Public versus Private:
A Dynamic Model of Health Insurance Choice*

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Preliminary

December 22, 2009

Abstract

In order to improve the health status of their populations, many countries have turned to a mix of both public and private health insurance plans. There is concern, however, that the private insurance market may cover the healthier in the population, leading to adverse selection for public insurance programs. This paper presents a model of insurance choice for the case of Chile, where workers must choose between public and private health insurance coverage. This dynamic structural model estimated using data from Chile's *Encuesta Protección Social* allows us to test whether the structure of the health system leads to adverse selection against public insurance and/or a crowding out of private insurance. We model the individual choice of health insurance type (public versus private) as a stochastic, dynamic process. Individuals take into account premiums, expected out-of pocket costs, and individual preferences in choosing health insurance type. However, there is asymmetry in restrictions for individuals with certain health conditions. Specifically, following a negative health shock, individuals may switch from private to public, but not vice versa, due to restrictions against pre-existing conditions among private insurance plans. The model predicts that the public system indeed services a less healthy and wealthy population. Simulation of the model over time predicts that the allocation of individuals in public insurance will actually decline over time to a slightly lower steady state value. *Ex-ante* program evaluation suggests that eliminating the restrictions on pre-existing conditions would ameliorate the disproportionate accumulation of less healthy individuals in the public insurance program over time.

Keywords: Health insurance, adverse selection, public health, Chile.

JEL Classification: I10; I11; I18.

*This is a preliminary and incomplete version. Please do not quote. Comments are welcome.

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1 Introduction

In order to improve health service quality and expand health insurance coverage among their populations, many countries have welcomed a mix of both public and private health insurance schemes. While in the United States, public insurance is reserved for individuals age 65 and over and individuals with very low incomes, policymakers are currently considering health insurance reform in order to cover the uninsured, improve coverage for the underinsured, and to contain escalating health care costs. Reforms considered include the introduction of a public insurance option and the elimination of the ability of private insurers to impose barriers to entry through pre-existing conditions clauses. While the United States has had no historical experience with such policies, there is much to be learned from countries that do have a public-private mix of health insurance options.

The case of Chile is an illustrative example of a health insurance system in which public and private health insurance schemes exist side-by-side to cover individuals of all ages. By analyzing insurance choices in this population, we can draw lessons for the purposes of insurance reform. Furthermore, the Chilean case allows us to perform policy simulations and *ex-ante* program evaluation, in which we can project whether adverse selection leads to crowding out of private insurance, as well as what would happen were a law to be implemented limiting the ability of private insurance from restricting entry based on pre-existing conditions.

In most countries, participation in private insurance is voluntary; while private health insurance premiums tend to depend on health risk, public insurance premiums often depend on income (Savedoff and Sekhri, 2004). If private insurance charges higher rates for less healthy individuals, there is a concern that individuals with higher health risks will avoid private insurance, leaving the public insurance system responsible for their care. If so, the public health system may incur higher health expenditures for providing care to the less healthy population, an issue of concern for policymakers and for the financial sustainability of publicly provided health services.

In Chile, workers and pensioners are required to purchase health insurance, and may choose either public or private coverage. The public system is known as FONASA (Fondo Nacional de Salud), and the private system is composed of a number of competitive private companies known as ISAPREs (*Instituciones de Salud Previsional*). Insurance premiums, benefits and out-of-pocket costs are structurally different between the two systems. By law, workers must spend at least seven percent of their salary on health coverage. While in the public system, the premium for public coverage is fixed at seven percent of one's salary, the private coverage premium varies by health risk and plan benefits. In the private system, insurance premiums take into account the basic health risk of the insured and his or her dependents (using publicly available information regarding age, sex, and family size), and plans typically include more benefits as the premium increases. In contrast, the public insurance premium increases solely with income (not with health risk), and the benefits package does not improve as the premium increases. However, the private system offers a wide variety of plans, access to better technology and often provides faster service. Meanwhile, the public system offers a single benefits package, relies on public hospitals (and some associated private facilities), and may have longer wait times.

Due to the structure of the overall health system, individuals with higher incomes are more likely to select a private plan, simply because they can get more for their money. In contrast, those who have higher health risks may be more likely to chose public health insurance, since they are not required to pay higher premium for greater service utilization and would face lower out-of-pocket costs with public coverage. Consequently, adverse selection arises, as the public system is more likely to insure riskier and poorer individuals. Furthermore, over time, this structure reinforces the accumulation of a population in poorer health in the public health system. Specifically, while people can move freely from the private to the public system, mobility in the other direction is limited. In particular, a negative health shock incurred while not covered by a given private plan will henceforth be considered a pre-existing condition which precludes coverage by that plan in the future. Meanwhile, there are no restrictions on pre-existing conditions in the public insurance system. This asymmetry in restrictions may imply that (i) sicker individuals accumulate in the public health system, as mobility from public to private is limited, and/or (ii) workers in the private system maintain private coverage longer than they might have otherwise, as they hope to keep private coverage in the future, in the event of an unforeseen negative health shock. The implication for accumulation of individuals in public insurance work in the opposite direction in these two scenarios. The concern of accumulation into public insurance is that private insurance schemes would be crowded out.

Previous research has examined choices around health and insurance among a variety of populations. For example, Yang et al. (2009) model the choice of supplemental health insurance decisions of Medicare beneficiaries in the United States. Gilleskie (1998) models medical care use and work absence, while Blau and Gilleskie (2000) and Gilleskie and Mroz (2004) develop a more complex dynamic model of employment, insurance and medical care utilization in the U.S., though these models have yet to be estimated with data. Cardon and Hendel (2001) estimate a structural model of health insurance and health care choices to examine the extent of adverse selection in the insurance market.

The choice between public and private insurance faced by individuals in Chile is somewhat unique, though individuals in some other countries do have a choice of whether to choose private insurance. Costa-Font and Garca-Villar (2009) analyze insurance choice in Spain, where individuals are captive to a public insurer but may elect to supplement with private insurance. Sanhueza and Ruiz-Tagle (2002) study the particular case of Chile, examining the determinants of insurance choice. They focus on the endogeneity of this choice relative to expected service utilization. Sapelli and Torche (2001) examine pricing and adverse selection in the Chilean health system. Relying on cross-sectional data, the authors find that the pricing system itself leads to rational segmentation of the healthy and wealthy into private insurance, and the poor and risky into public insurance. Both models, however, use static frameworks. That is, past decisions do not play a role in current decisions, making the examination of the potential importance of pre-existing conditions more difficult.

This paper develops a simple structural, dynamic model of health insurance choice in order to empirically test whether: (i) high-risk and poorer individuals are more likely to choose public insurance; (ii) the asymmetry in health insurance choice restrictions prevents mobility from public to private insurance following a health shock; (iii) whether the proportion of individuals in public insurance is predicted to increase over time, and (iv) what would happen to the proportion of individuals with public insurance were the restrictions on pre-existing conditions eliminated. The benefit of a dynamic structural model as opposed to a reduced form model is that it allows us to identify the underlying behavioral parameters driving individual behavior, given certain assumptions. Relying on these underlying parameters, we can then perform policy simulations to predict what will happen over time and perform the *ex-ante* evaluation of policy changes that have yet to be introduced.

In the next section, we present a description of the data, which is followed by section 3 describing the theoretical model and estimation method. Section 4 presents the results of the estimation and section 5 simulates insurance choice over time and performs *ex-ante* program evaluation. We conclude with a discussion of the findings in section 6.

2 Data

This analysis relies on data from the Encuesta de Protección Social (EPS), or Social Protection Survey, which follows a panel of individuals in Chile over time. While the first (2002) round of survey data only represents participants in the government-instituted private pension program, the 2004 and 2006 samples are nationally representative. The survey includes questions on health and insurance status at each point in time, as well as household demographic characteristics, labor market status, income, and extensive information on participation and knowledge of the country's private pension program. We use 2004 and 2006 data to estimate the model.

In this analysis, we categorize insurance status as public or private, although public insurance is in reality divided into several categories according to one's income and there are a number of different private insurers. Age is grouped by categories based on the cut-offs used by private insurance companies to determine premiums (Sapelli and Torche, 2001). Health status is measured by a self-reported general health status question, rated on a 6-point scale, from "very poor" to "excellent." For simplicity, we dichotomize this variable to health being either good to excellent (the top three categories) or fair to very poor (the bottom three categories). For the income variable, we compute an individual's total annual income from jobs, assets and all other sources. While more complete information on health risk behaviors and health service utilization is available in the data, we will reserve the inclusion of these variables for a more complex model in future work.

2.1 Determination of the Sample

The combined panel for 2004 and 2006 consists of 18,474 distinct individuals, of whom there are observations for both years for 14,696 individuals. First, we limit the sample to adults between the ages of 25 and 75, in order to focus on adults who have likely completed schooling and who are likely to have already made insurance changes (after age 75, premiums for private insurance do not change and income is not likely to change, as most individuals have retired). Second, we keep only individuals with zero dependents in both years. That is, in our sample, other household members, if any, have either their own insurance plan or no insurance. Clearly, family size will affect a household's health insurance decision, particularly since private insurance premiums vary by family size, while public insurance premiums do not. However, for tractability and comparability, we focus only on individuals with zero dependents for this analysis (modeling fertility involves a complexity that we reserve for future analysis). Note that this assumption does not necessarily exclude individuals that are married and/or have children.

Third, we eliminate cases where individuals have either zero years of schooling or no income in either year, in order to ensure a minimum level of education and participation in the formal labor market. Fourth, we exclude individuals who report having either no insurance or some other insurance in one of the two years, since we are interested only in switching between public and private insurance. It is important to note that a non-negligible percent of individuals report having no insurance in both years (Table 1), an issue worth pursuing in future work, along with indirect routes to the switch between public and private. Finally, we delete a few outlying cases where income is reported to increase by more than 50 percent from one year to the next and top-code

Table 1: Variable Means, Full Sample versus Estimation Sample

Insurance Type	2004	2006
Full sample		
% public	76.08	78.8
% private	12.34	11.49
% none	8.83	5.91
% other	2.74	3.81
Private/(public+private)	13.96	12.73
Observations	14,697	14,696
Estimation sample		
% public	85.29	86.03
% private	14.71	13.97
observations	3,501	3,501

Other Variables, 2004	Observations	Mean	Standard Deviation	Welch's t-stat
Full sample				
Age	14,697	45.72	15.85	
Female	14,697	0.50	0.50	
Years schooling	14,637	9.45	4.33	
Health fair to poor	14,697	0.36	0.48	
Income	14,697	2,333,345	15,900,000	
Estimation sample				
Age	3,501	47.35	14.22	5.96
Female	3,501	0.55	0.50	4.64
Years schooling	3,501	9.32	4.51	-1.45
Health fair to poor	3,501	0.38	0.48	1.92
Income	3,501	2,130,391	1,835,577	-1.52

incomes at the ninety-fifth percentile so that outliers do not drive the estimation of the model. In the few cases where individuals report inconsistency in level of education in the two years, we assume that the 2004 level reported is accurate.

Limiting the sample to adults between the ages of 25 and 75 reduces the sample to 12,920; keeping individuals with only zero dependents in both years reduces the sample to 7,280; eliminating cases where individuals have zero income in either year further reduces the sample to 4,922; dropping individuals who report having either no insurance or some other insurance in one of the two years reduces the sample to 3,841; deleting outlying cases where income is reported to increase by more than 50 percent from one year to the next brings our analysis sample to 3,501 individuals.

By reducing the sample size by these parameters, we may be introducing sample selection bias. In particular, the insurance choices of individuals in this limited sample may differ from the population. Table 1 shows the insurance status and descriptive characteristics in each year of individuals in the full and in our estimation sample. In this table we see that the proportion of individuals with private insurance out of those with either public or private is only slightly higher in the estimation sample as compared with the full sample. As we would expect, the age of individuals in 2004 is slightly higher in the estimation sample than that of the full sample, but the average number of years of schooling and the average health status is similar. Our estimation sample has a slightly higher percent female than the full sample, and this difference is statistically significant. We must keep this in mind in interpreting our findings. However, differences in years of schooling, health status and income are not statistically significant. Furthermore, the estimation sample may differ from the full sample in ways that we are not measuring; as a result, we can only cautiously interpret findings as representative of the behavior of individuals between the ages of 25 and 75 with no dependents in Chile.

2.2 Insurance Transitions

The EPS data provide evidence that the transition from public to private insurance is less frequent than a transition from private to public. Table 2, panel a, shows the transition matrix for individuals changing insurance status between 2004 and 2006 for the full EPS sample with observations in both years. The vast majority (91 percent) of individuals with public insurance in 2004 maintains public insurance in 2006, and only three percent switch to private insurance. Of individuals with private insurance in 2004, only three-quarters maintain this insurance status in 2006, while 20 percent move to public insurance. We also see in this table that individuals with other or no insurance status in 2004 are most likely to be in the public insurance system by 2006 compared to any other insurance status.

Table 2: Insurance Status Transitions, Full Sample

Status 2004	Status 2006				
	Public	Private	Other	None	Total
Public	90.84	2.23	3.97	2.96	100.00
Private	20.12	75.8	2.92	1.16	100.00
Other	65.56	3.54	26.04	4.85	100.00
None	51.36	4.47	8.19	35.98	100.00
Total	78.8	11.49	5.91	3.81	100.00

Note: The "Other" category includes individuals covered by the armed forces as well as those who do not know which insurance type they have.

There are some differences by age and sex in the likelihood of transitioning from public to private or vice versa. Both men and women are most likely to move from public to private insurance when they are less than 35 years old, with males nearly twice as likely as females in this age range to do so. Presumably, one may first gain access to public insurance in the beginning of one's career, which may be more likely for this age group. Women are most likely to move from private to public coverage in older ages, with 36 percent of women having private insurance in 2004 moving to public insurance between the ages of 65 and 74 (this figure increases to 42 percent for women over age 75). In contrast, men are most likely to move from private to public at younger ages. It may be that women move to public coverage when their spouse passes, and/or possibly move to public coverage when chronic disease or disability begins to affect them. Meanwhile, men may move with changes in job, income, health status, or health preference. In our estimation sample (table 3, panel b), the general direction of these differences is maintained, though the magnitudes are somewhat different. Perhaps most notably, women in our estimation sample are much more likely to move from public to private insurance when under 35 than they are in the full EPS sample. In addition, our estimation sample has a markedly greater share of women participating in the private as opposed to the public system (see share private column). This difference may be due to the elimination of non-earning individuals and individuals with dependents.

Table 3: Percent with public and private insurance, 2004, and change in 2006

	Percent private 2004	Change to public 2006	Percent public 2004	Change to private 2006	Share private = private/(public+private) 2004
a. Full sample					
Females	11.1	19.1	79.6	1.9	12.2
age <=34	12.6	22.8	76.8	4.0	14.1
age 35-44	13.7	16.9	77.0	2.2	15.1
age 45-64	11.5	16.4	79.6	1.1	12.7
age 65-74	2.7	35.7	90.2	0.2	2.9
age >74	2.8	41.7	89.1	0.0	3.0
Males	13.6	21.2	72.5	2.7	15.8
age <=34	17.7	25.6	65.2	7.2	21.3
age 35-44	14.9	22.4	72.3	2.7	17.1
age 45-64	13.0	15.7	72.5	1.1	15.2
age 65-74	5.6	19.4	87.5	0.4	6.0
age >74	3.3	9.1	88.0	0.4	3.6
All	12.3	20.1	76.1	2.2	14.0
Observations = 14,697					
b. Estimation sample					
Females	13.6	18.0	86.4	1.9	
age <=34	24.3	18.0	75.7	8.2	
age 35-44	20.0	18.3	80.0	2.3	
age 45-64	11.7	18.2	88.3	1.0	
age 65-74	2.1	42.9	98.0	0.3	
Males	16.1	25.5	83.9	4.2	
age <=34	23.7	27.4	76.3	11.1	
age 35-44	16.9	22.0	83.1	3.5	
age 45-64	11.9	16.7	88.1	0.7	
age 65-74	4.8	22.2	95.2	1.3	
All	14.8	21.4	85.3	2.9	
Observations = 3,501					

3 The Model

The main source of uncertainty in the model arises from the evolution of individuals' health status. In addition, as common in dynamic stochastic models, there is also uncertainty in individuals' income.

3.1 Annual Discrete Choice

The discrete choice that each individual makes annually is which type of health insurance to select (ℓ_t): private or public. For simplicity, since private insurance companies are competitive, we are able to assume that there are no qualitative differences among them. Then,

$$\ell = \begin{cases} 0 & \text{if Public} \\ 1 & \text{if Private} \end{cases} \tag{1}$$

3.2 State Variables

The state space as of the beginning of age t is given by the health insurance choice at age $t-1$ (ℓ_{t-1}) and health status at the beginning of age t (h_{t-1}), where

$$h = \begin{cases} 0 & \text{if} \quad \text{good to excellent} \\ 1 & \text{if} \quad \text{fair to poor} \end{cases} \tag{2}$$

3.3 Probability of Illness

The probability that an individual will be sick at age t (π_t) is a function of health status in the previous year, the individual's age (t), and sex (f):

$$\pi_t = \frac{\exp\{\gamma_0 + \gamma_1 h_{t-1} + \gamma_2 t + \gamma_3 t^2 + \gamma_4 f_t\}}{1 + \exp\{\gamma_0 + \gamma_1 h_{t-1} + \gamma_2 t + \gamma_3 t^2 + \gamma_4 f_t\}} \tag{3}$$

where parameters $\gamma_0, \gamma_1, \gamma_2, \gamma_3$ and γ_4 are estimated with the data.[1]

3.4 Utility Function and Budget Constraint

Let C_t be a bundle of goods for household consumption at age t. The utility an individual with health insurance choice ℓ receives every period is given by the following utility function:

$$U_\ell(C_t^\ell) = \alpha_0 + \alpha_1 \ell_t + C_t^\ell \tag{4}$$

[1] The logit log-likelihood optimization yielded the following coefficients and standard errors: $\gamma_0 = -2.35$ (1.08), $\gamma_1 = 0.71$ (0.22), $\gamma_2 = 0.031$ (0.031), $\gamma_3 = -0.0001$ (0.00026), $\gamma_4 = 0.069$ (0.081) and variance $= 0.31$ (0.11).

where the parameter α_1 captures the direct utility that the private insurance type's amenities, such as health care quality, provides to the insured individual. Parameters α_0 and α_1 will also come from the data.

The per-period budget constraint is given by:

$$C_t^\ell = Y_t - I_t^\ell - h_t m_t^\ell \tag{5}$$

where Y_t is the monthly income, I_t^ℓ is insurance premium, and m_t^ℓ is the out-of-pocket medical treatment costs during the year.

We assume there is uncertainty in wages, which are given by the standard earnings function

$$\log Y_t = \eta_0 + \eta_1 S + \eta_2 t + \eta_3 t^2 + \xi_t = W_t + \xi_t \tag{6}$$

where S is the person's years of formal schooling and ξ_t is a serially uncorrelated log-normally distributed shock with a zero mean and a finite σ_ξ^2 variance.

The out-of-pocket medical costs are represented by the function:

$$m_t^\ell = \rho_0 + \rho_1 \ell_t + \rho_2 \ell_t (1 - \ell_{t-1}) h_{t-1} \tag{7}$$

where coefficient ρ_1 captures the specific impact on medical costs of quality and amenities of the private system relative to the public system. In addition, the dummy variable $\ell_t(1 - \ell_{t-1})h_{t-1}$ captures the pre-existing condition problem. Specifically, an individual that is currently in the private system ($\ell_t = 1$) but receives a negative health shock while outside the private system in the previous period ($\ell_{t-1} = 0$ and $h_{t-1} = 1$) would face much larger out-of-pocket medical costs than if the person had received the shock while in the private system. Namely, the private health insurance company is entitled to expel or deny coverage if the person failed to declare any pre-existing health condition, and so the person would be forced to either pay all medical costs out-of-pocket or switch to the public system. Therefore, we expect a positive value for the ρ_2 coefficient. Note that this variable provides the dynamic feature in the model.

In terms of the insurance premium, workers pay 7 percent of their salary for public insurance in Chile, regardless of utilization. For private insurance, on the other hand, as mentioned earlier, the premium depends on coverage, and, for a given coverage level, is a deterministic function of age and sex of the head of the family and his or her dependants, as allowed by law.[2] Therefore,

[2]By law, private insurance companies cannot base their premiums on the member's current health status. Pre-existing condition restrictions are relevant to individuals outside the private system that would like to purchase private insurance.

the insurance premiums relevant for each period are given by the following functions:

$$\begin{aligned} I_t^0 &= 0.07Y_t \\ I_t^1 &= \delta_0 + [\delta_1 t + \delta_2 f_t](1 + \lambda_t) \end{aligned} \tag{8}$$

where λ_t represents the increase in the person's premium due to the addition of dependents to the plan. For the purposes of this analysis, we limit the sample to respondents with no dependants (i.e., $\lambda_t = 0$).

Let $s_t = (\ell_{t-1}, h_{t-1}, S, t, f_t, \xi_t)$ be the vector of state variables.

3.5 Solution

The present discounted value of lifetime utility from an individual of age a choosing health insurance of type ℓ at age t is

$$V(s_t) = \max_{p_\tau} E\left\{\sum_{\tau=t}^{T} \beta^{\tau-t}\left[p_\tau U_\tau^1(C_\tau^1) + (1-p_\tau)U_\tau^0(C_\tau^0)\right]\right\} = \max\left\{V_0(s_t), V_1(s_t)\right\} \tag{9}$$

where

$$V_\ell(s_t) = EU_\ell(C_t^\ell) + \beta EV_t(s_{t+1}|p_t = p_\ell) \tag{10}$$

In order to facilitate computational tractability, we set a maximum age $T = 75$ until which individuals actively make their health insurance choices. After age T, we assume that individuals will not switch between insurance types. It is possible to make this assumption since, after the age of 75, pension income tends to be rather predictable and premium rates for private insurance do not change.

Therefore, the value function at T includes a static decision problem that will affect both the individual's contemporaneous and future utility. The latter is captured by $\bar{V}_\ell = \bar{V}(s_T|p_T = p_\ell)$, which is a deterministic function of the state space at T.[3] The value function is given by

$$V(s_T) = \max\{V_0(s_T), V_1(s_T)\} \tag{11}$$

where[4]

$$\begin{aligned} V_0(s_T) &= \alpha_0 + \exp\{W_T + \xi_T\} - 0.07 \cdot \exp\{W_T + \xi_T\} - \pi_T\rho_0 + \beta\bar{V}_0 \\ V_1(s_T) &= \alpha_0 + \alpha_1 + \exp\{W_T + \xi_T\} - I_T^1 - \pi_T m_T^1 + \beta\bar{V}_1 \end{aligned} \tag{12}$$

[3] That is, $\bar{V}(s_T|p_T = p_\ell) = \theta_0 + \theta_1\ell_T + \theta_2 h_T$.

[4] Since health status (h_t) is unknown at the beginning of each year, then out-of-pocket costs of illness is given by its expected value $\pi_t m_t^\ell$.

Therefore, the individual would choose public insurance for ages $t \geq T$ if $V_0(s_T) \geq V_1(s_T)$. That is, if

$$\begin{aligned} \xi_t &\leq \log\left\{-\alpha_1 + \pi_T(m_T^1 - \rho_0) + I_T^1 + \beta[\bar{V}_0 - \bar{V}_1]\right\} - \log(0.07) - W_T \\ &= \xi_I^*(s_T) \end{aligned} \tag{13}$$

Consequently, the choice probability at age T has the binomial logit form:

$$p_T = \begin{cases} 0 & \text{if} \quad \xi_T \leq \xi^*(s_T) \\ 1 & \text{if} \quad \xi_T > \xi^*(s_T) \end{cases} \tag{14}$$

The expected discounted value function at age T is:

$$\begin{aligned} E_{T-1}V(s_T) &= \left[\alpha_0 - \pi_T\rho_0 + \beta\bar{V}_0\right] \cdot \Pr(\xi_T \leq \xi_T^*) \\ &\quad +(1-0.07)\exp\{W_T\}E_{T-1}\left\{e^{\xi_T}|\xi_T \leq \xi_T^*\right\}\Pr(\xi_T \leq \xi_T^*) \\ &\quad \left[\alpha_0 + \alpha_1 - I_T^1 - \pi_T m_T^1 + \beta\bar{V}_1\right] \cdot \Pr(\xi_T > \xi_T^*) \\ &\quad +\exp\{W_T\}E_{T-1}\left\{e^{\xi_T}|\xi_T > \xi_T^*\right\}\Pr(\xi_T > \xi_T^*) \end{aligned}$$

which, given the assumption of normal distribution for ξ, implies

$$\begin{aligned} E_{T-1}V(s_T) &= \alpha_0 - \left[\pi_T\rho_0 - \beta\bar{V}_0\right]\Phi\left(\frac{\xi_T^*}{\sigma_\xi}\right) + \left[\alpha_1 - I_T^1 - \pi_T m_T^1 + \beta\bar{V}_1\right]\left[1 - \Phi\left(\frac{\xi_T^*}{\sigma_\xi}\right)\right] \\ &\quad +\exp\{W_T\}e^{0.5\sigma_\xi^2}\left[1 - 0.07 \cdot \Phi\left(\frac{\xi_T^* - \sigma_\xi^2}{\sigma_\xi}\right)\right] \end{aligned} \tag{15}$$

where $\Phi(\cdot)$ is the cumulative distribution function for the normal distribution.

Solving backwards brings in the value functions, decision rules and probabilities for each age $t < T$ as a function of the relevant state space:

$$\begin{aligned} V_0(s_t) &= \alpha_0 + \exp\{W_t + \xi_t\} - 0.07\exp\{W_t + \xi_t\} - \pi_t\rho_0 + \beta E_t V(s_{t+1}|p_t = 0) \\ V_1(s_t) &= \alpha_0 + \alpha_1 + \exp\{W_t + \xi_t\} - I_t^1 - \pi_t m_t^1 + \beta E_t V(s_{t+1}|p_t = 1) \end{aligned} \tag{16}$$

which implies the following decision rule and expected discounted value function as of the beginning of age t:

$$p_t = \begin{cases} 0 \text{ if} \quad \xi_t & \leq \log\Big\{-\alpha_1 + \pi_t(m_t^1 - \rho_0) + I_t^1 \\ & \qquad +\beta[E_t V(s_{t+1}|p_t = 0) - E_t V(s_{t+1}|p_t = 1)]\Big\} - \log(0.07) - W_t \\ & = \xi^*(s_t) \\ 1 \text{ if} \quad \xi_t & > \xi^*(s_t) \end{cases} \tag{17}$$

$$
\begin{aligned}
E_{t-1}V(s_t) \quad &= \quad \alpha_0 - \left[h_t\rho_0 - \beta EV(s_{t+1}|P_t = 0)\right] \Phi\left(\tfrac{\xi_t^*}{\sigma_\xi}\right) \\
&\quad + \left[\alpha_1 - I_t^1 - h_t m_t^1 + \beta EV(s_{t+1}|P_t = 1)\right] \left[1 - \Phi\left(\tfrac{\xi_t^*}{\sigma_\xi}\right)\right] \\
&\quad + \exp\{W_t\}\, e^{0.5\sigma_\xi^2} \left[1 - 0.07 \cdot \Phi\left(\tfrac{\xi_t^* - \sigma_\xi^2}{\sigma_\xi}\right)\right]
\end{aligned} \tag{18}
$$

We also use the health status probability π_t (Equation [3]) to put together the likelihood function for each individual in the sample.

3.6 Likelihood Function

As in Eckstein and Wolpin (1989), we assume that the salaries are reported with error. Though this assumption does not affect the decision rules (equations 14 and 17), it allows us to alleviate the impact of outlier observations in the likelihood function.

$$
\log Y_t^r = \log Y_t + \psi_t \tag{19}
$$

where Y_t^r is the reported income, Y_t is the true income, $\psi_t \sim N(0, \sigma_\psi^2)$ and $E(\xi_t \psi_t) = 0$.

The likelihood function corresponding to each individual n is:

$$
L_n = \prod_{\tau=t}^{T} \Pr\big(\xi_\tau > \xi_\tau^*(s_\tau)\big)^{p_\tau} \Pr\big(\xi_\tau \leq \xi_\tau^*(s_\tau)\big)^{1-p_\tau} \tag{20}
$$

where

$$
\Pr(\xi_t \leq \xi_t^*(s_\tau), Y_\tau^r) = \Phi\left(\frac{\xi_\tau^* - \kappa \frac{\sigma_\xi^2}{\sigma_\xi^2} u_\tau}{\sigma_\xi \sqrt{1-\kappa^2}}\right) \frac{1}{\sigma_u}\, \phi\left(\frac{u_\tau}{\sigma_u}\right) \tag{21}
$$

and $u_\tau = \xi_\tau + \psi_\tau$, $\kappa = \sigma_\xi^2/\sigma_\psi^2$ and $\sigma_u = \sqrt{\sigma_\xi^2 + \sigma_\psi^2}\,(1-\kappa^2)$.

The likelihood for the complete sample is given by

$$
L = \prod_{n}^{N} L_n \tag{22}
$$

3.7 Identification

The following parameters are directly identified: α_1, ρ_0, ρ_1, ρ_2, δ_1, δ_2, η_1, η_2, η_3, η_4, σ_ξ^2 and σ_ψ^2. In addition, the following groups of parameters are identified: $\delta_0 - \alpha_1 - \beta\theta_1$, $\alpha_0 + \beta\theta_0$, $\rho_0 - \beta\theta_2$ and $\delta_0 - \alpha_1$, which allow us to identify δ_0, θ_1 and θ_2. Note that the dynamic model does not allow α_0 be distinguished from θ_0.

4 Results

Table 4 presents the maximum likelihood estimates and standard errors. First, as one might expect, the potential cost of pre-existing conditions reduces the marginal utility of participating in the private system (that is, $\rho_2 > 0$). This result suggests that the existence of the pre-existing condition restriction may lead to more individuals choosing public health insurance. In section 5 we conduct a policy simulation to evaluate the change in participation in public insurance were this constraint to be relaxed.

Table 4: Maximum likelihood estimates

Parameter	Coefficient	Parameter	Coefficient
α_1	54.73813	η_2	0.018794
	(2.08E+08)		(0.009545)
ρ_0	19.14107	η_3	-0.00011
	(60171000)		(9.37E-05)
ρ_1	8120.999	c_1	-9494.8
	(82156)		(67121)
ρ_2	293842.1	c_2	10.1869
	(113400)		(31539000)
δ_1	4860.744	c_3	17.30471
	(660.71)		(65427000)
δ_2	-7242.7	c_4	66258.11
	(8028.5)		(19855)
η_0	12.51175	σ_ξ^2	0.342651
	(0.24147)		(0.023029)
η_1	0.126389	σ_ψ^2	0.769646
	(0.004007)		(0.021227)
ln L	-6056.86		

Notes: Standard errors are in parentheses. From the value of coefficients $c_1 = \delta_0 - \alpha_1 - \beta\theta_1$, $c_2 = \alpha_0 + \beta\theta_0$, $c_3 = \rho_0 - \beta\theta_2$ and $c_4 = \delta_0 - \alpha_1$ it is possible to obtain the following values: $\delta_0 = 66313$, $\theta_1 = 83937$ and $\theta_2 = 2.03$.

Second, the marginal utility of participating in the private system decreases with age (that is, $\delta_1 > 0$), as the private insurance premium rises with age. This result suggests that as an individual ages through the life course, he may be more likely to chose public insurance over time. This result is clearly observed in the raw data for both women and men, as we see the pattern of accumulation in the public system at older ages.

At the same time, since wages increase with education ($\eta_1 > 0$) and increase (at a decreasing rate) over the life cycle ($\eta_2 > 0$ and $\eta_3 < 0$), an individual is less likely to choose public insurance as income increases, since the public premium increases along with income, but with no accompanying increase in benefits. An individual may be able to obtain greater benefits by purchasing private insurance with their minimum contribution of 7 percent of their monthly salaries.

Table 5 shows the actual insurance participation rates and the those predicted by the model for the overall sample as well as by age category, sex, years of schooling, income quintile and general health status. A chi-square test of goodness of fit for overall participation suggests the model does a relatively good job of estimating true participation (assuming a 95 percent confidence level).

As we may have expected from the raw data, table 5, panel *a* shows that participation in the public system increases with age category. Intuitively, the positive impact of age on the private insurance premiums tends to more than compensate for the increase in salary (and thus, in the public premium) that usually accompanies age. The chi-square test finds no statistically significant difference between the actual and predicted values. At the same time, we see that education positively affects wages, and through wages, it also positively impacts the public premium. As a result, higher levels of education imply lower levels of participation in the public system.

Panel *b* shows that the model predicts slightly higher female public participation. One could argue that women face higher premiums in the private insurance market due to higher medical costs from higher prevalence of chronic conditions and/or the costs around child-bearing. Also, recall that our estimation sample has a higher percentage of females than the original EPS sample. There may be something which distinguishes women in our estimation sample (more likely to be participating in the workforce, for example), that may also lead them to have greater participation in public insurance. In analyzing participation by sex and age category, we see that males are only more likely to participate in public insurance above age 50. For the age category 26-49, females are actually predicted to have lower participation in public insurance than males.

Next we consider participation in public insurance by both age and education (panel *c*). While individuals with low levels of education increasingly participate in the public system as age increases, the pattern is more erratic for people with some years of higher education. Though not statistically significantly different, the model's predictions do not fit the data as well for those with higher levels of education as it does for those with lower levels. The model predicts lower public participation with age for the group with some post-graduate education (years of schooling $\geqslant$ 18). Intuitively, as wages tend to grow more quickly for people with high skills, so does the premium in the public system. The 1.0 participation in the group with 62-75 years of age and 18 or more years of education should be ignored as there is not a sufficient number of observations to be statistically significant.

The actual and predicted values of participation by income quintile in panel *d* contain a result that is significantly different from actual values. However, this is mostly explained by poor goodness of fit for the highest wage quintile. In general, the model tends to predict slightly lower public participation than the actual data suggest, although it predicts higher public participation for the top income quintile. This result suggests that there may be something other than income driving participation in private insurance at higher income levels. Here as well, the actual and predicted values may well be statistically significantly different for the highest income quintile. It may be that

Table 5: Participation in Public Insurance, Actual and Predicted Values, Overall and by Age, Sex, Education, Income Quintile and Health Status

	Age Category										
	All Ages		26-37		38-49		50-61		62-75		Chi-square (row)
	A	P	A	P	A	P	A	P	A	P	
a. Overall	0.860 (3,012)	0.868	0.752 (911)	0.734	0.843 (864)	0.860	0.888 (872)	0.915	0.966 (854)	0.970	1.450
Chi-square (column)	1.600										
b. Sex											
Males	0.844 (1,573)	0.858	0.755	0.761	0.860	0.872	0.887	0.918	0.946	0.963	0.525
Females	0.874 (1,928)	0.875	0.747	0.689	0.828	0.850	0.888	0.913	0.977	0.973	2.356
Chi-square (column)	0.400		1.732		0.328		0.721		0.100		
c. Years of Schooling											
1-8	0.988 (1,538)	0.993	0.959	0.976	0.987	0.984	0.989	0.996	0.994	0.998	0.078
9-12	0.882 (1,267)	0.882	0.835	0.822	0.888	0.881	0.897	0.928	0.956	0.947	0.412
13-17	0.556 (640)	0.590	0.582	0.549	0.493	0.604	0.530	0.634	0.638	0.714	6.039
18+	0.339 (56)	0.289	0.400	0.270	0.188	0.316	0.308	0.304	1.000	0.225	7.737
Chi-square (column)	1.730		2.330		3.880		2.310		5.740		
d. Income Quintile											
Quintile 1	0.977 (660)	0.956	0.920	0.862	0.971	0.936	0.995	0.985	0.995	0.994	0.643
Quintile 2	0.974 (659)	0.957	0.896	0.808	0.952	0.932	0.988	0.970	0.991	0.990	0.731
Quintile 3	0.974 (645)	0.918	0.958	0.840	0.979	0.918	0.977	0.960	0.983	0.967	3.585
Quintile 4	0.885 (660)	0.851	0.803	0.748	0.872	0.870	0.957	0.921	1.000	0.965	1.326
Quintile 5	0.622 (703)	0.734	0.563	0.638	0.591	0.734	0.632	0.801	0.851	0.913	13.53*
Chi-square (column)	15.600		7.187		5.942		6.147		0.539		
e. Health Status											
Good to excellent	0.805 (2,184)	0.808	0.732	0.703	0.808	0.825	0.836	0.865	0.925	0.940	1.640
Fair to poor	0.951 (1,317)	0.966	0.864	0.903	0.927	0.946	0.943	0.969	0.994	0.990	0.610
Chi-square (column)	0.300		1.132		0.303		0.723		0.089		

Notes: A is actual value, P is predicted value,* signifies the actual and predicted to be statistically different, sample sizes are in parentheses.

income plays an important role in driving the decision to participate in public insurance, but given an individual with a particularly high income (in highest income quintile), the model has difficulty determining predicting the decision between public and private insurance, as other factors may play a role. However, both the actual data and the predicted values tend to show an increase in public participation with age for each income category. Intuitively, given one's income, a higher age raises the premium in the private system, thereby making one more likely to participate in public insurance. In addition, though public participation tends to decrease with income, this pattern is more erratic for the youngest age category in both actual and predicted values.

The results by health status in e reveal that indeed, individuals who receive a poor health shock are more likely to chose public insurance. This result may arise from the more predictable and generally lower out-of-pocket medical costs in the public system, but could also be a consequence of pre-existing condition clauses for private insurance. If private insurers do not accept individuals with a qualifying pre-existing condition, leaving the public system may not even be an option for those receiving a negative health shock. Considering these choices by both age and health status, both the model predictions and the actual data show higher public participation for people with poor health, regardless of age category. However, public participation increases with age for both categories of health status. At young ages, participation in the private system is substantially higher for those with good health as compared to those who receive a negative health shock.

5 Simulations

In section 4 we saw that the model predicts that indeed the private system covers a wealthier and healthier sub-population. Having estimated the structural parameters for the model, we may conduct simulations to determine whether the proportion of individuals in the public system will cumulate over time, leading to a crowding out of private insurance.

In addition, we can use the estimated model parameters to conduct *ex-ante* program evaluation to examine what would happen if certain policies were enacted. Of particular interest at a time of health reform in the United States is the restriction on pre-existing conditions. In particular, we may wish to see what would happen if these restrictions were relaxed, so that private insurers cannot put limits on the participation of individuals with pre-existing conditions. Third, we may consider the accumulation of individuals in public or private insurance with this policy in place.

Accumulation of Individuals Over Time

In this section, we project the decision to participate in public versus private insurance over time to 2050. To project mortality, we use age and sex-specific death rates from the 2006 World Health Organization (WHO) life table, converting them to probabilities of dying within two years (${}_2q_x$), which is the *de facto* period of analysis since data are collected every 2 years. While death may be more likely to occur among those with poor health, we assume for the purposes of this analysis that the death rate is the same for all subgroups of the population. While this assumption may have implications for our study findings, it is not obvious how one would optimally allocate a differing probability of survival to individuals with lower self-rated healths status.

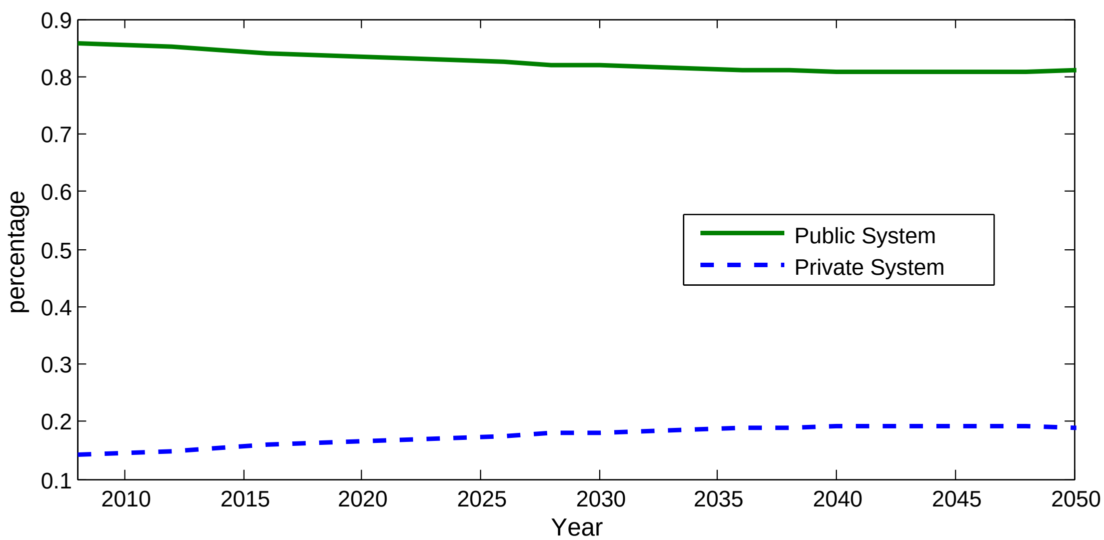

Figure 1: Private versus Public Participation Over Time (2008 - 2050)

For projections of fertility, we assume that the number of men entering into our sample at age 25 from each subsequent birth cohort declines by a simple rate, r. Imposing a sex ratio of 1.04, we calculate the number of men in the subsequent cohort based on the number of men from the previous cohort.[5] We take this approach, rather than estimating the number of births and subjecting them to the mortality rates from birth to age 24 as we are only interested in the adult population. Furthermore, in the absence of any major shocks mortality at younger ages (such as war or major disease), it is reasonable to assume that the proportion of individuals who have lived to age 25 will be very similar in subsequent cohorts. We use a growth rate of $r = .00479$ which is

[5] Recall that the original estimation sample has a disproportionate percentage of women. The higher proportion of women will phase out over time in the projected population

the average growth rate for births occurring between 1982 and 2005, the most complete data which are available from the United Nations Demographic Yearbook last updated in UNData in April 2009. We then project this rate into the future assuming that the growth rate will remain constant. While it is conventional to project fertility using assumptions of low, medium and high growth in fertility we use constant fertility for simplicity and to characterize long-range trends which are likely to continue into the future.

For tractability, we ignore migration in this analysis. However, it is important to note that immigration to Chile is not negligible and that migrants may be more likely to be low wage earners or domestic employees, and thus more likely to participate in public insurance.

We assume that average years of schooling remains constant in subsequent cohorts, as there are likely to be general equilibrium effects in the long run for increases in schooling. Individuals are subject to health shocks as they age, but the distribution of health shocks remains constant over time.

Figure 1 shows the projected participation in public and private insurance through year 2050. In this long term analysis, we see a gradual convergence over time of the percent of individuals who are in the public system each year, from about 86 percent in 2008 to a steady state of approximately 81 percent by around 2040. The gradual increase in the proportion choosing private insurance is due to higher average years of schooling for younger individuals in the estimation sample, which results in higher earning power over time, and, hence, more selection of private insurance. Since education then levels out with entering cohorts, the percent of individuals choosing public insurance levels out over time as well. While this convergence depends upon the assumptions we have made in the model, it is interesting that neither insurance type is crowded out over time. That is, we do not find evidence in support of the hypothesis that individuals cumulate in the public system over time.

Relaxing the Restriction on Pre-existing Conditions

The restrictions imposed by private insurance through pre-existing conditions clauses may be one of the reasons behind the disproportionate distribution of individuals of poor health to the public insurance program. In this section, we pose the question, what would the distribution between public and private insurance look like in the absence of barriers to entry to private insurance for those with pre-existing conditions?

A simple way to analyze this question is by setting the value of the parameter $\rho_2 = 0$. That is, in this hypothetical policy environment, given a negative health shock while not participating in private insurance, individuals would not expect higher out-of-pocket medical costs if they chose to participate in private insurance in the following period.

Table 6: Predicted private participation in 2006 with and without pre-existing condition clauses, overall and by health status and age

	Age Category										
	All Ages		26-37		38-49		50-61		62-75		Chi-square (row)
	C	NC	C	NC	C	NC	C	NC	C	NC	
Health Status											
Good to excellent	0.192	0.189	0.297	0.294	0.175	0.171	0.135	0.132	0.060	0.058	0.13
	(2,184)										
Fair to poor	0.034	0.064	0.097	0.170	0.054	0.108	0.031	0.054	0.010	0.020	17.96*
	(1,317)										
Chi-square (column)	17.91*		4.42*		6.74*		4.07*		2.85		
n (column)	(3,501)		(911)		(864)		(872)		(854)		

Notes: C is pre-existing conditions constraint in place, NC is no pre-existing conditions constraint in place, * signifies the actual and predicted to be statistically different, sample sizes are in parentheses.

The model suggests a noteworthy change in participation for individuals with poor health status. Table 6 shows that private participation among individuals with fair to poor health status rises from 3.4 percent to 6.4 percent. This finding suggests that the limitation on individuals with pre-existing conditions does impose a constraint for some individuals.

In addition, Table 6 also shows that participation in private insurance would be significantly higher among the lower age groups, in particular, for those under age 50, were there to be no barriers to entry into the private health insurance system for those with pre-existing conditions. Differences are less substantial at older ages.

The model, however, does not predict a significant change in participation in health insurance for the whole sample. The net flow of individuals towards the private system increases by less than 1 percent in 2006, and the projected participation over time, as shown in Figure 2, does not significantly increases either (about 2 percent by 2050).

A possible explanation is that pre-existing condition restrictions, that limit the flow of people with poor health towards the private system, also indirectly limit the flow in the opposite direction. The intuition is simple: as a barrier to entry, pre-existing condition clauses operate as barriers to exit. That is, under some circumstances (older individuals, for instance), individuals may find themselves captive of the private system knowing that if they ever exit they might be never able to return if their health unexpectedly deteriorates. This is particularly important for people in their older ages.

Therefore, given that the existence of pre-existence condition clauses limit the flow in both directions, in the overall, the elimination os these restrictions would not imply a significant net flow of people moving from the public system to the private system, as predicted by the model.

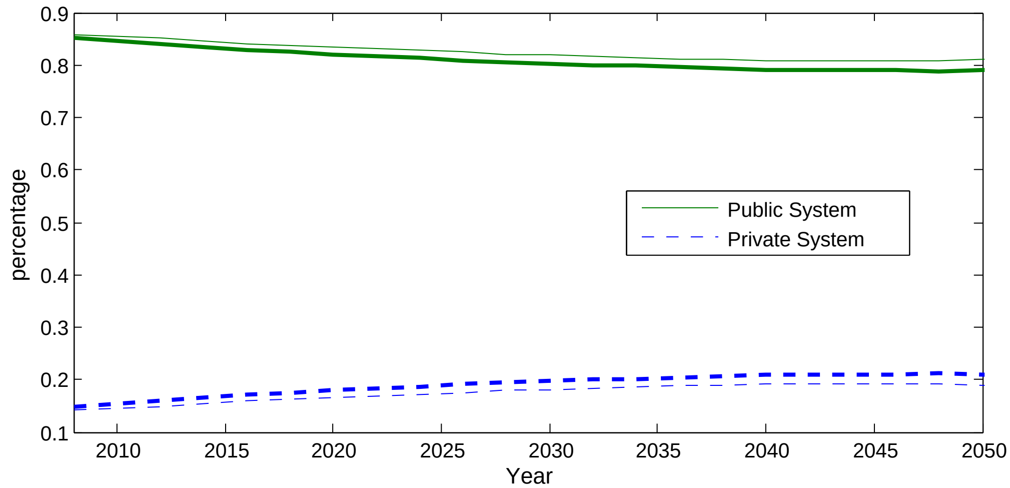

Figure 2: Impact of No Pre-existing Condition Restictions Over Time (2008 - 2050)

6 Concluding Remarks

This paper builds a dynamic stochastic model of an individual's choice of health insurance type. The model accounts for (i) asymmetry in restrictions regarding pre-existing health conditions, and (ii) differences insurance premium, allowing us to quantify the dynamic effects of these processes on individual health insurance choices. We estimate the model using data from Chile's *Encuesta Protección Social*.

Our findings suggest that the population insured by the public system is indeed less healthy and wealthy. Older individuals are more likely to choose public insurance, and over the life course, individuals are more likely to switch to public insurance. Women have higher predicted participation in public insurance than men on average, though at younger ages they actually have lower predicted participation in public insurance. There is higher public participation for people with poor health, regardless of age category, though public participation increases with age for both categories of health status. At young ages, participation in the private system is substantially higher for those with good health as compared to those who receive a negative health shock.

While we do find evidence of adverse selection for public insurance, we do not find evidence that the structural features of the insurance system will lead to the accumulation of individuals into public insurance or crowding out of private insurance. In contrast, the model predicts that over time, the percent of individuals choosing private insurance will gradually increase, and then will level off, as increases in education level off over time. That is, the increased earnings power associated with higher levels of education in the population drive a slight increase in the proportion of individuals choosing private insurance.

In *ex-ante* evaluation of a hypothetical policy eliminating restrictions on pre-existing conditions, we find that these restrictions are indeed binding for individuals having had a negative health shock. Forbidding such restrictions would almost double the percent of individuals with poor health status who choose private insurance.

In future work, we hope to develop this model further in order to handle the inclusion of individuals with dependents (for which it will be necessary to model fertility). We would also like to examine insurance choice between the three alternatives of public, private and no insurance, in order to examine alternative paths of switching between the two main insurance types. In addition to increasing the complexity of the model itself, we would like to perform further *ex-ante* program evaluation to examine additional policy scenarios, such as the introduction of catastrophic illness insurance to the private system, government mandated participation in some insurance program for all individuals (rather than the mandate for workers only), and mandating private insurance plans to provide a lower cost plan to low income beneficiaries.

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