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Effects of National Health Insurance on precautionary saving: new evidence from Taiwan

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Abstract In this article, we evaluate the crowd-out effects of the National Health Insurance (NHI) on household precautionary saving in Taiwan. Our analysis differs from existing studies in two respects. First, we do not exclude the households with negative saving that are about 18.9% of the entire sample. Second, we conduct a more complete treatment effect analysis. We estimate both average treatment effect (ATE) and quantile treatment effect (QTE) using the difference-in-differences method. We also partition some covariates (household income and the age of household head) into different groups and estimate the group-wise ATEs and QTEs. While supporting the existing finding that the NHI has negative impact on households saving, our empirical result shows that the QTEs are heterogeneous across saving quantiles, such that higher savers tend to have greater reduction in saving after the NHI is enforced. It is also found that the NHI has greater impact on the households with higher income and those with retiring heads, especially on high savers in these groups.

Keywords Average treatment effect · Difference-in-differences · National Health Insurance · Precautionary saving · Quantile treatment effect

JEL Classification D12 · I18 · I38

1 Introduction

Medical expense is one of the major idiosyncratic risks facing households over their life cycles. Threat of catastrophic medical expenditures forces households to save

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more and consume less. In theory, social safety net ought to reduce precautionary saving because of lower risk of uncertain medical expenditure; see, e.g., Hubbard et al. (1994a,b, 1995), and Kotlikoff (1979). Nevertheless, the existing empirical studies do not reach a consensus on the effects of welfare program on saving, let alone the signs and magnitudes of the displacement rates; see, e.g., Gruber and Yelowitz (1999), Chou et al. (2003, 2004), and Guariglia and Rossi (2004). Such ambiguity arises partly due to the selectivity of welfare program participation (e.g., Diamond and Hausman 1984; Hubbard et al. 1995) and endogeneity of welfare benefits (e.g., Hurst and Lusardi 2004; Attanasio and Brugiavini 2003). Quantifying the effects of a welfare program on saving is thus not as easy as one would like.

In this article, we evaluate the crowd-out effects of a welfare program on household precautionary saving based on the micro-data related to a unique experiment in Taiwan. The high saving rate of Taiwanese households in the 1980s and early 1990s was documented in the literature (e.g., Deaton and Paxson 1994), but it started declining from the mid-1990s. This decline roughly coincides with the enforcement of the National Health Insurance (NHI) in 1995. Prior to 1995, more than half of population in Taiwan was covered by three major insurance programs provided by the government. As a universal health plan, the NHI extends the coverage of these insurance plans to almost every one in Taiwan, without discrimination on program participation and benefits coverage. This natural experiment offers an excellent opportunity to evaluate to what extent the NHI crowds out precautionary saving. Chou et al. (2003, 2004) are two pioneer studies on this interesting topic, and they find that, among other things, the NHI significantly reduces the average saving in Taiwan.

Our analysis differs from Chou et al. (2003, 2004) in two important respects. First, we do not exclude the households with negative saving. Note that there is a large proportion (about 18.9%) of households that consume more than have earned. Such proportion increases from about 11.8% during 1990–1994 to 27.2% during 1996–2000; a detailed analysis of their distribution will be given in Sect. 4. Excluding these households, as done in Chou et al. (2003, 2004), would result in a serious sample selection problem and hence misleading inferences. To admit the households with negative saving, we, similar to Deaton and Paxson (1994), take saving rate as the target variable, which is approximated by the difference between the logarithm of income and the logarithm of consumption. Second, we conduct a more complete treatment effect analysis of saving rate. We estimate both average treatment effect (ATE) and quantile treatment effect (QTE) via the difference-in-differences (DID) approach and examine if the QTEs are heterogeneous across saving quantiles.[1] We also partition some important covariates (household income and the age of household head) into different groups and estimate the group-wise ATEs and QTEs. This allows us to evaluate how the ATEs and QTEs vary with different income groups and life cycle stages (age groups).

Our empirical results are very informative. While supporting the evidence that the NHI has a considerable, negative impact on households saving, we find that this crowd-out effect is not homogeneous but in fact increasing (in absolute term) with

[1] The studies of Chou et al. (2003, 2004) focus on ATE. Although Chou et al. (2003) also reported some supplementary estimates of QTE, they did not analyze these estimates in detail.

saving quantile. As such, higher savers tend to have greater reduction in saving after the NHI is enforced. This conclusion is opposite to that of Chou et al. (2003). It is also found that this difference is mainly due to the exclusion of households with negative saving. Our result further indicates that the NHI has greater impact on the saving of the households with higher income. Moreover, the NHI greatly affects the households with retiring heads (aged 60–69). This suggests that the elderly endure higher threat from health care cost uncertainty than the younger counterparts, cf. Chou et al. (2004).

The remainder of this article is as follows. Section 2 provides a brief discussion of the econometric methods for estimating ATE and QTE. Section 3 describes the NHI in Taiwan and the data used in this study. The specifications of the empirical models are presented in Sect. 4. The empirical results are reported in Sect. 5. Section 6 concludes the article.

2 Econometric methods

Given a treatment (policy or program), let D be the binary treatment indicator such that $D = 1$ for treatment group and $D = 0$ for control group. We observe either the response S_1 when $D = 1$ or the response S_0 when $D = 0$. Thus, the observed variable can be expressed as $S = DS_1 + (1 - D)S_0$. Let F_1 and F_0 denote the distributions of treatment response (S given $D = 1$) and control responses (S given $D = 0$), respectively, with their respective means $\mathbb{E}(S \mid D = 1)$ and $\mathbb{E}(S \mid D = 0)$. The ATE is defined as the difference between these means. Program (policy) evaluations are usually based on ATE only.

Instead of measuring ATE, one may also evaluate the treatment effect between F_1 and F_0 across quantiles, also known as (unconditional) QTE. Define $\delta(s)$ as the "horizontal distance" between F_1 and F_0 at s such that

$$F_0(s) = F_1(s + \delta(s)).$$

Thus, $\delta(s) = F_1^{-1}(F_0(s)) - s$. Letting $\theta = F_0(s)$, we have $s = F_0^{-1}(\theta)$ the θth quantile of F_0, so that

$$\delta(s) = F_1^{-1}(\theta) - F_0^{-1}(\theta).$$

This is the difference between the θth quantiles of F_1 and F_0 and hence a QTE. If F_1 and F_0 differ only in their locations, $\delta(s)$ would be a constant, and QTEs are homogeneous across quantiles. In this case, it suffices to find an ATE. On the other hand, an ATE may not be representative when QTEs vary considerably with quantiles.

In some applications, a response variable may also be affected by some unobserved factors of different groups. Thus, $\mathbb{E}(S \mid D = 1) - \mathbb{E}(S \mid D = 0)$ and $F_1^{-1}(\theta) - F_0^{-1}(\theta)$ involve not only the treatment effect of the program but also the effect of those unobserved factors. Nevertheless, it is still possible to identify treatment effects when the data for control and treatment groups are available in different periods.

To see this, let Λ denote the time indicator such that $\Lambda = 1$ if the subject is in t_1, the period after the introduction of a social program, and $\Lambda = 0$ if the subject is in t_0, the period before the program. Allowing the distribution of the response variable change over time, we have two distributions $F_{0,0}$ and $F_{0,1}$ for the control group before and after the program, with respective means $\mathbb{E}(S \mid D = 0, \Lambda = 0)$ and $\mathbb{E}(S \mid D = 0, \Lambda = 1)$. There are also two distributions $F_{1,0}$ and $F_{1,1}$ for the treatment group, with respective means $\mathbb{E}(S \mid D = 1, \Lambda = 0)$ and $\mathbb{E}(S \mid D = 1, \Lambda = 1)$. Then, the effect of unobserved factors on the control group may be eliminated by taking time difference of two within-group means: $\mathbb{E}(S \mid D = 0, \Lambda = 1) - \mathbb{E}(S \mid D = 0, \Lambda = 0)$; what remains is time effect (or trend). Similarly, one can remove the effect of unobserved factors on the treatment group by $\mathbb{E}(S \mid D = 1, \Lambda = 1) - \mathbb{E}(S \mid D = 1, \Lambda = 0)$, which now includes both time effect and program effect. Consequently, ATE is readily identified using the DID measure:

$$\begin{aligned}\big[\mathbb{E}(S \mid D = 1, \Lambda = 1) - \mathbb{E}(S \mid D = 1, \Lambda = 0)\big] \\ - \big[\mathbb{E}(S \mid D = 0, \Lambda = 1) - \mathbb{E}(S \mid D = 0, \Lambda = 0)\big].\end{aligned}$$

Similarly, for a given $0 < \theta < 1$,

$$[F_{1,1}^{-1}(\theta) - F_{1,0}^{-1}(\theta)] - [F_{0,1}^{-1}(\theta) - F_{0,0}^{-1}(\theta)]$$

is understood as the DID measure of the θth QTE.

The ideas of ATE and QTE discussed above carry over to the distributions conditional on some covariates X. Suppose we have the following data generating process (DGP) for the response variable S:

$$S_i = \alpha + X_i'\beta + D_i\gamma + e_i, \quad i = 1, \ldots, N, \tag{1}$$

where D is still the indicator of the treatment or control group, X is a vector of covariates, e is an error term, and α, β, and γ are unknown parameters. Here, $\alpha + X'\beta + D\gamma$ is the conditional mean $\mathbb{E}(S|D, X)$ under the condition that $\mathbb{E}(e|D, X) = 0$. The ATE conditional on D and X is thus the difference between the conditional means of the treatment and control groups:

$$\mathbb{E}(S \mid D = 1, X) - \mathbb{E}(S \mid D = 0, X) = (\alpha + X'\beta + \gamma) - (\alpha + X'\beta) = \gamma.$$

Provided that D and X are not endogenous, estimating (1) by the OLS method results in a consistent estimate of the conditional ATE γ.

Similarly, we can express the DGP of S as

$$S_i = \alpha(\theta) + X_i'\beta(\theta) + D_i\gamma(\theta) + e_{i,\theta}, \quad i = 1, \ldots, N, \tag{2}$$

where $\alpha(\theta) + X_i'\beta(\theta) + D_i\gamma(\theta)$ is $Q_{S|D,X}(\theta)$, the θth conditional quantile function of S, and the error term e_θ is such that $Q_{e_\theta|D,X}(\theta) = 0$. Note that the intercept and slope parameters may vary with quantiles. As such, the conditional QTE at θ is the difference of two θth conditional quantiles:

$$Q_{S|D=1,X}(\theta) - Q_{S|D=0,X}(\theta) = [\alpha(\theta) + X'\beta(\theta) + \gamma(\theta)] - [\alpha(\theta) + X'\beta(\theta)] = \gamma(\theta).$$

Estimating (2) by the quantile regression method of Koenker and Bassett (1978) results in a consistent estimate of the conditional QTE $\gamma(\theta)$, when D and X are not endogenous. For a thorough discussion of quantile regression we refer to Koenker (2005).

When some unobserved group effect, ν, is present in (1), it is easy to see that γ is no longer the desired ATE. Consider the following DGP that admits the group effect ν, an additively separable time effect characterized by the time indicator Λ for period t_1 or t_0, and the interaction between Λ and D:

$$S_i = \alpha + \nu_i + X_i'\beta + D_i\gamma + \Lambda_i\delta + (D_i\Lambda_i)\zeta + e_i, \quad i = 1, \ldots, N, \tag{3}$$

where $\mathbb{E}(e \mid D, \Lambda, X) = 0$. Provided that ν is time invariant, the time difference of the conditional means of the treatment group is:

$$\begin{aligned}
&\mathbb{E}(S \mid D = 1, \Lambda = 1, X) - \mathbb{E}(S \mid D = 1, \Lambda = 0, X)\\
&= \left[\alpha + \mathbb{E}(\nu \mid D = 1, \Lambda = 1, X) + X'\beta + \gamma + \delta + \zeta\right]\\
&\quad -\left[\alpha + \mathbb{E}(\nu \mid D = 1, \Lambda = 0, X) + X'\beta + \gamma\right]\\
&= \delta + \zeta.
\end{aligned}$$

Similarly, the time difference of the conditional means of the control group is:

$$\mathbb{E}(S \mid D = 0, \Lambda = 1, X) - \mathbb{E}(S \mid D = 0, \Lambda = 0, X) = \delta,$$

The difference of these two time differences, ζ, is the desired conditional ATE. Thus, the OLS estimate of ζ in (3) is the DID estimate of the conditional ATE, and it is consistent when D, Λ, and X are not endogenous.

Analogous to (2), we can also express S in terms of the conditional quantile function:

$$S_i = \alpha(\theta) + \nu_i(\theta) + X_i'\beta(\theta) + D_i\gamma(\theta) + \Lambda_i\delta(\theta) + (D_i\Lambda_i)\zeta(\theta) + e_{i,\theta}, \quad i = 1, \ldots, N, \tag{4}$$

where $Q_{S|D,\Lambda,X}(\theta) = \alpha(\theta) + \nu_i(\theta) + X_i'\beta(\theta) + D_i\gamma(\theta) + \Lambda_i\delta(\theta) + (D_i\Lambda_i)\zeta(\theta)$ and $Q_{e_\theta|D,\Lambda,X}(\theta) = 0$. Then, the time difference of the θth conditional quantiles of the treatment group is:

$$Q_{S|D=1,\Lambda=1,X}(\theta) - Q_{S|D=1,\Lambda=0,X}(\theta) = \delta(\theta) + \zeta(\theta),$$

and the time difference of the θth conditional quantiles of the control group is:

$$Q_{S|D=0,\Lambda=1,X}(\theta) - Q_{S|D=0,\Lambda=0,X}(\theta) = \delta(\theta).$$

It follows that the quantile regression estimate of $\zeta(\theta)$ in (4) is the DID estimate of the θth conditional QTE. This estimate would be consistent if D, Λ and X are not endogenous.

3 NHI in Taiwan and empirical data

3.1 NHI in Taiwan

The NHI in Taiwan was expanded from three major health insurance programs provided by the government: Labor Insurance, Government Employees' Insurance, and Farmers' Health Insurance launched in 1950, 1958, and 1985, respectively. Labor Insurance covers the employees of compliant business in certain industries in the private sector whose ages are between 15 and 60, but not their spouse, parents, and children. The employees (including retirees) in the public sector are protected by Government Employees' Insurance; the coverage of this program gradually extended to spouses in 1982, to parents in 1989, and to children in 1992.[2] Farmers' Health Insurance covers agricultural and fishery workers and extends to their household members in 1989. Aside from the coverage, the general provisions of these program are similar. On the other hand, there was virtually no private health insurance program in Taiwan, except some supplementary insurance for certain chronic diseases.

By 1994, 57% of total population was covered by the existing insurance programs; the remaining 43% of the uninsured population includes mainly those who are under age, students, the elderly, and non-working adults in the households whose heads are not in the public sector (Cheng and Chiang 1997). The coverage rate of the NHI soon boosts to 89.5% by the end of 1995 and reaches 97.8% in 2000.[3] In 1994, around 85% of hospitals and 70% of clinics were contracted with those insurance programs. After 1995, the Bureau of NHI (BNHI) becomes the monopsony of medical care services, and the contracted medical care institutions increase to around 96.5% of total hospitals and 89.5% of total clinics in 1997 (Chou et al. 2003). There are six categories of insurance premium, from 0% (mandatory military service men, veteran, and low income household members), 30% (employees) to 100% (employer and self-employed). Both private and public employers are required to share the premium for their employees from 10 to 70%; see BNHI (2007) for more details.

The NHI benefits are quite generous, covering outpatient visit, inpatient care, and prescription drugs. Almost all diseases (from small to chronical), even the catastrophic injuries and illnesses of the insured occurred outside Taiwan, are all covered by the NHI. For each outpatient visit, the patients pay only a registration fee from NT$50 to NT$150 (approximately US$1.5 to US$4.6) and partial cost for prescription drug. The co-payment of general hospitalization cares ranges from 5 to 30% of the total cost and is free for catastrophic injuries and illness. For more description of the NHI system in Taiwan see Cheng and Chiang (1997), Chou et al. (2003), and Peabody et al. (1995).

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[2] These coverage changes are different from those discussed in Finkelstein (2002). First, these changes are completely determined by government policy and hence exogenous. Second, all changes took place before the enforcement of the NHI. Hence, there is no time trend across the periods before and after treatment.

[3] This is reported in DGBAS (2007), where DGBAS stands for Directorate-General of Budget, Accounting, and Statistics which is the government agency in charge of government accounting and national statistics of Taiwan.

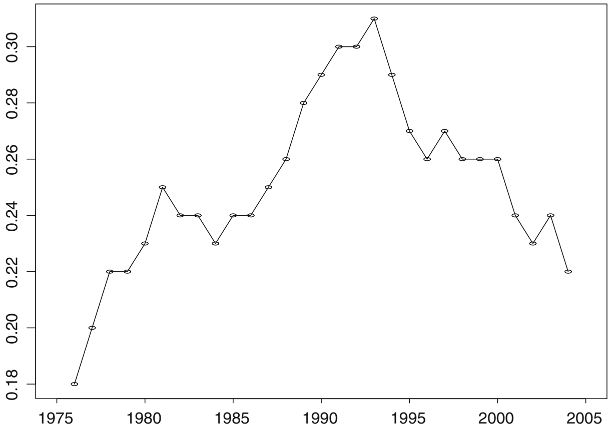

Fig. 1 The household saving rates in Taiwan: 1976–2004

3.2 Data

The data used in this study are taken from the Survey of Family Income and Expenditure (SFIE) conducted annually by the DGBAS. This nation-wide survey contains repeated cross sections, with new sampling every year. The sample size is about 16,000 each year in the early 1990s and drops to about 14,000 from the mid-1990s. The modules in the SFIE include individual socio-demographic and socio-economic characteristics along with income and outlays of each income earner within the household. Standard categorical consumption expenditures of the household are also collected. Unlike most budget surveys that contain limited information about household characteristics, the SFIE provides details on each household member's income sources (including earnings and unearned income) and job attributes that are crucial for identification of treatment/control groups.

We employ ten waves of SFIE from 1990 through 2000 (excluding 1995), with 1990–1994 and 1996–2000 as the periods before and after the enforcement of NHI, respectively. The data of 1995, the year that the NHI is launched, are excluded so as to avoid the mixed effects from two regimes.[4] Our sample includes only the households with non-farm heads aged 20-69 years and consists of 65,623 and 55,500 observations for the periods 1990–1994 and 1996–2000, respectively. The households in the agriculture sector are excluded because they typically have different income stream and hence different saving behavior.

Figure 1 shows the household saving rates in Taiwan from 1976 through 2004. It can be seen that the saving rate increases for most years prior to 1994 and peaks at 0.3 in 1993, and it drops to around 0.25 in 2000 and further down to 0.22 in 2004. Table 1 summarizes some statistics of the saving rates in the full sample and certain sub-samples (see below). While the average household real income increases moder-

[4] Chou et al. (2003, 2004) use only eight waves of SFIE from 1991 through 1998 in their analysis, with 1991–1994 and 1995–1998 as the periods before and after the NHI, respectively. Note that the data in 1995 are included in their analysis.

Table 1 Average saving rates and DID estimates of unconditional ATE

Sample	1990–1994			1996–2000			Difference	DID
	Obs.	Mean	SD	Obs.	Mean	SD		
Full sample	68,738	0.229	0.282	58,355	0.114	0.244	−0.115 (0.001)	
Control	13,589	0.281	0.220	9,520	0.195	0.215	−0.085 (0.003)	
Treatment	55,149	0.216	0.294	48,835	0.098	0.246	−0.118 (0.002)	−0.033 (0.003)
Strict control	2,476	0.341	0.195	1,717	0.263	0.200	−0.078 (0.006)	
Quasi control	11,113	0.267	0.223	7,803	0.180	0.215	−0.087 (0.003)	−0.009 (0.007)
Treatment 1	24,545	0.227	0.228	22,279	0.107	0.220	−0.120 (0.002)	−0.043 (0.007)
Treatment 2	30,600	0.208	0.338	26,556	0.091	0.265	−0.117 (0.003)	−0.041 (0.007)

Note The strict control group is the reference group to the quasi control, treatment 1 and treatment 2 groups. The numbers in the parentheses in the columns under Difference and DID are their respective standard errors

ately from NTD 0.97 million during 1990–1994 to more than NTD 1.2 million during 1996–2000,[5] the corresponding average saving rates decrease by 50%, from 0.229 during 1990–1994 to 0.114 during 1996–2000.

The validity of the DID method depends crucially on the choice of a control group that nets out the impact of all other factors on the trends. As the comprehensive coverage of the NHI is almost identical to that of Government Employees' Insurance, it is natural to take the households in the public sector as the control group. Specifically, we partition the sample according to the working status of household head and his/her spouse:

Control: households with at least one of the head and spouse in the public sector;
Treatment: households with neither head nor spouse in the public sector.

It is conceivable that the precautionary motive of the households in the control group is virtually intact after the enforcement of the NHI. As the households in the treatment group enjoy the benefit of the extended coverage of the NHI, their precautionary saving is likely to be affected. Indeed, from the period of 1990–1994 to 1996–2000, the average saving rate of the control group drops by 8.5%, but there is a larger decline (11.8%) in the treatment group. The estimated unconditional ATE is thus quite significant (−3.3% with a standard error of 0.003); see Table 1 for details.

To examine the robustness of the treatment effect estimates, we also follow Chou et al. (2003) and consider different control and treatment groups:

Strict control: households with both head and spouse in the public sector;
Quasi control: households with only one of the head and spouse in the public sector;
Treatment 1: households with both head and spouse in the private sector;
Treatment 2: households with one of the head and spouse in the private sector and the other unemployed (or out of labor force).

The insurance coverage of the households in the quasi control group is similar to that of the strict control group, except that the government employee's parents in law are

[5] All nominal pecuniary measures are deflated by the CPI with year 2000 as the base year.

not covered before the NHI is enforced. The other treatment sub-groups were only moderately covered prior to the NHI.

Table 1 shows that, in both periods, the average saving rate is the highest for the strict control group and the lowest for the treatment 2 group. With the strict control group as a reference, the quasi control group and two treatment sub-groups exhibit different saving reduction after the NHI is effective. While the DID estimates of the unconditional ATE on the quasi control group is not significant (−0.9% with a standard error of 0.007), the ATEs on the treatment sub-groups are significant and their magnitude is much larger (−4.3 and −4.1%), as shown in Table 1.

4 Empirical models

In this section, we discuss the empirical models in our study. We first note that there is a large proportion of households with negative saving. This proportion was 11.8% in 1990–1994 but jumped to 27.2% in 1996–2000, leading to an average of 18.9% of the entire sample.

To better understand the sub-sample of the households with negative saving, we summarize their distributions in Table 2. We first observe that, in both periods, the proportion of the observations with negative saving is the lowest (second lowest) in the strict (quasi) control group and higher in the treatment groups. We also observe that these proportions are not much different in different employment groups in the first period, but they are higher for employer, self-employed, and blue-collar worker in the second period. As one would expect, these proportions decrease with income quintiles in both periods, so that a higher income group has a lower proportion of observations with negative saving. Moreover, the group with head age 60–69 (40–49) has the highest (second highest) proportion in the first period, whereas the group with head age 40–49 (30–39) has the highest (second highest) proportion in the second period. Note that these proportions are all much higher in the second period than their counterparts in the first period. Overall speaking, the high proportions of the households with negative saving do not appear to exhibit an abnormal pattern, such as clustering in a particular group.

Despite a large sub-sample of the observations of negative saving, Chou et al. (2003, 2004) both take $\ln(Y - C)$, where Y is income and C is consumption, as the dependent variable. This choice is common in empirical studies but must exclude the households with negative saving. Omitting such considerable proportion of the sample causes a serious sample selection problem and may invalidate the resulting statistical inference.[6] To circumvent this problem, we follow Deaton and Paxson (1994) and take $S = \ln Y - \ln C$, which is an approximate saving rate, as the dependent variable. By doing so, we are able to include the entire sample in our analysis.

[6] For instance, after excluding the households with negative saving, the estimated unconditional ATEs are very different from those in Table 1. With the strict control group as a reference, the DID estimates of the unconditional ATE on the quasi control, treatment 1, and treatment 2 group are, respectively, 0.1, −1.1, and 0.0%. Hence, there would be no (unconditional) crowd-out effects for the quasi control and treatment 2 groups in this highly selected sample.

Table 2 The distributions of the observations with negative saving

Sample	1990–1994			1996–2000			Change over time	
	Obs.	Group%	Sample%	Obs.	Group%	Sample%	Group	Sample
Full sample	68,738		11.77	58,355		27.20		15.43
Control	13,589	8.34	1.65	9,520	15.87	2.59	7.53	0.94
Treatment	55,149	12.62	10.12	48,835	29.41	24.61	16.79	14.49
Strict control	2,476	4.60	0.17	1,717	8.39	0.25	3.78	0.08
Quasi control	11,113	9.17	1.48	7,803	17.52	2.34	8.35	0.86
Treatment 1	24,545	10.86	3.88	22,279	27.29	10.42	16.43	6.54
Treatment 2	30,600	14.02	6.24	26,556	31.18	14.19	17.17	7.95
Employer	3,806	11.11	0.62	3,495	28.70	1.72	17.58	1.10
Self-employed	12,604	11.93	2.19	10,530	30.37	5.48	18.44	3.29
Professional	6,724	9.12	0.89	6,079	20.37	2.12	11.25	1.23
Service worker	17,914	11.24	2.93	16,394	23.51	6.60	12.27	3.68
Blue collar	23,193	10.71	3.61	17,403	27.51	8.20	16.80	4.59
Others	4,497	23.42	1.53	4,454	40.19	3.07	16.77	1.54
First income quintile	13,748	20.60	4.12	11,671	39.73	7.95	19.12	3.82
Second income quintile	13,747	14.81	2.96	11,671	37.40	7.48	22.59	4.52
Third income quintile	13,746	11.21	2.24	11,672	28.62	5.72	17.41	3.48
Fourth income quintile	13,748	8.02	1.60	11,670	20.08	4.02	12.07	2.41
Fifth income quintile	13,749	4.41	0.88	11,671	10.60	2.12	6.19	1.24
Head age 20–29	8,690	10.20	1.29	6,115	23.24	2.44	13.04	1.15
Head age 30–39	26,058	11.30	4.28	18,563	28.01	8.91	16.72	4.63
Head age 40–49	18,678	13.01	3.54	19,710	30.52	10.31	17.51	6.77
Head age 50–59	9,432	9.80	1.34	9,001	20.69	3.19	10.89	1.85
Head age 60–69	5,880	15.41	1.32	4,966	27.65	2.35	12.24	1.04

Note Group% (Sample%) is the proportion of the observations with negative saving in a particular group (the entire sample). Service worker is the worker in the service industry; Blue collar denotes the blue-collar worker

Let $t_0 = \{1990, \ldots, 1994\}$ and $t_1 = \{1996, \ldots, 2000\}$ be the periods before and after the NHI is enforced, respectively. In view of (3), we estimate the following saving function

$$S_i = \alpha + X_i'\beta + D_i\gamma + (\mathrm{NHI}_i)\delta + [(\mathrm{NHI}_i) \times D_i]\zeta + e_i, \quad i = 1, \ldots, N, \tag{5}$$

where X_i is the vector of covariates of household i that may affect the saving rate, D_i is a binary indicator such that $D_i = 1$ if household i is in the treatment group and $D_i = 0$ if i is in the control group, NHI_i is a time indicator such that $\mathrm{NHI}_i = 1$ if i is in period t_1 and $\mathrm{NHI}_i = 0$ if i is in period t_0. The OLS estimate of ζ in (5) is the DID estimate of the ATE. By (4), we also estimate the following model by the quantile regression method:

$$S_i = \alpha(\theta) + X_i'\beta(\theta) + D_i\gamma(\theta) + (\mathrm{NHI}_i)\delta(\theta) + [(\mathrm{NHI}_i) \times D_i]\zeta(\theta) + e_{i,\theta},$$
$$i = 1, \ldots, N, \tag{6}$$

and obtain the DID estimate of the θth conditional QTE: $\zeta(\theta)$.

It should be clear that the NHI is exogenous because: (1) it is enforced by the government, and (2) it is a universal program (neither asset-based nor means-tested). As such, we do not suffer from the selection bias usually arising from the choice of a welfare (insurance) program. As for D, recall that the control and treatment groups are classified according to the working status of the household head and his/her spouse. There would be a selectivity problem if people can freely choose to join the public/private sector. For example, one may argue that those who are more risk averse or prudent (and tend to save more) are more likely to choose the public sector. This is, however, not quite the case in Taiwan because one has to pass a "civil service examination" before he/she can be a public servant. There are 4 levels of such examination, which are all highly selective with very low qualification rates; for example, the average of the qualification rates during 1990–2000 was only 6.4%. These examinations constitute entry barriers for the public sector and thus alleviate the selectivity problem, if any, to certain extent.[7]

Other than the dummy variables for the treatment groups and the time indicator for period t_1, we include the following covariates X in our models: dummy for gender of household head (with female head as reference); age of household head and its square; dummy for intact couple (with single/unmarried as reference); the educational years of the male and female heads; household size; number of earners in the household; two dependency ratios: proportion of household members aged under 20 and proportion of those over 65; two urbanization dummies: Urban and Suburban (with rural area as reference); and five regional dummies: Taipei, Kaohsiung, Northern Taiwan, Central Taiwan, Southern Taiwan (with Eastern Taiwan and outer islands as reference). In addition, the annual GDP growth rate and a time trend are added to control the year and trend effects. The summary statistics of these covariates are collected in Table 3.

We also consider two extensions of models (5) and (6). First, we do OLS estimation of the following model that admits multiple treatment groups:

$$S_i = \alpha + X_i'\beta + \sum_{j=0}^{2} D_i(j)\gamma_j + (\mathrm{NHI}_i)\delta + \sum_{j=0}^{2}[(\mathrm{NHI}_i)\times D_i(j)]\zeta_j + e_i, \quad i = 1, \ldots, N, \tag{7}$$

where $D(j)$ are the indicators of the jth treatment group, where $j = 0$, 1, and 2 correspond to, respectively, the quasi control, treatment 1, and treatment 2 groups. The corresponding θth quantile regression model is:

$$S_i = \alpha(\theta) + X_i'\beta(\theta) + \sum_{j=0}^{2} D_i(j)\gamma_j(\theta) + (\mathrm{NHI}_i)\delta(\theta) + \sum_{j=0}^{2}[(\mathrm{NHI}_i)\times D_i(j)]\zeta_j(\theta) + e_{i,\theta}, \quad i = 1, \ldots, N. \tag{8}$$

[7] Even with these examinations, we may not completely rule out the possibility of selection bias, as correctly pointed out by a referee. Hence, the inferences from this study should be drawn with care; see also footnote 7 of Chou et al. (2003).

Table 3 Summary statistics of covariates

Covariate	1990–1994		1996–2000	
	Mean	SD	Mean	SD
Head gender	0.875	0.331	0.829	0.376
Head age	41.251	10.965	42.586	10.760
Intact couple	0.778	0.415	0.734	0.442
Male head edu.	9.563	4.703	9.715	4.905
Female head edu.	7.944	4.859	8.505	5.060
Household size	4.154	1.677	3.873	1.636
No. of earners	1.726	0.891	1.737	0.869
Prop. of 0–19	0.319	0.239	0.268	0.237
Prop. of ≥65	0.065	0.172	0.083	0.194
GDP growth	0.071	0.008	0.058	0.007
Urban	0.626	0.484	0.675	0.468
Suburban	0.276	0.447	0.243	0.429
Taipei	0.176	0.381	0.198	0.398
Kaohsiung	0.081	0.273	0.094	0.293
North	0.263	0.440	0.257	0.437
Center	0.170	0.376	0.156	0.362
South	0.261	0.439	0.232	0.422

Note Head gender is the dummy for male head; Intact couple is the dummy for married couple; GDP growth is the annual GDP growth rate

The OLS estimate of ζ_j in (7) and quantile regression estimates of $\zeta_j(\theta)$ in (8) are the DID estimates of the ATE and QTEs of the treatment group j, respectively. Note that what Chou et al. (2003) did were pair-wise comparisons between the strict control group and each treatment group. Hence, they did not consider model (7) but instead estimated (5) for each treatment group.

We also explore possible heterogeneity of the treatment effects on different income groups and head age groups. To this end, we partition the data into five income groups (based on income quintiles) and five age groups (20–29,..., 60–69). We estimate the group-wise treatment effects based on the following extension of (5) and (6):

$$S_i = \alpha + X_i'\beta + \sum_{j=1}^{5} D_i K_i(j)\gamma_j + \sum_{j=1}^{5}(\mathrm{NHI}_i \times K_i(j))\delta_j + \sum_{j=1}^{5}[\mathrm{NHI}_i \times D_i \times K_i(j)]\zeta_j + e_i, \quad i = 1, \ldots, N, \tag{9}$$

and its corresponding quantile regression models, where D is still the binary indicator of the treatment group, and $K(j)$, $j = 1, \ldots, 5$, are the indicators of five income groups or five age groups. The OLS and quantile regression estimates of ζ_j are the DID estimates of the ATE and QTEs of the jth income (age) group, respectively.

5 Empirical results

In this section, we report and discuss the estimated ATEs and QTEs of the NHI based on the models discussed above.

5.1 Average and QTEs

The models (5) and (6) are first estimated by, respectively, the methods of OLS and quantile regression with $\theta = 0.1, 0.25, 0.5, 0.75, 0.9$. The estimation results are summarized in Table 4. Most estimated coefficients in OLS and quantile regressions are significantly different from zero at 5% level, except GDP growth. The DID estimate of the ATE is −3.2% and quite close to the unconditional ATE in Table 1.[8] The estimated QTEs exhibit some heterogeneity across quantiles, ranging from −1.9% at the 0.1th quantile to −4.4% at the 0.9th quantile. To be sure, we conduct inter-quantile tests of the equality of pair-wise treatment effects. It is found that the treatment effect at $\theta = 0.1$ ($\theta = 0.25$) is significantly different from that at $\theta = 0.9$ ($\theta = 0.75$) at 5% level. Yet, the treatment effects at $\theta = 0.9, 0.5$ (or $\theta = 0.1, 0.5$) are marginally significant at 10% level. To conserve space, we do not report all the testing results here.

Figure 2 shows the DID estimate of the ATE (solid line) with its 95% confidence interval in dashed lines and the DID estimates of the QTE (solid line with circles) with their 95% confidence interval in shaded area, where the horizontal axis labels θ. The heterogeneity of QTEs can be observed directly from this figure. In particular, the DID estimates of the QTE (in absolute term) increases with θ, i.e., the crowd-out effect of the NHI is larger for higher savers. Thus, the estimated ATE (in absolute term) tends to underestimate the effect on high savers but overestimate the effect on low savers.

Table 5 and Fig. 3 show the DID estimates of the ATE and QTE based on models (7) and (8). We first observe that the ATE and QTEs for the quasi control group are not significantly different from zero at 5% level, except the QTE at the 0.9th quantile. For the other two treatment groups, the estimated ATEs are −4.3% for treatment 1 and −3.5% for treatment 2, and the estimated QTEs have similar patterns. In particular, the QTEs are insignificant at $\theta = 0.1$, and their magnitude increases with θ and reaches around −8% at $\theta = 0.9$. Thus, the NHI also has greater crowd-out effect on high savers, as in the result of Table 4. The fact that the estimates for these two different treatment groups are close suggests that the estimated treatment effects are quite robust.

The greater crowd-out effect on high savers is quite reasonable. Typically, those who are more prudent save more to safeguard against future risk. Once the risk of

[8] We also estimate (5) with saving rate, $(Y - C)/Y$, as the dependent variable and obtain very similar estimate of the ATE (−3.3%). In this article, we choose approximate saving rate, $\ln Y - \ln C$, as the dependent variable because the estimation result is better in terms of parameter significance and adjusted R^2.

Table 4 The DID estimates of the ATE and QTE on household saving: models (5) and (6)

Variable	OLS		$\theta = 0.1$		$\theta = 0.25$		$\theta = 0.5$		$\theta = 0.75$		$\theta = 0.9$	
	Coeff.	SD	Coeff.	SD	Coeff.	SD	Coeff.	SD	Coeff.	SD	Coeff.	SD
Intercept	2.958*	1.050	−0.848	1.428	0.445	1.138	1.877	1.173	4.649*	1.432	5.058*	1.942
NHI × D	−0.032*	0.004	−0.019*	0.005	−0.019*	0.004	−0.027*	0.004	−0.031*	0.005	−0.044*	0.007
D	−0.127*	0.005	−0.095*	0.007	−0.111*	0.005	−0.130*	0.006	−0.154*	0.007	−0.174*	0.009
NHI	−0.058*	0.003	−0.041*	0.004	−0.052*	0.003	−0.060*	0.003	−0.061*	0.004	−0.049*	0.005
Head gender	−0.063*	0.003	−0.075*	0.004	−0.063*	0.003	−0.062*	0.003	−0.062*	0.004	−0.049*	0.006
Head age	0.008*	0.001	0.008*	0.001	0.008*	0.001	0.009*	0.001	0.008*	0.001	0.007*	0.001
Head age squared	−0.008*	0.001	−0.010*	0.001	−0.009*	0.001	−0.010*	0.001	−0.007*	0.001	−0.005*	0.001
Intact couple	−0.061*	0.003	−0.041*	0.004	−0.044*	0.003	−0.058*	0.003	−0.076*	0.004	−0.084*	0.005
Male head edu.	0.003*	0.000	0.000	0.000	0.001*	0.000	0.003*	0.000	0.004*	0.000	0.007*	0.000
Female head edu.	0.003*	0.000	0.002*	0.000	0.002*	0.000	0.002*	0.000	0.003*	0.000	0.004*	0.000
Household size	−0.031*	0.001	−0.020*	0.001	−0.023*	0.001	−0.030*	0.001	−0.037*	0.001	−0.041*	0.001
No. of earners	0.120*	0.001	0.094*	0.002	0.105*	0.001	0.123*	0.001	0.131*	0.001	0.128*	0.002
Ratio of 0–19	−0.094*	0.004	−0.024*	0.006	−0.056*	0.005	−0.094*	0.005	−0.120*	0.006	−0.145*	0.008
Ratio of ≥ 65	0.013*	0.005	0.024*	0.007	0.024*	0.005	0.016*	0.005	0.013*	0.006	0.012	0.009
GDP growth	0.066	0.101	0.047	0.138	−0.010	0.110	0.079	0.113	0.170	0.137	0.074	0.185
Time trend	−0.001*	0.001	0.000	0.001	0.000	0.001	−0.001	0.001	−0.002*	0.001	−0.002*	0.001
Urban	−0.067*	0.003	−0.055*	0.004	−0.055*	0.003	−0.062*	0.003	−0.073*	0.004	−0.085*	0.005
Suburban	−0.027*	0.003	−0.023*	0.004	−0.023*	0.003	−0.024*	0.003	−0.027*	0.004	−0.037*	0.005
Taipei	−0.004	0.004	0.077*	0.005	0.031*	0.004	−0.003	0.004	−0.046*	0.005	−0.084*	0.007
Kaohsiung	0.003	0.004	0.041*	0.006	0.019*	0.004	0.001	0.005	−0.013*	0.006	−0.022*	0.007
North	0.019*	0.003	0.027*	0.005	0.019*	0.004	0.023*	0.004	0.013*	0.005	0.000	0.006
Center	0.046*	0.004	0.037*	0.005	0.037*	0.004	0.045*	0.004	0.048*	0.005	0.048*	0.007
South	0.036*	0.003	0.049*	0.005	0.033*	0.004	0.034*	0.004	0.027*	0.005	0.021*	0.006

Note $D = 1$ if a household is in the treatment group (households with neither head nor spouse in the public sector), and $D = 0$ otherwise; ∗ significance at 5% level

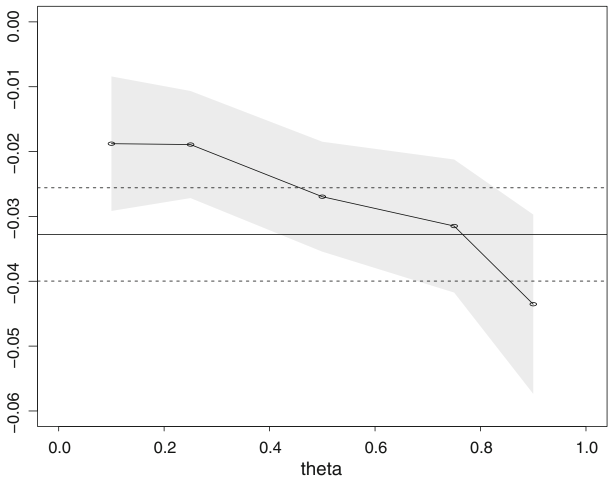

Fig. 2 The DID estimates of the ATE and QTE of the NHI: 1 treatment group

medical expense is removed, these high savers may, as a response to less uncertainty in medical care cost, tend to save much less than before. We note that the QTE pattern here is opposite to that of Chou et al. (2003) which find that, for the treatment 1 and treatment 2 groups, the magnitude of the QTE is larger for low savers but smaller for high savers. The finding of Chou et al. (2003) is somewhat counter-intuitive, as low savers do not have much room to dis-save.

We again conduct inter-quantile tests of the equality of pair-wise treatment effects. For the treatment 1 group, we find that, at 5% level, the treatment effect at $\theta = 0.9$ is significantly different from that at $\theta = 0.5$ and that at $\theta = 0.1$. But the pair-wise treatment effects at $\theta = 0.5, 0.1$ and those at $\theta = 0.75, 0.25$ are not significantly different even at 10% level. The heterogeneity pattern for the treatment 2 group is similar, except that he pair-wise treatment effects at $\theta = 0.75, 0.25$ are now significantly different at 10% level. Thus, the QTE heterogeneity in two treatment groups is more obvious at the right tail of the distribution; this is easily seen from Fig. 3b, c.

A major difference between this research and early studies, such as Chou et al. (2003), is that we use approximate saving rate as the dependent variable so that the observations with negative saving are allowed in our analysis. To see the impact of ignoring such observations, we estimate model (5) based on the observations with only positive saving. We find that the resulting ATE is −1.1%, which is about 1/3 of our result (−3.2%) reported in Table 4. Similarly, estimating model (7) with the restricted sample results in a significant but much smaller ATE (−1.8%) for treatment 1 group and an insignificant ATE for treatment 2 group.[9] We also estimate model (8) with the

[9] Note that our model (7) admits three treatment groups but Chou et al. (2003) did only pair-wise comparisons (e.g., strict control vs. treatment 1, or strict control vs. treatment 2). To be sure, we also conduct pair-wise comparisons based on the full sample and the sub-sample without negative saving. It turns out that the results are quite similar to those based on model (7). The resulting ATEs on two treatment groups for the full sample are −4.0% and −3.4% (both significant at 5% level), yet those based on restricted sample are only −1.5% (significant) for treatment 1 and an insignificant ATE for treatment 2.

Table 5 The DID estimates of the ATE and QTE on household saving: models (7) and (8)

Variable	OLS		$\theta = 0.1$		$\theta = 0.25$		$\theta = 0.5$		$\theta = 0.75$		$\theta = 0.9$	
	Coeff.	SD	Coeff.	SD	Coeff.	SD	Coeff.	SD	Coeff.	SD	Coeff.	SD
Intercept	2.897*	1.049	−1.006	1.479	0.710	0.983	1.385	1.087	4.627*	1.348	5.495*	1.862
NHI × D(0)	−0.008	0.009	0.001	0.013	−0.004	0.009	0.002	0.009	−0.015	0.012	−0.039*	0.016
NHI × D(1)	−0.043*	0.009	−0.018	0.012	−0.027*	0.008	−0.029*	0.009	−0.046*	0.011	−0.081*	0.015
NHI × D(2)	−0.035*	0.009	−0.017	0.012	−0.018*	0.008	−0.024*	0.009	−0.044*	0.011	−0.076*	0.015
D(0)	−0.121*	0.009	−0.096*	0.013	−0.107*	0.008	−0.133*	0.009	−0.141*	0.011	−0.139*	0.015
D(1)	−0.057*	0.006	−0.039*	0.008	−0.052*	0.006	−0.068*	0.006	−0.070*	0.008	−0.068*	0.010
D(2)	−0.097*	0.006	−0.071*	0.008	−0.090*	0.005	−0.109*	0.006	−0.113*	0.007	−0.090*	0.010
NHI	−0.119*	0.006	−0.082*	0.008	−0.105*	0.006	−0.130*	0.006	−0.134*	0.007	−0.122*	0.010
Head gender	−0.060*	0.003	−0.071*	0.004	−0.060*	0.003	−0.058*	0.003	−0.058*	0.004	−0.043*	0.005
Head age	0.008*	0.001	0.008*	0.001	0.007*	0.001	0.008*	0.001	0.007*	0.001	0.006*	0.001
Head age square	−0.008*	0.001	−0.009*	0.001	−0.008*	0.001	−0.009*	0.001	−0.007*	0.001	−0.004*	0.001
Intact couple	−0.067*	0.003	−0.043*	0.004	−0.047*	0.003	−0.065*	0.003	−0.083*	0.004	−0.097*	0.005
Male head edu.	0.003*	0.000	0.000	0.000	0.001*	0.000	0.003*	0.000	0.004*	0.000	0.006*	0.000
Female head edu.	0.002*	0.000	0.002*	0.000	0.001*	0.000	0.002*	0.000	0.003*	0.000	0.003*	0.000
Household size	−0.029*	0.001	−0.019*	0.001	−0.022*	0.001	−0.028*	0.001	−0.035*	0.001	−0.039*	0.001
No. of earners	0.116*	0.001	0.092*	0.002	0.102*	0.001	0.118*	0.001	0.126*	0.001	0.122*	0.002
Ratio of age 0–19	−0.101*	0.004	−0.028*	0.006	−0.061*	0.004	−0.101*	0.005	−0.130*	0.006	−0.157*	0.008
Ratio of ≥65	0.010*	0.005	0.023*	0.007	0.022*	0.005	0.014*	0.005	0.009	0.006	0.007	0.008
GDP growth	0.056	0.101	0.003	0.143	−0.002	0.095	0.035	0.105	0.188	0.129	0.106	0.177
Time trend	−0.001*	0.001	0.000	0.001	0.000	0.000	−0.001	0.001	−0.002*	0.001	−0.002*	0.001
Urban	−0.066*	0.003	−0.054*	0.004	−0.054*	0.003	−0.062*	0.003	−0.072*	0.004	−0.085*	0.005
Suburban	−0.026*	0.003	−0.022*	0.004	−0.023*	0.003	−0.024*	0.003	−0.026*	0.004	−0.038*	0.005
Taipei	−0.008*	0.004	0.076*	0.005	0.028*	0.004	−0.006	0.004	−0.048*	0.005	−0.092*	0.007
Kaohsiung	−0.001	0.004	0.040*	0.006	0.017*	0.004	−0.003	0.004	−0.016*	0.005	−0.031*	0.007
North	0.021*	0.003	0.029*	0.005	0.021*	0.003	0.025*	0.004	0.017*	0.004	0.002	0.006
Center	0.047*	0.004	0.039*	0.005	0.038*	0.003	0.046*	0.004	0.052*	0.005	0.050*	0.006
South	0.037*	0.003	0.051*	0.005	0.034*	0.003	0.035*	0.004	0.031*	0.004	0.023*	0.006

Note: $D(j) = 1$ if a household is in the jth treatment group, where $j = 0, 1,$ and 2 correspond to the quasi control, treatment 1, and treatment 2 groups, respectively; $*$ significance at 5% level

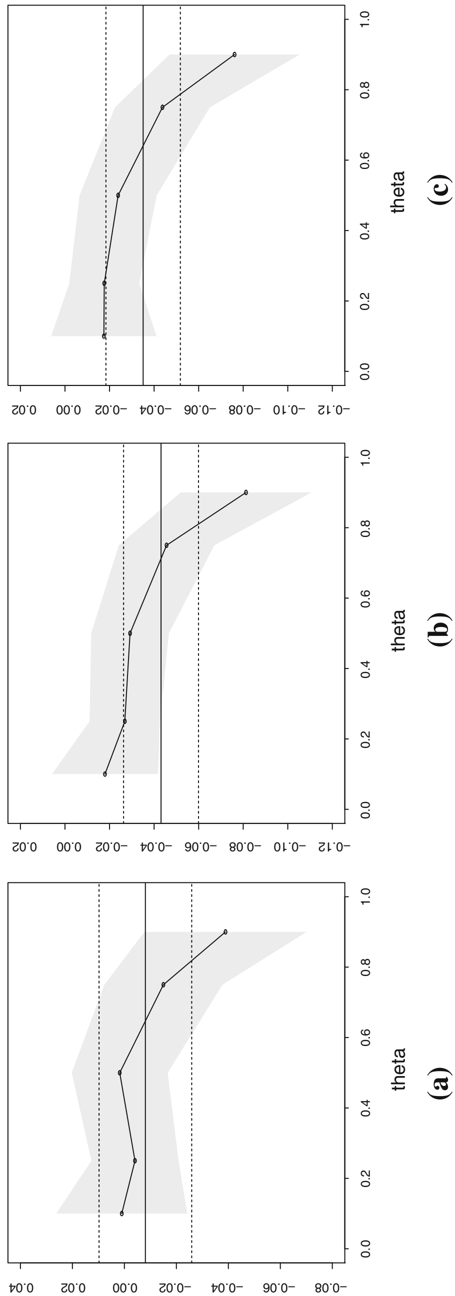

Fig. 3 The DID estimates of the ATE and QTE of the NHI: three treatment groups. **a** Quasi control, **b** treatment 1,**c** treatment 2

restricted sample and find that the resulting QTEs at lower quantiles are positive; that is, NHI induces more saving. Such result does not make much sense. These results suggests that whether the households with negative saving are included in the sample greatly affects the estimated treatment effects. Ignoring these households in the empirical analysis is likely to yield misleading results.

5.2 Treatment effects across covariate groups

We now examine the treatment effects of the NHI on saving across income quintile groups or five age groups by estimating model (9) and its corresponding quantile regressions. To conserve space, we summarize only the estimated ATEs and QTEs in Table 6; complete estimation results are available upon request.

We also plot the ATEs and QTEs and their confidence intervals for each income group in Fig. 4a–e; Fig. 4f is a 3D plot of the QTEs for all five income groups. In the 3D plot, θ for quantile regression is on one axis, whereas income quintile groups are on another, with the highest income group (Y_{q5}) on the left and the lowest group (Y_{q1}) on the right. Similarly, Fig. 5a–e contains the plots of the ATEs and QTEs for five age groups, and Fig. 5f is a 3D plot of the treatment effects for all age groups. In this 3D plot, we have θ for quantile regression on one axis and age groups on another, with the oldest group on the left and the youngest group on the right. To ease comparison across groups, we set the same vertical axis for Fig. 5a–e.

It can be seen that the DID estimate of the ATE for the second income quintile group is insignificantly different from zero and those for the first, third, and fourth income quintile groups are quite close (around -2.5%). The estimated ATE jumps to -5% for the highest income group. The QTEs are quite homogeneous across saving quantiles for the first three income quintile groups and exhibit heterogeneity in higher income groups. For the highest income group, we can see that the QTEs are stable at lower quantiles and change from -3.4% at $\theta = 0.5$ to -6.8% at $\theta = 0.9$. Thus, there is a stronger crowd-out effect for the highest income quintile group, in which the highest saver dis-saves the most. The QTE pattern can be clearly seen from Fig. 4f.

Our finding that the NHI results in the greatest crowd-out effect on the highest income quintile group is quite interesting. This is different from Hubbard et al. (1995) and Maynard and Qiu (2009), which find that the crowd-out effect concentrates more on middle wealth/income groups but not on upper and lower income groups. We note that the welfare program considered by Hubbard et al. (1995) and Maynard and Qiu (2009) is means tested. As high income households would not want to reduce their net-wealth/income just in order to qualify the welfare program. It is therefore not surprising that the welfare program has little effect on high income group. In contrast, Taiwan's NHI is universal, so that eligibility is not a concern at all. Thus, the households can freely respond to the enforcement of the NHI. In particular, those who have undertaken more precautionary saving, especially those with high income, are relatively easier to increase consumption and enjoy a larger crowd-out effect of the NHI.

For the treatment effects on head age groups, we first observe that the ATE varies a lot across age groups. The ATE is -11.9% for the oldest group (aged 60–69);

Table 6 The DID estimates of the ATE and QTE on household saving: five income groups and five age groups

NHI × D × $K(j)$	OLS		$\theta = 0.1$		$\theta = 0.25$		$\theta = 0.5$		$\theta = 0.75$		$\theta = 0.9$	
	Coeff.	SD	Coeff.	SD	Coeff.	SD	Coeff.	SD	Coeff.	SD	Coeff.	SD
$K(1)$ = first Y group	−0.025*	0.008	−0.023	0.012	−0.011	0.009	−0.012	0.008	−0.011	0.010	−0.012	0.013
$K(2)$ = second Y group	−0.012	0.008	−0.019	0.012	−0.011	0.009	−0.009	0.008	−0.009	0.010	−0.004	0.013
$K(3)$ = third Y group	−0.022*	0.008	−0.016	0.012	−0.016	0.009	−0.027*	0.008	−0.020*	0.010	−0.013	0.013
$K(4)$ = fourth Y group	−0.028*	0.008	−0.009	0.012	−0.038*	0.009	−0.031*	0.008	−0.025*	0.010	−0.022	0.013
$K(5)$ = fifth Y group	−0.050*	0.008	−0.032*	0.012	−0.036*	0.009	−0.034*	0.008	−0.060*	0.010	−0.068*	0.013
$K(1)$ = age (20–29)	−0.041*	0.012	−0.017	0.017	−0.018	0.012	−0.042*	0.013	−0.054*	0.017	−0.055*	0.023
$K(2)$ = age (30–39)	−0.043*	0.006	−0.043*	0.009	−0.037*	0.006	−0.042*	0.007	−0.036*	0.008	−0.040*	0.012
$K(3)$ = age (40–49)	−0.014*	0.006	−0.012	0.008	−0.003	0.006	−0.007	0.006	−0.014	0.008	−0.024*	0.011
$K(4)$ = age (50–59)	−0.023*	0.008	−0.003	0.011	−0.012	0.008	−0.023*	0.009	−0.024*	0.011	−0.040*	0.016
$K(5)$ = age (60–69)	−0.119*	0.014	−0.062*	0.020	−0.064*	0.014	−0.089*	0.015	−0.111*	0.020	−0.177*	0.027

Note: $D = 1$ if a household is in the treatment group (households with neither head nor spouse in the public sector), and $D = 0$ otherwise; $K(j) = 1$ if a household is in the jth income quintile group (head age group) in the upper (lower) panel, and $K(j) = 0$ otherwise; $*$ significance at 5% level

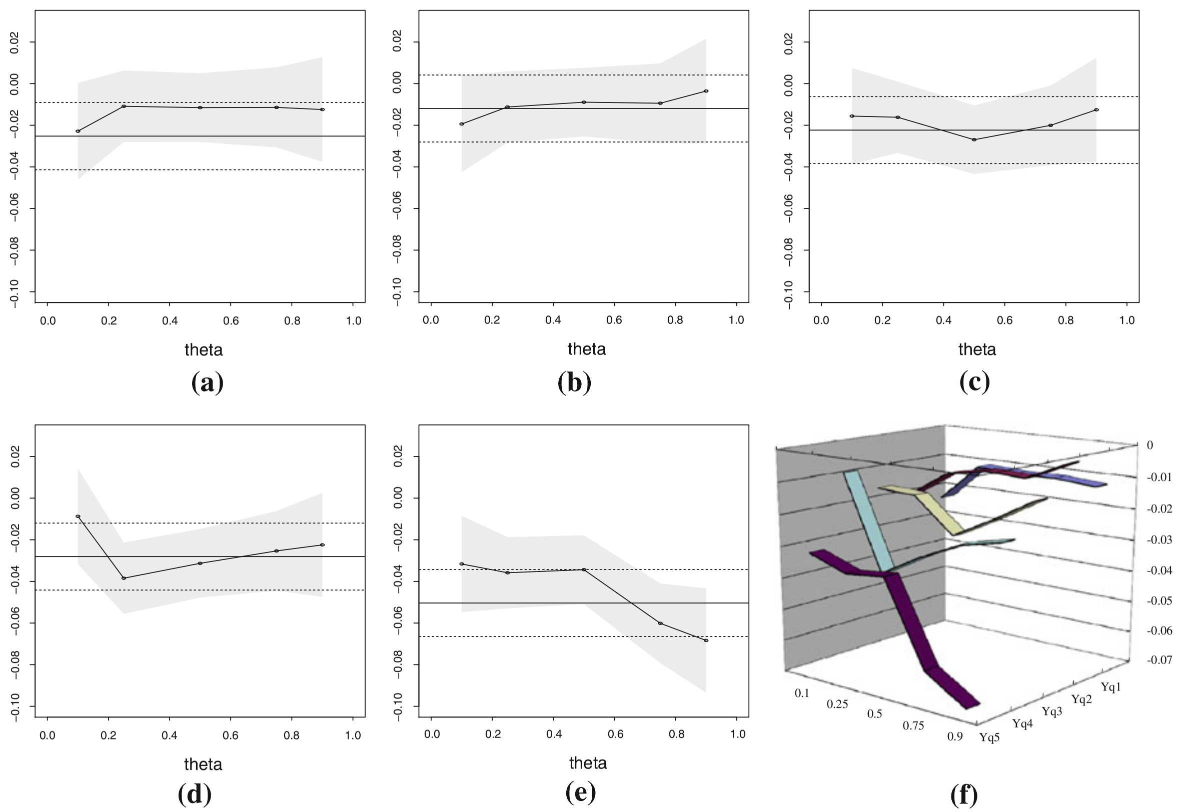

Fig. 4 The DID estimates of the ATE and QTE of the NHI: income quintile groups. **a** First, **b** second, **c** third, **d** fourth, **e** fifth, and **f** all quintiles

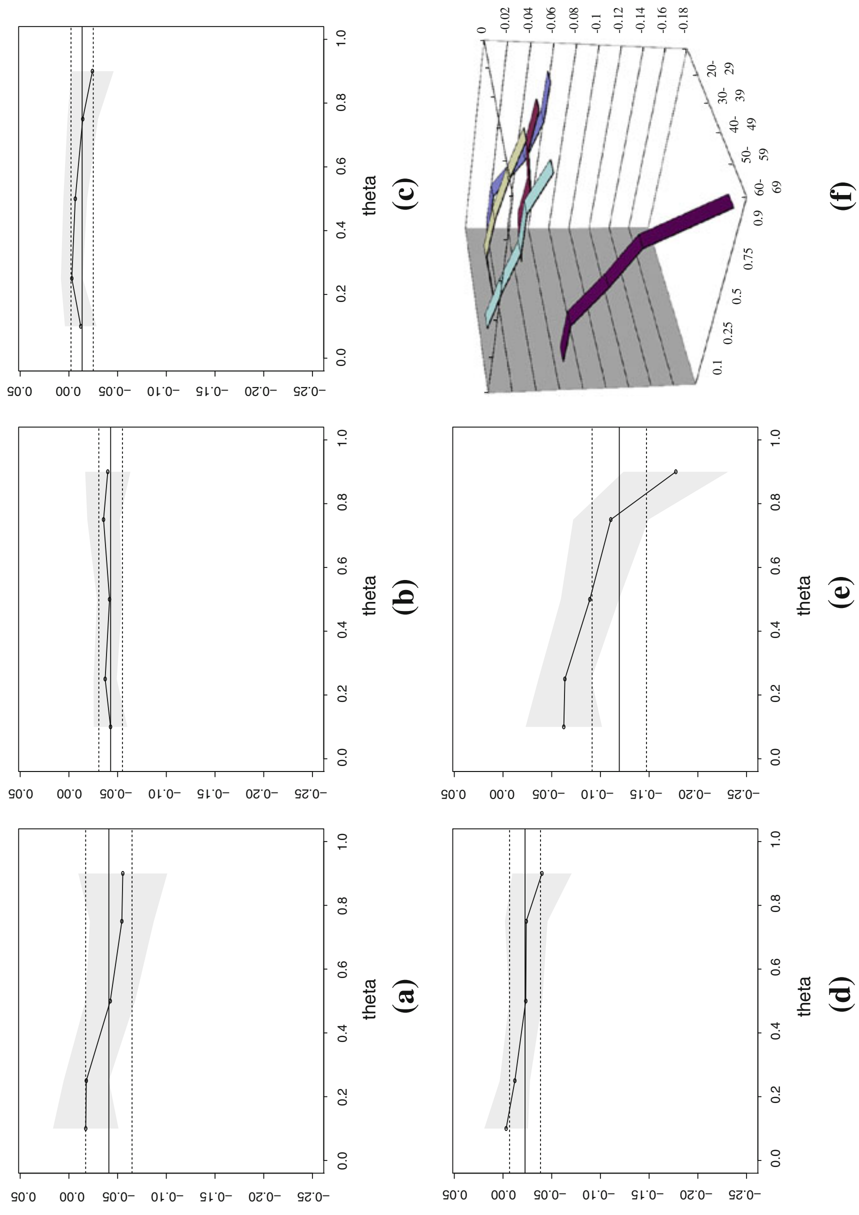

Fig. 5 The DID estimates of the ATE and QTE of the NHI: five age groups. **a** 20–29, **b** 30–39, **c** 40–49, **d** 50–59, **e** 60–69, and **f** all age groups

for other age groups (from older to the youngest), the ATEs are −2.3, −1.4, −4.3, and −4.1%. It can also be seen that the estimated QTEs are very heterogeneous for the oldest group, ranging from −6.2% at $\theta = 0.1$ to −17.7% at $\theta = 0.9$. For three younger age groups, the QTEs exhibit only mild heterogeneity; the crowd-out effects are still stronger and significant on high savers in these groups. Thus, while the NHI affects all age groups, especially the high savers in these groups, its greatest impact is on the elderly, for which the saving can be reduced by as much as 17%. This pattern is clearly illustrated in Fig. 5f.

Our results indicate that medical expenditure uncertainty is of different importance for people in different life stages.[10] The crowd-out effect of the NHI on the households at retiring age is much greater than that on younger age counterparts because the former faces higher medical risk and hence more income uncertainty. This is particularly relevant in Taiwan, because prior to the introduction of the NHI, Labor Insurance covers only the employees in the private sector up to age 60. Our estimates also show that the crowd-out effects of the NHI on younger groups are stronger than that on middle age groups. This is not easy to interpret. As the effects on these age groups are not much different and have relatively small magnitude, we may conclude that the NHI virtually has two types of age effect: the effect on the retiring group is the largest, and the effect on those who are younger and before retiring is modest.

6 Conclusions

This study illustrates the crowd-out effects of the NHI on precautionary saving in Taiwan. By including the samples with both positive and negative saving in our treatment effect analysis, we find that the QTEs of the NHI are opposite to the existing results in the literature. In particular, while the enforcement of the NHI does discourage precautionary saving, its effect is heterogeneous across saving distribution with greater impact on higher savers. Upon partitioning the data into different income or head age groups, it is also found that the NHI has a greater impact on the households with high income or the household heads at retiring stage. This effect is even stronger on the high savers in these groups. This suggests that, at the expense of lower saving rate, the NHI is able to alleviate the risk of catastrophic medical care cost and enhance the welfare of households. More can be said about the crowd-out effects of the NHI, e.g., the elasticity of the effects over time, if we extend the present study to incorporate more waves of SFIE in the analysis. We may also analyze the household saving behavior in more detail by considering further stratification of household types. These are left to future studies.

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[10] Our study includes all age groups and hence differs from those focusing on specific elderly groups, e.g., Feenberg and Skinner (1994), Kazarosian (1997), and Palumbo (1999).

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