These studies focused on the elimination of the earnings test, which makes the budget constraint line pivot and shift, meaning that the wage rate increased for some workers. Therefore, the *a priori* effect of the change in the earnings test on the labor supply is ambiguous: some workers might increase their supply of labor if the substitution effect dominates, whereas others might decrease their supply of labor if the income effect dominates. By contrast, the 2005 change in the earnings test rule moved the budget constraint line upward in parallel and therefore did not induce the substitution effect. The *a priori* effects of the change are then made clear.

Yamada (2012) is one of the few studies that previously addressed the 2005 change in the earnings test rule. Yamada (2012) used the 2009 Survey of Elderly Employment (*Konenreisha no Koyou Syugyo no Jittai ni Kansuru Chosa* in Japanese) and suggested the possibility that a change in the earnings test rule, which involved a 20% cut in the pension in 2005, affected the labor supply of the elderly. We support Yamada (2012)'s finding and argue that this may be because more elderly people chose to work as regular workers and accordingly, make contributions to the Employee Pension Insurance program.

This study also contributes to a stream of several studies such as those of Huttunen et al. (2013), Laun (2017), Freire (2018), and Carter and Breunig (2019) that have estimated the effects of policies that provide financial incentives to promote the labor supply of the elderly. Not all these studies have found a positive impact from such incentives on the labor supply of the elderly. Even when they find a positive effect, some find that it is not large and such a policy is expensive to implement. This study likewise found that Japan's 2005 change in the earnings test rule for pensions did not positively affect on the labor supply of the elderly as a whole, and only increased the ratio of full-time employees by a few percent. These studies suggest that we should be cautious in designing the system because financial incentives for labor supply can cause income effects and

may suppress the labor supply.

The remainder of the paper is structured as follows. Section 2 describes the institutional background. Section 3 explains the theoretical considerations Section 4 discusses empirical model and describes the data. Section 5 presents the empirical results. Section 6 provides some concluding remarks.

2 Background

In this section, we briefly describe the Japanese pension system before explaining the Japanese earnings test system upon which this paper is focused. All Japanese residents aged 20 to 59 are required to enroll in and contribute to the public pension program. The system consists of three categories. The first category is the Employee's Pension Insurance program (Kosei Nenkin), which applies to employees in establishments with over five employees. Regularly employed workers in this category must contribute to the pension based on their wage earnings, except for those over 70 years old. The key criterion for enrollment in this category is the number of work hours, with individuals considered regular workers if their contracted hours exceed three-quarters of a full-time worker's hours. The spouse of a worker enrolled in the Employee's Pension Insurance program whose income is lower than a certain threshold is in the second category (*san-go*, in Japanese). They are financially covered by their spouses' contributions. The third category is the National Pension (Kokumin Nenkin), which includes self-employed individuals and non-regular workers under 60 years of age. They pay fixed pension contributions regardless of their earnings, usually lower than those under the Employee's Pension Insurance.

Those insured by each pension program who continue to pay pension contributions over a certain period can receive pension benefits when they reach a certain age (62 years of age for males in 2004).

Next, we explain the earnings test rule, the so-called *Zaishoku-Rourei-Nenkin*, in Japanese. In Japan, the earnings test rule applies only to regular workers required to make Employee's Pension Insurance contributions. The earnings test rule has changed several times in Japan; however, this paper focuses on the most recent 2005 earnings test rule change. Prior to 2005, the Employee Pension Insurance benefit for regular workers required to make Employee's Pension Insurance contributions who were between the ages of 60 and 64 was reduced as follows. First, their Employee's Pension Insurance benefit was cut by 20% regardless of earnings. Second, if the wages plus the pension benefit of a regular worker exceeded a certain level (which varied by year but was 280,000 yen (about 2600 dollar) in 2004), the pension benefit for the worker was reduced by 1 yen for every 2 yen that the worker earned. Third, if the worker's earnings exceeded another specified level (which, again, varied by year but was 470,000 (about 4400 dollar) yen in 2004), the pension benefit for the worker was reduced by 1 yen for every 1 yen that the worker earned. A similar earnings test rule for regular workers between the ages of 65 and 69 was introduced in 2000 without the 20% pension cut. Employees who were not regular workers and not enrolled in the Employee's Pension Insurance program were unaffected by the earnings test rule. In 2005, the 20% cut in the pension benefit for Employee Pension Insurance pensioners aged 60 to 64 was removed.

We will discuss how much of an impact the removal of the 20% pension cut will have. Since there were approximately 3 million eligible persons aged 60–64 in Japan, the expected cost may be quite high. However, the average per capita financial incentive, approximately US 340 dollars, is

not as large as that found by Huttunen et al. (2013), and may not be large enough to affect labor supply.

Nevertheless, the pension amount varies from individual to individual and the impact of pensions on the elderly varies by country. Thus, we outline the size of pension benefits relative to working-age income, following OECD (2007) in the appendix. According to OECD (2007), Japan has one of the lowest replacement rates for average earners, similar to the UK and Ireland. Japan also has relatively modest pension wealth compared with other countries, with pension wealth of less than six times average earnings, similar to Belgium, Ireland, Mexico, the UK, and the US. This is about two-thirds of the OECD average.

3 Theoretical Background

Like many previous studies, this paper uses the basic standard static labor supply model, which consists of two goods, leisure and consumption. Figure 1 depicts the budget constraint between leisure and consumption for elderly persons aged 60–64 before and after 2005. The solid (dashed) line is the budget constraint before (after) the 2005 rule change. Segment h_0A can be considered non-labor income. Both the solid (before the change) and dashed (after the change) lines have a kinked point, D(E), at 280,000 yen that illustrate the earnings test threshold. The solid line has another kinked point, B, because the pension benefit of regular workers (who work longer than h_0h_1) was cut by 20% before the earnings test rule change. As we explained in the previous section, one of the most important criteria for determining if an employee is considered a regular worker and in the Employee's Pension Insurance program is their number of work hours. If the hours that the person is contracted to work exceed three-quarters of the hours of an equivalent full-time worker, he is considered to be a regular worker and is required to make Employee's Pension Insurance contributions and face the earnings test rule. Therefore, Segment BC can be considered to represent 20% of the pension benefit cut by the earnings test rule plus the Employee Pension Insurance contribution. After the 2005 earnings test rule change, the pension cut was removed and it merely involved a parallel upward shift to the solid line of the budget constraint. As shown in Figure 1, the removal of the 20% pension cut in 2005 did not involve a substitution effect because the budget constraint before the change, depicted with a solid line, moved upward in parallel to the dashed line, which depicts the budget constraint after the change.

Below we discuss how the change affects workers. Since the change only shifts the budget constraint on the left-hand side of h_1, it does not affect workers on the right-hand side of h_1. In other words, it does not affect the decision to work or not to work.

The effect on workers can be divided into two cases. The first is the impact on workers who had optimal working hours as h_1 before the institutional reform (in this case they become non-regular workers), which is illustrated in Figure 2. After the change, these workers will no longer consider h_1 as the optimal working hours, and the point on the budget constraint shifted by the change will be optimal. In other words, non-regular workers who considered h_1 to be optimal will become regular workers and their working hours will increase.

The second case is the effect on those who were regular workers before the change, which is shown in Figure 3. After the institutional reform, the budget constraint will shift to the right and upwards in parallel, so their working hours will decrease.

In summary, theoretically, the change has the following effects: (1) it does not affect the choice

of employment; (2) it reduces the number of non-regular workers and increases the number of regular workers and; (3) it reduces the working hours of regular workers; however since some non-regular workers may become regular workers and increase their working hours, the overall effect on working hours is not certain.

Because Japan is prominent for its lifetime employment system, which assumes that employees rarely change their employer, the assumption of no labor mobility cost in this model makes it too severe for analyzing the Japanese employment situation. However, OECD (2004) shows that such employment systems are only seen among large firms and there is a high degree of mobility in the labor market especially among the elderly, and particularly among those in their 60s, the age group covered in this study. The average number of years of service (i.e., the number of years of continuous employment with the same company) is approximately 30 years for employees in the 55-59 age group in large companies, but approximately 15 years on average for employees in the 60-64 age group. This means that although they work for the same company until mandatory retirement, there is no guarantee that they will continue to work for the same company after that, and approximately half of them are employed by different companies after mandatory retirement at age 60-64. This is lower than the 21 years in France and 22 years in Germany, and similar to the 14 years in the UK and the US. Also, if we compare the 5-year retention rate, that is, the percentage of workers who are still working at the same company after 5 years, the rates for age groups 55–59 and 60–64 are lower than those of the UK and the US. In other words, the labor market liquidity of this age group in Japan is not low.

4 Estimation

We employ a DID framework using two-period cross-sectional data as in previous studies, like the one by Haider and Loughran (2008), to examine the effect of the change in the earnings test rule on the labor supply of the elderly. We use the CSLC as a data source in which the selected individuals are obliged to participate in this survey under the Fundamental Statistics Act. The CSLC is compiled annually by Japan's Ministry of Health, Labor and Welfare. In addition, large-scale surveys are conducted every three years. Because detailed information available only from large-scale surveys is necessary when analyzing the behavior of the labor supply, we were restricted to use the CSLC in 2004 and 2007.

The CSLC has the following features. In CSLC, all of the previous year's monetary income of all household members is surveyed through interviews. Therefore, they are expected to be accurate than the surveys which participants fill out survey form regarding the income. Unfortunately, this CSLC is not comprised of panel data. Therefore, we performed a DID analysis using two distinct periods of cross-sectional data as many previous studies also have done. In addition to that, the CSLC does not survey past pension payment records, so we do not know exactly which pension an individual is eligible to receive.

It should be noted that not all people aged 60–64 can be included in the treated group because the mandatory retirement system also changed during this period. Since 1998, Japanese firms have been legally prohibited from setting a mandatory retirement age below 60 years of age. However, with the increase in the eligibility age for the employee pension, since 2004, Japanese firms are legally obliged to secure employment for workers until they reach the eligibility age. The eligibility age was 60 years of age in 2004 and 62 years of age in 2007. Kondo and Shigeoka (2015)

demonstrated that there are differences in employment behaviors between elderly males born after April 1946 (i.e., 61 years old or younger in 2007) and elderly males born before March 1946 (i.e., 62 years or older in 2007). Therefore, in this paper, we include males between the ages of 62 and 64 in the treated group. Along with males aged 62 to 64, we include males aged 55-59 and 65-69 as control groups because they did not face any change in the earnings test rule during the period that we analyze. We exclude the self-employed because their labor supply behavior differs from that of other types of employees.[1]

We estimate the following two models using samples of 62 to 64-year-old males (the treated group) alongside the control groups of 55-59 and 65-69 year-old males.

First, we use multinomial logit regression to estimate the effect of the change in the earnings test on work status choice.

Work status j is defined as follows. $j = 1$ denotes a regular worker, who works more than three-quarters of the hours of an equivalent full-time worker and must pay Employee's Pension Insurance. $j = 2$ denotes a non-regular worker, who works less than a regular worker and does not pay Employee's Pension Insurance. $j = 3$ denotes a person who does not work.

Second, the labor supply function is estimated using Tobit regression. The devendent variable is number of hours worked in one week.

The explanatory variables X, is comprised of the following proxy variables for non-labor income and taste for work. We use non-labor income (excluding pension benefits), total household savings, household loans, the total income of other household members, the amount of any corporate pension paid to the person, and the number of workers in the household (excluding the individual) to take account for non-labor income. We used the sum of the incomes of all household members minus their own incomes as one of the explanatory variables to avoid possible endogeneity. Unfortunately, educational level data is not available in CSLC, so we use a person's age and their age squared to take account for the level human capital. To take account for taste for work, we use the number of household members, the number of household members who need help, a dummy variable that indicates whether or not he needs help, and a dummy variable that indicates whether or not he is married. We use the prefectural unemployment rate to take account for local labor market conditions.

In addition to the variables above, the following three variables were used to estimate the effects of the change in the earnings tests in the DID framework. First, *Treated* is a dummy variable indicating whether a person is 62-64 years of age ($Treated = 1$) or not (65-69 or 55-59 years of age, $Treated = 0$). Second, *Year* is a dummy variable indicating whether or not the year is 2007 ($Year = 1$) or 2004 ($Year = 0$). Third, *YearTreat* is an interaction-term of these two variables. Table 1 provides selected descriptive statistics.

This paper's main interest is interaction effect, $\frac{\partial^2 E[(y|Year,Treated)]}{\partial Year \partial Treated}$. However, it should be noted that in nonlinear models, the signs of the coefficients of the interaction-terms do not necessarily show the signs of the interaction effects, which is the main interest of this paper as many previous papers using a DID, as Ai and Norton (2003) demonstrated. As Karaca-Mandic et al. (2012) noted, in general functional form, like:

$$E[y|x_1, x_2] = F(\beta_0, \beta_1 x_1 + \beta_2 x_2 + \beta_{12} x_1 \times x_2), \tag{1}$$

[1]We also exclude females because there were relatively few female regular workers aged 60-69 years in Japan during this period. The appendix contains the estimation results for females.

the interaction effect can be calculated as follows: $\frac{\partial^2 F}{\partial x_1 \partial x_2} = \beta_{12} F'(\cdot) + (\beta_1 + \beta_{12} x_2)(\beta_2 + \beta_{12} x_1) F''(\cdot)$. So that the sign of the interaction effect of $x_1 \times x_2$ is not consistent with the sign of β_{12}.

Therefore, we use the method proposed by Karaca-Mandic et al. (2012) to test whether the interaction effect is zero as follows. First, we calculate (1) marginal effects of treated dummy evaluated by year dummy = 1 and the average values of the other explanatory variables and (2) the marginal effects of treated dummy evaluated by year dummy = 0 and the average values of the other explanatory variables. Second, we test if there is a significant difference between them.

5 Results

Estimation results for the work status function are summarized in Table 2 and 3. The marginal effects evaluated by the average value of the explanatory variables are listed in both tables.

The results are generally consistent with our theoretical predictions, although some of the estimated coefficients for household savings and loans have incorrect signs but are statistically significant at the 5 % level. One possible reason is that the 2004 and 2007 editions of the CSLC did not include information about educational level, which is important for labor supply decision-making. The coefficients for savings and loans may capture this effect.

Next, we focus on the difference in the marginal effects of the treated dummy between 2004 and 2007. The difference in the marginal effects for the dummy variables between 2004 and 2007 is negative and significant at the 5% level for non-regular workers and positive and significant at the 5% level for regular workers. This suggests that the change in the earnings test rule increased the number of elderly males (aged 62–64) choosing to work as regular workers and decreased the number of elderly males (aged 62–64) choosing to work as non-regular workers, as the model predicts in the previous section. By contrast, the difference in the marginal effects for the dummy variables between 2004 and 2007 is not significant at the 5% level for non-workers. Therefore, the change seemed to not affect the labor participation decision-making of elderly males as the theory predicts[2]. In Table 3, which provides the results for the sample of males aged 55-59 and 62-64, the difference in the marginal effects of the dummy variable between 2004 and 2007 is also negative and significant at the 10% level for non-regular workers and positive and significant at the 5% level for regular workers. This is consistent with the results for the sample aged 62–69 and also demonstrates that the change affected the work status decision-making choice of elderly males aged 62–64.

By contrast, in Table 4 for the placebo study, which details the results for the sample of those aged 55-59 and 65-69, both of which were unaffected by the change in the earnings test rule, the difference in the marginal effects of the dummy variable between 2004 and 2007 is not significant, which suggests that both control groups (55–59 and 65–69) shared a common trend.

The estimation results of the labor supply (number of work hours) function are summarized in Table 5. In column 1, we summarize the results estimated using those aged 62-64 as a treated group and those aged 65-69 as a control group. In column 2, we summarize the results estimated

[2]It should be noted that the model predicts not that those who were non-regular employees before will become regular employees, but that those who would have been non-regular employees without this change will become regular employees. It seems that former full-time employees who had chosen to work part-time to avoid the pension reduction are now choosing to work full-time as the pension reduction has disappeared.

using those aged 62-64 as treated group and those aged 55-59 as a control group. In column 3, we summarize the results estimated using those aged 55-59 as a treated group and those aged 65-69 as a control group for the placebo study. In every column, estimated marginal effects are generally consistent with the usual theoretical predictions.

In every column, the difference in the marginal effects of the dummy variable between 2004 and 2007 is not statistically significant. This suggests that the change in the earnings test rule did not increase the overall labor supply of elderly males aged 62–64. There was no significant difference in the coefficients of working hours. This result is consistent with the results derived from the theoretical model, which indicates that the increase in the number of hours worked was due to an increase in the number of full-time employees working, while the effect of the increase was offset by a decrease in the number of hours worked by full-time employees.

6 Conclusion

This paper investigates how a change in the Japanese earnings test rule in 2005 affected the elderly. The estimation results are summarized as follows. First, there is no evidence that the change in the earnings test rule affected the labor participation decision-making of elderly males. Second, the estimation results imply that the change in the earnings test rule affected how elderly males work, with more elderly males working as regular workers paying Employee's Pension Insurance and fewer working as non-regular workers paying no Employee's Pension Insurance given the change in the earnings test rule. Third, the change in the earnings test rule did not increase the overall number of work hours of elderly males, although it did affect their choice of being regular or non-regular workers. This could be because regular workers ceased or at least decreased their hours of overtime work because the removal of the 20% cut in their pension benefit induced them to work less given the income effect with the decrease offset by the increase in the labor supply of new regular workers.

These results can be compared with the studies measuring the effects of policies that provide financial incentives to promote the labor supply of the elderly after retirement age. Freire (2018) measured the effect of a Workfare Income Supplement targeting older low-income workers in Singapore using DID and found that it increased female labor supply by 3.1–5.5 ppt, and Carter and Breunig (2019) estimated the effect of MAWTO (Australia's Mature Age Worker Tax Offset) for older Australians and found that it increased labor participation by 0.5 ppt for men and about 1.5 ppt for women. Laun (2017) analyzed the impact of the Swedish EITC and payroll tax credit reforms on retirement behavior. The reforms affected entry-exit behavior, but not the choice of work hours. Generally, these financial incentives do not substantially affect the labor supply and are considered expensive as policy approaches. (Carter and Breunig (2019), Laun (2017)).

Like this study, the work of Huttunen et al. (2013) focuses on financial incentives for full-time workers rather than all workers. Huttunen et al. (2013) analyzed the effects of an income tax subsidy scheme for full-time workers earning between 900 and 2000 euros per month aimed at low-wage full-time elderly workers in Finland and find no effect on the employment rate and a slight increase in hours worked. This study also finds that financial incentives do not affect the employment rate because the financial incentives are not very large and only work for the choice of full-time workers. We also learn that policies that provide financial incentives for labor supply should involve careful system design because the income effects may suppress the labor supply.

Compliance with Ethical Standards

Conflicts of interest: The authors declare that they have no conflicts of interest.

References

Ai, Chunrong and Edward C. Norton (2003) "Interaction Terms in Logit and Probit Models," *Economic Letters*, Vol. 80, pp. 123–129.

Baker, Michael and Dwayne Benjamin (1999) "How do Retirement Tests Affect the Labour Supply of Older Men ?" *Journal of Public Economics*, Vol. 71, pp. 27–51.

Carter, Andrew and Robert Breunig (2019) "Do Earned Income Tax Credits for Older Workers Prolong Labour Market Participation and Boost Earned Income? Evidence from Australia's Mature Age Worker Tax Offset," *Economic Record*, Vol. 95, No. 209, pp. 200–226.

Disney, Richard and Sarah Smith (2002) "The Labour Supply Effect of the Abolition of the Earnings Rule for Older Workers in the United Kingdom," *Economic Journal*, Vol. 112, pp. c136–c152.

Freire, Tiago (2018) "Wage subsidies and the Labor Supply of Older People: Evidence from Singapore ' s Workfare Income Supplement Scheme," *Singapore Economic Review*, Vol. 63, No. 5, pp. 1101–1139.

Friedberg, Leora (2000) "The Labor Supply Effects of the Social Security Earning Test," *Review of Economics and Statistics*, Vol. 82, No. 1, pp. 48–63.

Haider, Steven J. and David S. Loughran (2008) "The Effect of the Social Security Earnings Test on Male Labor Supply New Evidence from Survey and Administrative Data," *Journal of Human Resources*, Vol. 43, No. 1, pp. 57–87.

Hernæs, Erik and Zhiyang Jia (2013) "Earnings Distribution and Labour Supply after a Retirement Earnings Test Reform," *Oxford Bulletin of Economics and Statistics*, Vol. 75, No. 3, pp. 410–434.

Higuchi, Yoshio and Isamu Yamamoto (2002) "Labor Supply Behaviour of Japanese Male Aged People (*Wagakuni Dansei Koureisya no Roudou Kyokyu Mekanizumu in Japanese)*," *Financial Studies (Kinyu Kenkyu in Japanese)*, Vol. 21, No. 2.

Huttunen, Kristiina, Jukka Pirttilä, and Roope Uusitalo (2013) "The Employment Effects of Low-Wage Subsidies," *Journal of Public Economics*, Vol. 97, pp. 49–60.

Ishii, Kayoko and Masako Kurosawa (2009) "Pension Reform and the Labor Supply Effect for Elderly Males (*Nenkin seido kaisei ga dansei kounenreisyano roudoukyoukyuukoudouni ataeru eikyouno bunseki, in Japanese)*," *The Japanese Journal of Labour Studies (Nihon Roudou Kenkyu Zasshi)*, Vol. 589.

Karaca-Mandic, Pinar, Edward C. Norton, and Bryan Dowd (2012) "Interaction Terms in Nonlinear Models," *Health Services Research*, Vol. 47, No. 1, pp. 255–274.

Kondo, Ayako and Hitoshi Shigeoka (2015) "The Effectiveness of Demand-side Government Intervention to Promote Elderly Employment: Evidence from Japan,"Technical Report E-61, Tokyo Center for Economic Research (TCER).

Laun, Lisa (2017) "The Effect of Age-Targeted Tax Credits on Labor Force Participation of Older Workers," *Journal of Public Economics*, Vol. 152, pp. 102–118.

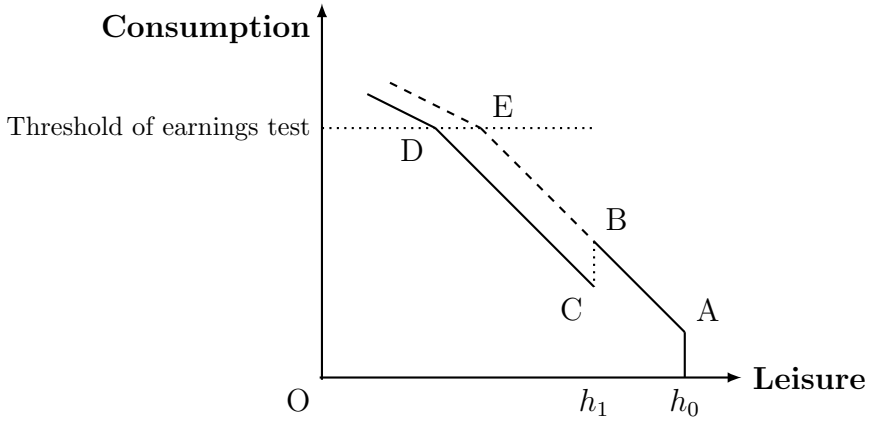
OECD (2004) *Aging and Employment Policies: Japan*: OECD Publications.

——— (2007) "Pension at a Glance,"Technical report, Organisation for Economic Co-Operation and Development.

Song, Jae G. and Joyce Manchester (2007) "New Evidence on Earnings and Benefit Claims Following Changes in the Retirement Earnings Test in 2000," *Journal of Public Economics*, Vol. 91, pp. 669–700.

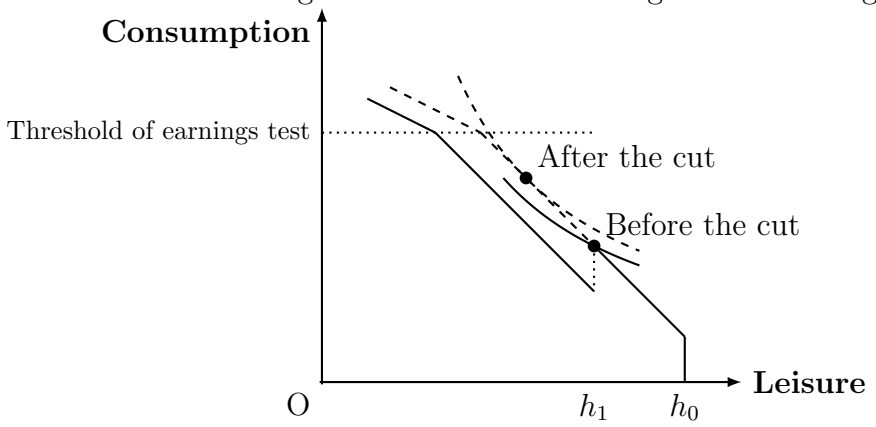
Yamada, Atsuhiro (2012) "The Labour Market Behaviour of Older People: Analysing the Impact of the Reformed "Earning Test" and New "Early Withdrawal" Rule (*Koyou to Nenkin no Setsuzoku Zaisyoku Rourei Nenkin no Syuugyoyokuseikouka to Roureikoureinennkin Jukyusikakusya no Kisonenkinkuriage Jukyuyoin ni Kansuru Bunseki)*," *Keio Journal of Economics (Mita Gakkai Zasshi)*, Vol. 104, No. 4, pp. 587–605.

Figure 1: Budget Constraints for Elderly Employees (aged 60–64)



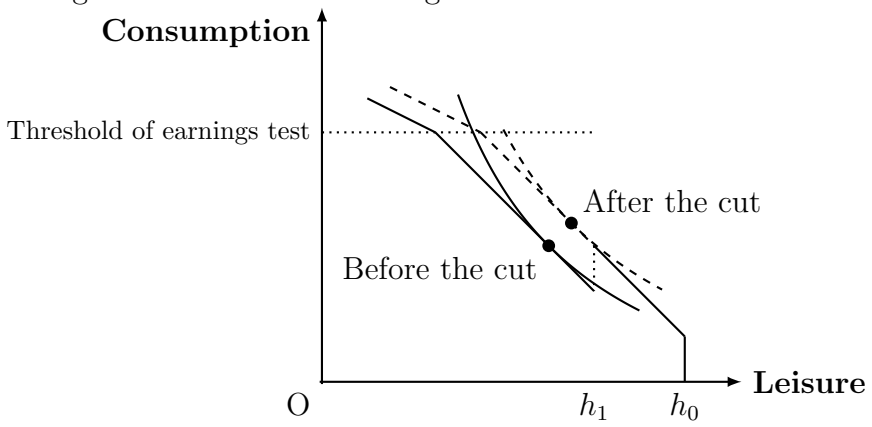
Notes: (1) The solid (dashed) line is the budget constraint before (after) the 2005 rule change.

Figure 2: Case I: The Change Increased Regular Workers



Notes:
(1) The solid (dashed) line is the budget constraint before (after) the 2005 rule change.
(2) Some individuals who chose a 'kinked point' as their corner solution (i.e,. they worked as non-regular workers) before 2005 would choose the point on the dashed line (i.e., they worked as regular workers) after the 2005 change, because it changed the budget constraint they faced. As a result, the change increased the number of regular workers and decreased the number of non-regular workers, as well as increasing the number of hours worked.

Figure 3: Case II: The change Reduced the Number of Hours Worked by Regular Workers



Notes:
(1) The solid (dashed) line is the budget constraint before (after) the 2005 rule change.
(2) Some individuals who chose the point on the solid line on the left of h_1 before 2005 (i.e., those working as a regular worker) chose the point on the dashed line after the 2005 change, because the budget constraint they faced changed. Because the change did not affect the relative price of earnings and since leisure is a normal good, its consumption would increase (alongside a corresponding decrease in the number of hours worked). In this sense, the change in the earnings test rule would decrease the number of hours worked by regular workers.

Table 1: Descriptive Statistics

	55-59		62-64		65-69	
	2004	2007	2004	2007	2004	2007
Household savings	13.95	14.63	15.49	16.30	15.81	15.42
	(29.48)	(29.26)	(20.66)	(21.56)	(41.69)	(27.92)
Household loans	4.17	3.68	1.93	1.84	1.68	2.03
	(10.27)	(8.23)	(6.79)	(7.29)	(7.43)	(7.46)
Firm pension	0.02	0.01	0.22	0.23	0.13	0.19
	(0.17)	(0.16)	(0.64)	(0.58)	(0.47)	(0.62)
Household income	2.81	2.47	2.12	1.97	2.17	1.84
(other than the individual)	(3.09)	(3.00)	(2.77)	(2.71)	(2.87)	(2.68)
# of household	3.19	3.10	2.70	2.77	2.75	2.63
	(1.34)	(1.35)	(1.21)	(1.28)	(1.42)	(1.24)
Yearly income	0.18	0.19	0.20	0.16	0.16	0.20
(other than income from work and pension)	(0.84)	(1.46)	(0.78)	(0.64)	(1.05)	(1.00)
=1 if he is with spouse	0.85	0.82	0.90	0.87	0.90	0.88
	(0.36)	(0.38)	(0.30)	(0.34)	(0.30)	(0.33)
=1 if he needs help	0.01	0.02	0.02	0.04	0.04	0.04
	(0.09)	(0.14)	(0.13)	(0.19)	(0.20)	(0.20)
# of workers in household	1.18	1.09	0.74	0.78	0.61	0.66
	(1.02)	(1.00)	(0.88)	(0.87)	(0.83)	(0.82)
# of individuals who need help	0.10	0.14	0.06	0.14	0.06	0.10
	(0.30)	(0.37)	(0.25)	(0.36)	(0.24)	(0.31)
Prefecture's unemployment rate	4.46	3.71	4.46	3.65	4.49	3.72
	(0.94)	(0.95)	(0.95)	(0.92)	(0.94)	(0.97)

Notes:
(1) Source: Comprehensive Survey of Living Conditions in 2004 and 2007.
(2) Standard errors in parentheses.
(3) Savings, loans, pensions, and income are in 10 thousand yen (approximately 90 US dollars) in 2004.

Table 2: Estimation Results of Work Status Function, 62–64 and 65–69 Years of Age

	Don't work	Non-regular worker	Regular worker
Household savings	-0.0004**	0.0001	0.0003***
	(0.0002)	(0.0002)	(0.0001)
Household loans	-0.0037***	0.0021***	0.0016***
	(0.0010)	(0.0008)	(0.0005)
Firm pension	0.0617***	-0.0461***	-0.0156*
	(0.0141)	(0.0134)	(0.0095)
Household income	0.0091***	-0.0099***	0.0008
(other than the individual)	(0.0035)	(0.0032)	(0.0021)
# in household	0.0237***	-0.0123	-0.0115**
	(0.0084)	(0.0075)	(0.0057)
Yearly income	-0.0026	0.0022	0.0004
(other than income from work and pension)	(0.0074)	(0.0066)	(0.0050)
=1 if he is with spouse	-0.0858***	0.0370*	0.0488***
	(0.0248)	(0.0224)	(0.0185)
=1 if he needs help	0.3064***	-0.2102***	-0.0962**
	(0.0568)	(0.0561)	(0.0425)
# of workers in household	-0.1047***	0.0774***	0.0274***
	(0.0123)	(0.0110)	(0.0082)
# of individuals who need help	0.0064	-0.0032	-0.0031
	(0.0254)	(0.0229)	(0.0165)
Unemployment rate	0.0293***	-0.0278***	-0.0015
	(0.0075)	(0.0069)	(0.0050)
Age	0.1915	-0.0698	-0.1217
	(0.2448)	(0.2151)	(0.1623)
Agesq	-0.0012	0.0004	0.0008
	(0.0018)	(0.0016)	(0.0012)
1 if treated	-0.0082	0.0143	-0.0061
	(0.0312)	(0.0279)	(0.0206)
1 if 2007	-0.0522***	-0.0273**	0.0794***
	(0.0154)	(0.0137)	(0.0104)
Marginal Effect of Treated Dummy	-0.0134	0.0574*	-0.0440***
(at Year = 2004)	(0.0349)	(0.0332)	(0.0165)
Marginal Effect of Treated Dummy	-0.0058	-0.0274	0.0332
(at Year = 2007)	(0.0352)	(0.0283)	(0.0289)
Difference	0.0076	-0.0848*	0.0772**
	(0.0495)	(0.0436)	(0.0333)
Obs		4080	

Notes:
(1) The estimation method is multinomial logit model. This table reports the average marginal effects.
(2) Standard errors in parentheses.
(3)*, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.
(4) Year dum = 1 is year = 2007 (after the rule change).
(5) Treated dum = 1 are persons aged 62–64 (affected by the rule change).

Table 3: Estimation Results of Work Status Function, 55–59 and 62–64 Years of Age

	Don't work	Non-regular worker	Regular worker
Household savings	-0.0011***	-0.0008***	0.0019***
	(0.0003)	(0.0003)	(0.0003)
Household loans	-0.0056***	0.0016**	0.0039***
	(0.0010)	(0.0006)	(0.0008)
Firm pension	0.0714***	-0.0267*	-0.0447**
	(0.0134)	(0.0156)	(0.0192)
Household income	0.0103***	-0.0040*	-0.0063***
(other than the individual)	(0.0025)	(0.0023)	(0.0024)
# in household	-0.0016	-0.0020	0.0036
	(0.0062)	(0.0057)	(0.0061)
Yearly income	0.0220***	0.0107**	-0.0327***
(other than income from work and pension)	(0.0050)	(0.0054)	(0.0054)
=1 if he is with spouse	-0.1237***	-0.0350**	0.1587***
	(0.0143)	(0.0143)	(0.0149)
=1 if he needs help	0.3480***	0.0229	-0.3709***
	(0.0367)	(0.0436)	(0.0535)
# of workers in household	-0.0376***	0.0297***	0.0079
	(0.0087)	(0.0078)	(0.0085)
# of individuals who need help	0.0216	-0.0194	-0.0022
	(0.0167)	(0.0169)	(0.0169)
Unemployment rate	0.0196***	-0.0020	-0.0176***
	(0.0053)	(0.0051)	(0.0056)
Age	-0.2592**	0.0243	0.2350*
	(0.1083)	(0.1015)	(0.1355)
Agesq	0.0024***	-0.0002	-0.0022*
	(0.0009)	(0.0009)	(0.0012)
1 if treated	0.1715***	0.2570***	-0.4285***
	(0.0501)	(0.0539)	(0.0624)
1 if 2007	-0.0279**	-0.0499***	0.0779***
	(0.0112)	(0.0105)	(0.0116)
Marginal Effect of Treated Dummy	0.2053***	0.3259***	-0.5312***
(at Year = 2004)	(0.0548)	(0.0598)	(0.0559)
Marginal Effect of Treated Dummy	0.1383***	0.1916***	-0.3300***
(at Year = 2007)	(0.0503)	(0.0532)	(0.0737)
Difference	-0.0670	-0.1343*	0.2013**
	(0.0744)	(0.0801)	(0.0925)
Obs		4933	

Notes:
(1) Estimation method is the multinomial logit model. This table reports the average marginal effects.
(2) Standard errors are in parentheses.
(3)*, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.
(4) Year dum = 1 is year = 2007 (after the change of rules).
(5) Treated dum = 1 are persons aged 62–64 years (affected by change of rules).

Table 4: Estimation Results of Work Status Function, 55–59 and 65–69 Years of Age

	Don't work	Non-regular worker	Regular worker
Household savings	-0.0004**	-0.0004*	0.0008***
	(0.0002)	(0.0002)	(0.0002)
Household loans	-0.0042***	0.0012**	0.0030***
	(0.0007)	(0.0005)	(0.0006)
Firm pension	0.0310***	0.0084	-0.0394**
	(0.0121)	(0.0107)	(0.0157)
Household income	0.0078***	-0.0059***	-0.0019
(other than the individual)	(0.0022)	(0.0020)	(0.0019)
# in household	0.0103*	-0.0070	-0.0032
	(0.0053)	(0.0048)	(0.0049)
Yearly income	0.0114***	0.0058	-0.0172***
(other than income from work and pension)	(0.0039)	(0.0039)	(0.0038)
=1 if he is with spouse	-0.1059***	-0.0328***	0.1387***
	(0.0136)	(0.0125)	(0.0125)
=1 if he needs help	0.3116***	-0.0532	-0.2584***
	(0.0331)	(0.0372)	(0.0391)
# of workers in household	-0.0527***	0.0415***	0.0112
	(0.0079)	(0.0069)	(0.0070)
# of individuals who need help	0.0143	-0.0157	0.0014
	(0.0159)	(0.0152)	(0.0142)
Unemployment rate	0.0247***	-0.0093**	-0.0154***
	(0.0048)	(0.0045)	(0.0046)
Age	-0.0331	0.0299	0.0032
	(0.0454)	(0.0410)	(0.0423)
Agesq	0.0004	-0.0003	-0.0001
	(0.0004)	(0.0003)	(0.0004)
1 if treated	0.3269***	0.1587***	-0.4856***
	(0.0605)	(0.0485)	(0.0604)
1 if 2007	-0.0252**	-0.0163*	0.0415***
	(0.0101)	(0.0092)	(0.0095)
Marginal Effect of Treated Dummy	0.3471***	0.1382***	-0.4853***
(at year=2004)	(0.0636)	(0.0526)	(0.0607)
Marginal Effect of Treated Dummy	0.3078***	0.1790***	-0.4868***
(at year=2007)	(0.0601)	(0.0468)	(0.0629)
Difference	-0.0393	0.0408	-0.0015
	(0.0875)	(0.0705)	(0.0874)
Obs		6241	

Notes:
(1) The estimation method is multinomial logit model. This table reports the average marginal effects.
(2) Standard errors are in parentheses.
(3)*, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.
(4) Year dum = 1 is year = 2007 (after the rule change).
(5) Treated dum = 1 are persons aged 65–69(affected by the rule change).

Table 5: Estimation Results of Work Hours Function

	55–59 vs. 62–64	62–64 vs. 65–59	55–59 vs. 65–69
Household savings	0.0315**	0.0710***	0.0394***
	(0.0140)	(0.0246)	(0.0111)
Household loans	0.2063***	0.4677***	0.2216***
	(0.0389)	(0.1014)	(0.0388)
Firm pension	-8.4032***	-7.7329***	-3.3845***
	(1.1873)	(1.5689)	(1.0314)
Household income	-0.4712***	-0.8338**	-0.3533**
(other than the individual)	(0.1517)	(0.3921)	(0.1495)
# in household	0.4626	-2.8182***	-0.2145
	(0.3852)	(0.9632)	(0.3792)
Yearly income	-0.7995**	0.3593	-0.7042**
(other than income from work and pension)	(0.3455)	(0.8742)	(0.3251)
=1 if he is with spouse	9.2981***	9.5362***	8.2213***
	(1.0854)	(2.8477)	(1.0928)
=1 if he needs help	-38.5412***	-34.4649***	-32.7391***
	(3.3344)	(5.8573)	(3.0338)
# of workers in household	1.9892***	12.0637***	2.9933***
	(0.5316)	(1.4634)	(0.5385)
# of individuals who need help	-1.9140*	-0.8096	-0.9679
	(1.0888)	(2.9142)	(1.1112)
Unemployment rate	-0.9397**	-2.3043***	-1.6149***
	(0.3708)	(0.8704)	(0.3686)
Age	35.3790***	-27.2247	7.1417**
	(8.4363)	(28.0887)	(3.1353)
Agesq	-0.3188***	0.1771	-0.0714***
	(0.0733)	(0.2117)	(0.0259)
1 if treated	-15.8966***	1.2397	-30.4850***
	(2.8949)	(4.0771)	(2.8512)
1 if 2007	1.3512	5.9057***	0.8220
	(0.8468)	(2.1762)	(0.8980)
Constant	-948.5716***	1003.9690	-139.3497
	(242.9785)	(931.4644)	(94.9702)
σ	23.1469***	41.6016***	24.7429***
	(0.2888)	(0.9630)	(0.3086)
Marginal Effect of Treated Dummy	-13.1309***	0.3872	-21.1266***
(at Year = 2004)	(2.3370)	(1.2786)	(1.9420)
Marginal Effect of Treated Dummy	-10.2944***	0.5326	-19.5076***
(at Year = 2007)	(2.4805)	(1.4018)	(1.9722)
Difference	2.8365	0.1454	1.6190
	(3.4079)	(1.8973)	(2.7678)
Obs	4156	4933	6249

Notes:
(1) The estimation method is the Tobit regression.
(2) Standard errors are in parentheses.
(3)*, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Appendix A: Estimation Results for Females

In this appendix, we briefly show the results for females. We estimate the work status function for females aged 62–69. The table below shows the difference in the marginal effects of treated dummies between 2004 and 2007. The difference in the marginal effects for the age 62 dummies between 2004 and 2007 is negative and significant at the 5% level for non-regular workers and positive and significant at the 5% level for regular workers. This suggests that the change in the earnings test rule increased the number of elderly females (aged 62) choosing to work as regular workers and decreased the number of elderly females (aged 62) choosing to work as non-regular workers, as the model predicts in the paper. Nonetheless, the results for other age groups were not as clear-cut as they were for males.

The possible reasons behind this result are as follows. The higher the income during working-years, the greater is the change in the pension-benefit amount that can be received as a result of this reform. However, since the female employment rate in Japan is not high (below 60% compared with 80% for males) and the ratio of full-time workers to employed females is not high (below 50% compared with over 80% for males), not many females had a change in the amount of their pension that was large enough to change their labor supply.

Table 6: Estimation Results of Work Status Function, 62–64 and 65–69 Years of Age

	Don't work	Non-regular worker	Regular worker
Difference between marginal effects of Age62 dummies	-0.0052	-0.0697*	0.0750***
	(0.0431)	(0.0383)	(0.0235)
Difference between marginal effects of Age63 dummies	-0.0626	-0.0183	0.0810***
	(0.0390)	(0.0352)	(0.0196)
Difference between marginal effects of Age64 dummies	0.0006	-0.0230	0.0225
	(0.0393)	(0.0364)	(0.0171)
Difference between marginal effects of Age65 dummies	-0.0323	0.0055	0.0268
	(0.0341)	(0.0297)	(0.0188)
Difference between marginal effects of Age66 dummies	0.0297	-0.0474*	0.0177
	(0.0289)	(0.0255)	(0.0145)
Difference between marginal effects of Age67 dummies	-0.0386	0.0153	0.0233
	(0.0311)	(0.0274)	(0.0162)
Difference between marginal effects of Age68 dummies	0.0083	-0.0229	0.0146
	(0.0315)	(0.0281)	(0.0156)
Obs		4439	

Notes:
(1) The estimation method is multinomial logit model. This table reports the difference in the average marginal effects for the age dummy variables between 2004 and 2007.
(2) Standard errors in parentheses.
(3)*, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Appendix B: International Comparison of Pension Systems

	First tier benefit	Schemes	Second tier (effective accrual rate), %	Eligibility ages	Gross replacement rate
Australia	25	None	-	65	45.9
Austria	28	DB	1.78	65	71.2
Belgium	34	DB	1.33	65	37.9
Canada	31	DB	0.63	65	49.5
Czech Republic	26	DB	0.45	63	49.1
Denmark	36	None	-	65	78.2
Finland	19	DB	1.5	65	58.2
France	32	DB/Points	1.75	60	37.5
Germany	19	Points	1	65	35.5
Greece	34	DB	2.57	65	92.9
Hungary	22	DB	1.22	62	66.8
Iceland	27	DB	1.4	67	74.8
Ireland	30	None	-	66	38.2
Italy	22	NDC	1.75	65	61.0
Japan	16	DB	0.55	65	34.4
Korea	30	DB	1.5	65	64.6
Luxembourg	39	DB	1.85	65	79.8
Mexico	26	None	-	65	31.5
Netherlands	31	DB	1.75	65	76.7
New Zealand	40	None	-	65	46.8
Norway	33	Points	1.05	67	59.0
Poland	23	NDC	0.67	65	53.3
Portugal	44	DB	w	65	54.3
Slovak Republic	22	Points	1.16	62	48.8
Spain	30	DB	y	65	81.2
Sweden	34	NDC/DB	1.18	65	60.5
Switzerland	24	DB	w/a	65	58.2
Turkey	28	DB	2.0	65	65.9
United Kingdom	30	DB	w	65	32.6
United States	22	DB	w	67	43.6

Notes:
(1) Source: OECD Pensions at a Glance (2007).
(2) First-tier benefit is shown as a percentage of average earnings for a full career worker.
(3) DB is defined benefit; DC is defined contribution; NDC is notional accounts.
(4)– = not relevant; [a] = varies with age; [w] = varies with earnings; [y] = varies with years of service.