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Essays on Public Finance

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Dedicated to my parents: Mahmoud and Ghada Zebian and to my siblings: Reem and Hussam.

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Essays on Public Finance

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In the first chapter, I investigate the welfare effect of the government subsidizing medical insurance. To that extent, I construct and simulate a partial equilibrium computational model of medical care consumption and choice of insurance contracts. I use the overall utility of agents as a welfare measure and find that it is not welfare improving to subsidize uninsured agents by taxing insured ones. In addition I use the framework to verify the insurance contract choice effect and find a strong insurance contract choice effect.

In Chapter 2, I investigate the effect of the price setting process under managed health care plans, such as HMOs and PPOs, on prices, profits of insurance companies and medical care providers, and household's welfare compared to the indemnity plans prevalent before the advent of managed care. I construct a simple game played between a representative insurance company and a medical care provider to determine the price of medical care paid by insured and uninsured households. In addition, insurance companies set premiums not through solving the usual principal-agent problem which forces a zero profit condition, but rather and more realistically by optimizing profits. The outcome of

this game is compared to the outcome of the indemnity plans where no price negotiations would occur.

In Chapter 3, I investigate the effect of the suggested reform to the United States' tax code in treatment of housing assets. In particular, I study the effect of the abolishment of the preferential tax treatment of housing assets (tax deductible mortgage interest payments and tax-free imputed rents) on the ownership and foreclosure rates in the housing market. I construct a model where heterogeneous agents decide on housing tenure in which default on housing mortgages occurs in equilibrium. I use this model to quantify the effect of this preferential tax treatment. I find that the elimination of the preferential tax treatment of housing assets results in a 33.4% reduction in foreclosures. Specifically, only eliminating the tax deductibility of interest on mortgage payments leads to a 12.4% reduction in foreclosure rates, while only taxing imputed rents generates a 32.5% reduction in foreclosure rates.

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Chapter 1: A Recursive Equilibrium Approach to Medical Care Demand and Insurance Choice

1.1. Introduction

The Patient Protection and Affordable Care Act was signed into United States law on March 23, 2010. This Act and the Health Care and Education Reconciliation Act of 2010 (signed into law on March 30, 2010) made up the health care reform of 2010. The Patient Protection Act is highly controversial, however, due to the rising cost of health care and the rising percentage of uninsured Americans, the need for reforming the medical care sector in the US is rarely in dispute. Thus, it is important to have a framework that allows us to analyze the benefits of reform to the medical care system.

US Medical care expenditures have grown at an average rate of 8.9 percent since 1980 while the gross domestic product average growth rate has been at about 6.3 percent over the same period. Medical care expenditure growing at a faster pace than the overall economy is observed in almost all the developed countries. In addition the cost for medical care has been steadily increasing. For example the total 2010 medical cost for a typical American family of four is $18,074 compared to the 2009 amount of $16,771, for an increase of 7.8 percent. This number represents an increase of 35.1 percent from the 2006 number of $13,382.[1] Increases of more than 8 percent have not been uncommon in previous years.

[1] 2010 and 2006 Milliman Medical Index

Given the increasing costs, access to insurance and how this access is provided to agents is an important aspect of any healthcare system discussion. This paper analyzes the welfare implications of subsidizing health insurance for uninsured individuals. To that purpose, I construct a dynamic model of insurance choice and medical care consumption where in equilibrium both insured and uninsured agents consume nondurables and medical services. Under uncertainty about income and health state, the model analyzes households' choices of: (i) consumption of non-durable goods, (ii) savings, (iii) insurance plan, and (iv) consumption of medical care.

Any attempt to study the welfare and demand implications of health care reform has to explicitly model both the agent's insurance choice and medical care demand. This paper achieves that and I am not aware of a similar framework to analyze medical care and insurance demand under uncertainty. Dusansky and Koc (2006) introduced and analyzed insurance contract choice effect on elasticity of medical care demand by analyzing a one period two-stage model of insurance choice and medical care demand under uncertainty of health state. The recursive equilibrium model presented and computed in this paper can be considered to be a generalization of the one period two-stage model used in Dusansky and Koc. The framework constructed in this paper will also be used to test the contract choice effect on elasticity of medical demand.

In what follows, Section 1.2 presents the environment, Section 1.3 presents the model, agents' behavior and describes the equilibrium, Section 1.4 presents the parameterization and calibration process, Section 1.5 presents the results, and Section 1.6 concludes.

1.2. Environment

I present an environment where time is discrete and infinite. The economy is made up of households and a health insurance company.

1.2.1. Households

The economy is populated by a unit measure of infinitely lived households that derive utility from consuming a basket of non-durable goods: (C) and health good: (H). Thus, household's utility function is given by $\mathrm{U}(\mathrm{C}, \mathrm{H})$.

The health good is generated by consumption of medical services (M) using a linear transformation technology given by $\mathrm{H}(\mathrm{M}, \mathrm{S})$, where (S) is the individual's health status.

Agents maximize the sum of their expected utility $\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \mathrm{U}(\mathrm{C}, \mathrm{H})$ Where $0 < \beta < 1$ is the discount factor.

Every period, agents' endowment (Y) and health state (S) are revealed. Endowment and health state are assumed to be independent and follow a first order Markov processes. Households have access to capital markets via financial intermediaries where they can save or borrow (A) at discount rate (q). Households also have access to health insurance provided by a health insurance company.[2] They choose health insurance policy (R, σ) where $\mathrm{R}(\sigma)$ is the insurance policy premium and (σ) is their share of medical expenses.[3]

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[2] Ketcham et al (2011) show evidence that consumers are rational when choosing health insurance contracts.

[3] As in Feldstein (1971) were a single measure is assumed to fully describe an insurance policy.

Dardanoni and Wagstaff (1990) discuss two types of uncertainty affecting the demand of medical care. Uncertainty about the occurrence of illness (what is referred to as type I uncertainty) and uncertainty about the effectiveness of treatment (type II uncertainty). In this paper, both types of uncertainty are being considered. Type I uncertainty is represented in the stochastic health state (S), while type II uncertainty is taken into account by having the health production function $H(\mathrm{M}, \mathrm{S})$ dependant on health state (S), thus the amount of health good created from consumption of a given level of medical services (M) (i.e. the effectiveness of treatment") varies by the health state.

1.2.2. Health Insurance Providers

Health insurance providers are assumed to be risk neutral agents that charge a premium (R) for providing insurance policy (R, σ). This corresponds to the insurance provider paying $(1-\sigma)$ of insured agent medical expenses. This paper assumes that price of medical care is the same for both insured and uninsured agents.[4]

Insurance providers have a zero profit condition where premium (R) for a policy (R, σ) is determined such that insurance providers break even on expectation. In determining R, insurance providers cannot discriminate based on household's levels of income, health state, or savings.

[4] Differences in prices faced by insured and uninsured agents is not within the scope of this chapter. I analyze the price setting process of medical care consumed by insured and uninsured agents in chapter II.

1.2.3. Transitions

A household's Income is assumed to be a one stage Markov process with transition matrix $\Pi_{Y'/Y} = \text{Prob}(Y_{t+1} = Y'/Y_t = Y)$. Similarly, health state is assumed to be a one stage Markov process with transition matrix $\Pi_{S'/S} = \text{Prob}(S_{t+1} = S'/S_t = S)$.

1.2.4. Timing

Every period is split into two stages.

Stage 1 is characterized by the following events:

- Household enters period with savings/borrowings (A) and she knows her health state (S_{-1}) from previous period;
- Endowment (Y) is revealed; and
- Household chooses insurance policy (R, σ).

Stage 2 is characterized by the following events:

- Health state (S) is realized; and
- Household chooses: current consumption of goods (C), current medical care consumption (M), and savings/borrowing for next period (A').

1.3. Equilibrium

1.3.1. Household's Problem

The household problem is formulated recursively. Given the above described environment, households solve a two step maximization problem. In the first stage, endowment (Y) is revealed while health state in previous period (S_{-1}) and savings (A) are already known by households. Households choose their insurance policy to maximize their future expected utility as of Stage 2 of current period.

$$\mathrm{V}(\mathrm{Y}, \mathrm{S}_{-1}, \mathrm{A}) = \max_{\sigma} \mathrm{E}_{\mathrm{S}/\mathrm{S}_{-1}} \mathrm{T}(\mathrm{Y}, \mathrm{S}, \sigma) \ldots. \text{Stage 1 : Insurance Decision}$$

In Stage 2, after health state for the period (S) is realized, households decide on consumption of non-durable goods (C), consumption of medical care (M), and savings/borrowing for next period (A') such as to maximize their future expected utility.

$$\mathrm{T}(\mathrm{Y}, \mathrm{S}, \mathrm{A}, \sigma) = \max_{\mathrm{A}\prime, \mathrm{M}, \mathrm{C}} \mathrm{E}_{\mathrm{S}/\mathrm{S}_{-1}} \mathrm{U}\big(\mathrm{C}, \mathrm{H}(\mathrm{M}, \mathrm{S})\big)$$

$$+ \beta \mathrm{E}_{\mathrm{S}\prime, \mathrm{Y}\prime/\mathrm{S}, \mathrm{Y}} \mathrm{V}(\mathrm{Y}', \mathrm{S}', \mathrm{A}') \ldots \text{Stage 2: Consumption/Savings Decisions}$$

$$\text{s.t.} \quad \mathrm{C} + \sigma\mathrm{M} + \mathrm{A}' + \mathrm{R}(\sigma) = \mathrm{q}.\mathrm{A} + \mathrm{Y}$$

Every period, the optimal decision functions are arrived to by backward induction. The agent solves the Stage 2 problem for every possible insurance plan (σ). Then, given the decision functions from Stage 2, and based on the agent's expectation on the transition of health states, the insurance plan decision choice is made.

The households' decision functions are given by:

- Insurance Decision: $\sigma^* = \mathrm{D}_1(\mathrm{Y}, \mathrm{S}_{-1}, \mathrm{A})$

- Goods Consumption Decision: $C^* = D_2(Y, S, A, \sigma)$
- Medical Care Consumption Decision: $M^* = D_3(Y, S, A, \sigma)$
- Future Savings Decision: $A'^* = D_4(Y, S, A, \sigma)$

If an agent chooses not to be insured, that is represented with the following contract $(0,1)$ where the agent pays no premium and pays the full share for her medical care consumption.

1.3.2. Health Insurance Provider Problem

As discussed above, the insurance provider cannot condition premiums on agent's current income, health state, or savings. However, insurers can solve for the agent's decision rules and thus can form expectations over agents' Income, savings, and health states, to determine the premium, $R(\sigma)$, associated with a given cost share σ. The premium is determined such that the insurance provider's expected profit is zero.

$$R(\sigma) = E_{S,Y,A}(1 - \sigma)M(Y, S, \sigma, A)$$

1.3.3. Recursive Equilibrium

Having solved for the households and health insurance provider decision functions and pricing problems we can define the recursive equilibrium for the above economy as follows:

The recursive equilibrium will be given by set of prices q, R, value functions V, T, decision rules on $\sigma = D_1(Y, S_{-1}, A)$, $C = D_2(Y, S, A, \sigma), M = D_3(Y, S, A, \sigma), A' = D_4(Y, S, A, \sigma)$, and by stationary distribution of agents $\Omega(Y, S, A', \sigma)$such that:

1. Given prices, the Value functions V and T are the solution to the household's optimization problem and $\sigma = D_1(Y, S_{-1}, A)$, $C = D_2(Y, S, A, \sigma)$, $M = D_3(Y, S, A, \sigma)$, $A' = D_4(Y, S, A, \sigma)$ are the corresponding decision rules;
2. R satisfies health insurance providers zero profit condition
3. q is such that borrowing markets clears
4. Given the transition function $\chi(Y, S, A', \sigma)$ implied by the optimal decision rules and the stochastic processes for Y and S, the stationary distribution of agents Ω is given by:

$$\Omega(Y, S, A', \sigma) = \int \chi(Y, S, A', \sigma) d\Omega$$

Appendix I explains the algorithm used in computing to the above equilibrium.

1.4. Parameterization and Calibration

1.4.1. Parameterization

For the dynamics of the model (income and health processes), I use data from the Panel Study of Income Dynamics survey ("PSID"). PSID Data is commonly used for income dynamics. To keep the source of exogenous states consistent (in this case Income and Health), I use the PSID for the health state dynamics as well.

Income evolves according to a two state Markov process calibrated from PSID. For the income process, I use the following $Y_l = 0.75$ and $Y_h = 1.25$ where $\Pi_{l/l} =$

0.76 and $\Pi_{h/h} = 0.74$ as in Akyol (2004) which is calibrated for a one year period. Other calibrations have been used in the literature, for example Imroholuglu (1992) calibrates the income process for a six week period to be given by $Y_l = 0.25$ and $Y_h = 1$ where $\Pi_{(l/l)} = 0.9565$ and $\Pi_{(h/h)} = 0.5$.

I used the self-assessed health states of individuals from the PSID to construct the health state transition matrix of a three state Markov process (S_l , S_m, S_h) as follows:

- $\Pi_{l/l} = 0.66$ and $\Pi_{l/m} = 0.24$
- $\Pi_{m/l} = 0.14$ and $\Pi_{m/m} = 0.51$
- $\Pi_{h/l} = 0.03$ and $\Pi_{h/m} = 0.17$

I use the following functional form of the period utility: $U(C, H) = C^{1-\eta}/1 - \eta + \psi\, H(M, S)^{1-\eta}/1 - \eta$ where utility is separable in consumption of the non-durable good C and medical services M. The health production function is given by $H(M, S) = \zeta M - \Theta_S$ where Θ_S is dependent on health state (S).[5] This implies a health state dependent utility of the form: $U(C, M, S) = C^{1-\eta}/1 - \eta + \psi\, (\zeta M - \Theta_S)^{1-\eta}/1 - \eta$.

This functional form of the utility function assumes no second order interaction between non-durable goods consumption, health state, and medical care consumption. By choosing this functional form, I am sacrificing any second order interactions that may occur between non-durable consumption and medical care consumption for the benefit of a traceable equilibrium.

[5] Θ_S dependence on health state is the Type II uncertainty discussed in section 1.2 above

1.4.2. Calibration

Θ_S, ζ, and ψ are jointly calibrated such that the output of the model matches the out of pocket expenditure of agents by health state, total expenditure on health care as a percentage of GDP, and percentage of uninsured agent. Out of pocket expenditures by health state are calculated from the Medical Expenditure Panel Survey, The ratio of total expenditure on health care to GDP is calculated from the National Health Expenditure Survey. All of the targeted ratios were calculated as of 2007.

The results of the calibration were as follows

Parameter	Description	Value
Θ_1	Health production function constant , Bad Health	0.79
Θ_2	Health production function constant , Medium Health	-0.41
Θ_3	Health production function constant , Good Health	-0.81
ξ	Health production function medical consumption coefficient[6]	7.94
ψ	Weight of utility derived from health generated by medical consumption	9.68

Table 1: Results of Calibration

For the discount factor β, I use a value of 0.96 for a one year period.

[6] In Section 1.6.2, I test the sensitivity of my results when this parameter is perturbed.

1.5. Results

In this section, I present the results of the computation of the recursive equilibrium. In specific, the dynamics of agent's choices on medical consumption and insurance are discussed in detail.

1.5.1. Medical services consumption

Figure 1 below plots an agent's medical services consumption as a function of savings for agents with low and high levels of income. The plot shows that two agents with the same health state and wealth will differ in their consumption of medical services based on the level of their current income. The agent with higher income will consume more of the medical good. In addition, it is no surprise that medical consumption is increasing in wealth.

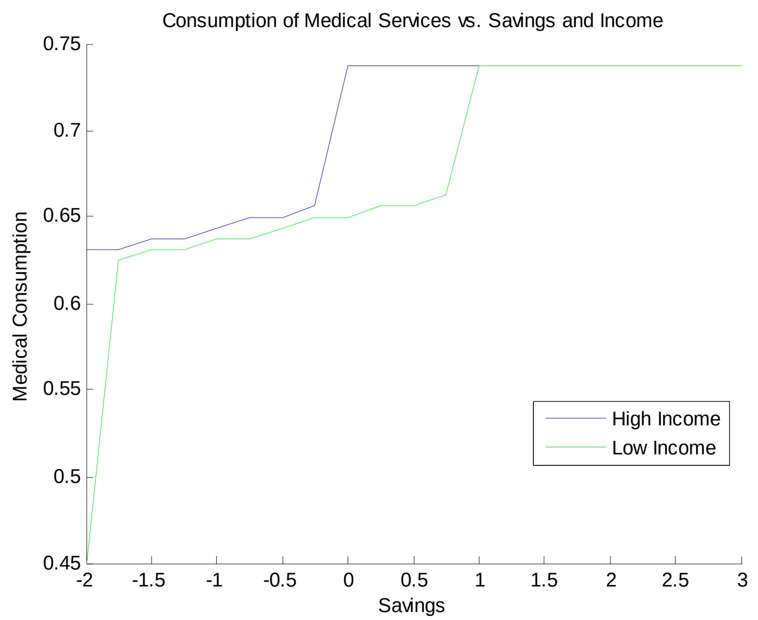

Figure 1: Medical services consumption as a function of savings and income

Figure 2 shows an agent's medical consumption as a function of savings for healthy and unhealthy agents. The plot shows that two agents with the same income level and wealth will differ in their consumption of the medical healthcare good based on their health state. The healthy agent will consume less of the medical good than the unhealthy one.

The fact that medical consumption is increasing in wealth level and income level is not surprising, this result is expected given the construction of the utility function in the model where agent's utility is increasing in consumption of the medical good. Consumption of the medical good being decreasing in the health level is an output of the model independent of the modeling choices per se. This intuitive result should be expected after examining the result of the calibration exercise to determine Θ_S.

Specifically since Θ_S is decreasing in health level, which means that a healthy agent consuming an amount x of the health good will receive a higher level of health services $H(x, 3)$ than an unhealthy agent who will receive $H(x, 1)$.

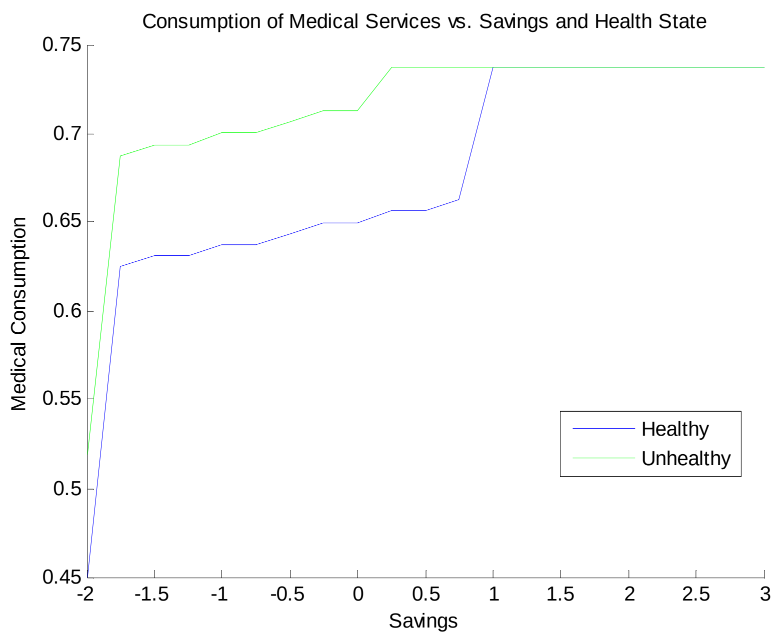

Figure 2: Medical services consumption as a function of savings and health

1.5.2. Insurance Choice

Figure 3 below plots an agent’s insurance choice as a function of savings for agents with low and high levels of income. The plot shows that two agents with the same health state and wealth level will differ in their choice of insurance based on the level of their current income. The agent with high income will decide to purchase insurance at a lower wealth level than agents with low income.

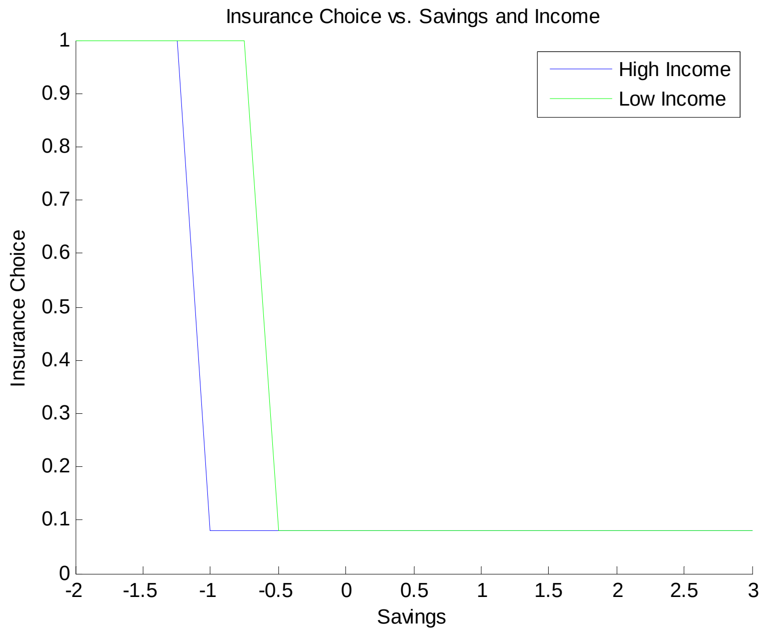

Figure 3: Insurance choice as a function of savings and income

Figure 4 shows an agent's insurance choice as a function of savings for healthy and unhealthy agents. The plot shows that two agents with the same income level and wealth will differ in their insurance decision based on their health state. An agent who has been unhealthy in the previous period will choose to buy insurance at a lower wealth level compared to an agent who was healthy in the previous period.

The above described dynamics of insurance choice with respect to wealth, savings, and health match the dynamics of medical care demand. Agents consuming more of the medical good when their wealth or savings increase or when their health deteriorates are expected to purchase more insurance as well.

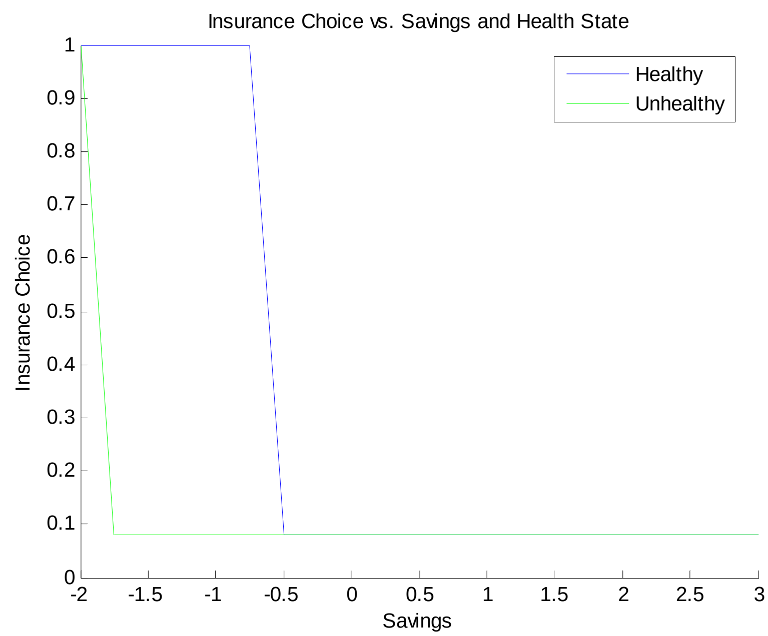

Figure 4: Insurance choice as a function of savings and health

1.6. Policy Evaluation

1.6.1. Subsidizing Insurance

In this section I study the effect of subsidizing the cost of insurance for uninsured agents. For this purpose I introduce a government into the economy that taxes insured agents to collect funds that it uses to subsidize insurance policies for uninsured agents. The government is assumed to run a balanced budget. The level of subsidized insurance (i.e. the cost share that previously uninsured agents will have to pay once their insurance is subsidized) could vary, and some of the results in this section depend on this parameter. I model the tax on insured agents as a tax on insurance premiums that agents have to pay in order to obtain insurance.[7]

The tax and subsequent subsidy affect the insurance choice decision of self-insured agents as well as the consumption and saving decisions of both self-insured and uninsured agents. In assessing the effect of the subsidy, I re-compute the equilibrium described in section 3.3 above such that self-insured agents remain insured[8] and uninsured agents receive subsidized insurance from the government. This constraint follows from the fact that for the government to properly implement the subsidy, it is necessary that agents who would normally purchase insurance (i.e., self-insured agents) are not allowed to go uninsured in order to benefit from the subsidy. All other decisions are re-computed at equilibrium.

Welfare in the economy decreases regardless of the level of subsidized insurance.[9] The subsidy affects the welfare of self-insured and uninsured agents differently. The welfare of self-insured agents will decrease due to the increase in premiums which reduces the agent's disposable income available for savings and consumption (of both non-durable and health goods). Uninsured agents will experience an increase in welfare due to the lower cost they face in consuming the medical services.[10] This overall

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[7] How this tax is levied shouldn't affect the results arrived to in this section. Taxing insurance premiums is a tractable approach to ensure that only insured agents are paying the tax subsidy.

[8] The level of insurance is allowed to vary just as in the baseline equilibrium case.

[9] I use the sum of utility of all agents at equilibrium as the measure of welfare.

[10] Due to the moral hazard effect of insurance and keeping income, health state, and savings constant previously uninsured agents will consume more medical services now that they are insured.

reduction in welfare is partly due to the fact that the majority of agents in this economy, about 85 percent, are self-insured.[11]

Given that part of the debate around the healthcare system is controlling the systemic increase in cost of healthcare over the past two decades, it is insightful to test the effect of the subsidy on the overall demand for medical care in the economy. As described above, the effect of the subsidy is a decrease in the amount of medical care consumed by self-insured agents and an increase in the amount of medical care consumed by previously uninsured agents. The relative strength of these two effects determines the overall response of total medical care demand in the economy. In turn, the strength of these two responses is a direct consequence of the level of cost share of the subsidized insurance plan. A low level of subsidized cost share means higher taxes on the self-insured and thus a larger decrease in consumption of medical care by this group while on the flip side, a low level of subsidized cost share also means a stronger moral hazard effect for the uninsured and thus a larger increase in the demand of this group.

1.6.2. Demand Response to Price Change

We can use the above framework to analyze the contract choice effect on demand of Medical Care. This effect was first analyzed by Dusansky and Koc (2006) where they derived conditions affecting price elasticity of medical care demand for a single agent with stochastic health state. The setup in this paper allows us to analyze the contract

[11] Of course, subsidizing health insurance for the poor, or any other measure with a similar goal of helping low income agents gain access to medical care is associated with a social responsibility that is difficult to measure in terms of utility functions and welfare measures.

choice effect on an economy wide basis. In addition, given that this paper actually computes insurance choice decisions based on a finite set of insurance contracts, switching over contracts may not be possible (for example an agent that is already choosing the insurance contract with the lowest cost share available). So some agents may not exhibit a change in their insurance choice as a response to a price change.

The above economy shows a positive elasticity of 0.095 for medical care demand. As described in Dusansky and Koc, a positive elasticity of medical care demand is possible when insurance demand is elastic.[12] I calculate an elasticity of 1.114 for Insurance demand.[13] As Dusansky and Koc note, Feldstein's (1971) estimates a statistically significant insurance demand elasticity of 1.2 when analyzing changes in prices of hospital care.

The dynamics leading to such a result are explained in detail in Dusansky and Koc (2006) but are worth repeating briefly here. When the price of medical care changes agents respond not only by changing their demand (the neo-classical response) but by adjusting their insurance choices as well. An agent's response to an increase in the price of medical care when insurance choice is kept constant is the neo-classical decrease in demand. Contract choice effect arises when an agent is allowed to adjust her choice of insurance contract. Dusansky and Koc show that a necessary condition for medical care being elastic is that the contract choice effect be positive and strong. That is an agent decreases her cost share (purchases "more" insurance) as a response to an increase in

12 Equation 7 in Dusansky and Koc (2006)

13 A sensitivity analysis was performed on the resultant elasticity due to changing ζ , the health production function medical consumption coefficient. Using a ζ of 8.84 instead of 7.94 which is a change of 10 percent will yield a medical demand elasticity of 0.14 and an insurance demand elasticity of 1.5.

price, the more generous insurance plan allows her to purchase more medical care which offsets the effect of the neo-classical response. An aspect not explicitly discussed by Dusansky and Koc is that insurance premiums also change in response to a change in the price of medical care. An increase in price will lead to an increase in premiums. The positive elasticity of 0.095 reported here takes this effect into consideration. Thus agents choose to increase their demand for insurance despite the increase in premiums observed when medical care prices increase.

It is worth noting here that the response of insurance demand when premiums increase due to an increase in the price of medical care (an increase in insurance demand in this case) is different from the response of insurance demand when premiums increase with medical care prices being constant (such as when a tax levied on insurance premiums as in section 6.1 above). In the latter case, demand for insurance is decreasing in premiums.

1.7. Conclusion

I describe and compute a dynamic equilibrium model of insurance choice, medical care consumption, non-durable goods consumption, and savings to estimate the effect of suggested medical care reform. One of these reforms is subsidizing medical care insurance for uninsured agents. Such a policy shows a decrease in the total welfare of the economy. The effect on medical care demand as a whole, which is essential in terms of effect of this policy on cost of medical care depends on the level of subsidized insurance.

In addition the computed economy displays a positive elasticity of medical care demand as a response to price change of medical care.

Chapter 2: Insurance Regime and Price Formation

2.1. Introduction

I investigate the effect of the price setting process under managed health care plans, such as HMOs and PPOs, on prices, profits of insurance companies and medical care providers, and household's welfare compared to the indemnity plans prevalent before the advent of managed care. I construct a simple game played between a representative insurance company and a medical care provider to determine the price of medical care paid by insured and uninsured households. In addition, insurance companies set premiums not through solving the usual principal-agent problem which forces a zero profit condition, but rather and more realistically by optimizing profits. The outcome of this game is compared to the outcome of the indemnity plans where no price negotiations would occur.[14]

2.2. Environment

I build a one period economy populated by consumers, a medical insurance company, and a medical care provider that interact to determine demand, supply, and price(s) of medical care.

2.2.1. Consumers

Consumers in this economy differ by their level of income. A consumer can be a "high" type with income (w_H) or a "low" type with income (w_L). Whether a consumer is

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[14] Under indemnity plans, insurance companies paid a percentage share of the Usual, Customary and Reasonable "UCR" price. The UCR price was determined as the price charged by a certain percentage of care providers.

high or low type is private information unavailable to the medical insurance company or to the medical care provider.

Consumers solve a single period two-stage planning problem. In the first stage, a consumer knows her income type but not her health state and makes a choice on her insurance plan. In the second stage, after the health state is revealed, she decides on the consumption of the non-durable and medical care goods.[15] I restrict the choice of insurance plan to whether the consumer purchases insurance or chooses to be uninsured. This assumption will not affect the results of this paper, since my conclusions are independent of the specifics of the insurance contract purchased. Thus going forward, an insured agent is assumed to purchase a representative insurance contract $(\mathrm{R}(\sigma), \sigma)$. (R) is the premium and (σ) is the share of medical expenses paid by the insured consumer.

Consumers get sick with probability (γ). If a consumer is sick, she gets utility from consumption of medical care (Q) in the second stage of the period. A healthy consumer gets no utility out of consumption of medical care and thus will demand zero (Q).[16] In addition, all consumers get utility from consumption of a non-durable good (C). If we let (S) denote the agent's health state with a value of 1 when agent is sick, then an agent's second stage utility is given by:

$$\mathrm{U}(\mathrm{C}, \mathrm{Q}) = \mathrm{Z}(\mathrm{C}) + (\mathrm{S} = 1). \mathrm{A}. \mathrm{V}(\mathrm{Q})$$

[15] This set up of the one period two stage problem is similar to the setup used by Dusansky and Koc (2006).

[16] This simplifying assumption is both factual and non restrictive. The results of this paper should apply if we assume agents demand a certain level of medical care when healthy.

In the above, I have assumed utility to be separable in the consumption of non-durable and medical care goods. This simplification allows for a more traceable analysis at the expense of not capturing second order interactions between non-durables consumption and medical care consumption. (A) is a positive constant that represents the weight of utility derived from medical care in the agent's overall utility. Both $Z(\cdot)$ and $V(\cdot)$ are assumed to be continuous, bounded and concave. Since consumers in this economy live for only one period, they will exhaust all of their income on consumption.

The consumer's second stage budget constraint will depend on the type, health state, as well as the insurance choice from stage 1 and given as follows.

$$w_{H/L} - (S = 1).\left(P_{UI}Q_{UI,H/L}\right) - C_{UI,H/L} = 0 \qquad \text{Uninsured}$$

$$w_{H/L} - R - (S = 1).\left(\sigma P_I Q_{I,H/L}\right) - C_{I,H/L} = 0, \qquad \text{Insured}$$

Where:

w_H and w_L denote the income for high and low types respectively;

$C_{I,H}$ and $C_{I,L}$ denote the consumption of the non-durable good by insured high and low types respectively;

$C_{UI,H}$ and $C_{UI,L}$ denote the consumption of the non-durable good by uninsured high and low types respectively;

$Q_{I,H}$ and $Q_{I,L}$ denote the consumption of medical care by insured high and low types respectively;

$Q_{UI,H}$ and $Q_{UI,L}$ denote the demand for medical care by uninsured high and low types respectively;

P_{UI} is the price of medical care faced by uninsured agents;

P_I is the price of medical care faced by insured agents;

In the above, I allow for the medical care price faced by the consumer to be different for insured and uninsured consumers to account for the characteristics of managed health care. These prices are known to all consumers at the beginning of the period.

We can now solve for the consumer's decision functions in the different states of stage 2. A high type insured consumer's demand of medical care $Q_{I,H}$ solves the problem

$$\text{Max } U(C, Q) = Z(C) + (S = 1). A. V(Q)$$

$$\text{s.t. } w_H - R - (S = 1). \sigma P_I Q - C = 0$$

Thus medical care demand in this case is a function of income after payment of insurance contract and price of medical care and expressed as $Q_{I,H}(w_H - R, \sigma P_I)$. The demand for medical care is zero is agent is healthy (i.e. S = 0). Similarly a medical care demand for a low type insured $Q_{I,L}$ agent is given by $Q_{I,L}(w_L - R, \sigma P_I)$.

A high type uninsured consumer's demand for medical care $Q_{UI,H}$ solves the problem

$$\text{Max } U(C, Q) = Z(C) + (S = 1). A. V(Q)$$

$$\text{s.t. } w_H - (S = 1). P_{UI} Q - C = 0$$

Thus medical care demand in this case is a function of income and price of medical care and expressed as $Q_{UI,H}(w_H, P_{UI})$. Similarly, medical care demand for a low type uninsured consumer is given by $Q_{UI,L}(w_L, P_{UI})$.

Given the utility functions and budget constraints it is straight forward to show that all individual demand functions are increasing in residual wealth and decreasing in price of medical care.

A high type consumer will purchase the representative insurance contract $(\mathrm{R}(\sigma), \sigma)$ if being insured will lead to a higher expected utility than being uninsured, i.e. if $\mathrm{EU}_{\mathrm{IH}} \geq \mathrm{EU}_{\mathrm{UH}}$and similarly a low type consumer will purchase insurance if $\mathrm{EU}_{\mathrm{IL}} \geq \mathrm{EU}_{\mathrm{UL}}$. Where we can express the expected utilities as follows:

$$\mathrm{EU}_{\mathrm{I,H}} = (\gamma).\,\mathrm{U}\big(\mathrm{C}_{\mathrm{I,H,S=1}}, \mathrm{Q}_{\mathrm{I,H}}\big) + (1-\gamma).\,\mathrm{U}\big(\mathrm{C}_{\mathrm{I,H,S=0}}, 0\big) \cdots\cdots\cdots (1)$$

$$\mathrm{EU}_{\mathrm{UI,H}} = (\gamma).\,\mathrm{U}\big(\mathrm{C}_{\mathrm{UI,H,S=1}}, \mathrm{Q}_{\mathrm{UI,H}}\big) + (1-\gamma).\,\mathrm{U}\big(\mathrm{C}_{\mathrm{UI,H,S=0}}, 0\big) \cdots\cdots\cdots (2)$$

$$\mathrm{EU}_{\mathrm{I,L}} = (\gamma).\,\mathrm{U}\big(\mathrm{C}_{\mathrm{I,L,S=1}}, \mathrm{Q}_{\mathrm{I,L}}\big) + (1-\gamma).\,\mathrm{U}\big(\mathrm{C}_{\mathrm{I,L,S=0}}, 0\big) \cdots\cdots\cdots (3)$$

$$\mathrm{EU}_{\mathrm{UI,L}} = (\gamma).\,\mathrm{U}\big(\mathrm{C}_{\mathrm{UI,L,S=1}}, \mathrm{Q}_{\mathrm{UI,L}}\big) + (1-\gamma).\,\mathrm{U}\big(\mathrm{C}_{\mathrm{UI,L,S=0}}, 0\big) \cdots\cdots\cdots (4)$$

2.2.2. Medical Care Provider

The medical care provider in this economy maximizes his profit (π_{MP}) by setting prices for providing medical care for consumers. Thus price of medical care solves the general problem

$$\mathrm{Max}\,_{\mathrm{P}}\pi_{\mathrm{MP}} = \gamma\{\mathrm{PQ} - \psi(\mathrm{Q})\}$$

Where $\psi(\cdot)$ is the medical provider's cost function and γ is the probability of agents getting sick. The specifics of determining the provider's profit function and thus the prices of medical care will differ depending on the insurance regime being considered. I solve for the care provider's problem in detail after specifying the different insurance regimes in section 2.2 below.

2.2.3. Insurance Provider

Insurance provider offers the consumer a representative insurance contract (R, σ) discussed above where (R) is the premium and (σ) is the share of medical expenses paid by the insured.

The insurance provider is a profit maximizing entity where for a given cost share (σ), premium $R(\sigma)$ is determined such that profit $\Pi_{\mathrm{IP}} = \mathrm{R} - \gamma.(1-\sigma).P_I Q$ is maximized.

2.3. Insurance Regimes and Equilibrium

I solve the above economy for both the indemnity and managed care regimes and compare the outcomes in terms of prices, profitability of insurance and care providers and consumers' welfare.

Under an indemnity plan, Insurance companies pay $(1-\sigma)$ of price of medical care set by medical care providers without negotiating a price for the insured. That is there is a single price (P) for medical care that the provider receives in return for its services.

Under managed care, Insurance companies offer care providers what amounts to a take it or leave price $\mathrm{P_I}$ when serving an insured patient. The patient pays her cost share, σ, of said price while insurance pays the remainder. In addition, doctors are free to set their price for providing services to uninsured agents $\mathrm{P_{UI}}$.

I solve for a separating equilibrium in this economy where the insurance provider sets prices such that in equilibrium all high type agents are insured and all low type agents are uninsured. In 2004 two-thirds of the uninsured in the U.S. were low-income individuals or came from low-income families.[17] A separating equilibrium where low type agents are uninsured will capture this fact. In addition, uninsured agents face prices that are different from insured agents, and a separating equilibrium also allows for this fact in the model.

2.3.1. Indemnity

A separating equilibrium in the indemnity regime is given by price for medical care P, a representative insurance contract (R, σ), and demand for medical care (Q_I, Q_{UI}) where:

- Taking prices as given, high type consumers are insured while low type consumers are uninsured;
- Taking prices as given, agents demand $Q_{I,H}, Q_{UI,L}$ of medical care to maximize their utility;
- Insurance provider decides R for the representative insurance plan; and
- Medical Care provider decides P.

Under the separating equilibrium described above, high type consumers will purchase insurance and demand $Q_{I,H}(w_H - R, \sigma P)$ in medical care in stage 2 while low type consumers will be uninsured and demand $Q_{UI,L}(w_L, P)$ in stage 2.

[17] The Kaiser Commission on Medicaid and the Uninsured 2006 Report.

$Q_{I,H}(\cdot,\cdot)$ and $Q_{UI,L}(\cdot,\cdot)$ have the characteristics described in section 1 above , that is both functions are increasing in income , decreasing in premium (applicable only for insured agent's demand) , and decreasing in price of medical care.

The care provider sets price P to maximize its profit, thus P is the solution to the following problem

$$\mathrm{Max}_P\, \pi_{MP-Indemnity} = \mathrm{Max}_P \gamma. \{P_{Indemnity}(\tau Q_{I,H} + (1-\tau)Q_{UI,L}) - \psi(\tau Q_{I,H} + (1-\tau)Q_{UI,L})\}$$

$\psi(\cdot)$ is the medical care provider's cost function and τ is the proportion of high type agents in the economy. Where I assume that the cost function is such that $\psi(\tau Q_{I,H} + (1-\tau)Q_{UI,L}) = \tau\emptyset(Q_{I,H}) + (1-\tau)\emptyset(Q_{UI,L})$.[18]

Now the provider's problem is given by:

$$\mathrm{Max}_P \gamma. \tau\left(P_{Indemnity}Q_{I,H} - \emptyset(Q_{I,H})\right) + \gamma. (1-\tau)\left(P_{Indemnity}Q_{UI,L} - \emptyset(Q_{UI,L})\right)$$

Where in the above, $\gamma. \tau\left(P_{Indemnity}Q_{I,H} - \emptyset(Q_{I,H})\right)$ is the provider's profit from insured patients, while $\gamma. (1-\tau)\left(P_{Indemnity}Q_{UI,L} - \emptyset(Q_{UI,L})\right)$ is the providers profit from uninsured patients. The first order condition (F.O.C.) for the medical care provider is given by:

[18] This assumption is reasonable for medical procedures that don't considerably vary across individuals.

$$\left(Q_{I,H} + P_{Indemnity}\frac{\partial Q_{I,H}}{\partial P_{Indemnity}} - \frac{\partial \emptyset}{\partial Q_{I,H}}\frac{\partial Q_{I,H}}{\partial P_{Indemnity}}\right)$$

$$+ (1-\tau)\left(Q_{I,H} + P_{Indemnity}\frac{\partial Q_{UI,L}}{\partial P_{Indemnity}} - \frac{\partial \emptyset}{\partial Q_{UI,L}}\frac{\partial Q_{UI,L}}{\partial P_{Indemnity}}\right)$$

$$= 0 \quad \cdots\cdots\cdots (5)$$

The insurance provider takes the price $(P_{Indemnity})$ set by the medical provider as given and determines premium $R_{Indemnity}$ to maximize profits $\Pi_{IP-Indemnity}$ by solving

$$\mathrm{Max}_R\ \Pi_{IP-Indemnity}$$

$$\text{s.t.}\ EU_{IH-Indemnity} \geq EU_{UH-Indemnity} \ \cdots\cdots\cdots (IC-1)$$

$$EU_{UIL-Indemnity} \geq EU_{IL-Indemnity} \cdots\cdots\cdots (IC-2)$$

$(IC-1)$ is the incentive compatibility constraint for the high types stating that insurance provider will set premium $R_{Indemnity}$ such that high types will always choose to be insured. Similarly, equation $(IC-2)$ is the incentive compatibility constraint for the low types stating that premium $R_{Indemnity}$ is such that low types will always choose to be uninsured. I assume that the incentive compatibility for the low type is satisfied by the selection of a low enough w_L as income for the low type consumer. Thus moving forward, I drop $IC-2$ from the solution describing the separating equilibrium.

We can re-write the insurance problem as follows:

$$\mathrm{Max}_R\ R_{Indemnity} - \gamma\, Q_{I,H}.(1-\sigma)(P_{Indemnity})$$

$$\text{s.t.}\ (\gamma).U(C_{I,H,S=1}, Q_{I,H}) + (1-\gamma).U(C_{I,H,S=0}, 0)$$

$$\geq (\gamma).U(C_{UI,H,S=1}, Q_{UI,H}) + (1-\gamma).U(C_{UI,H,S=0}, 0) \cdots (IC-1)$$

Where I substituted for $\mathrm{EU_{IH}}$& $\mathrm{EU_{UH}}$ from equations (1) & (2) above.

Proposition 1: *Under an indemnity regime, insurance premium $R_{Indemnity}$ is such that the expected utility of an insured agent is equal to the expected utility of an uninsured agent*

$$EU_{IH-Indemnity} = EU_{UH-Indemnity} \cdots\cdots\cdots (6)$$

Proof*: Appendix II*

$\mathrm{IC}-1$ is binding because the insurance provider's profit is increasing in the premium $\mathrm{R_{Indemnity}}$, the left hand side of $\mathrm{IC}-1$ is decreasing in R while the right hand side of $\mathrm{IC}-1$ is independent of $\mathrm{R_{Indemnity}}$. Remembering that the insurance provider in this economy is a profit maximizing entity, this result makes sense allowing the insurance provider to extract as much premium as possible from the insured.

2.3.2. Managed Care

A separating equilibrium in the managed care regime is given by prices for medical care $\mathrm{P_{I-MC}}$,$\mathrm{P_{UI-MC}}$, representative insurance contract $(\mathrm{R_{MC}}, \sigma)$, and demand for medical care $(\mathrm{Q_I}, \mathrm{Q_{UI}})$ where:

- Taking prices as given, high type consumers are insured while low type agents are uninsured;
- Taking prices as given, consumers demand $\mathrm{Q_{I,H}}, \mathrm{Q_{UI,L}}$ of medical care to maximize their utility;
- Insurance provider decides on $\mathrm{R_{MC}}$ and $\mathrm{P_{I-MC}}$ to maximize profits $\Pi_{\mathrm{IP-MC}}$; and

- Medical Care provider decides P_{UI-MC} to maximize $\Pi_{MP-uninsured}$

Under the separating equilibrium described above, high type consumers will purchase insurance and demand $Q_{I,H}(w_H - R_{MC}, \sigma P_{I-MC})$ in medical care in stage 2 while low type consumers will be uninsured and demand $Q_{UI,L}(w_L, P_{UI-MC})$ in stage 2.

$Q_{I,H}(\cdot,\cdot)$ and $Q_{UI,L}(\cdot,\cdot)$ have the characteristics described in section 1 above , that is increasing in income, decreasing in premium (applicable only for insured agent's demand), and decreasing in price of medical care.

Care providers set price of medical services for uninsured consumers to maximize profit $\Pi_{MP-uninsured}$. That is P_{UI-MC} is the solution to

$$\mathrm{Max}_{(P_{UI-MC})}\Pi_{MP-uninsured} = \mathrm{Max}_{(P_{UI-MC})}\gamma\,(1-\tau)\left(P_{UI-MC}.\,Q_{UI,L} - \emptyset\left(Q_{UI,L}\right)\right)$$

The F.O.C. of the care provider's problem is given by

$$(1-\tau)\left(Q_{UI,L} + P_{UI-MC}\frac{\partial Q_{UI,L}}{\partial P_{UI-MC}} - \frac{\partial \emptyset}{\partial Q_{UI,L}}\frac{\partial Q_{UI,L}}{\partial P_{UI-MC}}\right) = 0 \quad \cdots\cdots\cdots (7)$$

Note here that the care provider does not set the price for insured customers, P_{I-MC}, as that is set by the insurance provider. I assume that if P_{I-MC} is such that the care provider is indifferent between providing and not providing services, the care provider will choose to provide said services.

As in the indemnity case, insurance provider maximizes profits Π_{IP-MC} . However, under managed care, in addition to setting the premiums paid by insured consumers for the insurance contract (R_{MC}, σ) , the insurance provider sets the price received by medical providers P_{I-MC} for services provided to insured agents.

The insurance provider's problem is given by

$$\mathrm{Max}_{R_{MC}}\,\Pi_{IP-MC}$$

$$\mathrm{s.t.}\,EU_{IH-MC} \geq EU_{UH-MC} \;\cdots\cdots\cdots (IC-3)$$

$$EU_{UIL-MC} \geq EU_{IL-MC} \qquad \cdots\cdots\cdots (IC-4)$$

$$\Pi_{MP-insured} \geq 0 \quad \cdots\cdots\cdots (IC-5)$$

$IC-3$ and $IC-4$ are similar conditions to $IC-1$ and $IC-2$ in the case of indemnity insuring that high type customers will choose to purchase insurance while low type customers will choose to be uninsured. As in the indemnity case, I assume that $IC-4$ is satisfied by choice of w_L and is dropped from the description of the equilibrium.

$IC-5$ is unique to the managed care scenario and it states that the medical care provider will have non-negative profits from serving insured customers. This condition is needed to insure the care provider's participation in the managed care system. Incentive compatibility constraints under managed care are constraints on the pair of prices determined by the insurance provider (P_{I-MC}, R_{MC}) which adds complexity to determining the outcome of the equilibrium.

Using the definition of the care provider's profit form insured agents as well as equations (1) & (2), we can re-write the insurance providers problem as follows:

$$\mathrm{Max}_{R_{MC},P_{I-MC}}\,\Pi_{IP-MC} = \mathrm{Max}_{R_{MC},P_{I-MC}}\,R_{MC} - \gamma\,Q_{I-MC}\,(1-\sigma)(P_{I-MC}).$$

$$\mathrm{s.t.}\,(\gamma).\,U\big(C_{I,H,S=1}, Q_{I,H}\big) + (1-\gamma).\,U\big(C_{I,H,S=0}, 0\big)$$

$$\geq (\gamma).\,U\big(C_{UI,H,S=1}, Q_{UI,H}\big) + (1-\gamma).\,U\big(C_{UI,H,S=0}, 0\big) \cdots (IC-3)$$

and

$$(\tau)\left(\mathrm{P}_{\mathrm{I-MC}}\mathrm{Q}_{\mathrm{I,H}} - \emptyset\left(\mathrm{Q}_{\mathrm{I,H}}\right)\right) \geq 0 \cdots (\mathrm{IC}-5)$$

Proposition 2: *$IC-3$ is binding if demand is elastic or if demand is inelastic and $P_{I-MC}$is larger than marginal cost. i.e.*

$$EU_{IH-MC} = EU_{UH-MC} \cdots\cdots\cdots (8)$$

$$if\ \varepsilon_{Q,P} < -1 \ \cdots\cdots\cdots Condition\ (1)$$

$$Or\ if\ \varepsilon_{Q,P1} \geq -1\ \&\ P_{I-MC} < \frac{\partial\emptyset}{\partial Q} \cdots\cdots\cdots Condition\ (2)$$

Proof: *Appendix II*

2.4. Comparison of Regimes

In comparing the Indemnity and Managed Care regimes, and under the separating equilibrium, the percentage of insured and uninsured customers is the same regardless of the regime given that it is controlled by the percentage of low and high type consumers in the economy. Also, the comparisons have to be made for the same cost share in the insurance contract.

2.4.1. Medical care prices

Proposition 3: *Under Managed Care, uninsured agents pay more for medical care, $P_{UI-MC} \geq P_{UI-Indemnity}$, when compared to the Indemnity regime if the elasticity of demand is such that* $\varepsilon_{\mathrm{Q,P}} \leq \left(\frac{\partial\emptyset}{\partial Q_{I,H}}\frac{\partial Q_{I,H}}{\partial P_{I-MC}}\right) - 1 \ldots.(condition\ 3)$

***Proof**: Appendix II*

Since $\left(\frac{\partial\emptyset}{\partial Q_{I,H}}\frac{\partial Q_{I,H}}{\partial P_{I-MC}}\right) < 0$ Proposition 3 states that for $P_{UI-MC} \geq P_{UI-Indemnity}$ to hold, demand for medical care needs to be highly elastic. If condition 3 does not hold, uninsured agents pay less under managed care than under indemnity.

2.4.2. Agents' welfare

It is easy to see that condition 2 and condition 3 cannot be satisfied at the same time, while condition 3 holding implies that condition 1 holds as well.

Proposition 4: *If condition 3 holds, welfare declines for both insured and uninsured agents under the Managed Care regime when compared to the Indemnity regime. Alternatively if condition 2 holds welfare under managed care is larger than welfare under indemnity for insured and uninsured agents.*

Proof:

If condition 3 holds then the following is true:

1- Under the Indemnity regime, IC-1 binds and equation 6 states that $EU_{IH-Indemnity} = EU_{UH-Indemnity}$. Note here that equation 6 is satisfied regardless of condition 3 holding.

2- Under the Managed care regime, IC-3 binds and equation 8 states that $EU_{IH-MC} = EU_{UH-MC}$

3- Price paid by uninsured agents under managed care is greater than or equal to the price paid by agents under indemnity, i.e. $P_{UI-MC} \geq P_{UI-Indemnity}$

Using equation 2, the off equilibrium path expected utility of high type uninsured agents is given by:

$$\mathrm{EU}_{\mathrm{UI,H}} = (\gamma).\,\mathrm{U}\left(\mathrm{C}_{\mathrm{UI,H,S=1}}, \mathrm{Q}_{\mathrm{UI,H}}\right) + (1-\gamma).\,\mathrm{U}\left(\mathrm{C}_{\mathrm{UI,H,S=0}}, 0\right) \cdots\cdots\cdots (2)$$

Equation 2 is independent of the insurance premium and dependant on only the price paid for medical care by the uninsured agent P_{UI}. It is straightforward to prove that $\frac{\partial \mathrm{EU}_{\mathrm{UI,H}}}{\partial \mathrm{P}_{\mathrm{UI}}}$ is negative and since $\mathrm{P}_{\mathrm{UI-MC}} \geq \mathrm{P}_{\mathrm{UI-Indemnity}}$ we get that

$$\mathrm{EU}_{\mathrm{UH-MC}} \leq \mathrm{EU}_{\mathrm{UH-Indemnity}} \cdots\cdots\cdots (9)$$

That is the off the equilibrium path expected utility of uninsured high types is lower under managed care than under indemnity. However, since IC-1 and IC-3 bind as stated above, we get that

$$\mathrm{EU}_{\mathrm{IH-MC}} \leq \mathrm{EU}_{\mathrm{IH-Indemnity}} \cdots\cdots\cdots (10)$$

That is the expected utility of insured agents is lower under managed care than under indemnity.

If on the other hand Condition 2 holds, it is easy to show in the same manner as above that:

$$\mathrm{EU}_{\mathrm{IH-MC}} \geq \mathrm{EU}_{\mathrm{IH-Indemnity}} \cdots\cdots\cdots (11)$$

As for uninsured agents in equilibrium, their expected utility is given by equation 4 as

$$\mathrm{EU}_{\mathrm{UI,L}} = (\gamma).\,\mathrm{U}\left(\mathrm{C}_{\mathrm{UI,L,S=1}}, \mathrm{Q}_{\mathrm{UI,L}}\right) + (1-\gamma).\,\mathrm{U}\left(\mathrm{C}_{\mathrm{UI,L,S=0}}, 0\right)$$

It is straightforward to show that $\frac{\partial \mathrm{EU}_{\mathrm{UI,L}}}{\partial \mathrm{P}_{\mathrm{uninsured}}}$ is negative and given that

$P_{UI-MC} \geq P_{UI-Indemnity}$ under condition 3 it is straightforward to show that

$$\mathrm{EU}_{\mathrm{UL-MC}} \leq \mathrm{EU}_{\mathrm{UL-Indemnity}} \cdots\cdots\cdots (12)$$

and given that $P_{UI-MC} \leq P_{UI-Indemnity}$ under condition 2 we will have,

$$\mathrm{EU}_{\mathrm{UL-MC}} \geq \mathrm{EU}_{\mathrm{UL-Indemnity}} \cdots\cdots\cdots (13) \blacksquare$$

Most research indicates that demand for medical care is inelastic which falls under the requirements of Condition 2. Even though we cannot show that Condition 2 holds without investigation of the care provider's cost function, the fact that demand for medical care is inelastic excludes Condition 3 from holding which would steer us away from concluding that managed care reduces consumer's welfare. On the other hand, if it is the case that demand for a specific type of medical care is elastic, say preventive care, that would lead us to conclude that for these specific services, the managed care regime reduces the agent's welfare.

Also, we can show that under managed care the profit of the care provider is reduced since the insurance provider holds more bargaining power by setting the price paid by insured agents. Indeed, Appendix II shows that when demand for medical care is inelastic, the insurance provider's profit function is inversely related to the price of medical services, and as thus the insurance provider is incentivized to reduce the price it offers medical care providers. In fact when demand for medical care in inelastic IC-5 will always bind and thus the care provider will not earn any profits from serving insured agents. Even though this paragraph states that the insurance provider is getting more profit under Managed Care than under Indemnity, it does not mean that the premiums are necessary higher under managed care. The proper way to interpret the insurance provider's increased profit is that under Managed Care, the price pair (R_{MC}, P_{I-MC}) is such that the insurance provider profit is larger than that under indemnity.

A full list of the outcomes based on the interaction between the elasticity of medical care demand and the provider's cost function is in table A1 in Appendix II.

2.5. Conclusion

In this chapter, I construct a three agent economy where the prices of medical care and insurance are set in equilibrium. I assume a separating equilibrium where high type agents are insured while low type agents are not. Without assuming specific functional forms for utilities, profit, and cost functions, I derive conditions to compare the indemnity and managed care insurance regimes. Under my framework above, it seems to be the case that for inelastic medical services, managed care provides a welfare benefit for the agents and distributes welfare away from care providers.

Chapter 3: Effect of Housing Tax Regime on Mortgage Default Rates

3.1. Introduction

The subprime mortgage crisis, indications of which could have been detected as early as 2007, put the U.S. economy into the worst recession since the Great Depression and caused a domino effect that threatened to bring down the global financial system.

Various explanations have been given as reasons for the crisis including: lax borrowing constraints (subprime mortgages, adjustable rate mortgages, low down payment requirements, etc…), lack of regulation and oversight, and lack of understanding of the complex financial assets built around subprime mortgages. No doubt the recent crisis can be linked to the above mentioned reasons. However, a fundamental factor that contributed to the crisis is the housing asset price bubble which led to the over accumulation of housing assets. Preferential tax treatment of housing assets makes owning a house more attractive than renting which contributes to the over accumulation of housing assets.

Indeed, housing assets receive preferential tax treatment in the U.S. compared to capital. Specifically, interest on mortgage payments is tax deductible and imputed rents from owner occupied housing are not taxed. The literature on optimal capital and housing taxation suggests that it is welfare improving to eliminate the preferential tax treatment that house owners receive. However, the question of the effect of said preferential treatment on foreclosure had not been investigated. Given that the subprime mortgage crisis was manifested by homeowners defaulting on their mortgages, this is an important avenue to investigate.

To estimate this effect, I construct and compute an economy where agents value both housing services and consumption. Agents can choose to either rent or buy their housing services. Homeowners enter into simple mortgages with a financial intermediary, where every period they choose to either make payments on or default. Government expenditure is exogenous every period and the government has no access to lump sum taxes, thus it uses distortionary taxes to levy income.

On the housing side of the literature, optimal housing taxation has been investigated, and as stated above the prevailing conclusion is that all types of households prefer to be in a world where housing is taxed in a similar fashion to capital. Nakajima(2007) builds an overlapping generation model with un-insurable idiosyncratic shocks to individual earnings where agents age stochastically and renting is not an option. He then analyzes the interaction between housing and financial assets, and determines optimal taxes on housing. Gervais (2002) also constructs a similar model but without intra-generational heterogeneity. Some other papers have infinitely lived agents as in Diaz and Luengo-Prado(2006).

It is important to note here that while the above described literature is relevant to this paper's question, what I attempt to answer here is not the welfare implications of tax reform but rather the effect of the current tax structure on foreclosures in the housing markets. Also worth noting is that this chapter is concerned only with agents housing tenure choices and consumption patterns.

In what follows, Section 2 presents the environment, Section 3 presents the model, agents' behavior and describes the equilibrium, Section 4 presents the parameterization and calibration process and Section 5 presents the results.

3.2. Environment

I present an environment where time is discrete and infinite. The economy is populated by households, a production firm, a financial intermediary, and a government.

3.2.1. Households

The economy is populated by a unit measure of infinitely lived households that derive utility from consuming a basket of non-durable goods: (c) and housing services: (h). Thus, household's utility function is given by: $U(c, h)$. A transformation technology exists between house size and housing service. Living in a house of size (x) will generate housing services $h = g(x)$. Agents maximize the sum of their expected utility $\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \mathrm{U}(\mathrm{c}, \mathrm{h})$ where $0 < \beta < 1$ is the discount factor.

Agents have an endowment of one unit of time every period and supply labor in-elastically. However, households differ in their productivity, z, which is stochastic and assumed to follow a first order Markov process. Households can invest in capital: (k) and earn a return on capital (r).

Households can either rent or buy housing. When agents rent, they simply pay rent. When they own a house of size (x), they enter into a simple mortgage with the financial intermediary and borrow $(1-\lambda)x$. Thus λx is the down payment requirement.[19] Households pay their mortgage over a period of 30 years. At any time during this 30 yeas period, agents can default on their mortgage, and they will lose their owned house and will be forced to rent. Owners who default on their mortgage are allowed to own a house after a period of seven years which matches the duration of the period for which credit bureaus keep records on defaults. Owners are not allowed to buy another house before the end of the 30 mortgage period.

3.2.2. Production Firm

Production in this economy is undertaken by a firm that pays w and r in return for labor and capital respectively. The firm has a production function $Y = F(K, L)$.

3.2.3. Financial Intermediary

The Financial intermediary is assumed to be risk neutral with access to financial markets where they can borrow at risk free interest rate (r).[20] They issue simple mortgages to a homeowner at a discount rate (q).[21] The discount rate charged by the financial intermediary is not the same for all borrowers since (q) is determined based on the probability of an agent's default such that the intermediary's expected profit is zero.

[19] This assumes that the housing size is a proxy for the value of the house .
[20] No arbitrage condition implies that risk free interest rate and return on capital are the same.
[21] For simplicity reasons, simple mortgage contracts are assumed to be the only type of contracts available to agents. In addition, for purposes of assessing the effect of the deductibility of interest in mortgage payment on default rates, any other assumption on the type of contracts (adjustable rate mortgages for example) would produce more dramatic results.

3.2.4. Government

The government levies taxes on labor and capital income (τ_K) and (τ_L) respectively. Government expenditure is constant and set at G every period. I restrict the government's access to borrowing markets, so it runs a balanced budget, using tax revenues to finance its expenditures which do not affect individuals at the margin[22].

3.2.5. Tax System

As mentioned previously, the government only has access to distortionary taxes. It taxes Labor income at rate (τ_L) and capital income at rate (τ_K). Mortgage interest payments are tax deductible, and government does not tax imputed rents. This system replicates the tax system currently implemented in the U.S.

When assessing the effect of the tax system on foreclosures, I change the assumptions on the tax regime such that mortgage interest payments are not tax deductible and government taxes imputed rents at rate (τ_H).

3.2.6. Timing

Households start every period with the amount of savings k decided the previous period. Their stochastic productivity for the period z is revealed and they make their consumption, housing, and savings decisions.

A household entering the current period as a renter has the choice to either continue to rent or buy a house.

[22] This is a standard assumption of the literature, see Gervais 2002 for example.

A household entering the current period as an owner can either pay her current mortgage payment or default. If she chooses to make the mortgage payment, she will continue to own her housing unit. If she defaults on her mortgage, she will lose her house and will be forced to rent.

3.3. Equilibrium

3.3.1. Household's Problem

3.3.1.1. Renters

Renters choose how much to consume of the non-durable good c, housing h, and how much to invest in capital $k^{'}$. A renter's value function is given by:

$$V^{Rent}(z,k) = Max_{h,c,k',h} U(c,h) + \beta E_{z'/z} V(z',k')$$

$$s.t.\, c + k^{'} + r.h = w.z.(1-\tau_L) + k(1-\delta_K) + r.k.(1-\tau_K)$$

Where:

- (r) is the return on capital;
- (h) is the size of house rented this period
- (r. h) is the rent paid for housing unit of size h
- (δ_K) is capital depreciation
- (k') is the capital savings for next period

$V(z',k')$ is the value function for entering next period with productivity $z'$and savings k' and deciding whether to rent or buy housing. Thus:

$$V(z,k) = Max\{V^{Buy}(z,k), V^{Rent}(z,k)\}$$

3.3.1.2. Ownership Decision

If an agent decides to buy a house this period, she chooses how much to consume of the non-durable good c, the size of house she will buy h, and how much to invest in capital k'.

The value function of buying a house V^{Buy} is given by

$$V^{Buy}(z,k) = \mathrm{Max}_{k',h,c,} U(c,h) + \beta E_{z'/z}\left\{V^{Own}\left(z', k', 1, P(z,k,h)\right)\right\}$$

$$s.t.\ c + k' = w.z.(1-\tau_L) + k.(1-\delta_K) + r.k.(1-\tau_K) - (1-\lambda).h$$

Where:

- $(1-\lambda).h$ is the down payment requirement for buying a house of size h.
- V^{Own} is the value function of owning a house. The third state variable in V^{Own} (one in this case) represents the number of periods an agent has been in a mortgage contract.
- (P) is an index state variable representing the size of the house and the agent's income and capital combination at which the house was purchased. Every combination of income, capital, and housing purchased leads to a specific probability of default that the intermediaries use to determine the discount rate they will charge, the mortgage payments $M(P)$ and the interest paid every period $I(P,0)$.

3.3.1.3. Owners

An owner entering a period with an owned house of size (h) and is in year (o) of her mortgage can either pay the mortgage for that period or default on her loan. The decision whether to repay or default is such that the sum of expected future utility is maximized, thus the value function for owning is given by:

$$V^{Own}(z,k,o,P) = Max\{V^{Repay}(z,k,o,P), V^{Default}(z,k,1)\}$$

Where $\mathrm{V}^{\mathrm{Repay}}(\mathrm{z},\mathrm{k},\mathrm{o},\mathrm{P})$ is the agent's value of paying this period's mortgage payment and remaining a homeowner and $\mathrm{V}^{\mathrm{Default}}(\mathrm{z},\mathrm{k},1)$ is the agent's value function of not paying this period's mortgage payment and thus being in the first year of default. The repayment and default value functions are derived in the following sections.

3.3.1.4. Repayment

If a homeowner decides to pay her mortgage payment for the period, she will remain an owner for next period, and decide on her consumption c and savings $k^{'}$'. The value function for repayment is V^{Repay} such that:

$$V^{Repay}(z,k,o,P) = Max_{k',c}U(c,h) + \beta E_{z'/z}V^{Repay}(z^{'},k^{'},o+1,P)$$

$$s.t.\, c + k^{'} = w.z.(1-\tau_L) + k.(1-\delta_K) + r.k.(1-\tau_K) - M(P) + I(P,O).\tau_L$$

Where:

- $M(P)$ is the mortgage payment due every period,
- $I(P,o)$ is the interest portion of the mortgage payment. This interest is tax deductible and hence it appears in the households budget constraint multiplied by the tax rate on labor income.

While the mortgage payment is fixed every period, the interest portion of the mortgage payment is decreasing with the number of periods (o) for which the mortgage had been entered into. This is a result of the simple mortgage contracts which I assume are the only type of contract available to agents as discussed in section 2.3 above.

Note here that the owner does not make a decision on housing size every period. The size of housing decision is made only when purchasing the house.

3.3.1.5. Default

If a homeowner decides not to pay her mortgage payment for the period and thus default, she will lose her house and will be forced to rent. The value function for defaulting in any given period $V^{Default}$ is such that:

$$V^{Default}(z,k,e) = Max_{k',h,C,}U(c,h) + \beta E_{z'/z}V^{Default}(z',k',e+1)$$

$$s.t.\, c + k' + r.h = w.z.(1-\tau_L) + k.(1-\delta_K) + r.k.(1-\tau_K)$$

Since an agent in default is forced to rent, her budget constraint is identical to that of a renter, and since that budget constraint is independent on the value of the owned house agent vacated, the default value function will be independent on the size of house (mortgage) being defaulted on. After defaulting this period, an agent is not allowed to buy own another house until after seven periods, that is until after $e = 7$.

Thus

$$V^{Default}(z,k,7) = Max_{k\prime,h,C,}U(c,h) + \beta E_{z\prime/z}V(z',k')$$

$$s.t.\; c + k' + r.h = w.z.(1-\tau_L) + k.(1-\delta_K) + r.k.(1-\tau_K)$$

Where after seven periods from a default, the agent is allowed to own again, but also has the option to rent. Thus, the discounted future value function showing up in the definition of $V^{Default}(z, k, 7)$ is $V(z', k')$.

Now that we have the value functions for a household's different actions, we can derive the ownership and default sets.

Ownership set (Own) is given by:

$$Own(z, k) = \{z, k \ s.t. V^{buy}(Z, K) > V^{Rent}(Z, K)\}$$

And Default set (Def) is given by:

$$Def(z, k, o, P) = \{z, k, o, P \ s.t. V^{Default}(z, k) > V^{Repay}(z, k, o, P)\}$$

3.3.2. Firm's Problem

The representative firm in this economy has a production function $\mathrm{Y} = \mathrm{F}(\mathrm{K}, \mathrm{L})$. The firm pays agents wage $\mathrm{w} = \mathrm{F}_2(\mathrm{K}, \mathrm{L})$ and $\mathrm{r} = \mathrm{F}_1(\mathrm{K}, \mathrm{L})$ in return for providing labor and capital respectively.

3.3.3. Financial Intermediary's problem

Financial Intermediary provides mortgage contracts to agents purchasing a house. Intermediary determines interest rate to break even on expectation taking into account agent's probability of default. Probability of default Γ is a function of agent's current income and capital savings as well as the size of the house being purchased and is given by:

$$\Gamma(z, k', h) = \int_{Def} f(z', z) dz'$$

Where $f(z', z)$ is the probability density function of the stochastic labor productivity. In other words, probability of defaulting in the future on a house of size h given that current income is z and savings is k' is the sum of probabilities of a z' being realized where (z', k') belongs to the default set.

The interest rate of a given mortgage defined by the triplet (z, k', h), is set by the financial intermediary so that, given the probability of default on the mortgage, it breaks even in expectation. Simple calculations implies that this interest rate $R_m(z, k', h)$ is such that

$$\frac{1}{1+R_m(z,k',h)} = \frac{\left(1-\Gamma(z,k',h)+\Gamma(z,k',h)(1-\xi)\right)}{1+r_0}$$

Where $\Gamma(z, k', h)$ is the probability of default determined above and ξ is the loss in value of a housing asset after a default. The above equation determines the interest rate to be charged by the intermediary as a risk adjusted rate based on the intermediary's expected loss in case of default.

3.4. Recursive Equilibrium

Solving the household's problem yields decision functions on consumption X, savings Δ, housing services Σ, and ownership and default sets (Own) and (Def).

A recursive equilibrium of the above model economy is defined by set of prices (r, w, q, M, I); value functions $\left(V, V^{Buy}, V^{Rent}, V^{Default}, V^{Repay}, V^{Own}\right)$; decision rules

$(\mathrm{X}, \Delta, \Sigma)$; ownership and default sets ($\mathrm{Own}, \mathrm{Def}$); Probability of default function (Γ); and stationary distribution of agents (μ) such that :

1. Given prices, the value functions $\mathrm{V}, \mathrm{V}^{\mathrm{Buy}}, \mathrm{V}^{\mathrm{Rent}}, \mathrm{V}^{\mathrm{Default}}, \mathrm{V}^{\mathrm{Repay}}, \mathrm{V}^{\mathrm{Own}}$ are the solution to the household's optimization problem, $\mathrm{X}, \Delta, \Sigma$ are the resultant decision rules, and $(\mathrm{Own}), (\mathrm{Def})$ are the resultant ownership and default sets;
2. r and w solve the firm's optimization problem;
3. Given Γ, q solves the financial intermediary problem;
4. Government Budget constraint is satisfied;
5. Labor and Capital markets clear;
6. Given the decision rules, ownership, and default sets get the transition function $\mathrm{T}(\mathrm{z}, \mathrm{k}', \mathrm{o}, \mathrm{e}, \mathrm{P}, \mathrm{F})$ s.t.

$$\mu(\mathrm{z}, \mathrm{k}', \mathrm{o}, \mathrm{e}, \mathrm{P}, \mathrm{F}) = \int \mathrm{T}(\mathrm{z}, \mathrm{k}', \mathrm{o}, \mathrm{e}, \mathrm{P}, \mathrm{F})\, \mathrm{d}\mu$$

Where F differentiates whether an agent is an owner, a renter, or in default.

Appendix III explains the algorithm used in arriving to the above equilibrium.

3.5. Parameterization and Calibration

3.5.1. Parameterization

For the productivity shocks dynamics, I use a first order 12 state Markov process previously used in Nakajima (2007).

I use the following functional form of the period utility

$$U(c,h) = C^{1-\eta}/1-\eta + \psi\, h^{1-\eta}/1-\eta$$

A linear transformation technology exists between house value and housing services $h = g(x)$. Living in a house of value (x) will generate $h = x$ of housing services.[23]

The firm is assumed to have a Cobb-Douglas production technology $Y = AK^{\alpha}L^{(1-\alpha)}$ where (K) is the aggregate capital in the economy and (L) is the aggregate labor. Thus, $w = (1-\alpha)AK^{\alpha}L^{(-\alpha)}$ and $r = \alpha AK^{(\alpha-1)}L^{(1-\alpha)}$.

3.5.2. Calibration

A and ψ are jointly calibrated to match the following data moments: capital share of total output, ownership rate in 2007, and default rates in 2007.

For ξ, the decrease in value of the housing asset after default, I use data from the Case-Shiller Index on housing which approximates the decrease in same house prices to be 20% between December of 2007 and December of 2008.[24]

[23] This assumption of linear transformation is used in Gervais (2002) and Nakajima (2007).

[24] Originally compiled and published by economists Karl Case, Robert Shiller, and Allan Weiss; the S&P/Case–Shiller U.S. National Home Price Index is a composite of single-family home price indices for

For the remaining parameters in the model, I use values previously used in the literature. Specifically for the discount factor β I use a value of 0.96, for the Cobb Douglas production function I use an α of 0.28 and for the coefficient of relative risk aversion η, I use a value of 2.

The results of the calibration were as follows

Parameter	Description	Value
A	Production function coefficient	0.275
ψ	Weight of housing in utility function	0.183[25]

Table 2: Results of Calibration.

3.6. Results

In this section, I present the results of the computation of the recursive equilibrium described above under the environment described in Section 2 – the "Baseline Model".

3.6.1. Size of Houses

Figure 5 and 6 below show the sizes of rented and owned houses are increasing in both capital savings and income. This is an expected result as utility of households is increasing with the level of housing services consumed. Figure 5 plots the agent's decision if she was to always rent, while figure 6 shows the agent's decision if she was to

the nine U.S. Census divisions. Options and futures based on the Case–Shiller index are traded on the Chicago Mercantile Exchange.

[25] When calculating the results of this paper, I run a sensitivity analysis on this parameter where I increase the value of this parameter by 10%.

always own. The equilibrium size of house occupied (via both renting and owning) is shown in Figure 7 which also shows the increasing relationship between size of house occupied versus income and savings.

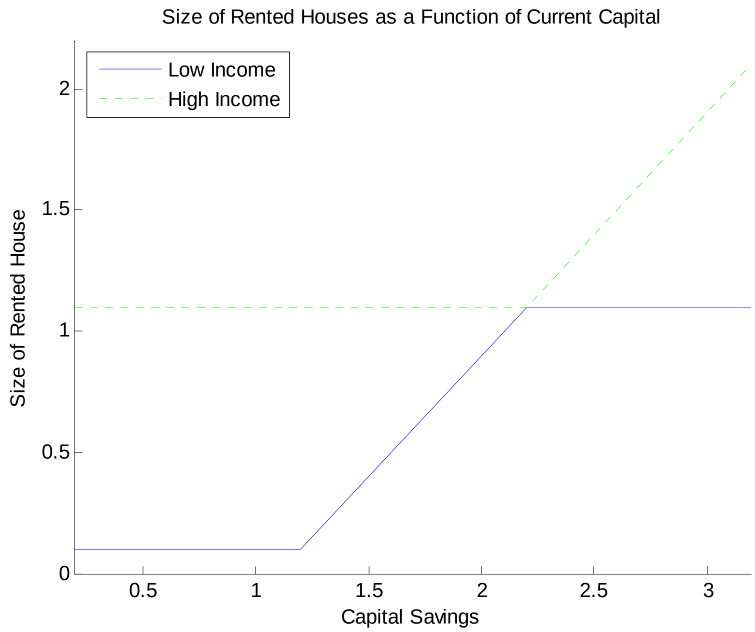

Figure 5: Size of Rented house as a function of savings and income

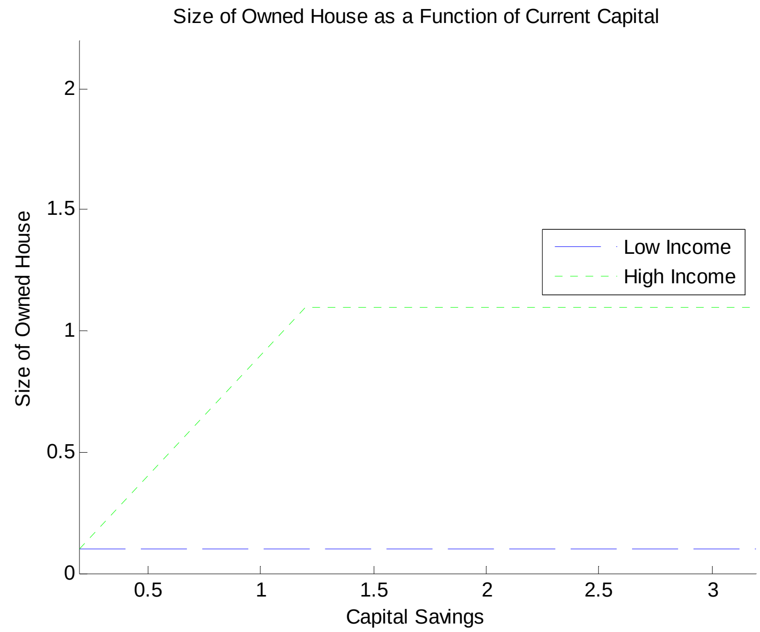

Figure 6: Size of owned house as a function of savings and income

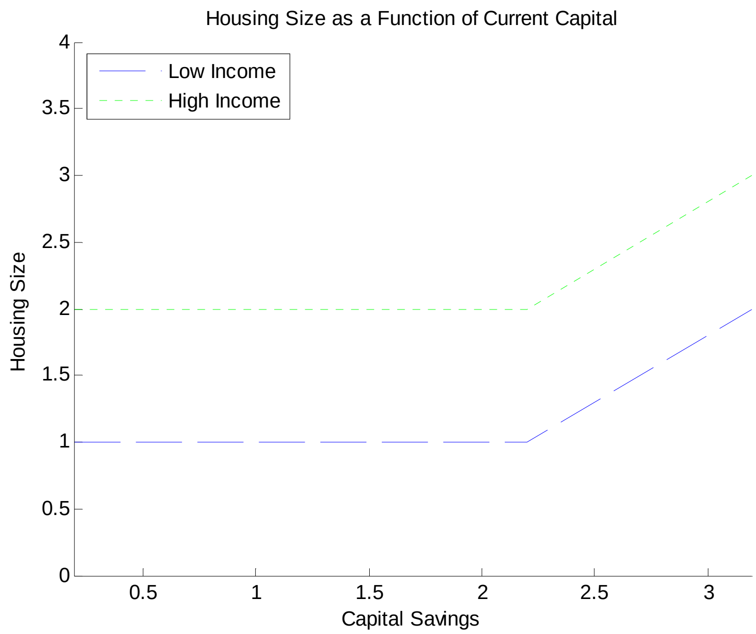

Figure 7: Size of agent's housing (rented or owned) at equilibrium as a function of savings and income

3.6.2. Ownership and Default Decision

Ownership is increasing in capital savings and income as shown in Figure 8 and default is decreasing in income as shown in Figure 9. These figures show that as agent's income increase not only they are more likely to own, but they are more likely to continue to own (i.e. not default).

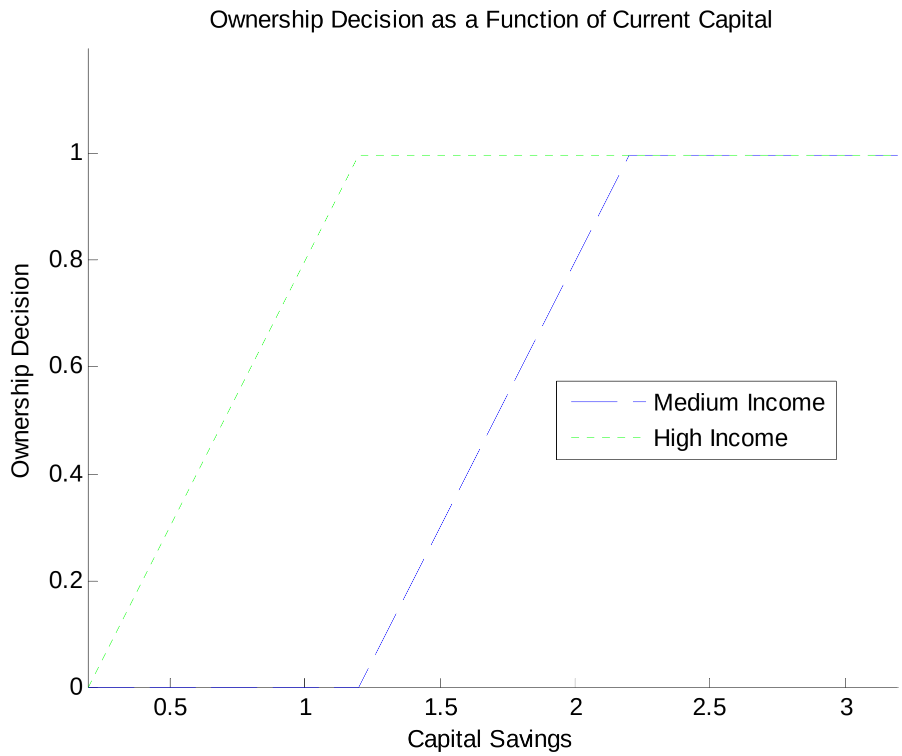

Figure 8: Ownership decision as a function of savings income

3.6.3. Default Decision

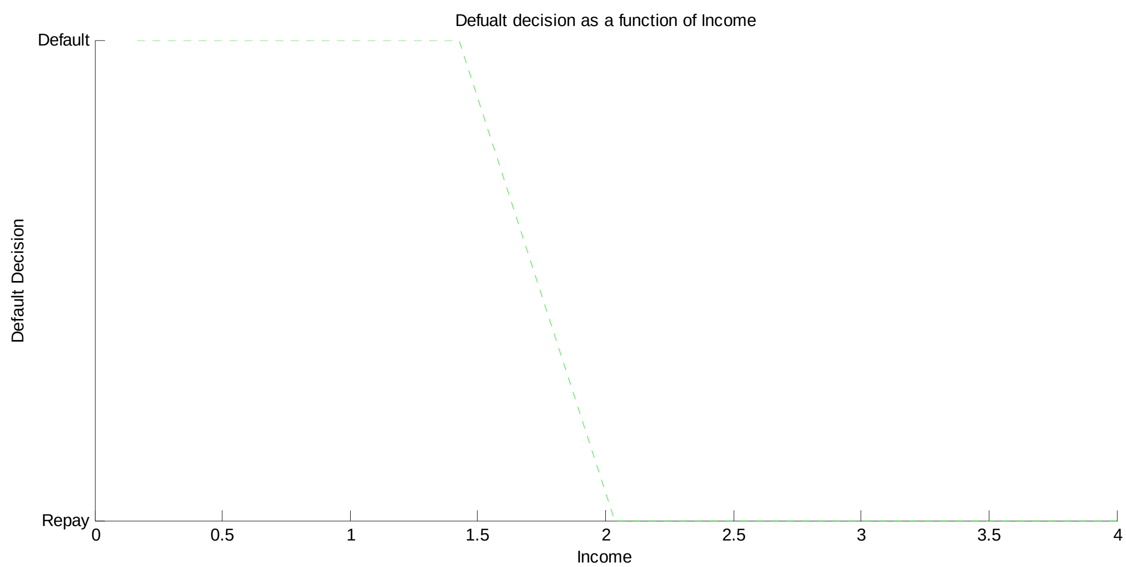

Figure 9: Default decision as a function of income

3.7. Tax Reform

To assess the effect of the preferential tax treatment of housing assets on defaults, I recalculate the foreclosure rate in the economy after adjusting for the preferential tax characteristics. In particular, I analyze the change in foreclosures when implicit rents from owner occupied housing are taxed and the change when interest in mortgage payments are not tax deductible.

I note here that the evaluation in this section is not concerned with the welfare implications of such tax reforms and thus does not comment on the optimality of these tax changes. The optimality of the tax code changes under a setup similar to the one described in this paper and in the literature in general would have to be performed while keeping the government's tax revenue constant.[26] The suggested tax reform being evaluated in this paper relates to increasing tax revenue as well as overall market reform in relation to housing assets.

Both changes to the tax code considered here will affect the equilibrium of the model in directionally similar ways. Implicit rent is the rent the home owners would have paid had they rented their house. Due to the no arbitrage condition, this rent is given by $r_0 h$ where h is the size of the house. Adjusting the tax code in the Baseline Model such that owners are taxed on this implicit income will lead to a reduction in the value of owning a house for all house sizes for all owners. That is, given that an agent is an owner, her $V^{Repay}(z, k, o, P)$ decreases for all values of o and P. Recall that o is the number of periods the mortgage has been entered into and P is the index variable that represents the triplet of income, saving and size of house purchased at the time the purchase decision is made. Similarly disallowing deduction of the interest portion of mortgage payments will lead to a decrease in $V^{Repay}(z, k, o, P)$ decreases for all values of o and P for all owners. For obvious reasons, the reforms to the tax code do not apply to renters and thus the value function associated with an agent being a renter, $V^{Rent}(z, k)$, is unchanged.

Given the discussion in the above paragraph, the value of buying a house, $\mathrm{V^{Buy}(z, k)}$, is a relatively less favorable option post implementation of the reforms

[26] The literature assumes the condition on government's tax revenue remaining constant when assessing the welfare implications of tax reform because individuals do not get marginal utility from government expenditure. Thus an increase in tax revenue and consequently increased government spending under the balanced budget assumption has no channel to contribute to the utility of agents.

compared to owning a house under the Baseline Model and thus the ownership rate will unambiguously fall due to both reforms.[27]

The decrease in the ownership rate means that in equilibrium the economy will have fewer owners and thus fewer agents will have the option of defaulting which reduces the rate of foreclosure. On the other hand, since the value function of entering into default, $V^{Default}(z,k,1)$, is independent of the size of the mortgage defaulted on (that is the size of the house owned at the time of the default), more owners will choose to default when comparing a decreasing $V^{Repay}(z,k,o,P)$ to a constant $V^{Default}(z,k,1)$. So even though ownership rate can be analytically tracked to decrease as a result of the tax reforms, the net effect on foreclosure rates is ambiguous analytically and will depend on the computational results of the model.

The results of re-computing the Baseline Model with the changes described in this section are presented in Table 3 below.

Tax Code Change	Ownership Rate	Foreclosure Rate
Taxing imputed rents	49.01 percent – Reduction of 30.7 percent from Baseline Model	4.04 percent - Reduction of 32.5 4.05 percent from Baseline 4.06 Model
Interest mortgage payments not deductible	68.44 percent – Reduction of 3.2 percent from Baseline Model	5.25 percent- Reduction of 12.4 percent from Baseline Model
Taxing imputed rents and interest mortgage payments not deductible	47.32 percent - Reduction of 33.1 percent from Baseline Model	3.99 percent- Reduction of 33.4 percent from Baseline Model

Table 3: Effect of changes to tax code[28]

[27] Since $V^{Buy}(z,k)$ includes the discounted value function of owning a house, $V^{Own}(z,k,o,P)$, which in turn is determined by $V^{Repay}(z,k,o,P)$ and $V^{Repay}(z,k,o,P)$ is decreasing for all owners.

3.8. Conclusion

I construct a recursive equilibrium model of consumption, housing, and tenure choice where agents default in equilibrium. I use my framework to test the effect of the current US housing tax regime on the foreclosure rate. The idea that the current tax regime incentivizes agents to over accumulate housing assets is not a new one, however the effect of this over accumulation on foreclosures is of interest especially after the recession of 2008. I investigate the effect of two tax reforms – taxing imputed rents and disallowing deductibility of interest in mortgage payments.

The results of this paper indicate that the current tax regime leads to an ownership rate that is 30 percent higher than it would be under a tax regime that equates housing assets to other capital assets in the economy. In addition, the reforms discussed in this paper lead to a 33.5 percent reduction in the foreclosure rate at equilibrium.

[28] Under the sensitivity analysis, the results are as follows:
Taxing Imputed Rents: Ownership Rate = 49.13% Default Rate= 3.96%
Interest Mortgage Not Deductible: Ownership Rate = 70.01% Default Rate= 5.6%
Both Reforms: Ownership Rate = 47.33% Default Rate= 5.6%

APPENDIX I

Algorithm for Recursive Equilibrium – Chapter 1

Following is the algorithm used to compute the recursive equilibrium describes in Section 1.3.3 of Chapter 1.

Given the set of calibrated parameter values, do the following:

BEGIN

Step 1: Initializations

- Start with values for discount rate (q) and premiums (R) , call them q_1 and R_1 respectively
- Start with initial distribution of agents (Ω) , call it (Ω_1)
- Start with a starting point for value functions (V, T) call them $(\mathrm{V}_1, \mathrm{T}_1)$

Step 2: Value Function Iterations

Given current estimates of value functions $(\mathrm{V}_1, \mathrm{T}_1)$, discount rate (q), premiums (R), and agent distribution (Ω)

Step 2.a: Solve for agents decision functions and calculate new estimates for value functions $(\mathrm{V}_2, \mathrm{T}_2)$

Step 2.b: Test for convergence of value function

- If value functions did not converge-i.e. if $(\mathrm{V}_2, \mathrm{T}_2)$ are different from $(\mathrm{V}_1, \mathrm{T}_1)$ - update value function estimates such that $(\mathrm{V}_1, \mathrm{T}_1) = (\mathrm{V}_2, \mathrm{T}_2)$ and repeat **Step 2**
- If value functions converged, continue to Step 3

Step 3: Update distribution of agents

Starting with current estimate of distribution of agents (Ω_1)

Step 3.a: use optimal decision functions from Step 2 and transition processes for income and health states to calculate new estimate of agent distribution function (Ω_2) ,

Step 3.b: Test for convergence of distribution function

- If distribution function did not converge-i.e. if (Ω_2) is different from (Ω_1) - update distribution function estimate such that $(\Omega_1) = (\Omega_2)$ and repeat **Step 3**
- If distribution function converged, continue to **Step 4**

Step 4: Insurance market clearing

Given estimates of optimal decision functions from Step 2 and estimate of stationary distribution of agents from Step 3

Step 4.a: Calculate new premiums (R_2) using the insurance provider's zero profit condition.

Step 4.b: convergence of premiums

- If premiums did not converge-i.e. if (R_2) is different from (R_1) - update premium estimate such that $(\mathrm{R}_1) = (\mathrm{R}_2)$ and go back to **Step 2**

- If distribution function converged, continue to **Step 5**

Step 5: Asset Market clearing

Given the estimates of the value functions, optimal decision functions, and stationary agent distribution from Steps 2 and 4 above

Step 5.a: Calculate total asset holdings in the economy, call it (A)

Step 5.b: Asset market clearing

- if asset market does not clear – i.e. if $(\mathrm{A} \neq 0)$- adjust estimate of discount rate and go back to **Step 2** above
- if asset market clears – i.e. if $(\mathrm{A} = 0)$ - END

Once the algorithm describes above exists Step 5, all the recursive equilibrium conditions described in section 1.3.3 above would be met.

APPENDIX II

Proofs – Chapter 2

Proposition 1: *Under an indemnity regime, insurance premium R is such that the expected utility of an insured agent is equal to the expected utility of an uninsured agent*

$$EU_{IH-Indemnity} = EU_{UH-Indemnity}$$

Proof

The insurance provider's problem is given by

$$\mathrm{Max}_{\mathrm{R}}\ \mathrm{R}_{\mathrm{Indemnity}} - \gamma\, \mathrm{Q}_{\mathrm{I,H}}.(1-\sigma)\left(\mathrm{P}_{\mathrm{Indemnity}}\right)$$

$$\text{s.t.}\ (\gamma).\mathrm{U}\left(\mathrm{C}_{\mathrm{I,H,S=1}}, \mathrm{Q}_{\mathrm{I,H}}\right) + (1-\gamma).\mathrm{U}\left(\mathrm{C}_{\mathrm{I,H,S=0}}, 0\right)$$

$$\geq (\gamma).\mathrm{U}\left(\mathrm{C}_{\mathrm{UI,H,S=1}}, \mathrm{Q}_{\mathrm{UI,H}}\right) + (1-\gamma).\mathrm{U}\left(\mathrm{C}_{\mathrm{UI,H,S=0}}, 0\right) \cdots (\mathrm{IC}-1)$$

The insurance provider takes price set by the care provider as given and under the separating equilibrium where the percentage of insured agents is constant and equal to the percentage of high type individuals in the economy.

The insurance provider's profit is given by

$$\frac{\partial \Pi_{\mathrm{IP}}}{\partial \mathrm{R}_{\mathrm{Indemnity}}} = 1 - \gamma \frac{\partial Q_{I,H}}{\partial R_{Indemnity}} (1-\sigma)\left(P_{Indemnity}\right)$$

Demand for medical care is decreasing in premium $\mathrm{R}_{\mathrm{Indemnity}}$, i.e. $\frac{\partial \mathrm{Q}_{\mathrm{I,H}}}{\partial \mathrm{R}_{\mathrm{Indemnity}}} < 0$. So insurance provider's profit is increasing in premium $\mathrm{R}_{\mathrm{Indemnity}}$,that is $\frac{\partial \Pi_{\mathrm{IP}}}{\partial \mathrm{R}_{\mathrm{Indemnity}}} > 0$.

The right hand side of $\mathrm{IC}-1$, expected utility of uninsured agents is independent of R, while the left hand side of $\mathrm{IC}-1$ is decreasing in R. Thus for the profit maximizing insurance provider, $\mathrm{IC}-1$ is binding and R is such that $\mathrm{EU}_{\mathrm{IH-Indemnity}} = \mathrm{EU}_{\mathrm{UH-Indemnity}}$. ■

Proposition 2: $IC - 3$ *is binding if demand is elastic or if demand is inelastic and* P_{I-MC} *is larger than marginal cost. i.e.*

$$EU_{IH-MC} = EU_{UH-MC} \cdots\cdots\cdots (8)$$

$$if\ \varepsilon_{Q,P} < -1 \quad \cdots\cdots\cdots Condition\ (1)$$

$$OR\ if\ \varepsilon_{Q,P1} \geq -1\ \&\ P_{I-MC} < \frac{\partial \emptyset}{\partial Q} \cdots\cdots\cdots Condition\ (2)$$

Proof

The insurance provider's problem under managed care is given by

$$\mathrm{Max}_{\mathrm{R_{MC}},\mathrm{P_{I-MC}}}\ \Pi_{\mathrm{IP-MC}} = \mathrm{Max}_{\mathrm{R_{MC}},\mathrm{P_{I-MC}}}\ \mathrm{R_{MC}} - \gamma\, \mathrm{Q_{I-MC}}\,(1-\sigma)(\mathrm{P_{I-MC}}).$$

$$\text{s.t.}\ (\gamma).\,\mathrm{U}\big(\mathrm{C_{I,H,S=1}}, \mathrm{Q_{I,H}}\big) + (1-\gamma).\,\mathrm{U}\big(\mathrm{C_{I,H,S=0}}, 0\big) - (\gamma).\,\mathrm{U}\big(\mathrm{C_{UI,H,S=1}}, \mathrm{Q_{UI,H}}\big) + (1-\gamma).\,\mathrm{U}\big(\mathrm{C_{UI,H,S=0}}, 0\big) \geq 0 \cdots (\mathrm{IC}-3)$$

and

$$(\tau)\Big(\mathrm{P_{I-MC}}\mathrm{Q_{I,H}} - \emptyset\big(\mathrm{Q_{I,H}}\big)\Big) \geq 0 \cdots (\mathrm{IC}-5)$$

Proposition 2 can be shown by deriving partial derivatives as follows:

- $\frac{\partial \Pi_{\mathrm{IP-MC}}}{\partial \mathrm{R}} = 1 - \gamma\ \frac{\partial Q_{I-MC}}{\partial R}\ (1-\sigma)(P_{I-MC}) > 0$
- $\frac{\partial(\mathrm{IC}-3)}{\partial \mathrm{R}} = (\gamma).\frac{\partial \mathrm{U}(\mathrm{C_{I,H,S=1}},\mathrm{Q_{I,H}})}{\partial \mathrm{R}} + (1-\gamma).\frac{\partial\, \mathrm{U}(\mathrm{C_{I,H,S=0}},0)}{\partial \mathrm{R}} < 0$
- $\frac{\partial(\mathrm{IC}-5)}{\partial \mathrm{R}} = (\tau)\Big(\mathrm{P_{I-MC}} - \frac{\partial \emptyset}{\partial \mathrm{Q}}\Big)\frac{\partial \mathrm{Q_{I,H}}}{\partial \mathrm{R}}$

- Since $\frac{\partial Q_{I,H}}{\partial R} < 0, \frac{\partial(IC-5)}{\partial R} > 0$ if $P_{I-MC} < \frac{\partial \emptyset}{\partial Q}$

- $\frac{\partial \Pi_{IP-MC}}{\partial P_{I-MC}} = -\gamma\,(1-\sigma)\left(Q_{I-MC} + P_{I-MC}\frac{\partial Q_{I-MC}}{\partial P_{I-MC}}\right) =$

  $-\gamma\,(1-\sigma)(Q_{I-MC})\left(1+\varepsilon_{Q,P}\right)$

  - $\frac{\partial \Pi_{IP-MC}}{\partial P_{I-MC}} < 0$ if $\varepsilon_{Q,P} > -1$
  - $\frac{\partial \Pi_{IP-MC}}{\partial P_{I-MC}} > 0$ if $\varepsilon_{Q,P} < -1$

- $\frac{\partial(IC-3)}{\partial P_{I-MC}} = (\gamma).\frac{\partial U\left(C_{I,H,S=1},Q_{I,H}\right)}{\partial P} + (1-\gamma).\frac{\partial\, U\left(C_{I,H,S=0},0\right)}{\partial P} < 0$

- $\frac{\partial(IC-5)}{\partial P_{I-MC}} = (\tau)\left(Q_{I,H}\right)\left(1+\varepsilon_{Q,P} - \frac{\partial \emptyset}{\partial P_{I-MC}}\frac{1}{Q_{I,H}}\right)$

  - $\frac{\partial(IC-5)}{\partial P_{I-MC}} > 0$ if $\varepsilon_{Q,P} > \frac{\partial \emptyset}{\partial P_{I-MC}}\frac{1}{Q_{I,H}} - 1$
  - $\frac{\partial(IC-5)}{\partial P_{I-MC}} < 0$ if $\varepsilon_{Q,P} < \frac{\partial \emptyset}{\partial P_{I-MC}}\frac{1}{Q_{I,H}} - 1$

Based on the conditions derived above, we can construct the following matrix along with effect on the incentive compatibility constraints.

	$\boldsymbol{\varepsilon_{Q,P} < \frac{\partial \emptyset}{\partial P_{I-MC}}\frac{1}{Q_{I,H}} - 1}$	$\boldsymbol{\frac{\partial \emptyset}{\partial P_{I-MC}}\frac{1}{Q_{I,H}} - 1 < \varepsilon_{Q,P}}$ <-1	-1< $\boldsymbol{\varepsilon_{Q,P}}$ <0
$\boldsymbol{P_{I-MC} < \frac{\partial \emptyset}{\partial Q}}$	IC-3 binds IC-5 may or may not bind	IC-3 Binds IC-5 Doesn't bind	IC-3 Binds IC-5 Binds
$\boldsymbol{P_{I-MC} > \frac{\partial \emptyset}{\partial Q}}$	IC-3 binds or IC-5 binds or both bind	IC-3 Binds IC-5 May or may not bind	IC-3 May/May not Bind IC-5: Binds

Table A1: Summary of Conditions

To prove the conclusions in Table A.1 above, let us start with the case of -1< $\varepsilon_{Q,P}$ <0 and $P_{I-MC} < \frac{\partial \emptyset}{\partial Q}$ and show that the solution to the insurance problem is such that IC-3 and IC-5 both bind. Under the specific conditions on $\varepsilon_{Q,P}$ and P_{I-MC} in this case, the following holds:

- $\frac{\partial \Pi_{IP-MC}}{\partial R} > 0$, $\frac{\partial (IC-3)}{\partial R} < 0$, $\frac{\partial (IC-5)}{\partial R} > 0$ and
- $\frac{\partial \Pi_{IP-MC}}{\partial P_{I-MC}} < 0$, $\frac{\partial (IC-3)}{\partial P_{I-MC}} < 0$, $\frac{\partial (IC-5)}{\partial P_{I-MC}} > 0$

Assume that the pair (R^*, P^*_{I-MC}) is a solution to the insurance provider problem such that IC-3 is not binding. Then given the inequalities stated above, there exists a premium $R^1 > R^*$ such that IC-3 binds, IC-5 is not violated, and $\Pi_{IP-MC}(R^1, P^*_{I-MC}) > \Pi_{IP-MC}(R^*, P^*_{I-MC})$. Then (R^*, P^*_{I-MC}) cannot be a solution to the insurance maximization problem. So for a pair $(R^\dagger, P^\dagger_{I-MC})$ to be a solution, IC-3 must bind.

Now assume that (R^{**}, P^{**}_{I-MC}) is a solution to the insurance provider problem such that IC-5 is not binding. Then given the inequalities stated above, there exists a price $P^1_{I-MC} < P^{**}_{I-MC}$ such that IC-5 binds in P_{I-MC}, IC-3 is not violated, and $\Pi_{IP-MC}(R^{**}, P^1_{I-MC}) > \Pi_{IP-MC}(R^{**}, P^{**}_{I-MC})$. Then (R^{**}, P^{**}_{I-MC}) cannot be a solution to the insurance maximization problem. So for a pair $(R^\dagger, P^\dagger_{I-MC})$ to be a solution, IC-5 must bind.

Hence if 0< $\varepsilon_{Q,P}$ <-1 and $P_{I-MC} < \frac{\partial \emptyset}{\partial Q}$ the solution to the insurance problem is a pair of prices $(R^\dagger, P^\dagger_{I-MC})$ such that both IC-3 and IC-5 are binding.

Using an approach similar to the above, we can prove the other conclusions in Table A.1.

Combining the conclusions of Table A.1, proves proposition 2. ■

Proposition 3: *Under Managed Care, uninsured agents pay more for medical care,* $P_{UI-MC} \geq P_{UI-Indemnity}$, *when compared to the Indemnity regime if the elasticity of demand is such that* $\varepsilon_{Q,P} \leq \left(\frac{\partial \emptyset}{\partial Q_{I,H}} \frac{\partial Q_{I,H}}{\partial P_{I-MC}}\right) - 1 \ldots.(condition\ 3)$

Proof

Equations 5 and 7 above are the F.O.C. for the care provider under the Indemnity and managed care regimes respectively and are repeated here for convenience

$$\tau\left(Q_{I,H} + P\frac{\partial Q_{I,H}}{\partial P} - \frac{\partial \emptyset}{\partial Q_{I,H}}\frac{\partial Q_{I,H}}{\partial P}\right) + (1-\tau)\left(Q_{UI,L} + P\frac{\partial Q_{UI,L}}{\partial P} - \frac{\partial \emptyset}{\partial Q_{UI,L}}\frac{\partial Q_{UI,L}}{\partial P}\right)$$

$$= 0 \qquad \cdots\cdots\cdots(5)$$

$$(1-\tau)\left(Q_{UI,L} + P_{UI-MC}\frac{\partial Q_{UI,L}}{\partial P_{UI-MC}} - \frac{\partial \emptyset}{\partial Q_{UI,L}}\frac{\partial Q_{UI,L}}{\partial P_{UI-MC}}\right) = 0 \ \cdots\cdots\cdots(7)$$

Evaluating the indemnity F.O.C. at the solution to the care provider's problem under managed care P^*_{UI-MC} gives us

$$\left.\frac{\partial \pi_{MP}}{\partial P}\right|_{P^*_{UI-MC}} = \tau\left(Q_{I,H} + P\frac{\partial Q_{I,H}}{\partial P} - \frac{\partial \emptyset}{\partial Q_{I,H}}\left.\frac{\partial Q_{I,H}}{\partial P}\right|_{P^*_{UI-MC}}\right) = 0\cdots\cdots\cdots(9)$$

Where the second term in the equation above is zero as in equation (7).

The sign of $\left.\frac{\partial \pi_{MP}}{\partial P}\right|_{P^*_{UI-MC}}$ determines the relationship between price under indemnity,P, and the price paid by the uninsured under managed care, P^*_{UI-MC}.

In specific if $\left.\frac{\partial \pi_{MP}}{\partial P}\right|_{P^*_{UI-MC}} > 0$ then $P^*_{UI-MC} < P$ and if $\left.\frac{\partial \pi_{MP}}{\partial P}\right|_{P^*_{UI-MC}} < 0$ then $P^*_{UI-MC} > P$.

Keeping in mind that $P = P_{UI-Indemnity}$, deriving proposition 3 is straightforward from the above. ■

APPENDIX III

Algorithm for Recursive Equilibrium – Chapter 3

Following is the algorithm used to compute the recursive equilibrium describes in Section 3.4 of Chapter 3.

Given the set of calibrated parameter values, do the following:

BEGIN

<u>Step 1: Initializations</u>

- Start with initial values for prices $(\mathrm{r}, \mathrm{w}, \mathrm{q}, \mathrm{M}, \mathrm{I})$ call them $(\mathrm{r}_1, \mathrm{w}_1, \mathrm{q}_1, \mathrm{M}_1, \mathrm{I}_1)$
- Start with initial distribution of agents (μ) call it (μ_1)
- Start with initial values for value functions $\left(\mathrm{V}, \mathrm{V}^{\mathrm{Buy}}, \mathrm{V}^{\mathrm{Rent}}, \mathrm{V}^{\mathrm{Default}}, \mathrm{V}^{\mathrm{Repay}}, \mathrm{V}^{\mathrm{Own}}\right)$ call them $\left(\mathrm{V}_1, \mathrm{V}_1^{\mathrm{Buy}}, \mathrm{V}_1^{\mathrm{Rent}}, \mathrm{V}_1^{\mathrm{Default}}, \mathrm{V}_1^{\mathrm{Repay}}, \mathrm{V}_1^{\mathrm{Own}}\right)$

<u>Step 2: Value Function Iterations</u>

Given current estimates of value functions, prices, and agent distribution function

Step 2.a: Solve for agents decision functions and calculate new estimates for all value functions $\left(\mathrm{V}_2, \mathrm{V}_2^{Buy}, \mathrm{V}_2^{Rent}, \mathrm{V}_2^{Default}, \mathrm{V}_2^{Repay}, \mathrm{V}_2^{Own}\right)$

Step 2.b: Test for convergence of value functions

- If value functions did not converge-i.e. if $\left(\mathrm{V}_2, \mathrm{V}_2^{\mathrm{Buy}}, \mathrm{V}_2^{\mathrm{Rent}}, \mathrm{V}_2^{\mathrm{Default}}, \mathrm{V}_2^{\mathrm{Repay}}, \mathrm{V}_2^{\mathrm{Own}}\right) \neq \left(\mathrm{V}_1, \mathrm{V}_1^{\mathrm{Buy}}, \mathrm{V}_1^{\mathrm{Rent}}, \mathrm{V}_1^{\mathrm{Default}}, \mathrm{V}_1^{\mathrm{Repay}}, \mathrm{V}_1^{\mathrm{Own}}\right)$ – equate starting estimate to new estimate and repeat **Step 2**
- If value functions converged, continue to **Step 3**

Step 2.c: Update probability of default (Γ)and ownership and default sets ($\mathrm{Own}, \mathrm{Def}$)

Step 3: Update distribution of agents

Starting with current estimate of distribution of agents (μ_1)

Step 3.a: use optimal decision functions, the probability of default function, and ownership and default sets from **Step 2** as well as transition processes for income to calculate new estimate of agent distribution function (μ_2) ,

Step 3.b: Test for convergence of distribution function

- If distribution function did not converge-i.e. if ($\mu_1 \neq \mu_2$)- update distribution function estimate such that ($\mu_1 = \mu_2$)and repeat **Step 3**
- If distribution function converged, continue to **Step 4**

Step 4: Labor and Capital Markets Clearing

Given optimal decision functions from **Step 2** and stationary distribution of agents from **Step 3**

Step 4.a: Calculate total capital and total labor in the economy and use them to calculate updated prices ($\mathrm{r}_2, \mathrm{w}_2$)

Step 4.b: Capital and Labor Market clearing

- if Capital Market or Labor Market does not clear – i.e. if ($\mathrm{r}_1 \neq \mathrm{r}_2$) or ($\mathrm{w}_1 \neq \mathrm{w}_2$) - adjust value of total capital and/or total labor and go back to **Step 2**
- if asset market clears – i.e. if ($\mathrm{r}_1 = \mathrm{r}_2$) AND ($\mathrm{w}_1 = \mathrm{w}_2$) - **END**

Once the Algorithm describes above exists Step 4, all the recursive equilibrium conditions described in section 1.3.3 above would be met.

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