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

Anh Nguyen†

August 2018

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. However, this can exacerbate adverse selection *across* households. 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 and develop a model of household insurance bundle choice and medical utilization. The estimation 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.

Keywords: Adverse selection; Household bundling; Health insurance.

*I am grateful to Kate Ho, Mike Riordan, Bernard Salanié, and Tobias Salz for their invaluable guidance and support. This paper has benefited greatly from numerous discussions with Teck Yong Tan. I would also like to thank So Yoon Ahn, Charles Angelucci, Pierre-André Chiappori, Xiaodong Fan, Adam Kapor, Alan Krueger, Liisa Laine, Suresh Naidu, Loi Nguyen, Dan O'Flaherty, Krishna Pendakur, Andrea Prat, Rodrigo Soares, Danyan Zha and participants at various seminars for helpful comments. I gratefully acknowledge financial support from the Becker Friedman Institute's Health Economics Research Initiative.

†anhnguyen@cmu.edu. Tepper School of Business, Carnegie Mellon University

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 insurance subsidies 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. This paper explores how the social planner can exploit this distinction through the use of household bundling – i.e., bundling the insurance contracts of household members – 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 subset of its members. Each household will then buy health insurance only 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 then 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 the two households have identical compositions, they have the same willingness to pay (WTP) 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. By contrast, 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.

In this paper, I empirically study the welfare effect of household bundling in the context of the Social Health Insurance (SHI) Program in Vietnam, where 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 certain health indicators for each member, as well as each household member's insurance status.

While schemes such as employer-sponsored health insurance are also forms of bundling, the mechanism underlying household bundling is distinct from that of most group insurance policies. The potential welfare gain from household bundling is due to both risk pooling and the fact that household members know each other's health risks. The latter distinction is crucial because it ensures efficient bargaining within the household when the household jointly decides whether to buy health insurance. By contrast, in an arbitrary group in which members do not know each other's health risks, forcing the group to make a joint decision to buy health insurance might lead to an inefficient outcome (Myerson and Satterthwaite, 1983). For example, the group may choose not to buy health insurance even when all members benefit from buying health insurance.

The rationale behind how household bundling of health insurance affects insurance enrollment and welfare is also applicable to other government-sponsored health insurance programs. 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.[1] 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

[1] For the employer-sponsored health insurance market in the US, Sinaiko et al. (2017) finds that the variation in medical spending under family pooling is lower than the individual variation. This also suggests that household bundling can be potentially applicable in this market.

nations that are still struggling with low health insurance coverage.[2]

I first develop a structural model of a household's health insurance choices and medical care that helps to quantify the source of adverse selection and 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, adverse selection could arise not only from the unobserved heterogeneity in health types but also from the unobserved heterogeneity in preferences for medical care among household members. The household choice model incorporates the stylized features from the data: (1) medical care as a normal good (the income effect), (2) medical care consumption for different household members are substitutes (cross-member substitution effects), and (3) moral hazard.

My model takes into account various factors related to the household demand for medical care and risk preferences that 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 WTP 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 buy insurance for only some but not all members, hence contributing to within-household adverse selection.

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 thresh-

[2] 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.

old 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 care 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 partially enrolled in insurance due to both the substitutability of health insurance for different household members 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 WTP for the second member's insurance is, on average, 51% of its WTP 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, a significant portion of 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 charge only 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. This means that the number of individuals who buy insurance only 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

[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.

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 WTP 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 finding 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 will be insured, and the market will unravel. In my estimates, the market begins to unravel under individual purchase when the level of government subsidy decreases 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 my empirical framework, while Section 5 discusses the identification and parameterization of the model. The results of the structural estimation are provided in Section 6. Section 7 analyzes the welfare impact of household bundling policies, and Section 8 concludes.

[4]Under the assumption that the social planner chooses only 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.

2 Related Literature

This paper is related to several distinct literatures. The modeling approach in this paper is built on 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 WTP for insurance is determined jointly 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, medical care utilization 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 WTP 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 in which 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' WTP (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 solves a Ramsey pricing problem (Ramsey, 1927) and does not merely maximize 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 to both 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 their 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, and hence, 50% of formal sector workers are not enrolled in compulsory insurance (Somanathan et al., 2014).[5] These individuals are then eligible to purchase voluntary insurance. As of 2012, 31.9 million Vietnamese, or 30% of the population, were not enrolled in SHI. Among these, 15.7 million were non-poor informal sector workers, and 6.2 million were formal sector workers (Somanathan et al., 2014).

Each enrollee type is assigned a type-specific insurance contract, and there have been substantial variations in the cost-sharing features of the SHI contracts across years and enrollee types. Table 3.1 summarizes the coinsurance structures of SHI contracts in selected years.[6] SHI contracts cover only the enrollees and not their dependents. In general, 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 accidents, suicide, or drug addiction. These exclusions have remained constant 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 (MW), which varies 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 in selected years is summarized in Table 3.2. In the period from 2005 to 2007, household bundling was implemented together with a premium reduction and a requirement on commune-level participation rates.[8] In this period, voluntary SHI was only

[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 its 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.

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

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 (OOP) costs not exceeding 4666 40% For additional expense	0% If expense is below 7000 100% For additional expense, but OOP costs not exceeding 4666 40% For additional expense
2008	0%	0% If expense is below 7000 100% For additional expense, but OOP 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 OOP cost is a continuous function of total health expenditure. In 2010 and 2012, however, there is a jump in OOP costs between expense below 100 KVND and above 100 KVND.

available in communes in which at least 10% of households were 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 enrolled in insurance. This pricing scheme is nonlinear pricing in the form of bundle size pricing.

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 a low quality of care, stigma, or the 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 that must accept SHI.[11] Private providers can also

[9] Evidence from the data suggests that this was due primarily to the commune requirement. For further details, see Appendix B.

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

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

Table 3.2 – Premium structure for households with members eligible for voluntary SHI

Year	Eligible Member	Individual Premium (Non-student)[1]			Policy
2004	1 2+	4.5% 4.275%			Individual purchase
2006	1 2 3 4+	3.0% 3.0% 2.7% 2.4%			Household bundling
2008	1 2 3 4+	4.5% 4.5% 4.05% 3.6%			Individual purchase
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 receive lower premiums only if the household is fully enrolled in insurance.
Note: All premiums are indexed to MW. Per the Health Insurance Law of 1998, the maximum individual premium for voluntary enrollees is capped at 6% of MW.

apply to accept SHI enrollees as long as they meet sufficient quality standards. Most SHI reimbursement is at the provider level, and the reduced 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 because it does not exclude pre-existing conditions.

Vietnam's participation in the SHI scheme was part of a larger effort initiated by the 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 preferable to the tax-financed system when a country's tax revenue is insufficient to fund health care (Hsiao et al., 2006). Moreover, since SHI only partially relies on public tax revenue, implementing SHI 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, the Philippines, Colombia, Thailand, and Vietnam.[12]

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

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 by the General Statistic Office of Vietnam once every two years on more than 9000 households to monitor living standards. The survey has a rolling panel structure whereby 50% of households are randomly chosen to be interviewed in two consecutive waves. The data consist of the demographic characteristics of household members, income, expenditures, education level and information on health status, health expenditure, and health insurance status. The sample of households in VHLSS is selected as a representative sample of the entire population. I supplement these survey data with the administrative data on yearly revenue collected from health insurance premiums and payments by VSS. The data are grouped by enrollee type and city from 2008 to 2012.

Table 3.3 shows the summary statistics of the data 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 increased 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% and 4% of per-member average income for out-of-pocket (OOP) costs. When the sample is restricted to only individuals who have at least 1 doctor visit per year, 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 needs an inpatient visit. The OOP costs once medical utilization occurs account for approximately 10% of the average per-member income.

The percentages of each enrollee type and the uninsured are summarized in Figure 3.1. Most of the decrease in the number of uninsured individuals results 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 rollout of the policy which was implemented only at selected communes.

[13] The large increase in income in local currency (KVND) over time also 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.

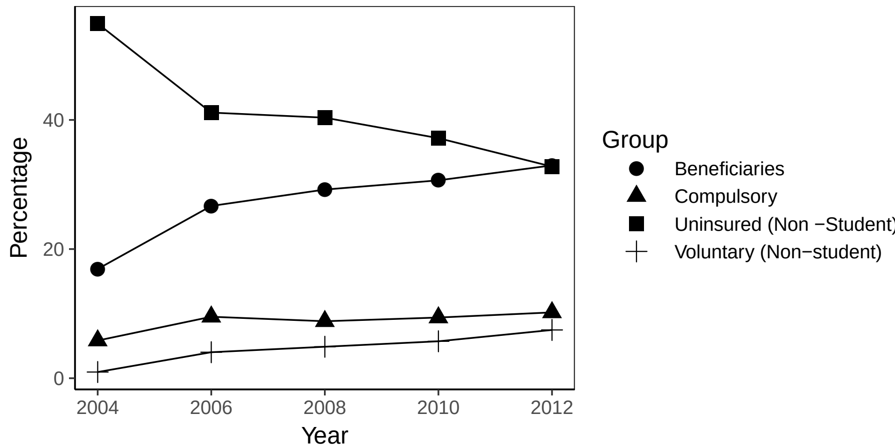
Table 3.3 – Summary statistics of the full sample

	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 OOP cost is measured in KVND. Average income is measured annually in KVND, calculated as the total household income divided by the number of household members.

Throughout this paper, I will focus only on the non-student members who are eligible for voluntary SHI because premiums for student SHI are usually included in tuition fees; hence, households cannot opt out of student SHI. In the data, most students are fully insured (Figure G.2), and most households choose to insure all their student members (Figure G.1). However, when a household chooses to opt out of student SHI for some of its members,

Figure 3.1 – Proportions of different enrollment types in the data sample by year



I assume that whether the household would like to buy student SHI is still part of the household's choice set.

Within-Household vs. Across-Household Selection Into Insurance. Table H.13 decomposes the variance in voluntary insurance enrollment across individuals in the data into within-household variance and across-household variance. Within-household variance accounts for between 23.7% and 34.5% of the variation in voluntary enrollment, among which 13.4% of the total variation cannot be attributed to age differences among household members. However, when the sample is restricted to households with at least one member buying voluntary health insurance, within-household variation can explain between 56.8% and 65.1% of the total variance, and between only 35.5% and 40.5% of the total variation is due to within-household age differences (Table H.14). This suggests that within-household selection into health insurance plays an important role in the data, and this selection cannot be solved with only age-based pricing.

4 Model

This section presents a model of household health insurance choice and demand for medical care. The model extends the commonly used two-stage modeling approach to a unitary household framework in which each household has a representative agent – henceforth the decision maker (DM) – who makes all 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 household income. In this section, I abstract 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 $\boldsymbol{m}_h := (m_{hj})_{j=1,2,...,n}$, where m_{hj} is member j's medical utilization in monetary value.

Next, the health shocks of household h are denoted by $\boldsymbol{\theta}_h := (\theta_{hj})_{j=1,2,...,n_h}$, 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 $\boldsymbol{\kappa}_h := (\kappa_{hj})_{j=1,2,...,n_h}$, 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 $\pi(\boldsymbol{\kappa}_h)$.[14] In period 2, health shocks $\boldsymbol{\theta}_h$ 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 household members' utility under consumption basket $(c_h, \boldsymbol{m}_h)$ and health shock realization $\boldsymbol{\theta}_h$. The objective of the DM is to maximize the ex ante expected value of U_h.

4.1 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 as follows:

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

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 the insurance premium, and the left-hand side represents expenditure on the consumption good and the OOP costs of medical care.

[14] Note that in Vietnam's SHI setting, each household takes the coinsurance rate under insurance as given but can 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 $\{(1, 0.2), (0.2, 1), (1, 1), (0.2, 0.2)\}$.

By the integrability theorem (Hurwicz, 1971), the ordinal utility function U can be specified if the demand system of the household is known. Thus, I will directly make assumptions on the demand system to exhibit these properties; Appendix A.1 provides the details to recover the underlying utility function U_h.

Let the residual income of the household be

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

The residual income is the remaining household income after paying the health insurance premium $\pi\left(\boldsymbol{\kappa}_h\right)$, the total OOP costs of necessary care for all household members $\boldsymbol{\theta}_h \cdot \boldsymbol{\kappa}_h$, and the subsistence expenditure.[15]

Assumption 4.1. *The demand for medical care is assumed to take the following functional form:*

$$m_{hj}\left(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h\right) = \underbrace{\theta_{hj}}_{\textit{Necessary medical care}} + \underbrace{\delta_{hj}\theta_{hj}\left(\max\left\{R\left(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h\right), 0\right\}\right)^{\omega_h}\left(1+\kappa_{hj}\right)^{-\gamma_{hj}}}_{\textit{Optional medical care}} \tag{4.1}$$

Assumption 4.1 ensures that the demand system exhibits multiple stylized features from the data, which includes: (1) medical care is a normal good, (2) the demand for medical care exhibits moral hazard, and (3) the household views medical care consumption for different household members as substitutes (cross-member substitution effect). The reduced form evidence of these stylized features is included in Appendix B.

The demand for medical care consists of two components: a necessary component, which is the same as the health shock θ_{hj}, and an optional component. The optional care is positive and dependent on household income only if the household has positive residual income $R()$, in other words, if the household is sufficiently wealthy. The income elasticity of medical care is then represented by $\omega_h > 0$, which is common across all household members within a household h.

The amount of optional care for each member is negatively affected by his coinsurance rate κ_{hj}, thus implying moral hazard. The demand for medical care of different household

[15] Following Xu et al. (2003), the subsistence expenditure is calculated as the expenditure on food among households between the 35th and the 55th percentiles of income.

members can exhibit different degrees of moral hazard, which is characterized by the moral hazard coefficient $\gamma_{hj} > 0$. The functional form of moral hazard is chosen such that there exists an upper bound on medical utilization when medical care is free (the coinsurance rate is 0), which also implies that the marginal utility of medical care is zero for sufficiently high spending.[16]

Since the total OOP cost of necessary care affects the household's residual income, the cross-member substitution effect arises indirectly from the income effect. If a household member has a higher coinsurance rate of medical care, the household has to pay more OOP costs for his necessary care, thus lowering the residual income and reducing the amount of optional care for all other household members.[17]

In order to capture some aspects of intra-household bargaining, the demand for optional care is also dependent on an individual-household-specific weight δ_{hj}, which represents the bargaining weight of each household member. This allows the levels of optional care relative to necessary care to vary across household members. For example, the household might value the demand for the head of the household (HoH) more than other members and hence consume more medical care for the HoH at any given health shock. In addition, the optional care is assumed to be linearly dependent on the necessary care.[18]

Proposition 4.2. *The demand specification in Assumption 4.1 satisfies the integrability theorem when $c_h > 0$ and the following condition holds:*

$$R(\theta_h, Y_h, \kappa_h) > \sum_{j=1}^{n_h} \frac{\omega_h(1+\kappa_{hj})}{\gamma_{hj}}(m_{hj} - \theta_{hj}) \tag{4.2}$$

Intuitively, Proposition 4.2 places an upper bound on the income elasticity ω_h to ensure that the cross-price effect of the (Hicksian) demand, which enters through the effect on the residual income, is smaller than the own-price effect in absolute terms.

[16] An alternative way to prevent infinite consumption at zero price is a 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-member household model, as will be shown later.

[17] 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 $i \neq j$.

[18] Neither linearity nor positive correlation between the optional care and the necessary care are required for the model. Under a more general specification $m_{hj}(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h) = \theta_{hj} + \delta_{hj}\theta_{hj}^{\alpha}\left(\max\left\{R\left(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h\right), 0\right\}\right)^{\omega_h}\left(1+\kappa_{hj}\right)^{-\gamma_{hj}}$, the estimated α is very close to 1. Hence, I impose $\alpha = 1$ for expositional clarity.

Corollary 4.3. *Under the condition of Proposition 4.2, the following is an indirect utility function of the preference derived from Assumption 4.1.*

$$U^*\left(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h\right) = \begin{cases} \frac{(R(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h))^{1-\omega_h}}{1-\omega_h} - \sum_{j=1}^{n_h} \delta_{hj}\theta_{hj} \frac{\left(1+\kappa_{hj}\right)^{1-\gamma_{hj}}-1}{1-\gamma_{hj}} & \textit{if} \quad R(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h) > 0 \\ R(\boldsymbol{\theta}_h, Y_h, \boldsymbol{\kappa}_h) - u & \textit{Otherwise} \end{cases} \tag{4.3}$$

When the residual income is positive, the first term of Equation (4.3) is an increasing function of the residual income and thus could be considered the indirect utility from income. The second term is the sum of the disutility from sickness of household members weighted by their bargaining weights δ_{hj}. This disutility is an increasing function of each member's health shock and an increasing function of the price of medical care. It 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 sufficient medical care.

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

4.2 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.[19] The DM's period-1 optimization problem is

$$\max_{\boldsymbol{\kappa}_h \in K_h} \ \mathbb{E}_{\boldsymbol{\theta}_h} - \exp\Big(- r_h U^*\left(\boldsymbol{\theta}_h, y_h, \boldsymbol{\kappa}_h\right)\Big) \tag{4.4}$$

Equation (4.4) yields familiar characterizations of the WTP for insurance in terms of risk aversion r_h and the distribution of health shocks $F_{\theta_{hj}}$. For any member, the household has higher WTP for insurance if its risk aversion is higher or if the household's belief about his health shock is worse. Due to the presence of the bargaining weights, the household's willingness to pay for insurance is higher for members with higher bargaining weights δ_{hj}. The comparative statics with respect to the moral hazard coefficient γ_{hj} is less straightforward due to two countervailing effects. A member with a higher moral hazard coefficient γ_{hj}

[19] This set can vary across households with different observed characteristics. In the empirical setting of this paper, this set is dependent on the household size.

will increase his medical utilization more when insured, thus implying that the household has higher WTP for his insurance. At the same time, his flexibility in medical utilization suggests that the household's marginal utility from his medical care is relatively low, hence reducing the household's WTP for his insurance. In my model, the latter effect dominates the former, and the household's WTP for insurance is a decreasing function of γ_{hj}.

Furthermore, 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 WTP for the second member's insurance is lower than that of the first.[20] In other words, health insurance plans 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 and thus being able to consume more medical care for the second member becomes less significant.[21] In Appendix B, I provide some suggestive evidence of the substitutability in the household demand for health insurance for different household members.

Implication of Within-Household Selection In my model, when the price of insurance is the same for every member, the household could choose to be partially insured for one of the following reasons. First, the household might believe that some members are sicker and have worse health shocks. Second, the household might buy insurance only for members who have high bargaining weights 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 with insurance does not affect the average cost of providing insurance.

5 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 preferences r_h are identified under parametric assumptions on the

[20] 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 WTP even without income elasticity ($\omega_h = 0$).

[21] Using similar logic, the household has lower WTP for one member if other members become healthier.

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, data on medical utilization are used to recover the parameters that characterize the household's demand for medical care. In the second step, 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 Assumption 4.1 but will require more data.

5.1 Identification

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

Let Z_{hj} be an indicator variable that takes a value of 0 if an individual has compulsory or free health insurance and a value of 1 if he is eligible for voluntary 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 follows:

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

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 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 from the observation that 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 5.1.

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 5.1.a is needed because of the nonlinearity of θ_{hj} in the demand specification (Assumption 4.1). Assumption 5.1.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. In Appendix D, I show some reduced-form evidence that supports this assumption by considering the decision to buy voluntary insurance of individuals who switch into or out of the compulsory group due to job changes. There are multiple reasons why this assumption is likely to be valid in Vietnam's SHI context.[22] As of 2004 (the beginning of the sample period), both voluntary SHI and compulsory SHI were available. Furthermore, the premium for compulsory SHI is indexed to the individual wage and thus is usually higher than the voluntary premium (Table H.12). In addition, the cost-sharing policies for the two enrollee types are largely similar. Assumption 5.1.b also assumes that the distributions 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 5.2. *Under Assumption 5.1, 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 the identification of nonlinear random coefficient models, especially in a continuous demand system (see, for example, Lewbel and Pendakur (2017)). Instead, identification here is achieved sequentially for each parameter 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 with full insurance whose family members did not incur any medical care

[22] 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.

and with average household income ($Y_h = 1$) are 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 distributions 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 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 an insurance bundle.

5.2 Estimation

The main computational challenge involves the estimation of the expected indirect utility (Equation 4.4), 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 beliefs about all household members' health shocks. In addition, since I allow for unobserved heterogeneity in all demand parameters $(\omega_h, \boldsymbol{\gamma}_h, \boldsymbol{\delta}_h)$ and risk aversion r_h, approaches such as maximum likelihood or the method of moments require integration of the random coefficients for all combinations of observed household and individual characteristics. Because household compositions vary, these methods are computationally burdensome. Thus, I opt for a Bayesian approach using Gibbs sampling 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 the estimation, I assume the following additional distributional assumptions on $(\omega_h, \boldsymbol{\delta}_h, \boldsymbol{\gamma}_h)$ as follows:

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

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

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 $\epsilon_{hj} \sim \mathcal{N}(0, \sigma_\epsilon)$.[23] $\boldsymbol{W}_h := (W_{hj})_{j=1,\ldots,n_h}$ represents the effect of the household's common shock to each household member. W_{hj} is linearly dependent on the member's observed characteristics $W_{hj} = X_{hj}\beta_W$. Since we can 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 4, there is no uncertainty over 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 OOP 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

[23]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 5.1 – 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	
$\beta_\zeta^0, \beta_\zeta^1$	Probability of zero and full coverage

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

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

where $p_0(X_{hj}) = \frac{\exp(X_{hj}\beta_\zeta^0)}{1+\exp(X_{hj}\beta_\zeta^0)+\exp(X_{hj}\beta_\zeta^1)}$ and $p_1(X_{hj}) = \frac{exp(X_{hj}\beta_\zeta^1)}{1+\exp(X_{hj}\beta_\zeta^0)+\exp(X_{hj}\beta_\zeta^1)}$. 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 that some are not covered. However, for other diseases, households do not know whether the diseases are covered. As shown in Figure G.3, the majority of individuals either receive no coverage or have complete coverage; therefore, the uniform distribution assumption does not have a large effect on the estimation.

The objects of interests are summarized in Table 5.1. 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.

6 Results

Table H.5 in the Appendix presents the estimates of all parameters from the model. Table 6.1 shows the implied distributions of the parameters characterizing the preferences for medical care, households' risk preferences, the distribution of health types, and the distribution of medical care consumption.

Table 6.1 – Implied distributions 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 estimate is similar to previous estimates in the literature, which are between -0.1 and -0.4 (Chandra et al., 2010).[24] My estimates suggest that moral hazard exists but does not have a large impact on medical care consumption. On average, household members spend 113 KVND more when switching from being uninsured to having full insurance.[25] This shift represents a 17% increase in total medical care consumption.

The average income elasticity ω is 0.589, which is higher than the reduced form correlation found in Appendix B, which was between 0.204 and 0.316. This is because both the moral hazard coefficient γ and income elasticity ω affect only 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 an average income ($Y_h = 1$) and a financial risk that might occur with 50% probability. If the risk occurs, the household will lose 5% of its household income. In this case, the estimated risk coefficient implies that the household is willing to pay 3.56% of its income to insure against this risk.

The average necessary care for each individual is 441.8 KVND and accounts for 1.1% of household income. Under the observed 2012 insurance contract, the amount of medical care consumed by each household member is approximately 1.3% of 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 in Vietnam. For example, the World Bank estimated that health expenditure in Vietnam was between 5% and 7% of GDP in the 2004-2012 period (World Bank, 2016). The estimates also suggest that health shocks could be a significant financial burden when 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.

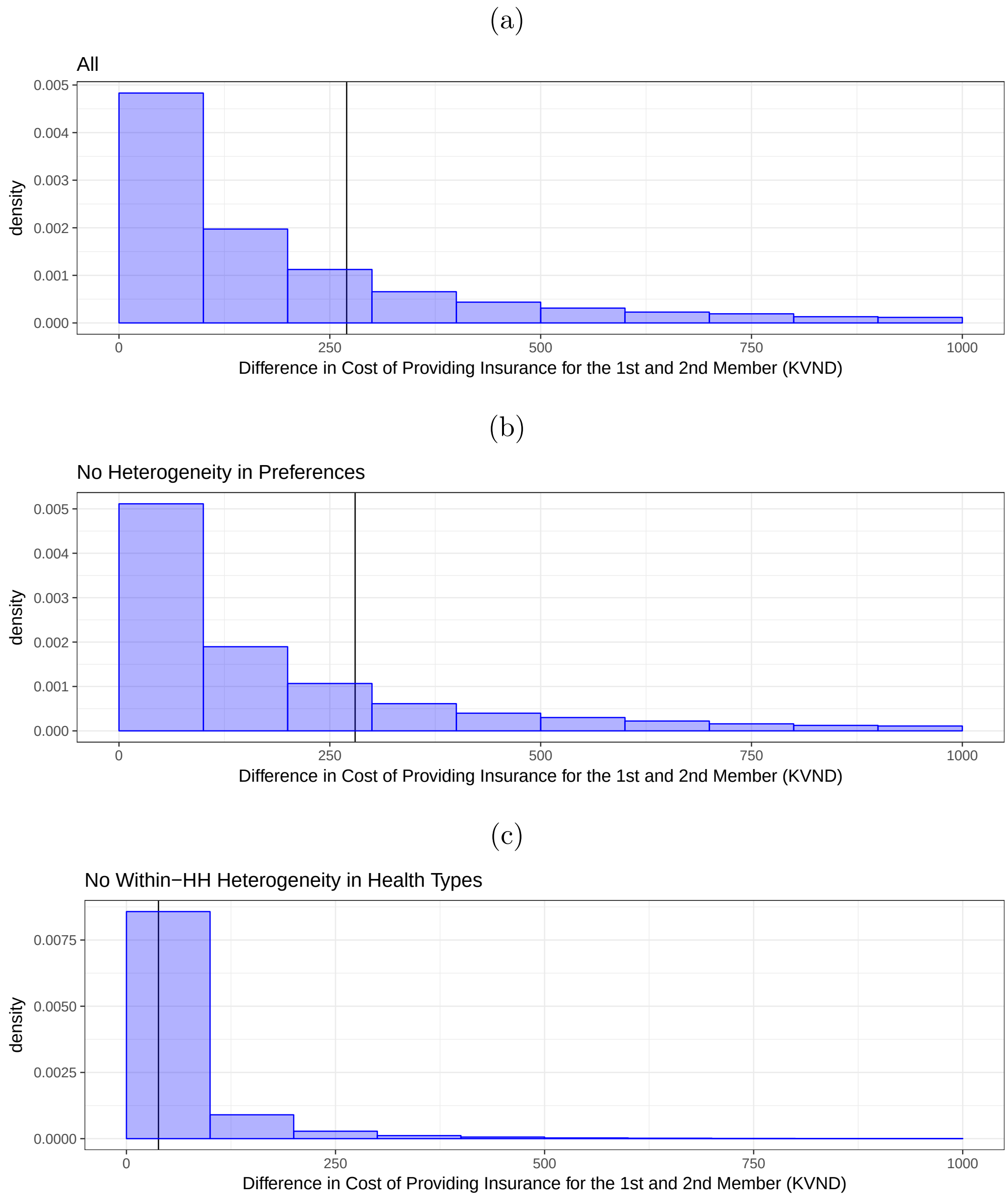
Within-Household Selection and the Source of Selection There are two potential sources of selection that could explain households' partial insurance enrollment: (1) heterogeneity in members' preferences for medical care ($\boldsymbol{\gamma}_h, \boldsymbol{\delta}_h$) and (2) heterogeneity in health

[24] 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 being uninsured to having complete insurance ($\kappa_2 = 0$, $\kappa_1 = 0$).

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

types $\bar{\boldsymbol{\theta}}_h$.

Figure 6.1 – Distribution of Difference in the Expected Cost of Providing Full Insurance for First and Second Members



Note: Black lines represent the mean of the distribution

To study the source of selection, for each household, I first identify two members for whom the household has the highest WTP for full insurance, assuming that the household can buy insurance for at most one member. The two members are henceforth termed the first and the second members. Under adverse selection, the cost of providing full insurance for the first member must be higher than that of providing full insurance for the second member. Panel (a) of Figure 6.1 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 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 finding 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.[26]

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 caused mainly by the heterogeneity in health types.

Within- and Across-Household Adverse Selection According to Table 6.2, within-household variance accounts for 40% of the total variance in health types, which implies 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 between only 1% and 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.

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

Table 6.2 – 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	

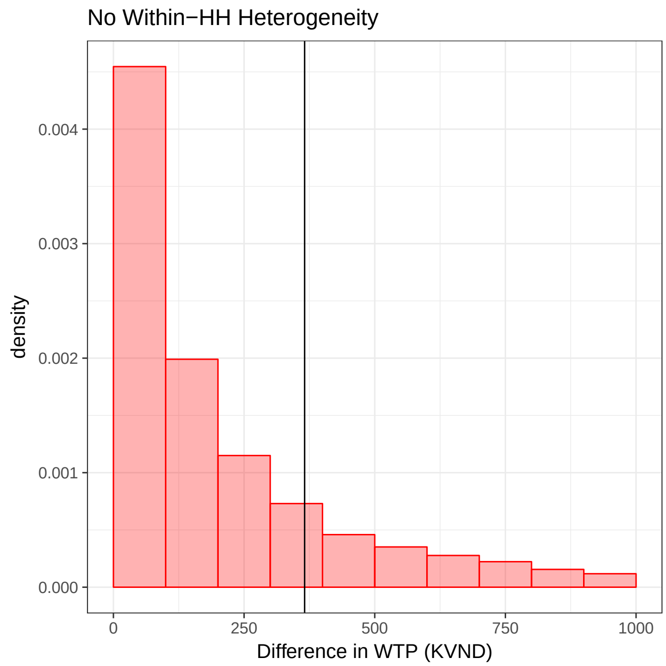
Income Effect and the Substitutability of Insurance As mentioned in Section 4, the role of the income effect here is twofold. First, it rationalizes the difference in the consumption of medical care across households with different income levels. Second, it affects the household's WTP for an additional member's insurance. Figure 6.2 depicts the distribution of the WTP for the first and second members' full insurance, assuming that all household members have identical preferences for medical care and identical distributions of health shocks. The average decrease in WTP is estimated to be 370 KVND, approximately 84% of the average necessary care.

Model Fit In the following, I compare the predicted and actual distributions of OOP costs and insurance enrollment for the set of households excluded from the 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 of no selection on enrollee types (Assumption 5.1.b). Furthermore, it also alleviates concerns about possible non-monetary costs associated with household bundling that are not modeled. An example of such costs is 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 7.1. 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 groups 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)

Figure 6.2 – Distribution of the difference in WTP for 1st and 2nd full insurance of households with identical members



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

and over-predicts for the fourth income quantile (242 KVND compared to 354 KVND). The predicted insurance enrollment is 16.24%, which is within the 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, which is comparable to the actual sample average of 384 KVND. The over-estimation of spending concentrates in households with lower incomes and individuals above the age of 64. The in-sample prediction of insurance enrollment is 11.9%, which is 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. Note that household income affects medical spending and insurance enrollment only through the income effect and does not enter as a mean shifter of any parameter.

Table 7.1 – 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 calculated only for individuals who are eligible for voluntary SHI. A household might have both eligible and ineligible members.

7 Effect of Household Bundling Policy

This section studies the welfare consequences of a household bundling policy using the results of the structural household choice analysis. In the counterfactual exercises, I assume that the social planner, who is the sole provider of health insurance, chooses the insurance premium and whether to implement household bundling to maximize 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 for how a household bundling policy can improve social welfare is through the potential enrollment of healthier household members, which reduces the average cost of insuring the population for the social planner and subsequently allow the premium to decrease. The reduction in the 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 of the structural model confirm that there is significant within-household adverse selection, which is caused mainly 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 responds 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 because of the interdependency in a household's WTP for insurance among members. As previously mentioned, the potential premium reduction under 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 WTP 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 WTP 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 a 0% coinsurance rate for expenses below 100 KVND and a rate of 20% for higher expenses. Similar to the pricing structure implemented in practice, the set of potential prices considered here is indexed to the MW, which varies across geographical areas, 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 the MW, in line with the Health Insurance Law of 1998. This restriction also significantly reduces the choice space of prices. The counterfactual analysis is conducted on the sample of households in the year 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 during the sample period. Second, the exercise 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 the premium subsidy under individual purchase is unable to keep the market from completely unraveling.

7.1 Household Bundling under Uniform Pricing

I first simulate the market outcome under the optimal household bundling policy and individual purchase policy while 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 7.2 illustrates the set of insurance bundles K_h available to a household of size 2 under each policy.

The effect of bundling on insurance demand and the average cost of providing insurance is illustrated in Figure 7.1. At high insurance premiums, 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 forces out some sicker members of otherwise healthy households. When the premium is low, the number of newly

Table 7.2 – 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)	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.

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

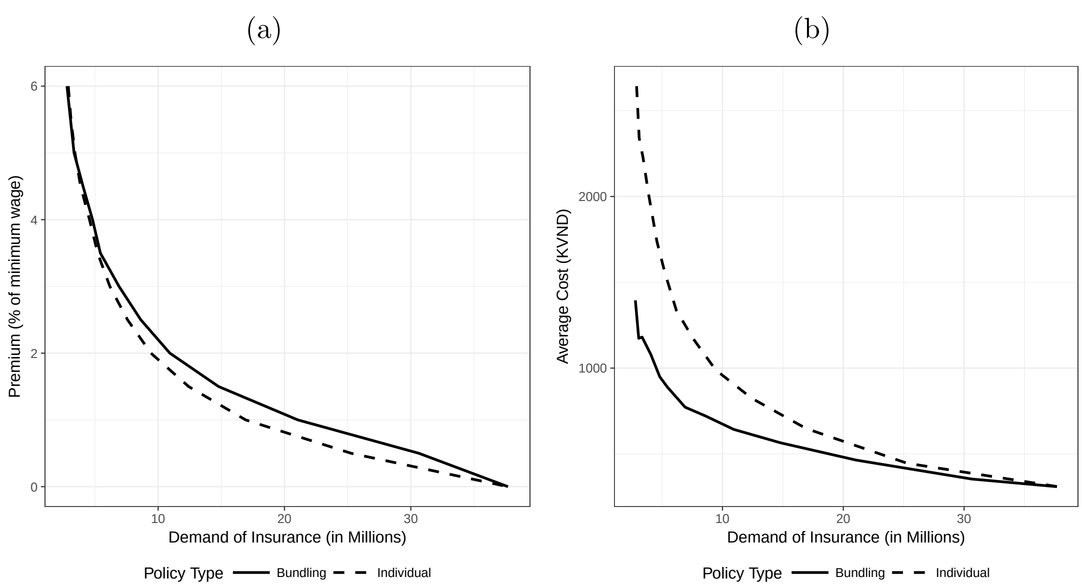


Table 7.3 compares the characteristics of the insured under household bundling and individual purchase under a 4.5% MW uniform premium. Individuals who have insurance under both household bundling and individual purchase have worse health types and are more likely to be older. They also belong to households with higher income. The difference in the health types of individuals who enroll only under household bundling and individuals who enroll only under individual purchase explains the change in the average cost of providing insurance, as shown in Figure 7.1. Individuals who enroll only under household bundling

are, on average, younger and have better health types than individuals who enroll only under individual purchase.

Table 7.3 – 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%

Table 7.4 summarizes the average enrollment and consumer surplus attained under the 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 improvements come from the reduction in the premium under 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 the premium to decrease. At this lower premium, more households can afford insurance, and the gain in consumer surplus more than offsets the loss from having fewer bundle choices.

Table 7.4 – Effect of the optimal household bundling policy 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 as a percentage of total GDP.

7.2 Household Bundling under Nonlinear Pricing

One way to encourage more household members to enroll in insurance under individual purchase is to offer a lower premium for additional household members. Analogously, under household bundling, the social planner could price discriminate based on household size. An example of such nonlinear prices is included in Table 7.5. Note that these are also the pricing policies that have been implemented in Vietnam (Table 3.2).

Table 7.5 – 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 in Section 6, households' partial enrollment in insurance is due primarily to two factors: (1) the effect of income on the WTP for additional insurance and (2) within-household adverse selection. If households' partial enrollment in insurance is due only to the income effect, individual purchase with nonlinear pricing can significantly increase enrollment. However, this 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 7.6 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.[27] 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. Furthermore, under optimal nonlinear pricing, individual purchase still leads to lower insurance enrollment and consumer

[27] Table H.7 in the Appendix shows the optimal prices under household bundling and individual purchase and the observed nonlinear pricing in 2012.

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 a nearly 50% increase in consumer surplus compared to individual purchase. These results highlight the importance of eliminating within-household adverse selection, which can be done only through household bundling.

Table 7.6 – 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.

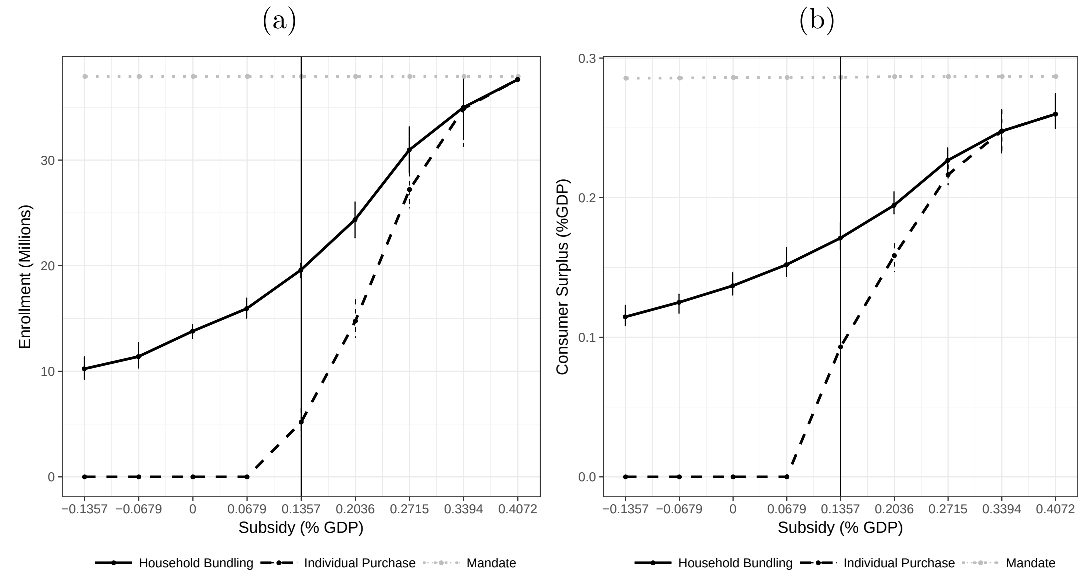
7.3 Household Bundling and Market Unraveling

This counterfactual exercise explores the use of household bundling when the government cannot provide an 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, the premium (without a subsidy) exceeds the market-level actuarially fair value. When such costs increase, premiums increase, leading to the drop out of healthier enrollees and further increasing costs.

Figure 7.2 illustrates the effect of household bundling on consumer surplus and insurance enrollment at different levels of market-wide subsidy. The subsidy level of 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% of GDP. My results suggest that the market begins to unravel under individual purchase when the level of subsidy is cut by 50%. However, at this subsidy under household bundling, insurance enrollment is 16.34 million, generating 0.15% of GDP in 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. These results are contrary to those in the literature (Somanathan et al., 2014) that while a household bundling policy might increase enrollment, it requires a large increase in government subsidies to cover

Figure 7.2 – Household bundling under different premium subsidies



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

the cost of insuring additional household members. This intuition, however, does not take into account the cost saving from the participation by healthier household members. My results suggest that household bundling can be especially beneficial for countries with limited funding for insurance, and it could be used to accumulate surplus in the early period of the SHI program.

8 Conclusion

This paper studies the potential welfare gain from bundling the 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 from selecting only sick members to enroll in insurance. It might, however, lead to the complete dropout of relatively healthier households, thereby worsening the welfare loss from adverse selection across households. Whether this trade off results in a 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 services and the household demand for health insurance.

I empirically study this issue using data from Vietnam's SHI program. While my setting is Vietnam, the country's similarity to other developing nations suggests a 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 was 7.07% of GDP, a similar level to those of several other lower-middle-income nations. Vietnam's variance of average per-member medical OOP costs across households, which is a possible indicator of adverse selection across households, is also comparable to that of other developing nations.

Motivated by the descriptive evidence from 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 a decreasing WTP for an 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 a 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 can choose nonlinear pricing, thereby 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 for 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.

References

Akerlof, George A. (1970), "The market for "lemons": Quality uncertainty and the market mechanism." *The Quarterly Journal of Economics*, 84, 488–500. 1, 2

Armstrong, Mark (2013), "A more general theory of commodity bundling." *Journal of Economic Theory*, 148, 448–472. 2

Bajari, Patrick, Christina Dalton, Han Hong, and Ahmed Khwaja (2014), "Moral hazard, adverse selection, and health expenditures: A semiparametric analysis." *The RAND Journal of Economics*, 45, 747–763. 1, 2

Bundorf, M Kate, Jonathan Levin, and Neale Mahoney (2012), "Pricing and welfare in health plan choice." *The American Economic Review*, 102, 3214. 2

Cardon, James H and Igal Hendel (2001), "Asymmetric information in health insurance: evidence from the national medical expenditure survey." *RAND Journal of Economics*, 408–427. 1, 2

Carlin, Caroline and Robert Town (2009), "Adverse selection, welfare and optimal pricing of employer-sponsored health plans." *U. Minnesota Working Paper*. 1, 2

Carpenter, Bob, Andrew Gelman, Matt Hoffman, Daniel Lee, Ben Goodrich, Michael Betancourt, Michael A Brubaker, Jiqiang Guo, Peter Li, and Allen Riddell (2016), "Stan: A probabilistic programming language." *Journal of Statistical Software*, 20, 1–37. 5.2

Carrin, Guy and Chris James (2005), "Social health insurance: key factors affecting the transition towards universal coverage." *International Social Security Review*, 58, 45–64. 12

Chandra, Amitabh, Jonathan Gruber, and Robin McKnight (2010), "Patient cost sharing in low income populations." *The American Economic Review*, 100, 303–308. 6

Chen, Yongmin and Michael H Riordan (2013), "Profitability of product bundling*." *International Economic Review*, 54, 35–57. 2

Cohen, Alma and Liran Einav (2007), "Estimating risk preferences from deductible choice." *American Economic Review*, 97, 745–788. 2

Cotlear, Daniel, Somil Nagpal, Owen Smith, Ajay Tandon, and Rafael Cortez (2015), *Going universal: how 24 developing countries are implementing universal health coverage from the bottom up*. World Bank Publications. 2

Currie, Janet (2004), "The take up of social benefits." Technical report, National Bureau of Economic Research. 10

Deaton, Angus and John Muellbauer (1980), "An almost ideal demand system." *The American Economic Review*, 70, 312–326. B.2

Einav, Liran, Amy Finkelstein, Stephen P Ryan, Paul Schrimpf, and Mark R Cullen (2013), "Selection on moral hazard in health insurance." *The American Economic Review*, 103, 178–219. 1, 2, 16

Einav, Liran, Amy Finkelstein, and Paul Schrimpf (2010), "Optimal mandates and the welfare cost of asymmetric information: Evidence from the uk annuity market." *Econometrica*, 78, 1031–1092. 2

Ericson, Keith M Marzilli and Amanda Starc (2015), "Pricing regulation and imperfect competition on the massachusetts health insurance exchange." *Review of Economics and Statistics*, 97, 667–682. 2

Fang, Hanming and Peter Norman (2006), "To bundle or not to bundle." *The RAND Journal of Economics*, 37, 946–963. 2

Finkelstein, Amy and Kathleen McGarry (2006), "Multiple dimensions of private information: evidence from the long-term care insurance market." *American Economic Review*, 96, 938–958. 2

Finkelstein, Amy, Sarah Taubman, Bill Wright, Mira Bernstein, Jonathan Gruber, Joseph P Newhouse, Heidi Allen, Katherine Baicker, Oregon Health Study Group, et al. (2012), "The oregon health insurance experiment: evidence from the first year." *The Quarterly Journal of Economics*, qjs020. B.3

Gelman, Andrew and Donald B Rubin (1992), "Inference from iterative simulation using multiple sequences." *Statistical science*, 457–472. E

Getzen, Thomas E (2000), "Health care is an individual necessity and a national luxury: applying multilevel decision models to the analysis of health care expenditures." *Journal of health economics*, 19, 259–270. 28

Handel, Benjamin R (2013), "Adverse selection and inertia in health insurance markets: When nudging hurts." *The American Economic Review*, 103, 2643–2682. 1, 2

Handel, Benjamin R, Jonathan T Kolstad, and Johannes Spinnewijn (2015), "Information frictions and adverse selection: Policy interventions in health insurance markets." Technical report, National Bureau of Economic Research. 2

Hausman, Jerry, Gregory Leonard, and J Douglas Zona (1994), "Competitive analysis with differenciated products." *Annales d'Economie et de Statistique*, 159–180. 29

Ho, Kate and Robin S Lee (2017), "Insurer competition in health care markets." *Econometrica*, 85, 379–417. 2

Hsiao, W, R Shaw, Andrew Fraker, Piya Hanvoravongchai, Matthew Jowett, Diana Pinto, and Sreekanth Ramachandra (2006), "Social health insurance for developing nations." *WBI Development Studies, The World Bank, Washington DC*. 3.1

Hurwicz, Leonid (1971), "On the integrability of demand functions." *Preferences, utility and demand*. 4.1, A.1

Jaffe, Sonia P and Mark Shepard (2017), "Price-linked subsidies and health insurance markups." Technical report, National Bureau of Economic Research. 2

Keeler, Emmett B and John E Rolph (1988), "The demand for episodes of treatment in the health insurance experiment." *Journal of health economics*, 7, 337–367. 24

Lewbel, Arthur and Krishna Pendakur (2017), "Unobserved preference heterogeneity in demand using generalized random coefficients." *Journal of Political Economy*, 125, 000–000. 5.1

Long, John B (1984), "Comments on" gaussian demand and commodity bundling"." *Journal of Business*, S235–S246. 2

Madrian, Brigitte C (1994), "Employment-based health insurance and job mobility: Is there evidence of job-lock?" *The Quarterly Journal of Economics*, 109, 27–54. 22

Manning, Willard G, Joseph P Newhouse, Naihua Duan, Emmett B Keeler, and Arleen Leibowitz (1987), "Health insurance and the demand for medical care: evidence from a randomized experiment." *The American Economic Review*, 251–277. B.3

Matzkin, Rosa L (2003), "Nonparametric estimation of nonadditive random functions." *Econometrica*, 71, 1339–1375. C, C

Myerson, Roger B and Mark A Satterthwaite (1983), "Efficient mechanisms for bilateral trading." *Journal of economic theory*, 29, 265–281. 1

Neal, Radford M et al. (2011), "Mcmc using hamiltonian dynamics." *Handbook of Markov Chain Monte Carlo*, 2, 113–162. 5.2

Polyakova, Maria (2016), "Regulation of insurance with adverse selection and switching costs: Evidence from medicare part d." *American Economic Journal: Applied Economics*, 8, 165–195. 1

Ramsey, Frank P (1927), "A contribution to the theory of taxation." *The Economic Journal*, 37, 47–61. 2

Rothschild, Michael and Joseph Stiglitz (1976), "Equilibrium in competitive insurance markets: An essay on the economics of imperfect information." *The Quaterly Journal of Economics*, 90, 629–649. 2

Schmalensee, Richard (1984), "Gaussian demand and commodity bundling." *Journal of Business*, S211–S230. 2

Sinaiko, Anna D, Timothy J Layton, Sherri Rose, and Thomas G McGuire (2017), "Implications of family risk pooling for individual health insurance markets." *Health Services and Outcomes Research Methodology*, 17, 219–236. 1

Somanathan, Aparnaa, Ajay Tandon, Huong Lan Dao, Kari L Hurt, and Hernan L Fuenzalida-Puelma (2014), "Moving toward universal coverage of social health insurance in vietnam: assessment and options." *Directions in development, The World Bank, Washington DC*. 3.1, 7.3

Tebaldi, Pietro (2016), "Estimating equilibrium in health insurance exchanges: Price competition and subsidy design under the aca." 2

World Bank (2016), "World development indicators." Retrieved from `http://data.worldbank.org/indicator/NY.GDP.PCAP.CD`. 3.2, 6

Xu, Ke, David B Evans, Kei Kawabata, Riadh Zeramdini, Jan Klavus, and Christopher JL Murray (2003), "Household catastrophic health expenditure: a multicountry analysis." *The lancet*, 362, 111–117. 15

A Proofs

A.1 Proof of Proposition 4.2

I first start by restating the integrability theorem (Hurwicz, 1971).

Theorem A.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* $v \in \mathbb{R}^n$,

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

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* $m \geq 0$

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

   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 $\{x \in X : p \cdot x \leq y\}$

Proof of Proposition 4.2. In Assumption 4.1, the price of the consumption good has been normalized to 1. WLOG, assume the subsistence income level is 0. 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 $n \times n$ symmetric matrix to be negative semidefinite is that the determinant of all its leading 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.

In the following, subscript h is omitted. Let $B_i = 1 + \frac{\kappa_{hj}}{p_c}$ and $A = \frac{R}{p_c} = \frac{Y - \sum_{j=1}^n \theta_j \kappa_j}{p_c}$.

$$\frac{\partial m_i}{\partial \kappa_i} = -(m_i - \theta_i)\left(\frac{\omega\theta_i}{Ap_c} + \frac{\gamma_i}{B_i p_c}\right)$$
$$\frac{\partial m_i}{\partial Y} = (m_i - \theta_i)\frac{\omega}{Ap_c}$$
$$\frac{\partial m_i}{\partial p_c} = (m_i - \theta_i)\left(-\frac{\omega}{p_c} + \frac{\gamma_i\kappa_i}{B_i p_c^2}\right)$$
$$\frac{\partial m_i}{\partial \kappa_j} = -(m_i - \theta_i)\frac{\omega\theta_j}{Ap_c}$$

Therefore, the elements of the Slutsky matrix σ are given by

$$\sigma_{ii} = -(m_i - \theta_i)\left(\frac{\gamma_i}{B_i p_c} - (m_i - \theta_i)\frac{\omega}{Ap_c}\right)$$
$$\sigma_{nn} = -\left(\sum_{j=1}^{n}(m_j - \theta_j)\frac{\kappa_j}{p_c}\right)^2 \frac{\omega}{p_c A} - \sum_{j=1}^{n}(m_j - \theta_j)\frac{\gamma_j \kappa_j^2}{B_j p_c^3}$$
$$\sigma_{ij} = (m_i - \theta_i)(m_j - \theta_j)\frac{\omega}{Ap_c} \text{ for } i < n, j < n$$
$$\sigma_{in} = (m_i - \theta_i)\left(-\frac{\omega}{Ap_c}\sum_{j=1}^{n}(m_j - \theta_j)\frac{\kappa_j}{p_c} + \frac{\gamma_i \kappa_i}{B_i p_c^2}\right) \text{ for } i < n$$

Let σ_j be the j-column of σ, it is readily verified that

$$\sum_{j=1}^{n-1} \sigma_j \frac{\kappa_j}{p_c} + \sigma_n = 0$$

Therefore, $\det(\sigma) = 0$ since σ is singular.

Let $x = (x_1, x_2, \ldots, x_n)$ be a $1 \times n$ vector. For notational convenience, denote $m_i - \theta_i = \Delta_i$, $\frac{\omega}{Ap_c} = a$, and $\frac{\gamma_i}{B_i p_c} = b_i$. Let $\tilde{\sigma}$ be the leading principle minor of order $n-1$. Since σ is symmetric, it suffices to show that $\tilde{\sigma}$ is negative definite. Consider:

$$\begin{aligned}
x\tilde{\sigma}x' &= \sum_{i=1}^{n}\sum_{j=1}^{n} x_i x_j \sigma_{ij} \\
&= \sum_{i=1}^{n} x_i^2(\Delta_i^2 a - \Delta_i b_i) + \sum_{i=1}^{n}\sum_{j=1, j\neq i}^{n}(x_i x_j \Delta_i \Delta_j a) \\
&< a\left(\left(\sum_{i=1}^{n}(x_i \Delta_i)\right)^2 - \sum_{j=1}^{n}\frac{\Delta_j}{b_j}\sum_{i=1}^{n}(x_i^2 \Delta_i b_i)\right) \\
&= a\left(\sum_{i=1}^{n}\sum_{j=1}^{n}\underbrace{\left(x_i x_j \Delta_i \Delta_j - x_i^2 \Delta_i \Delta_j \frac{b_i}{b_j}\right)}_{z_{ij}}\right)
\end{aligned}$$

where the third inequality follows from the sufficient condition 4.2. Since

$$\begin{aligned} z_{ij} + z_{ji} &= 2x_i x_j \Delta_i \Delta_j - x_i^2 \Delta_i \Delta_j \frac{b_i}{b_j} - x_j^2 \Delta_i \Delta_j \frac{b_j}{b_i} \\ &= -\Delta_i \Delta_j \left(x_i \sqrt{\frac{b_i}{b_j}} - x_j \sqrt{\frac{b_j}{b_i}} \right)^2 \leq 0 \end{aligned}$$

$\forall i, j, \;\; x\tilde{\sigma}x' \leq 0 \; \forall x \in \mathbb{R}^n$. Hence, $\tilde{\sigma}$ is negative definite and σ is also negative semidefinite. □

Indifference Curve and Indirect Utility The expenditure function is 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 can be rewritten as

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

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 A.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.

$$u := \frac{c_h^{1-\omega_h} - 1}{1-\omega_h} \Big|_{\boldsymbol{\kappa}_h = 0} \tag{A.2}$$

The form of Equation (A.2) 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 $\boldsymbol{\kappa}_h$

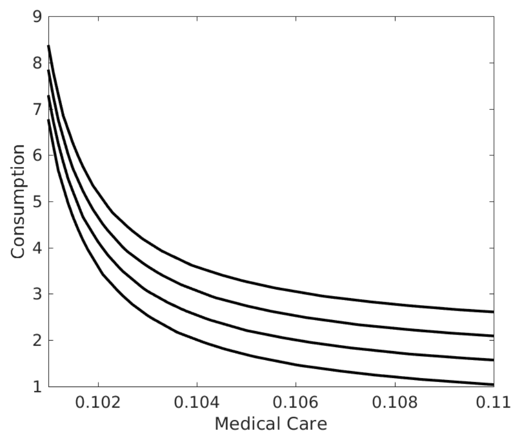
$$Y_h = e_h(\boldsymbol{\kappa}_h, u) = \left((1-\omega_h)\left(u + \sum_{j=1}^{n_h} \frac{\delta_{hj}\theta_{hj}(\kappa_{hj}+1)^{1-\gamma_{hj}} - 1}{1-\gamma_{hj}}\right)\right)^{\frac{1}{1-\omega_h}} + \sum_{j=1}^{n_h} \theta_{hj}\kappa_{hj}$$

$$\Rightarrow \quad u = \frac{\left(Y_h - \sum_{j=1}^{n_h} \theta_{hj}\kappa_{hj}\right)^{1-\omega_h}}{1-\omega_h} - \sum_{j=1}^{n_h} \frac{\delta_{hj}\theta_{hj}(\kappa_{hj}+1)^{1-\gamma_{hj}} - 1}{1-\gamma_{hj}} \tag{A.3}$$

Equation (A.3) is an indirect utility function that is consistent with the demand specifications in Assumption 4.1. Furthermore, any monotonically increasing transformation of (A.3) would also be consistent with the demand specifications.

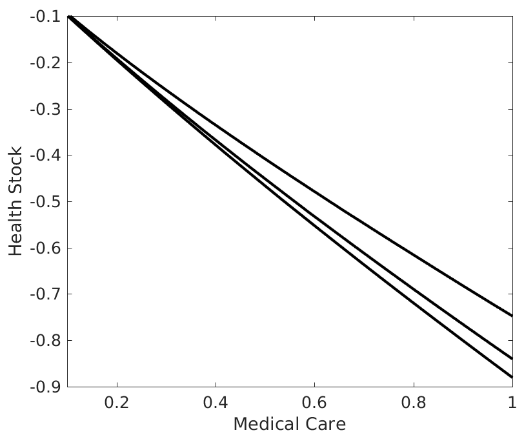
Figure A.1 and A.2 illustrate the indifference curves and the isoquants of the health production function at specific parameter values when the household has only one member with sufficient income. The indifference curves show that both medical utilization and the consumption good exhibits decreasing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

Figure A.1 – Example of indifference curves 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 A.2 – Example of isoquants for a single-member household



The preference parameters are set at $\gamma = 0.6$, $\omega = 0.1$, and $\delta = 1$.

A.2 Proof of Proposition 5.2

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 4.1 for this subgroup then becomes

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

Let t be an integer, and 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 that Y_h will be 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 the data, all moments of ω_h are identified, and hence the distribution of ω_h is identified.

We can 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 $-\gamma_{hj}$ are identified, and hence, the distribution of γ_{hj} is also identified. □

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

This section provides details on the stylized features of the household demand for medical care and the household demand for health insurance in Vietnam's SHI program mentioned in Section 4.

B.1 Medical Care as a Normal Good

Table B.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.[28]

Whether medical care is a normal good has important implications for 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 an 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. However, if the correlations 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 the same

[28] 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 the studies that use micro data, the estimates are between 0 and 0.7

Table B.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.

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

B.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 the following, I use estimates from the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer, 1980) to investigate the substitution patterns in the medical utilization of household members.

Consider a household h with n_h members that 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 OOP cost and the total cost of medical care for each member. When all medical expenses are covered by insurance, the spot coinsurance rate is the same as the coinsurance rate specified in the contract. When some medical expenses are 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 for 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 to satisfy 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) HoH, spouse, children, parents, and others.[29]

Table B.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 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 for a household member acts as a substitute for that of the others, but the estimates are less precise. This substitution effect is statistically significant among the HoH, his wife and their children.

[29]That is, there is a single coefficient for each pair of different categories and 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 the HoH, and only one member as the head's spouse. An alternative approach is multi-stage budgeting (Hausman et al., 1994).

Table B.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 or health realization. The number of households in this sample is $N = 11112$.

Implication for the Household Demand for Health Insurance Since the medical care consumption of different household members is substitutable, the household demand for health insurance for different household members will also be substitutes if the household risk preference does not exhibit too strong increasing absolute risk aversion.

Table B.3 presents suggestive evidence that is consistent with the substitution effect in the household demand for health insurance for different members. Here, I consider the set of households in which: (1) one or more members received free social health insurance and these members did not have voluntary health insurance prior to receiving free social health insurance, and (2) the household was buying voluntary health insurance for at least one other household member prior to receiving additional free SHI. As mentioned in Section 3, the Vietnamese government has been expanding the pool of people who are eligible for free

SHI. The econometric specification is given by

$$\#\text{Voluntary Members}_{ht} = \beta_0 + \beta_1 D_{ht} + \boldsymbol{\beta_2 X}_{ht} + \epsilon_{ht}$$

, where $D_{ht} = 1$ if the household h receives free SHI in year t and 0 otherwise, and $\boldsymbol{X}_{ht}$ represents household variables such as income and composition. The results suggest that these households will then reduce the number of members buying voluntary SHI by approximately 1. Table B.4 presents a similar analysis on the set of households that received compulsory health insurance for members who previously did not have voluntary SHI. However, unlike in the previous analysis, the treatment here is associated with an occupation change. Thus, while the results of Table B.4 are qualitatively similar to Table B.3, the reduction in the number of voluntary members in Table B.4 is more likely due to the change in household income associated with the occupation change.

Table B.3 – Effect on voluntary enrollment when households receive free SHI

	(1) # Voluntary	(2) # Voluntary	(3) # Voluntary
Receive free SHI	-0.856***	-1.014	-0.963
	(0.0795)	(1.139)	(1.142)
Log HH Income		0.0731	0.0970
		(0.0794)	(0.0781)
Receive free SHI × Log HH Income		0.0186	0.00999
		(0.121)	(0.122)
# Compulsory			-0.127*
			(0.0562)
Receive free SHI × # Compulsory			0.0324
			(0.103)
Observations	382	382	382
Adjusted R^2	0.227	0.227	0.231

B.3 Moral Hazard in the Demand for Medical Care

A major empirical challenge in estimating the effect of insurance on the demand for medical care is the endogeneity between health insurance status and unobserved health conditions. Some of the most reliable evidence on this moral hazard effect was established in Manning et al. (1987) and more recently by 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 B.4 – Effect on voluntary enrollment when household members have compulsory enrollment

	(1) # Voluntary	(2) # Voluntary	(3) # Voluntary
Compulsory Enrollment	-1.002***	-0.219	-0.190
	(0.0764)	(1.110)	(1.101)
Log HH Income		0.136	0.123
		(0.0894)	(0.0882)
Compulsory Enrollment × Log HH Income		-0.0815	-0.0833
		(0.113)	(0.112)
# Beneficiaries			-0.0732
			(0.0771)
Compulsory Enrollment × # Beneficiaries			-0.0582
			(0.103)
Observations	459	459	459
Adjusted R^2	0.273	0.275	0.277

Table B.5 – Summary statistics of the treatment and control groups

Variable	(Panel A) Treatment	Control	Difference	(Panel B) 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 must participate in health insurance for voluntary SHI to be available in that commune. In addition, household bundling was implemented in this period. In the data, I observe households that attempted to purchase voluntary SHI but were ultimately denied due to the lack of participation by 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 B.5 shows the summary statistics of the control and treatment groups in the sample. On average, the treatment group has higher household income and is 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 households' and individuals' observed characteristics,[30] excluding individual health indicators.

Panel B of Table B.5 shows the summary statistics of the matched control and 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.

Table B.6 reports the results of the average treatment effect in the overall sample and in groups with and without chronic diseases. On average, insured individuals increase outpatient visits by 0.7 visits and inpatient visits by 0.06 visits. The treatment effect on inpatient visits is significantly larger for people with chronic conditions, but people without chronic conditions are more likely to have an increased number of outpatient visits. The results suggest that the increase in medical utilization due to enrollment in voluntary SHI is correlated with underlying health status.

Table B.6 – 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 outpatient and inpatient visits, respectively.

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

B.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, and 20% for higher expenses.[31] 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 greater detail in Section 5.

Panel A of Table B.7 shows the summary statistics of the treatment and control groups. On average, the treatment group (voluntary enrollees) have lower household income per member and are 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 B.7 shows the summary statistics of the matched treatment and control groups.

Table B.7 – 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 effects on the matched treatment and control groups are summarized in Table B.8. Compared to the control group, the treatment group has 0.8 more outpatient visits per year, 0.03 more inpatient visits per year, and higher OOP costs. The

[31] 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 of adverse selection.

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 for pre-existing conditions, this could also be considered direct evidence of adverse selection in the SHI program.[32]

Table B.8 – 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 annual outpatient visits and inpatient visits, respectively. As shown in Table 3.3, the average OOP 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.

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 premiums, 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 of the demand for medical care is achieved. The demand for medical care is

[32]Data on chronic conditions are not available for 2010 and 2012.

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 is exogenous; the threshold $\bar{Y}$ is also known. Our objects 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 occurs only 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 has only one member, without Equation C.2 (or equivalently $\bar{Y} = \infty$), we can identify m_1 only 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 an 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.3. *Suppose that Assumption C.1 and C.2 are satisfied,* $\boldsymbol{m}(\cdot)$ *is identified.*

Proof of Proposition C.3. 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 result 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 to 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 can 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 bound 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 Discussion of Assumption 5.1.b

This section provides supporting evidence for Assumption 5.1.b that there is no selection into job types based on preferences for medical care or health types conditional on observed characteristics.

I consider a subsample of individuals who were observed in two consecutive surveys and employed in both periods. I categorize these individuals as follows:

- "Into Compulsory" (Group 1): workers who were previously employed but not eligible for compulsory insurance and are now enrolled in compulsory insurance due to job changes.
- "Out of Compulsory" (Group 2): workers who were previously employed and had compulsory insurance, but are now not eligible for compulsory insurance due to job changes.
- "Not eligible for Compulsory" (Group 3): workers who were not eligible for compulsory insurance either before or after job changes.
- "Stay Compulsory" (Group 4): workers who were eligible for compulsory insurance both before and after job changes.
- "No Change" (Group 5): workers who did not change jobs.

where a job change is defined as a change in the employer's type.[33]

Table D.1 shows the summary statistics of individual characteristics for each group of workers. On average, group 1, 2 and 3 have more females and are more educated. They also have relatively higher inpatient visits per year. Moreover, group 2 and 3 are more likely to buy voluntary insurance.[34] This difference in voluntary enrollment could be due to the difference in either observed or unobserved characteristics. The latter would be a violation of Assumption 5.1.b.

In order to quantify the extent to which observed characteristics could explain the difference in the voluntary enrollment rates between people in the compulsory group and people who are not, I estimate the treatment effect of people who are in the compulsory group

[33]Employer's type for each individual is categorized as: (1) Farming, forestry, aquaculture; (2) Family business; (3) Cooperative; (4) Private; (5) State-owned; and (6) Foreign invested.

[34]Group 4 never buys voluntary insurance because individuals in group 4 always have compulsory insurance. This group is also dropped from the analysis in Table D.2.

Table D.1 – Summary statistics of different groups of workers who were observed in two consecutive surveys

	Into Compulsory	Out of Compulsory	Not eligible for Compulsory	Stay in Compulsory	No change
Age	36	37.21	33.75	37.07	34.62
	(10.32)	(11.08)	(11.18)	(9.783)	(11.35)
Female	0.483	0.454	0.290	0.489	0.322
	(0.500)	(0.500)	(0.454)	(0.500)	(0.467)
Individual Income	14262.4	29259.5	11099.8	26755.9	20812.3
	(12636.2)	(27196.2)	(9994.0)	(17403.6)	(19155.1)
Household Income	41291.8	89081.9	40102.7	78143.4	65553.3
	(36930.7)	(66488.4)	(28285.5)	(44225.1)	(47454.8)
College Education	0.747	0.479	0.132	0.824	0.293
	(0.435)	(0.502)	(0.339)	(0.381)	(0.455)
# Outpatient visits	0.361	0.748	0.820	1.096	0.724
	(1.260)	(1.738)	(2.202)	(2.280)	(2.095)
# Inpatient visits	0.0655	0.101	0.0487	0.104	0.0578
	(0.274)	(0.377)	(0.248)	(0.356)	(0.291)
Voluntary Insurance	0.0880	0.235	0.0583	0	0.0478
	(0.284)	(0.426)	(0.234)	(0)	(0.213)
Observations	443	119	1561	1028	2198

Note: Except for the first two columns, the summary statistics are based on the first year the individual appeared in the survey. The summary statistics for the first two columns are based on the year when the individual was eligible for voluntary insurance.

(group 1 and 2) on voluntary enrollment using a matching estimator. Table D.2 shows the treatment effect when different observed characteristics are taken into account. It appears that gender, education, individual income, and relationship to the HoH can explain most of the difference in the voluntary enrollment rates between the two groups.

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 observed only for data for the year 2008. I assume that the distribution of coverage does not differ across years and will distribute any time-varying 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

Table D.2 – Treatment effect of being in the compulsory group on voluntary enrollment

	(1)	(2)	(3)	(4)
ATE	0.0678*** (0.0188)	0.0467* (0.0211)	0.0377 (0.0220)	0.0246 (0.0210)
Observations	4321	4321	4321	4321
Exact Matching	Gender, College Education, Geographical Areas			
Nearest Neighbor Matching		Log Ind. Income	Log Ind. Income, Relationship to HoH	Log Ind. Income, Relationship to HoH, Age Categories

Note: Estimators use Abadie-Imbens robust standard errors with bias adjustment for continuous matching variables.

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 time on the posteriors of the hyper parameters, I allow s_θ to vary across households. s_θ is assumed to be log-normally 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. Once a sample of lower-level parameters is drawn, the posteriors of the hyper parameters are straightforward and can be drawn directly if using conjugate priors.

E.1 Sampling of Lower-Level Parameters

The observed data at the household level include (1) medical spending on each member if incurred, 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 OOP costs, which are 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, 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 the coinsurance rate is nonlinear. For the former, the posterior is integrated over all possible realizations of ζ_{hj}.

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

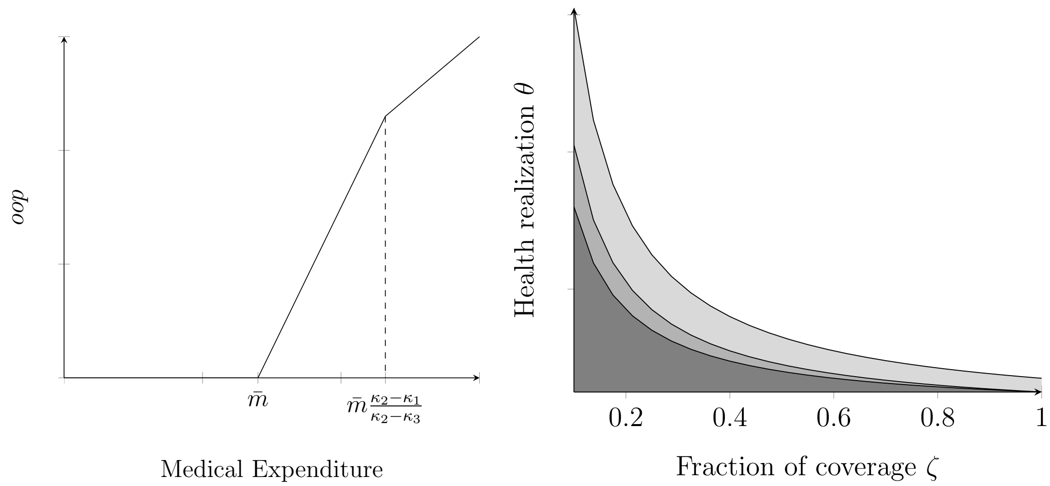
where $F(\kappa(\boldsymbol{\iota}_h))$ is specified in Section 5. In order to estimate this integral, I use Gauss Legendre quadrature.

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 care outweighs the gain from a lower coinsurance rate, and the individual will increase his medical spending and pay 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 – Example of bunching under piecewise coinsurance rates



The left figure illustrates the insurance contract that determines the OOP 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 $\kappa_3 < \kappa_2$

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 the income effect creates interdependency between the decisions 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 member's 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, that the household is better off not insuring another member or not buying insurance for a currently insured member.[35] 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 $L(\bar{\theta}_{hj}) \leq \bar{\theta}_{hj} \leq U(\bar{\theta}_{hj})$ to ensure that the observed bundle is 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.[36] Similarly, the upper bound is the minimum value of $\bar{\theta}_{hj}$ such that the household prefers to buy insurance

[35] 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 and the out-of-sample validity test, the full set of constraints was checked

[36] As mentioned in Section 4, the household is more likely to buy insurance for a member if other members are sicker.

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 constraint that the household should not have any utility-improving one-member deviation is checked directly within each drawn conditional on the 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 to sample the upper-level parameters. Except for β_θ, σ_λ, σ_e, and β_W, the other hyper-parameters can be drawn directly from the posteriors, which are usually a normal distribution or an inverse gamma distribution.

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 OOP costs exceed 6 months of the state's MW 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 OOP costs exceed 1500KNVD per year, the coinsurance rate is 0 and OOP costs are capped at 1500K. If costs are under 20KVND, we have 0% coinsurance rates	77/2003/TTLT-BTC-BYT

2005	Compulsory (including policy beneficiaries)		100 % For expenses under 7000 KVND. For expenses above 7000KVND, policy beneficiaries have 0% coinsurance rates, but for the majority of policy beneficiaries, the payment from coinsurance is capped at 20,000KNVD. For others, health insurance pays the greater of 60% of charges or 7000KVND, but payments are also capped at 20,000KVND	21/2005/TTLT-BYT-BTC
2005	Voluntary Insurance	100KVND - 160KVND for urban, 70KVND - 120 KVND for rural areas	for expenses under 7000 KVND. For expenses above 7000KVND, policy beneficiaries have 0% coinsurance rates, but for the majority of policy beneficiaries, the payment from coinsurance is capped at 20,000KNVD. For others, health insurance pays the greater of 40% of charges or 7000KVND, but payments are also capped at 20,000KVND	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 and 80% for higher costs but capped at 20,000KVND	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 non-student voluntary SHI enrollees and/or student being uninsured

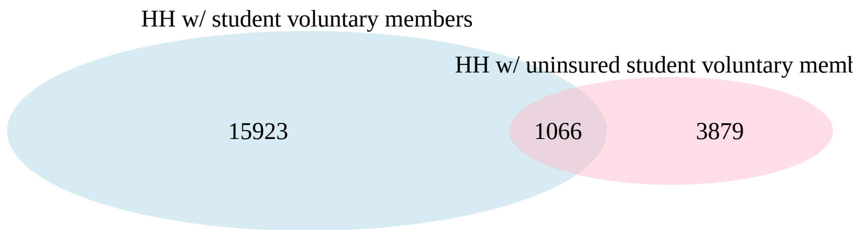


Figure G.2 – Proportions of Student Enrollment in the Data Sample by Year

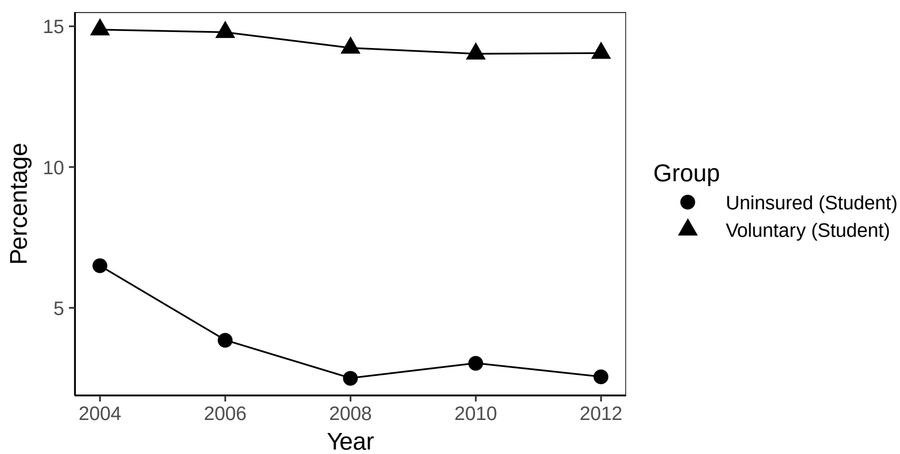


Figure G.3 – The distribution of the probability of coverage from data on reimbursement in 2008.

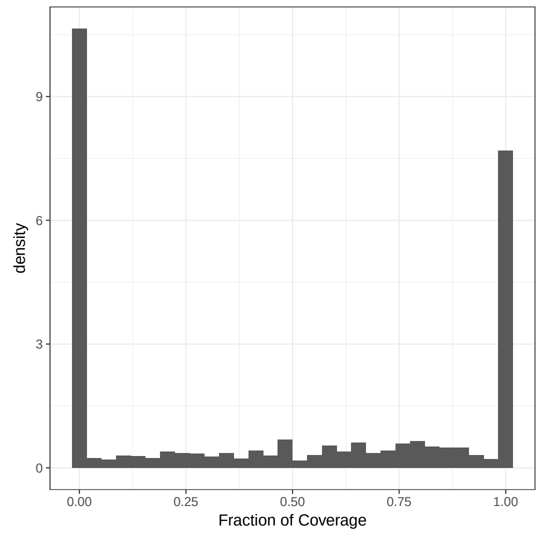
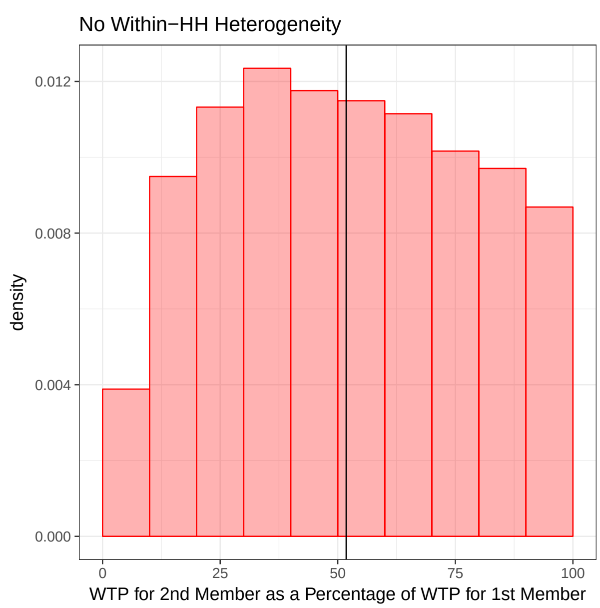
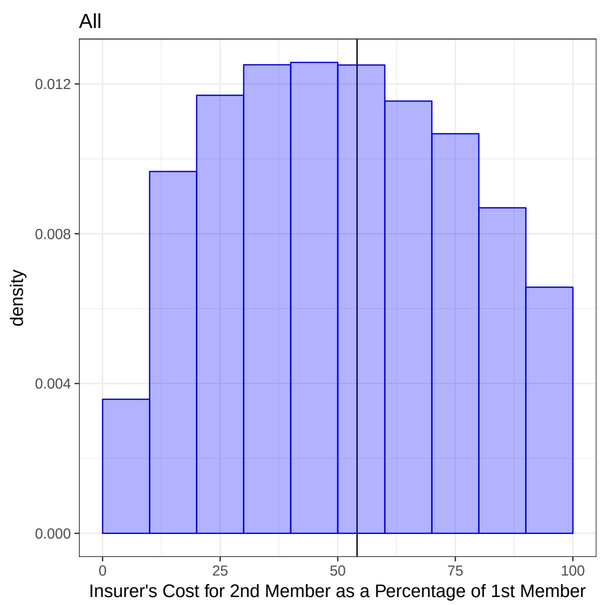


Figure G.4 – Distribution of the WTP for insurance for the second member as a percentage of that of the first



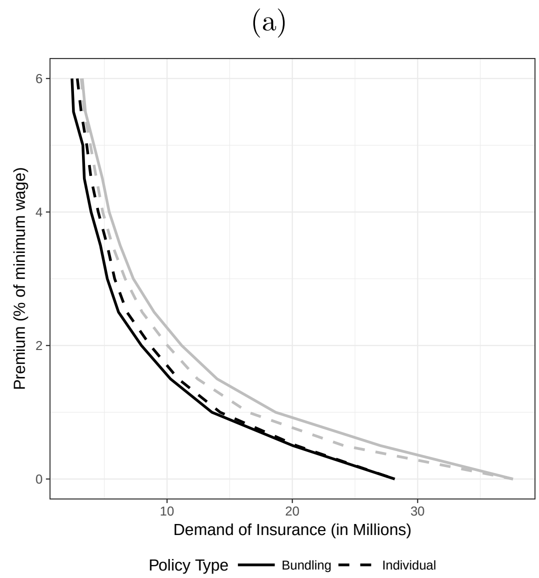
Note: The vertical black line represents the mean of the distribution.

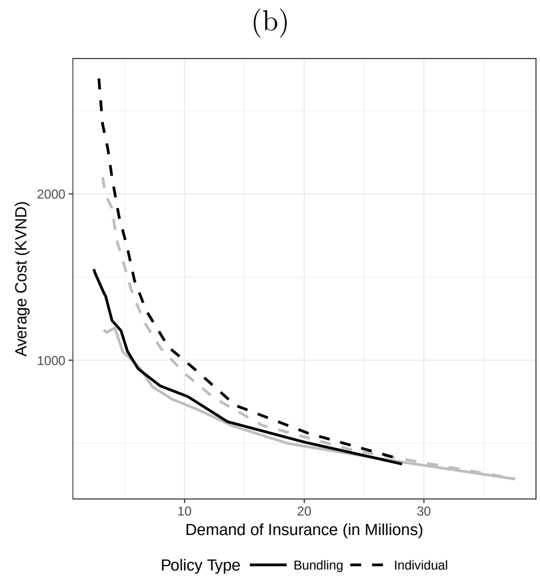
Figure G.5 – Distribution of the cost of providing insurance for the second member as a percentage of that of the first



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

Figure G.6 – The demand for 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 approach 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 7.1), the exclusion of members with 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 that previously bought insurance only to keep the sickest member from being uninsured will now drop out of insurance.

H Additional Tables

Table H.1 – Summary statistics of medical spending in the data sample by year, restricted to individuals with positive medical expenditure

	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

The OOP cost 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 households in 2006 that have at least 1 member eligible for household bundling. Enrollment is calculated only for 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 the 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 the percentage of total GDP. The consumer surplus obtained under the mandate assumes the optimal (under the mandate) household size pricing. The third and fourth column assume nonlinear pricing.

Table H.11 – The effect of household bundling, individual pricing, and the 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 the mandate assumes the optimal (under mandate) household size pricing. The third and fourth column assume nonlinear pricing.

Table H.12 – Comparison between the 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: The premium for compulsory SHI does not include the premium subsidy paid by employers.

Table H.13 – Variance decomposition of insurance enrollment

	2004	2006	2008	2010	2012
Within-Household	34.5%	27.6%	25.5%	27.4%	23.7%
Within-Household Due to Age	21%	17.8%	17.2%	17.6%	14.8%
Within-Household Due to Other	13.4%	9.8%	8.2%	9.7%	8.9%
Across-Household	65.5%	72.4%	74.5%	72.6%	76.3%

Table H.14 – Variance decomposition of insurance enrollment in the data, restricted to the sample of households with at least one voluntary member

	2004	2006	2008	2010	2012
Within-Household	65.1%	62.8%	59%	61%	56.8%
Within-Household Due to Age	39.7%	40.5%	40%	39.3%	35.5%
Within-Household Due to Other	25.4%	22.3%	19.1%	21.7%	21.2%
Across-Household	34.9%	37.2%	41%	39%	43.2%