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Household Bundling to Reduce Adverse Selection: Application to Social Health Insurance

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Abstract

This paper explores the use of bundling to reduce adverse selection in insurance markets and its application to social health insurance programs. When the choice to buy health insurance is made at the household level, bundling the insurance policies of household members eliminates the effect of adverse selection *within* a household since the household can no longer select only sick members to enroll. However, this can exacerbate adverse selection *across* households, as healthier households might choose to drop out of the insurance market. The net effect of this trade-off depends on the characteristics of the household demand for medical care and risk preferences. I explore this issue using individual survey data on insurance enrollment and medical spending in Vietnam that contain detailed information about the structure of the household. The reduced-form evidence suggests that income, own-price and cross-member substitution effects play important roles in the demand for medical care, which affects a household's selection of members into insurance. I then develop and estimate a model of household insurance bundle choice and medical utilization that accounts for these features. The results suggest that much of the adverse selection is concentrated within the household. Counterfactual analysis reveals that under optimal pricing, household bundling yields significantly higher consumer surplus and insurance enrollment than individual purchase. Furthermore, the insurance market is less susceptible to complete unraveling under household bundling.

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1 Introduction

How can government intervention reduce inefficiency caused by asymmetric information in the health insurance market? Since the seminal work of Akerlof (1970), a rich literature has studied various aspects of this question, ranging from whether and how the government should mandate insurance coverage to how subsidies for insurance should be designed. While much of the literature has focused on incentivizing individuals to make the optimal insurance choice, in many situations, this choice is made at the household level. What distinguishes the household as a common decision maker from individual decision making is that the household is likely to have complete information about its members. Therefore, the household's decisions to buy insurance for different members are interdependent. This paper explores the use of household bundling to reduce adverse selection in insurance markets and its application to social health insurance programs.

In general, the heterogeneity in individual health types in the population can be decomposed into two components: heterogeneity within each household and heterogeneity across households. When there is only one available health insurance contract, under *individual purchase*, households can buy insurance for any subsets of their members. Each household will then only buy health insurance for its sicker members, resulting in *within-household adverse selection*. Under *household bundling*, either the entire household is insured or no one is insured, which eliminates within-household adverse selection. However, *across-household adverse selection* now arises, whereby only the sicker households buy insurance whereas the healthier households do not. This can result in some sick individuals who need insurance the most not having insurance because their other household members are very healthy. Therefore, whether household bundling can improve upon individual purchase in terms of welfare and/or insurance enrollment depends on the relative magnitude of within and across household heterogeneity in health types.

To starkly illustrate this intuition, suppose that the population is composed of only two households, A and B, each with two members, of whom one is healthy and one is sick. Under individual purchase, each household will buy insurance only for its sick member (within-household adverse selection). However, since two households have identical composition, they have the same willingness to pay for the first best insurance bundle (no across-household adverse selection), and thus, the insurer can achieve the optimal social welfare by selling only the first best insurance bundle under a household bundling scheme.

To see that household bundling can also adversely affect social welfare, suppose now that household A has two sick members while household B remains with one healthy and one sick member. Under individual purchase, the three sick members in the population will buy insurance. On the other hand, under household bundling, only the sicker household A will buy insurance while the healthier household B drops out of the insurance market (across-household adverse selection), thus causing the sick member of household B to become uninsured.

Other factors related to the household demand for medical utilization and risk preferences also affect the potential welfare gain of household bundling in comparison to individual purchase. In particular, a household might view insurance contracts for different members as substitutes. For example, in a household, if the wife is already insured, the household is able to spend more on the husband's medical care which decreases the utility gain from buying insurance for the husband. Thus, the household might not be willing to pay as much for the husband's insurance as for the wife's insurance even if both members have the same health type. In this case, the premium under household bundling needs to be sufficiently low to overcome this decrease in the willingness to pay for subsequent insured members. Other dimensions of heterogeneity in members' preferences for medical care unrelated to risk types could also cause households to prefer to only buy insurance for some but not all members, hence contributing to within-household adverse selection.

In this paper, I empirically study the welfare effect of household bundling in the context of the Social Health Insurance (SHI) Program in Vietnam in which adverse selection is the key issue that contributes to low insurance take-up. SHI is a government-sponsored program in which enrollment is voluntary for part of the population. The Vietnam setting is suitable for my study because with an under-developed private market for health insurance, SHI is the only insurance provider for the majority of the population in Vietnam. This allows me to abstract from various supply side issues that would complicate the analysis. My main source of data is a representative rolling-panel sample of households from 2004 to 2012. The data consist of detailed information about each household's structure, income and demographics, yearly medical spending and some health indicators of each member, as well as each household member's insurance status.

The rationale behind how household bundling of health insurance affects insurance enrollment and welfare is also applicable to other government-sponsored health insurance program. For example, the Medicare program in the US also suffers from adverse selection (Polyakova, 2016), and thus healthy enrollees choose to buy too little insurance coverage, which can be mitigated by household bundling. In addition, since Vietnam's health insurance situation is similar to that of many other developing countries, the immediate policy implications in this paper are applicable to health care policy design in other developing nations that are still struggling with low health insurance coverage.[1]

I first conduct a reduced-form analysis that captures some key features of the household demand for medical care and health insurance. These features motivate the subsequent structural modeling choices. The analysis confirms the existence of adverse selection and separately detects moral hazard.[2] In addition, using an Almost Ideal Demand System, I show that medical care utilization of different household members are substitutes. Medical care is also a normal good with an income elasticity of out-of-pocket cost between 0.2 and 0.3.

I then develop a structural model of households' health insurance choices and medical care that helps to quantify the source of adverse selection as well as the degree of within and across household adverse selection. The model extends the commonly used two-stage modeling approach (Cardon and Hendel, 2001; Carlin and Town, 2009; Einav et al., 2013; Handel, 2013; Bajari et al., 2014) to a household decision making framework. Each household is assumed to be unitary: there is a representative agent who makes all the decisions for the household. In the first period, the household makes the health insurance choice for its members based on its belief about future health shocks. In the second period, the health shocks are realized, and the household makes the optimal choice of medical care utilization for each of its members. In my model, besides the unobserved heterogeneity in health types, adverse selection could also arise from the unobserved heterogeneity in preferences for medical care among household members.

The household choice model incorporates the stylized features from the data, namely, the income effect, the cross-member substitution effect, and moral hazard. The household demand for each member's medical care is assumed to consist of necessary care and optional care. The necessary care is the amount of medical care that must be consumed when a member is sick. A sick member can also consume some optional care if the household has sufficient income after paying for all of its members' out-of-pocket costs for necessary care. The optimal amount of optional care for each household member is dependent on (i) the household's residual income, (ii) his coinsurance rate, and (iii) his necessary care. The cross-member substitution effect arises through the income effect. For example, a member with a worse health shock requires higher necessary care, thus reducing the household's

[1] According to the World Bank (Cotlear et al., 2015), 24 developing countries, which include Brazil, China, and India, are implementing health coverage reforms to expand access to health care.

[2] Following Pauly (1968) and Cutler and Zeckhauser (2000), moral hazard refers to the effect of insurance on the demand for medical care due to the price elasticity.

residual income that, in turn, decreases other members' optional care consumption through the income effect.

Identification of the parameters in the model exploits the existence of enrollees who have mandated insurance or receive free health insurance and the variation in coinsurance rates. Identification is obtained under the following assumptions. First, households have correct beliefs about the distribution of future health shocks. Second, there exists an income threshold known to the econometrician such that households with incomes under this threshold do not consume any optional care. Third, the parameters characterizing the demand for medical utilization and the distribution of individual health types are mutually independent and independent of whether health insurance is mandatory, free, or voluntary. I estimate the model using Markov Chain Monte Carlo through Gibbs Sampling.

The results of the estimation reveal that households are not fully enrolled in insurance because of both the income effect and within-household adverse selection. Due to the income effect in the demand for medical care, in the absence of any differences in health types and preferences for medical care between household members, the household's willingness to pay for the second member's insurance is, on average, 49% less than its willingness to pay for the first member's insurance. When heterogeneity in preferences and health types is taken into account, the insurer's cost of providing insurance for the second member selected into insurance by the household is, on average, 54% of the cost of providing insurance for the first household member, implying within-household adverse selection. Most of this within-household adverse selection is generated by the heterogeneity in health types instead of the heterogeneity in preferences for medical care utilization. In addition, much of the adverse selection due to health types is concentrated within each household: the degree of variation in within-household health types accounts for 40% of the variation in health types across individuals in the population.

I then use the model to examine the effect of a household bundling policy on welfare and insurance enrollment in the context of Vietnam's SHI. In the counterfactual exercises, the social planner is the sole provider of health insurance and assumed to maximize consumer welfare. The social planner can subsidize the insurance premium but operates under a budget constraint. When the social planner can only charge a uniform premium,[3] the results suggest that household bundling leads to a weakly higher demand for insurance and a strictly lower average cost of providing insurance than individual purchase at any given uniform premium.

[3]This means that the premium per member under household bundling is the same for all households, and the premium per enrollee under individual purchase is the same for all individuals.

This means that the number of individuals who only buy insurance under household bundling dominates the number of individuals who drop out of insurance due to household bundling. In addition, the new enrollees are, on average, healthier. Insurance enrollment under the optimally priced household bundling policy is estimated to be 17.1 million, which generates a consumer surplus equivalent to 0.28% of Vietnam's GDP. In comparison, the insurance enrollment and the consumer surplus under optimally priced individual purchase are 3.5 million and 0.18% of GDP, respectively.[4]

Can individual purchase with nonlinear pricing perform better than household bundling? By offering a lower premium per member when a household has multiple members buying insurance, the social planner can attract a larger number of healthier members into insurance under individual purchase without restricting households' choices. However, while nonlinear pricing under individual purchase can take into account the decrease in the willingness to pay for additional insurance due to the income effect, it cannot eliminate within-household adverse selection. This is because the social planner's cost saving from having healthier household members in the insurance pool is now offset by the reduction in the insurance premium. My results suggest that even with nonlinear pricing, the levels of insurance enrollment and consumer surplus under individual purchase are still 11 million and 0.07% of GDP lower, respectively, than that of household bundling with uniform pricing. This underlines the large magnitude of within-household adverse selection and its welfare loss in my setting.

Finally, I explore the use of household bundling to prevent market unraveling. If the government provides a lower level of subsidy for the market, insurance premiums increase, forcing healthier enrollees to drop out of insurance. This worsens the risk pool and further increases insurance premiums. If the cycle continues, it is possible that no one is insured, and the market unravels. In my estimates, the market starts to unravel under individual purchase when the level of government subsidy is decreased by 50%. However, at this level of subsidy but under household bundling, insurance enrollment remains at 16.3 million, generating a consumer surplus equivalent to 0.15% of GDP. This suggests that the market is less susceptible to market unraveling under household bundling than under individual purchase.

The rest of the paper proceeds as follows. The next section discusses the related literature, and Section 3 describes the data and the institutional setting of Vietnam's SHI program. Section 4 presents the characteristics of the demand for insurance and the demand for medical

[4]Under the assumption that the social planner only chooses a uniform premium, the optimal premium is simply the lowest premium that satisfies the budget constraint under the chosen level of government subsidy. The results here assume that the government provides the same level of subsidy as in its 2012 policy.

care from the reduced-form analysis. Section 5 presents my empirical framework while Section 6 discusses the identification and parameterization of the model. The results of the structural estimation are provided in Section 7. Section 8 analyzes the welfare impact of household bundling policies, and Section 9 concludes.

2 Related Literature

This paper is related to several distinct literatures. The modeling approach in this paper is built upon a rich literature that studies the demand for health insurance using a two-stage approach (Cardon and Hendel, 2001; Carlin and Town, 2009; Einav et al., 2013; Handel, 2013; Bajari et al., 2014) and extended to a household framework. In these papers, the willingness to pay for insurance is jointly determined by the demand for medical utilization and risk preferences, with both being explicitly modeled. While my model retains common features from the literature such as the effect of income and moral hazard on the demand for medical care, the focus of the paper is on the interactions within the household. In this paper, the medical care of a household member is dependent on other household members' medical spending, which is modeled through the effect of income. This interdependence translates into a nonlinear relationship in the household's willingness to pay for insurance for its members. Although much of my analysis centers on selection on health types, the model is rich enough to also allow for selection on moral hazard (Einav et al., 2013) and risk aversion (Finkelstein and McGarry, 2006; Cohen and Einav, 2007). My paper is not the first to estimate the demand for insurance in a household context. Bundorf et al. (2012) and Ho and Lee (2017), for example, estimate the choice of plans at the household level using aggregate measures of household characteristics. While their approach is suitable for settings in which the household is assumed to always choose a single plan for all of its members (i.e. employer-sponsored health insurance), my model allows the household to make different insurance choices for different household members.

My analysis on the effect of household bundling on social welfare also contributes to a growing literature on market design in markets with asymmetric information (Akerlof, 1970; Rothschild and Stiglitz, 1976). In the classical framework of Akerlof (1970), mandated full insurance is socially optimal when there is no moral hazard or other dimensions of heterogeneity that affect the optimal contract for each individual. When this condition is violated, mandated full insurance is unlikely to be optimal and could be detrimental to welfare (Einav et al., 2010). In other settings where a mandate is not feasible, the government could intervene by providing premium subsidies (Ericson and Starc, 2015; Tebaldi, 2016; Jaffe and Shepard, 2017) to encourage low-risk individuals to enroll. Other works have also considered policies that target dimensions of consumer demand other than risks such as consumers' inertia (Handel, 2013) and information frictions (Handel et al., 2015). My paper provides an alternative policy that exploits the fact that the household has complete information about its members, which is largely unexplored in the literature.

The intuition of using household bundling to reduce adverse selection in insurance markets is closely related to the well-known literature on product bundling. Household bundling is a form of product bundling when insurance for each household member is considered a separate product. However, the application of bundling to social health insurance in this paper highlights interesting deviations from the traditional bundling literature. First, although product bundling has been shown to almost always increase the monopolist's profit since it reduces the heterogeneity in consumers' willingness to pay (Long, 1984; Schmalensee, 1984; Fang and Norman, 2006; Chen and Riordan, 2013), the effect of bundling on social welfare is ambiguous. In a social health insurance setting, the social planner is solving a Ramsey pricing problem (Ramsey, 1927) and not just maximizing profits. Second, in any insurance market, adverse selection on risk types affects both the demand for insurance and the average cost of providing insurance. Therefore, the effect of any bundling policy will depend not only on the insurance enrollment but also on the composition of the insurance pool. Third, while much of the literature on bundling has assumed that the valuation of a bundle is the sum of the valuations for consuming the items in isolation (with the notable exception of Armstrong (2013)), this assumption is likely to be violated when applied to health insurance, due both to risk preferences and the characteristics of the demand for medical care. In my model, insurance plans for different household members are substitutes due to the income effect in the household's demand for medical care.

3 Institutional Setting and Data

This section outlines institutional details of the SHI program in Vietnam and the overview of the data.

3.1 Social Health Insurance in Vietnam

Vietnam's SHI is a government-sponsored program, funded by mandatory contributions, voluntary premiums, and tax revenues. There are three types of enrollees: *compulsory enrollees*, *policy beneficiaries*, and *voluntary enrollees*. The compulsory group consists of workers in the formal sector whose enrollment is mandated and premiums are directly deducted from their wages. Their employers are required to subsidize 2/3 of the premiums. The policy beneficiaries group includes the poor, pensioners, veterans, and children under 6 who receive free SHI. The rest of the population is eligible to purchase voluntary health insurance at a premium. It is important to note that the compliance rate of firms in the formal sector is low, hence 50% of the formal sector workers are not enrolled in compulsory insurance (Somanathan et al., 2014).[5] These individuals are then eligible to purchase voluntary insurance.

For each enrollee type, there is only one insurance contract, which only covers the enrollee but not his dependents. The SHI contracts differ among enrollee types and also across years. Table (3.1) summarizes the coinsurance structures of SHI contracts in selected years.[6] In general, the SHI contracts feature piecewise-linear coinsurance rates with no deductible and are more generous for policy beneficiaries. The lack of deductibles and co-payments here suggests that the government is less concerned about potential moral hazard. SHI does not cover a certain set of diseases (some of which are paid by another government agency, for example tuberculosis, malaria, HIV/AIDS, STDs . . .), family planning, assisted reproductive technologies, organ transplantation, vaccination, and cosmetic surgery. It also does not cover innate disability, occupational disease, traffic accident, suicide, and drug addiction. These exclusions have stayed the same for all enrollee types and over time.

SHI premiums are set differently for different enrollee types. As previously mentioned, SHI is free for policy beneficiaries. For compulsory enrollees, pre-subsidized annual individual premiums are 6% of their annual wage. For voluntary enrollees, annual premiums are indexed to the minimum wage, which vary across years and geographical areas. The premiums for voluntary enrollees are also dependent on whether other household members are enrolled in voluntary insurance and household types.[7] Household types are categorized as (1) households in the agricultural sector, (2) households with at least one compulsory enrollee, and (3) self-employed households.

The premium structure is summarized in Table (3.2) for selected years. In the period from 2005 to 2007, household bundling was implemented together with a reduction in premium

[5]Formal-sector firms in Vietnam subsidize SHI premiums but do not have to bear any costs of medical utilization. Whether a firm complies and provides compulsory SHI is therefore unlikely to be due to the health status of their enrollees.

[6]The selected years are chosen to correspond to the years of the available data. The actual timeline of these policy changes is summarized in Appendix F.

[7]In Vietnam, each "household" is defined to include all members who are registered in the same address (the household's registry). This is similar to the household registry system in China.

Table 3.1 – Coinsurance Structures of SHI Contracts

Year	Policy Beneficiaries	Compulsory Enrollees	Voluntary Enrollees
2004	0%	20% If expense is below 1500 0% For additional expense	20% If expense is below 1500 0% Otherwise
2006	0%	0% If expense is below 7000 100% For additional expense, but out-of-pocket costs not exceeding 4666 40% For additional expense	0% If expense is below 7000 100% For additional expense, but out-of-pocket costs not exceeding 4666 40% For additional expense
2008	0%	0% If expense is below 7000 100% For additional expense, but out-of-pocket costs not exceeding 4666 40% For additional expense	0% If expense is below 100 20% For expense above 100
2010	0% If expense is below 100 5% For expense above 100	0% If expense is below 100 20% For expense above 100	0% If expense is below 100 20% For expense above 100
2012	0% If expense is below 100 5% For expense above 100	0% If expense is below 100 20% For expense above 100	0% If expense is below 100 20% For expense above 100

Note: All units are in KVND. From 2004 to 2008, the out-of-pocket cost is a continuous function of total health expenditure. In 2010 and 2012, however, there is a jump in out-of-pocket cost between expense below 100 KVND and above 100 KVND,

and a requirement on commune-level participation rates.[8] In this period, voluntary SHI is only available in communes with at least 10% of households fully insured, either through voluntary SHI or compulsory and free SHI. For each household, all members who are eligible for voluntary SHI must purchase insurance or no one is insured. Household bundling was repealed in late 2007 due to a 1.5 million decrease in insurance enrollment.[9] In other years, households could be partially enrolled in insurance but receive greater premium discounts when more household members enroll in insurance. This is nonlinear pricing in the form of bundle size pricing.

As of 2012, there were still 31.9 million Vietnamese who were not enrolled in SHI, accounting for 30% of the population. Among these, 15.7 million were non-poor informal sector workers, and 6.2 million were formal sector workers (Somanathan et al., 2014). Figure (3.1) shows the percentage enrolled in SHI in each enrollment group. Enrollment is highest among

[8]Each commune has between 1000 to 10,000 households.

[9]Evidence from the data suggests that this is mainly due to the commune requirement. More details are included in Section 4.

Table 3.2 – Premium Structure for Households with Members Eligible for Voluntary SHI

Year	Eligible Member	Individual Premium (Non-student)[1]			Policy
2004	1	4.5%			Individual Purchase
	2+	4.275%			
2006	1	3.0%			Household Bundling
	2	3.0%			
	3	2.7%			
	4+	2.4%			
2008	1	4.5%			Individual Purchase
	2	4.5%			
	3	4.05%			
	4+	3.6%			
2010, 2012		Agricultural HH	Formal-sector HH	Self-employed HH	Individual Purchase
	1	4.5%	4.5%	4.5 %	
	2	4.05%[2]	4.05%	4.5 %	
	3	3.6%[2]	3.6%	4.5%	
	4+	3.15%[2]	3.15%	4.5%	

(1) Student premium is always at 3.15% of minimum wage.

(2) Additional household members only receive lower premiums if the household is fully enrolled in insurance.

Note: All premiums are indexed to the minimum wage. Per the Health Insurance Law of 1998, the maximum individual premium for voluntary enrollees is capped at 6% of the minimum wage.

the poor, pensioners, and civil servants as these groups receive free SHI. Enrollment for children under 6 is surprisingly low (approximately 80%), although this group is also qualified for free SHI. Among people who are eligible for voluntary SHI but excluding students, only 20% are enrolled in SHI. However, insurance enrollment is much higher for students (80%) since in many schools student SHI is considered a part of tuition fees.

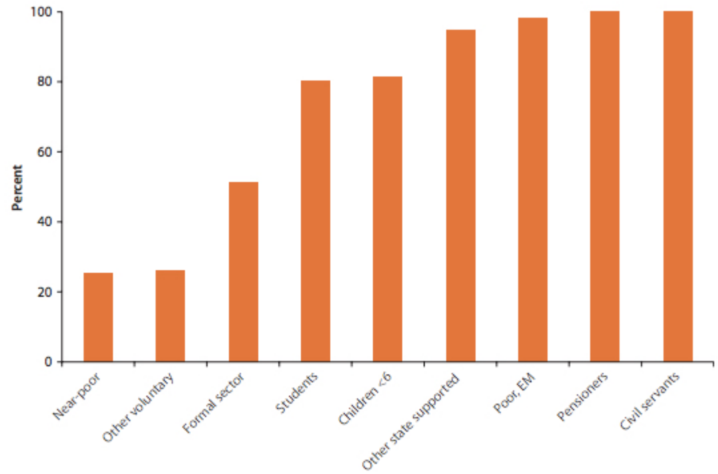
Adverse selection is likely to be the main cause of low SHI take-up in Vietnam. While it has been noted that low take-up of social insurance in general could be due to low quality of care, stigma, or high administrative costs of either purchasing or utilization, these concerns are less likely to be valid in Vietnam's SHI context.[10] Most health care providers in Vietnam are public facilities who are required to accept SHI.[11] Private providers could also apply to accept SHI enrollees as long as they meet sufficient quality standards. Most SHI reimbursement happens at the provider level in which the reduction in payment is directly applied at the time of payment, hence the administrative cost of utilization is unlikely to be high. Purchase of SHI is also relatively easy as it does not exclude pre-existing conditions.

Vietnam's participation in the SHI scheme was part of a larger effort initiated by the

[10] Currie (2004) provides an excellent review of the literature in the US and UK context.

[11] In some large public hospitals, there are separate facilities that serve only people who opt out of SHI. However, these facilities are utilized mostly by high income individuals for out-patient services.

Figure 3.1 – Insurance Enrollment by Groups



Source: Somanathan et al. (2014)

World Bank in the early 2000s. While universal health insurance coverage is a common goal for many countries, using SHI to achieve this goal is especially relevant to developing nations. There are two general methods to provide universal health care: free insurance completely funded by tax revenue, and SHI. SHI can be favored over the tax revenue financing system when a country's tax revenue is insufficient to fund health care (Hsiao et al., 2006). Also, since SHI only partially relies on the public tax revenue, implementing SHI also frees up public funds for other health related expenses such as quality improvement. Several developing countries have chosen to implement SHI, for example Kenya, Ghana, Philippines, Colombia, Thailand, and Vietnam.[12]

3.2 Data

I obtained data from two main sources: the Vietnamese Household Living Standard Survey (VHLSS) from 2004 to 2012, and the administrative data from the Vietnamese Social Security Agency (VSS) from 2008 to 2012. The VHLSS is a survey conducted once every two years on more than 9000 households by the General Statistic Office of Vietnam to monitor living standards. The survey follows a rolling panel structure in which 50% of households are randomly chosen to be interviewed in two consecutive waves. The data consists of demographic characteristics of household members, income, expenditure, education level and

[12]Multiple advanced nations have also adopted SHI in the past and achieved universal coverage (Austria, Belgium, Germany, Israel, Japan, Republic of Korea, and Luxembourg among others (Carrin and James, 2005)).

information on health status, health expenditure, as well as health insurance status. The sample of households in VHLSS is selected as a representative sample of the entire population. I supplement this survey data with the administrative data on yearly revenue collected from health insurance premium and payment paid by VSS. The data is grouped by enrollee types and cities from 2008 to 2012. Table (3.3) shows the summary statistics of the data

Table 3.3 – Summary Statistics of the Full Sample

	2004	2006	2008	2010	2012
Individual Characteristics					
Age	29.70	30.81	31.65	31.20	32.20
	(19.84)	(20.09)	(20.50)	(20.49)	(20.90)
Female	0.503	0.508	0.507	0.508	0.508
	(0.500)	(0.500)	(0.500)	(0.500)	(0.500)
College Degree	0.147	0.162	0.181	0.191	0.204
	(0.354)	(0.368)	(0.385)	(0.393)	(0.403)
Married	0.722	0.720	0.735	0.766	0.779
	(0.448)	(0.449)	(0.441)	(0.423)	(0.415)
Individual Income	1615.2	2277.7	3428.7	5586.1	8460.3
	(4500.6)	(6469.6)	(9976.4)	(14984.6)	(20744.4)
Observations	38450	38312	37723	36695	36503
Household Characteristics					
HH Average Age	31.55	33.06	33.20	33.73	34.22
	(12.21)	(12.89)	(14.90)	(14.27)	(16.31)
HH Eldest Member	52.05	53.17	50.69	52.36	50.19
	(15.43)	(15.09)	(18.41)	(15.84)	(18.71)
HH Size	4.464	4.292	3.817	3.943	3.556
	(1.598)	(1.579)	(1.659)	(1.516)	(1.579)
Total Household Income	26425.9	33766.8	48817.9	65106.5	92334.1
	(24189.2)	(34716.3)	(64030.2)	(115084.9)	(100243.6)
Average Income per Member	6382.4	8461.0	15794.6	17804.4	31208.5
	(6038.4)	(9106.9)	(27416.1)	(35871.5)	(38689.3)
Observations	8619	8926	9885	9308	10266
Individual Medical Utilization					
Outpatient visits	0.981	1.220	1.136	1.355	1.240
	(2.716)	(3.306)	(3.259)	(3.610)	(3.121)
Inpatient visits	0.0938	0.0922	0.0921	0.123	0.108
	(0.481)	(0.427)	(0.433)	(0.558)	(0.489)
OOP	214.9	240.7	314.2	559.9	684.7
	(1580.4)	(1533.2)	(2574.7)	(3365.2)	(4105.0)
Medical OOP as Share of Average Income	0.0427	0.0389	0.0347	0.0460	0.0370
	(0.325)	(0.303)	(0.230)	(0.295)	(0.274)
Observations	38450	38312	37723	36695	36503

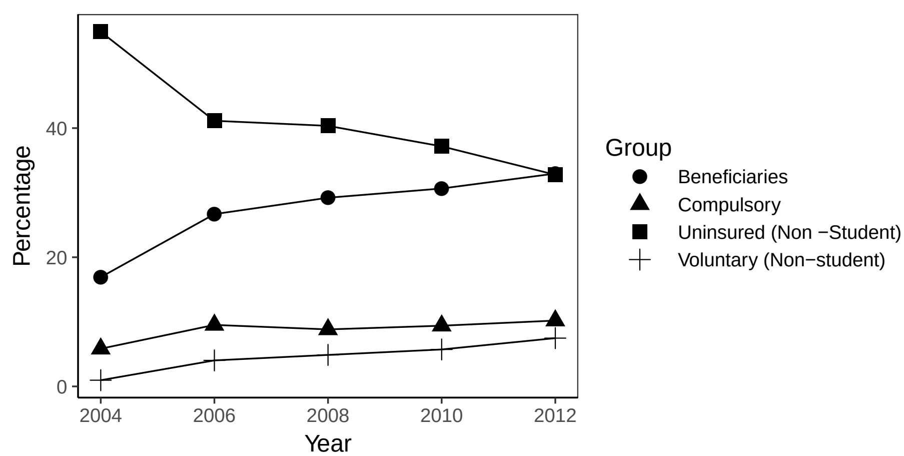
Note: The out-of-pocket cost (OOP) is measured in KVND. Average income is measured annually in KVND, calculated as the total household income divided by the number of household members.

at the individual level and household level. Households in the sample have on average 4 members, with the eldest member being 50 years old on average. The aggregate household income per member is close to the actual nominal GDP per capita, which increases from \$606.89 in 2004 to \$1755.27 in 2012 (World Bank, 2016).[13]

The average individual in the sample has 1 outpatient visit per year, and pays between 3 to 4% of per-member average income for out-of-pocket (OOP) costs. When the sample is restricted to only individuals who have at least one doctor visit, which accounts for approximately 30% to 40% of the total sample, the average number of outpatient visits per year per individual is 2 (Table H.1). Among these people, on average 1 out of 5 individuals needs an inpatient visit. The OOP costs once medical utilization occurs account for about 10% of the average per-member income.

The percentages of each enrollee type and the uninsured are summarized in Figure (3.2). Most of the reduction in the number of uninsured individuals comes from the expansion of the free SHI program. There is also a modest upward trend in voluntary SHI enrollment. The number of individuals who remained uninsured by 2012 is close to 30% of the sample, which is similar to the population statistics. The low enrollment rate in 2004 is due to the partial roll-out of the policy which was implemented only at selected communes.

Figure 3.2 – Proportions of Different Enrollment Types in the Data Sample by Year



Throughout this paper, I will only focus on the non-student members who are eligible for voluntary SHI. This is because premiums for student SHI are usually included in tuition fees,

[13]The large increase in income over time reflects the high inflation rates in this period which reached 23.116% in 2008 and 18.677% in 2011. The average individual income is much lower than the GDP per capita because this statistic does not take into account income from household business which is reported separately.

hence households cannot opt out of student SHI. In the data, most students are fully insured (Figure G.4), and most households choose to cover all of its student members (Figure G.3).[14] Within-household selection mainly occurs on non-student voluntary members. The majority of households have some members eligible for non-student voluntary SHI, yet only 14% of households have some voluntarily non-student insured members. Among these households, 50% of households are partially covered under SHI (Figure G.1 and G.2).

4 Descriptive Characteristics of the Demand for Medical Care and the Demand for Insurance

I start by presenting the descriptive characteristics of the demand for medical care and the demand for health insurance in Vietnam's SHI program. The data suggests that (1) income effect, (2) cross-member substitution effect, and (3) moral hazard are present in the demand for medical utilization. There is also strong evidence of adverse selection in the demand for health insurance. The analysis here motivates my modeling choice in the subsequent sections.

4.1 Medical Care as a Normal Good

Table (4.1) summarizes the cross-sectional income elasticity of OOP costs controlling for insurance status and observed individual characteristics. The elasticity is between 0.204 and 0.316 and is statistically significant for all enrollee types.[15]

Whether medical care is a normal good has important implications on welfare. Without allowing for the positive income effect, any correlation between medical spending and income is attributed to the difference in the underlying health types. For example, in the absence of income effect, a positive correlation between income and medical spending implies counter-intuitively that richer individuals are sicker. It is thus more efficient from the social planner's perspective to insure higher income individuals. On the other hand, if all correlation between income and medical spending is due to the positive income elasticity, it might be socially more efficient to insure low income individuals. This is because when facing with the same

[14] Figure (G.3) also shows that a small fraction of households opt out of student SHI completely. For these households, I assume that whether the household would like to buy student SHI is part of the household's choice set.

[15] The estimates for income elasticity of the demand for health expenditure vary widely in the literature (Getzen, 2000), ranging from 0 to about 1.5. Among studies that use micro data, the estimates are between 0 to 0.7

Table 4.1 – Cross-sectional Income Elasticity on OOP Costs by Enrollee Types

	Correlation (log OOP, log HH Income)
Policy Beneficiaries	0.316***
	(0.0374)
Compulsory Enrollees	0.282***
	(0.0382)
Voluntary Enrollees (Non-Student)	0.204***
	(0.0344)
Uninsured (Non-Student)	0.257***
	(0.0217)
Voluntary Enrollees (Student)	0.224***
	(0.0371)
Uninsured (Student)	0.287***
	(0.0465)
Individual Characteristics	Yes
Province FEs	Yes
Time FEs	Yes
Observations	61663
Adjusted R^2	0.926

Standard errors are adjusted for heteroskedasticity and correlation within geographical area

Note: The set of individual characteristics included in the regression is: age, educational level, marital status, gender, and job type. The sample is restricted to individuals with positive OOP costs only.

health shock, individuals with lower income have higher marginal utility of consumption and thus are more adversely affected by the health shock than higher income individuals.

4.2 Cross-member Effects

One of the key differences between the *household* demand for medical care and the *individual* demand for medical care is that the former exhibits substitution effects between different members' medical utilization. In what follows, I use estimates from the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer, 1980) to investigate the substitution patterns in medical utilization of household members. Here, each household is assumed to consume 6 goods, which include a consumption good and medical care for each member category. Members are categorized as Head of the household,[16] Spouse, Children, Parents, and Others. The detailed implementation of the AIDS is included in Appendix D.

Table (4.2) presents the estimates of the AIDS in the sample of households who are fully covered through compulsory or free SHI. This sample restriction eliminates the endogeneity

[16] The VHLSS survey asks each household to identify the household's head. This information is also recorded in the official household's registry.

Table 4.2 – Estimates for the Almost Ideal Demand System.

Dependent Variable: Expenditure Shares

Coefficient	Mean	St. Dev.
Price (Head)	-0.067^{***}	0.018
Price (Spouse)	-0.048^{***}	0.012
Price (Children)	-0.031^{***}	0.008
Price (Parents)	-0.008	0.017
Price (Others)	-0.029	0.029
Price (Head - Spouse)	0.0002	0.013
Price (Head - Children)	0.012^{**}	0.006
Price (Head - Parents)	0.0004	0.023
Price (Head - Others)	0.018	0.016
Price (Spouse - Children)	0.006^{**}	0.003
Price (Spouse - Parents)	0.009	0.012
Price (Spouse - Others)	0.010	0.009
Price (Children - Children)	0.005	0.004
Price (Children - Parents)	0.003	0.007
Price (Children - Others)	0.010	0.008
Price (Parents - Parents)	0.005	0.015
Price (Parents - Others)	0.011	0.017
Price (Others - Others)	0.004	0.016
Income (Head)	-0.034^{***}	0.008
Income (Spouse)	-0.020^{***}	0.004
Income (Children)	-0.012^{***}	0.003
Income (Parents)	-0.011	0.009
Income (Others)	-0.010	0.011

Note: The sample here is limited to the set of households that are fully covered under compulsory or free enrollment. This ensures that the observed medical prices are not correlated with the unobserved health type and health realization. The number of households in this sample is $N = 11112$.

concern between the price of medical care and the unobserved health types. The estimates of own-price elasticities are negative and mostly significant. The estimates of cross-price elasticities are all positive, suggesting that medical care of different members are substitutes, but the estimates are less precise. This substitution effect is statistically significant between the head of the household, his wife and their children.

4.3 Moral Hazard in the Demand for Medical Care

A major empirical challenge in estimating the effect of insurance on the demand of medical care is the endogeneity between health insurance status and unobserved health conditions. One of the most reliable evidence on this moral hazard effect was established in Manning et al. (1987) and more recently Finkelstein et al. (2012) in which random assignments of insurance were given to individuals in the US. Here, I utilize a similar natural experiment to study the effect of moral hazard in Vietnam's SHI program.

Table 4.3 – Summary Statistics of the Treatment and Control Groups

Variable	(Panel A)			(Panel B)		
	Treatment	Control	Difference	Matched Treatment	Matched Control	Difference
Age	44.84	35.13	9.7***	33.03	33.71	-0.68
	(16.29)	(21.06)		(20.27)	(20.51)	
Female	0.59	0.53	0.06***	0.51	0.53	-0.02
	(0.49)	(0.5)		(0.5)	(0.5)	
HH Size	4.18	4.76	−0.58***	4.62	4.64	-0.02
	(1.5)	(1.5)		(1.62)	(1.52)	
College Degree	0.24	0.1	0.13***	0.14	0.14	0.01
	(0.42)	(0.3)		(0.35)	(0.34)	
Log HH Income (Per Member)	9.1	8.66	0.45***	8.99	8.95	0.05**
	(0.65)	(0.64)		(0.69)	(0.82)	
Chronic Disease	0.16	0.1	0.06***	0.09	0.1	-0.01
	(0.37)	(0.3)		(0.28)	(0.3)	
N	853	1787		2640	2640	

A feature of the voluntary SHI in 2006 is the requirement that at least 10% of households in a commune need to participate in health insurance in order for voluntary SHI to be available in that commune. In addition, household bundling was implemented in this period. In the data, I observe households who attempted to purchase voluntary SHI but were ultimately denied due to the lack of participation of other households in the commune. I then construct a treatment group of individuals who were able to obtain voluntary SHI and a control group of individuals who were unable to obtain voluntary SHI due to the commune requirement.

Panel A of Table (4.3) shows the summary statistics of the control and treatment groups in the sample. On average, the treatment group has higher household income, older, and more educated than the control group. Furthermore, the treatment group is more likely to have chronic diseases. The control and treatment groups are therefore not directly comparable. To correct for the difference in the observed characteristics of the control and treatment groups, I construct a matched sample using nearest-neighbor matching on propensity scores based on a logistic regression using household's observed characteristics and individual's observed characteristics,[17] excluding individual health indicators.

Panel B of Table (4.3) shows the summary statistics of the matched control and matched

[17]The set of household characteristics includes the number of members needed to buy insurance, log household income, fixed effects for geographical areas, and the average household's education level. The set of individual's observed characteristics includes individual age categories, gender, marital status, and education level.

treatment groups. After matching, the differences in demographic variables between the treatment and control groups are negligible. The difference in the probability of having chronic diseases is also largely eliminated, thus alleviating concerns of adverse selection that could lead to an over-estimation of the treatment effect of moral hazard.

Tables (4.4) reports the results of the average treatment effect in the overall sample and by whether an individual has chronic diseases. On average, insured individuals increase out-patient visits by 0.7 visit and in-patient visits by 0.06 visit. The treatment effect on in-patient visits is significantly larger for people with chronic conditions, but people without chronic conditions are more likely to increase the number of out-patient visits. The results suggest that the increase in medical utilization due to enrollment in voluntary SHI is correlated with the underlying health status.

Table 4.4 – Average Treatment Effect on Medical Utilization Associated with Enrollment in Voluntary SHI

	(1) OPV	(2) IPV	(3) OPV (chronic)	(4) IPV (chronic)	(5) OPV (non chronic)	(6) IPV (non chronic)
ATE	0.672***	0.0602*	-0.447	0.253**	0.740***	0.0539*
	(0.199)	(0.0275)	(1.289)	(0.0966)	(0.166)	(0.0269)
Observations	2640	2640	300	300	2189	2189

Standard errors are adjusted for heteroskedasticity.

Note: OPV and IPV are the number of out-patient and in-patient visits respectively.

4.4 Adverse Selection in the SHI Program

To separate the existence of adverse selection from moral hazard, I compare medical utilization between two groups of enrollees in 2010 and 2012: voluntary enrollees and compulsory enrollees. These years were chosen because the coinsurance rates are identical between the two groups and largely linear. In this period, the coinsurance rate is 0% for medical expense under 100 KVND,[18] and 20% for higher expense.[19] The compulsory enrollees are a valid control group because they do not self-select into insurance. The validity of this assumption will be discussed in more details in Section 6.

Panel A of Table (4.5) shows the summary statistics of the treatment and control groups. On average, the treatment group (voluntary enrollees) have lower household income per

[18]Vietnamese Dong (VND) is the local currency. 1 KVND = 1000 VND ≈ 0.04 USD (in 2017).

[19]Since the average OOP cost in 2010 and 2012, including individuals with no medical utilization, is 560 KVND and 685 KVND respectively (Table 3.3), the change in the coinsurance rate at 100 KVND is unlikely to have a large impact on medical utilization. Even when this nonlinearity is taken into account, the impact of moral hazard is greater for healthier individuals, which will strengthen any evidence on adverse selection.

member, less educated, and older. To make the groups more comparable, I construct matched treatment and control groups. Specifically, I use exact matching on age categories, gender, and whether the individual has a college degree, and nearest-neighbor matching on household income per member. Panel B of Table (4.5) shows the summary statistics of the matched treatment and control groups.

Table 4.5 – Summary Statistics of the Control and Treatment Groups

Variable	(Panel A)			(Panel B)		
	Treatment	Control	Difference	Matched Treatment	Matched Control	Difference
Age	47.45	40.36	7.09^{***}	43	43.22	-0.22
	(16.6)	(15.52)		(16.7)	(16.6)	
Female	0.6	0.5	0.11^{***}	0.54	0.54	0
	(0.49)	(0.5)		(0.5)	(0.5)	
HH Size	4.12	4.03	0.08^{***}	4.12	4.02	0.1^{***}
	(1.55)	(1.46)		(1.51)	(1.51)	
College Degree	0.23	0.7	-0.47^{***}	0.51	0.51	0
	(0.42)	(0.46)		(0.5)	(0.5)	
Log HH Income (Per Member)	9.97	10.29	-0.32^{***}	10.15	10.16	-0.01
	(0.69)	(0.64)		(0.67)	(0.67)	
N	4827	7169		11996	11996	

The average treatment effect on the matched treatment and control groups are summarized in Table (4.6). Compared to the control group, the treatment group has 0.8 more out-patient visits, 0.03 more in-patient visits per year, and higher OOP costs. The results suggest that people who self-select into insurance have worse health status on average. In addition, Table (H.3) shows that a voluntary enrollee in 2006 is much more likely to have a chronic condition than the uninsured (19.7% compared to 9.2%). Since chronic conditions are covered under SHI and there is no exclusion to pre-existing conditions, this could also be considered a direct evidence of adverse selection in the SHI program.[20]

5 Model

This section presents a model of household health insurance choice and demand for medical care, incorporating the features that were established in the previous section. The model extends the commonly used two-stage modeling approach to a unitary household framework where each household has a representative agent - henceforth the decision maker (DM) -

[20] The data on chronic conditions is not available for 2010 and 2012.

Table 4.6 – The Difference in Medical Utilization between Voluntary and Compulsory Enrollees in 2010 and 2012

	(1) OPV	(2) IPV	(3) log(OOP + 1)
ATE	0.793***	0.0269	0.871***
	(0.0954)	(0.0150)	(0.0914)
Observations	11996	11996	11996

Standard errors are adjusted for heteroskedasticity

Note: OPV and IPV are the number of out-patient visits and in-patient visits, respectively. As shown in Table (3.3), the average out-of-pocket spending is approximately 560KVND, which includes individuals who do not incur any medical spending. Hence, the addition of 1 into OOP does not affect the results

who makes all the decisions on behalf of the household. Medical care is modeled as a good whose demand depends on the underlying health shock, the coinsurance rate of medical care, and the household income. In this section, I abstract away from some empirically-relevant details that are introduced later.

Let h denote a unitary household with n_h members and household income Y_h. Let subscript j denote a member of the household, and let bold symbols denote vectors of household variables. The household consumes a basket of n_h+1 goods. This basket includes a consumption good c_h, whose price is normalized to 1, and all members' medical care utilization $\boldsymbol{m}_h := (m_{hj})_{j=1,2,\ldots,n}$, where m_{hj} is member j's medical utilization in monetary value.

Next, the health shocks of household h are denoted by $\boldsymbol{\theta}_h := (\theta_{hj})_{j=1,2,\ldots,n_h}$, where θ_{hj} is the health shock of member j. When $\theta_{hj} = 0$, member j is healthy and does not require any medical care. When $\theta_{hj} > 0$, θ_{hj} is the amount of *necessary* medical care in monetary value that is required for member j. The household's belief about the distribution of $\boldsymbol{\theta}_h$ is denoted by $F_{\boldsymbol{\theta}_h}$. Finally, an insurance bundle for household h is represented by $\boldsymbol{\kappa}_h := (\kappa_{hj})_{j=1,2,\ldots,n_h}$, where $\kappa_{hj} \leq 1$ is the coinsurance rate of member j. For example, $\kappa_{hj} = 1$ means that j has no insurance, while $\kappa_{hj} = 0$ means that j has full insurance.

The time line is as follows. In period 1, given the set of available insurance bundles, the DM chooses a bundle $\boldsymbol{\kappa}_h$ and incurs a premium of $\pi(\boldsymbol{\kappa}_h)$.[21] In period 2, health shocks

[21]Note that in Vietnam's SHI setting, each household takes the coinsurance rate under insurance as given but could choose to buy insurance for any subset of its members. For example, if the coinsurance rate is 20%, a household of size 2 can choose the following bundles $\{(1, 0.2), (0.2, 1), (1, 1), (0.2, 0.2)\}$.

$\boldsymbol{\theta}_h$ are realized. Given the health shocks and the insurance bundle chosen in period 1, the DM then chooses the consumption basket $(c_h, \mathbf{m}_h)$. Let $U_h(c_h, \boldsymbol{m}_h | \boldsymbol{\theta}_h)$ be a weighted sum of all the household members' utility under consumption basket $(c_h, \boldsymbol{m}_h)$ and health shocks realization $\boldsymbol{\theta}_h$. The objective of the DM is to maximize the ex-ante expected value of U_h.

5.1 Period 2: Choice of Medical Care Utilization

Using backward induction, I first solve for the DM's optimal consumption in period 2. Taking the insurance bundle $\boldsymbol{\kappa}_h$ and the health shocks $\boldsymbol{\theta}_h$ as given, the DM's utility maximization problem is:

$$U_h^*(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h) := \max_{c_h, \boldsymbol{m}_h} U_h(c_h, \mathbf{m}_h | \boldsymbol{\theta}_h)$$

subject to the budget constraint: $c_h + \mathbf{m}_h \cdot \boldsymbol{\kappa}_h \leq Y_h - \pi(\boldsymbol{\kappa}_h)$. The right hand side of the budget constraint is the net household income after paying for the insurance premium, and the left hand side is the expenditure of the consumption good and the OOP costs of medical care.

As mentioned previously, the (Marshallian) demand for medical care of member j should exhibit income effect, moral hazard, and cross-member effects. By the integrability theorem (Hurwicz, 1971), the ordinal utility function U can be pinned down if the demand system of the household is known. Thus, I will directly make assumptions on the demand system to exhibit these properties; Appendix B provides the details to recover the underlying utility function U_h.

Let the residual income of the household be:

$$R(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h) := Y_h - \pi(\boldsymbol{\kappa}_h) - \boldsymbol{\theta}_h \cdot \boldsymbol{\kappa}_h - (\text{subsistence expenditure})$$

The residual income is the remaining of household income after paying for the health insurance premium $\pi(\boldsymbol{\kappa}_h)$, the total OOP costs of necessary care for all household members $\boldsymbol{\theta}_h \cdot \boldsymbol{\kappa}_h$, and the subsistence expenditure.[22] I assume that the demand for medical care takes

[22]Following Xu et al. (2003), the subsistence expenditure is calculated as the expenditure on food for households between the 35 and the 55 percentile of income.

the following functional form:

$$m_{hj}\left(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h\right) = \underbrace{\theta_{hj}}_{\text{Necessary medical care}} + \underbrace{\delta_{hj}\theta_{hj}\Bigg(\max\left\{R\left(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h\right), 0\right\}\Bigg)^{\omega_h}\Bigg(1+\kappa_{hj}\Bigg)^{-\gamma_{hj}}}_{\text{Optional medical care}} \tag{5.1}$$

The demand of medical care consists of two components: a necessity component, which is the same as the health shock θ_{hj}, and an optional component. The optional care exhibits all three features: (1) income effect, (2) moral hazard, and (3) cross-member substitution effect. First, the optional care is positive and dependent on the household income only if the household has positive residual income $R()$, in other words, if the household is sufficiently wealthy. Second, the amount of optional care for each member is negatively affected by his coinsurance rate κ_{hj}, implying moral hazard. Third, if a household member has higher coinsurance rate of medical care, the household has to pay more OOP cost for his necessary care, lowering the residual income and reducing the amount of optional care for all other household members. This implies that the amount of medical care of different members are substitutes.[23]

The income elasticity of medical care is represented by $\omega_h > 0$, which is common across all household members within a household h. The demand for medical care of different household members can exhibit different degrees of moral hazard, which is characterized by the moral hazard coefficient $\gamma_{hj} > 0$. The functional form of this moral hazard is chosen such that there exists an upper bound on medical utilization when medical care is free (coinsurance rate is 0), which also implies that the marginal utility of medical care is zero for sufficiently high amount of spending.[24] I also allow for an individual-household-specific weight δ_{hj}, which represents the bargaining weight of each household member, to allow for different levels of optional care relative to the necessary care. In addition, the optional care is assumed to be linearly dependent on the necessary care.[25]

[23] To see this, note that when $\tilde{\kappa}_{hj} > \kappa_{hj}$, the household needs to be given an additional amount of income $\Delta_Y > \theta_{hj}(\tilde{\kappa}_{hj} - \kappa_{hj})$ in order to afford the original basket under κ_{hj}. This implies that $\tilde{m}_{hi} > m_{hi}$ for $i \neq j$.

[24] An alternative way to prevent infinite consumption at zero price is an utility function that exhibits a bliss point (for example, see (Einav et al., 2013)). The only advantage of the functional form chosen in this paper is that it generates a convenient indirect utility function for a multiple household model as will be shown later.

[25] Under a more general specification $m_{hj}\left(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h\right) = \theta_{hj} + \delta_{hj}\theta_{hj}^{\alpha}\Bigg(\max\left\{R\left(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h\right), 0\right\}\Bigg)^{\omega_h}\Bigg(1+\kappa_{hj}\Bigg)^{-\gamma_{hj}}$, the estimated α is very close to 1.

Next, the resulting indirect utility function (See Appendix B) is:[26]

$$U^*\left(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h\right) = \begin{cases} \frac{(R(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h)))^{1-\omega_h}}{1-\omega_h} - \sum_{j=1}^{n_h} \delta_{hj}\theta_{hj}\frac{\left(1+\kappa_{hj}\right)^{1-\gamma_{hj}}-1}{1-\gamma_{hj}} & \text{if} \quad R(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h)) > 0 \\ R(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h)) - u & \text{Otherwise} \end{cases} \tag{5.2}$$

When the residual income is positive, the first term of Equation (5.2) is an increasing function of the residual income and thus could be considered the indirect utility from income. The second term is an increasing function of each member's health shock and also an increasing function of the price of medical care. This disutility is normalized such that when medical care is free, the disutility degenerates to 0. This implies that any disutility from sickness disappears when an individual receives enough medical care.

When the residual income is non-positive, the household only consumes the necessary care. The disutility from being sick here is equivalent to an income loss from having to pay for the necessary care. In this case, the residual income needs to be normalized by a sufficiently large constant $u > 0$ to ensure that the utility is increasing in Y_h.

5.2 Period 1: Choice of Health Insurance

The household's risk preference is parameterized by a CARA function with a household-specific risk parameter r_h. Let K_h be the set of insurance bundles offered.[27] The DM's period-1 optimization problem is

$$\max_{\boldsymbol{\kappa}_h \in K_h} \ \mathbb{E}_{\boldsymbol{\theta}_h} - \exp\Big(- r_h U^*\left(\boldsymbol{\theta}_h, y_h, \boldsymbol{\kappa}_h\right) \Big) \tag{5.3}$$

Equation (5.3) yields characterizations of the willingness to pay for insurance in terms of risk aversion r_h, distribution of health shocks $F_{\theta_{hj}}$, the moral hazard coefficient γ_{hj}, and the weight of the optional care δ_{hj}. For any member, the household has higher willingness to pay for insurance if its risk aversion is higher, if the household's belief about his health shock is worse, or if the weight of the optional care is higher. The comparative static with respect to the moral hazard coefficient γ_{hj} is less straightforward. The presence of γ_{hj} increases the willingness to pay for insurance since an insured individual is going to increase his medical utilization due to the price decrease of medical care. At the same time, the individual's

[26]Note that this is only unique up to a monotone transformation.

[27]To be precise, the set of insurance bundles available to each household is only household-specific because household has different sizes.

flexibility in medical utilization suggests that the household's marginal utility of his medical care is relatively low, lowering the household's willingness to pay for his insurance. In my model, the latter effect dominates the former, and the household's willingness to pay for insurance is a decreasing function of γ_{hj}.

More importantly, even when all household members have identical preferences for medical care $(\gamma_{hj}, \delta_{hj})$ and distribution of health shocks $F_{\theta_{hj}}$, the household's willingness to pay for the second member's insurance is lower than that of the first.[28] In other words, health insurance for different members are substitutes. The intuition is the following. When the household chooses to insure the first member, the household expects to have more residual income in the second period. Since medical utilization has decreasing marginal utility, the benefit of having insurance thus being able to consume more medical care for the second member becomes less significant.[29]

Implication of Within-household Selection In my model, when the price of insurance for every household member is the same, the household could choose to be partially insured due to one of the following factors. First, the household believes that some members are sicker and have worse health shocks. Second, the household might only buy insurance for members who have high bargaining weight δ_{hj} and hence higher optional medical care. In both cases, the cost of providing insurance for the additional member is lower than that of the first, corresponding to within-household adverse selection.

On the other hand, partial enrollment in insurance does not necessarily imply within-household adverse selection. Due to the income effect, the household might be partially insured even when all members are identical. In this case, having more household members into insurance does not affect the average cost of providing insurance. In addition, in the extreme case in which selection into insurance only occurs due to the differences in the degree of moral hazard, the cost of providing insurance for the additional member is higher for the insurer, implying advantageous selection.[30]

[28] This substitutability arises only from the income effect of the demand for medical care because of the CARA assumption on risk preferences. An alternative specification such as CRRA would lead to a decrease in willingness to pay even without income elasticity ($\omega_h = 0$).

[29] Using similar logic, the household has lower willingness to pay for one member if other members become healthier.

[30] Einav et al. (2013) provides an alternative functional form that gives rise to (adverse) selection in moral hazard. In Vietnam's SHI context, there is no clear evidence of whether advantageous or adverse selection in moral hazard occurs.

6 Identification and Estimation

In this section, I explain how the distribution of the parameters of the demand for medical care $\left(\omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h\right)$ and risk preference r_h are identified under parametric assumptions on the household's belief about health shocks.

Throughout this section, I assume that the household's beliefs about the distribution of health shocks are correct, and the household's preference parameters $(\omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h)$ are constant over time. Identification is achieved in two steps. In the first step, the data on medical utilization is used to recover the parameters that characterize the household's demand for medical care. In the second step, the data on insurance choice combined with some assumptions on risk preferences identify both the household's beliefs about health shocks and the distribution of risk aversion. In Appendix C, I show how identification can be achieved without Equation (5.1) but will require more data.

6.1 Identification

In the data, a household is only observed for at most two periods, and the household could choose among at most 2^{n_h} insurance bundles, each of which specifies the set of voluntarily insured household members. An individual could belong to the compulsory group, the policy beneficiaries group, or be eligible for voluntary SHI. There is also substantial variation in coinsurance rates across enrollee types and years (Table 3.1).

Let Z_{hj} be an indicator variable, taking a value of 0 if an individual has compulsory or free health insurance. Let X_{hj} denote a vector of observed characteristics of individual j in household h, and X_h denote a vector of observed characteristics of household h. Note that both X_{hj} and X_h do not include household income Y_h. Let $q_s(X_{hj}) \in [0, 1]$ be the probability that an individual with observed characteristics X_{hj} has $\theta_{hj} > 0$. The household's belief about θ_{hj} is parameterized as the following:

$$\theta_{hj} = \begin{cases} 0 & \text{With probability } q_s(X_{hj}) \\ \sim \log N(\bar{\theta}_{hj}, \sigma_\theta) & \text{With probability } 1 - q_s(X_{hj}) \end{cases}$$

For individuals with similar observed characteristics X_{hj}, the only difference in their distribution of health shocks is represented by $\bar{\theta}_{hj}$. Thus, any unobserved heterogeneity in $\bar{\theta}_{hj}$ indicates adverse selection in health types, and $\bar{\theta}_{hj}$ is henceforth termed as the individual's *health type*. In addition, conditional on $\bar{\boldsymbol{\theta}}_h$, the realizations of the health shocks $\boldsymbol{\theta}_h$ are assumed to be independent across household members. The mixed distribution was empirically motivated as a large fraction of individuals in the data has no medical utilization, and the distribution of OOP costs once medical utilization occurs is highly skewed.

The household's risk aversion r_h is assumed to be log-normally distributed:

$$r_h \sim \log \mathcal{N}(X_h \beta_r, \sigma_r)$$

Assumption 6.1.

a) δ_{hj}, γ_{hj}*,* ω_h*, and* $\bar{\theta}_{hj}$ *are mutually independent conditional on* X_{hj}*.*

b) $(\delta_{hj}, \gamma_{hj}, \omega_h, \bar{\theta}_{hj}) \perp Z_{hj}, Y_h | X_{hj}$*.*

c) The distributions of $(\delta_{hj}, \gamma_{hj}, \omega_h, \bar{\theta}_{hj})$ *can be identified from their integer moments.*

Assumption (6.1.a) is needed because of the nonlinearity of θ_{hj} in Equation (5.1). Assumption (6.1.b) implies that there is no selection into enrollment types, which also suggests that there is no selection into job types based on preferences for medical care or health types. This assumption is likely to be valid in Vietnam's SHI context. This is because as of 2004 (the beginning of the data sample), both voluntary SHI and compulsory SHI are available. Furthermore, the premium of compulsory SHI is indexed to the individual wage, which is higher than the minimum wage. Hence, compulsory SHI's premiums are higher than that of voluntary SHI (Table H.12). In addition, the cost-sharing policy for the two enrollee types are largely similar.[31] Assumption (6.1.b) also assumes that the distribution of the preference parameters and health shocks are independent of household income conditional on observed characteristics. This assumption is necessary to identify the income effect.

Proposition 6.1. *Under Assumption (6.1), the distributions of* $\delta_{hj}, \gamma_{hj}, \omega_h$ *are identified.*

In our setting, the income effect is highly nonlinear in the latent health shock θ_{hj} and the income elasticity ω_h, preventing us from directly applying previous work in the literature on identification of nonlinear random coefficient model, especially on continuous demand system (for example, Lewbel and Pendakur (2017)). Instead, identification here is achieved for each parameter sequentially using only the sample with exogenous insurance status ($Z_{hj} = 0$). I also normalize the average household income to 1. In the first step, data on individuals

[31] In another setting such as the employer-sponsored health insurance market in the US, this assumption is unlikely to hold. For example, Madrian (1994) found that people are less likely to switch jobs to retain their health insurance provided by the current firm.

with full insurance whose family members did not incur any medical care and with average household income ($Y_h = 1$) is used to identify the distribution of δ_{hj}. In the second step, the distribution of income elasticity ω_h is identified from the variation in medical care of the same set of individuals but at different income levels. In the third step, the distribution of moral hazard γ_{hj} is identified using the now known distribution of δ_{hj}, ω_h and the variation in coinsurance rates.

In these steps, the parameterization of the household's belief about θ_{hj} is not required. The distribution of $\bar{\theta}_{hj}$ is also not identified. This is because there is no information about health types for individuals with exogenous insurance status, and only the unconditional distribution of θ_{hj} can be identified. The parameters (β_r, σ_r, σ_θ) characterizing the parametric distribution of θ_{hj} and r_h are then identified parametrically from households' choices of insurance bundle.

6.2 Estimation

The main computational challenge involves the estimation of the expected indirect utility (Equation 5.3), which determines the household's choice of the optimal insurance bundle. In a multiple-member household, the computation of the household's indirect utility involves integrating over the household's belief of all household members' health shocks. In addition, since I allow for unobserved heterogeneity in all demand parameters $(\omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h)$ as well as risk aversion r_h, approaches such as maximum likelihood or method of moments require integration of the random coefficients for all combinations of household and individual observed characteristics. Because household compositions vary, these methods are computationally burdensome. Thus, I opt for a Bayesian approach using Gibbs sampler with Hamiltonian Monte Carlo (HMC) (Neal et al., 2011). HMC converges much faster than the traditional Metropolis-Hasting algorithm but requires the computation of the posterior's gradient. HMC sampling is done in Stan (Carpenter et al., 2016).

To aid with estimation, I assume additional distributional assumptions on $(\omega_h, \boldsymbol{\delta}_h, \boldsymbol{\gamma}_h)$ as the following:

$$\omega_h \sim \log \mathcal{N}(X_h \beta_\omega, \sigma_\omega)$$
$$\delta_{hj} \sim \log \mathcal{N}(X_{hj} \beta_\delta, \sigma_\delta)$$
$$\gamma_{hj} \sim \log \mathcal{N}(X_{hj} \beta_\gamma, \sigma_\gamma)$$

The probability of $\theta_{hj} = 0$ is also parameterized as $q_s(X_{hj}) = \frac{\exp(X_{hj}\beta_s)}{1+\exp(X_{hj}\beta_s)}$.

The health types of members within a household are allowed to be correlated and follow a multivariate normal distribution:

$$\bar{\boldsymbol{\theta}}_h = \boldsymbol{X}_h\beta_\theta + \boldsymbol{W}_h\lambda_h + \begin{bmatrix} \epsilon_{h1} \\ \vdots \\ \epsilon_{hn_h} \end{bmatrix}$$

$\lambda_h \sim \mathcal{N}(0, \sigma_\lambda)$ is the household-specific type and uncorrelated with the idiosyncratic shocks ϵ_{hj}, where $\epsilon_{hj} \sim \mathcal{N}(0, \sigma_\epsilon)$.[32] $\boldsymbol{W}_h := (W_{hj})_{j=1,\ldots,n_h}$ represents the effect of the household's common shock to each household member. W_{hj} is linearly dependent on member's observed characteristics $W_{hj} = X_{hj}\beta_W$. Since we could always rescale $\boldsymbol{W}_h$ by rescaling λ_h, σ_λ is normalized to 1. The covariance matrix of the household's health types is then given by:

$$\Omega_h = \boldsymbol{W}_h\boldsymbol{W}_h' + \sigma_\epsilon^2$$

In the empirical framework of Section 5, there is no uncertainty about the coinsurance rate in the second period. In the data, however, I observe that most insured individuals pay more than the coinsurance rates of the insurance contract because some medical expenses are not covered under SHI. Let $\zeta_{hj} \in [0, 1]$ be the fraction of annual medical expense that is eligible for insurance coverage, the actual out-of-pocket coinsurance rate is given by:

$$\tilde{\kappa}_{hj} = (1 - \zeta_{hj}) + \zeta_{hj}\kappa_{hj}$$

For example, if the coinsurance rate specified in the insurance contract is 0.2, and all medical expenses are eligible for insurance coverage, $\zeta_{hj} = 1$, and $\tilde{\kappa}_{hj} = \kappa_{hj} = 0.2$. If only 40% of medical expenses are eligible for insurance coverage, $\zeta_{hj} = 0.4$, and $\tilde{\kappa}_{hj} = 0.6 + 0.4 \times 0.2 = 0.68$. While ζ_{hj} is observed for 2008, it is not observed for other years. It is therefore assumed

[32] When a household is observed for two periods, I assume that the preference parameters ω_h, r_h, γ_{hj}, and δ_{hj} are constant over time. Members' health types could be serially correlated through the serial correlation in λ_{ht}. Although I do not directly estimate this serial correlation since it is not the focus of my analysis, the estimation relies on the unconditional distribution of λ_{ht}, and hence my estimates are consistent with any process of λ_{ht} as long as it is stationary.

Table 6.1 – Summary of Parameters for Estimation

Parameters	Notes
Distribution of Health Types and Health Shocks	
β_θ	Mean shifter for the average health types
σ_ϵ	Distribution of individual-specific component
β_W	Effect of HH-specific component on health types
σ_θ	Uncertainty in the distribution of health shocks
β_s	Mean shifter for the probability of sickness
Preference for Medical Utilization	
β_ω	Mean shifter for income elasticity
σ_ω	SD of unobserved heterogeneity in income elasticity
β_γ	Mean shifter for moral hazard
σ_γ	SD of unobserved heterogeneity in moral hazard
β_γ	Mean shifter of the weight of optional care
σ_γ	SD of unobserved heterogeneity in the weight of optional care
Risk Preference	
β_r	Mean shifter for risk aversion
σ_r	SD of unobserved heterogeneity of risk aversion
Probability of Insurance Coverage	
$\beta^0_\zeta, \beta^1_\zeta$	Probability of zero and full coverage

that the distribution of ζ_{hj} is the same across years and parameterized as the following:

$$\zeta_{hj} = \begin{cases} 0 & \text{With probability } p_0(X_{hj}) \\ 1 & \text{With probability } p_1(X_{hj}) \\ \sim U(0,1) & \text{With probability } 1 - p_0(X_{hj}) - p_1(X_{hj}) \end{cases}$$

where $p_0(X_{hj}) = \frac{\exp(X_{hj}\beta^0_\zeta)}{1+\exp(X_{hj}\beta^0_\zeta)+\exp(X_{hj}\beta^1_\zeta)}$ and $p_1(X_{hj}) = \frac{exp(X_{hj}\beta^1_\zeta)}{1+\exp(X_{hj}\beta^0_\zeta)+\exp(X_{hj}\beta^1_\zeta)}$. I also assume that households have correct beliefs and no private information about the distribution of ζ_{hj}. This parameterization essentially assumes that households know for certain that some diseases are covered and some are not covered. However, for other diseases, households do not know whether the diseases are covered or not. As shown in Figure (G.5), the majority of individuals either receive no coverage or complete coverage, therefore the uniform distribution assumption does not have a large effect on the estimation.

The object of interests are summarized in Table 6.1. Conditional on these hyper-parameters, $(\bar{\boldsymbol{\theta}}_h, \omega_h, r_h, \boldsymbol{\delta}_h, \boldsymbol{\gamma}_h)$ can be drawn independently across households. The parameters characterizing the probability of an individual being sick β_s and the distribution of ζ_{hj}

are estimated independently of the other parameters using the observed data on whether the individual incurred any medical utilization and the actual coverage probability. The detailed sampling algorithm for all parameters is included in Appendix E.

7 Results

Table (H.5) in the Appendix presents the estimates of all parameters from the model. Table (7.1) shows the implied distributions of the parameters characterizing the preferences for medical care as well as households' risk preferences, the distribution of health types, and the distribution of medical care consumption.

Table 7.1 – Implied Quantities of Preference, Health Shocks, and Medical Care

Variable	Mean	St. Dev.	25 pct	50 pct	75 pct
Moral Hazard Coefficient (γ)	0.758	0.293	0.549	0.707	0.909
Income elasticity (ω)	0.589	0.381	0.329	0.494	0.739
Risk Aversion Coefficient (r)	1.006	0.026	0.990	1.008	1.023
Health Types ($\bar{\theta}$)	-5.309	1.361	-6.215	-5.292	-4.382

Medical Care (KVND)	Mean	St. Dev.	75 pct	95 pct
Necessary Medical Care	441.8	2,541.9	132.7	1,893.6
Medical Care - Full Insurance	652.9	3,950.8	179.6	2,729.3
Medical Care - No Insurance	539.7	2,896.5	161.6	2,361.1
Medical Care - Current Contract	566.9	3,204.1	164.8	2,436.1
Necessary Medical Care (>0)	1,216.9	4,105.3	946.7	4,656.1
Medical Care - Full Insurance (>0)	1,798.2	6,397.9	1,340.1	6,913.6
Medical Care - No Insurance (>0)	1,486.6	4,658.3	1,179.2	5,808.4
Medical Care - Current Contract (>0)	1,561.5	5,169.5	1,206.8	6,054.4

Medical Care (% of HH Income)	Mean	St. Dev.	75 pct	95 pct
Necessary Medical Care	1.1	7.2	0.3	4.6
Medical Care - Full Insurance	1.4	8.6	0.4	6.0
Medical Care - No Insurance	1.2	7.4	0.4	5.3
Medical Care - Current Contract	1.3	7.7	0.4	5.5
Necessary Medical Care (>0)	3.1	11.8	2.2	11.9
Medical Care - Full Insurance (>0)	3.9	13.8	3.0	15.2
Medical Care - No Insurance (>0)	3.4	12.0	2.7	13.5
Medical Care - Current Contract (>0)	3.5	12.4	2.7	13.9

Note: The current contract is the 2012 SHI contract for each enrollee type. The full insurance contract has $\kappa_{hj} = 0$ with complete coverage.

The average moral hazard coefficient γ is estimated to be 0.758, which implies an arc-elasticity on optional care of -0.248. This is similar to previous estimates in the literature, which are between -0.1 and -0.4 (Chandra et al., 2010).[33] My estimates suggest that moral hazard exists but does not have a big impact on medical care consumption. On average, household members spend 113 KVND more when switching from being uninsured to having full insurance.[34] This represents a 17% increase in total medical care consumption.

The average income elasticity ω is 0.589. This is higher than the reduced form correlation found in Section 4, which was between 0.204 and 0.316. It is important to note that both the moral hazard coefficient γ and income elasticity ω only affect the optional care. The total effect on medical care, which includes necessary care, will therefore be lower because the necessary care does not respond to changes in coinsurance rates or income. The average risk aversion coefficient is 1.0. To understand its magnitude, consider a household with the average income ($Y_h = 1$) who has a *financial* risk that might occur with 50% probability. If the risk occurs, the household will lose 5% of their household income. In this case, the estimated risk coefficient implies that the household is willing to pay 3.56% of their income to insure against this risk.

The average necessity care for each individual is 441.8KVND and accounts for 1.1% of household income. Under the observed 2012 insurance contract, the amount of medical care consumed for each household member is approximately 1.3% of the household income. Total medical care consumption of the household is on average 5.2% since each household has on average 4 members (Table 3.3). This estimate is similar to other aggregate measures of national health expenditure of Vietnam. For example, the World Bank estimated that health expenditure in Vietnam is between 5% to 7% of GDP in the 2004-2012 period (World Bank, 2016). The estimates also suggest that health shocks could be a significant financial burden once they occur. When $\theta_{hj} > 0$, the average necessary medical care is equivalent to 3.1% of household income. At the 95th percentile, the amount of necessary medical care required is 11.9% of household income.

Within-Household Selection and the Source of Selection There are two potential sources of selection that could explain households' partial insurance enrollment: (1) heterogeneity in members' preferences for medical care $(\boldsymbol{\gamma}_h, \boldsymbol{\delta}_h)$, and (2) heterogeneity in health types $\bar{\boldsymbol{\theta}}_h$.

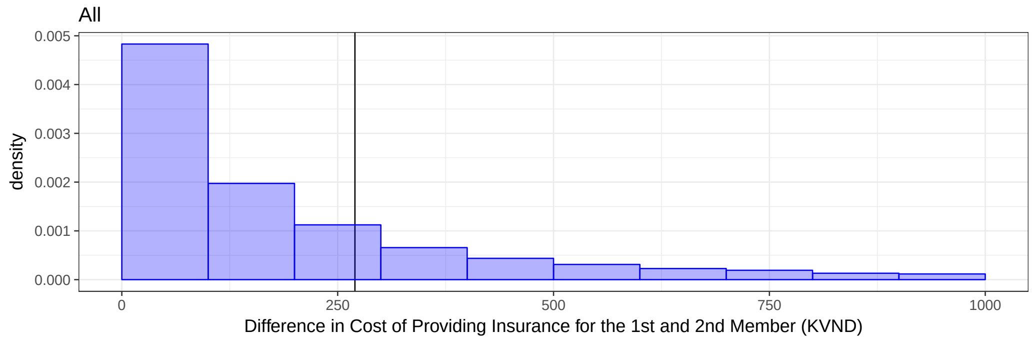
To study the source of selection, for each household I first identify two members for

[33] Following Keeler and Rolph (1988), the arc elasticity is defined as $\frac{(m_2-m_1)/(m_1+m_2)/2}{(\kappa_2-\kappa_1)/(\kappa_1+\kappa_2)/2}$. In this calculation, the arc-elasticity is measured as the change from uninsured to complete insurance ($\kappa_2 = 0$, $\kappa_1 = 0$).

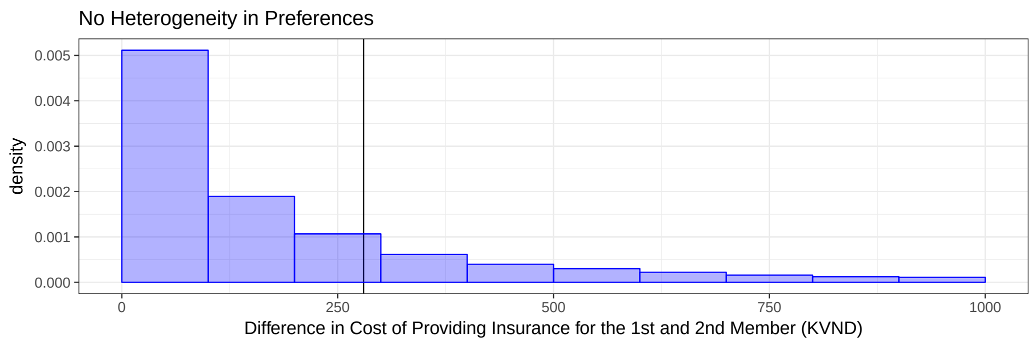
[34] This means that coinsurance rate is 0%, and all medical expenses are covered in the insurance contract.

Figure 7.1 – Distribution of Difference in the Expected Cost of Providing Full Insurance for First and Second Members

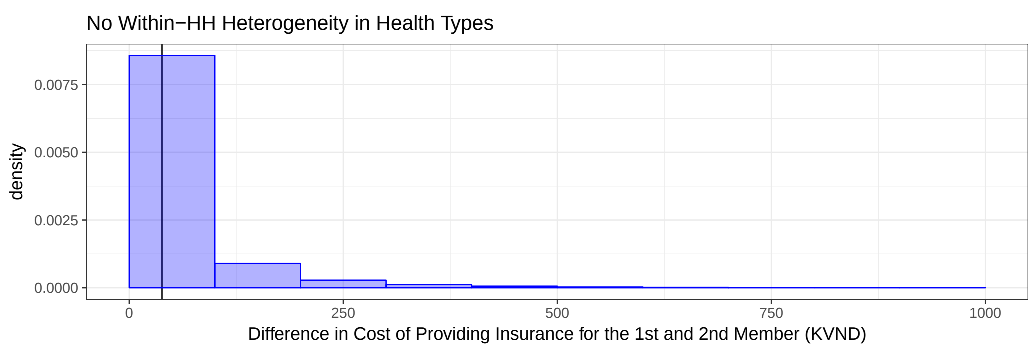
(a)



(b)



(c)



Note: Black lines represent the mean of the distribution

whom the household has the highest willingness to pay (WTP) for full insurance, assuming that the household could only buy insurance for at most one member. The two members are henceforth termed the first and the second member. Under adverse selection, the cost of providing full insurance for the first member must be higher than the cost of providing full insurance for the second member. Panel (a) of Figure (7.1) graphs the distribution of the difference in the cost of providing full insurance for the two members for all households under the estimated distribution of health types and preferences for medical care. Panel (b) graphs the distribution under the assumption that there is no difference in the preferences for medical care within each household, and $(\boldsymbol{\gamma}_h, \boldsymbol{\delta}_h)$ are assumed to take the mean value of the actual draws within each household. Panel (c) assumes that there is no heterogeneity in health types. That is, the health type of each household member $\bar{\theta}_{hj}$ is assumed to take the mean value of the actual draws of $\bar{\boldsymbol{\theta}}_h$.

When full heterogeneity is allowed, the difference between the cost of providing full insurance for the first and the second members is on average 260 KVND, approximately 59% of the average necessary care (Panel a). This suggests that within-household adverse selection exists. When the within-household heterogeneity in the preferences for medical care is removed, the average difference in the cost of insurance is 270 KVND (Panel b). The increase in the average difference from 260 KVND to 270 KVND when the preference heterogeneity is eliminated implies that there is a small degree of selection on moral hazard.[35]

The largest change occurs in Panel (d), which eliminates all heterogeneity in health types within each household. The average difference in the cost of providing full insurance in this case is only 30 KVND, 12% of the original difference in Panel (a). This suggests that within-household adverse selection is mainly caused by the heterogeneity in health types.

Within and Across Household Adverse Selection According to Table (7.2), within-household variance accounts for 40% of the total variance in health types, implying significant within-household adverse selection. In addition, a large portion of both the within and across household variance cannot be explained by observed individual and household characteristics. For example, only 43% of the within-household variance is due to the difference in age among household members. Variation in household size and household age composition explains only between 1% to 4% of the total across-household variance. These results suggest that even if the government can price based on observed individual and household characteristics, both within and across household adverse selection cannot be fully resolved.

Income Effect and the Substitutability of Insurance As mentioned in Section 5, the role of income effect here is twofold. First, it rationalizes the difference in the consumption of medical care across households with different income level. Second, it affects the household's

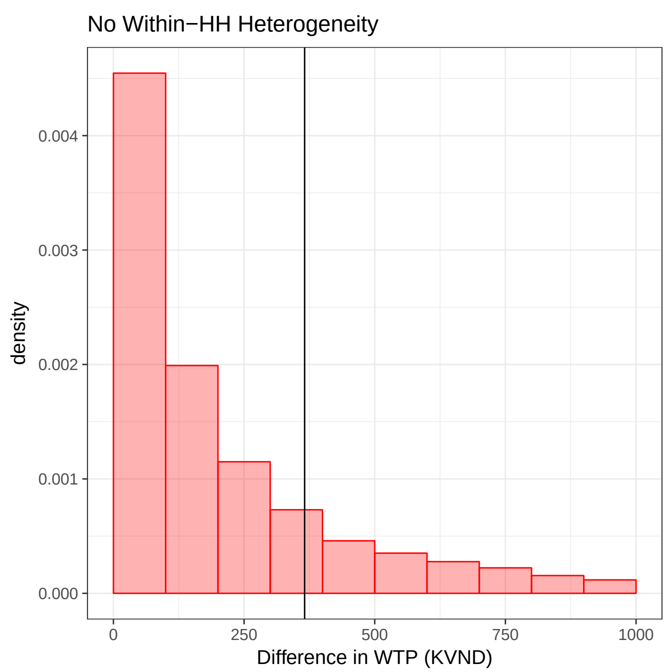
[35] As previously mentioned, the parametric assumption on the demand for health insurance exhibits an advantageous selection in moral hazard.

Table 7.2 – Variance Decomposition of Health Types Within and Across Households

	Variance	Percentage
Within-Household		
Total	0.70	39.54%
Due to Age Differences	0.30	43.08%
Across-Household		
Total	1.07	60.46%
Due to Household Size	0.02	1.51%
Due to Number of Members above 65	0.01	1.24%
Due to Number of Members under 18	0.04	3.44%
Total Variance	1.77	

willingness to pay for an additional member's insurance. Figure (7.2) depicts the distribution of the willingness to pay for the first and the second full insurance, assuming that all household members have identical preferences for medical care and identical distribution of health shocks. The average decrease in WTP is estimated to be 370 KVND, approximately 84% of the average necessary care.

Figure 7.2 – Distribution of the Difference in WTP for 1st and 2nd Full Insurance with Identical Members



Note: Black line represents the mean of the distribution.

Model Fit In the following, I compare the predicted and actual distribution of OOP costs and insurance enrollment on the set of households that were excluded from estimation. These are households that have at least 1 member eligible for voluntary SHI under the household bundling policy of 2006.

This out-of-sample fit exercise serves two purposes. First, since this sample includes only households with members eligible for voluntary SHI, a reasonable out-of-sample fit provides reassurance for the assumption on no selection on enrollee types (Assumption 6.1.b). Furthermore, it also alleviates concerns about possible non-monetary costs associated with household bundling that are not being modeled. An example of such cost could be the cost of providing evidence of household membership, or evidence that some members have compulsory SHI or are policy beneficiaries.

The results of the out-of-sample fit are reported in Table (8.1). The average OOP cost is predicted to be 225.2 KNVD, close to the actual OOP cost of 226.1 KVND. The fit across different age group is also reasonable. The model slightly under-predicts the average OOP cost for households in the second income quantile (218.5 KVND compared to 184.5 KVND), and over-predicts for the forth income quantile (242 KVND compared to 354 KVND). The predicted insurance enrollment is 16.24%, within 95% confidence interval of the actual enrollment rate of 15.77%. The model also performs reasonably in predicting enrollment for different age groups and income groups and other demographics.

In Table (H.6) in the Appendix, I report the actual and in-sample prediction of OOP costs for the entire sample and each subgroup of the population. The model predicts an average OOP cost of 425.33 KVND, comparable to the actual sample average of 384 KVND. The over-estimation of spending concentrates at households with lower income and individuals above the age of 64. The in-sample prediction of insurance enrollment is 11.9%, slightly higher than the actual enrollment rate of 9.6%. This again is a consequence of the over-prediction of medical spending across low income households. It is important to note that household income only affects medical spending and insurance enrollment through the income effect and does not enter as mean shifters of any parameters.

8 Effect of Household Bundling Policy

This section studies the welfare consequence of a household bundling policy using the results from the structural household choice analysis. In the counterfactual exercises, I assume that the social planner, who is the sole provider of health insurance, choose insurance premium

Table 8.1 – Out-of-sample Fit

Characteristics	Predicted Spending	Actual Spending	N
College Education	239.9103 (15.0963)	245.0986	5986
Married	274.2368 (5.1554)	267.288	24497
Female	274.1153 (9.0397)	234.8549	17394
Employed	194.0749 (10.7596)	190.5092	8572
18 - 35	153.6107 (9.181)	191.1943	9374
35 - 54	270.0012 (8.5003)	288.7687	9302
54 - 64	471.3137 (39.1556)	420.0507	2248
64 -	580.0835 (54.8308)	556.4151	2339
Income - 1st Quantile	225.2543 (4.5977)	226.2117	34447
Income - 2nd Quantile	218.5689 (13.8126)	184.5859	7982
Income - 3rd Quantile	248.9544 (12.836)	245.827	8262
Income - 4th Quantile	242.6043 (14.5191)	354.7564	8942
Full Sample	225.1972 (4.5995)	226.1494	34457

Characteristics	Predicted Enrollment	Actual Enrollment	N
College Education	0.193 (0.0104)	0.1674	2592
Married	0.1609 (0.0044)	0.1761	12965
Female	0.1649 (0.0038)	0.1747	9117
Employed	0.1492 (0.0044)	0.1392	4707
18 - 35	0.1617 (0.0083)	0.1314	5717
35 - 54	0.1417 (0.0053)	0.1809	6346
54 - 64	0.2218 (0.0131)	0.2292	1296
64 -	0.2588 (0.0105)	0.2484	1409
Income - 1st Quantile	0.1459 (0.0086)	0.1197	3784
Income - 2nd Quantile	0.1522 (0.0074)	0.1538	4453
Income - 3rd Quantile	0.1626 (0.0094)	0.1715	4705
Income - 4th Quantile	0.1862 (0.0161)	0.1787	4527
Full Sample	0.1624 (0.0045)	0.1577	17469

Note: The out of sample fit was conducted on the sample of households in 2006 that have at least 1 member eligible for household bundling. Enrollment is only calculated on individuals who are eligible for voluntary SHI. Also, a household might have both eligible and ineligible members.

and whether to implement household bundling to maximize the consumer surplus.

If medical care consumption does not respond to coinsurance rates or income, it is equivalent to a pure income loss. In this case, the welfare consequence of a household bundling policy hinges only on the distribution of risk types within and across households and household risk preferences. The mechanism of how a household bundling policy can improve social welfare is through the potential enrollment of healthier household members, which reduce the average cost of insuring the population for the social planner and subsequently allow premium to decrease. The reduction in premium will allow more healthier households to enroll in insurance, and the cycle continues.

Whether a household bundling policy can attract a healthier population in the first place, however, depends crucially on the distribution of health types in the population. The policy works best in a scenario in which households have similar risk compositions, i.e. no across-household adverse selection. When this is the case, the welfare loss from adverse selection is eliminated even in the presence of within-household adverse selection, as the social planner could offer an insurance bundle at a price that is low enough for *all* households to enroll. The results from the structural model confirms that there is significant within-household adverse selection, which is mainly caused by the heterogeneity in within-household health types. However, across-household adverse selection also exists. Therefore, household bundling might lead to the complete drop out of some relatively healthier households, which might raise the average cost of the insurance pool.

When medical consumption responses to changes in the price of coinsurance rates and income, as in the context of this paper, the income effect also plays a central role in determining whether a household bundling policy improves welfare. This is due to the interdependency in household's willingness to pay for insurance among members. As previously mentioned, the potential premium reduction in household bundling comes from the cost reduction of having healthier household members buying health insurance. With the income effect, however, this premium reduction needs to be sufficiently large to offset the lower willingness to pay for the insurance bundle due to the income effect.

The setting of the counterfactual exercises resembles the actual SHI program. The social planner operates under a budget constraint but is allowed to provide a fixed subsidy for the entire population. Consumer surplus here is measured as the willingness to pay for insurance at a given contract net of the insurance premium. The insurance cost-sharing policy is fixed at the observed 2012 policy, which features 0% coinsurance rate for expense below 100 KVND, and 20% for higher expenses. Similar to what have been implemented in practice, the set of potential prices considered here is indexed to the minimum wage (MW), which varies across geographical area, and the social planner does not price discriminate based on other individual or household demographics. I also limit all potential prices per member to be under 6% of MW, aligned with the Health Insurance Law of 1998. This restriction also significantly reduces the choice space of prices. The counterfactual analysis is done on the sample of households in the year of 2012.

In the first exercise, I consider a uniform pricing policy in which all potential enrollees pay the same per-member premium. I then extend the analysis to the case in which the government could choose nonlinear prices based on the bundle size for both individual purchase and household bundling. This second exercise serves two purposes. First, similar nonlinear prices were implemented in Vietnam in the period of the data sample. Second, it helps to disentangle the impact of the income effect on the relative performance of household bundling and individual purchase. The third counterfactual exercise discusses how household bundling could sustain the insurance market when premium subsidy under individual purchase is unable to keep the market from complete unraveling.

8.1 Household Bundling under Uniform Pricing

I first simulate the market outcome under the optimal household bundling policy and individual purchase policy assuming that the social planner's subsidy for the entire insurance pool is the same as the subsidy observed in the data. Under individual purchase, the government chooses a single price for all potential enrollees. Under household bundling, the government chooses a single price per member for all households. Table (8.2) illustrates the set of insurance bundles K_h available to a household of size 2 under each policy.

Table 8.2 – Example of Household Bundling and Individual Purchase under Uniform Pricing

Insurance Bundle $\boldsymbol{\kappa}_h$	Premium $\pi(\boldsymbol{\kappa}_h)$ Individual Purchase (Uniform Pricing at 4% MW)	Premium $\pi(\boldsymbol{\kappa}_h)$ Household Bundling (Uniform Pricing at 3% MW)
(1, 1)	0%	0%
(0.2, 0.2)	8%	6%
(1, 0.2)	4%	N/A
(0.2, 1)	4%	N/A

Note: The insurance policy in this example has a coinsurance rate of 0.2.

The effect of bundling on insurance demand and the average cost of providing insurance is illustrated in Figure (8.1). At high insurance premium, limiting household choice by implementing household bundling has a negligible impact on the demand for insurance, but it significantly changes the composition of the insurance pool as shown by the difference in the average costs. Using household bundling in the presence of within-household adverse selection induces healthier members of some households to enroll but force out some sicker members of otherwise healthy households. When the premium is low, the number of newly added members under household bundling increases while the number of households choosing to drop out diminishes. This occurs until the premium is sufficiently low and all households are fully covered under both policies.

Figure 8.1 – The demand of insurance (a) and the average cost of insurance (b) under household bundling and individual purchase under uniform pricing.

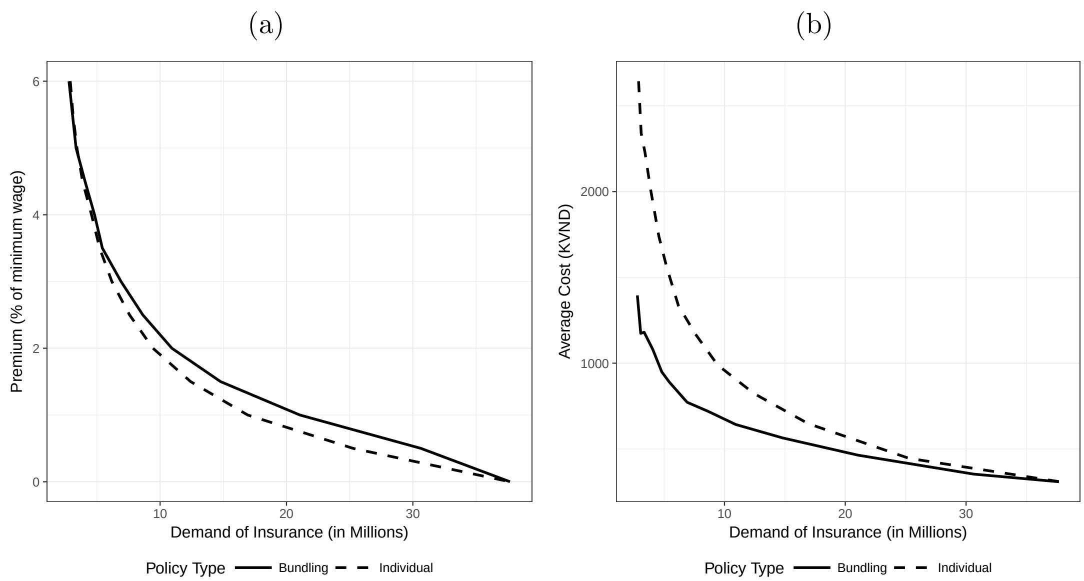


Table (8.3) compares the characteristics of the insured under household bundling and individual purchase under a 4.5% MW uniform premium. Individuals who have insurance under both household bundling and individual purchase have worse health types and more likely to be older. They also belong to households with higher income. The difference in the health types of individuals who only enroll under household bundling and individuals who only enroll under individual purchase explains the change in the average cost of providing insurance as shown in Figure (8.1). Individuals who only enroll under household bundling are on average younger and have better health types than individuals who only enroll under individual purchase.

Table (8.4) summarizes the average enrollment and consumer surplus attained under the

Table 8.3 – Compositions of Members Who Are Enrolled under Individual Purchase and Household Bundling at 4.5% MW uniform premium

Characteristics	Only Individual Purchase	Only Household Bundling	Both
<18	0.042	0.141	0.027
18 - 35	0.225	0.362	0.224
35 - 54	0.376	0.341	0.379
55 - 64	0.225	0.093	0.207
>65	0.131	0.064	0.163
Health Types $\bar{\theta}_{hj}$	−3.027	−3.786	−2.557
Female	0.565	0.463	0.565
Household Income	1.087	1.084	1.206
Percentage	3.1%	4.0%	8.2%

optimal uniform prices. Under household bundling, insurance enrollment is estimated to be 17.1 million, compared to 3.5 million under the optimal pricing under individual purchase. Consumer surplus also increases by more than half, from 0.18% to 0.28% of total GDP under household bundling. These significant improvement comes from the reduction in the premium of household bundling due to the change in the risk pool. To see this, note that when household bundling and individual purchase have the same uniform premium, consumer surplus under household bundling is weakly worse due to the restriction of choices for households. However, household bundling induces healthier household members to enroll, which allows premium to decrease. At this lower premium, more households could afford insurance, and the gain in consumer surplus more than offset the loss from having fewer bundle choices.

Table 8.4 – Effect of the Optimal Household Bundling on Welfare and Demand

	Individual Purchase (Optimal Uniform Price)	Household Bundling (Optimal Uniform Price)
Enrollment	3.5737	17.0579
	(0.5532)	(2.3603)
Consumer Surplus	0.1846	0.2824
	(0.0104)	(0.0101)

Note: Enrollment is measured in millions, and consumer surplus is measured in % of total GDP.

8.2 Household Bundling under Nonlinear Pricing

One way to attract more household members to enroll in insurance under individual purchase is by offering a lower premium for additional household members. Analogously, under household bundling, the social planner could price discriminate based on household sizes. An example of such nonlinear prices is included in Table (8.5). Note that these are also the pricing policies that have been implemented in Vietnam (Table 3.2).

Table 8.5 – Example of Household Bundling and Individual Purchase under Nonlinear Pricing

Household Size n_h	Insurance Bundle $\boldsymbol{\kappa}_h$	Premium $\pi(\boldsymbol{\kappa}_h)$ Individual Purchase	Premium $\pi(\boldsymbol{\kappa}_h)$ Household Bundling
		Nonlinear Pricing at $(2\%, 3\%)$	
$n_h = 1$	(1)	0%	0%
	(0.2)	2%	2%
$n_h = 2$	(1,1)	0%	0%
	(0.2, 0.2)	3%	3%
	(0.2, 1)	2%	N/A
	(1, 0.2)	2%	N/A

Note: The insurance policy in this example has a coinsurance rate of 0.2.

As suggested by the results of Section 7, households' partial enrollment into insurance are mainly due to two factors: (1) the effect of income on the willingness to pay for additional insurance, and (2) within-household adverse selection. If households' partial enrollment into insurance is only due to the income effect, individual purchase with nonlinear pricing can significantly increase enrollment. However, it does not eliminate within-household adverse selection as households can still self-select into insurance. The gain from having healthier household members under individual purchase is now undermined by the discount in premiums.

Table (8.6) presents the impact of household bundling on consumer surplus and insurance enrollment compared to individual purchase under nonlinear pricing for both policies. The table also includes the amount of consumer surplus and insurance enrollment under the 2012 insurance contracts.[36] Compared to the uniform pricing case, nonlinear pricing increases the demand for insurance by 2.4 million under individual purchase and 2.7 million under household bundling. The consumer surplus also increases by 0.04% and 0.03% of GDP, respectively. The results suggest that the 2012 premiums are not optimal, but the difference in consumer surplus due to this non-optimality is insignificant. More importantly, under the optimal nonlinear pricing, individual purchase still leads to lower insurance enrollment and consumer surplus than household bundling. Insurance enrollment under household bundling is 19.7 million, compared to 5.9 million under individual purchase. Household bundling also leads to almost 50% increase in consumer surplus compared to individual purchase. These

[36]Table (H.7) in the Appendix shows the optimal prices under household bundling and individual purchase as well as the observed nonlinear pricing in 2012.

results highlight the importance of eliminating within-household adverse selection, which could only be done through household bundling.

Table 8.6 – Effect of the Optimal Nonlinear Pricing on Welfare and Demand

	Household Bundling (Optimal Nonlinear Prices)	Individual Purchase (Optimal Nonlinear Prices)	Current Policy (Nonlinear Prices)
Enrollment	19.7265	5.9282	4.1443
	(1.1911)	(1.1052)	(0.1438)
Consumer Surplus	0.3192	0.2139	0.1931
	(0.0097)	(0.0104)	(0.0093)

Note: The Current Policy is the observed policy in 2012 that allows for individual purchase. Enrollment is measured in millions, and consumer surplus is measured in % of total GDP.

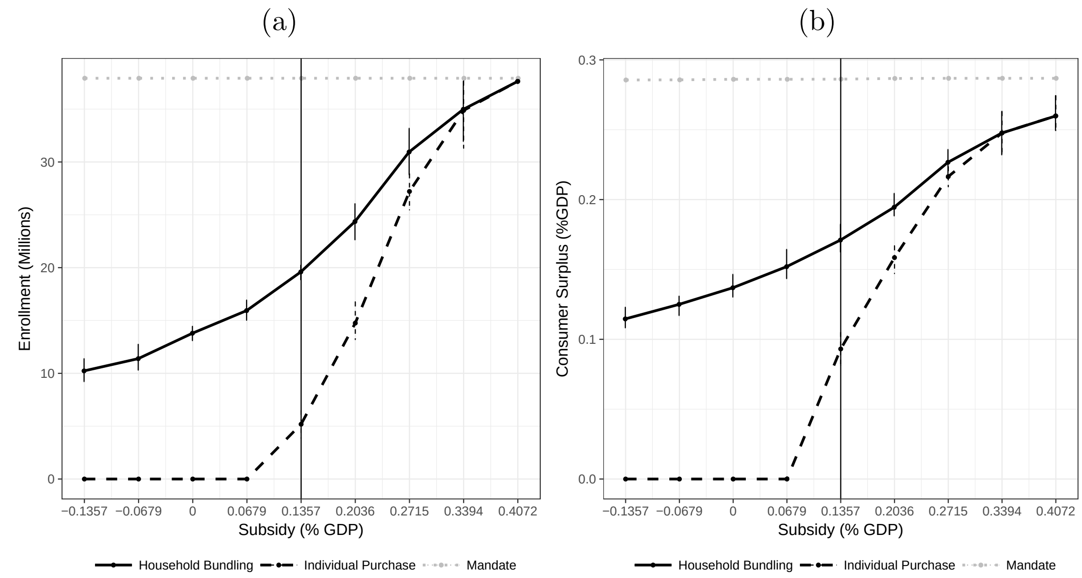
8.3 Household Bundling and Market Unraveling

This counterfactual exercise explores the use of household bundling when the government cannot provide adequate premium subsidy and the market unravels under individual purchase. In my model, this can also be interpreted as an increase in the administrative costs or overhead management not associated with the cost of medical care. If these costs exist, premium (without subsidy) exceeds the market-level actuarially fair value. When such costs increase, premiums increase as a result, leading to the drop out of healthier enrollees and further increasing costs.

Figure (8.2) illustrates the effect of household bundling on consumer surplus and insurance enrollment at different levels of market-wide subsidy. The level of subsidy at 0 implies that the social planner prices at the market-level actuarially fair premium. At the 2012 subsidy level, the market-wide subsidy level is 0.14% GDP. My results suggest that the market starts to unravel under individual purchase when the level of subsidy is cut by 50%. However, at this subsidy under household bundling, insurance enrollment is at 16.34 million, generating 0.15% of GDP consumer surplus. Furthermore, the market can still be sustained under household bundling even when the amount of subsidy is negative and premiums exceed the market-level actuarially fair value for consumers.

This exercise has important implications for policy implementation. The results here are contrary to what has been suggested in the literature (Somanathan et al., 2014) that while a household bundling policy might increase enrollment, it requires a large increase in government subsidy in order to cover the cost of insuring additional household members. This intuition, however, does not take into account the cost saving from the participation of healthier household members. My results suggest that household bundling can be especially

Figure 8.2 – Household Bundling under Different Premium Subsidies



Note: The vertical line represents the current level of subsidy.

beneficial for countries with limited funding for insurance, and it could be used to accumulate surplus in the early period of the SHI program.

9 Conclusion

This paper studies the potential welfare gain from bundling insurance contracts of members within a household to eliminate within-household adverse selection. In the context of health insurance, a household bundling policy works by preventing households to select only sick members to enroll into insurance. It might, however, lead to the complete drop out of relatively healthier households, worsening the welfare loss from adverse selection across households. Whether this trade off results in positive welfare gain depends not only on the distribution of risk types within and across households but also on the characteristics of the household demand for medical utilization and the household demand for health insurance.

I empirically study this issue using data from Vietnam's SHI program. While my setting has focused on Vietnam, Vietnam's similarity to other developing nations suggests promising application of the results to other developing countries that are still struggling to achieve universal health coverage. As of 2014, Vietnam's national health expenditure is at 7.07% of GDP, similar to several other lower middle income nations. Vietnam's variance of average per-member medical out-of-pocket costs across households, which is a possible indicator of adverse selection across households, is also comparable to other developing nations.

Motivated by the descriptive evidence of the data, I develop a structural model of insurance bundle choice and medical utilization that takes into account: (i) income elasticity, (ii) own-price elasticity, and (iii) cross-member effects. Due to the income effect, households have decreasing willingness to pay for additional member's insurance even in the absence of adverse selection within the household. The estimates of the health insurance choice and medical utilization model imply that partial household enrollment is caused by both within-household adverse selection and the substitutability of insurance due to the income effect. I then study the impact of household bundling on the demand for insurance and the cost of providing insurance. The results suggest that household bundling leads to a weakly higher demand for insurance and lower average cost of providing insurance than individual purchase under uniform pricing. As a result, insurance enrollment and consumer surplus is 13.5 million and 0.1% of GDP higher, respectively. The same results hold when the social planner could choose nonlinear pricing, eliminating the loss in demand due to the income effect. Furthermore, the insurance market is less susceptible to complete unraveling under household bundling than individual purchase.

A household bundling policy could be implemented together with other price discrimination schemes to resolve adverse selection. The implementation is straightforward when premiums are dependent on individual and household demographics. When there is a menu of contracts, healthier individuals are no longer uninsured but are still under-insured. The social planner could then offer a menu of bundled contracts to induce healthier household members to choose the more socially efficient insurance contracts.

Finally, the application of household bundling is not limited to a social health insurance program. The intuition from household bundling could be extended to other contexts in which several risks of the same individual are separately insured. Future work could evaluate a household bundling policy in the presence of a competitive market of health insurers. In this case, even when unilaterally offering a household bundle is not profitable for firms, the government might be able to improve welfare by mandating household bundling for all market participants.

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A Proof of Proposition 6.1

We first identify the distribution of ω_h using the sample of individuals with free insurance whose household members do not incur any medical spending. Equation 5.1 for this subgroup then becomes:

$$m_{hj} = \theta_{hj} + \theta_{hj}\delta_{hj}Y_h^{\omega_h}$$

Let t be an integer, consider:

$$\mathbb{E}(m_{hj}^t|Y_h = 1) = \mathbb{E}\theta_{hj}^t\mathbb{E}(1+\delta_{hj})^t$$

Since the distribution of θ_{hj} is identified directly from individuals with $Y_h \leq 0$, the distribution of $1+\delta_{hj}$ and hence δ_{hj} is then identified. As has been mentioned before, Y_h is disposable income and there is a positive probability of Y_h being negative.

$$\begin{aligned}
&\int_{supp(Y_h)} \mathbb{E}_{\theta_{hj},\delta_{hj},\omega_h}(m_{hj}|Y_h)(\log Y_h)^{-t+1}d(\log Y_h)\\
=&\int_{supp(Y_h)}\int_{supp(\omega_h)} \mathbb{E}_{\theta_{hj},\delta_{hj}}(m_{hj})(\log Y_h)^{-t+1}dF_{\omega_h}d(\log Y_h)\\
=&\int_{supp(\omega_h)}\int_{supp(Y_h)} \mathbb{E}_{\theta_{hj},\delta_{hj}}(m_{hj})(\log Y_h)^{-t+1}d(\log Y_h)dF_{\omega_h}\\
=&\int_{supp(\omega_h)}\int_{supp(Y_h)} \mathbb{E}_{\theta_{hj},\delta_{hj}}(m_{hj})(\log Y_h)^{-t+1}d(\log Y_h)dF_{\omega_h}\\
=&\int_{supp(\omega_h)}\int_{supp(Y_h)} \mathbb{E}_{\theta_{hj},\delta_{hj}}(\theta_{hj}+\theta_{hj}\delta_{hj}\exp(s))s^{-t+1}\omega_h^t\ ds\ dF_{\omega_h}\\
=&\left(\int_{supp(Y_h)} \mathbb{E}_{\theta_{hj},\delta_{hj}}(\theta_{hj}+\theta_{hj}\exp(s))s^{-t+1}ds\right)\mathbb{E}(\omega_h^t)
\end{aligned}$$

where the second to last equality follows a change of variable $s = \omega \log Y_h$ and $supp(Y_h) = supp(Y_h^{\omega_h})$. Since both the left hand-side and the first parenthesis in the last equation can be estimated from data, all moments of ω_h are identified, and hence the distribution of ω_h is identified.

We could now identify γ_{hj} from data on all individuals with exogenous insurance status using the same approach. Let $G(\boldsymbol{\kappa}_h) = \int_{supp(Y_h)} \mathbb{E}_{\theta_{hj},\omega_h,\delta_{hj}}\theta_{hj}\delta_{hj}(Y_h - \sum_{i=1}^{N_h}\theta_{hi}\kappa_{hi})^{\omega_h}$. Since we are able to identify $F_{\theta_{hj}}$, F_{ω_h} and $F_{\delta_{hj}}$, $G(\boldsymbol{\kappa}_h)$ is identified. Consider the following:

$$\begin{aligned}
&\int_{supp(\boldsymbol{\kappa}_h)} \int_{supp(Y_h)} \mathbb{E}_{\theta_{hj},\delta_{hj},\omega_h,\gamma_{hj}} \left(\frac{(m_{hj}|\boldsymbol{\kappa}_h, Y_h) - \mathbb{E}(\theta_{hj})}{G(\boldsymbol{\kappa}_h)} \right) \frac{1}{1+\kappa_{hj}} \left(\log(1+\kappa_{hj})^{-t} \right) dY_h d\boldsymbol{\kappa}_h \\
&= \int_{supp(\boldsymbol{\kappa}_h)} \int_{supp(\gamma_{hj})} (1+\kappa_{hj})^{-\gamma_{hj}} \frac{1}{1+\kappa_{hj}} \left(\log(1+\kappa_{hj})^{-t} \right) dF_{\gamma_{hj}} d\boldsymbol{\kappa} \\
&= \int_{supp(\gamma_{hj})} \int_{supp(\boldsymbol{\kappa}_h)} \exp(s) s^{-t} (-\gamma_{hj})^t ds \\
&= \mathbb{E}(-\gamma_{hj})^t \left(\int_{supp(\boldsymbol{\kappa}_h)} \exp(s) s^{-t} ds \right)
\end{aligned}$$

All moments of $-\gamma_{hj}$ is identified, hence the distribution of γ_{hj} is also identified.

B Check that Equation 5.1 satisfies the integrability theorem

Theorem 1 (Hurwicz - Uzawa Integrability Theorem). *Let* $\zeta :: \mathbb{R}^n_{++} \times \mathbb{R}_+ \to \mathbb{R}^n_+$. *Assume*

1. *The budget exhaustion condition*

$$p \cdot \zeta(p, y) = y$$

   is satisfied for every $(p, y) \in \mathbb{R}^n_{++} \times \mathbb{R}_+$

2. *Each component function* ζ_i *is differentiable everywhere on* $\mathbb{R}^n_{++} \times \mathbb{R}_+$

3. *The Slutsky matrix is symmetric, that is, for every* $(p, y) \in \mathbb{R}^n_{++} \times \mathbb{R}_+$

$$\sigma_{i,j}(p, y) = \sigma_{j,i}(p, y)$$

   for $i, j = 1, \ldots, n$ *where*

$$\sigma_{i,j}(p, y) = \frac{\partial \zeta_i(p, y)}{\partial p_j} + \zeta_j(p, y) \frac{\partial \zeta_i(p, y)}{\partial y}$$

4. *The Slutsky matrix is negative semidefinite, that is, for every* $(p, y) \in \mathbb{R}^n_{++} \times \mathbb{R}_+$ *and*

every $v \in \mathbb{R}^n$,

$$\sum_{i=1}^{n}\sum_{j=1}^{n}\sigma_{i,j}(p,y)v_iv_j \leq 0$$

5. *The function ζ satisfies the following boundedness condition on the partial derivative with respect to income. For every $0 \leq \underline{a} \leq \bar{a} \in \mathbb{R}^n_{++}$, there exists a (finite) real number $M_{\underline{a},\bar{a}}$ such that for all $m \geq 0$*

$$\underline{a} \leq p \leq \bar{a} \Rightarrow \left|\frac{\partial \zeta_i(p,y)}{\partial y}\right| \leq M_{\underline{a},\bar{a}}, \quad i = 1,\ldots,n$$

Let X denote the range of ζ,

$$X = \{\zeta(p,y) \in \mathbb{R}^n_+ : (p,y) \in \mathbb{R}^n_{++} \times \mathbb{R}_+\}$$

Then there exists a utility function $u : X \to R$ on the range X such that for each $(p,y) \in \mathbb{R}^n_{++} \times \mathbb{R}_+$. $\zeta(p,y)$ is the unique maximizer of u over the budget set $\{x \in X : p \cdot x \leq y\}$

In Equation 5.1, the price of the consumption good has been normalized to 1. The full system with a flexible price for the consumption good p_c is given by:

$$m_{hi} = \theta_{hi} + \theta_{hi}\delta_{hi}\left(\frac{Y_h}{p_c} - \sum_{j=1}^{n_h}\theta_{hj}\frac{\kappa_{hj}}{p_c}\right)^{\omega_h}\left(1 + \frac{\kappa_{hj}}{p_c}\right)^{-\gamma_{hj}}$$

and the demand for the consumption good is pinned down by the budget constraint:

$$c_h = \frac{Y_h}{p_c} - \sum_{i=1}^{n_h} m_{hi}\frac{\kappa_{hi}}{p_c}$$

The full demand system thus satisfies condition 1 of the integrability theorem by construction. It also satisfies condition 2, 3 (with some tedious algebra), and 5. As for condition 4, a sufficient condition for a $n \times n$ matrix to be negative semidefinite is that the determinant of all of its principal minors of order k where $1 \leq k \leq n-1$ has the same sign as $(-1)^k$, and the determinant of the matrix is 0. It could be checked that the determinant of the Slutsky matrix is indeed 0, and the determinants of the principal minors have expected signs as long as the following constraint holds:

$$\frac{\omega_h}{\gamma_{hj}}(p_c + \kappa_{hj})\frac{m_i - \theta_{hi}\kappa_{hi}}{Y_h - \sum_{j=1}^{n_h}\theta_{hj}\kappa_{hj}} < 1 \;\forall i = 1,2,\ldots,n_h \tag{B.1}$$

Intuitively, the constraint ensures that the non-negativity constraint on the consumption good is not binding, and the demand is downward sloping.

Indifference curve and indirect utility Given Equation (B.1) is satisfied, the indifference curve and indirect utility could be derived.

The expenditure function could be derived from the ordinary differential equation $\frac{\partial e_h(\boldsymbol{\kappa}_h, u_0)}{\partial \kappa_{hj}} = m_{hj}(\kappa_{hj}, e_h(\kappa_{hj}, u_0)) \ \forall \ j$. The solution is given by:

$$e_h(\boldsymbol{\kappa}_h, u_0) = \left((1-\omega_h) \left(v_0 + \sum_{j=1}^{n_h} \delta_{hj} \frac{\theta_{hj}(\kappa_{hj}+1)^{1-\gamma_{hj}}}{1-\gamma_{hj}} \right) \right)^{\frac{1}{1-\omega}} + \sum_{j=1}^{n_h} \theta_{hj}\kappa_{hj}$$

where v_0 is a constant that satisfies the initial condition:

$$e_h(\mathbf{0}, u_0) = Y_h$$

The expenditure function could be rewritten as:

$$e_h(\boldsymbol{\kappa}_h, u_0) = \left((1-\omega_h) \left(\frac{\left[e_h(\mathbf{0}, u_0) - \sum_{j=1}^{n_h} \theta_{hj}\kappa_{hj} \right]^{1-\omega_h}}{1-\omega_h} + \sum_{j=1}^{n_h} \frac{\delta_{hj}\theta_{hj}(\kappa_{hj}+1)^{1-\gamma_{hj}} - 1}{1-\gamma_{hj}} \right) \right)^{\frac{1}{1-\omega_h}} \tag{B.2}$$

The upper contour (at-least-as-good) set that defines the set of all consumption basket $(\boldsymbol{m}_h, c_h)$ that yields utility weakly greater than u_0 is given by:

$$V_{u_0} = \{(\boldsymbol{m}_h, c_h) : \sum_{j=1}^{n_h} m_{hj}\kappa_{hj} + c_h \geq e_h(\boldsymbol{\kappa}_h, u_0) \ \ \forall \boldsymbol{\kappa}_h\}$$

Figure (B.1) shows an example of the indifference curves for $n_h = 1$ and $\gamma_{h1} = 0.6$, $\omega_h = 0.1$ and $\delta_{h1} = 1$. In order to label the indifference curve, I define utility as a CRRA transformation of the amount of consumption when $\boldsymbol{\kappa}_h = 0$ on each indifference curve.

$$u := \frac{c_h^{1-\omega_h} - 1}{1-\omega_h} \Big| \boldsymbol{\kappa}_h = 0 \tag{B.3}$$

The form of Equation (B.3) is convenient since it allows me to obtain the indirect utility function. To see why, note that when $\boldsymbol{\kappa}_h = 0$ and p_c normalized to 1, the amount of consumption is also equal to the expenditure function. Given an income level Y_h and price

$\boldsymbol{\kappa}_h$:

$$Y_h = e_h(\boldsymbol{\kappa}_h, u) = \left((1-\omega_h)\left(u + \sum_{j=1}^{n_h} \frac{\delta_{hj}\theta_{hj}(\kappa_{hj}+1)^{1-\gamma_{hj}} - 1}{1-\gamma_{hj}}\right)\right)^{\frac{1}{1-\omega_h}} + \sum_{j=1}^{n_h} \theta_{hj}\kappa_{hj}$$

$$\Rightarrow \quad u = \frac{\left(Y_h - \sum_{j=1}^{n_h}\theta_{hj}\kappa_{hj}\right)^{1-\omega_h}}{1-\omega_h} - \sum_{j=1}^{n_h} \frac{\delta_{hj}\theta_{hj}(\kappa_{hj}+1)^{1-\gamma_{hj}} - 1}{1-\gamma_{hj}} \tag{B.4}$$

Equation (B.4) is an indirect utility function that is consistent with the demand specifications (5.1). Furthermore, any monotonically increasing transformation of (B.4) would also be consistent with the demand specifications.

Figure (B.1) and (B.2) illustrate the indifference curves and the isoquants of the health production function at specific parameter values when the household only has one member with sufficient income. The indifference curves show that both medical utilization and the consumption good exhibits decreasing marginal utility. The health production function in figure (B.2) shows that medical care has greater marginal impact on health when sickness is less severe, i.e. with worse health shock.

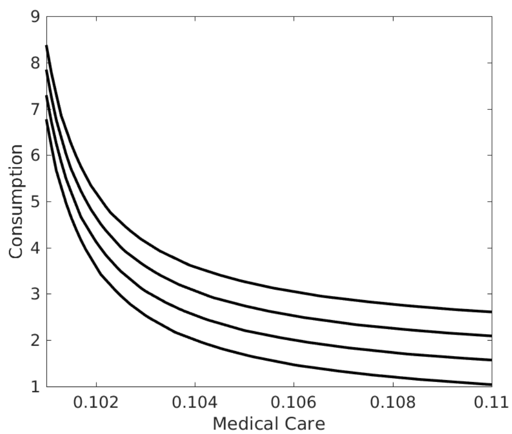


Figure B.1 – Example of the indifference curves for different levels of utility for a single-member household. The preference parameters are set at $\gamma = 0.6$, $\omega = 0.1$, $\delta = 1$. The health shock is $\theta = 0.1$

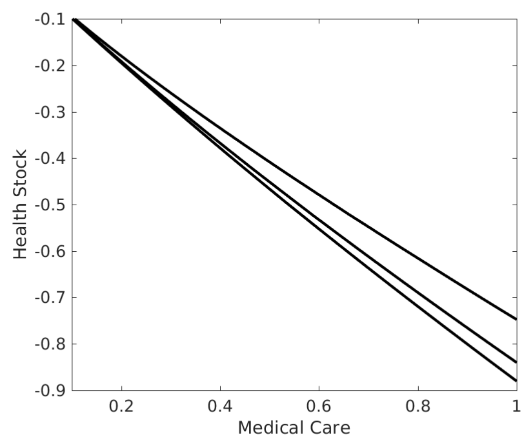


Figure B.2 – Example of the isoquants of the health production function at different level of health for a single-member household. The preference parameters are set at $\gamma = 0.6$, $\omega = 0.1$, and $\delta = 1$.

C Identification with ideal data

With the ideal data, each household is observed for multiple periods and faces a menu of insurance coverage each period. There are exogenous changes in the menu's premium, which is necessary to generate variance in the coinsurance rate of each member once the insurance bundle is chosen. Identification is obtained separately for each household, hence the subscript for household h is omitted for notational convenience. The distribution of health shocks, and hence the household's belief, is invariant across time. I first show how identification for the demand of medical care is achieved. The demand for medical care is given by the following system:

$$\begin{aligned} M_1 &= m_1(\theta_1, \theta_2, \ldots, \theta_n, Y, \kappa_1, \kappa_2, \ldots, \kappa_n | Y > \bar{Y}) \\ M_2 &= m_2(\theta_1, \theta_2, \ldots, \theta_n, Y, \kappa_1, \kappa_2, \ldots, \kappa_n | Y > \bar{Y}) \\ &\ldots \\ M_n &= m_n(\theta_1, \theta_2, \ldots, \theta_n, Y, \kappa_1, \kappa_2, \ldots, \kappa_n | Y > \bar{Y}) \end{aligned} \tag{C.1}$$

and

$$M_i = \theta_i \text{ if } Y \leq \bar{Y} \tag{C.2}$$

where $(M_1, M_2, \ldots, M_n)$ is a vector of observed medical care consumption for all members, $(\kappa_1, \kappa_2, \ldots, \kappa_n)$ is an observed vector of coinsurance rates which are assumed to be exogenous, and $(\theta_1, \theta_2, \ldots, \theta_n)$ is a vector of latent health shocks. Y is the household's total income and also exogenous; the threshold $\bar{Y}$ is also known. Our object of interests include the unknown functions $m_i(\cdot)$ and the distribution of the latent health shocks $F_{\boldsymbol{\theta}}$. $F_{\boldsymbol{\theta}}$ does not have any zero mass.

Assumption C.1. *$\boldsymbol{m}(\cdot)$ is a continuous, differentiable, and $\dfrac{\partial m_i(\cdot)}{\partial \theta_i} > 0 \forall i$. There exists a function $\boldsymbol{v}(\cdot)$ such that $\boldsymbol{\theta} = \boldsymbol{v}(\boldsymbol{M}, Y, \boldsymbol{\kappa})$. Also, $\forall i$, $m_i(\cdot | \theta_i = 0) = 0$.*

Assumption C.1 restricts medical care consumption of a particular member to be a strictly increasing function of that member's health shock, and medical care consumption only occurs if the member has $\theta_j > 0$. The functions $\boldsymbol{m}(\cdot)$ need to be well-behaved such that $\boldsymbol{\theta}$ is the unique solution of the system. When the household only has one member, without Equation C.2 (or equivalently $\bar{Y} = \infty$), we can only identify m_1 up to an increasing transformation (Matzkin, 2003). Equation C.2 therefore serves as a normalization for $m_i()$ and directly identifies $F_{\boldsymbol{\theta}}$.

Without additional restriction on $m_i(\cdot)$, system C.1 cannot be identified. Let $\psi(\boldsymbol{\theta}^{-i}, \boldsymbol{\kappa}^{-i}, Y)$ be a symmetric function in $(\boldsymbol{\theta}, \boldsymbol{\kappa})$. That is, if $(\tilde{\boldsymbol{\theta}}, \tilde{\boldsymbol{\kappa}})$ is a permutation of $(\boldsymbol{\theta}, \boldsymbol{\kappa})$, then $\psi(\tilde{\boldsymbol{\theta}}, \tilde{\boldsymbol{\kappa}}, Y) = \psi(\boldsymbol{\theta}, \boldsymbol{\kappa}, Y)$. Also, let $\boldsymbol{\theta}^i = (0, \ldots, 0, \theta_i, 0, \ldots, 0)$, $\boldsymbol{\theta}^{-i} = (\theta_1, \ldots, \theta_{i-1}, \theta_{i+1}, \ldots \theta_n)$, and $\boldsymbol{\kappa}^{-i} = (\kappa_1, \ldots, \kappa_{i-1}, \kappa_{i+1}, \ldots \kappa_n)$.

Assumption C.2. $m_i(\boldsymbol{\theta}, y, \boldsymbol{\kappa}) = m_i(\boldsymbol{\theta}^i, y - \psi(\boldsymbol{\theta}^{-i}, \boldsymbol{\kappa}^{-i}, y), \boldsymbol{\kappa})$.

Assumption C.2 restricts the cross effect of different members' medical care consumption to be channeled exclusively through the income effect. Such cross-member effects are assumed to be equivalent to an income loss of $\psi(\boldsymbol{\theta}^{-i}, \boldsymbol{\kappa}^{-i})$. Furthermore, this income loss is symmetric among household members.

Proposition C.1. *Suppose that Assumption C.1 and C.2 are satisfied,* $\boldsymbol{m}(\cdot)$ *is identified.*

Proof of Proposition C.1. We first consider the case in which only one member of the household receives a positive health shock, $\boldsymbol{\theta} = \boldsymbol{\theta}^i = (0, \ldots, 0, \theta_i, 0, \ldots, 0)$. Using the same approach as in Matzkin (2003), $m_i(\boldsymbol{\theta}^i, Y, \kappa_i)$ is identified when $F_j^{\theta}(\theta_j | \theta_{-j} = 0)$ is known. Note that this is achieved due to the assumption that $m_i()$ is strictly increasing in θ_i at any given pair $(Y, \boldsymbol{\kappa})$, and $F_i^{\theta, \theta_{-j}}$ is also strictly increasing.

If there exists at least two members i, j such that $\theta_j, \theta_i > 0$:

$$
\begin{aligned}
f_{\boldsymbol{\theta}}(\boldsymbol{\theta}) &= f^{\boldsymbol{m}|(Y,\boldsymbol{\kappa})}(\boldsymbol{m}(\boldsymbol{\theta}, Y, \boldsymbol{\kappa})) \left| \frac{\partial \boldsymbol{m}(\boldsymbol{\theta}, Y, \boldsymbol{\kappa})}{\partial \boldsymbol{\theta}} \right| \\
&= f^{\boldsymbol{m}|(Y,\boldsymbol{\kappa})} \left(m_1(\boldsymbol{\theta}^1, Y - \psi(\boldsymbol{\theta}^{-1}, \boldsymbol{\kappa}^{-1}, Y), \boldsymbol{\kappa}), \cdots, m_n(\boldsymbol{\theta}^n, Y - \psi(\boldsymbol{\theta}^{-n}, \boldsymbol{\kappa}^{-n}, Y), \boldsymbol{\kappa}) \right) \cdot \\
&\quad \begin{vmatrix} \frac{\partial m_1(\boldsymbol{\theta}^1, Y - \psi(\boldsymbol{\theta}^{-1}, \boldsymbol{\kappa}^{-1}, Y), \boldsymbol{\kappa})}{\partial \boldsymbol{\theta}} \\ \vdots \\ \frac{\partial m_n(\boldsymbol{\theta}^n, Y - \psi(\boldsymbol{\theta}^{-n}, \boldsymbol{\kappa}^{-n}, Y), \boldsymbol{\kappa})}{\partial \boldsymbol{\theta}} \end{vmatrix}
\end{aligned}
\tag{C.3}
$$

When $(\theta_i, \kappa_i) = (t, k)\ \forall i$, $\psi(\boldsymbol{\theta}^{-i}, \boldsymbol{\kappa}^{-i}, Y) = \psi(\boldsymbol{\theta}^{-j}, \boldsymbol{\kappa}^{-j}, Y) = \psi^0(t, k, Y)\ \ \forall i, j$. Equation C.3 becomes an ODE with the initial condition $\psi^0(0, k, Y) = 0$, and $\psi^0(t, k, Y)$ is identified.

If there exists one pair $(\theta_i, \kappa_i) = (t, k') \neq (t, k)$, let $\psi(\boldsymbol{\theta}^{-j}, \boldsymbol{\kappa}^{-j}, Y) = \psi^1(t, k, k', Y)$ for any $j \neq i$. Since $\psi(\boldsymbol{\theta}^{-i}, \boldsymbol{\kappa}^{-i}) = \psi^0(t, k)$, equation C.3 becomes an ODE of ψ^1 as a function of t. Using the initial condition $\psi^1(0, k, k', Y) = 0$, $\psi^1(t, k, k')$ is identified. Using similar arguments, we can identify $\psi^{n-1}(t, \boldsymbol{\kappa}^{-i}, Y) = \psi((t, t, \ldots, t), \boldsymbol{\kappa}^{-i}, Y)$ for an arbitrary $\boldsymbol{\kappa}$.

If $\theta_j = t\ \forall j \neq i$, and $\theta_i = t' \neq t$, let $\psi_1^{n-1}(t', t, \boldsymbol{\kappa}, Y) = \psi(\boldsymbol{\theta}^{-j}, \boldsymbol{\kappa}^{-j}, Y)\ \forall j \neq i$. Using the fact that $\psi(\boldsymbol{\theta}^{-i}, \boldsymbol{\kappa}^{-i}, Y) = \psi^{n-1}(t, \boldsymbol{\kappa}^{-i}, Y)$ has already been identified, $\psi_1^{n-1}(t', \cdot)$ is the solution of the ODE in equation C.3 with the initial condition $\psi_1^{n-1}(t, t, \boldsymbol{\kappa}^{-j}) = \psi^n(t, \boldsymbol{\kappa}^{-j})$. Similar to the above arguments, we could identify $\psi()$ for any $\boldsymbol{\theta}^{-i}$ and $\boldsymbol{\kappa}^{-i}$. □

When the menu of insurance coverage is discrete, the household's observed choice of insurance coverage implies an upper and lower bound on the household's risk aversion, and the risk aversion coefficient r_h is partially identified. If the menu of insurance coverage is continuous, there is a 1-1 mapping between the household's choice of insurance and its risk aversion conditional on the distribution of health shocks of household members. In this case, r_h is point identified.

D More Details on the Almost Ideal Demand System

Consider a household h with n_h members who consumes $n_h + 1$ goods which include medical care for each member and a consumption good for the entire household. The price of the consumption good $p_{h,j+1}$ is normalized to 1. The price of each member's medical care $p_{h,j}$ is the spot coinsurance rate of medical expenditure, computed as the ratio between the out of pocket cost and the total cost of medical care for each member. When all medical expenses are covered in insurance, the spot coinsurance rate is the same as the coinsurance rate specified in the contract. When some medical expense is not eligible for insurance coverage, the realized coinsurance rate is strictly smaller.

Let w_{hj} with $j = 1, 2, \ldots n$ denote the budget share of medical care for member j, and w_{h,n_h+1} denote the budget share of the consumption good. The AIDS specification is given by:

$$w_{hi} = \alpha_{hi} + \sum_j \gamma_{hij} \log p_{hj} + \beta_{hi} \log \frac{Y_h}{P_h}$$

where α_{hi}, γ_{hij}, and β_{hi} are parameters that characterize the demand of medical care for member i. Specifically, γ_{hij} represents the effect of a change in the relative price of medical care between i and j on the demand for medical care of i. P_h is a price index defined by:

$$\log P_h = \alpha_{h0} + \sum_k \alpha_{hk} \log p_{hk} + \frac{1}{2} \sum_j \sum_k \gamma_{hkj} \log p_{hk} \log p_{hj}$$

The system is subject to the following constraints in order to satisfy the Slutsky symmetry:

$$\sum_{i=1}^{n+1} \alpha_{hj} = 1, \quad \sum_{i=1}^{n+1} \gamma_{hij} = 0, \quad \sum_{i=1}^{n+1} \beta_{hi} = 0, \quad \gamma_{ihj} = \gamma_{jih}$$

I assume that there is no preference heterogeneity among households. That is, $\gamma_{hkj} = \gamma_{kj}$, $\beta_{hj} = \beta_j$, and $\alpha_{hj} = \alpha_j$. I allow for the average expenditure share of medical care to be dependent on age groups. Since household compositions (including the number of members and their relationship to the head of the household) vary, I reduce the number of parameters by classifying members into 5 categories: (Male) Head of Household, Spouse, Children, Parents, and Others.[37]

E Sampling Algorithm

To prioritize speed, β_s and β_ζ are estimated separately from the rest of the parameters. Whether an individual is sick is observed for the entire sample, whereas the fraction of coverage is only observed for data in 2008. I'm assuming that the distribution of coverage does not differ across years, and will distribute any time-variant component of medical spending and/or insurance choice to a time fixed effect in the distribution of health types $\bar{\theta}$. With specified priors on β_s and β_ζ, the posteriors are known, and Hamiltonian Monte Carlo through Stan is used to directly sample β_s and β_ζ. The estimates are robust to the choice of priors, whether weakly informative or uninformative, and are similar to the MLE estimates. Throughout this section, I use Gelman and Rubin's test (Gelman and Rubin, 1992) to test for convergence.

The rest of the parameters are sampled using Gibbs sampling. The hyper parameters include $\mathcal{H} = \{\beta_\omega, \beta_r, \beta_\gamma, \beta_\delta, \beta_\theta, s_\omega, s_r, s_\delta, s_\gamma, s_\theta, \beta_W, \sigma_\lambda, \sigma_\epsilon, \alpha, s_\theta\}$. Conditional on these hyper-parameters, $(\bar{\boldsymbol{\theta}}_h, \omega_h, r_h, \delta_{hj}, \gamma_{hj})$ can be drawn independent across households. To reduce computational speed on the posteriors of the hyper parameters, I allow s_θ to vary across households. s_θ is assumed to be lognormally distributed with a known small variance.

I begin with notation. $\pi(X|Y)$ denotes the prior of a variable X conditional on Y, and $\Pi(X|Y)$ denotes the posterior. Likelihood is denoted by the usual $\mathcal{L}$. $\phi()$ and $\Phi()$ are the pdf and cdf of a normal distribution respectively and, with an abuse of notation, of a multivariate normal distribution as well. Once a sample of lower-level parameters are drawn, the posterior of the hyper parameters are straightforward and could be drawn directly if using conjugate priors.

[37] That is, there is a single coefficient for each pair of different categories as well as a single coefficient for pairs of members within a category. For this 5-category case, we have 15 parameters for own-price elasticities and cross-price elasticities between categories, and additionally 3 parameters for within-category cross-price elasticities. Note that there is only one member as head of the household, and only one member as the head's spouse. An alternative approach is multi-stage budgeting (Hausman et al., 1994).

E.1 Sampling of lower-level parameters

The observed data at the household level includes (1) medical spending of each member if incurs, and (2) the household's choice of insurance bundle. For any given household h, at a draw of $(\omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_{h3})$ and observed disposable income Y_h and $\boldsymbol{\kappa}_h$, $\boldsymbol{\theta}_h = \boldsymbol{m}_h$ when y is less than the out-of-pocket costs, which is observed. Otherwise, $\boldsymbol{\theta}_h$ is the solution of:

$$m_{hj} = \theta_{hj} + \delta_{hj}\theta_{hj}\left[y_h^* - \pi(\boldsymbol{\iota}_h) - \boldsymbol{\theta}_h \cdot \boldsymbol{\kappa}(\boldsymbol{\iota}_h)\right]^{\omega_h}(1 + \kappa(\iota_{hj}))^{-\gamma_{hj}} \tag{E.1}$$

When the spot price $\kappa(\boldsymbol{\iota}_h)$ is fully observed, the Newton's method works well in finding the unique roots.

$$\Pi(\theta_{hj}|(\kappa(\boldsymbol{\iota}_h), \boldsymbol{m}_h), (\bar{\boldsymbol{\theta}}_h, s_\theta, \omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h)) = \phi\left(\frac{\log\theta_{hj}(\boldsymbol{m}_h, \kappa(\boldsymbol{\iota}_h), \omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h) - \bar{\theta}_{hj}}{s_\theta}\right)$$

Using the implicit function theorem, we can derive $\dfrac{\partial\theta_{hj}(\boldsymbol{m}_h, \kappa(\boldsymbol{\iota}_h), \omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h)}{\partial\mathcal{H}}$. Some complications arise when the actual price is not observed, and when coinsurance rate is nonlinear. For the former, the posterior is integrated over all possible realizations of ζ_{hj}.

$$\Pi(\theta_{hj}|(\kappa(\boldsymbol{\iota}_h), \boldsymbol{m}_h), (\bar{\boldsymbol{\theta}}_h, s_\theta, \omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h)) = \int_{\kappa(\boldsymbol{\iota}_h)} \phi\left(\frac{\log\theta_{hj}(\boldsymbol{m}_h, \kappa(\boldsymbol{\iota}_h), \omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h) - \bar{\theta}_{hj}}{s_\theta}\right) dF(\kappa(\boldsymbol{\iota}_h))$$

where $F(\kappa(\boldsymbol{\iota}_h))$ is specified in Section 6. In order to estimate this integral, I use Gauss Legendre quadrature.

When coinsurance rate is piecewise linear (for example, for compulsory enrollees in 2006 and 2008, Table (3.1)), bunching might occur. Figure E.1 illustrates the insurance contract and optimal medical choice for a one-member household with a compulsory enrollee in 2006-2008. In this example, the insurance contract for any given fraction of coverage $\zeta \in [0.1]$ has the following form:

$$oop_i = \begin{cases} (1 - \zeta + \zeta\kappa_1)m_i & \text{If } m_i\zeta \leq \bar{m} \\ (1 - \zeta + \zeta\kappa_2)\left(m_i - \frac{\bar{m}}{\zeta}\right) + \frac{\bar{m}}{\zeta}(1 - \zeta + \zeta\kappa_1) & \text{If } \bar{m} \leq m_i\zeta \leq \bar{m}\frac{\kappa_2 - \kappa_1}{\kappa_2 - \kappa_3} \\ (1 - \zeta + \zeta\kappa_3)m_i & \text{If } m_i\zeta > \bar{m}\frac{\kappa_2 - \kappa_1}{\kappa_2 - \kappa_3} \end{cases} \tag{E.2}$$

Bunching occurs when the optimal medical spending under κ_1 exceeds the threshold $\bar{m}$, and the individual finds it optimal to keep spending at $\bar{m}$ to enjoy the lower coinsurance rate. As the health shock increases, the disutility from underspending on medical spending outweighs the gain from lower coinsurance rate, and he will increase his medical spending and pay at the spot coinsurance rate κ_2. There is no bunching at the second threshold between κ_2 and κ_3 because $\kappa_3 < \kappa_2$. The regions in Figure E.1 can be derived numerically using the indirect utility function.

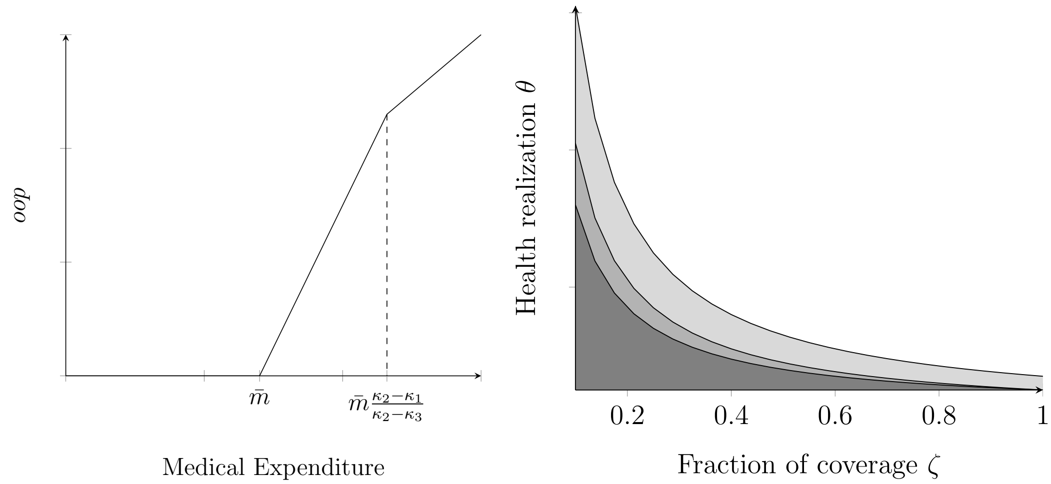


Figure E.1 – The left figure illustrates the insurance contract which determines the out-of-pocket payment from medical spending. In this example, the first coinsurance rate for spending below $\bar{m}$ is $\kappa_1 = 0$. For higher spending, coinsurance is $\kappa_2 = 1$ until medical expense reaches $\bar{m}\frac{\kappa_2-\kappa_1}{\kappa_2-\kappa_3}$, where $\kappa_3 = 0.4$ is the coinsurance rate for expense exceeding the second threshold. The right figure shows the optimal medical spending choice. From left to right: spend at κ_1, bunching, spend at κ_2, and spend at κ_3. There is no bunching at κ_2 because the $\kappa_3 < \kappa_2$

For individuals who can choose to enroll in insurance, the observed insurance choice carries information about their health *types*. In an individual framework, the posterior of $\bar{\theta}_{hj}$ is a truncated distribution. In our household framework, however, the existence of income effect creates interdependency between the decision to buy insurance for different members. That is, the threshold for $\bar{\theta}_{hj}$ in order for j to be insured is dependent on the value of $\bar{\theta}_{h,-j}$. Due to this complication, each members' health type is drawn conditional on other members' health types. To save on computational time, I only impose that no single-member deviation is utility improving for the household, that is, the household is better off not insuring another member nor not buying insurance for a currently insured members[38]. Conditional on other members' types and all other parameters, there exists an upper bound $U(\bar{\theta}_{hj})$ and a lower bound $L(\bar{\theta}_{hj})$ such that $L(\bar{\theta}_{hj}) \leq \bar{\theta}_{hj} \leq U(\bar{\theta}_{hj})$ in order to ensure that the observed bundle is

[38]For a household of size n_h, single-member deviation generates only n_h constraints, whereas full optimality requires the bundle to satisfy 2^{n_h} constraints. In assessing the model fit as well as the out-of-sample validity test, the full set of constraints were checked

optimal. The lower bound is the maximum value of $\bar{\theta}_{hj}$ such that the household prefers not to enroll another currently uninsured member into insurance[39]. Similarly, the upper bound is the minimum value of $\bar{\theta}_{hj}$ such that the household prefers to buy insurance for a currently insured member. These thresholds are computed using the bisection method. The posterior of $\bar{\theta}_{hj}$ is then given by:

$$\Pi(\bar{\theta}_{hj}|\kappa(\boldsymbol{\iota}_h), \boldsymbol{m}_h, \bar{\theta}_{h,-j}, r_h, \omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h, \mathcal{H}) = \begin{cases} -\infty \text{ If } \bar{\theta}_{hj} < L(\bar{\theta}_{hj}|\kappa(\boldsymbol{\iota}_h), \bar{\theta}_{h,-j}, r_h, \omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h, \mathcal{H}) \\ -\infty \text{ If } \bar{\theta}_{hj} > U(\bar{\theta}_{hj}|\kappa(\boldsymbol{\iota}_h), \bar{\theta}_{h,-j}, r_h, \omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h, \mathcal{H}) \\ \Pi(\theta_{hj}|(\kappa(\boldsymbol{\iota}_h), \boldsymbol{m}_h), (\bar{\boldsymbol{\theta}}_h, s_\theta, \omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h)) \times \pi(\bar{\theta}_{hj}|\mathcal{H}, \bar{\theta}_{h,-j}) \text{ If otherwise} \end{cases}$$

where $\pi(\bar{\theta}_{hj}|\mathcal{H}, \bar{\theta}_{h,-j})$ is the conditional distribution of a multivariate normal distribution.

For $(r_h, \omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h)$, the constraints that the household should not have any utility-improving one-member deviation is checked directly within each drawn conditional on draws of health types. When the constraint is satisfied, the posterior of $r_h, \omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h$ is given by:

$$\Pi(r_h, \omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h|\boldsymbol{\iota}_h, \bar{\theta}_{hj}, \mathcal{H}) = \Pi(\theta_{hj}|(\kappa(\boldsymbol{\iota}_h), \boldsymbol{m}_h), (\bar{\boldsymbol{\theta}}_h, s_\theta, \omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h)) \times \pi(r_h|\mathcal{H}) \times \pi(\omega_h|\mathcal{H}) \times \pi(\boldsymbol{\gamma}_h|\mathcal{H}) \times \pi(\boldsymbol{\delta}_h|\mathcal{H})$$

E.2 Sampling of hyper-parameters

Due to the large sample size, I use conjugate priors with large variance to reduce computational time for sampling of the upper level parameters. Except for β_θ, σ_λ, σ_e, and β_W, all other hyper-parameters could be drawn directly from the posteriors, which are usually a normal distribution or an inverse gamma distribution.

[39] As mentioned in Section 5, the household is more likely to buy insurance for a member if other members are sicker.

F Further Details on Vietnam's SHI

Year	Insurance type	Premiums	Coinsurance	Sources
1998	Compulsory (Including Policy beneficiaries)		100% for policy beneficiaries. For others, 20% coinsurance rates. If, however, the out-of-pocket costs exceed 6 months of the state's minimum wage in that year, the coinsurance rates is 0 afterwards. If the patient does not obtain referral from primary care service providers, he/she is still covered under the same rule but only up to the equivalent amount of a person under referral services	15/1998/TTLT-BYT-BTC-BLDTBXH
2003	Voluntary Insurance	80 KVND - 140KVND for urban, 60 - 100 for rural (different rates for students but not considered here)	20% coinsurance rate, but if out-of-pocket costs exceeds 1500K per year, coinsurance rate is 0 and out-of-pocket costs are capped at 1500K. If costs are under 20, also 0% coinsurance rates	77/2003/TTLT-BTC-BYT

2005	Compulsory (Including Policy beneficiaries)		100 % for expense under 7000 KVND. For expense above 7000KVND, policy beneficiaries have 0% coinsurance rates, but for majority of policy beneficiaries payment from coinsurance is capped at 20000KNVD. For others, health insurance pays the greater of 60% of charges or 7000KVND, but payments are also capped at 20000KVND	21/2005/TTLT-BYT-BTC
2005	Voluntary Insurance	100KVND - 160KVND for urban, 70KVND - 120 KVND for rural areas	for expense under 7000 KVND. For expense above 7000KVND, policy beneficiaries have 0% coinsurance rates, but for majority of policy beneficiaries payment from coinsurance is capped at 20000KNVD. For others, health insurance pays the greater of 40% of charges or 7000KVND, but payments are also capped at 20000KVND	22/2005/TTLT-BYT-BTC
2007	Voluntary Insurance	160KVND - 320KVND for urban, 120K -240K for rural areas	health insurance pays 100% if costs are under 100KVND, 80% for higher costs but are capped at 20000KVND	06/2007/TTLT-BYT-BTC
2008	All Insurance types	Maximum 6% minimum wage for voluntary members	0% coinsurance rate for all member types if costs are under the province level-service providers (100KVND), 95% for policy beneficiaries (the majority), and 80% for other member types	25/2008/QH12

G Additional Figures

Figure G.1 – Number of households in the sample with some members eligible for non-student voluntary SHI and/or fully covered under SHI

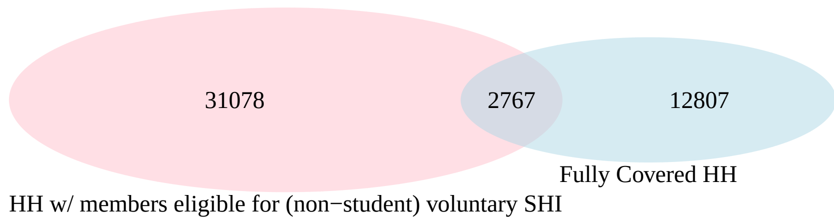


Figure G.2 – Number of households in the sample with some non-student voluntary SHI enrollees and/or non-student members being uninsured

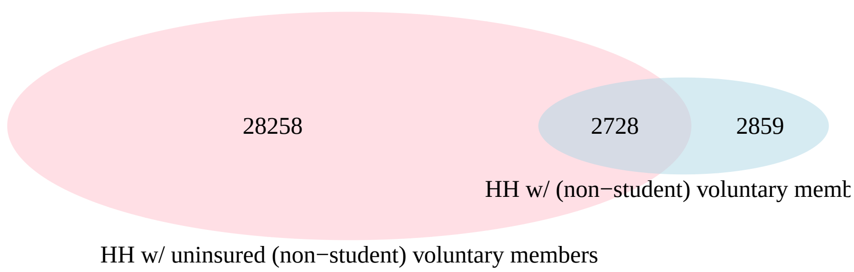


Figure G.3 – Number of households in the sample with some non-student voluntary SHI enrollees and/or student being uninsured

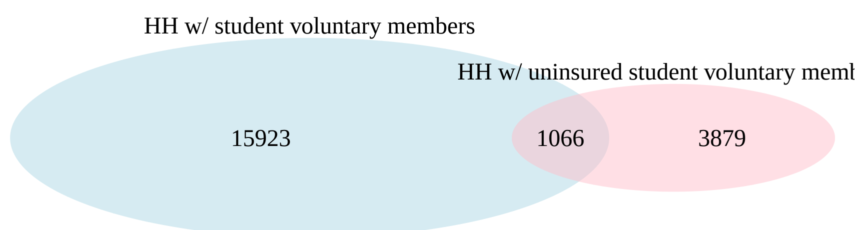


Figure G.4 – Proportions of Student Enrollment in the Data Sample by Year

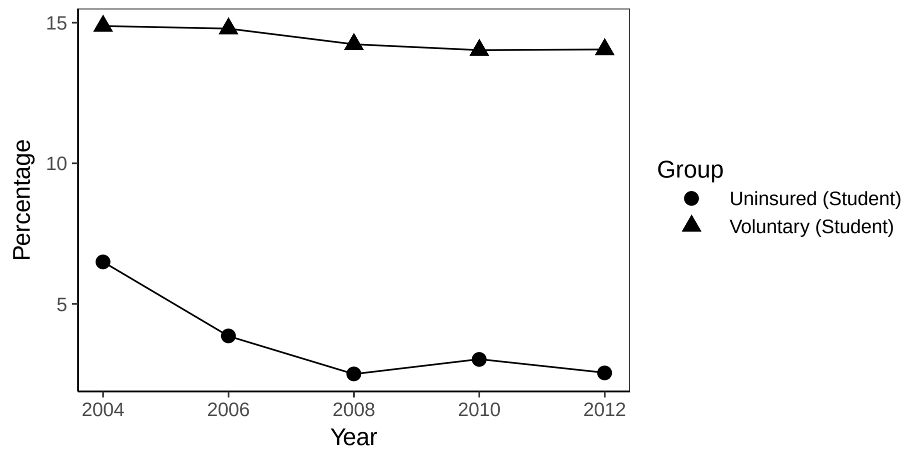


Figure G.5 – The distribution of the probability of coverage from data on reimbursement in 2008.

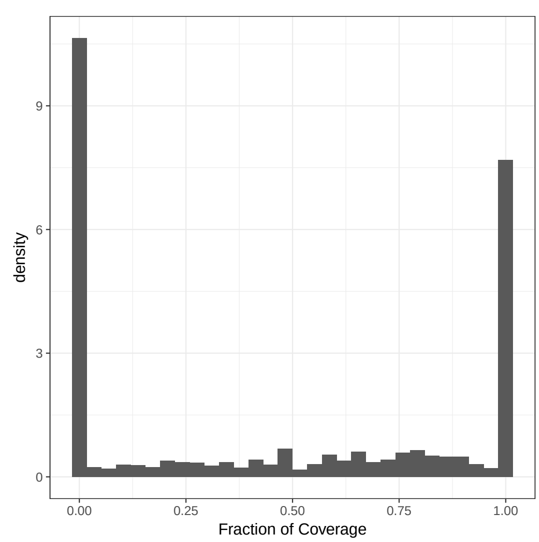
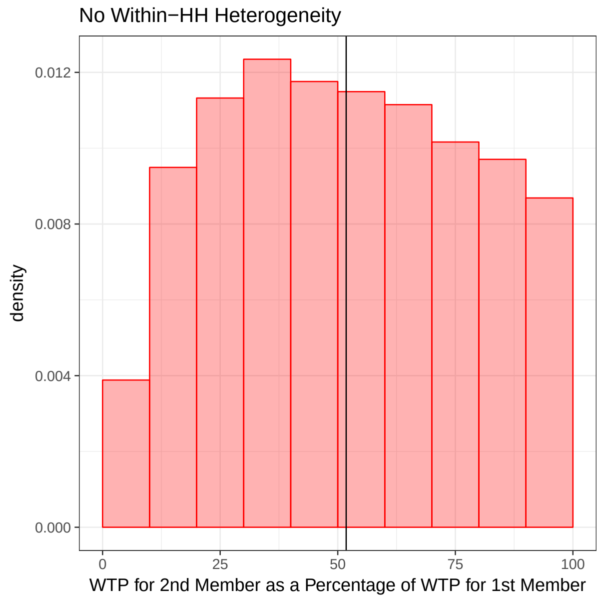
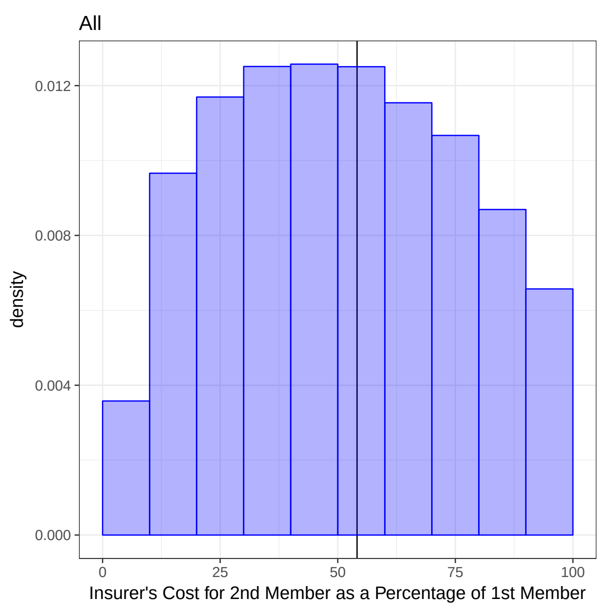


Figure G.6 – Distribution of the WTP for insurance for the second member as a percentage of that of the first



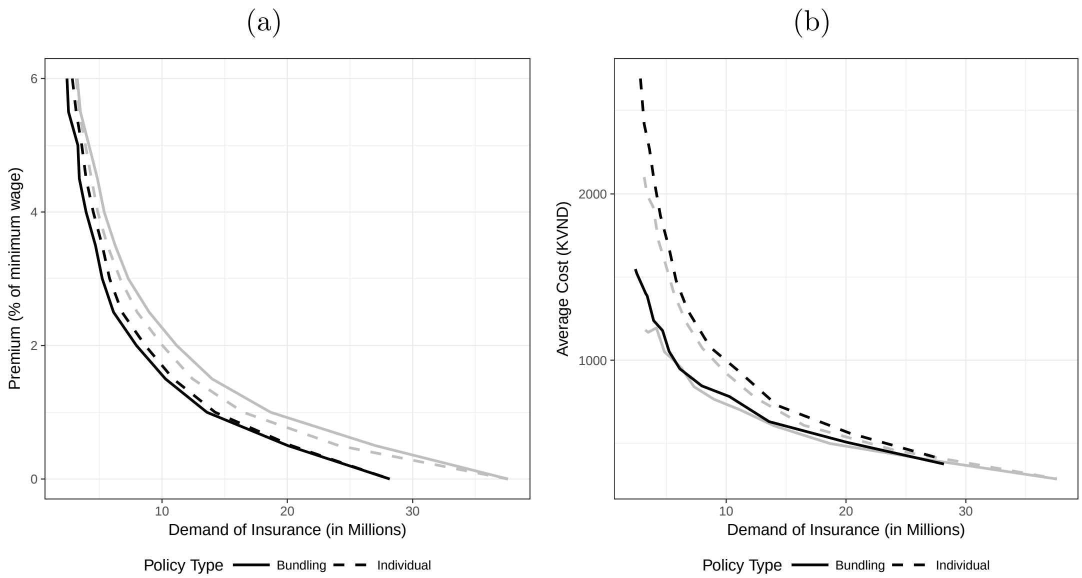
Note: the vertical black line represents the mean of the distribution.

Figure G.7 – Distribution of the cost of providing insurance for the second member as a percentage of that of the first



Note: the vertical black line represents the mean of the distribution.

Figure G.8 – The demand of insurance (a) and the average cost of insurance (b) under household bundling and individual purchase under uniform premium and less within-household adverse selection.



Note: In this exercise, I assume that the member with the worse health type within each household ($\arg\max_j \bar{\boldsymbol{\theta}}_h$) has free SHI. Since these members are now excluded from the voluntary SHI pool, there is less within-household adverse selection. Alternatively, one could directly change the parameters that characterize the distribution of health types within the household ($\sigma_\lambda, \sigma_\epsilon, \beta_W$). However, this will change the degree of adverse selection across households as well.

While household bundling still reduces the average cost of providing insurance, it leads to a lower demand for insurance. Compared to the original benchmark (Figure 8.1), the exclusion of members with the worse health types within each household affect households' willingness to pay for insurance in two ways. First, households' willingness to pay for any bundle is now lower due to the income effect of not having to pay for the first insurance. Second, under household bundling, households who previously buy insurance only to keep the sickest member from being uninsured will now drop out of insurance.

H Additional Tables

	2004	2006	2008	2010	2012
Outpatient visits	2.885	3.201	3.252	3.301	3.153
	(4.026)	(4.725)	(4.851)	(5.032)	(4.330)
Inpatient visits	0.276	0.242	0.264	0.301	0.274
	(0.794)	(0.665)	(0.701)	(0.840)	(0.749)
OOP	632.2	631.4	899.5	1364.0	1741.5
	(2661.5)	(2433.3)	(4295.4)	(5147.4)	(6404.7)
Medical OOP as Share of Average Income	0.126	0.102	0.0993	0.112	0.0942
	(0.549)	(0.484)	(0.381)	(0.453)	(0.431)
Observations	13072	14603	13178	15061	14352

Table H.1 – Summary statistics of medical spending in the data sample by year, restricted to individuals with positive medical expenditure. The out-of-pocket cost (OOP) is measured in KVND. Average income is measured annually in KVND, calculated as the total household income divided by the number of household members.

Table H.2 – Summary statistics of individual characteristics between individuals who are voluntarily insured and uninsured individuals (excluding students).

	With Voluntary Insurance	Uninsured
Age	46.92	36.94
	(16.97)	(17.78)
Female	0.604	0.515
	(0.489)	(0.500)
HH Size	4.235	4.623
	(1.567)	(1.615)
College Degree	0.225	0.131
	(0.418)	(0.337)
Total Household Income	83518.2	53181.1
	(86275.7)	(77870.4)
Individual Income	4638.1	3755.7
	(13663.2)	(9968.4)
Outpatient visits	2.714	1.108
	(5.532)	(3.126)
Inpatient visits	0.220	0.0746
	(0.711)	(0.375)
Observations	8575	77703

Table H.3 – Summary statistics of health indicators between individuals who are voluntarily insured and uninsured individuals (excluding students) in 2006.

	With Voluntary Insurance	Uninsured
Smoke	0.255	0.325
	(0.436)	(0.469)
With Chronic Diseases	0.197	0.0919
	(0.398)	(0.289)
Observations	1540	15161

Table H.4 – Summary of Estimates of Variance of Health Types and Uncertainty of Health Shocks

Within-HH Covariance Matrix of Within-HH's Health Types					
	Head of HH	Spouse	Children	Parents	Others
Head of HH	1.0372	0.4829	0.4605	0.396	0.5154
	(0.2276)	(0.3711)	(0.3606)	(0.305)	(0.4023)
Spouse	0.4829	1.5602	0.8543	0.7388	0.9628
	(0.3711)	(0.0272)	(0.0894)	(0.0683)	(0.0977)
Children	0.4605	0.8543	1.4808	0.7049	0.9199
	(0.3606)	(0.0894)	(0.067)	(0.0765)	(0.1187)
Parents	0.396	0.7388	0.7049	1.2756	0.7948
	(0.305)	(0.0683)	(0.0765)	(0.0817)	(0.0866)
Others	0.5154	0.9628	0.9199	0.7948	1.7023
	(0.4023)	(0.0977)	(0.1187)	(0.0866)	(0.1138)
Uncertainty	0.9948				
	(7e-04)				

Table H.5 – Summary of Estimates

Observed Characteristics	β_θ	π_s	β_ω	β_r	β_γ	β_δ
Constant	-6.5368	0.6175	-1.1041	-0.0046	-0.3488	-0.8545
	(0.0341)	(0.0064)	(0.1994)	(0.0018)	(0.02)	(0.112)
College	0.2781				0.0134	0.0305
	(0.0291)				(0.0112)	(0.0108)
Married	0.0014				0.0054	0.0435
	(0.0198)				(0.0159)	(0.0222)
Female	0.0381	0.0094			-0.0103	0.0282
	(0.0228)	(0.0042)			(0.005)	(0.0096)
Employed	-0.0856				-0.0183	-0.0569
	(0.0182)				(0.0086)	(0.021)
Age 0-18	(Dropped)	(Dropped)			(Dropped)	(Dropped)
Age 18-35	0.2902	-0.0482			-0.0198	0.0664
	(0.0258)	(0.0089)			(0.0152)	(0.0119)
Age 35-54	0.5348	-0.1073			-0.0499	0.1022
	(0.0433)	(0.0105)			(0.0099)	(0.0256)
Age 54-64	0.8551	-0.1493			-0.0643	0.0877
	(0.0392)	(0.0213)			(0.0164)	(0.0225)
Age 64+	1.0206	-0.1995			-0.0248	0.084
	(0.035)	(0.011)			(0.0361)	(0.018)
2004	(Dropped)					
2006	0.4985					
	(0.0331)					
2008	0.7939					
	(0.0183)					
2010	1.2219					
	(0.0153)					
2012	1.4492					
	(0.0334)					
Ind. Income Share						-7e-04
						(0)
HoH						(Dropped)
Spouse						-0.0544
						(0.0162)
Children						0.0198
						(0.0243)
Parent						-0.0041
						(0.0548)
Other						0.0585
						(0.033)
Eldest member			0.1128	0.0137		
			(0.0175)	(7e-04)		
Ratio of Females			-0.0275	-0.0083		
			(0.084)	(0.0022)		
Average age			-0.0793	-0.0177		
			(0.0212)	(9e-04)		
Number of members			0.0592	0.0018		
			(0.0148)	(3e-04)		
Avg. Education			0.0404	-0.0083		
			(0.0198)	(4e-04)		
Agricultural HH			(Dropped)	(Dropped)		
Formal sector HH			-0.1477	0.0308		
			(0.0405)	(0.0018)		
Self employed HH			0.0266	-0.0328		
			(0.0315)	(8e-04)		
			Unobserved Heterogeneity			
	Table H.4	—	s_ω	s_r	s_γ	s_δ
			0.419	0.000	0.148	0.322
			(0.074)	(0.000)	(0.046)	0.050

Table H.6 – In-sample Fit

Characteristics	Predicted Spending	Actual Spending	N
College Education	456.0382	466.8742	26662
	(21.4514)		
Married	508.5571	454.8552	107872
	(16.1184)		
Female	509.2673	419.1365	73067
	(17.4493)		
Employed	362.5862	336.7943	37438
	(14.1873)		
18 - 35	282.4619	290.1258	39394
	(13.5302)		
35 - 54	479.2727	498.8892	38569
	(13.7281)		
54 - 64	895.247	816.9197	10669
	(25.0268)		
64 -	1147.2847	961.1489	9942
	(79.9024)		
Income - 1st Quantile	365.4047	205.1497	40700
	(23.3577)		
Income - 2nd Quantile	309.5344	291.1287	34818
	(18.8007)		
Income - 3rd Quantile	408.5393	409.975	34512
	(21.4297)		
Income - 4th Quantile	627.9152	660.6398	34815
	(9.4608)		
Full Sample	425.3257	384.087	144854
	(13.8209)		

Characteristics	Predicted Enrollment	Actual Enrollment	N
College Education	0.1493	0.1408	10722
	(0.0069)		
Married	0.1258	0.1093	52971
	(0.0058)		
Female	0.1324	0.1111	35315
	(0.0042)		
Employed	0.1013	0.0823	19300
	(0.0061)		
18 - 35	0.1039	0.0652	21760
	(0.0047)		
35 - 54	0.126	0.1083	25005
	(0.0063)		
54 - 64	0.1781	0.1893	5885
	(0.0086)		
64 -	0.1972	0.2293	4958
	(0.0086)		
Income - 1st Quantile	0.0994	0.0464	14627
	(0.0041)		
Income - 2nd Quantile	0.1055	0.0639	18831
	(0.0051)		
Income - 3rd Quantile	0.1183	0.1001	18413
	(0.0058)		
Income - 4th Quantile	0.1515	0.172	16498
	(0.0071)		
Full Sample	0.1187	0.096	68369
	(0.0046)		

Note: The in-sample fit excludes the sample of household in 2006 that have at least 1 member eligible for household bundling. Enrollment is calculated only on individuals who are eligible for voluntary SHI.

Table H.7 – The optimal prices under the observed 2012 benchmark, household bundling, and individual purchase with nonlinear pricing

Bundle Size	Current Policy	Household Bundling	Individual Purchase
1	4.5	1.65	5.15
		(0.3375)	(0.7091)
2	8.55	2.69	7.955
		(0.2025)	(1.4052)
3	12.15	3.215	9.275
		(0.3317)	(1.4688)
4	15.3	3.395	9.58
		(0.3912)	(1.4986)
5	18.45	3.575	9.885
		(0.5329)	(1.6757)
6	21.6	3.755	10.19
		(0.7092)	(1.9606)

Note: The prices are indexed to the minimum wage of 2012.

Table H.8 – Comparison of consumer surplus across groups of individuals with different observed characteristics.

Characteristics	Current Policy	Optimal Household Bundling	Optimal Individual Purchase
1 Eligible Member	188.9435	291.0182	182.6037
	(21.3873)	(36.3367)	(31.0466)
2 Eligible Members	321.3571	498.8662	316.6726
	(36.8176)	(31.1894)	(45.2085)
3 Eligible Members	487.3417	744.411	516.7517
	(65.086)	(22.8783)	(59.1256)
4 Eligible Members	595.2727	978.6602	673.2693
	(72.7018)	(123.2617)	(90.87)
>4 Eligible Members	827.5155	1182.9059	927.6377
	(134.4906)	(144.4302)	(118.797)
Income - 1st Quantile	244.3033	377.8188	254.1447
	(17.6495)	(18.7131)	(20.1513)
Income - 2nd Quantile	249.5775	388.2009	256.0596
	(16.9733)	(25.8362)	(25.9364)
Income - 3rd Quantile	303.6379	459.5977	308.025
	(38.9381)	(25.4719)	(39.9501)
Income - 4th Quantile	357.7735	534.0323	373.8589
	(31.3068)	(39.5613)	(32.8252)

Note: The first column indicates the percentage of enrollment for the 2012 policy. The second column indicates the fraction of enrollment under the optimal household size pricing, and the third column reports the outcome under the optimal bundle size pricing. The cost-sharing structures are fixed at the 2012 contracts.

Table H.9 – Comparison of insurance enrollment across groups of individuals with different observed characteristics.

Characteristics	Current Policy	Optimal Household Bundling	Optimal Individual Purchase
College Education	0.129	0.5418	0.1619
	(0.0068)	(0.0366)	(0.0328)
Married	0.1148	0.5089	0.1444
	(0.005)	(0.0348)	(0.0269)
Female	0.1317	0.5126	0.1596
	(0.0074)	(0.0341)	(0.0259)
Employed	0.0621	0.4393	0.0949
	(0.0034)	(0.038)	(0.0277)
18 - 35	0.0812	0.4886	0.1212
	(0.0057)	(0.0396)	(0.0315)
35 - 54	0.1015	0.4863	0.1275
	(0.0061)	(0.0327)	(0.0265)
54 - 64	0.1812	0.6123	0.2115
	(0.0169)	(0.0488)	(0.0296)
64 -	0.2212	0.6482	0.249
	(0.0126)	(0.0377)	(0.0388)
Income - 1st Quantile	0.1078	0.5115	0.141
	(0.0043)	(0.0357)	(0.0293)
Income - 2nd Quantile	0.1089	0.4895	0.1345
	(0.006)	(0.035)	(0.0295)
Income - 3rd Quantile	0.1025	0.5091	0.132
	(0.0063)	(0.0361)	(0.0285)
Income - 4th Quantile	0.1259	0.5673	0.1725
	(0.0061)	(0.0349)	(0.0364)

Note: The first column indicates the percentage of enrollment for the 2012 policy. The second column indicates the fraction of enrollment under the optimal household size pricing, and the third column reports the outcome under the optimal bundle size pricing. The cost-sharing structures are fixed at the 2012 contracts.

Table H.10 – The effect of household bundling, individual pricing, and mandate on consumer surplus under different levels of subsidy.

Additional Subsidy	Single - Individual	Single - Bundling	Individual Purchase	Household Bundling	Mandate
-0.136 %	0	0	0	0.1147	0.2856
	(0)	(0)	(0)	(0.0055)	(0.0095)
-0.068 %	0	0	0	0.1248	0.2857
	(0)	(0)	(0)	(0.0058)	(0.0095)
0 %	0	0	0	0.1368	0.2861
	(0)	(0)	(0)	(0.0071)	(0.0094)
0.068 %	0	0	0	0.1523	0.2861
	(0)	(0)	(0)	(0.0083)	(0.0094)
0.136 %	0	0.1707	0.0936	0.1707	0.2862
	(0)	(0.0083)	(0.0085)	(0.0083)	(0.0094)
0.204 %	0.0448	0.1729	0.1596	0.1953	0.2867
	(0.0721)	(0.0104)	(0.0075)	(0.0076)	(0.0096)
0.272 %	0.1764	0.1729	0.2173	0.2277	0.2868
	(0.0092)	(0.0104)	(0.0076)	(0.0083)	(0.0094)
0.34 %	0.1764	0.1729	0.2465	0.2464	0.2868
	(0.0092)	(0.0104)	(0.0126)	(0.013)	(0.0094)
0.408 %	0.1764	0.1729	0.2599	0.2598	0.2868
	(0.0092)	(0.0104)	(0.0094)	(0.0094)	(0.0094)

Note: The unit of consumer surplus is percent of total GDP. The consumer surplus obtained under mandate assumes the optimal (under mandate) household size pricing. The third and fourth column assume nonlinear pricing.

Table H.11 – The effect of household bundling, individual pricing, and mandate on insurance enrollment (in millions) under different levels of subsidy.

Additional Subsidy	Single - Individual	Single - Bundling	Individual Purchase	Household Bundling	Mandate
-0.136 %	0	0	0	10.2357	37.9215
	(0)	(0)	(0)	(0.8197)	(0)
-0.068 %	0	0	0	11.4003	37.9215
	(0)	(0)	(0)	(0.9346)	(0)
0 %	0	0	0	13.6721	37.9215
	(0)	(0)	(0)	(0.6387)	(0)
0.068 %	0	0	0	15.8493	37.9215
	(0)	(0)	(0)	(0.9377)	(0)
0.136 %	0	19.5225	5.2505	19.5225	37.9215
	(0)	(1.0281)	(0.8113)	(1.0281)	(0)
0.204 %	5.3265	19.8918	14.7208	24.3173	37.9215
	(8.5773)	(1.1697)	(2.208)	(1.4133)	(0)
0.272 %	17.8581	19.8918	27.6712	31.0664	37.9215
	(1.7216)	(1.1697)	(2.1002)	(1.0219)	(0)
0.34 %	17.8581	19.8918	34.9842	34.9954	37.9215
	(1.7216)	(1.1697)	(2.5921)	(2.4004)	(0)
0.408 %	17.8581	19.8918	37.6333	37.6149	37.9215
	(1.7216)	(1.1697)	(0.0314)	(0.035)	(0)

Note: The enrollment obtained under mandate assumes the optimal (under mandate) household size pricing. The third and fourth column assume nonlinear pricing.

Table H.12 – Comparison between Voluntary Premium and Post-subsidy Compulsory Premium

	(1) Premium	(2) Premium	(3) Premium
$\text{Premium}_{\text{Voluntary}} - \text{Premium}_{\text{Compulsory}}$	-133.8***	-87.08***	-88.18***
	(3.942)	(3.242)	(3.276)
Year FE	No	Yes	Yes
Geography FE	No	Yes	Yes
Age FE	No	No	Yes

Standard errors are adjusted for heteroskedasticity

Note: Premium for compulsory SHI does not include the premium subsidy paid by employers.