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Exploitation of Government Intervention on the Supply Side of Elderly Care Market

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Effects of Informal Elderly Care on Labor Supply: Exploitation of Government Intervention on the Supply Side of Elderly Care Market*

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Abstract

This study analyzes the effect of informal elderly care on caregiver labor supply. Since the Japanese government intervenes on the supply side of the elderly care market and market entry of nursing home suppliers is regulated, this analysis utilizes exogenous variations from the supply side of government intervention on the elderly care market. Owing to such intervention and regulation, public nursing home capacity exogenously changes for caregivers, which we use to estimate the effect of informal elderly care on labor supply. To the best of our knowledge, no study has thus far utilized exogenous institutional variation as an instrument to estimate this effect. Analysis results reveal that the effect of informal elderly care on female labor force participation is negative. By contrast, male labor force participation is not affected by such care, since, in Japan, females spend more time on informal care than males. The increase in nursing home capacity is thus effective for decreasing the female burden of informal care.

JEL Classification Numbers: J14, J18, J22, I18
Keywords: informal care, labor supply, government intervention, JSTAR

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1 Introduction

Many developed countries have been facing problems of a decreasing birthrate and an aging population. As population ages, the cost of social security and social welfare increases, eroding the country's budget. As such, numerous developed countries have reformed the social security systems to reduce the cost of social security and social welfare, thus generating a fair amount of attention towards these policy reforms. Countries such as the United States, the United Kingdom, and Korea have decided to increase the pension eligibility age in subsequent decades, while Japan has already increased it. As population ages in developed countries, countries such as Germany and Korea have also been reformed the nursing care system for the elderly. In Germany, a mandatory and universal system of long-term care insurance (LTCI) was implemented in 1995 (Schulz (2010)). The national mandatory elderly LTCI was introduced in Korea in 2008 (Kwon (2009), Won (2013) and Chul et al. (2015)).

With the growing interest in nursing care systems in the United States and Europe, since the 1980s, both demand and supply side of the elderly care market have been analyzed. One important topic in the analysis of the demand side of the elderly care market is the effect of informal care on labor supply. As we explain in section 2, hitherto, related studies in the United States and Europe analyzing the effect of informal care on labor supply have employed family structure and parental health as instrumental variables. As such, they have not utilized institutional change as a natural experiment in estimating the effect of informal care on labor supply. As Van Houtven, Coe, and Skira (2013) point out, some of the instruments employed in literature are weak or their exogeneity is questionable.

In 2000, the Japanese government has also implemented LTCI.[1] In the Japanese care system, there are two important characteristics related to our study. First, there are three types of public nursing homes. Second, the supply of these nursing homes is regulated by the government. The goal of this study is to examine the causal effect of informal care on labor supply, and the analysis utilizes the exogenous variation of government intervention on the supply side of the elderly care market to estimate this effect. Since the supply of public nursing home is regulated by the government, we utilize this exogenous variation for estimating the effect of informal care for the elderly on labor supply. To the best of our knowledge, there is hitherto no study to utilize the exogenous variation of nursing home supply regulated by the government as an instrument to estimate the effect of informal care for the elderly on labor supply. Kondo (2016) utilizes the exogenous variation of nursing home capacity. However, Kondo (2016) does not estimate the effect of informal care on labor supply, and includes directly the capacity of nursing home as an explanatory variable, estimating directly the effect of this capacity on labor supply. In Japan, there are also some studies analyzing the effect of LTCI introduction on labor supply, while they do not directly estimate the effect of informal care on labor supply.[2] According to our results, the effect of informal care for elderly on female labor supply is negative. On the other hand, there is no effect of informal care on male labor supply, since, in Japan, females spending more time on informal care than males spending time on informal care. As such, the government

[1] Tamiya et al. (2011) explain this system in detail.

[2] For example, Shimizutani et al. (2008), Sugawara and Nakamura (2014), and Fukahori et al. (2015)

intervention becomes effective for decreasing the female burden of informal care.

The remainder of this paper is organized as follows: section 2 reviews literature; section 3 discusses the data uses; section 4 explains the institutional background and instruments used in this study; section 5 discusses gender differences in providing informal care; section 6 discusses the analysis methods; section 7 presents the results, which are discussed in section 8 discusses; and section 9 concludes this paper and identifies the scope for future research.

2 Literature Review

Since the 1980s, the elderly care market has been analyzed from both supply and demand sides.[3] One of the central topics regarding the demand side of the elderly care market is the effect of informal care on labor supply. Lilly et al. (2007) and Bauer and Sousa-Poza (2015) review studies on the effect of informal care on labor supply in detail,[4] which is beyond the scope of this study.[5]

After 2000, analysis on the effect of informal care on labor supply has also been carried out. The most important issue in these studies is controlling the endogeneity of providing informal care, followed by which instruments the studies should employ. In Table 1, we review which instruments have been employed in the literature after 2000. As Van Houtven et al. (2013) point out, some of the instruments employed in literature are weak or their exogeneity is questioned. Some other studies use other techniques, such as simultaneous equations or dynamic panel data methods, without using the instrumental variables methods. However, the causal influence of exogenous variation on providing informal care cannot is unavailable in these studies. As Table 1 shows, in literature, variables such as parental health and family structure have been used as instrumental variables and no study utilizes institutional exogenous variation. Therefore, we propose the estimation procedure to utilize the exogenous variations causal influence on providing informal care.

As previously mentioned, in Japan, the supply side of elderly care market is regulated by the government. Since 2000, the LTCI system has been introduced in Japan. The government has also determine how many public nursing homes to be supplied, thus exogenously controlling the supply of public nursing homes. Additionally, there is an exogenous variation of this supply of public nursing homes depending on municipality. In other words, the availability of formal care is heterogeneous among different municipalities. We utilize this exogenous variation to estimate the effect of informal care on labor supply.

Finally, we introduce the Japanese literature. Since 2000, Japanese researchers have analyzed the effect of informal care on labor supply. However, Shimizutani et al. (2008),

[3]For example, the literature analyzing the supply side of the care market is represented by Nyman (1985, 1988, 1994), Gertler (1989, 1992), Connelly (1992), Norton (1992), Ettner (1993), Cohen and Spector (1996), Grabowski (2001), Grabowski et al. (2008), and Ching et al. (2015).

[4]For example, the related literature includes Wolf and Soldo (1994), Hoerger et al. (1996), Carmichael and Charles (1998, 2003), Heitmueller and Inglis (2007), Carmichael et al. (2010), Lilly et al. (2010), Leigh (2010), Michaud et al. (2010)

[5]Additionally, public health is represented by studies such as Tan (2000), Berecki-gisolf et al. (2008) Hassink and Berg (2011) Trong and Brian (2014). However, we focus on the economics literature.

Sugawara and Nakamura (2014), Fukahori et al. (2015) and Kondo (2016) do not estimate the direct effect of informal care on labor supply, which Wakabayashi and Donato (2005), Ishii (2015), Yamada and Shimizutani (2015) and Moriwaki (2016) do. Nonetheless, the later do not utilize the exogenous variation caused by the exogenous change in the supply side of the informal care market. Additionally, the magnitude seems inconsistent across. We compare the results of these studies with our results in section A.1.

Table 1: The Instruments Employed in Literature

	Instruments	Memo
Main		
Heitmueller (2007)	•The number of sick and disabled people in the household •The age of the three closest friends of the respondent •The age of the parents and the geographical proximity of parents and friends	
Bolin et al (2008)	•Mother have bad health •Father have bad health •Age of mother •Age of father •Mother lives far away •Father lives far away •Mother deceased •Father deceased •Number of siblings	
Ciani (2012)	•The presence of disabled individuals living in the household •The presence of at least one co-resident individual reporting poor health	
Van Houtven, Coe and Skira (2013)	•Mother ill •Mother in-law ill •Mom died •Dad died •Mother in-law died •Father in-law died •Mother recently widowed •Mother in-law recently widowed	
Meng (2013)	•The four categories of ADL and IADL in which the impaired individual needs help are used as instruments •The variable which indicates whether disabled individuals are present in the household	
Others		
Van Houtven and Norton (2004)	•Proportion of daughters •Distance to the nearest child	•2nd stage dependent variable: the utilization of formal care
Bonsang (2009)	•Number of siblings	•2nd stage dependent variable: the utilization of formal care

3 Data

We use the Japanese Study of Aging and Retirement (JSTAR), [6] which is a panel survey of elderly people aged 50 or older conducted by the Research Institute of Economy, Trade and Industry, Hitotsubashi University, and, more recently, the University of Tokyo. The JSTAR has been conducted since 2007 has survey counterparts in other countries, such as the China Health and Retirement Longitudinal Study (CHARLS), the English Longitudinal Survey on Aging (ELSA), the Health and Retirement Study (HRS) in the US, the Korean Longitudinal Study of Aging (KLoSA), the Longitudinal Aging Study in India (LASI), and the Survey on Health, Aging, and Retirement in Europe (SHARE). Ichimura et al. (2009) explain the details of the JSTAR, such as the sampling design and other detailed information on the survey.

There are three types of JSTAR data, which differ by security level: high, very high, and ultra-high. Our study uses the very high level, which contains the full sample data, including birth month and geographic information, which allows us to identify the nursing home capacity for each municipality. The survey years used in the study are 2007, 2009, 2011 and 2013. The JSTAR includes a rich variety of variables that capture the characteristics of individuals — their economic and health status, family background, and social and work status. In the JSTAR, labor participation, informal care to the parents, respondent demographics, and the place of residence information are available for the elderly. As such, this dataset is a suitable panel data for this study. Generally, we used the Harmonized JSTAR data set. [7] However, when variables were not available in the Harmonized JSTAR, we used the original JSTAR. Table 2 shows the summary statistics of the data. For this analysis, we impute the asset-level data by replacing missing data with the substituted values of a respondent as explained it in section A.2. We use a similar imputation method to the RAND HRS. (Hurd et al. (2016))

We also use the Population Census of 2005 and 2010 [8] and the Survey of Institutions and Establishments for Long-Term Care for 2007, 2009, 2011, and 2014 to define the instrumental variables for this study. [9] We explain how to use these datasets in section 4.

[6] See the website at (http://www.rieti.go.jp/en/projects/jstar/) for details on the JSTAR.

[7] The Gateway to Global Aging Data (http://gateway.usc.edu) provides harmonized versions of data from the international aging and retirement studies (e.g., HRS, ELSA, SHARE, and JSTAR). All variables of each dataset aim to have the same items and follow the same naming conventions. The harmonized datasets enable researchers to conduct cross-national comparative studies. The program code for generating the Harmonized JSTAR dataset from the original JSTAR dataset is provided by the Center for Global Aging Research, USC Davis School of Gerontology, and the Center for Economic and Social Research (CESR). Some variables, such as measures of assets and income, are imputed by this code.

[8] See the website at (http://www.stat.go.jp/english/data/kokusei/) for details on the Population Census.

[9] See the website at (http://www.mhlw.go.jp/english/database/db-hss/siel-index.html) for details on the Survey of Institutions and Establishments for Long-term Care.

Table 2: Summary Statistics

	(1) **5 cities**		(2) **2 cities**		(3) **3 cities**	
	mean	sd	mean	sd	mean	sd
Demographics						
Age	62.87	7.05	62.99	7.32	62.64	6.86
Age $\geq$ PA	0.58	0.49	0.55	0.50	0.52	0.50
Educ. $\geq$ Univ.	0.12	0.33	0.16	0.36	0.24	0.42
Female	0.50	0.50	0.53	0.50	0.55	0.50
Mariage	0.81	0.39	0.75	0.43	0.78	0.41
N um.of children	2.05	0.97	2.16	1.39	1.70	1.07
Economic variables						
HH income (US$)	41641	32794	44800	38118	61081	53419
Own house	0.77	0.42	0.63	0.48	0.69	0.46
Saving(imputed,US$)	63934	87361	54559	90933	91997	111633
Working status						
Not working for pay	0.43	0.49	0.51	0.50	0.43	0.49
Working hours $\geq$ 5	0.55	0.50	0.46	0.50	0.52	0.50
Working hours $\geq$ 10	0.52	0.50	0.44	0.50	0.49	0.50
Working hours $\geq$ 20	0.48	0.50	0.41	0.49	0.43	0.50
Full time worker (at 1st intw or age 54)	0.49	0.50	0.46	0.50	0.49	0.50
Nursing care and parents' information						
Provide informal care	0.13	0.33	0.11	0.31	0.15	0.35
Formal care utilization (for most severe parent)	0.10	0.30	0.14	0.34	0.14	0.34
NCL (for most severe parent) $\geq$ S1	0.23	0.42	0.24	0.43	0.30	0.46
NCL (for most severe parent) $\geq$ C3	0.13	0.34	0.13	0.34	0.15	0.36
Parents age(for most severe parent)	87.99	5.89	88.55	6.39	88.13	5.52
Year of 1st interview	2007		2009		2011	
Num. of waves	4 waves		3 waves		2 waves	

4 Institutional Background

Since the implementation of the LTCI system in 2000, all Japanese people above 40 have to join the LTCI and are able to receive public care services depending on their age and nursing care level. All those between 40 and 64 can receive public care services with a co-payment ratio of only 10 percent when they have specific diseases due to aging. On the other hand, those above 65 can receive public care services with a co-payment ratio of 10 percent when they "require long-term care." The government assesses the nursing care level for the elderly to decide whether they "require long-term care." As a result, public care services are provided based on the nursing care level as exemplified below for those over 65. Figure 1 shows the process to determine which nursing care level is to be provided. [10]

- Step 1: A family member who finds that an elderly individual in the household has a physical problem can ask the local government to decide the nursing care level.
- Step 2: Depending on the health condition of the elderly and household characteristics, such as the number of adults who can provide informal care, the local government decides the nursing care level, based on which, the choice set of available public care services from which an applicant can choose is determined. For example, the applicant can use a particular nursing home when they have more than nursing care level 1. [11] The following table 3 shows the nursing care level as per Moriwaki (2016). [12] We quote Table 1 from Moriwaki (2016).

Table 3: Care Levels (Table 1 in Moriwaki (2016))

Care Level	Description
Special Elders	Currently independent, needs preventive healthcare
Support Level 1	Having difficulties in standing up, getting up, and/or standing on one foot
Support Level 2 Care Level 1	In addition, having difficulties in walking, washing body, keeping track of the personal finances, and/or clipping nails
Care Level 2	In addition, having difficulties in dressing, moving, and/or decision-making
Care Level 3	In addition, having difficulties in washing face, grooming, tooth-brushing, urination/defecation, and/or use of public transportation
Care Level 4	In addition, having difficulties in eating, and/or communication
Care Level 5	In addition, having difficulties in swallowing, memorizing and/or understanding

More importantly, there are two judgment procedures (the first and second) to determine the nursing care level. In the first judgment procedure, the computer automatically carries out the first judgment based on standardized information. In the second procedure, academic experts judge the final nursing care level referring to special report

[10] We sincerely thank Hisataka Anezaki and Tetsuya Iwamoto for explaining this point.

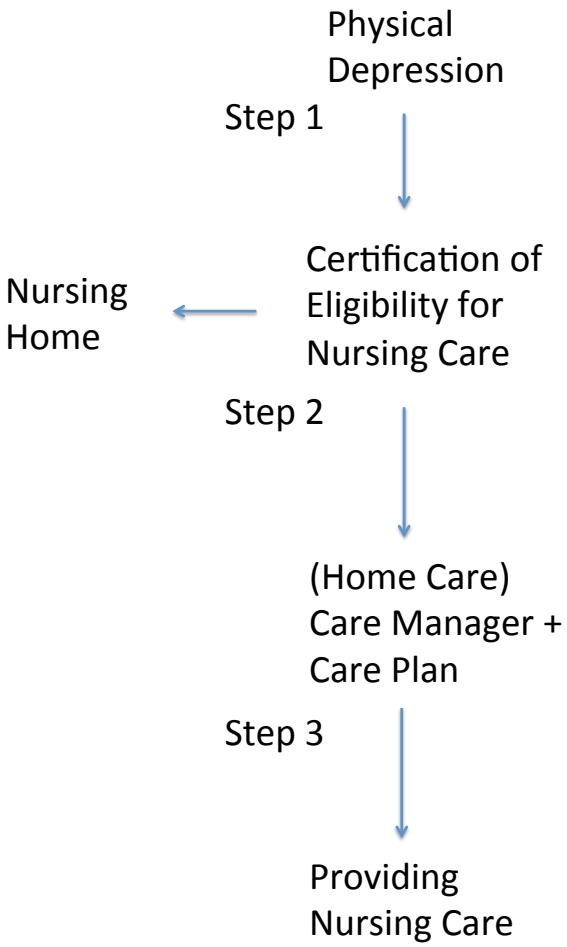
[11] After 2015, this restriction became effective. Before 2015, the restriction was referring to more than nursing care level 1.

[12] With respect to the decision of nursing care level, see the website at (http://www.mhlw.go.jp/topics/kaigo/nintei/gaiyo2.html) for details. (Ministry of Health, Labour and Welfare)(in Japanese)

from a doctor. In this report, information about the household of an applicant might be included. The judgment about the nursing care level is influenced by this information on the household, except for the applicant's health status. Additionally, after the nursing care level has been decided, an applicant can apply for a reexamination based on the situation of the applicant's household.

- Step 3: Finally, if an applicant decides to use a home care, they will discuss with a care manager [13] with respect to which care service they will use.

Figure 1: The Process to Determine Which Nursing Care is Provided



According to the explanation above, in Step 2, an applicant can stay in a public nursing home when their nursing care level is above a certain level. There are three public nursing

[13] A care manager is a specialist who plans the care service that an applicant will use.

homes in Japan as per Table 4, [14] Facility Covered by Public Aid Providing Long-Term Care to the Elderly (Tokuyo), Long-Term Care Health Facility (Roken), and Designated Medical Long-Term Care Sanatoriums. In these three public nursing homes, Tokuyo is the most popular nursing home because the price of nursing care is relatively low. As you can observe in Table 4, its utilization rate is almost 100 percent. Basically, most elderly individuals are provided nursing care in Tokuyo or Roken. Additionally, the purpose of each nursing home is different. The allowed length of stay in Tokuyo is unlimited, while in Roken is from three months to one year. The purpose of Roken is to provide the services that help with the rehabilitation of the elderly. The Designated Medical Long-Term Care Sanatoriums are not that common for providing nursing care for the elderly.

Table 4: Three Public Nursing Homes in Japan

	Facility Covered by Public Aid Providing Long-Term Care to the Elderly (Tokuyo)	Long-Term Care Health Facility (Roken)	Designated Medical Long-Term Care Sanatoriums
Number of Facilities	7065	3857	1318
Admission Capacity	484353	339142	58419
Utilization Rate	97.4	89.2	91.1
Average Nursing Care Level	3.87	3.26	4.38

Source: Survey of Institutions and Establishments for Long-term Care October, 2015

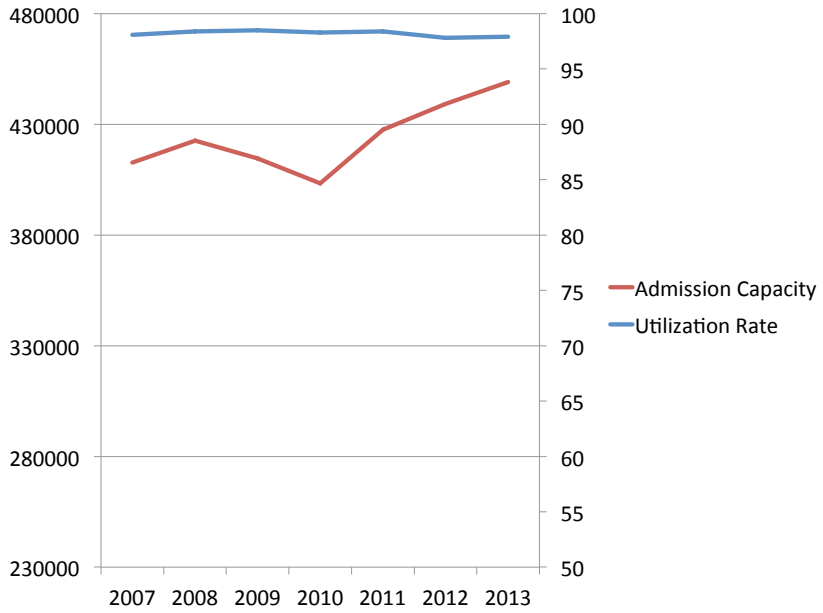
The important point is that these three nursing homes for the elderly are exogenously supplied by the government on the elderly in the demand side of the elderly care market. For example, as you can see in Table 4, the numbers receiving care services in Tokuyo are close to the upper bound of capacity. We thus utilize this exogenous variation of the capacity for controlling the endogeneity of providing informal care. In Figure 2, we show the admission capacity and utilization rate of Tokuyo. Obviously, although admission capacity changes exogenously, the utilization rate does not change (almost 100 percent). The ratio of people who must provide informal care is influenced by the exogenous change of the admission capacity.

In fact, there is an exogenous variation of the admission capacity in different regions and over different periods. In Figure 3, we show the admission capacity per capita for those above 65 for Tokuyo as 100 $\times$ (Capacity of Tokuyo in Each Region)/(Total Population More Than Age 65 in Each Region)) in each region. Here, we use the Population Census 2005 and 2010 and the Survey of Institutions and Establishments for Long-term Care 2007, 2009, 2011, and 2014 to build this variable. [15] Here, the variation in the value is exogenous for a caregiver in a household, which we use this variation to control the endogeneity of informal care. Importantly, a household cannot use the nursing home outside the region of residence.

[14] See the website at (http://www.mhlw.go.jp/english/database/db-hss/siel-index.html) for details. (Ministry of Health, Labour and Welfare)

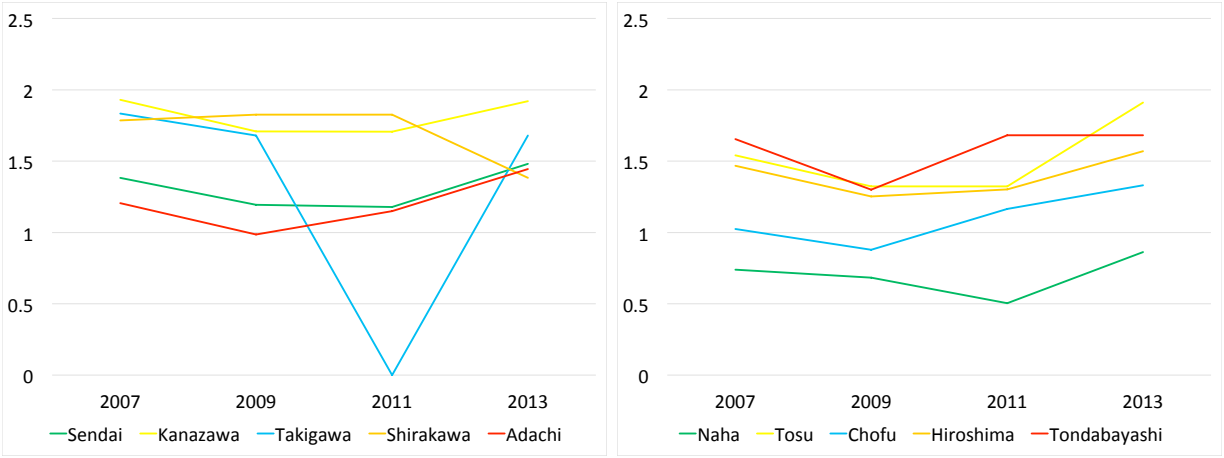
[15] We only have 2005 and 2010 population information, and use the information nearest to the surveyed year of capacity.

Figure 2: Admission Capacity and Utilization Rate of Tokuyo in Japan



Source: Survey of Institutions and Establishments for Long-term Care October, 2007-2013

Figure 3: Admission Capacity Per Capita More Than Age 65 of Tokuyo in Japan (Vertical Line: 100 × (Capacity of Tokuyo in Each Region)/(The Total Population More Than Age 65 in Each Region))

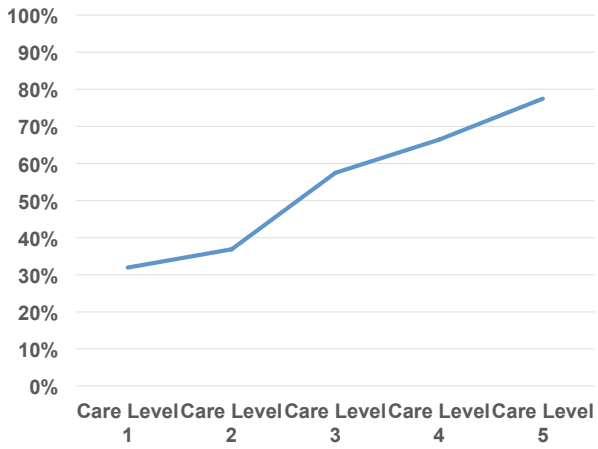


Source: Survey of Institutions and Establishments for Long-term Care October, 2007, 2009, 2011, 2014 and Census 2005 and 2010

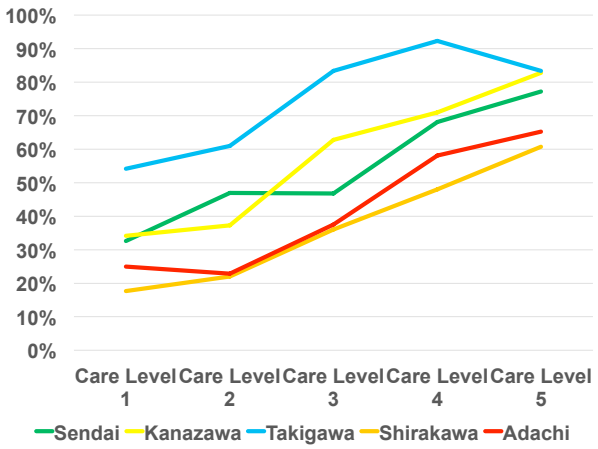
Before 2015, the requirement to apply for admission to Tokuyo is being categorized above nursing care level 1. Moreover, the elderly with a higher nursing care level, who are difficult to give a nursing home care to, were preferably assigned to public nursing homes, although this was not stipulated. We show the utilization rate of formal care by care level in Figure 4. The utilization includes the usage of public and private nursing home. According to Figure 4, the utilization rate increases as the nursing care level increases. In fact, as Table 4 shows, the average nursing care level in Tokuyo was above 3 in 2005. We also use the nursing care level of parents in addition to the exogenous variation of public nursing care home designing the instrumental variable.

According to Figure 5, formal care utilization strongly influences the decision of providing informal care in the household. Figure 5 shows the distribution of who provides informal care in a household with parents certified as being above care level 1. In a household utilizing formal care, the ratio of both male and female members not providing informal care is high. Here, we also use instruments related to government intervention on the supply side of the care market, such as dummy variables indicating the number of parents certified as more than care level 1. The cross term of (parental age) $\times$ (dummy variable indicating more than support level 1) is also used. The details are explained in section 6.2.

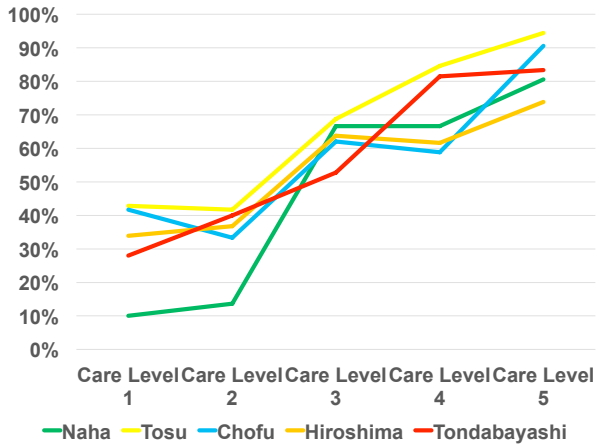
Figure 4: The Utilization Rate of Formal Care by Care Level (Total and By City, City: The Residence of a Respondent)(Horizontal Line: Nursing Care Level of Parents)



(a) Total



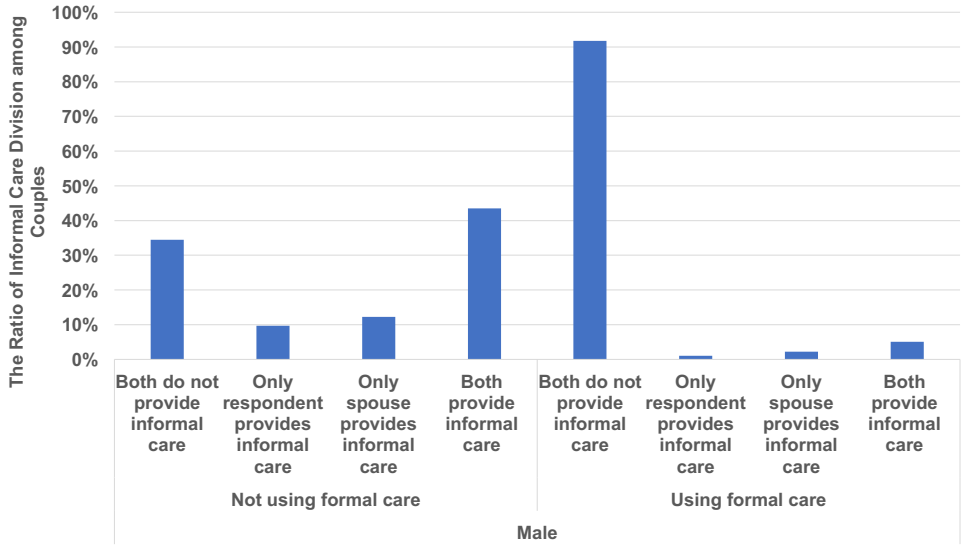
(b) Sendai, Kanazawa, Takikawa, Shirakawa and Adachi



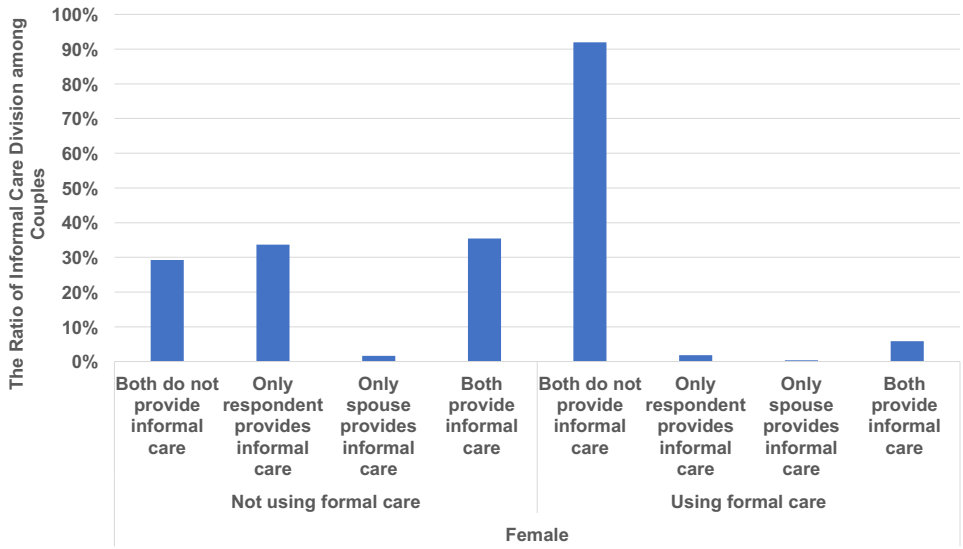
(c) Naha, Tosu, Chofu, Hiroshima and Tondabayashi

Source: JSTAR 2007-2013

Figure 5: Formal care utilization and informal care provision among couples with certified parents



(a) Male



(b) Female

Source: JSTAR 2007-2013

5 Discussion: Gender Difference in the Role of Providing Informal Care

Before we empirically analyze the effect of informal care on labor supply, we must discuss who provides nursing care in a household and difference in the role of providing nursing care between male and female household members, which is critical in Japan, and which we confirm here. According to the discussion in this section, we should consider the heterogeneity of male and female household members when considering the estimated results.

Figure 6 shows long-term care time by gender, which is significantly longer for females than males. Long-term care time for working females is even longer than for males who do not work, which reflects in the estimated results. Next, we focus on long-term care time, depending on whether other household members help or not and whether husbands works or not. According to Figure 6 (c), as expected, long-term care time for females without support is longer than otherwise. Additionally, whether a husband is working or not does not influence long-term care time. Accordingly, when household members have to provide informal care for the elderly, the task is concentrated on a female household member. Figure 6 (e) and (f) shows male household behavior. Figure 6 (e) shows whether male spouses help with providing informal care. Even if the husband is not working for pay, the ratio of the husband helping the wife is 70 percent. On the other hand, the ratio is 60 percent if the husband is working for pay. Overall, husbands are not helping their wives in about 30 percent of households. Figure 6 (f) shows long-term care time for males people when their spouse provides informal care. When not working, the difference in long-term care time is about one hour compared to the case when males do work.

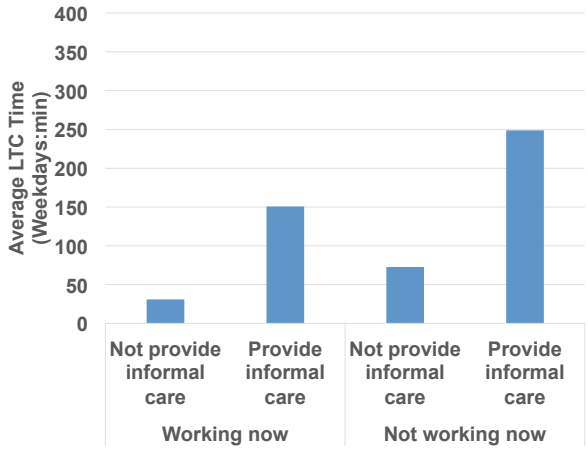
We discuss the relationship between labor force participation rate and informal care. Figure 7 describes the proportion of not working for pay. Basically, the labor force participation rate of males is higher than that of females. In panel (a), the difference in labor force participation rate is about 5 percent between elderly providing informal care and those who are not providing informal care (both female and male). Figure 7 (c), (d), and (e) shows the relationship between the transition of providing informal care and of not working for pay. According to panels (b), (c), (d), and (e), among males, providing informal care in the second interview seems to influence their labor force participation rate. Almost all males work in the first wave. For females, providing informal care in the second interview seems to influence the labor force participation rate, regardless of the working status in the first wave.

In panel (d), we find that the female elderly continue to work even if they provide nursing care in the second interview. One reason might be that almost all people can use home care services covered by nursing care insurance. Since, in JSTAR, the information with respect to home care services is not available, we use information from the Comprehensive Survey of Living Conditions 2013. [16] Figure 8 shows the long-term care service utilization covered by nursing care insurance when a person who requires nursing care lives in a household. The care service includes home-visiting nursing care services, meal delivery service, and so on.

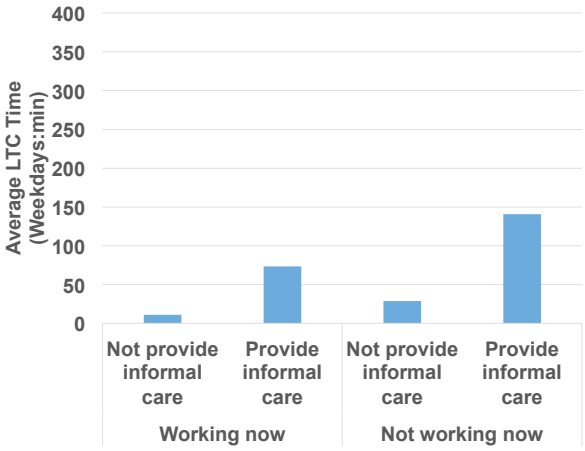
[16] See the website at (http://www.mhlw.go.jp/english/database/db-hss/cslc-index.html) for details. (Ministry of Health, Labour and Welfare)

According to Figure 8, most children and their spouses utilize these services when parents require long-term care services. The rate of utilization does not seem to be related to the work status since most dependents can utilize the service.

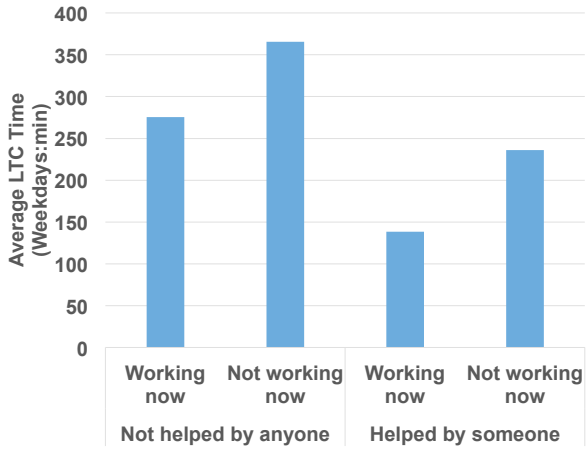
Figure 6: Long Term Care Time



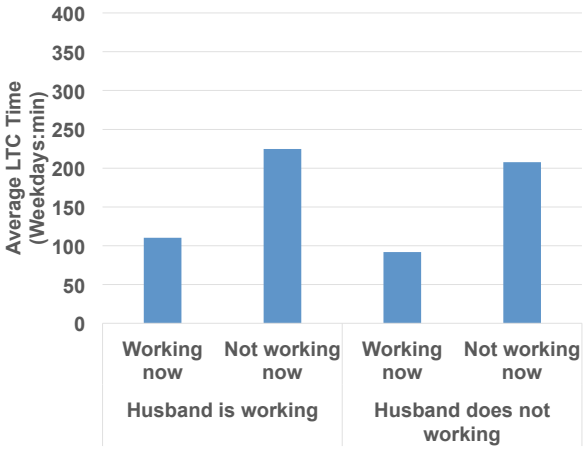
(a) Female



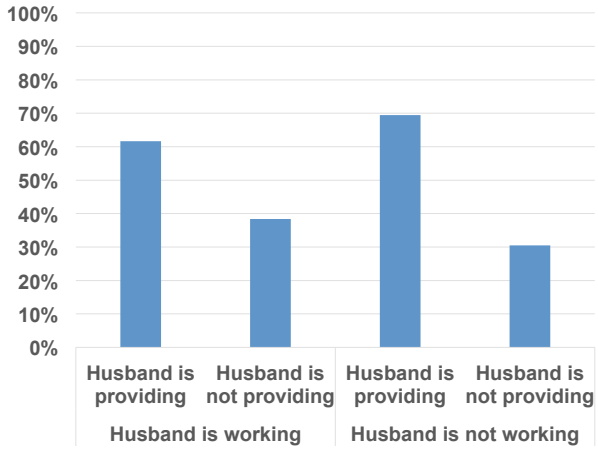
(b) Male



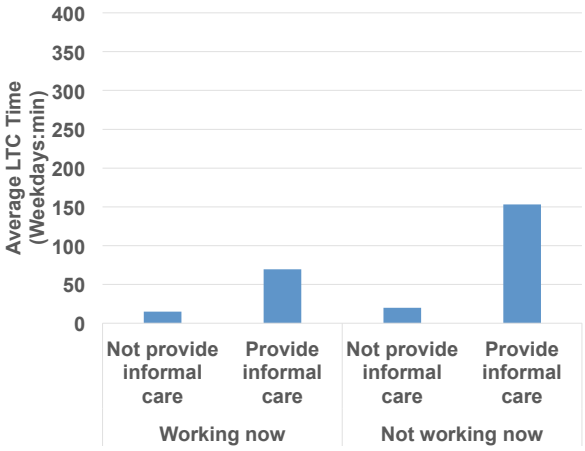
(c) Female by any help



(d) Female by husband' working status



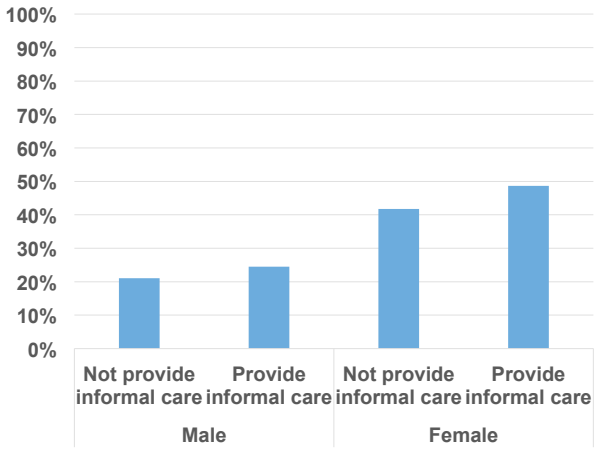
(e) Husband' help for female providing LTC



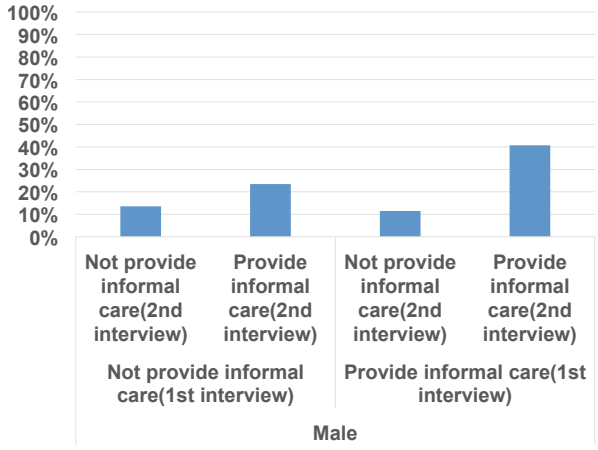
(f) Male who have wife providing LTC

Source: JSTAR 2007-2013

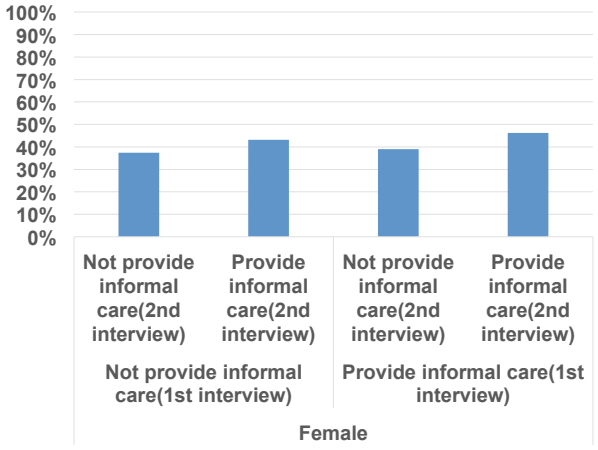
Figure 7: The Proportion of Not Working For Pay



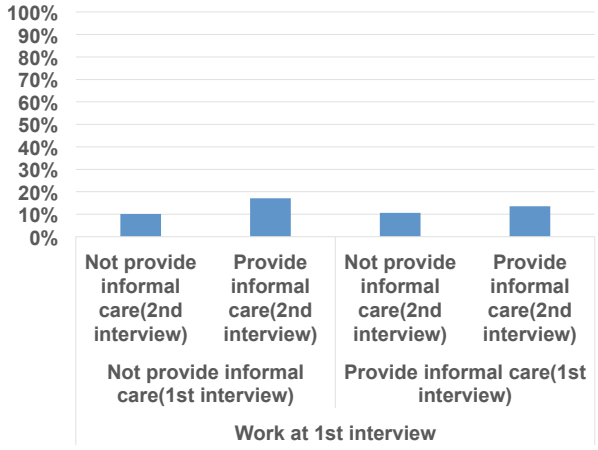
(a) Total



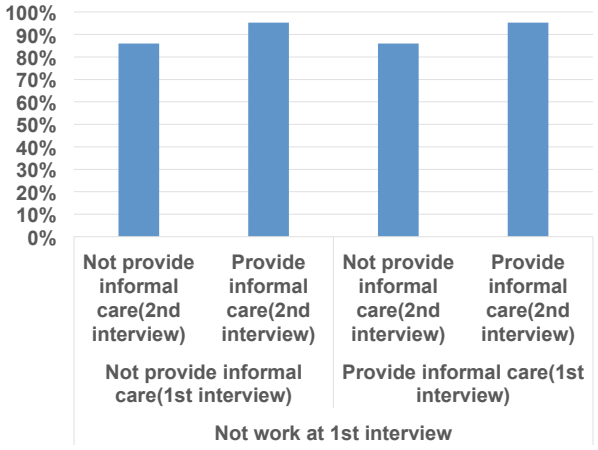
(b) LFP at 2nd INTW by 1st INTW status (Male)



(c) LFP at 2nd INTW by 1st INTW status (Female)



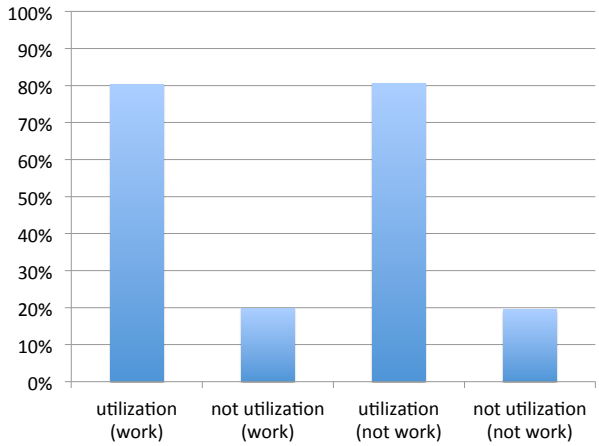
(d) Female working at 1st interview



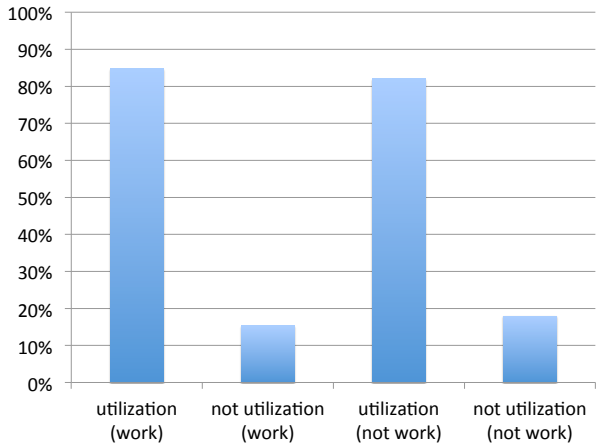
(e) Female not working at 1st interview

Source: JSTAR 2007-2013

Figure 8: The Long Term Care Service Utilization Covered by Nurse Care Insurance When a Person Who Requires Nursing Care Lives in the Household



(a) children (relationship with the member requiring nursing care)



(b) children's spouse (relationship with the member requiring nursing care)

Source: Comprehensive Survey of Living Conditions 2013

6 Analysis Method

6.1 Relationship between Labor Supply and Informal Care

We discuss the division of informal care in a household by using a simple economic model, confirming its relationship with the labor division. By using this model, we will consider the causal relationships (1) between labor supply and informal care, (2) between informal care and formal care utilization, (3) between formal care utilization and spouse informal care, and (4) between spouse informal care and informal care. Figure 9 confirms these relationships. The following is a household collective model, including the division of informal care. [17]

$$\begin{aligned} \max_{\{c^A, l^A, c^B, l^B, I, \alpha, Apply\}} & \mu(w,y,z)u(c^A, \tilde{l}^A) + (1-\mu(w,y,z))u(c^B, \tilde{l}^B) \\ s.t.\ & c^A + c^B + w^A\tilde{l}^A + w^B\tilde{l}^B \leq y^H + w^A T^A + w^B T^B - p \cdot \tilde{F} \\ 0 \leq \tilde{l}^A \leq T^A, & 0 \leq \tilde{l}^B \leq T^B, CareSum \geq C \cdot 1\{ParentalHealth = Bad\} \end{aligned} \tag{1}$$

We add the variables such as $\alpha, I, \tilde{F}$ in the usual collective model. There are two agents in this household (agent A and agent B). The notations are following.

- $c^j (j = A, B)$: consumption, $\tilde{l}^j (j = A, B)$: finally consumed leisure.
- $l^j (j = A, B)$: leisure, I: quantity of informal care.
- $T^j (j = A, B)$: endowment, $w = (w^A, w^B)$: wage vector.
- F: supplied formal care amount from the government
- p: formal care price, C: needed care amount if a parent is not healthy.
- y_H: household income except wage

$Apply, Availability \in \{0, 1\}$. $ParentalHealth \in \{Good, Bad\}$. We define $CareSum, \tilde{l}^A, \tilde{l}^B, \tilde{F}$ in the following way.

$$CareSum = I + \tilde{F} \tag{2}$$
$$\tilde{l}^A = l^A - \alpha \cdot I \tag{3}$$
$$\tilde{l}^B = l^B - (1-\alpha) \cdot I \tag{4}$$
$$\tilde{F} = F \cdot 1\{Apply = 1\} \cdot 1\{Availability = 1\} \cdot 1\{ParentalHealth = Bad\} \tag{5}$$

$Availability = 1$ if the government supplies formal care to this household. $ParentalHealth = 1$ if one of the parents is not healthy. Equation (3) shows the direct relationship between

[17] With respect to collective household models, please see Vermeulen (2002).

labor supply and informal care. Equation (2) shows the direct relationship between informal care and formal care utilization, and the direct relationship between formal care utilization and spouse informal care. Finally, the household informal care I is divided into agent A informal care and agent B informal care, which shows the direct relationship between agent A informal care and agent B informal care. When $Availability = 1$ and $ParentalHealth = 1$, a household can utilize formal care according to (5). When $ParentalHealth = 1$, $CareSum \geq C \cdot 1\{ParentalHealth = Bad\}$ is true. In other words, $1\{ParentalHealth = Bad\}$ influences directly household informal care (both agent A and agent B informal care). Summing these relationships, we can describe Figure 9. By the way, the event that $Availability = 1$ and $ParentalHealth = 1$ happens exogenously from the decision making of the household.

Define variables Z_{1it}, Z_{2it} as $Z_{1it} = 1\{Availability = 1\}$ and $Z_{2it} = 1\{ParentalHealth = Bad\}$. Let vector $\tilde{Z}_{3it}$ be other instruments. We use the following equation based on the relationship among labor supply, informal care, formal care utilization, and informal care supply in the household, where $\tilde{X}^j_{it}(j = A, B)$ is an explanatory variable of agent j.

- The Functions:

$$\begin{aligned}
y^A_{it} &= F_{y^A}(IC^A_{it}, \tilde{X}^A_{it}),\\
y^B_{it} &= F_{y^B}(IC^B_{it}, \tilde{X}^B_{it}),\\
IC^A_{it} &= F_{IC^A}(y^A_{it}, IC^B_{it}, FC_{it}, Z_{2it}, \tilde{Z}_{3it}, \tilde{X}^A_{it}),\\
IC^B_{it} &= F_{IC^B}(y^B_{it}, IC^A_{it}, FC_{it}, Z_{2it}, \tilde{Z}_{3it}, \tilde{X}^B_{it}),\\
FC_{it} &= F_{FC}(IC^A_{it}, IC^B_{it}, Z_{1it}, Z_{2it}, \tilde{X}^A_{it}, \tilde{X}^B_{it}).
\end{aligned}$$

- $y^j_{it}(j = A, B)$: labor supply of agent j, $IC^j_{it}(j = A, B)$: informal care supply of agent j, FC_{it}: formal care utilization of household.

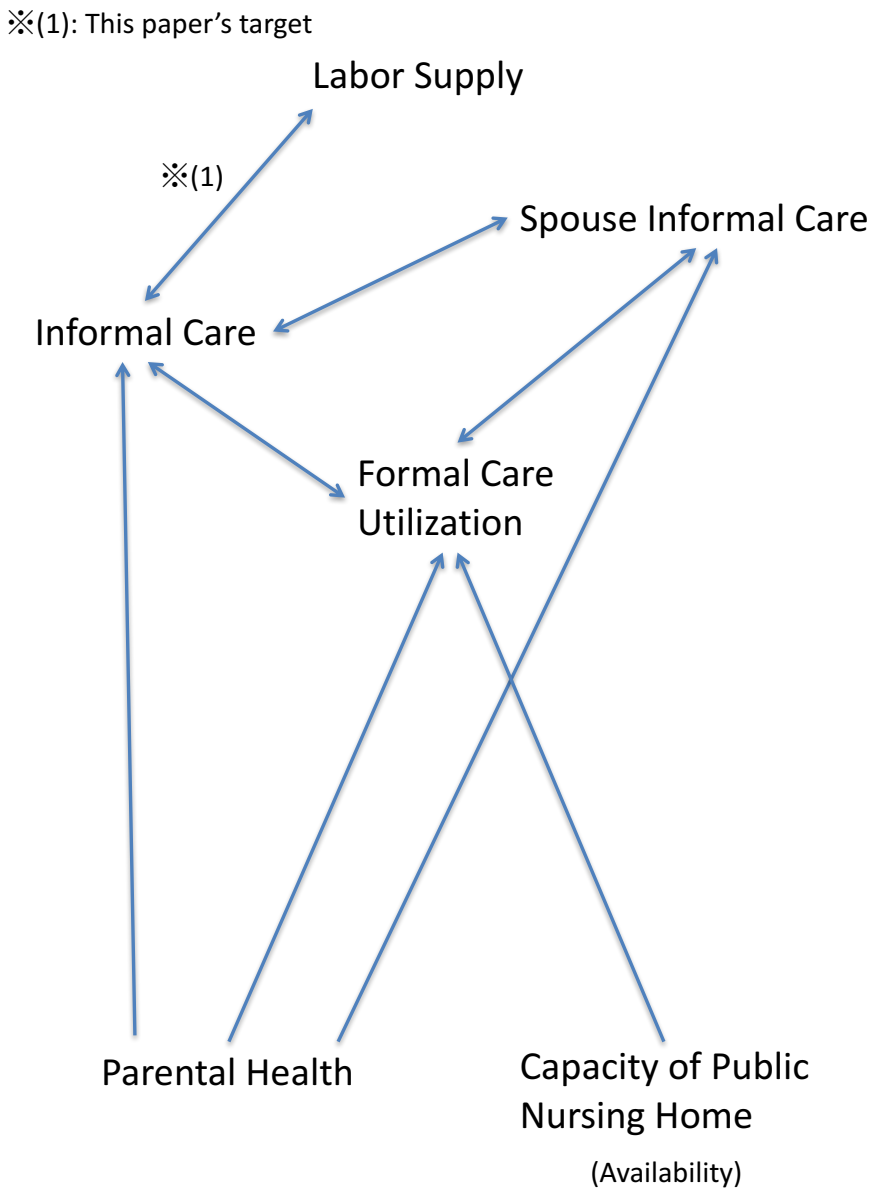
We derive the following functions based on this system of equations.

$$\begin{aligned}
y^A_{it} &= f_{y^A}(Z_{1it}, Z_{2it}, \tilde{Z}_{3it}, \tilde{X}^A_{it}, \tilde{X}^B_{it}),\\
y^B_{it} &= f_{y^B}(Z_{1it}, Z_{2it}, \tilde{Z}_{3it}, \tilde{X}^A_{it}, \tilde{X}^B_{it}),\\
IC^A_{it} &= f_{IC^A}(Z_{1it}, Z_{2it}, \tilde{Z}_{3it}, \tilde{X}^A_{it}, \tilde{X}^B_{it}),\\
IC^B_{it} &= f_{IC^B}(Z_{1it}, Z_{2it}, \tilde{Z}_{3it}, \tilde{X}^A_{it}, \tilde{X}^B_{it}),\\
FC_{it} &= f_{FC}(Z_{1it}, Z_{2it}, \tilde{Z}_{3it}, \tilde{X}^A_{it}, \tilde{X}^B_{it}).
\end{aligned}$$

When we estimate the effect of informal care on labor supply, we use the following functions.

$$\begin{aligned}
y^j_{it} &= F_{y^j}(IC^j_{it}, \tilde{X}^j_{it})(j = A, B),\\
IC^j_{it} &= f_{IC^j}(Z_{1it}, Z_{2it}, \tilde{Z}_{3it}, \tilde{X}^A_{it}, \tilde{X}^B_{it})(j = A, B).
\end{aligned}$$

Figure 9: The Relationship between Labor Supply and Informal Care



6.2 Estimation Method

In this section, we explain how to estimate the effect of informal care for the elderly on labor supply, and estimate the following equations. [18] As discussed in section 4, we utilize the variation of public nursing home capacity by government intervention on the supply side of the elderly care market when estimating the effect of informal care for the elderly on labor supply, where i is the individual number and $j = j(i)$ $(1 \leq j \leq N_R)$ is the region of residence number.

$$y_{it} = \beta_0 + \beta_1 IC_{it} + X'_{it}\delta_1 + \theta_i + \eta_{jt} + \epsilon_{1it} \tag{6}$$

$$IC_{it} = \alpha_0 + \alpha_1 1\{NursingCareLevel_{it} \geq n_1\} \cdot PA_{it} \tag{7}$$
$$+\alpha_2 1\{NursingCareLevel_{it} \geq n_2\} \cdot Capacity_{it} + \tilde{Z}'_{3it}\alpha_3 + X'_{it}\delta_2 + \xi_i + p_{jt} + \epsilon_{2it}$$

We have discussed the causal relationship between informal care, spouse informal care, formal care utilization, and labor supply in section 6.1. We use $1\{NursingCareLevel_{it} \geq n_1\} \cdot PA_{it}$ as a proxy of $ParentalHealth$ and $1\{NursingCareLevel_{it} \geq n_2\} \cdot Capacity_{it}$ as a proxy of $Availability$. The followings are the definition of variables.

- $Capacity_{it}$: $Capacity\ Index_{it} = 100 \times \frac{Capacity\ of\ Tokuyo_{it}}{\#\ of\ the\ people\ Aged\ over\ 65_{it}}$,
  where $Capacity\ of\ Tokuyo_{it}$: The Capacity of Tokuyo in the residence of respondent at period t, $\#\ of\ the\ people\ Aged\ over\ 65_{it}$: Population above 65 in the residence of respondent at period t. [19]

- $NursingCareLevel_{it}$: The maximum value of nursing care level of parents (only parents in contact with the respondent).

- PA_{it}: The age of parent who has maximum nursing care level (equal to zero if all parents are not certified as needing long-term care, only parents in contact with the respondent).

- IC_{it}: Dummy variable, which is equal to 1 if the respondent provides informal care.

- X_{it}: Other control variables, such as family characteristics, household assets and income.

- $\tilde{Z}_{3it}$: Other instruments such as the dummy variables indicating the number of parents certified as above care level one.

- θ_i, ξ_i: Fixed effects.

- η_{jt}, p_{jt}: Year-residence region effects.

[18] All models are estimated using the STATA module xtivreg2. See Schaffer (2010) for further details.
[19] We only have 2005 and 2010 population information. We use the population nearest to period t.

- n_1, n_2: Natural numbers indicating an nursing care level.

We assume the following when estimating the effect of informal care for the elderly on labor supply. Let $Z_{1it} = 1\{NursingCareLevel_{it} \geq n_1\} \cdot PA_{it}$ and $Z_{2it} = 1\{NursingCareLevel_{it} \geq n_2\} \cdot Capacity_{it}$. We also define $Time_{it} = (1\{t = 1\}...1\{t = T\})'$ and $Region_{it} = (1\{j(i) = 1\}...1\{j(i) = N_R\})'$. Additionally, let $l_{it} = (Z_{1it}, Z_{2it}, \tilde{Z}'_{3it}, X'_{it}, Time'_{it}, Region'_{it})'$.

$$\textbf{Assumption A}: E[\epsilon_{1it}|L_i] = 0 \ (t = 1, 2, ..., T)$$
$$L'_i = (l_{i1}, l_{i2}, ..., l_{iT})$$

For example, ϵ_{1it} includes unexpected shocks to decrease the labor supply, such as a sudden injury to the respondent. When the assumption is valid, it is easy to show the identifiability of parameters by using the above assumption. T is the total number of periods. We define the following notations $\overline{A}_i \equiv \frac{1}{T}\sum_t A_{it}$ (A is a representative letter).

$$(y_{it} - \overline{y}_i) = \beta_1(IC_{it} - \overline{IC}_i) + (X'_{it} - \overline{X'}_i)\delta_1 + \eta_{jt} - \overline{\eta_j} + (\epsilon_{1it} - \overline{\epsilon}_{1i}) \tag{8}$$

Then, we rewrite equations (6) and (7) in the following way.

$$(y_{it} - \overline{y}_i) = \beta_1(IC_{it} - \overline{IC}_i) + (X'_{it} - \overline{X'}_i)\delta_1 + \eta_{jt} - \overline{\eta_j} + (\epsilon_{1it} - \overline{\epsilon}_{1i}) \tag{9}$$

$$\begin{aligned}(IC_{it} - \overline{IC}_i) = \alpha_1(Z_{1it} - \overline{Z}_{1i}) + \alpha_2(Z_{2it} - \overline{Z}_{2i}) + (\tilde{Z}'_{3it} - \overline{\tilde{Z}}'_{3i})\alpha_3 \\ +(X'_{it} - \overline{X'}_i)\delta_2 + p_{jt} - \overline{p_j} + (\epsilon_{2it} - \overline{\epsilon}_{2i})\end{aligned} \tag{10}$$

Let $\tilde{L}_{it} = [(Z_{1it} - \overline{Z}_{1i}), (Z_{2it} - \overline{Z}_{2i}), (\tilde{Z}_{3it} - \overline{\tilde{Z}}_{3i})', (X_{it} - \overline{X}_i)', (Time_{it} \otimes Region_{it} - \overline{Time_i \otimes Region_i})']'$. Then, $\tilde{L}_{it}$ is a function of L_i, and we can write $\tilde{L}_{it} = A(L_i)$. As a result, $E[\tilde{L}_{it}(\epsilon_{1it} - \overline{\epsilon}_{1i})] = E[A(L_i)(\epsilon_{1it} - \overline{\epsilon}_{1i})] = 0$ by the Assumption A. We can identify the parameter $\eta_{jt} - \overline{\eta_j}$ in equation (9) by using the variables such as $Time_{it} \otimes Region_{it} - \overline{Time_i \otimes Region_i}$.

As explained in the previous section, in Japan, the nursing care level is determined by the local government based on the health condition of an applicant and the situation of household economic and family structure. Let $ParentalHealth_{it}$ be the health condition of an applicant. In other words, it is possible that $NursingCareLevel_{it}$ is a function of variables such as X_{it} and $ParentalHealth_{it}$ in the following way.

$$NursingCareLevel_{it} = f(X_{it}, ParentalHealth_{it}). \tag{11}$$

With respect to the unexpected shocks influencing the labor supply, the Assumption A seems to be valid. Here, the validity of Assumption A is checked by an over-identifying restriction test. The variable $1\{NursingCareLevel_{it} \geq n_1\} \cdot PA_{it}$ is a proxy variable of parental health. For example, $ParentalHealth_{it}$ is a function of PA_{it} and M_{it}, which are factors deciding the parental health.

$$ParentalHealth_{it} = g(PA_{it}, M_{it}). \tag{12}$$

On the other hand, $1\{NursingCareLevel_{it} \geq n_2\} \cdot Capacity_{it}$ controls the institutional factor to cause the respondent to provide informal care. When the respondent lives in an area where the capacity of Tokuyo is small, the probability to provide informal care becomes high because it is difficult to get admission to Tokuyo. We discuss this point from the analysis results in section 7.

Finally, we use models (9) and (10) to verify that there is no correlation between $(\epsilon_{1it} - \overline{\epsilon}_{1i})$ and $(IC_{it} - \overline{IC}_i)$. It is possible that $(IC_{it} - \overline{IC}_i)$ is exogenous. In fact, it is reported that providing informal care is exogenous in some studies. (e.g., Ishii (2015)) We check the endogeneity of $(IC_{it} - \overline{IC}_i)$ by using the Durbin-Wu-Hausman (DWH) test. [20] We analyze only samples having a parent who is alive and has a contact with the respondent. The household structure is different between couple and respondent without spouse. In this analysis, it is preferable that the respondent without spouse and couple are separately analyzed because the model differs. However, because the sample size of respondent without spouse is small, we only analyze couple's behavior.

7 Results

7.1 The Validity of Instruments

In this section, we check the validity of using the capacity of Tokuyo as instrument when we estimate the effect of informal care on labor supply. According to our discussion in section 6.1, the capacity of nursing homes (availability) indirectly influences informal care through the change in formal care utilization and directly influences formal care utilization, as equation (13) shows (informal care is influenced through the change in formal care utilization, which is influenced by the capacity of Tokuyo (Z_{1it})). Here, we estimate the equation (14).

$$IC^j_{it} = F_{IC^j}(y^j, IC^k_{it}, FC_{it}, Z_{2it}, \tilde{Z}_{3it}, \tilde{X}^j_{it}) \tag{13}$$

$$FC_{it} = F_{FC}(IC^A_{it}, IC^B_{it}, Z_{1it}, Z_{2it}, \tilde{X}^A_{it}, \tilde{X}^B_{it}) = f_{FC}(Z_{1it}, Z_{2it}, \tilde{Z}_{3it}, \tilde{X}^A_{it}, \tilde{X}^B_{it}) \tag{14}$$

As per Table 5, there is a positive significant effect of capacity of Tokuyo on formal care utilization. The magnitude is around 0.2 in all categories. With respect to the substitution effect of formal care utilization for the elderly on informal care, please see Nishimura and Oikawa (2017), who show the existence of the substitution effect of formal care utilization for the elderly on informal care, thus explaining why we can use the capacity as an instrumental variable in this study.

Importantly, as discussed in section 5, many people use public home care services when they do not use public nursing homes. As such, while the instrument Z_{1it} influences the allocation of formal care utilization, we do not utilize **the exogenous variation to stop formal care utilization completely** as later discussed in section 8.

[20] For a terse explanation of the DWH test, see Cameron and Trivedi (2010).

Table 5: The Capacity of Tokuyo and Formal Care Utilization

	Age range			
Dependent variable:	**50-60**		**50-70**	
Formal care utilization(facility utilization only)	**Male**	**Female**	**Male**	**Female**
Capacity index				
$Capa \times 1\{NCL \geq C3\}$	0.188***	0.214***	0.149***	0.179***
	(0.046)	(0.047)	(0.032)	(0.034)
Other some controls				
PA ($Parent's\ age \times 1\{NCL \geq S1\}$)	0.003***	0.002***	0.003***	0.003***
	(0.001)	(0.001)	(0.000)	(0.001)
N of certified ($Care$) =1	-0.087	0.043	-0.042	0.018
	(0.085)	(0.075)	(0.050)	(0.059)
N of certified ($Care$) ≥2	-0.240*	0.086	0.037	0.072
	(0.132)	(0.123)	(0.082)	(0.086)
Certified ($\geq C2$) female parent	0.243***	0.105	0.133**	0.104*
	(0.085)	(0.075)	(0.055)	(0.059)
Observations	957	911	2022	1602
Model	FE	FE	FE	FE

[1] Standard errors in parentheses.
[2] All specification include age, age squared, $Age \geq PEA$(PEA:pension eligibility age), N of children, HH income, house ownership, HH saving(imputed), and year-municipality dummies.
[3] * $p < .1$, ** $p < .05$, *** $p < .01$

7.2 Main Results

The main results are presented in Tables 6, 7, 8, and 9. $C1$ means "Care Level 1," $S1$ indicates "Support Level 1," "N of certified (Care) = 1 ($\geq$ 2)" is the dummy indicating that the number of parents with care level above 1 is 1 ($\geq$ 2), "Certified ($\geq$ C2) female parent" is the dummy variable indicating that the parent with care level above 1 is female. With respect to working hours per week, we use a dummy variable indicating whether working hours per week are more than 5, 10, or 20 hours ($\geq 5, \geq 10, \geq 20$). We test the endogeneity of informal care with the DWH test. When we do not reject the null hypothesis, we support the results of fixed effects (FE) model.

- According to Table 6, there is no effect of informal care on working for pay in male elderly. With respect to working hours per week in male elderly, there is no effect in all categories. On the other hand, the effect of informal care on working for pay is negative in female elderly (0.088). With respect to working hours per week in female elderly, there is no effect in all categories. Whether informal care is exogenous or not depends on gender. Male informal care is endogenous, while female informal care is exogenous. This point can be explained by who decides the allocation of informal care share ratio, α. We also discuss this point in the section 8.

- According to Table 7, the effect of informal care on working for pay is negative. We separate the female sample into two groups: females who are or are not working full time at the first interview or have reached age 54. According to Table 7, in the first group, the effect of informal care on working for pay is negative (0.082). In the second

group, the effect of informal care on working for pay is also negative (0.069). The negative effect in females who are not full time workers is stronger than in female people who are full time workers. Informal care is exogenous in both groups.

- We expand the age range in Tables 8 and 9. We check the effect of including more retired elderly. As expected, the effect of informal care on working for pay becomes weaker. The effect is not so much different compared to the age group 50–60. There is no effect of informal care on working for pay in male elderly. The effect of informal care on working for pay is negative in female elderly (0.058). However, the effect is weaker than in the age group 50–60. Additionally, only in full-time working females or those aged 54, the effect of informal care on working for pay is negative (0.079). When we compare Tables 7 and 9, we can discuss the effect of including female retirees more on the "Provide care" coefficient. In the group "Female: Not full time worker at first interview or aged 54," the coefficient is not largely different between Table 7 and Table 9. However, in the group "Female: Full time worker at first interview or aged 54," there is no effect of "Provide care" on labor force participation in Table 9, although there is a negative effect in Table 7 (0.069).

- According to Table 10, we analyze the effect of spending informal care time on labor supply. As per Figure 10, males scarcely spend time on informal care. Thus, we omit the analysis of the effect of male elderlys informal care time spent on labor supply and only analyze female labor supply. As per Table 10, the effect of female elderly's informal care time spending on labor supply is not small. "LTC variables" indicate spending time on informal care more than 0, 5, 10, or 15 hours in each column. Only in the column "$\geq 15h$," informal care is endogenous. However, also in the columns "$\geq 5h$" and "$\geq 10h$," the p-values of informal care are small. According to these results, the effect of spending more than 15 hours per week on informal care on labor supply is not small (0.412).

Table 6: Labor Force Participation and Working Hour (Respondent Age:50-60, Only Couple)

	(1)		(2)		(3)		(4)	
			Working hours per week					
Dep.	Not working		$\geq$ 5h		$\geq$ 10h		$\geq$ 20h	
	FE	FE-IV	FE	FE-IV	FE	FE-IV	FE	FE-IV
Male								
1st stage								
$Capa \times 1\{NCL \geq C3\}$		-0.130**		-0.136***		-0.136***		-0.136***
		(0.051)		(0.048)		(0.048)		(0.048)
PA ($Parent's\ age \times 1\{NCL \geq S1\}$)		0.003**		0.003**		0.003**		0.003**
		(0.001)		(0.001)		(0.001)		(0.001)
N of certified ($Care$) =1		0.180		0.227*		0.227*		0.227*
		(0.118)		(0.121)		(0.121)		(0.121)
N of certified ($Care$) $\geq$2		0.406**		0.451**		0.451**		0.451**
		(0.192)		(0.189)		(0.189)		(0.189)
Certified ($\geq C2$) female parent		-0.122		-0.190*		-0.190*		-0.190*
		(0.104)		(0.100)		(0.100)		(0.100)
2nd stage								
Provide care	-0.004	-0.090	0.001	0.084	-0.006	0.037	-0.021	0.075
	(0.018)	(0.060)	(0.019)	(0.063)	(0.022)	(0.031)	(0.013)	(0.049)
Observations	983	983	883	883	883	883	883	883
OverID p-value		0.754		0.776		0.573		0.311
DWH p-value		0.066		0.085		0.220		0.042
Female								
1st stage								
$Capa \times 1\{NCL \geq C3\}$		-0.213***		-0.225***		-0.225***		-0.225***
		(0.045)		(0.046)		(0.046)		(0.046)
PA ($Parent's\ age \times 1\{NCL \geq S1\}$)		0.006***		0.006***		0.006***		0.006***
		(0.001)		(0.001)		(0.001)		(0.001)
N of certified ($Care$) =1		0.057		0.112		0.112		0.112
		(0.099)		(0.100)		(0.100)		(0.100)
N of certified ($Care$) $\geq$2		0.155		0.165		0.165		0.165
		(0.140)		(0.147)		(0.147)		(0.147)
Certified ($\geq C2$) female parent		0.048		0.009		0.009		0.009
		(0.078)		(0.079)		(0.079)		(0.079)
2nd stage								
Provide care	0.088**	0.150**	-0.046	-0.128*	-0.037	-0.104	-0.036	-0.059
	(0.036)	(0.068)	(0.037)	(0.068)	(0.038)	(0.074)	(0.042)	(0.084)
Observations	921	921	839	839	839	839	839	839
OverID p-value		0.983		0.991		0.936		0.637
DWH p-value		0.220		0.129		0.264		0.755

[1] Standard errors in parentheses.
[2] All specification include age, age squared, $Age \geq PEA$(PEA:pension eligibility age), N of children, HH income, house ownership, HH saving(imputed), and year-municipality dummies.
[3] * $p < .1$, ** $p < .05$, *** $p < .01$

Table 7: Labor Force Participation and Working Hour (Respondent Age:50-60 (Only Female), Only Couple)

	(1)		(2)		(3)		(4)	
			Working hours per week					
Dep.	Not working		$\geq$ 5h		$\geq$ 10h		$\geq$ 20h	
	FE	FE-IV	FE	FE-IV	FE	FE-IV	FE	FE-IV
Female:Not full time worker at 1st interview or aged 54								
1st stage								
$Capa \times 1\{NCL \geq C3\}$		-0.221***		-0.254***		-0.254***		-0.254***
		(0.058)		(0.057)		(0.057)		(0.057)
PA ($Parent's\ age \times 1\{NCL \geq S1\}$)		0.005***		0.004***		0.004***		0.004***
		(0.001)		(0.001)		(0.001)		(0.001)
N of certified ($Care$) =1		0.068		0.144		0.144		0.144
		(0.125)		(0.122)		(0.122)		(0.122)
N of certified ($Care$) $\geq$2		0.271		0.342**		0.342**		0.342**
		(0.167)		(0.164)		(0.164)		(0.164)
Certified ($\geq C2$) female parent		0.054		0.032		0.032		0.032
		(0.089)		(0.089)		(0.089)		(0.089)
2nd stage								
Provide care	0.082*	0.169*	-0.021	-0.131	-0.006	-0.105	-0.028	-0.031
	(0.047)	(0.096)	(0.046)	(0.094)	(0.049)	(0.104)	(0.050)	(0.117)
Observations	680	680	632	632	632	632	632	632
OverID p-value		0.505		0.821		0.541		0.410
DWH p-value		0.238		0.148		0.258		0.977
Female:Full time worker at 1st interview or aged 54								
1st stage								
$Capa \times 1\{NCL \geq C3\}$		-0.225***		-0.203***		-0.203***		-0.203***
		(0.062)		(0.064)		(0.064)		(0.064)
PA ($Parent's\ age \times 1\{NCL \geq S1\}$)		0.007***		0.007***		0.007***		0.007***
		(0.001)		(0.001)		(0.001)		(0.001)
N of certified ($Care$) =1		0.106		0.196		0.196		0.196
		(0.168)		(0.171)		(0.171)		(0.171)
N of certified ($Care$) $\geq$2		-0.000		-0.086		-0.086		-0.086
		(0.259)		(0.325)		(0.325)		(0.325)
Certified ($\geq C2$) female parent		0.068		-0.038		-0.038		-0.038
		(0.151)		(0.145)		(0.145)		(0.145)
2nd stage								
Provide care	0.069*	0.070	-0.084	-0.064	-0.094*	-0.062	-0.023	-0.017
	(0.041)	(0.066)	(0.052)	(0.074)	(0.057)	(0.076)	(0.072)	(0.090)
Observations	233	233	203	203	203	203	203	203
OverID p-value		0.501		0.302		0.315		0.154
DWH p-value		0.973		0.648		0.477		0.908

[1] Standard errors in parentheses.

[2] All specification include age, age squared, $Age \geq PEA$(PEA:pension eligibility age), N of children, HH income, house ownership, HH saving(imputed), and year-municipality dummies.

[3] * $p < .1$, ** $p < .05$, *** $p < .01$

[4] In the estimation for the female full-timer, we replace the year-municipality dummies with the year dummies and year-municipality dummies that have enough non-zero values because we cannot compute over-identifying test statistics due to the dummies without enough non-zero values.

Table 8: Labor Force Participation and Working Hour (Respondent Age:50-70, Only Couple)

	(1)		(2)		(3)		(4)	
			Working hours per week					
Dep.	Not working		$\geq$ 5h		$\geq$ 10h		$\geq$ 20h	
	FE	FE-IV	FE	FE-IV	FE	FE-IV	FE	FE-IV
Male								
1st stage								
$Capa \times 1\{NCL \geq C3\}$		-0.088***		-0.076**		-0.076**		-0.076**
		(0.031)		(0.031)		(0.031)		(0.031)
PA ($Parent's\ age \times 1\{NCL \geq S1\}$)		0.002***		0.002***		0.002***		0.002***
		(0.001)		(0.001)		(0.001)		(0.001)
N of certified ($Care$) =1		0.202***		0.204***		0.204***		0.204***
		(0.063)		(0.064)		(0.064)		(0.064)
N of certified ($Care$) $\geq$2		0.334***		0.283***		0.283***		0.283***
		(0.099)		(0.102)		(0.102)		(0.102)
Certified ($\geq C2$) female parent		-0.063		-0.088		-0.088		-0.088
		(0.063)		(0.064)		(0.064)		(0.064)
2nd stage								
Provide care	-0.005	-0.073	-0.012	0.089	-0.021	0.079	-0.041	0.144
	(0.025)	(0.072)	(0.026)	(0.083)	(0.028)	(0.088)	(0.028)	(0.101)
Observations	2082	2082	1883	1883	1883	1883	1883	1883
OverID p-value		0.323		0.545		0.289		0.405
DWH p-value		0.318		0.191		0.227		0.058
Female								
1st stage								
$Capa \times 1\{NCL \geq C3\}$		-0.187***		-0.186***		-0.186***		-0.186***
		(0.032)		(0.032)		(0.032)		(0.032)
PA ($Parent's\ age \times 1\{NCL \geq S1\}$)		0.005***		0.005***		0.005***		0.005***
		(0.001)		(0.001)		(0.001)		(0.001)
N of certified ($Care$) =1		0.077		0.106		0.106		0.106
		(0.071)		(0.072)		(0.072)		(0.072)
N of certified ($Care$) $\geq$2		0.183*		0.181*		0.181*		0.181*
		(0.096)		(0.097)		(0.097)		(0.097)
Certified ($\geq C2$) female parent		-0.010		-0.040		-0.040		-0.040
		(0.062)		(0.062)		(0.062)		(0.062)
2nd stage								
Provide care	0.058**	0.036	-0.035	-0.014	-0.024	-0.003	-0.026	-0.039
	(0.027)	(0.059)	(0.027)	(0.061)	(0.029)	(0.068)	(0.030)	(0.071)
Observations	1639	1639	1498	1498	1498	1498	1498	1498
OverID p-value		0.509		0.426		0.554		0.976
DWH p-value		0.664		0.689		0.728		0.837

[1] Standard errors in parentheses.
[2] All specification include age, age squared, $Age \geq PEA$(PEA:pension eligibility age), N of children, HH income, house ownership, HH saving(imputed), and year-municipality dummies.
[3] * $p < .1$, ** $p < .05$, *** $p < .01$

Table 9: Labor Force Participation and Working Hour (Respondent Age:50-70 (Only Female), Only Couple)

	(1)		(2)		(3)		(4)	
			Working hours per week					
Dep.	Not working		$\geq$ 5h		$\geq$ 10h		$\geq$ 20h	
	FE	FE-IV	FE	FE-IV	FE	FE-IV	FE	FE-IV
Female:Not full time worker at 1st interview or aged 54								
1st stage								
$Capa \times 1\{NCL \geq C3\}$		-0.167***		-0.181***		-0.181***		-0.181***
		(0.038)		(0.038)		(0.038)		(0.038)
PA ($Parent's\ age \times 1\{NCL \geq S1\}$)		0.004***		0.004***		0.004***		0.004***
		(0.001)		(0.001)		(0.001)		(0.001)
N of certified ($Care$) =1		0.108		0.149*		0.149*		0.149*
		(0.087)		(0.086)		(0.086)		(0.086)
N of certified ($Care$) $\geq$2		0.289***		0.302***		0.302***		0.302***
		(0.112)		(0.109)		(0.109)		(0.109)
Certified ($\geq C2$) female parent		-0.054		-0.070		-0.070		-0.070
		(0.070)		(0.070)		(0.070)		(0.070)
2nd stage								
Provide care	0.079**	0.096	-0.048	-0.040	-0.023	-0.020	-0.034	-0.069
	(0.032)	(0.081)	(0.030)	(0.085)	(0.034)	(0.094)	(0.034)	(0.096)
Observations	1174	1174	1088	1088	1088	1088	1088	1088
OverID p-value		0.476		0.400		0.286		0.613
DWH p-value		0.813		0.920		0.973		0.704
Female:Full time worker at 1st interview or aged 54								
1st stage								
$Capa \times 1\{NCL \geq C3\}$		-0.217***		-0.179***		-0.179***		-0.179***
		(0.060)		(0.061)		(0.061)		(0.061)
PA ($Parent's\ age \times 1\{NCL \geq S1\}$)		0.006***		0.006***		0.006***		0.006***
		(0.001)		(0.001)		(0.001)		(0.001)
N of certified ($Care$) =1		0.064		0.059		0.059		0.059
		(0.123)		(0.130)		(0.130)		(0.130)
N of certified ($Care$) $\geq$2		-0.005		-0.029		-0.029		-0.029
		(0.171)		(0.185)		(0.185)		(0.185)
Certified ($\geq C2$) female parent		0.060		-0.022		-0.022		-0.022
		(0.138)		(0.130)		(0.130)		(0.130)
2nd stage								
Provide care	0.022	-0.075	-0.008	0.065	-0.027	0.041	-0.002	0.087
	(0.048)	(0.088)	(0.052)	(0.089)	(0.054)	(0.097)	(0.064)	(0.104)
Observations	442	442	401	401	401	401	401	401
OverID p-value		0.306		0.331		0.576		0.081
DWH p-value		0.124		0.209		0.325		0.229

[1] Standard errors in parentheses.

[2] All specification include age, age squared, $Age \geq PEA$(PEA:pension eligibility age), N of children, HH income, house ownership, HH saving(imputed), and year-municipality dummies.

[3] * $p < .1$, ** $p < .05$, *** $p < .01$

Figure 10: The Distribution of Informal Care Time Spending

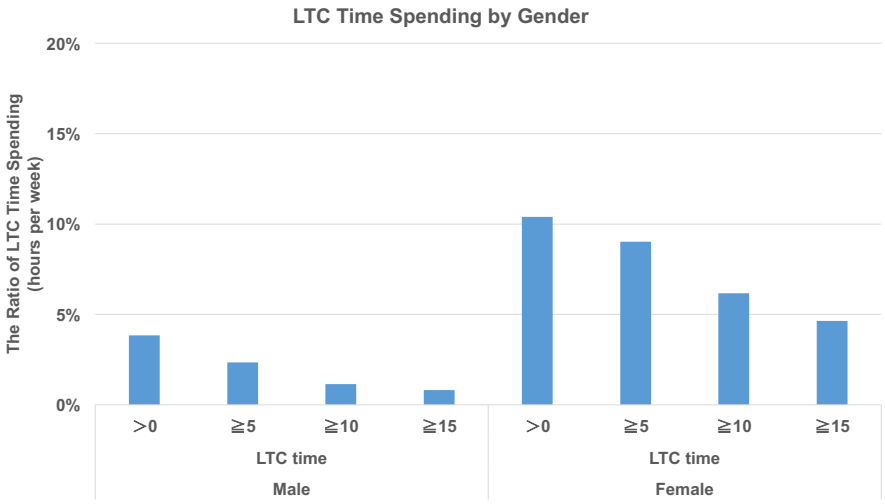


Table 10: Labor Force Participation (Respondent Age:50-60, Only Couple)

Dependent variable: Not working	(1)		(2)		(3)		(4)	
	LTC time (hours per week)							
LTC variables	$>$ 0h		$\geq$ 5h		$\geq$ 10h		$\geq$ 15h	
	FE	FE-IV	FE	FE-IV	FE	FE-IV	FE	FE-IV
Female								
1st stage								
$Capa \times 1\{NCL \geq C3\}$		-0.213***		-0.150***		-0.096***		-0.064**
		(0.045)		(0.043)		(0.035)		(0.031)
PA ($Parent's\ age \times 1\{NCL \geq S1\}$)		0.006***		0.004***		0.003***		0.002***
		(0.001)		(0.001)		(0.001)		(0.001)
N of certified ($Care$) =1		0.057		0.039		-0.084		-0.085
		(0.099)		(0.088)		(0.073)		(0.062)
N of certified ($Care$) $\geq$2		0.155		0.108		-0.087		-0.015
		(0.140)		(0.139)		(0.110)		(0.097)
Certified ($\geq C2$) female parent		0.048		0.065		0.119*		0.092
		(0.078)		(0.069)		(0.071)		(0.057)
2nd stage								
LTC variables	0.088**	0.150**	0.080*	0.216**	0.087	0.333**	0.100	0.412**
	(0.036)	(0.068)	(0.047)	(0.101)	(0.058)	(0.168)	(0.071)	(0.201)
Observations	921	921	871	871	871	871	871	871
OverID p-value		0.983		0.979		0.976		0.995
DWH p-value		0.220		0.151		0.122		0.093

[1] Standard errors in parentheses.
[2] All specification include age, age squared, $Age \geq PEA$(PEA:pension eligibility age), N of children, HH income, house ownership, HH saving(imputed), and year-municipality dummies.
[3] * $p < .1$, ** $p < .05$, *** $p < .01$

7.3 The Difference in the Role of Instrumental Variables between Male Elderly and Female Elderly

Next, we discuss the structural difference in the estimated equations between male elderly and female elderly. Table 11 shows the estimated results, adding a spousal informal care dummy, which indicates whether the spouse helps provide informal care in the first stage. According to Table 11, in the first stage of male "Not working," we can find that there is only a significant effect in the coefficient of "Provide care (SP)." On the other hand, in the first stage of female "Not working," we can find that there are also significant effects in the coefficients of "$Capa \times 1\{NCL \geq C3\}$" and "$PA(Parent'sage \times 1\{NCL \geq S1\})$." According to this result, the instruments "$Capa \times 1\{NCL \geq C3\}$" and "$PA(Parent'sage \times 1\{NCL \geq S1\})$" directly influences female informal care. However, these instruments do not directly influence male informal care, but do so indirectly through the influence of female informal care.

According to this discussion, we suggest the following relationship in the male and female informal care functions. We note A = husband and B = wife. In the informal care function of male household members (A = husband), it is possible that formal care is not included.

$$IC_{it}^{A} = F_{IC^{A}}(y_{it}^{A}, IC_{it}^{B}, \tilde{X}_{it}^{A})$$
$$IC_{it}^{B} = F_{IC^{B}}(y_{it}^{B}, IC_{it}^{A}, FC_{it}, Z_{2it}, \tilde{Z}_{3it}, \tilde{X}_{it}^{B})$$

Table 11: Labor Force Participation and Working Hour (Respondent Age:50-60, Only Couple)

	(1)		(2)		(3)		(4)	
			Working hours per week					
Dep.	Not working		$\geq$ 5h		$\geq$ 10h		$\geq$ 20h	
	FE	FE-IV	FE	FE-IV	FE	FE-IV	FE	FE-IV
Male								
1st stage								
$Capa \times 1\{NCL \geq C3\}$		-0.053		-0.069*		-0.069*		-0.069*
		(0.042)		(0.041)		(0.041)		(0.041)
PA ($Parent's\ age \times 1\{NCL \geq S1\}$)		0.000		0.000		0.000		0.000
		(0.001)		(0.001)		(0.001)		(0.001)
N of certified ($Care$) =1		-0.026		0.036		0.036		0.036
		(0.091)		(0.091)		(0.091)		(0.091)
N of certified ($Care$) $\geq$2		-0.083		-0.026		-0.026		-0.026
		(0.145)		(0.146)		(0.146)		(0.146)
Certified ($\geq C2$) female parent		0.057		0.023		0.023		0.023
		(0.077)		(0.073)		(0.073)		(0.073)
Provide care (SP)		0.673***		0.677***		0.677***		0.677***
		(0.056)		(0.059)		(0.059)		(0.059)
2nd stage								
Provide care	-0.005	0.011	0.003	-0.012	-0.004	-0.004	-0.020	-0.028
	(0.018)	(0.030)	(0.019)	(0.033)	(0.022)	(0.035)	(0.013)	(0.029)
Observations	980	980	879	879	879	879	879	879
OverID p-value		0.357		0.369		0.621		0.269
DWH p-value		0.427		0.514		0.990		0.755
Female								
1st stage								
$Capa \times 1\{NCL \geq C3\}$		-0.132***		-0.138***		-0.138***		-0.138***
		(0.037)		(0.038)		(0.038)		(0.038)
PA ($Parent's\ age \times 1\{NCL \geq S1\}$)		0.004***		0.004***		0.004***		0.004***
		(0.001)		(0.001)		(0.001)		(0.001)
N of certified ($Care$) =1		-0.028		-0.012		-0.012		-0.012
		(0.076)		(0.082)		(0.082)		(0.082)
N of certified ($Care$) $\geq$2		-0.027		-0.074		-0.074		-0.074
		(0.106)		(0.108)		(0.108)		(0.108)
Certified ($\geq C2$) female parent		0.099		0.087		0.087		0.087
		(0.061)		(0.063)		(0.063)		(0.063)
Provide care (SP)		0.603***		0.604***		0.604***		0.604***
		(0.059)		(0.063)		(0.063)		(0.063)
2nd stage								
Provide care	0.088**	0.081	-0.046	-0.043	-0.037	-0.026	-0.036	0.006
	(0.036)	(0.057)	(0.037)	(0.054)	(0.038)	(0.056)	(0.042)	(0.061)
Observations	921	921	839	839	839	839	839	839
OverID p-value		0.541		0.371		0.441		0.604
DWH p-value		0.853		0.941		0.807		0.399

[1] Standard errors in parentheses.
[2] All specification include age, age squared, $Age \geq PEA$(PEA:pension eligibility age), N of children, HH income, house ownership, HH saving(imputed), and year-municipality dummies.
[3] * $p < .1$, ** $p < .05$, *** $p < .01$

7.4 Robustness Check: The Instrumental Variables in the Related Literature

Figure 12 shows the estimated results, including in the first stage, when the variables indicate whether both parents and parents-in-law are alive or not. For example, Bolin et al. (2008) and Van Houtven et al. (2013) use whether parents are alive or not as instrumental variables. We also include these variables in the first stage. Figure 12 shows these results. In all age ranges (50–60, 50–64, 50–70), the estimated results are not significantly different compared to the estimated results without the variables of whether both parents and parents-in-law are alive or not. However, the important point is that the p-value of the over-identification test is low compared to the results without these variables. In the age range 50–64, the analysis of "Not working" indicates the rejection of the null hypothesis in the over-identification test.

Table 12: Labor Force Participation and Working Hour (Additional Instruments: Both parents are alive, Both parents-in-law are alive)

	(1)		(2)		(3)		(4)	
			Working hours per week					
Dep.	Not working		$\geq$ 5h		$\geq$ 10h		$\geq$ 20h	
	FE	FE-IV	FE	FE-IV	FE	FE-IV	FE	FE-IV
Age: 50 to 60								
Male								
Provide care	-0.005	-0.080	0.002	0.084	-0.004	0.040	-0.020	0.050
	(0.018)	(0.052)	(0.019)	(0.058)	(0.022)	(0.034)	(0.013)	(0.048)
Observations	976	976	875	875	875	875	875	875
OverID p-value		0.771		0.784		0.650		0.416
DWH p-value		0.053		0.063		0.233		0.137
Female								
Provide care	0.090**	0.123*	-0.049	-0.097	-0.039	-0.073	-0.038	-0.017
	(0.037)	(0.067)	(0.037)	(0.069)	(0.038)	(0.074)	(0.042)	(0.080)
Observations	918	918	836	836	836	836	836	836
OverID p-value		0.293		0.495		0.280		0.182
DWH p-value		0.493		0.389		0.578		0.764
Age: 50 to 64								
Male								
Provide care	-0.014	-0.035	0.019	0.066	0.013	0.052	0.011	0.094
	(0.021)	(0.047)	(0.022)	(0.050)	(0.022)	(0.067)	(0.027)	(0.084)
Observations	1559	1559	1400	1400	1400	1400	1400	1400
OverID p-value		0.380		0.740		0.736		0.289
DWH p-value		0.624		0.312		0.549		0.296
Female								
Provide care	0.095***	0.032	-0.062**	-0.010	-0.057*	0.003	-0.058*	-0.015
	(0.030)	(0.064)	(0.031)	(0.065)	(0.033)	(0.070)	(0.034)	(0.072)
Observations	1334	1334	1219	1219	1219	1219	1219	1219
OverID p-value		0.098		0.124		0.399		0.660
DWH p-value		0.225		0.338		0.312		0.490
Age: 50 to 70								
Male								
Provide care	-0.005	-0.047	-0.012	0.072	-0.020	0.061	-0.041	0.112
	(0.026)	(0.066)	(0.026)	(0.077)	(0.028)	(0.081)	(0.029)	(0.095)
Observations	2072	2072	1873	1873	1873	1873	1873	1873
OverID p-value		0.445		0.700		0.432		0.289
DWH p-value		0.505		0.241		0.289		0.093
Female								
Provide care	0.067**	0.003	-0.039	0.022	-0.028	0.020	-0.030	-0.007
	(0.027)	(0.060)	(0.028)	(0.061)	(0.030)	(0.067)	(0.031)	(0.068)
Observations	1630	1630	1490	1490	1490	1490	1490	1490
OverID p-value		0.176		0.212		0.383		0.814
DWH p-value		0.211		0.239		0.414		0.700

[1] Standard errors in parentheses.
[2] All specification include age, age squared, $Age \geq PEA$(PEA:pension eligibility age), N of children, HH income, house ownership, HH saving(imputed), and year-municipality dummies.
[3] * $p < .1$, ** $p < .05$, *** $p < .01$

8 Discussion

We will shortly discuss our main results as follows.

- **Why is female informal care exogenous? and why is male informal care endogenous?**

  We interpret the results based on the model in section 6.1. Whether male and female informal care is endogenous or not is influenced by who decides the informal care sharing rate, α. According to the discussion of 6.1, if α is decided by a male household member, female informal care is exogenous for female household member.

- **Why is the effect of informal care on labor supply small?**

  As discussed in section 5, in Japan, the public (home) care service is available when a person who requires nursing care lives in a household. This is most important in explaining our results, as we do not separate the samples into a group utilizing home care and a group not utilizing home care. As we discuss in section 7.2, the effect of spending more than 15 hours per week on informal care on labor supply is not small. Overall, spending time on informal care is small both in male and female elderly. This is because home care services are easily available in Japan.

- **The effect of the government intervention on the supply side of elderly the care market**

  For analyzing the effect of government intervention on the supply side of the elderly care market on informal care in Japan, we check the coefficient of "$Capa \times 1\{NCL \geq C3\}$." This coefficient suggests the effect of increasing the capacity of Tokuyo per capita on providing informal care. As per Table 6, the absolute value of the female coefficient is larger than that of the male coefficient. Additionally, as Table 11 shows, male informal care is indirectly influenced by the capacity of Tokuyo per capita through the female informal care. The effect of the capacity of Tokuyo per capita on providing informal care is strong in female elderly. Overall, the effect of informal care on labor supply is small in Japan. With public home care services also available, the government intervention on the supply side of the elderly care market is effective for labor supply in Japan.

9 Conclusion

This study analyzes the effect of informal care for elderly on labor supply, utilizing the exogenous variation of government intervention on the supply side of the elderly care market in Japan to estimate this effect. As a result, the supply of public nursing care is controlled by the government. We utilize this exogenous variation for estimating the effect of informal care for elderly on labor supply. According to our results, the following points are clarified.

- The effect of informal care for elderly on labor supply in both males and females is small. Especially, when compared with literature, the effect is smaller than in extant studies.

- The time spent on informal care in households is the focus on female household members. The government intervention is effective for increasing female labor supply.

In future work, the heterogeneity of utilizing home care services should be considered. Our analysis does not consider separating the group utilizing home care from the group not utilizing home care. As a result, the effect of informal care on labor supply is small. In fact, in the group not utilizing home care service, it is possible that the effect is very strong.

A Appendix

A.1 Comparison with the Japanese Literature

We summarize the results of Japanese studies in Table 13, [21] comparing the results of this study with the results in the listed studies. In Japan, the studies directly analyzing the effect of informal care on labor supply are Yamada and Shimizutani (2015), Ishii (2015), and Moriwaki (2016). Other studies estimate the effect of LTCI or nursing home capacity on labor supply, but do not directly estimate the effect of informal care on labor supply. According to Yamada and Shimizutani (2015) and Moriwaki (2016), there is a negative effect of informal care on male labor supply. Conversely, we find no effect of informal care on male labor supply by using the exogenous variation of the supply side of the elderly care market. Additionally, our estimates with respect to the effect of informal care on female labor supply are small compared to Yamada and Shimizutani (2015) and Ishii (2015). This is because we use the different instruments compared to theses studies.

[21] We omit Wakabayashi and Donato (2005) because it does not consider the endogeneity of informal care.

Table 13: Japanese Literature

	Analysis Method	Instruments	Results	Data
Shimizutani et al (2008)	DID	-	Not Direct Effect	•Survey on Long-term Care Users •Survey on Elderly Medical Care Insurance
Sugawara and Nakamura (2014)	Two part model	-	Not Direct Effect	Comprehensive Survey of Living Conditions
Yamada and Shimizutani (2015)	IV method	Age, Health Status, and Gender of a Parent.	•Negative Effect on Labor Force Participation (-0.202, Male)(-0.581, Female) (The effect of being a maincare-giver on labor supply)	Comprehensive Survey of Living Conditions
Fukahori et al (2015)	DID	-	Not Direct Effect	Comprehensive Survey of Living Conditions
Ishii (2015)	IV method	Age of Eldest Parent	•Exogeneity of Daily Care •Negative Effect on Female Labor Participation (-0.134 (Coresident, OLS))	JSTAR (only female)
Moriwaki (2016)	FEIV method	Care Level	•Negative Effect on Male Labor Force Participation (-0.545)	JSTAR
Kondo (2016)	OLS	-	Not Direct Effect	•Labour Force Survey •Employment Status Survey

A.2 Asset Level Imputation

Here, we explain saving variable imputation procedures. First, we show the structure of the JSTAR questionnaire with respect to the saving variable and explain reasons why some saving values are missing. Then, we explain the imputation procedures, which are the simplified version of the HRS method. [22] Finally, we compare the imputed saving values with the original saving values and the harmonized JSTAR imputation values.

A.2.1 Questionnaire structure of saving variable

The JSTAR has two types of interviews. One is the leave-behind (LB) questionnaire interview and the other is a computer-assisted personal interviewing (CAPI). Basically, respondents are required to answer the LB questionnaire first and the CAPI afterwards. The questions about saving are asked in both questionnaires. Figure 11 shows the structure of questions with respect to saving values. [23]

First, in the LB questionnaire, respondents are asked to answer questions on the ownership and saving value for a respondent and his/her spouse. The procedure is as follows:

1. A respondent indicates the ownership of their saving. (Q32)
2. If answering "yes" in Q32, respondents indicate the value of their own saving. (Q32-1)
3. If a respondent manages his/her assets together with their spouse (Q31) [24], they move to questions about his/her spouse's saving information.
4. A respondent identifies the ownership of his/her spouse's saving. (Q35)
5. If answering "yes" in Q35, a respondent indicates the value of his/her spouse's saving. (Q35-1)

If not answering the saving information in the LB questionnaire, a respondent is asked to indicate household level saving in the CAPI. The procedure of the CAPI questions is as follows:

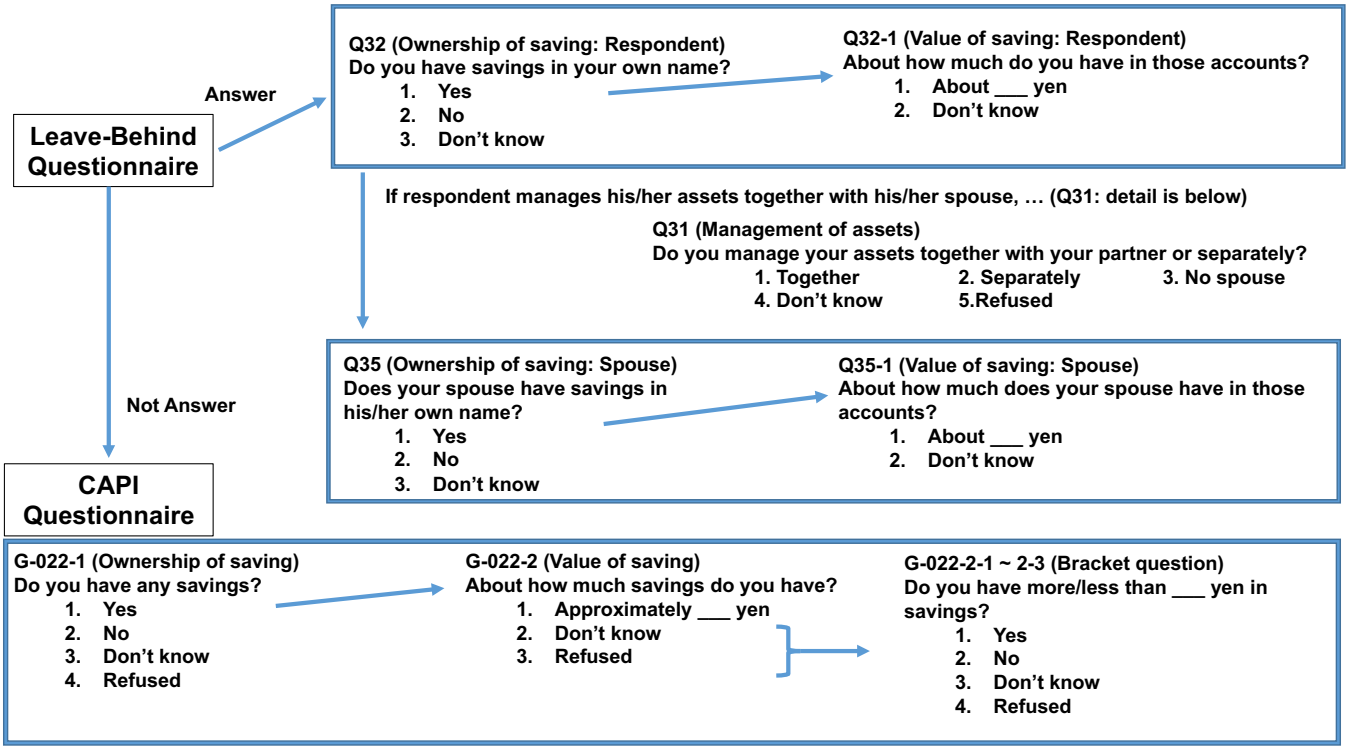
1. A respondent indicates the ownership of saving. (G-022-1)
2. If answering "yes" in G-022-1, a respondent identifies the value of saving. (G-022-2)
3. If the saving value is not answered in G-022-2, a respondent is asked to answer the saving value as the brackets three times. (G-022-2-1 $\sim$ G-022-2-3)

[22] See Hurd et al. (2016) for details of HRS method.

[23] Figure 11 shows the structure of 2007 JSTAR.

[24] Question Q31 states "Do you manage your assets together with your spouse (or common-law spouse) or separately?" and the answer choices are "1. together"; "2. separately"; "3. no spouse"; "4. don't know"; and "5. refused."

Figure 11: JSTAR's questionnaire structure of saving variable



As a result, we can obtain either the individual level (respondent and/or spouse) saving variables (ownership and value) or the household level saving variables (ownership and value (or brackets)). Finally, using this information, we can construct the household-level saving values as follows:

Case 1: continuous values;

Case 2: bracket values;

Case 3: only ownership;

Case 4: no information about ownership.

In Cases 2, 3, and 4, saving values are missing and cannot be used for analysis. We impute the saving values in all these cases, although the Harmonized JSTAR provides the imputed saving values only in Cases 2 and 3. [25]

[25] See the codebook of the Harmonized JSTAR at `https://g2aging.org/startfile.php?f=codebooks/Harmonized%20JSTAR%20B.pdf` for more details.

A.2.2 Imputation Procedures

We use the simplified version of the HRS method for the saving values imputation using cross-sectional variations.[22] The outline of imputation procedure is as follows:

Step 0: Constructing the HH level variables.

- Step 0-1: Construct the HH level variables using LB questionnaire information.
- Step 0-2: If there are missing values in variables constructed above, merge those with the variables surveyed in CAPI.

Step 1: Ownership imputation.

- Step 1-1: Estimate the ownership imputation model using a binary logit model.
- Step 1-2: Calculate the predicted probabilities of ownership.
- Step 1-3: Take a draw random variables from the uniform distribution.
- Step 1-4: Assign ownership using the predicted probabilities and random variables.

Step 2: Bracket imputation.

- Step 2-1: Estimate the bracket imputation model using an ordered logit model.
- Step 2-2: Calculate the predicted probabilities in the j-th bracket.
- Step 2-2: Take a draw random variables from the uniform distribution.
- Step 2-2: Assign bracket j using the predicted probabilities and random variables.

Step 3: Value imputation

- Step 3-a: Nearest neighbor method for closed brackets
  - Step 3-a-1: Estimate the linear value imputation model.
  - Step 3-a-2: Calculate the predicted saving values.
  - Step 3-a-3: Define donor groups
  - Step 3-a-4: Assign the imputed values from the donor group.
- Step 3-b: Tobit 25 method for upper open brackets
  - Step 3-b-1: Estimate the tobit value imputation model.
  - Step 3-b-2: Assign the imputed values from the estimated distribution.

In Step 0, we construct the household level variables such as the ownership, values, and bracket values of savings using both LB questionnaire and CAPI information. First, we construct the household level ownership and values of saving using individual level variables surveyed in LB questionnaire. If there are missing values in the variables, we merge those with the household level variables surveyed in CAPI section. Then, we generate the household level

bracket values using CAPI variables.[26] Finally, we obtain three household level variables, the ownership, values, and bracket values of saving and call these as original household level variables.

In Step 1, we impute the ownership of savings using the logit model. First, we regress the original ownership on covariates using logit and obtain the predicted probabilities of saving ownership, p_{it}.[27] Second, we draw a random variable, u_{it}, from the uniform distribution, $U(0,1]$, and assign ownership $(=1)$ if $u_{it} < p_{it}$ and non-ownership $(=0)$ otherwise.

In Step 2, we impute the bracket value of saving using an ordered logit model. We regress the bracket categories on the covariates using an ordered logit model and obatain the predicted probabilities being in the j-th bracket, p_{ijt}. Then, we calculate the cumulative probabilities for each bracket, $P_{ijt} = \sum_{k=1}^{j} p_{ikt}$. Finally, we draw a random variable, v_{it}, from the uniform distribution, $U(0,1]$, and if $P_{i,j-1,t} < v_{it} \leq P_{ijt}$, we assign bracket j.

In Step 3, we impute the saving values using two imputation methods, depending on the bracket values. There are two types of brackets: closed brackets, which have a closed interval, and upper open brackets, which have an open upper interval. [28] In the case of closed brackets, we use the nearest neighbor (NN) method. First, we regress the saving values which are applied the inverse hyperbolic sine transformation on the covariates using linear regression model for all households and obtain the predicted values of saving. Second, for each bracket, we define a donor group from the households who report a value within the bracket of interest. Finally, from the donor group, the reported value that is closest to the predicted value is assigned to the each household who has missing continuous values and original or imputed bracket.

On the other hand, in the case of upper open brackets, we use the tobit 25 method. First, we regress the logged saving values on covariates using the tobit model with a threshold that is the 25th percentile of the saving value distribution. Second, from the estimated distribution, we assign the imputed values for households with upper open brackets conditional on the given bracket.

A.2.3 Imputation Results

Table 14 shows the summary statistics of original and imputed saving values for each wave. The column "original" shows the summary of original saving values, column "imputed values: ours" shows the values imputed by our method, column shows "imputed values: H JSTAR," which is the values imputed by the harmonized JSTAR. The unit of saving values is JPY ten thousand. In all waves, we recover the 1.5 times observations as original values. Figure 12 illustrates the distributions of the values. The blue solid lines indicate the distribution of original values, the red dashed lines that of our imputation values, and the green dashed lines that of the harmonized JSTAR imputation values. The distributions of our imputation variables have roughly similar forms to the distributions of the original values.

[26] Here, for simplicity, we reconstruct the brackets as [0,500), [500,1500), [1500,∞). (unit: JPY 10k)

[27] We use female dummy, age, age squared, education dummies, marital status dummies, number of children, and municipality dummies as covariates.

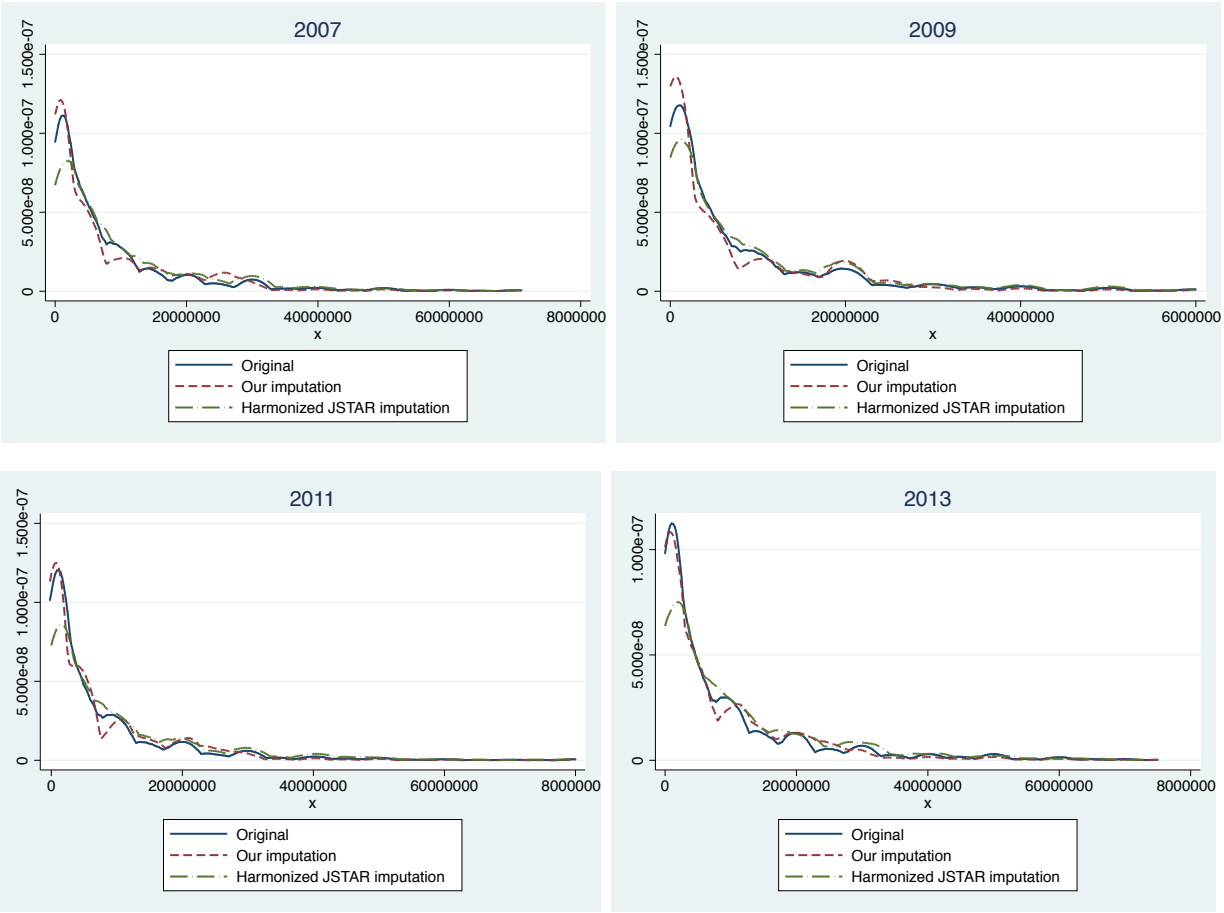
[28] Here, [0,500) and [500,1500) are the closed brackets and [1500,∞) is the upper open bracket.

Table 14: Summary statistics of original and imputed saving values

		Imputed values				Imputed values	
Statistics	**Original**	**Ours**	**H JSTAR**	**Statistics**	**Original**	**Ours**	**H JSTAR**
2007				**2011**			
Observations	2479	4198	3170	Observations	2861	5330	4234
mean	850	783	1060	mean	1200	915	1420
sd	1460	1260	1550	sd	19100	13700	16000
min	0	0	0	min	0	0	0
p10	0	0	0	p10	0	0	0
p25	100	40	150	p25	50	30	100
p50	400	303	500	p50	300	350	500
p75	1000	1040	1400	p75	1000	1020	1400
p90	2100	2300	3000	p90	2000	2030	3000
p95	3000	2800	3700	p95	3000	2600	4000
p99	7000	5390	7500	p99	6500	5000	9000
max	30000	30000	30000	max	1000000	1000000	1000000
2009				**2013**			
Observations	2574	4555	3369	Observations	2495	4370	3143
mean	817	700	994	mean	994	849	1170
sd	1580	1300	1670	sd	2230	1760	1790
min	0	0	0	min	0	0	0
p10	0	0	0	p10	0	0	0
p25	44	10	100	p25	100	23	100
p50	300	200	500	p50	400	400	600
p75	1000	1000	1300	p75	1010	1100	1500
p90	2000	2000	2500	p90	2500	2200	3000
p95	3150	2500	4000	p95	4000	2840	4000
p99	6000	5000	6200	p99	7500	6000	8000
max	40000	40000	40000	max	50000	50000	27000

[1] Unit: 10k yen

Figure 12: Distributions of original and imputed saving values



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