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Does Financial Difficulty Damage Cognitive Function?

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Yumi Ishikawa

PhD student, Osaka School of International Public Policy (OSIPP)

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【Abstract】

This study aims to estimate the effect of financial difficulty on cognitive function in a sample of the Japanese elderly population, using a panel dataset which includes randomly selected elderly Japanese citizens aged 60 and over from the National Survey of the Japanese Elderly. It is appropriate dataset to capture the effect on cognitive impairment in the sense that cognitive function can gradually degenerate after retirement in many cases. We estimate the effect of household income on the probability of the onset of cognitive impairment at a following survey point using random-effect probit model. There is a significant negative effect from financial difficulty on cognitive function. When participants' household income drops by 1%, they are 2.2% more likely to develop cognitive impairment. Financial support plays an important role in improving recipients' cognitive function. It should be noted that we found the effect of financial difficulty even in Japan which has a universal health coverage.

Correspondence: y-ishikawa@osipp.osaka-u.ac.jp

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1. Introduction

Cognitive function impairment is one of the leading causes of disability among older people worldwide. It is commonly accompanied by mild neurocognitive disorder or, in the worst case, dementia. In 2015, 45.7 million people, suffered from dementia (Prince et al., 2015). Japan has one of the largest populations of people with dementia (Prince et al., 2013). The Japanese cost of dementia, which consists of medical, social, and informal care costs, was estimated to be about US$ 133 billion in 2015 (Cabinet Office Japan, 2016). The burden of impairment in cognitive function affects patients, their families, and society.

Previous studies report that financial difficulty damages cognitive function (Al Hazzouri et al., 2017; Lynch, Kaplan, & Shema, 1997; Marden, Tchetgen, Kawachi, & Glymour, 2017). Anandi et al. (2013) also find that farmers' cognitive function declines before harvest, when they are in a financially difficult situation. However, Carvalho et al. (2016) provide evidence that there is no difference in cognitive function before and after payday. As indicated above, a growing body of literature focuses on the effect of financial difficulty on cognitive function, however there is still a discrepancy in the results. If there is any relationship between financial difficulty and cognitive function, it has important policy implications. That is, financial support plays an important role not only in improving recipients' financial situations, but also in improving their cognitive function.

In addition, financial difficulty may affect the risk factors for cognitive impairment, which are well-established in past studies. Livingston et al. (2017) demonstrate that mental illness and unhealthy behaviours such as smoking and physical inactivity are risk factors for cognitive impairment. These risk factors may be affected by financial difficulty (Grip, Lindeboom, & Montizaan, 2011; M. G. Marmot, Shipley, & Rose, 1984).

This study aims to estimate the effect of financial difficulty on cognitive function in a sample of the Japanese elderly population. The remainder of this paper is structured as follows: Chapter 2 illustrates the empirical strategies, data, and variables; Chapter 3 presents the results of the analyses; Chapter 4 discusses the reasons for the results; and is followed by conclusions in Chapter 5.

2. Method

2.1 Empirical strategy

To identify the effect of financial difficulty on the probability of the onset of cognitive impairment, we estimate the following model:

$$CI_{it} = \beta_{hhinc} HHINC_{it-1} + \mathbf{X'}_{it-1}\gamma + \varepsilon_{it}$$

$$\varepsilon_{it} = \mu_i + e_{it}$$

CI_{it} is a dummy variable which equals one if the individual suffers from cognitive impairment, $HHINC_{it-1}$ represents household income, X_{it-1} is a vector of other controls, μ_i denotes an unobservable individual heterogeneity, and e_{it} is an error term. i denotes individuals and t denotes the survey year. β_{hhinc} and γ are the parameters to be estimated, where β_{hhinc} is the parameter of interest.

This study uses household income including pension as a proxy for financial situation. By using household income instead of individual income, we partially address potential endogeneity, that is, the possibility that unobservable individual heterogeneity, such as patience, may be associated with both cognitive functioning and individual income. We also address potential reverse causality, that is, the possibility that participants who have poor cognitive function retire early, which then leads to an individual income drop. We show estimation results which use alternative indicators for financial situation and discuss the appropriateness of using income later in Chapter 3.

OLS regressions yield biased estimates when unobservable individual heterogeneity causes autocorrelation. In this study, the equation is estimated using the random-effect probit model considering individual heterogeneity by μ_i. We do not apply the fixed-effect model. This is because this survey asks about household income using multiple-choice questions with several income brackets, treating it as a kind of status, and the fixed-effect model is not suitable for capturing time-invariant effects. To address reverse causality further, we regress cognitive impairment at time t on household income at time t-1.

The role of financial difficulty in determining cognitive function is consistent with the social determinant's hypothesis. The hypothesis assumes that financial difficulty leads to poor health outcomes (Marmot, 2005). Thus, we expect that the smaller the household income, the worse the cognitive function, that is $\beta_{hhinc} < 0$. All statistical analyses are conducted using STATA 15 (StataCorp, 2017).

2.2 Data

This study uses a panel dataset which includes randomly selected elderly Japanese citizens aged 60 and over from the National Survey of the Japanese Elderly. It consists of six waves of surveys conducted in 1987, 1990, 1993, 1996, 1999, and 2002, and contains individual information about household income, cognitive function, socio-demographics, socioeconomic status, health, and health behaviours. The population aged 60 and older was initially selected by two-stage stratified random

sampling in 1987 and followed up in succeeding surveys (Tokyo Metropolitan Institute of Gerontology & University of Michigan, 1993). Additional younger samples were supplemented in 1990, 1996, and 1999 (Tokyo Metropolitan Institute of Gerontology & University of Michigan, 1993). The sample is nationally representative of Japanese citizens aged 60 and over (Tokyo Metropolitan Institute of Gerontology & University of Michigan, 1993) . The data are provided by the Social Science Japan Data Archive, Centre for Social Research and Data Archives, Institute of Social Science, The University of Tokyo. Informed consent is gathered for each survey point and ethical approval is obtained from Tokyo Metropolitan Institute of Gerontology Ethics Committee.

2.3 Measures

Cognitive function

Cognitive function is measured by a memory-related questionnaire. The questionnaire is similar to a short portable mental status questionnaire (SPMSQ), which detects the presence of cognitive impairment and assesses the degree (Pfeiffer, 1975). The questionnaire contains nine questions: (1) 'What is your address?'; (2) 'What are the date, month, and year today?'; (3) 'What day of the week is it?'; (4) 'What was your mother's maiden name?'; (5) 'Who is the current prime minister?'; (6) 'Who was the prime minister before him?'; (7) 'Can you count backwards from 20 by 3's?'; (8) 'What is your date of birth?'; and (9) 'How old are you?'. For each question, a correct answer is allocated one point and an incorrect answer is allocated zero points; these answers form a cognitive function score ranging from 0 to 9. We use this score to produce a binary measure of cognitive function. Participants whose cognitive function score is 7 or over are categorised as the base group: 'No cognitive impairment'. Participants whose scores are 6 or less are categorised as 'Cognitively impaired'. This measure is based on SPMSQ criteria: zero to two errors signifying normal cognitive function, three to four errors signifying mild cognitive impairment, five to seven errors signifying moderate cognitive impairment, and eight or more errors signifying severe cognitive impairment (Pfeiffer, 1975). In this study, 'Cognitively impaired' includes mild neurocognitive disorder and dementia. They are both characterised by a decline from a previous level of cognitive function but in dementia, in contrast to mild neurocognitive disorder, the decline affects independence in the person's performance of daily living activities (WHO, 2018).

Table 1 reports statistics Summary on variables used in the analyses. The mean cognitive function score is 8.02 out of 9. The estimated population prevalence of scoring 6 or lower, which is the category of 'Cognitively impaired', is 12%.

TABLE 1 : Statistics Summary

Variables	Mean	Std. Dev.	Min	Max
Cognitive function score	8.02	1.27	0	9
Cognitive impairment	0.12	0.33	0	1
Household income	271.66	146.00	42.43	1000
Household income < bottom 20%	0.29	0.45	0	1
Household income < bottom 40%	0.45	0.50	0	1
Household income < bottom 60%	0.65	0.48	0	1
Household income < bottom 80%	0.82	0.39	0	1
Hospital availability	8.00	2.56	5.20	14.39
Sex	0.57	0.50	0	1
Age	72.09	7.11	60	99
City size	2.27	1.49	0	4
Marital status	0.72	0.97	0	3
Family size	3.35	1.90	1	12
Years of schooling	8.99	2.77	0	17
Employment status	0.28	0.45	0	1

The sample sizes are as follows: 3,288 in 1987, 2780 in 1990, 2441 in 1993, 3436 in 1996, 4969 in1999, and 4337 in 2002.

Financial Situation

This study uses household income as a proxy for financial situation. Specifically, we use equivalent income, which divides household income by the square root of family size (OECD, 2009). In the survey, household income is measured by multiple choice questions with several income brackets. We produce a continuous scale of household income by taking median values of each income bracket.

Hospital availability

This study uses the number of hospitals per 100,000 population in the area[1] where participants live. The data on the number of hospitals by area and survey year is obtained from surveys of medical institutions which are conducted by the Health Statistics Office, Director-General for Statistics and Information Policy, Ministry of Health, Labour and Welfare. The data on population by area and survey year is obtained from a demographic survey conducted by the Ministry of Internal Affairs and Communications.

[1] Hokkaido, Tohoku, Kanto, Hokuriku, Tosan, Tokai, Kansai, Chugoku, Shikoku Kita-Kitakyushu and Minami-Kitakyushu were used as areas.

Socio-demographic indicators

Socio-demographic variables include sex, age, urban scale, marital status, and family size. Urban scale is grouped into five categories: (1) Principal cities, including the twenty-three wards in central Tokyo, Osaka city, Yokohama city, Nagoya city, Kyoto city, Kitakyusyu city, Sapporo city, Kawasaki city, Kobe city, Hiroshima city and Fukuoka city; (2) Cities with a population of 200,000 or higher; (3) Cities with a population of 100,000 or higher; (4) Cities with a population of 100,000 or lower; and (5) Towns / Villages. Marital status was grouped into four categories: (1) married; (2) separated/divorced; (3) widowed; and (4) never married. 'Do not know' answers are originally measured, but they are later excluded from this analysis.

Socio-economic indicators

Socioeconomic variables include employment status and years of schooling. Employment status is originally measured as employed, taking a medical leave of absence, unpaid, unemployed, retired, unable to work due to disability, housework, and other. For this project, employment status was recoded as a binary variable (employed vs not employed) from which other was excluded.

3. Result

Table 2 presents the effect of household income on the probability of the onset of cognitive impairment. Column (1) shows the result of the simple regression only on income. The coefficient of income is -0.412, which is negative and statistically significant. The marginal effect of income is -0.051, which is reported in the last row in each column as $\phi(\mathbf{x}'\boldsymbol{\beta}) \cdot \hat{\beta}_{hhinc}$ where $\hat{\beta}_{hhinc}$ is the obtained estimate on income and ϕ is a density function of bivariate normal distribution. This means that participants are 5.1% more likely to develop cognitive impairment when their income drops by 1%. Column (2) represents the case with other covariates such as the availability of hospitals and socio-demographic indicators. Although the magnitude of the estimate and thus its marginal effect decreases, the effect is still statistically significant at the 1% significance level. Column (3) reports the case including socioeconomic indicators. Although the estimate decreases further in absolute value, the effect is still statistically significant at the 1% significance level. The results indicate that financial difficulty leads to low cognitive function.

TABLE 2: Association between household income and cognitive impairment (Random-effects probit model)

Dependent Variable: A binary indicator that equals one if there are positive screens for cognitive impairment (cognitive function score < 7) and zero otherwise

		(1)	(2)	(3)
VARIABLES	***CATEGORIES***			
ln household income		-0.412***	-0.372***	-0.188***
		(0.060)	(0.067)	(0.068)
Hospital availability			0.012	0.009
			(0.014)	(0.014)
Sex	Male[a]		-	-
	Female		0.059	-0.090
			(0.080)	(0.080)
Age			0.064***	0.054***
			(0.006)	(0.006)
City size	Principal cities[a※]		-	-
	Cities >= 200,000		-0.066	-0.054
			(0.116)	(0.113)
	Cities >= 100,000		-0.120	-0.117
			(0.136)	(0.134)
	Cities < 100,000		-0.019	-0.063
			(0.117)	(0.113)
	Towns / Villages		0.086	0.035
			(0.111)	(0.108)
Marital status	Married[a]		-	-
	Separated / Divorced		0.433**	0.405**
			(0.210)	(0.205)
	Widowed		0.220**	0.161*
			(0.089)	(0.087)
	Never married		-0.100	-0.109
			(0.296)	(0.291)
Family size			0.005	-0.015
			(0.021)	(0.020)
Years of schooling				-0.128***
				(0.015)
Employment status	Not employed[a]			-
	Employed			-0.218***
				(0.078)
Constant		0.495	-4.486***	-3.295***
		(0.325)	(0.604)	(0.583)
MARGINAL EFFECTS				
ln household income		-0.051	-0.043	-0.022
Observations		5,973	5,952	5,883
Number of id		2,976	2,969	2,918
Log likelihood		-1,719.394	-1,611.763	-1,543.680
Wald Statistic		46.81***	172.73***	212.33***

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[a] base category

※Principal cities: the twenty-three wards in central Tokyo, Osaka city, Yokohama city, Nagoya city, Kyoto city, Kitakyusyu city, Sapporo city, Kawasaki city, Kobe city,

As for other explanatory variables, age, marital status, years of schooling, and employment status have statistically significant effects at least at the 10% significance level. Older participants are more likely to develop cognitive impairment. Compared with married participants, separated/divorced or widowed participants are more likely to develop cognitive impairment. Highly educated participants and employed participants are less likely to develop cognitive impairment.

To verify our finding, we conduct three sets of robustness checks. First, we use alternative indicators of financial situation to check whether the finding is sensitive to our choice of income. Although income including pension should be strongly related to financial situation for the elderly people, income may be insufficient to capture their financial situation. It is often said that consumption is a better indicator of an individual's welfare reflecting his/her life-time conventional financial situation. Because our survey asks questions about monthly living expenses, we use this instead of income. The result shows that the negative effect of consumption on the cognitive impairment rate remains statistically significant at the 5% significance level, although information on consumption is available only in 1999 and 2002 and the number of the sample is decreased. Thus, we can say that the definition of financial situation does not affect the result.

Second, we use a different functional form of income without taking its logarithm. The result shows that the negative effect of income remains statistically significant at the 1% significance level. We also investigate at what level of income we can still observe its negative effect. We regress the onset of cognitive impairment on four income dummy variables separately. The coefficient of the bottom 20% income dummy, the bottom 40% income dummy, and the bottom 60% income dummy are statistically significant. The only exception is the bottom 80% income dummy, where the coefficient is statistically insignificant. That is, at most income levels, except for the top 20% of income distribution, financial situation has a negative effect on cognitive function.

Finally, we assess the sensitivity of the measure of cognitive function. In our analyses, we use the 6-point cut-off of memory score to produce a binary measure of cognitive impairment. Although we replace this cut-off with the 5-point and the 7-point cut-offs, the income effect remained statistically significant at the 5% significance level. Moreover, we attempted changing the definition of cognitive impairment. In our survey, the memory-related questionnaire includes two questions about the names of the past prime ministers. There is a possibility that these answers reflect the participants' interest in politics, instead of cognitive ability. Participants who are apathetic about politics may fail to answer these questions correctly, which does not necessarily mean that they are cognitively impaired. Therefore, we re-estimate the income effect with the cognitive function measured by seven questions excluding those two. The income effect remains statistically significant at the 5% significance level.

Thus, the level and the definition of cognitive impairment do not alter our obtained results.

4. Discussion: the link between financial difficulty and cognitive function

In the previous section, we find that financial difficulty has a negative effect on cognitive function, and this effect is observed at most income levels. Why do the financially needy have lower cognitive function? There are three possible pathways from financial difficulty to cognitive function.

First, financial stress could damage an individual's cognitive function. To see whether this is a possibility for our sample, we estimate the effect of income on the depression rate[2] in our sample. Other confounding variables are the same as Column (3) of Table 2. The coefficient of income is negative and statistically significant, meaning that low-income participants are more likely to develop depression. As Grip et al. (2011) suggest, for their Dutch elderly male sample, a reduction in pension may lead to a higher depression rate. Alternatively, as Livingston et al. (2017) demonstrate, depression can be a risk factor for cognitive impairment.

Second, financial resources could prevent cognitive impairment through health behaviour. There is an established association between healthy behaviours and adequate financial resources (Marmot et al. 1984). Table 3 confirms this possibility, showing the estimation result of regressing various health behaviours on income. The first column shows the effect of income on the frequency of physical activity. The coefficient of income is positive and statistically significant, meaning that high-income participants spend more time in physical activity. The second column represents the income effect on smoking. The coefficient of income is negative and statistically significant, indicating that high-income participants are less likely to smoke. These results are in line with the findings from Marmot et al. (1984). Livingston et al. (2017) also demonstrate that physical activity is important for preventing cognitive impairment, whereas smoking is a risk factor for cognitive impairment. Furthermore, we examine the income effect on frequency of medical check-ups and report the results in the third column. The coefficient of income is positive and statistically significant, meaning that high-income participants take more frequent medical check-ups, although information on medical check-ups is available only in 1990 and the number of the sample is decreased. Thus, financial resources can affect these healthy behaviours, and accordingly improve cognitive function.

[2] In our analysis, depression is a binary indicator that equals one if there are positive screens for depression which are measured using the CES-D.

TABLE3: Association between household income and health behaviours

	Random-effects probit model		OLS
DEPENDENT VARIABLES	Physical Activity[a]	Smoking[b]	Medical Check-up[c]
VARIABLES			
ln household income	0.187***	-0.229**	0.281***
	(0.040)	(0.096)	(0.133)
Hospital availability	YES	YES	YES
Socio-demographics indicators	YES	YES	YES
Socio-economic indicators	YES	YES	YES
MARGINAL EFFECTS			
ln household income	0.049	-0.016	0.281
Observations	9,111	9,126	1,333
Number of id	3,808	3,810	
Log likelihood	-5316.077	-2911.97	
Wald Statistic	163.93***	708.16***	
R-squared			0.0201

*** p<0.01, ** p<0.05, * p<0.1

a: equals one if high-physical activity and zero otherwise

b: equals one if smoking and zero otherwise

c: the number of medical check-ups during the past year

Finally, financial resources could mitigate cognitive decline through treatment even after cognitive function starts to decline. Although Japan has a national health insurance program, there are some out-of-pocket medical expenses, which are generally 10%-30% of the insured treatment cost. In addition to the out-of-pocket fee, patients need to pay travel costs to access treatment. Thus, participants with adequate financial resources seem more likely to access medical care which then makes it easy for them to mitigate cognitive decline. Furthermore, the gap in access to out-of-pocket treatment, which is not covered by a national health insurance program, seems to be larger. Eisenberg et al. (1993) indicate that individuals with adequate financial resources are more likely to use unconventional therapy in the US population sample. Although we are not able to examine this pathway because of data limitations, it could be argued that financial resources affect cognitive impairment through improving access to medical care and broadening treatment options.

5. Conclusion

This study assessed the effect of financial difficulty on cognitive function in a sample of the Japanese elderly population. The results suggest that financial difficulty impedes cognitive function, even after controlling for other confounding variables such as hospital availability, socio-demographic, and socioeconomic indicators. Income support may play an important role not only in improving recipients' financial situations but also in improving their cognitive function.

This study used longitudinal data on the elderly population in Japan from 1987 to 2002, to capture the determinants of changes in cognitive impairment. Our panel data targeting the elderly population is appropriate because cognitive function can gradually degenerate after retirement in many cases. It is also appropriate because Japan has an interesting social, economic, and medical environment for the elderly population. There is a mandatory retirement age of sixty-five years old: many people retire as they turn 65. After that age, most people are covered by universal health coverage and pension. It should be noted that we found the effect of financial difficulty on cognitive function even in Japan which has a national health insurance program. This suggests that in countries without universal health coverage, financial difficulty may have a stronger effect on cognitive function.

Future research is needed to clarify the role of medical interventions in cognitive impairment. Although we controlled for the number of hospitals by area in our study, the individual usage of medical care and its quality cannot be examined because of lack of information. Future research can be extended to understanding the role of the quantity and quality of healthcare availability in the relationship between financial difficulty and cognitive function.

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