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HEALTH INSURANCE COVERAGE, INCOME DISTRIBUTION AND HEALTHCARE QUALITY IN LOCAL HEALTHCARE MARKETS

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ABSTRACT

We develop a theoretical model of a local healthcare system in which consumers, health insurance companies, and healthcare providers interact with each other in markets for health insurance and healthcare services. When income and health status are heterogeneous, and healthcare quality is associated with fixed costs, the market equilibrium level of healthcare quality will be underprovided. Thus, healthcare reform provisions and proposals to cover the uninsured can be interpreted as an attempt to correct this market failure. We illustrate with a numerical example that if consumers at the local level clearly understand the linkages between health insurance coverage and the quality of local healthcare services, health insurance coverage proposals are more likely to enjoy public support.

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1. INTRODUCTION

About 16% of the US population (48.6 million people) did not have health insurance coverage in 2010 (Cohen *et al*., 2011). Lack of health insurance coverage is strongly associated with lower access to healthcare and poorer health outcomes (McWilliams, 2009), and extant research suggests that uninsurance is not only detrimental to the health of uninsured individuals but also it could have a substantial impact on the quality and structure of local healthcare systems (Pauly and Pagán, 2007). The Congressional Budget Office estimates that the Patient Protection and Affordable Care Act (PPACA) of 2010 will reduce the number of uninsured in 2019 by 32 million people (KFF, 2011). However, it is unclear whether some PPACA provisions targeting reductions in the uninsured population (e.g. health insurance premium subsidies) will be implemented fully or even partly, given the rising costs of Medicare, slow US economic growth and concerns about the size of US budget deficits. The high costs of some PPACA provisions imply that taxpayers will start to 'ask for better evidence on the benefits from it, and, if evidence is lacking, cut back on the program in order to hold their overall taxes down' (Pauly, 2010: P. 5).

In its most recent (2009) health insurance report (*America's Uninsured Crisis: Consequences for Health and Health Care*), the Institute of Medicine's (IOM) Committee on Health Insurance Status and Its Consequences concluded that the size of the local population without health insurance coverage

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affects not just the uninsured but also the insured population in the same community. As healthcare services are rendered in the communities where physicians practice medicine and patients seek care, the availability and the quality of healthcare services may be tied to the characteristics of these local healthcare markets. One of the key findings of this IOM report is that 'local health care delivery appears to be vulnerable to the financial pressures associated with high community-level uninsurance rates' (IOM, 2009: P. 9). Thus, the proportion of the population with health insurance coverage at the local level is likely to be an important determinant of service quality, given that the insured population is the main revenue driver for local healthcare providers.

In this paper, we construct an equilibrium model, which explicitly recognizes the interdependence between the rate of uninsurance at the local level and the quality of healthcare services available in that community. The major conclusion of the model is that this interdependence generates a lower than optimal service quality level and a higher than optimal uninsurance rate in a local healthcare market. Efforts to extend health insurance coverage (e.g. by providing coverage to lower income community residents) may be welfare improving because they impact service quality at the local level. The effectiveness of initiatives that seek to extend health insurance coverage, however, depends on the characteristics of the local community, which has not been explicitly considered in the healthcare reform discussions to date.

As an example of the phenomena we try to capture, consider a hospital outpatient department, which sees rising numbers of uninsured patients. As these patients are unable to pay, the hospital department might be forced to stop providing some costly services, reduce its investments in expensive equipment or limit its hours of operation. Thus, services associated with high fixed costs (such as scanning or radiology services, or specialized care) are unlikely to be available even to insured patients who are willing and able to pay for services rendered to them (Pauly and Pagán, 2007). Although these community effects of uninsurance will not be evident at the national level, they are likely to arise at the local level, particularly in smaller communities, cities and states (Pauly and Pagán, 2008; Pagán and Pauly, 2006; Pagán *et al*., 2008; Pagán *et al*., 2007).

2. THE MODEL

Our model describes the interaction among *insurance companies*, *individuals* and *healthcare providers* in a local healthcare market. In this model, health insurance companies operate in a competitive market by offering health insurance contracts to individuals who have private information about their risk (probability) of getting sick and incurring medical costs. Depending on their risk type and their income, individuals decided whether to purchase health insurance coverage and, based on this decision, what type of health insurance contract to purchase. Healthcare providers decide on the quality of healthcare services offered in the market. In this model, *health insurance contracts*, *decisions to purchase health insurance coverage*, and *quality of healthcare services* are determined endogenously as a Nash equilibrium of the market game. In the following sections, we will analyze how healthcare reform efforts affect these equilibrium choices and the welfare of market participants. We continue with a more detailed description of the market setting.

2.1. Health insurance companies

We model the health insurance market as a free-entry competitive market in which health insurance companies offer insurance contracts as in the Rotschild–Stiglitz model (Rothschild and Stiglitz, 1976). In this market, individuals vary in their probability of developing a medical condition: high risk individuals have a probability of getting sick p^H (and incurring medical costs), and low-risk individuals have a corresponding probability of p^L, where $0 < p^L < p^H < 1$. Consumers have private information about their probability of getting sick and adverse selection leads to the existence of two health insurance contracts, one for each risk group.

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2.1.1. Rotschild–Stiglitz equilibrium contracts. In this market, health insurance companies offer two separate contracts for each risk group, whereby insurers earn an expected profit of zero with each of the contracts. The high-risk individuals are offered an actuarially fair full insurance contract, and the low-risk individuals are attracted by an actuarially fair co-insurance contract, which is designed in such a way that the high-risk individuals weakly prefer the full insurance contract to the co-insurance contract (see Rothschild and Stiglitz, 1976, Figure 3 on p. 636).[1]

2.2. Consumers

We assume that consumers vary by their income and their privately known health status. The size of the population in the local healthcare market is normalized to one, and it is assumed that income in the community follows a Pareto distribution.[2] We denote by $F(x) = 1 - \left[{}^{x_m}/_{x}\right]^{\alpha}$ the percentage of the population with income not higher than x. The parameters $x_m \geq 0$ and $\alpha > 1$ capture the lowest income and the income inequality in the community, respectively. Furthermore, for each income level x, the share of the high risk types is given by $h > 0$ and the share of low risk types by $l = 1 - h > 0$. The utility of consumers depends on their income (x) and the quality of healthcare services they can access (q), and the utility function takes the multiplicative form $u(x) \cdot v(q)$. Note that, although we allow for variation in service quality across local healthcare markets, service quality for a given market and provider is constant in the sense that providers deliver services of equal quality to all their customers, whether they are insured or uninsured (e.g. because of high fixed costs of differentiation, regulatory restrictions, etc.). We assume that individuals are strictly risk averse, that is, $u'(x) > 0$ and $u''(x) < 0$; the term $v(q)$ is increasing in q at a decreasing rate, that is, $v'(q) > 0$, and $v''(q) < 0$. Furthermore, $v(0) > 0$ so that individuals have a positive expected utility even if they do not use healthcare services.

Consumers seek to maximize their expected utility by deciding whether they purchase a health insurance contract and use the healthcare services available in the community. Healthcare providers offer healthcare services of quality q and charge a predetermined price for that quality equal to $p(q)$, which is an increasing function of the quality. With these preliminaries, the expected utility of high-risk consumers with income x who purchase the actuarially fair full insurance contract (FI) is given by

$$U^H(x, q; FI) = u\left(x - p^H \cdot q\right) \cdot v(q) \tag{1}$$

The expected utility of low-risk consumers with income x who purchase the co-insurance contract (CI_α) designed for them is given by

$$U^L(x, q; CI_\alpha) = \left[p^L \cdot u\left(x - (1-\alpha) \cdot p^L \cdot q - \alpha \cdot q\right) + \left(1 - p^L\right) \cdot u\left(x - (1-\alpha) \cdot p^L \cdot q\right)\right] \cdot v(q) \tag{2}$$

where α is the co-insurance rate. The amount that the individuals pay out of pocket for healthcare services used is $\alpha \cdot p(q)$, and the actuarially fair insurance premium is $(1-\alpha) \cdot p^L \cdot q$.

2.2.1. Equilibrium contracts and consumer choices. The Rotschild–Stiglitz equilibrium co-insurance rate α is such that high-risk types weakly prefer to purchase the full insurance contract, that is,

$$\begin{gathered} U^H(x, q; FI) = U^H(x, q; CI_\alpha) \Leftrightarrow \\ u(x - p^H \cdot q) = p^H \cdot u(x - (1-\alpha) \cdot p^L \cdot q - \alpha \cdot q) + (1 - p^H) \cdot u(x - (1-\alpha) \cdot p^L \cdot q) \end{gathered} \tag{3}$$

In this setting, the decision to obtain health insurance coverage and use healthcare services depends on the income level. An individual without health insurance coverage retains its entire income x but does not have

[1]It is well known that the Rotschild-Stiglitz model might not have an equilibrium. Equilibrium exists, however, when the costs for the low risk individuals of pooling with the high risk individuals are sufficiently high. This occurs when the probabilities p^H and p^L are sufficiently different or when the share of high risks in the population is large enough so that no firm can enter the market and attract all individuals with a full insurance contract. Our model assumes that this is the case.

[2]The Pareto density has traditionally been used in economics to represent the distribution of personal income (Champernowne, 1953; Mandelbrot, 1960; Singh and Maddala, 1976).

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access to healthcare and realizes a utility of $U(x,0) = u(x) \cdot v(0)$. We define the threshold levels at and above which high-risk and low-risk individuals purchase health insurance by the equations

$$x_T^H(q) : U^H(x, q; FI) = U(x, 0) \tag{4}$$

$$x_T^L(q) : U^L(x, q; CI_\alpha) = U(x, 0) \tag{5}$$

In the following analysis, we restrict attention to utility functions U^H and U^L such that these threshold values are increasing in q.

2.3. Healthcare system

Healthcare quality is associated with fixed costs $k(q)$, and it is assumed that $k'(q) > 0$ and $k''(q) > 0$. The expected total cost of the local healthcare system is given by

$$C\left(q, I^H, I^L\right) = k(q) + c \cdot \left(p^H \cdot I^H + p^L \cdot I^L\right) \tag{6}$$

where $I^H = h\left[1 - F\left(x_T^H\right)\right]$ is the share of the high-risk individuals with health insurance, and $I^L = l\left[1 - F\left(x_T^L\right)\right]$ is the share of low-risk individuals with health insurance. The marginal cost of the service is given by $c > 0$. The expected revenue of healthcare providers from serving individuals of risk group $i = H, L$ is given by

$$R\left(q, I^i\right) = p(q) \cdot p^i \cdot I^i. \tag{7}$$

Total revenue is then

$$R\left(q, I^H, I^L\right) = R\left(q, I^H\right) + R\left(q, I^L\right) \text{ and} \tag{8}$$

the quality of services provided in the local healthcare system q is determined in such a way that the profit

$$\pi\left(q, I^H, I^L\right) = R\left(q, I^H, I^L\right) - C\left(q, I^H, I^L\right) \tag{9}$$

is maximized.

2.4. Equilibrium

A Nash equilibrium in this market consists of a pair of *health insurance contracts* $\left\{(FI)^*, (CI_\alpha)^*\right\}$, income *threshold levels* $\left\{x_T^{H*}, x_T^{L*}\right\}$ corresponding to *population shares* of insured individuals $\{I^{H*}, I^{L*}\}$, and *quality* of healthcare services q^* satisfying the following three conditions:

A) Insurance companies offer a full insurance contract $(FI)^*$ at a premium rate of $p^H \cdot q^*$ and a co-insurance contract at a premium rate $(1 - \alpha^*) \cdot p^L \cdot q^*$ where α^* is the solution to Equation (3).
B) High (low) risk individuals with income at or above x_T^{H*} $\left(x_T^{L*}\right)$ find it optimal to purchase health insurance coverage, and individuals with incomes below these thresholds find it optimal to remain uninsured.
C) The service quality q^* maximizes the expected profit of the healthcare system $\pi(q, I^{H*}, I^{L*})$.

With these preliminaries, we can now graphically describe the equilibrium allocation as a pair of the proportion of the local population with health insurance coverage and the healthcare quality level. Let us denote by $I(q) = p^H \cdot I^H(q) + p^L \cdot I^L(q)$ the number of individuals who have health insurance coverage and use healthcare services when sick. Similarly, we denote by $q(I)$ the optimal healthcare quality, given the proportion of individuals with health insurance coverage in the community. The equilibrium quality and health insurance coverage rates are presented by the solid lines in Figure 1.

Next, we explore how the quality of the service available and the percentage of insured individuals depend on the characteristics of the income distribution in the community, captured by average income and income inequality. In the following analysis, we use the following property of the Pareto distribution.

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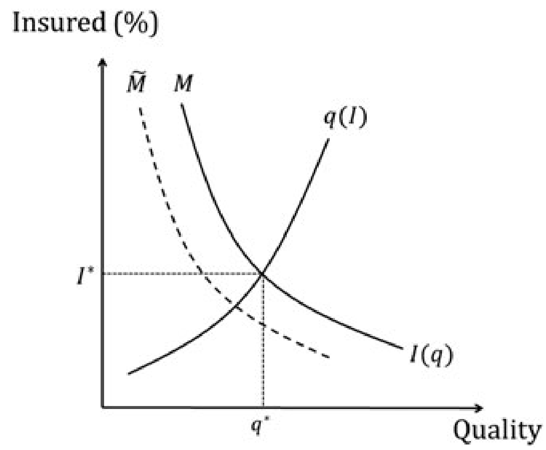

Figure 1. Best responses of consumers and healthcare providers (solid lines) and the Nash equilibrium in the local healthcare market

Property 1 (Average Income and Inequality). *Let Y be the average income and let G be the Gini (income inequality) index of a community with Pareto income distribution given by*

$$F(x) = 1 - \left[{}^{x_m}/_{x}\right]^{\alpha}.$$

The income distribution can be expressed in terms of Y and *G as follows*

$$F(x;Y,G) = 1 - \left[\frac{Y\cdot(1-G)}{(1+G)} \Big/ x\right]^{(1+G)/2G}$$

Proof. The Gini index and the average income depend on the coefficients of the Pareto distribution as follows (see e.g. Gastwirth 1972)

$$G = {}^{1}/_{(2\alpha-1)}$$

$$Y = {}^{\alpha\cdot x_m}/_{(2\alpha-1)}$$

Solving this system of equations for the parameters of the Pareto distribution, we obtain

$$x_m = {}^{Y\cdot(1-G)}\Big/_{(1+G)}$$

$$\alpha = {}^{(1+G)}\Big/_{2G}$$

The next property describes the effect of average income on quality and uninsurance in the local healthcare market.

Property 2 (Variation in Average Income). *Consider two communities, M and $\tilde{M}$, with the same income inequality (Gini) index but different average incomes, and assume that average income in community $\tilde{M}$ is lower. In equilibrium, the less affluent community will have a higher percentage of uninsured individuals and a lower quality of healthcare services.*

Proof. We will first show that if $Y > \tilde{Y}$, then the income distribution function $F(x;Y,G)$ stochastically dominates the function $F\left(x;\tilde{Y},G\right)$ to the first degree. That is, $F(x;Y,G) < F\left(x;\tilde{Y},G\right)$ for all $x \geq {}^{Y}\cdot(1-G)/_{(1+G)}$. For this purpose, it will suffice to show that $F(x;Y;G)$ is decreasing in Y. The partial derivative with respect to Y is given by

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$$\frac{\partial F(x;Y,G)}{\partial Y} = -\frac{d\left[Y^{(1+G)}\big/_{2G}\right]}{dx}\cdot\left[\frac{(1-G)}{(1+G)}\Big/_{x}\right]^{(1+G)\big/_{2G}} < 0.$$

Observe that the income threshold values $x_T^H(q)$ and $x_T^L(q)$ determined by Equations 4 and 5 are independent of the income distribution in the community. As the income distribution in community M stochastically dominates the income distribution in community $\tilde{M}$ to the first degree, for given thresholds $x_T^H(q)$ and $x_T^L(q)$, the percentage of people with incomes higher than these cutoff levels will be smaller in community $\tilde{M}$ (i.e. if $F(x;Y,G) < F\left(x;\tilde{Y},G\right)$ then $I = 1 - F\left(x_T^i(q);Y,G\right) > 1 - F\left(x_T^i(q);\tilde{Y},G\right) = \tilde{I}$, $i = H, L$). Hence, the position of the 'best response' curves M and $\tilde{M}$ relative to each other is as shown in Figure 1.

The next property establishes a relationship between income inequality and the health insurance coverage rates.

Property 3 (Variation in Inequality). *Consider two communities, M and $\tilde{M}$, with the same average income but different income inequality (Gini) indices. Assume that community M has a more equitable distribution of income (i.e. $G < \tilde{G}$) and that the average-income citizens of both risk groups are uninsured in equilibrium. The community with the higher income inequality, $\tilde{M}$, has a higher percentage of uninsured individuals and a lower quality of healthcare services.*

The proof is given in the Appendix.

3. WELFARE ANALYSIS

In this section, we analyze the welfare properties of the equilibrium allocation. We measure the consumer surplus of a community member by his/her willingness to pay for access to the service. The willingness to pay for a healthcare service of quality q of an individual with income x and a risk type $i = H, L$ is given by $\varphi_i(x,q)$. The high risk consumers have access to a full insurance contract, and therefore, the maximum amount they would pay is given by the equation

$$\varphi_H(x,q) : u(x - \varphi_H(x,q))\cdot v(q) = U^H(x,0). \tag{10}$$

The low risk types buy a co-insurance contract, and their willingness to pay an insurance premium $\tilde{\varphi}_L(x,q)$ for this contract is determined by the equation:

$$\tilde{\varphi}_L(x,q) : [p_L\cdot u(x - \tilde{\varphi}_L(x,q) - \alpha\cdot p(q)) + (1-p_L)u(x - \tilde{\varphi}_L(x,q))]\cdot v(q) = U^L(x,0). \tag{11}$$

As the low risk types also pay out of pocket, their willingness to pay for the entire service is then the sum of the insurance premium and the (expected) co-insurance payment:

$$\varphi_L(x,q) = \tilde{\varphi}_L(x,q) + p_L\cdot\alpha\cdot p(q).$$

With this definition, the following relationships can be established:

Property 4. *The willingness to pay $\varphi_i(x,q)$ is increasing in income x for any given quality q.*

Proof. We establish this relationship for the high-risk consumer. The proof for the low-risk consumer is analogous. From the definition of $\varphi_H(x,q)$, we have

$$\frac{u(x-\varphi_H)}{u(x)} = \frac{v(0)}{v(q)} \Leftrightarrow$$
$$\frac{u(x) - u(x-\varphi_H)}{u(x)} = 1 - \frac{v(0)}{v(q)}$$

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From the assumption that $u(x)$ is increasing and concave, it follows that the numerator of the left-hand side is decreasing in x and increasing in φ_i and the denominator is increasing in x. It follows that the left-hand side is decreasing in x and increasing in φ_H. The right-hand side is constant when q is fixed. Hence, an increase in x needs to be offset by an increase in φ_H for the left hand-side quotient to remain constant, and $\varphi_H(x,q)$ is thus increasing in x.

Property 5. *The willingness to pay for an increase in quality is higher for higher income community members. Alternatively, an increase in income brings more value to members of communities with a higher quality of care. Formally,*

$$\frac{\partial^2 \varphi_i(x,q)}{\partial x \partial q} > 0.$$

Proof. We establish this relationship for the high-risk consumer. The proof for the low-risk consumer is analogous. From the definition of $\varphi_i(x,q)$, we obtain

$$u(x) = \frac{v(q)}{v(0)} \cdot u(x - \varphi_H(x,q)).$$

The derivative with respect to x can be expressed as

$$\frac{du(x)}{dx} = \frac{v(q)}{v(0)} \cdot \left[\frac{\partial u(x-\varphi_H)}{\partial x} + \frac{\partial u(x-\varphi_H)}{\partial \varphi_H} \cdot \frac{\partial \varphi_H(x,q)}{\partial x}\right] \Leftrightarrow$$
$$\frac{du(x)}{dx} = \frac{v(q)}{v(0)} \cdot \frac{\partial u(x-\varphi_H)}{\partial x}\left[1 - \frac{\partial \varphi_H(x,q)}{\partial x}\right].$$

If x is kept constant and q increases, $\partial u(x - \varphi_H(x,q))/\partial x$ also increases because $v(q)$ and $\varphi_H(x,q)$ are increasing in q. We conclude that $1 - \partial \varphi_H(x,q)/\partial x$ must be decreasing in q, and therefore, $\partial \varphi_H(x,q)/\partial x$ is increasing in q. Alternatively, $\partial \varphi_H(x,q)/\partial q$ is increasing in x.

Social optimum. To derive the socially optimal quality, we consider the problem of a social planner who chooses the quality of the service and the recipients of healthcare services so as to maximize total welfare (measured by total consumer surplus minus costs). For a given quality q, to maximize welfare, the social planner serves all individuals with willingness to pay $\varphi_i(x,q)$, $i = H, L$ not lower than the expected marginal cost $p^i \cdot c$. Let us denote by $x_e^i(q^*)$ the (efficiency) threshold values of income above which the consumer surplus exceeds the expected marginal cost of the service as shown in Figure 2. For a given quality q, total consumer surplus of risk group i is

$$S_i(q) = \int_{x_e^i(q)}^{\infty} \varphi_i(x,q) \cdot f(x) dx$$

The social planner chooses the quality of the service so as to maximize total welfare

$$W(q) = S_H(q) + S_L(q) - C(q).$$

The first order condition for the welfare maximizing quality is thus

$$S'_H(q) + S'_L(q) = C'(q).$$

Before we present our main result on the welfare properties of the Nash equilibrium, we provide an auxiliary result to be used in the subsequent analysis.

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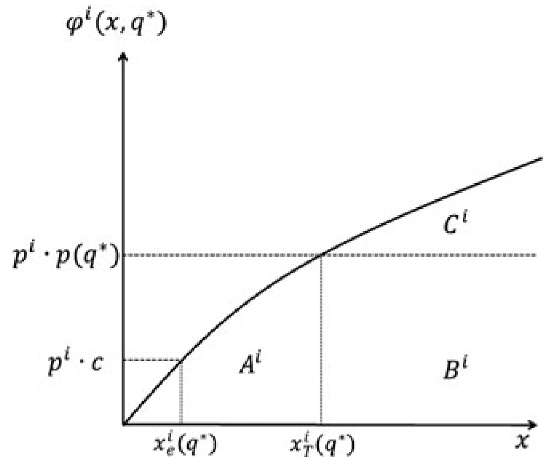

Figure 2. Income thresholds and consumer surplus

Property 6. *For each quality level q, the local healthcare system will be serving less customers than socially optimal in each risk group* $i = H, L$. *The socially optimal income threshold value* $x_e^i(q)$ *is lower than the market threshold value* $x_T^i(q)$ *for each risk group.*

Proof. The profit maximizing local healthcare system will provide the service only if it can make non-negative profits. Therefore, because of the fixed cost component $k(q)$ associated with the provision of healthcare services, the local healthcare system charges a price $p(q)$ higher than the marginal cost c if a quality $q > 0$ is offered in the market. Recall that $x_e^i(q)$ and $x_T^i(q)$ are the solutions to the equations $\varphi_i(x,q) = p^i \cdot c$ and $\varphi_i(x,q) = p^i \cdot p(q^*)$, respectively, and because $\varphi_i(x,q)$ is increasing in x (see Property 4), it follows that $x_e^i(q) < x_T^i(q)$ as shown in Figure 2.

Theorem 1 (*Main Result*). If all community residents pay health insurance premiums that are actuarially fair for their risk group, in Nash equilibrium, the quality of the healthcare service at the local level will be underprovided (compared with the socially optimal level).

Proof. We will show that, for the equilibrium service quality, the social benefit of a marginal increase in the quality of the service is greater than the marginal revenue obtained by the healthcare system. As a consequence, although an increase in quality beyond the market equilibrium level is socially desirable, this increase will not materialize because of the lack of incentives on the supply side of the local healthcare market. We break down the total consumer surplus for various income groups as follows:

$$A^i(q^*) = \int_{x_T^i(q^*)}^{x_e^i(q^*)} \varphi_i(x, q^*) \cdot f(x) dx$$

$$B^i(q^*) = \int_{x_T(q^*)}^{\infty} \varphi_i\left(x_T^i(q^*), q^*\right) \cdot f(x) dx = p^i \cdot p(q^*) \cdot \left[1 - F\left(x_T^i(q^*)\right)\right]$$

$$C^i(q^*) = \int_{x_T(q^*)}^{\infty} \left[\varphi_i(x, q^*) - \varphi_i\left(x_T^i(q^*), q^*\right)\right] \cdot f(x) dx$$

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These sections of consumer surplus are represented in Figure 2. The expression $A_i(q^*)$ captures the surplus of individuals who remain uninsured, yet their surplus is above the marginal cost of the healthcare providers. In equilibrium, these individuals do not receive care and do not pay, yet it would be socially efficient to provide services to them, and they would potentially benefit from an increase in service quality. The section $B_i(q^*) + C_i(q^*)$ represents the social surplus of the insured individuals. We note that the healthcare system receives in revenue only $B^i(q^*)$ because all insured individuals pay the same health insurance premium (adjusted for their risk group), which equals the surplus of the consumer with the threshold income $x_T^i(q^*)$. With these definitions, we obtain for the social surplus

$$S_i(q^*) = A_i(q^*) + B_i(q^*) + C_i(q^*),$$

and for the healthcare system revenue

$$R_i\left(q^*, I^{i*}\right) = B_i(q^*).$$

In Property 4, we established that $\varphi^i(x,q)$ is increasing in q and, hence, $A'_i(q) + C'_i(q) > 0$ for $q \geq q^*$ (Figure 2). It follows that

$$S'_i(q) > B'_i(q) = R'_i(q, I^*).$$

Hence

$$S'_H(q^*) + S'_L(q^*) > R'_H(q^*, I^*) + R'_L(q^*, I^*) = C'_H(q^*).$$

That is, increasing healthcare quality above the Nash equilibrium quality generates a social surplus in excess of the healthcare system's additional cost. The result follows.

The market failure described in Theorem 1 bears some resemblance to the market failure existing in standard adverse selection models. In a market where individuals vary by risk type, the availability of a single insurance premium causes low-risk types to leave the market. It is well known that this behavior leads to a Pareto inferior situation where only high-risk types buy insurance contracts at high premiums.

Similarly, in the current model, high-income individuals experience a greater benefit from an increase in healthcare quality than lower income individuals. If individuals pay actuarially fair premiums regardless of their income, a potential increase in quality—and potentially higher premiums—causes lower income individuals to drop coverage. In other words, we observe adverse selection into insurance based on income.[3] This behavior reduces healthcare provider revenues leading to lower than optimal healthcare quality. Thus, in our model, even if the standard adverse selection problem is resolved because of the availability of different insurance contracts, inefficiency remains when the premiums do not vary additionally by income.

There are two sources of inefficiency in the market allocation, leading to lower than socially optimal quality. First, the residents who are willing to pay a price above marginal cost—but below the equilibrium price—are uninsured and do not receive care. They would benefit from an increase in the quality of the service, yet the market solution does not account for this benefit. Second, residents with incomes higher than the threshold resident (i.e. the resident with income $x_T(q^*)$) would benefit more than the threshold resident from an increase in the quality of the service (see Property 5), yet this potential benefit is not reflected in the profit maximization problem of healthcare providers.

[3]We thank an anonymous reviewer for suggesting this analogy to the inefficiency arising in markets with adverse selection.

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4. HEALTHCARE REFORM PROPOSALS

In this section, we analyze the social desirability of different healthcare reform provisions. We present a general formulation of a reform proposal, and then focus on some specific examples of reforms. A reform proposal $(P_r(x), \tau_r(x))$ is defined by the function $P_r(x)$ specifying the subsidy (expressed as a percentage of the cost of the insurance policy) to an individual with income x for the purchase of a health insurance policy, and an income tax rate $\tau_r(x)$ that generate tax revenues to finance the reform expenditures. A reform proposal is feasible if the tax revenue is sufficient to finance the subsidy to individuals. This budget constraint is given by

$$\int_{x_m}^{\infty} P_r(x) \cdot f(x) dx = \int_{x_m}^{\infty} \tau_r(x) \cdot f(x) dx.$$

We will focus on proposals which combine a mandate to purchase health insurance coverage and a subsidy to provide coverage for a particular income group and analyze the social/political support for two examples of such reforms. These types of reforms can easily be analyzed in the current setting because if all community members are covered, then $I_r = 1$, $q_r = q(I_r) = q(1)$, and the price of the insurance policy corresponds to the average individual healthcare expenditures $E(q_r) = (l \cdot p^L + h \cdot p^H) \cdot p(q_r)$. Furthermore, if the reform is financed by a proportional income tax, the budget constraint is given by

$$\int_{x_m}^{\infty} E(q_r) \cdot P_r(x) \cdot f(x) dx = \int_{x_m}^{\infty} \tau_r \cdot x \cdot f(x) dx \Leftrightarrow$$

$$E(q_r) \cdot \int_{x_m}^{\infty} P_r(x) \cdot f(x) dx = \tau_r \cdot Y.$$

The social/political support for a particular reform will be measured by the percentage of people who would vote in favor of the proposal, where being in favor of the proposal means having a higher consumer surplus with the reform proposal compared with the utility attained in the Nash equilibrium of the market. We define for each risk group $i = H, L$ the indicator function

$$V_r^i(x) = \begin{cases} 1 & \text{if} \quad \varphi_i(x, q_r) - \tau_r x + P_r(x) \geq \varphi_i(x, q^*) - p^i \cdot p(q^*) \\ 0 & \text{otherwise} \end{cases}$$

which assigns the value of one if the individual with income x derives a higher consumer surplus under the proposed reform r as compared with the status quo (the Nash equilibrium), and zero otherwise. The percentage of people in favor of the proposal can thus be calculated as

$$\sum_{i=H,L} \int_{x_m}^{\infty} V_r^i(x) \cdot f(x) dx.$$

4.1. Universal coverage (U)

This proposal provides free coverage to all community members financed entirely through a (proportional) income tax. Thus, $P_U(x) = 1$ for all $x \geq x_m$. The budget constraint is given by $E(q_r) = \tau_r \cdot Y \Leftrightarrow \tau_r = E(q_r)/Y$.

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4.2. Low-income coverage (e.g. Medicaid) (M)

This proposal sets an income threshold x_M below which individuals receive free coverage, and finances these expenses with a proportional income tax. Thus,

$$P_M(x) = \begin{cases} E(q_r) & \text{for } x_m \le x \le x_M \\ 0 & \text{for } x > x_M \end{cases}$$

The budget constraint is given by

$$E(q_r) \cdot F(x_M) = \tau_M \cdot Y \Leftrightarrow \tau_M = E(q_r) \cdot F(x_M)/Y.$$

Property 7. *An optimally designed low-income coverage reform proposal enjoys public support at least as high as the support for universal coverage.*

Proof. In the optimal low-income coverage proposal, x_M is chosen in such a way that the percentage of people in favor of the proposal is maximized. Universal coverage is, thus, a special case of the low-income coverage proposal in which $x_M = \infty$ and public support for this particular proposal cannot be larger than the support for the low-income coverage proposal.

5. NUMERICAL EXAMPLE

To illustrate how consumers with different characteristics would respond to these proposals, we use a numerical example in which the willingness to pay of high and low medical risk individuals is given as follows:

$$\varphi_L(x,q) = a_L \cdot \sqrt{x}\sqrt{q},$$
$$\varphi_H(x,q) = a_H \cdot \sqrt{x}\sqrt{q},$$

where a_H and a_L are parameters, $0 < a_L < a_H$. Further, we assume that the healthcare system sets a price $p(q) = q$, the fixed cost of providing the service is given by $k(q) = q^2/4$ and the marginal cost for providing healthcare services is normalized to zero. The distribution of income, as previously noted, is given by a Pareto distribution $F(x) = 1 - \left[{}^{x_m}/_{x}\right]^{\alpha}$ where $\alpha > 1$. Our next property describes the Nash equilibrium quality and the percentage of insured individuals for this numerical example.

Property 8. *In a Nash equilibrium, the percentage of insured individuals I* and the quality q* of healthcare services is described by the following best response functions*

$$I(q) = h \cdot \left(\frac{\left[\frac{a_H}{p^H}\right]^2 \cdot x_m}{q} \right)^{a} + l \cdot \left(\frac{\left[\frac{a_L}{p^L}\right]^2 \cdot x_m}{q} \right)^{\alpha}$$
$$q(I) = 2 \cdot (h \cdot p^H + l \cdot p^L) I$$

Proof. For a given quality q, the threshold values $x_T^i(q)$ are determined by the solution to the equations

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$$a_i \cdot \sqrt{x}\sqrt{q} = p^i \cdot q, i = H, L \Leftrightarrow$$
$$x_T^i = \left[\frac{p^i}{a_i}\right]^2 \cdot q.$$

The total share of insured individuals in the community is then

$$I(q) = l \cdot \left[1 - F\left(x_T^L(q)\right)\right] + h \cdot \left[1 - F\left(x_T^H(q)\right)\right] = l \cdot \left(\frac{\left[\frac{a_L}{p^L}\right]^2 \cdot x_m}{q}\right)^\alpha + h \cdot \left(\frac{\left[\frac{a_H}{p^H}\right]^2 \cdot x_m}{q}\right)^\alpha$$

The healthcare system maximizes profit $(h \cdot p^H + l \cdot p^L)\, I \cdot q - q^2/4$, which reaches a maximum for $q(I) = 2 \cdot (h \cdot p^H + l \cdot p^L)\, I$.

For analytical tractability of the following policy proposals, we assume there is just one risk group. In particular, we consider the values $a_L = p^L = 1/2$, $a_H = p^H = 1/2$ and $l = h = 1/2$ in the following calculations. We obtain $\varphi_L(x,q) = \varphi_H(x,q) := \varphi(x,q) = \frac{1}{2}\sqrt{x}\sqrt{q}$. For these values, we obtain the equilibrium insurance level and quality as follows: $I^* = q^* = (x_m)^{\alpha/(\alpha+1)}$.

We consider now four communities that vary in the parameter for the lowest income, x_m, and the parameter α of the Pareto distribution. Income is measured in units of \$10,000, and the four communities considered are given in Table I below. In this table, we provide the average per capita income, Y, the Gini index G, and the equilibrium level of insurance I^* we calculated for each of the four communities considered.

In agreement with Properties 3 and 4, communities with higher income inequality and communities with lower average income have a smaller percentage of insured individuals in equilibrium.

5.1. Universal coverage

Next, we examine the popularity of the universal health coverage proposal financed with a proportional income tax. Who will be in favor and who will be opposing this proposal? An individual who has health insurance coverage will be in favor only if the additional surplus from the increased healthcare quality exceeds the additional tax burden associated with financing universal coverage. These are the individuals with income below $\hat{x}$ depicted in Figure 3.

We solved the current numerical examples with *Mathematica* and reported the income thresholds, the proportional income tax, and the percentage of the population in favor of universal coverage in Table II below.

Table II illustrates that in more affluent communities, there is a stronger support for universal coverage (compare A versus C and B versus D) because the income tax to be imposed on the community residents to finance this proposal is lower. Table III also shows that in communities with a greater income inequality (compare A versus D), there is more support for the universal coverage proposal. To understand this result, observe that higher income inequality is associated with higher uninsurance rates (Table I), so covering the uninsured in these communities leads to greater improvements in service quality, and thus, the proposal will receive the support from more affluent residents.

Table I. Average income, Gini coefficient, and percentage of insured individuals in a local healthcare market

Y, G, I^*	$\alpha = 1.5$	$\alpha = 2$
$x_m = 1/2$	(A): $15,000; \frac{1}{2}; 65.98\%$	(C): $10,000; \frac{1}{3}; 62.10\%$
$x_m = 3/4$	(B): $22,500; \frac{1}{2}; 84.15\%$	(D): $15,000; \frac{1}{3}; 82.55\%$

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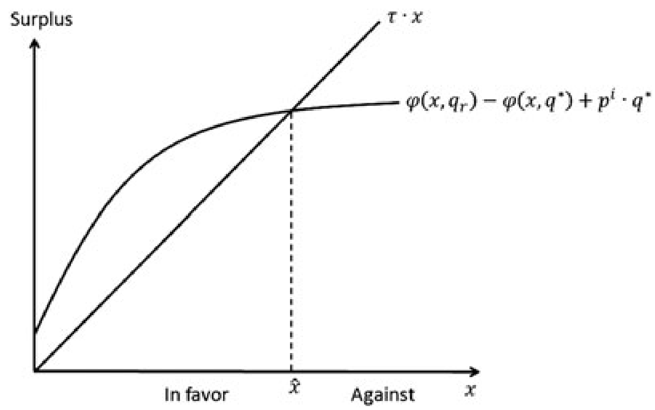

Figure 3. Consumer surplus, income tax and income threshold

Table II. Universal coverage: percentage of the population in favor, proportional income tax τ (%), income threshold $\hat{x}$ below which individuals are in favor of the proposal

% in favor, τ, $\hat{x}$	$\alpha = 1.5$	$\alpha = 2$
$x_m = 1/2$	(A): 76.5%, $\tau = 33.3\%, \hat{x} = 13,122$	(B): 62.5%, $\tau = 50.0\%, \hat{x} = 8,164$
$x_m = 3/4$	(C): 79.6%, $\tau = 22.2\%,\ \hat{x} = 21,672$	(D): 71.3%, $\tau = 33.3\%, \hat{x} = 14,005$

Table III. Expansion of healthcare coverage for low-income individuals: percentage of the population in favor, proportional income tax (%)

% in favor, t	$\alpha = 1.5$	$\alpha = 2$
$x_m = 1/2$	(A): 82.9%, $t = 27.6\,\%$	(B): 78.4%, $t = 39.2\,\%$
$x_m = 3/4$	(C): 84.5%, $t = 18.8\,\%$	(D): 81.5%, $t = 27.2\,\%$

5.2. Low-income coverage

The optimal policy sets the threshold income level x_M (below which people receive health insurance coverage) so that the public support for the proposal measured by the percentage of the community in favor of the proposal,

$$\int_{x_m}^{\infty} V_M(x) \cdot f(x) dx,$$

is maximized given the budget constraint.

$$q_r \cdot F(x_M) = \tau_M \cdot Y \Leftrightarrow \tau_M = E(q_r) \cdot F(x_M)/Y.$$

The results are presented in Table III above.

Probably the most important conclusion to draw when comparing Tables II and III is that the expansion of health insurance coverage to low-income persons receives greater public support than universal coverage because of the relatively lower tax rates needed to implement such an income eligibility expansion. Similar to universal coverage, however, the expansion of health insurance coverage to low-income persons is more desired in the more affluent communities (compare A versus C and B versus D) and enjoys a greater support in the community with greater income inequality (compare A versus D).

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6. CONCLUSION

In this paper, we modeled the interaction among individuals, health insurance companies, and healthcare providers in local healthcare markets. In this model, individuals decide whether to purchase health insurance depending on their income, risk type, and insurance contracts available; health insurance companies design insurance contracts for each risk type; and healthcare providers decide on the quality of healthcare services in the market. Our model shows that when the quality of healthcare services in a local market/community is associated with high fixed costs, then healthcare quality is underprovided. The model takes into account the endogeneity of health insurance purchasing decisions by individuals, the incentives of healthcare providers to provide high quality care, and the distribution of income in the local community. When healthcare providers charge a price not lower than average cost, individuals who are willing and able to pay a price above marginal cost (but below the Nash equilibrium price) have no access to healthcare services. These people would potentially benefit from an increase in the quality of the service, yet this gain remains unrealized. Thus, proposals to cover the uninsured population not only benefit individuals who lack adequate access to the healthcare system but also they could have a significant impact on healthcare quality at the local level by addressing this market failure. Support for covering the local-level uninsured population will vary substantially across both income levels and the distribution of income in local communities. This last finding is certainly reflected in the varying degrees of enthusiasm—and the heterogeneity in political will—by which local communities and states have attempted to addressed healthcare reform in recent years (e.g. Massachusetts versus California; Gruber, 2008a).

We also show that if the linkages between community-level health insurance coverage and healthcare quality were transparent (i.e. clearly understood), then policy proposals to extend coverage to income groups that would otherwise remain uninsured would enjoy higher public support compared with the status quo. Thus, the potential benefits resulting from health insurance coverage reform efforts based on premium subsidies or tax credits targeting low-income people could be larger than previously thought (e.g. Gruber, 2008b) because of the way in which increasing coverage addresses a key community level market failure arising from higher quality being associated with higher fixed costs.

Besides the potential theoretical benefits of the different health insurance coverage approaches analyzed here, there is also some empirical evidence of how health insurance coverage can benefit individual health outcomes (Pauly, 2010; McWilliams, 2009) as well as the quality of local healthcare services available to everyone (IOM, 2009; Pauly and Pagán, 2008). In the end, the eventual adoption of different features of PPACA dealing with health insurance coverage—and the consideration of new alternatives to coverage under the changing political and ideological landscape—over the next few years will hinge in our knowledge on how these features (i.e. premium subsidies, tax credits, etc.) can lead to perceived individual and social benefits as seen by taxpayers.

APPENDIX

PROOF OF PROPERTY 3

We will show that $F(x;Y,G) < F\left(x;Y,\tilde{G}\right)$ for all $x \geq Y$ and use arguments similar to the ones presented in the proof of Property 2 to establish the claim. Again, it will be sufficient to show that $F(x;Y,G)$ is increasing in G for $x < Y$. Rearranging terms we obtain

$$F(x;Y,G) = 1 - \left[{}^{Y}\!\big/_{x}\right]^{(1+G)/2G} \left[{}^{(1-G)}\!\big/_{(1+G)}\right]^{(1+G)/2G}.$$

To demonstrate that $F(x;Y,G)$ is increasing in G, we will show that the functions

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$$\left[{}^{Y}\!\big/_{x}\right]^{(1+G)/_{2G}}$$

and

$$\left[{}^{(1-G)}\!\big/_{(1+G)}\right]^{(1+G)/_{2G}}$$

are both decreasing in G. It is easy to see that the first term is decreasing in G because the expression in the exponent ${}^{(1+G)}\!/_{2G} = {}^{1}\!/_{2G} + {}^{1}\!/_{2}$ is decreasing in G, and ${}^{Y}\!/_{x} > 1$ for $x < Y$. For the partial derivative of the second term, we obtain

$$\frac{d}{dG}\left[{}^{(1-G)}\!\big/_{(1+G)}\right]^{(1+G)/_{2G}} = \left[{}^{(1-G)}\!\big/_{(1+G)}\right]^{(1+G)/_{2G}} \cdot \left[-\frac{1}{G(1-G)} - \frac{1}{2G^2}\cdot ln\left[{}^{(1-G)}\!\big/_{(1+G)}\right]\right]$$

To show that this partial derivative is negative, we need to demonstrate that

$$-\frac{1}{G(1-G)} - \frac{1}{2G^2}\cdot ln\left[{}^{(1-G)}\!\big/_{(1+G)}\right] < 0.$$

This inequality is equivalent to

$$\begin{aligned} -\frac{1}{(1-G)} - \frac{1}{2G}\cdot ln\left[{}^{(1-G)}\!\big/_{(1+G)}\right] < 0 &\Leftrightarrow \\ -\frac{2G}{(1-G)} < ln\left[{}^{(1-G)}\!\big/_{(1+G)}\right] &\Leftrightarrow \\ e^{-{}^{2G}/_{(1-G)}} < \frac{1-G}{1+G} &\Leftrightarrow \\ e^{{}^{2G}/_{(1-G)}} > \frac{1+G}{1-G}. & \end{aligned}$$

The inequalities

$$e^{{}^{2G}/_{(1-G)}} > e^{{}^{(1+G)}/_{(1-G)}} > {}^{(1+G)}\!\big/_{(1-G)}$$

establish the desired result (recall that $0 < G < 1$).

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