Assessing the Distributional Effects of Alternative Pharmaceutical Payment Structures

Christina M.L. Kelton*
College of Business
University of Cincinnati
P.O. Box 210223
Cincinnati, OH 45221, USA
chris.kelton@uc.edu

Robert P. Rebelein
Department of Economics
Vassar College
124 Raymond Ave., Box 290
Poughkeepsie, NY 12604, USA
rebelein@vassar.edu

January 2009

Abstract

This research uses a general-equilibrium monopoly production model with heterogeneous consumers to assess the distributional impact of different classes of public policies that could potentially be used to deal with high and rising pharmaceutical costs. We evaluate programs similar to Medicaid and Medicare as well as a program of universal prescription drug coverage. The model is calibrated to approximate the United States economy and its pharmaceutical industry. Results suggest that average social welfare is highest in an economy without prescription drug insurance. However, certain cohorts, such as those eligible for Medicare and pharmaceutical manufacturers, are worse off without publicly-funded insurance. Whereas universal insurance is shown to improve social welfare overall, it does not necessarily improve the well-being of the uninsured.

Key words: public health care expenditures, general equilibrium, pharmaceutical markets, pharmaceutical insurance, Medicare and Medicaid.

JEL Codes: H51, I11, D61

*We thank Neil Wallace for allowing us to use this model, which is based on an unpublished manuscript, available from the authors on request. We are also very grateful to W. David Kelton for suggesting the Beta distribution as a tractable approach to account for income heterogeneity. An earlier version of this paper was presented at the 2008 Western Economic Association International Annual Conference. We thank Nan Maxwell for her comments there. Special thanks to the participants of the Five-College Seminar Series in Economics for helpful suggestions on an earlier draft. We thank Margaret K. Pasquale and Jeff J. Guo for their continued collaboration and support in the area of pharmaceutical economics. Professor Rebelein gratefully acknowledges the generous financial support of the Elinor Nims Brink Fund. All errors are the responsibility of the authors. Comments and suggestions are welcome and can be directed to the authors at chris.kelton@uc.edu or rebelein@vassar.edu.

1 Introduction

In 2006 (and again in 2007), health care expenditures in the United States exceeded $2 trillion,[1] with prescription pharmaceuticals accounting for $275 billion of the total[2] or 2.1 percent of gross domestic product. The pharmaceutical sector's current large size results from double-digit annual increases in drug spending over the last two decades, which have caught the attention of academics and policy makers. While some of the expenditure increase can be attributed to rising drug prices, much also can be accounted for by rising utilization – due in part to increased prescription drug insurance coverage.[3] According to the Kaiser Family Foundation, out-of-pocket expenditures represented about 22 percent of spending on pharmaceuticals in 2006; the remainder was covered by private insurance, Medicaid, Medicare, and other public programs.[4] Passage of the Medicare Modernization Act of 2003 (Medicare Part D) further increases the burden on the public sector; the newness of this program means the full effect has yet to be realized.

Unfortunately, in the rush to cover outpatient prescription drug expenses for the elderly, the majority of economic analyses focused on evaluating the impact of parameter variations for a particular program structure, rather than answering the more important questions "what trade-offs exist between different program structures" and "which program structure is best?"[5] This paper seeks to fill that gap by comparing the current situation to several other possible scenarios for funding pharmaceutical expenses, including the much discussed universal coverage.

1.1 Prescription Drug Insurance

Employers are the principal source of health insurance in the United States. Sixty percent of employers offered health insurance to their employees in 2007, and 65 percent of employees in those firms are covered by their employer's health plan, while other employees may be covered through a spouse. Nearly all of covered workers in employer-sponsored plans have a prescription drug benefit.[6]

[1] See Centers for Medicare and Medicaid Services (2008).
[2] See Hoffman, et al. (2008).
[3] See National Institute of Health Care Management (2002).
[4] See Kaiser Family Foundation (2008).
[5] See, for example, Goldman, Joyce, and Malkin (2002) and Cline and Mott (2003).
[6] Kaiser Family Foundation (2008).

A majority of covered workers (91 percent in 2007) have some sort of tiered cost-sharing formula for prescription drugs.[7] Cost-sharing tiers are associated with the placement by a health plan of a drug on a formulary or preferred drug list, which generally classifies drugs as generic, preferred brand-name drugs, or nonpreferred brand-name drugs. More recently, a few plans have created a fourth tier of cost sharing, which is generally used for lifestyle drugs or expensive biologics. For covered workers in plans with three or four tiers of cost sharing for prescription drugs, the average drug copayments for generic, preferred, and nonpreferred drugs were $11, $25, and $43, respectively, in 2007. For those covered employees who face coinsurance rather than copayments, coinsurance levels averaged 21 percent, 26 percent, and 40 percent for generic drugs, preferred drugs, and nonpreferred drugs, respectively, in 2007. About 11 percent of covered workers with drug coverage face a separate drug deductible, in addition to any general annual deductible the plan may have. Another small percentage (8 percent of covered workers) have a separate annual out-of-pocket maximum that applies to prescription drugs.

Medicaid, Title XIX of the Social Security Act, is the nation's public health insurance program for individuals with low income. It is jointly financed by the federal and state governments, and each state has considerable flexibility over how its program is implemented.[8] Although not required to do so, all state Medicaid programs provide coverage for prescription drugs, and none requires more than minimal cost-sharing for beneficiaries.[9] State Medicaid programs have been responding to the high annual increases in spending on pharmaceuticals through a variety of cost-containment strategies. Some states have adopted prior authorization programs for more expensive medicines. Others have preferred drug lists or formularies. Almost all either encourage or require generic drugs if available. Many states have copay systems, some tiered with lower copayments for generic drugs, and some have physician education programs.[10] By adopting strict prescription drug policies, a state Medicaid program may be able to reduce average reimbursement rates across medications in the market by taking advantage of whatever (latent) competition exists among pharmaceutical manufacturers.[11]

[7]See Kaiser Family Foundation and Health Research and Educational Trust (2007). Subsequent statistics in this paragraph are also from this source.

[8]See Elam (2007).

[9]National Pharmaceutical Council, Inc. (2005).

[10]See Kaiser Commission on Medicaid and the Uninsured (2003).

[11]See Guo and Kelton (2007).

The Medicare Prescription Drug, Improvement, and Modernization Act of 2003 established a voluntary Medicare outpatient prescription drug benefit (known as Medicare Part D). As of January 2006, the benefit became available to all Medicare beneficiaries, regardless of income, health status, geographic location, or choice of health plan (traditional fee-for-service Medicare or Medicare Advantage plan). Beneficiaries receive coverage by enrolling in a private plan — either a Medicare Advantage plan that offers drug coverage or a private, Medicare-approved prescription drug plan. The standard benefit for 2006 was a $250 annual deductible. For the next $2,000 in drug spending, drug cost was split 25 percent and 75 percent between the beneficiary and Medicare plan. After this, the beneficiary received no benefit until total out-of-pocket drug spending reached $3,600. Once this amount of spending was reached, the beneficiary received a catastrophic benefit which covered up to 95 percent of the cost of any additional drug spending. The deductible and benefit limits are pegged to the growth in prescription drug spending by Medicare beneficiaries, so rise over time. The benefit offers extra assistance to many lower-income beneficiaries. Actual plans are required only to be actuarially equivalent to the standard benefit so do not necessarily have a deductible and may offer supplemental coverage in the coverage gap.[12] As of January 2008, about 90 percent of Medicare beneficiaries had drug coverage, but not all under Medicare Part D. Approximately 10 million beneficiaries were covered by creditable employer or union retiree plans, and 4 million had coverage from the VA and other public sources.[13]

1.2 A General-Equilibrium Approach

We use a two-sector general-equilibrium production model, introduced by Kelton and Rebelein (2007), which can accommodate prescription drug insurance as a model feature. The prescription drug sector is modeled as a monopoly, which mimics well the situation for most new drugs during the commercial life of the drugs' patent.[14] Consumers are heterogeneous with regard to their need for the pharmaceutical product and with respect to their earnings ability. The distribution of earnings is represented by a Beta distribution that closely approximates the distribution found in the United States. Other model parameters are chosen so that the benchmark model – incorporating Medicaid,

[12] See Gross (2007).
[13] See Kaiser Family Foundation (2008).
[14] See Guo and Kelton (2007).

Medicare, and private insurance – matches observations of the U.S. economy, such as the share of GDP spent on prescription drugs, the aggregate prescription drug utilization rate, numbers of individuals covered by Medicaid and Medicare, labor productivity, and drug insurance subsidy rates. Using the calibrated parameter values, we compare various aggregates of the benchmark regime, including average social welfare, to those from five other policy regimes: no insurance, private insurance only, private insurance plus Medicaid, private insurance plus Medicare, and universal public insurance. Although the model is specific to the pharmaceutical sector, we believe the results can also shed light on health care spending more generally.

2 The Model

This section describes the model, which is particularly applicable to pharmaceutical markets since it incorporates a licensing, rather than increasing-returns-to-scale, rationale for monopoly. With three preference assumptions, it can be shown that a monopoly equilibrium (consisting of an equilibrium consumption, production, and labor allocation; a good-one price; and a wage) exists and is unique.[15] Kelton and Rebelein (2007) provides a detailed description of the model in the context of consumers with identical earnings and without insurance. The analysis here extends that model to incorporate income heterogeneity and differences in pharmaceutical insurance coverage across individuals.

There is a continuum of individuals, each distinguished by effective labor endowment l_j and by utility parameter ρ_i. There are two goods; we assume good one is the pharmaceutical product and good two represents all other goods. Let l_{1j} and l_{2j} be the amounts of labor that individual ij devotes to production of good one and good two, respectively. Let a_1 and a_2 be the respective technological coefficients for good-one and good-two production. The coefficient a_h is the rate, measured in units of good h per unit of labor, at which an individual can produce good h. Hence,

[15] See Kelton and Wallace (1995). The first two of these assumptions are as follows. (1) There must exist a price, say P_H, above which there is no nonmonopolist demand for good one. (2) The total revenue function, defined below for the monopolists, is strictly concave. The third assumption ensures trade will occur between the monopolists and nonmonopolists: as a group, the monopolists will choose positive amounts of both goods in equilibrium, as will the nonmonopolists. The equilibrium is unique in the sense of a unique price and unique sales of good one. There is nonsignificant multiplicity of equilibrium labor and output pairs. In fact, even aggregate employment of nonmonopolists is not uniquely determined since monopolists are free to substitute some of their own labor for the labor of non-license holders. The monopoly allocation is not Pareto efficient. One of the necessary conditions for Pareto efficiency is violated since the monopoly price exceeds the marginal rate of transformation of good-two producers.

an individual ij produces an amount of good one equal to $a_1 l_{1j}$ and an amount of good two equal to $a_2 l_{2j}$.[16] Let L be the maximum effective labor endowment across the individuals, and let α_j be a parameter between 0 and 1 such that $\alpha_j L = l_j$. To capture differences in income (labor income equals $a_2 l_j = a_2 \alpha_j L$ in equilibrium) across consumers, we assume $a_2 \alpha_j L$ has a distribution that mimics the distribution of income in the United States.

Each consumer has preferences over the two goods, with (c_{1ij}, c_{2ij}) denoting individual ij's (good one, good two) consumption pair. The utility for individual ij is given by

$$u_{ij}(c_{1ij}, c_{2ij}) = (c_{1ij} + \sigma)^{\rho_i} (c_{2ij})^{(1-\rho_i)}, \tag{1}$$

where $\rho_i \in (0, R]$, $R < 1$, varies uniformly across consumers; the probability density function for ρ is $f(\rho) = 1/R$.[17] The upper bound, R, on values of ρ ensures that individuals will not spend unrealistically large portions of their income on good one. The parameter σ is an additional preference parameter. We can think of σ as indicating (inversely) a consumer's benefit from good one; the lower σ is, the more the individual benefits from consuming a unit of good one. This is in contrast to ρ_i, which indicates the need consumer ij experiences for good one. To simplify the analysis, we choose to fix σ for all consumers.

Committing ourselves to a particular utility function for the economy's agents provides a tractable alternative to a partial-equilibrium framework. Given a set of values for the model's parameters we can numerically compute equilibrium price, sales, output, and profits. Moreover, we can determine the effects on social welfare of various insurance policies, which we do below.

2.1 Drug Benefit Coverage

Individuals fall into four groups, depending on their pharmaceutical insurance coverage.

[16] The assumption that all individuals possess identical technologies is a simplifying assumption. Situations of one or a few sellers arise naturally if the technologies are such that only a small number of individuals are capable of producing one of the goods.

[17] This utility function, a generalization of the Cobb-Douglas function, was suggested by Xiangkang Yin (2001a). A significant feature of equation (1) is that a consumer will choose not to purchase good one when its price exceeds the individual's "reservation price" for the good. Note that $u_{ij}(\cdot,\cdot)$ satisfies $u_{ij1} > 0$ and $u_{ij2} > 0$, and the matrix of second derivatives is negative semi-definite.

Many people in the United States receive prescription pharmaceutical insurance through their employers. Their specific coverage depends on several factors such as the size of their employer, full- versus part-time employment, and health status. Nevertheless, for simplification, it seems reasonable to assume that most people with employer-offered insurance hold full-time permanent jobs, and, therefore, tend to have higher incomes than do people without insurance. Hence, we identify an income threshold $a_2\alpha_p L$ such that nonmonopolists with income greater than or equal to $a_2\alpha_p L$ (but who are not eligible for Medicare as described below) purchase private health insurance for a fixed premium amount τ. The private insurance covers the portion δ_p (the private insurance subsidy rate) of the drug's price, implying a coinsurance rate of $1 - \delta_p$. The private insurance is assumed to be actuarily fair so that the premium amount is set to cover exactly all payments made by the company; therefore the insurance company makes no profit. While there are almost certainly a multiplicity of (τ, δ_p) pairs that will satisfy the balanced-budget constraint, there exists a unique τ for each δ_p.[18]

Low-income individuals are covered by a "Medicaid-like" program. We select an income threshold α_{MD} such that people with $\alpha_j \leq \alpha_{MD}$ are eligible for this public insurance. Medicaid covers the portion δ_{MD} of the prescription drug costs incurred by the poor. A coinsurance rate of $1-\delta_{MD}$ is applied to each drug purchase, since copayments are the current practice of most state Medicaid programs. Funding for this public insurance comes from a progressive tax, of rate $t_{MD}(\alpha_j)$, imposed on all wage income earned in the economy. We assume the premium paid by privately insured individuals, discussed above, is deducted from income before the wage income tax is applied, to be consistent with the current practice of deducting health insurance premiums prior to application of the public-insurance payroll tax. The tax rate is set to cover exactly the subsidy payments under this program.

High-need individuals are covered by a "Medicare-like" program. We identify a need threshold ρ_{MR} such that individuals with $\rho_i \geq \rho_{MR}$ are eligible for the program. Beneficiaries of this insurance receive a government-funded subsidy, of rate δ_{MR}, on purchases of the pharmaceutical product. The program is financed by a progressive tax, of rate $t_{MR}(\alpha_j)$, imposed on all labor income earned in

[18] See Kelton and Rebelein (2007) for a proof of a similar relationship in a model in which everyone has the same labor income.

the economy. Again, we assume the premium paid by privately insured individuals is deducted from income before the wage income tax is applied and that the tax rate is set to cover exactly the subsidy payments under this program. Whereas dual eligibles (for both Medicaid and Medicare) in the United States are covered by Medicare in practice, the model includes them in the Medicaid group, ensuring minimum copays for those with low incomes.

The remaining individuals in the model have no pharmaceutical insurance. Their income is neither low enough for them to qualify for Medicaid nor high enough to enable them to purchase private insurance; nor is their need high enough for them to qualify for Medicare.

2.2 Monopoly Equilibrium

A license is required to produce good one, the pharmaceutical. A group of individuals, each denoted m for monopolist, share such a license, and receive equal shares of the profits earned by the monopoly. We assume c is the fraction of the population that owns shares in the monopoly and, for convenience, that the monopolists are drawn from the least-needy members of the population.[19] Specifically, the monopolists have contiguous values of $\rho_m \in (0, cR]$.

Monopolists may use their own labor to produce good one and may hire any or all of the other individuals to produce good one, paying a wage rate w, measured in units of good two per unit of labor. We assume the labor market is competitive, so $w = a_2$ in equilibrium.[20] The monopolists own all units of good one that are produced. They may sell good one to nonmonopolists at price P (measured in units of good two per unit of good one). A monopolist's utility is given by equation (1) for $ij = mj$. The distribution of earned income for monopolists is the same as that for nonmonopolists. Monopolists are not covered by any type of insurance. However, their labor income is taxed to pay for the Medicaid-like and Medicare-like programs.

[19] A significant assumption of Kelton and Wallace (1995), and thus of our model, is that the monopoly shareholder(s) can essentially acquire good one at its production cost. The assumption has some empirical support. (See, for example, Yin (2001b).) We realize, however, that product discounting is not a pervasive practice for large corporations and seek to counteract this assumption by making the monopolists less likely to purchase the drug (i.e., by assigning them lower values of ρ_i). Individuals who do not consume good one will neither gain nor lose from price changes resulting from changes in insurance coverage.

[20] At $w = a_2$ nonmonopolists are indifferent between working for themselves to produce good two or working for the monopolists.

The other individuals (the nonmonopolists) behave competitively given the price P and the wage rate w. They choose consumption amounts and a time allocation, dividing their labor between working for the monopolists to produce good one and producing good two on their own. In the continuum of consumers, they have ρ_i values that span the interval $(cR, R]$.

2.3 Affordability

Nonmonopolist ij, covered by private insurance, faces the affordability constraint $P(1-\delta_p)c_{1ij} + c_{2ij} \leq (wl_{1j} + a_2 l_{2j} - \tau)(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j))$. Total consumption of both the subsidized pharmaceutical and good two cannot exceed total after-tax income. Since $w = a_2$ in equilibrium, and because the affordability constraint will be satisfied with equality in equilibrium, this relationship becomes

$$P(1-\delta_p)c_{1ij} + c_{2ij} = (a_2\alpha_j L - \tau)(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j)). \tag{2}$$

For those covered by Medicaid, Medicare, or no insurance, the affordability constraints are given by

$$P(1-\delta_{MD})c_{1ij} + c_{2ij} = a_2\alpha_j L(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j)), \tag{3}$$

$$P(1-\delta_{MR})c_{1ij} + c_{2ij} = a_2\alpha_j L(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j)), \tag{4}$$

or

$$Pc_{1ij} + c_{2ij} = a_2\alpha_j L(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j)), \tag{5}$$

respectively. Finally, a monopolist m with effective labor l_j faces the affordability constraint

$$(a_2/a_1)c_{1mj} + c_{2mj} = a_2\alpha_j L(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j)) + (\pi^*/c), \tag{6}$$

where (π^*/c) is an individual monopolist's share of the total profits π^* generated by the monopoly.

2.4 Nonmonopolist Demand

Consumer ij maximizes utility (equation (1)) subject to his or her affordability constraint, given in one of the equations (2)-(5). The nature of the utility function makes it likely that, at each price P, some individuals are able and willing to purchase good one while others are not. Indeed, for each group of nonmonopolists described above, there exists a ρ value such that anyone with a higher ρ_i

has positive demand for good one at price P. For those with private insurance, we denote such a value $\rho_p^*(P, \alpha_j)$.

The individual demands for good one and good two, as functions of the monopoly price P and income parameter α_j, are given by equations (7) and (8), respectively, for those with private insurance coverage:

$$d_{1ij}(P, \alpha_j) = \begin{cases} \rho_i(a_2\alpha_j L - \tau)(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j))/P(1-\delta_p) - \sigma(1-\rho) & \text{for } \rho_i > \rho_p^*(P, \alpha_j) \\ 0 & \text{for } \rho_i \leq \rho_p^*(P, \alpha_j), \end{cases} \tag{7}$$

and

$$d_{2ij}(P, \alpha_j) = \begin{cases} (1-\rho_i)((a_2\alpha_j L - \tau)(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j)) + P(1-\delta_p)\sigma) & \text{for } \rho_i > \rho_p^*(P, \alpha_j) \\ (a_2\alpha_j L - \tau)(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j)) & \text{for } \rho_i \leq \rho_p^*(P, \alpha_j). \end{cases} \tag{8}$$

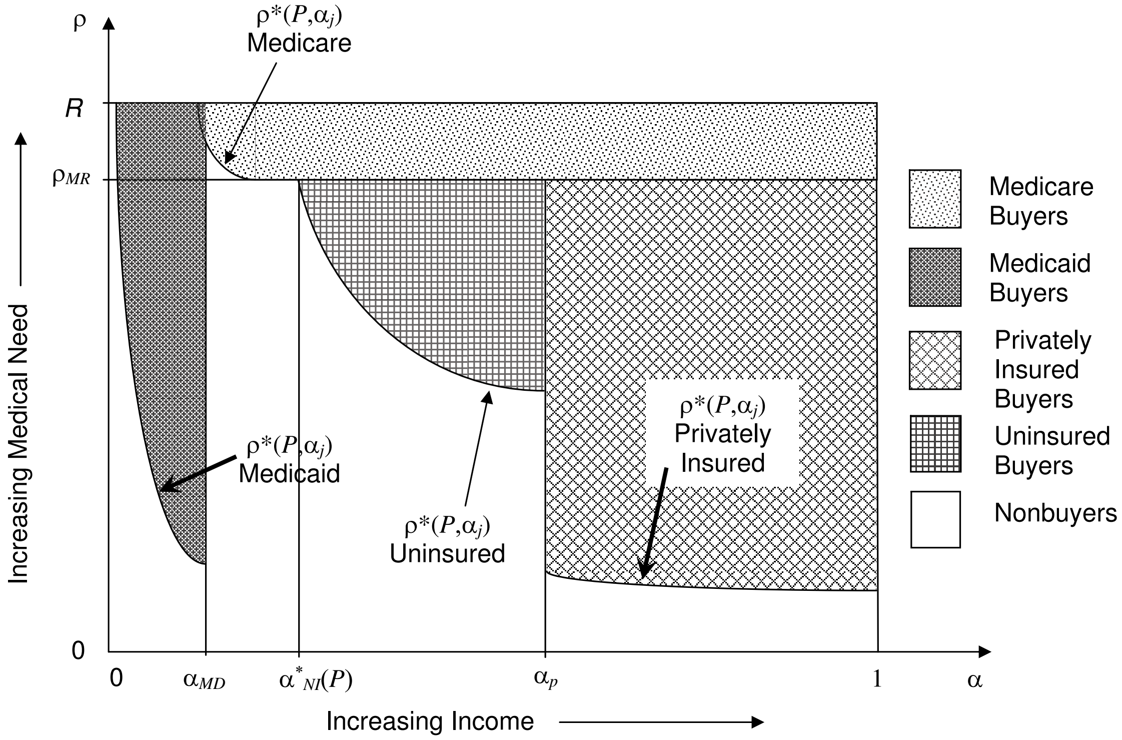
For those individuals with private prescription drug coverage, the cutoff $\rho_p^*(P, \alpha_j)$ is found by setting the first line in (7) equal to 0. The solution is

$$\rho_p^*(P, \alpha_j) = \frac{P(1-\delta_p)\sigma}{(a_2\alpha_j L - \tau)(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j)) + P(1-\delta_p)\sigma}. \tag{9}$$

Individual demands and cutoff ρ values for the other three insurance groups can be found similarly, noting that none of the other nonmonopolists pay an insurance premium; they are covered by public insurance, or, alternatively, have no prescription drug insurance. We denote the cutoff thresholds as $\rho_{MD}^*(P, \alpha_j)$, $\rho_{MR}^*(P, \alpha_j)$, and $\rho_{NI}^*(P, \alpha_j)$, for the three groups, respectively. Figure 1 shows the distribution of positive demand for good one across the four different insurance groups. Those with need parameter above their ρ-threshold consume some of the drug, while those with values below their threshold consume only good two.

In addition, the model implies an income cutoff for positive demand for the drug. Only those individuals whose α_j value exceeds the cutoff consume positive amounts of good one. An expression for this cutoff $\alpha_p^*(P)$ for those covered by private insurance can be developed by noting that it occurs where the $\rho_p^*(P, \alpha_j)$ curve intersects the maximum ρ value, ρ_{MR}, for this group of consumers. (This particular intersection is not shown in Figure 1.) Setting $\rho_p^*(P, \alpha_j)$ from equation (9) equal to ρ_{MR}

Figure 1: Demand of Nonmonopolists for the Pharmaceutical



and solving for α gives

$$\alpha_p^*(P) = \frac{P(1-\delta_p)\sigma(1-\rho_{MR})}{\rho_{MR}(a_2L-\tau)(1-t_{MD}(\alpha^*)-t_{MR}(\alpha^*))}. \tag{10}$$

Similar income thresholds, denoted $\alpha^*_{MD}(P)$, $\alpha^*_{MR}(P)$, and $\alpha^*_{NI}(P)$, respectively, can be determined similarly for the other groups of nonmonopolists. (The latter threshold, $\alpha^*_{NI}(P)$, is shown in Figure 1.)

To find total demand for good one for those covered by private insurance, we integrate (7) over those individuals with nonzero demand:

$$D_{1p}(P) = \int_{max(\alpha_p^*,\alpha_p)}^{1} \int_{max(\rho_p^*,cR)}^{\rho_{MR}} \Big[\frac{\rho(a_2\alpha L-\tau)(1-t_{MD}(\alpha)-t_{MR}(\alpha))}{P(1-\delta_p)} - \sigma(1-\rho)\Big] dF(\rho)dF(\alpha). \tag{11}$$

The lower limit on the outer integral ensures that individuals without insurance are not counted among those with private insurance. The lower limit on the inner integral ensures that only nonmonopolists benefit from private insurance.

Following a similar approach, we can represent the other areas in Figure 1 as double integrals (over appropriate ρ and α values) of individual demands for good one for those with Medicaid, those with Medicare, and those without insurance. Then, letting these group demands be denoted $D_{1MD}(P)$, $D_{1MR}(P)$, and $D_{1NI}(P)$, respectively, we find total nonmonopolist demand for good one, $D_1(P)$, as

$$D_1(P) = D_{1p}(P) + D_{1MD}(P) + D_{1MR}(P) + D_{1NI}(P). \tag{12}$$

Given the income distribution that we use for the analysis below, there exists a closed-form solution to (12), although it is nontrivial.

2.5 Monopoly Sales, Price and Profit

Given $D_1(P)$, let $D_1^{-1}(q)$ be the price at which nonmonopolists demand in total the quantity q of good one. Then $TR(q) = qD_1^{-1}(q)$ is the total revenue from selling q units of good one. Defining $MR(q)$ to be $\partial TR/\partial q$, and setting $MR(q) = MC(q)$ (where $MC(q) = a_2/a_1$) we find monopoly sales q_1^* and the monopoly equilibrium price P^*.

The monopolists' aggregate profit in equilibrium is

$$\pi^* = q_1^*(P^* - (a_2/a_1)).$$

This profit is divided equally among the owners of the monopoly.

2.6 Monopoly Output and Employment

Whereas q_1^* is the monopolists' profit-maximizing sales, total equilibrium production of good one, Q_1^*, equals q_1^* plus the monopolists' consumption of good one. Subtracting the monopolists' own good-one production (good one produced with their own labor), enough nonmonopolist labor is hired to produce the remainder of Q_1^*.

2.7 Monopolist Consumption

A monopolist m with effective labor l_j also maximizes his or her individual utility ((1) for $i = m$) subject to his or her affordability constraint (6).

A type-j monopolist's utility maximization leads to the preferred consumption pair (c^*_{1mj}, c^*_{2mj}):

$$c^*_{1mj} = \begin{cases} \rho_m(a_1\alpha_j L(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j)) + \frac{a_1\pi^*}{a_2 c} + \sigma) - \sigma & \text{for } \rho_m > \rho^*_{mj} \\ 0 & \text{for } \rho_m \leq \rho^*_{mj} \end{cases}$$

and

$$c^*_{2mj} = \begin{cases} (1 - \rho_m)(a_2\alpha_j L(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j)) + \frac{\pi^*}{c} + \frac{a_2\sigma}{a_1}) & \text{for } \rho_m > \rho^*_{mj} \\ a_2\alpha_j L(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j)) + \pi^*/c & \text{for } \rho_m \leq \rho^*_{mj}, \end{cases}$$

where ρ^*_{mj} is the minimum value of ρ for which monopolist m with effective labor l_j has positive demand for good one. Specifically,

$$\rho^*_{mj} = \frac{a_2\sigma}{a_2\sigma + a_1 a_2 \alpha_j L(1 - t_{MD}(\alpha_j) - t_{MR}(\alpha_j)) + a_1(\pi^*/c)}. \tag{13}$$

2.8 Balanced Insurance Budgets

All three insurance programs are required to have balanced budgets in equilibrium. The total benefits paid by the private insurance program are $\delta_p P D_{1p}(P)$. The payout must equal the total amount of premium revenue collected from participants in the program:

$$\delta_p P D_{1p}(P) = \int_{\alpha_p}^{1} \int_{Rc}^{\rho_{MR}} \tau dF(\rho) dF(\alpha), \tag{14}$$

assuming $\alpha_p > \alpha^*_p$.

Similarly, the Medicaid and Medicare programs are subject to the following balanced-budget requirements, respectively, in equilibrium:

$$\delta_{MD} P D_{1MD}(P) = \int_0^1 \int_0^R t_{MD}(\alpha) a_2 \alpha L dF(\rho) dF(\alpha) - \int_{\alpha_p}^1 \int_{cR}^R t_{MD}(\alpha) \tau dF(\rho) dF(\alpha) \tag{15}$$

and

$$\delta_{MR} P D_{1MR}(P) = \int_0^1 \int_0^R t_{MR}(\alpha) a_2 \alpha L dF(\rho) dF(\alpha) - \int_{\alpha_p}^1 \int_{cR}^R t_{MR}(\alpha) \tau dF(\rho) dF(\alpha), \tag{16}$$

where the second term in equations (15) and (16) indicates the revenue foregone because the private insurance premiums are exempt from payroll taxes.

2.9 Other Insurance Regimes

The study compares equilibrium utility and social welfare in the base case insurance regime with those under five other possible insurance regimes, including (1) a regime with no insurance; (2) a regime with private insurance only (for those whose income equals or exceeds α_p); (3) a regime with private insurance (for those whose income equals or exceeds α_p) and public insurance for the poor (for those whose income is lower than or equal to α_{MD}); (4) a regime with private insurance (for those whose income equals or exceeds α_p and whose need is below ρ_{MR}) and public insurance for the elderly (for those whose need parameter is at least ρ_{MR}); and (5) universal insurance under which a public insurance program covers all people in the economy.

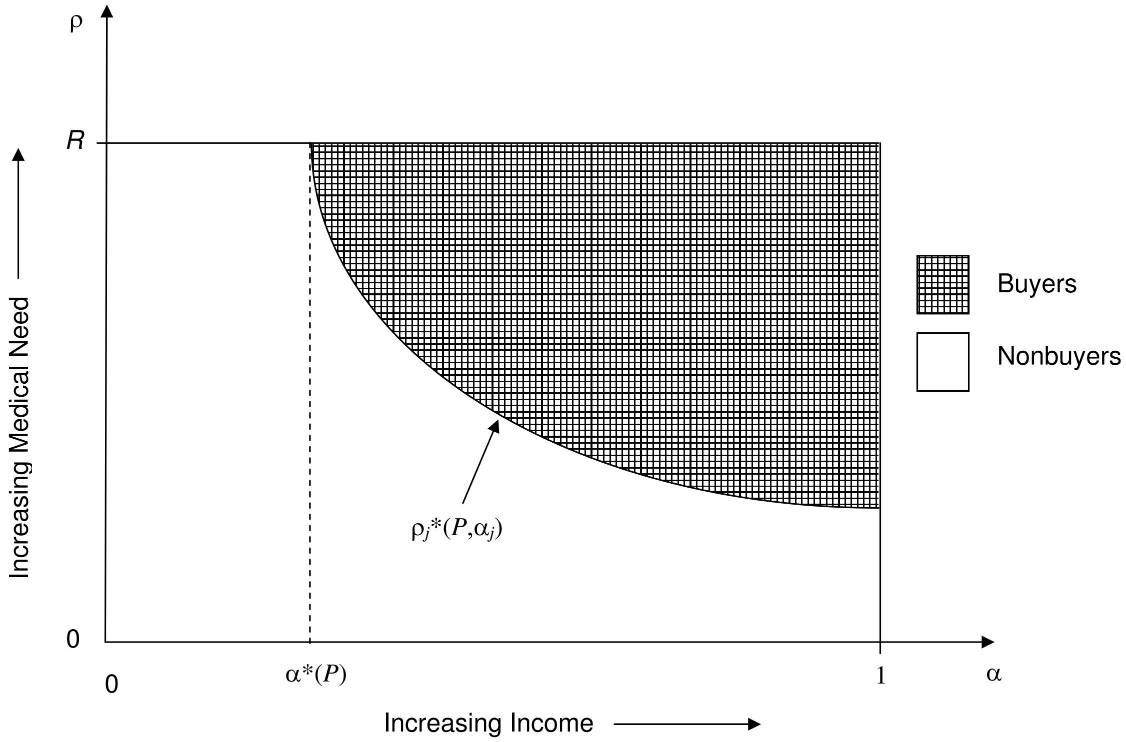
While the term "universal coverage" has been used to refer to a family of possible policies, the program in this model provides benefits in the form of a subsidy, of rate δ_{UI}, on all nonmonopolist purchases of the pharmaceutical product. The program is financed by a progressive income tax, $t_{UI}(\alpha_j)$, imposed on all wage income in the economy. We continue to assume monopolists must contribute to the public insurance program via taxes imposed on their wage income, but that they are not eligible to share in the benefits of the program. We require the government to run a balanced budget with regard to the universal insurance program.

Figure 2 shows the distribution of positive demand for good one under the modeled universal insurance program. Those with need parameter above the $\rho^*_{UI}(P, \alpha_j)$ threshold and income parameter above the $\alpha^*_{UI}(P)$ cutoff consume some of the pharmaceutical.

3 Calibration Outcomes

In order to use the model developed above to speak to public policy issues, substantial work was done to calibrate the model to the U.S. economy. While our primary welfare results are presented in the next section, the outcomes of the calibration are also of interest, and are described in this section.

Figure 2: Demand of Nonmonopolists for Pharmaceuticals under Universal Insurance



3.1 The Distribution of Income

The distribution of income, $f(\alpha)$, is selected both to mimic the actual distribution of U.S. income and to preserve analytical tractability through equation (12). A Beta(1,7) distribution, with probability density function $f(\alpha) = (1-\alpha)^6/K$, is selected to model the distribution of the α_js, where K is a scaling constant equal to 0.1428. While both the lognormal and Beta distributions have been popular in the literature as ways to characterize the distribution of income in the United states, a number of researchers have suggested that the generalized Beta distribution provides a more accurate representation than does the lognormal distribution, particularly at higher income levels.[21] Further, the functional form of the Beta(a,b) distribution, constrained to integer values for both a and b, offers considerable analytical advantages over the lognormal distribution, allowing us to develop our model analytically quite some distance before resorting to numerical techniques.

[21] See, for example, Chotikapanich, Rao and Tang (2007), Mulligan (2002), McDonald (1984), McDonald and Ransom (1979), and Thurow (1970).

To find the best-fitting (a,b) parameters, we assume the maximum labor effort corresponds to an income of \$500,000.[22] Assuming α_j follows a Beta(a,b) distribution on the interval $[0, 1]$, we evaluated several alternative integer values a and b to identify the closest approximation to the actual U.S. income distribution. Table 1 contrasts the quintile thresholds for the three closest parameterizations with the actual quintile thresholds in the U.S. distribution of income in 2005. The lower part of Table 1 gives standard goodness-of-fit statistics. Based on the results in Table 1, we selected the Beta(1,7) distribution for this study.

Table 1: Quintile Upper Thresholds

	Beta(1,6)	Beta(1,7)	Beta(1,8)	U.S. Distribution
Lowest Quintile	\$18,249	\$15,650	\$13,775	\$19,178
Second Lowest Quintile	\$40,799	\$35,150	\$30,925	\$36,000
Middle Quintile	\$70,799	\$61,300	\$54,125	\$57,660
Second Highest Quintile	\$117,599	\$102,650	\$91,125	\$91,125
Highest Quintile	\$500,000	\$500,000	\$500,000	infinite
Gini Coefficient	0.4614	0.4666	0.4705	0.469
RMSE	14,723	6,046	4,116	
R^2	0.9275	0.9261	0.9117	

Figure 3 illustrates the actual U.S. income distribution in 2005 compared with a normalized Beta(1,7) distribution. Since each unit of effective labor receives the same wage in the model, the distribution of labor income will be identical to the distribution of labor effort.

With the Beta(1,7) distribution, there exists a closed-form solution to (12). However, it is difficult to work with, and, fortunately, the solution to the integral can be very closely approximated (with R^2 values ≥ 0.995) by the equation

$$D_1(P) = \theta P^{-1/\eta}, \tag{17}$$

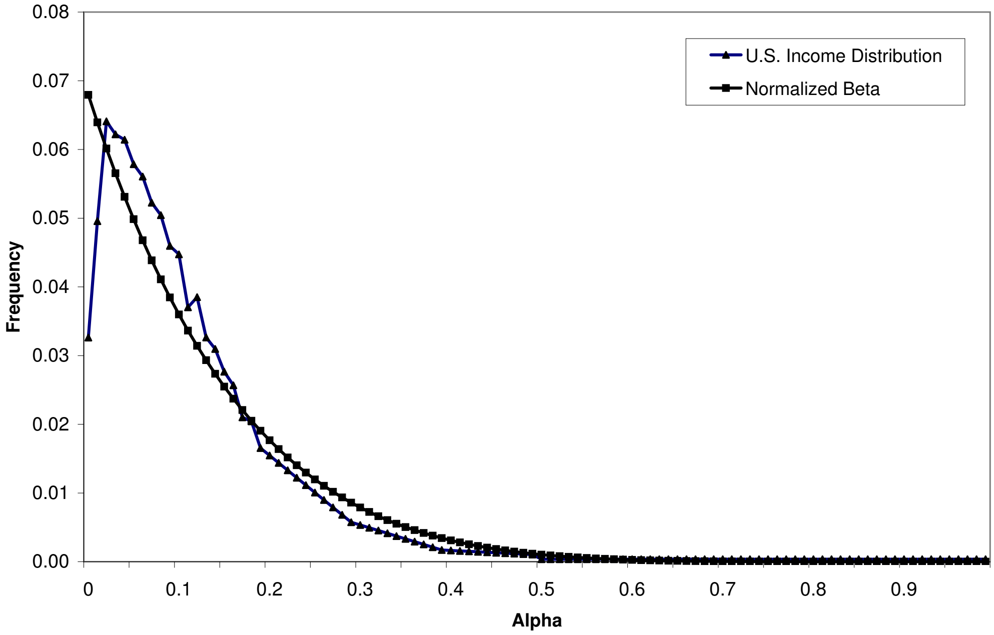
where θ and η are functions of the model parameters.

3.2 Parameters Based on Observed Data

Many of the parameter values — including a_1, a_2, c, α_{MD}, α_p, ρ_{MR}, δ_{MD}, δ_{MR}, δ_p, and δ_{UI} — are inferred from direct observations of the U.S. economy. Two additional parameters, λ_1

[22] Less than one percent of the population had income in excess of \$500,000 in 2005 (U.S. Census Bureau (2006b)).

Figure 3: Comparison of the Density Function for Beta(1,7) with the 2005 U.S. Income Distribution



and λ_2, related to the progressive income-tax structure in the model, are also taken from data. The progressive taxes for Medicaid, Medicare, and universal insurance are characterized by three tax brackets. Those individuals with $\alpha_j < \alpha_{MD}$ pay at the lowest rate; those with α_j such that $\alpha_{MD} \leq \alpha_j < \alpha_p$ pay at a higher rate; and those with $\alpha_j \geq \alpha_p$ pay at the highest rate.[23] For simplification, we assume that the two lower rates are proportional to the highest rate, with proportionality constants λ_1 and λ_2 for the lowest and middle rates, respectively; these constants, λ_1 and λ_2, are taken from data.

While details are relegated to the Appendix, Table 2 contains the values for the model parameters that are based on observed data. All values are either 2006 values or adjusted to 2006 values.

Our method of calibration for a_2, combined with the fact that we normalize the good-two price to unity in the model, essentially places a value of \$1 on each unit of good 2.

[23]Note that, because of the profit they receive, the labor income tax rate applied to the monopolists is the highest rate available, regardless of their specific value of α_j.

Table 2: Parameters from Data

a_1	\$155.32	a_2	\$47.34
c	0.00058	ρ_{MR}	0.9083
α_{MD}	0.025	α_p	0.060
δ_{UI}	0.78	δ_p	0.78
δ_{MD}	0.97	δ_{MR}	0.78
λ_1	0.00	λ_2	0.30

3.3 Parameters Based on Calibration Targets

The remaining model parameters — R, L, σ, τ, and the highest progressive tax rates under each regime — are chosen to ensure that selected model aggregates match key aggregates for the U.S. economy and that all insurance budgets are balanced. We perform our calibration in two stages. In the first stage, we approximate values for τ and the tax rates and vary L, σ, and R to hit three calibration targets discussed below. We perform the first stage for the baseline insurance regime. In the second stage, which we perform for each individual regime, we vary the private insurance premium and tax rates to make sure that the private and public programs all run a balanced budget.

The first calibration target is pharmaceutical share of GDP. According to Hoffman, *et al.* (2008), expenditures on pharmaceuticals were approximately $275 billion in 2006. Dividing this amount by 2006 GDP gives a GDP share of spending on good one of 2.1 percent. As it turns out, the GDP share is particularly sensitive to variations in the parameter R. Second, we seek to approximate a 45.5 percent prescription drug utilization rate as suggested by the Center on an Aging Society (2002). The drug utilization rate is most sensitive to variations in σ. Larger values of σ translate to a lower need for the pharmaceutical, while lower values of σ suggest a higher need. Our third target is GDP per capita ($44,111 in 2006). It turns out that this final target is quite sensitive to the value of L.

This first calibration stage produces the results shown in Table 3.

Table 3: Paramaters from Calibration (Base Case)

R	0.01795	σ	1859.2	L	7363.5

Note that the results from Tables 2 and 3 imply that the highest wage income in the model, a_2L, is \$348,588 (in 2006 dollars). The income cutoff for those on Medicaid, $a_2\alpha_{MD}L$, is \$8,715. The income required to purchase private insurance, $a_2\alpha_pL$, is \$20,915.

The values for the private insurance premium and the public insurance tax rates for those in the highest-income tax bracket are selected to ensure balanced budgets for all insurance programs. Tables 4 and 5 give these values for the baseline insurance regime and all other insurance regimes, respectively.[24]

Table 4: Premium and Tax Rates (Base Case)

τ	876.43		
$t_{MD}(\alpha)$	0.00 for $\alpha_j < \alpha_{MD}$ 0.00047 for $\alpha_{MD} \leq \alpha_j < \alpha_p$ 0.00157 for $\alpha_P \leq \alpha_j$	$t_{MR}(\alpha)$	0.00 for $\alpha_j < \alpha_{MD}$ 0.00116 for $\alpha_{MD} \leq \alpha_j < \alpha_P$ 0.00387 for $\alpha_P \leq \alpha_j$

In Table 4, the τ value of 876.43 implies that, in the baseline regime, a privately insured individual spent approximately \$900 on pharmaceutical insurance. Since the average cost of private health insurance was over \$4,700 in 2008, and since the share of pharmaceutical spending is approximately 10 percent of health-care spending, the calibrated figure is higher than target. However, since prescription drug insurance is most often bundled with other health-care insurance for employees, health insurance companies may realize some savings in offering more comprehensive insurance packages. Table 4 also shows that the top tax rate for funding the Medicare program is 0.387 percent. The actual Medicare payroll tax is currently 2.9 percent of wages, spread evenly across employers and employees; 0.29 percent for pharmaceutical coverage approximates our model finding of 0.387 percent as the top tax rate for Medicare.

[24]Note that the low- and middle-income tax rates are found by applying λ_1 and λ_2, respectively, from Table 2 to the highest tax rates.

Table 5: Premium and Tax Rates for Non-Base-Case Regimes

Policy Regime	Premium and Tax Rates
Private Insurance Only	$\tau = 1006.48$
Private Insurance + Medicaid	$\tau = 1031.83$ $t_{MD}(\alpha) = 0.00047$ for $\alpha_{MD} \leq \alpha_j < \alpha_P$ $t_{MD}(\alpha) = 0.00157$ for $\alpha_P \leq \alpha_j$
Private Insurance + Medicare	$\tau = 853.30$ $t_{MR}(\alpha) = 0.00114$ for $\alpha_{MD} \leq \alpha_j < \alpha_P$ $t_{MR}(\alpha) = 0.00380$ for $\alpha_P \leq \alpha_j$
Universal Insurance	$t_{UI}(\alpha) = 0.0$ for $\alpha_j < \alpha_{MD}$ $t_{UI}(\alpha) = 0.00483$ for $\alpha_{MD} \leq \alpha_j < \alpha_P$ $t_{UI}(\alpha) = 0.01612$ for $\alpha_P \leq \alpha_j$

3.4 Additional Outcomes

Using the above parameter values, found in Tables 2 through 5, we compute the equilibrium price, good-one sales, GDP share of pharmaceutical consumption, and utilization rate under each of the six pharmaceutical insurance regimes. Table 6 shows a GDP share of 2.10 percent in the base case and a utilization rate of 45.51 percent. The model also gives GDP per capita of \$44,111.23, implying that we are able to hit all three calibration targets almost exactly. At 0.7796, equilibrium price exceeds marginal cost (a_2/a_1=0.3048) by over two-fold.

Table 6: Equilibrium Results

Policy Regime	Pharmaceutical Price	Pharmaceutical Quantity	GDP Share	Utilization Rate
Base Insurance Regime	0.7796	1,132	2.10%	45.51%
No Insurance	0.4762	130	0.14%	12.61%
Private Insurance	0.8164	981	1.89%	38.20%
Private + Medicaid	0.7830	1,121	2.09%	45.03%
Private + Medicare	0.8121	992	1.91%	38.59%
Universal Insurance	0.8000	1,013	1.92%	39.33%

In comparison to the base case, both equilibrium price and quantity sold are much lower under the No Insurance regime. At P^*=0.4762, monopoly mark up over marginal cost is (only) 56.2 percent. Meanwhile, q_1=130. Both the share of good one in GDP and the utilization rate are significantly lower than in the base case.

4 Welfare and Distributional Analysis and Results

We compute the utility obtained by each person in the base case and his or her utility under each of the other regimes. The equivalent variation, γ_{ij}, is defined as the percentage increase in income individual ij would need to receive, relative to his or her base-case income, in order to bring his or her base-case utility up to that received under an alternative regime. If $\gamma_{ij} > 0$ then the alternative regime would be considered an improvement for that person relative to the base case. If $\gamma_{ij} < 0$ then the person would be worse off under the alternative regime relative to the base case. The total equivalent variation (that is, the average social welfare difference occurring under a policy regime relative to the base case regime), Γ, is the weighted average of all individual γ_{ij}'s. Besides generating results for individuals and the economy as a whole, this method also allows us to make welfare comparisons for different groups of people.

The first line in Table 7 presents average equivalent variation statistics for each of the pharmaceutical insurance regimes. The equivalent variation value, 1.29 percent, for the No Insurance regime suggests that welfare is higher when no one is insured. On average, a 1.29 percent increase in income would be required in order to allow individuals to enjoy as much utility in the base case as they enjoy in an economy with no pharmaceutical insurance. An overall increase in social welfare is also noted in the Private Insurance regime relative to the base case. While privately insured individuals pay a larger premium $\tau = 1006$, no one is subject to a government tax to fund Medicare or Medicaid. The Private + Medicare regime also provides greater social welfare than the base case. On average, individuals would need an increase in income of 0.12 percent to be as well off under the base case as in an economy without Medicaid. This comparison is consistent with the comparison between the base case and Private + Medicaid, which has a lower social welfare; income would have to decline approximately 0.06 percent in order to give individuals the same utility as they have in an economy without Medicare. Finally, universal (public) insurance is seen to have higher overall social welfare than the base-case regime. On average, 0.34 percent increase in income is required to make individuals as well off in the base case as they are under universal insurance.

Table 7 also gives results for different groups within the model economy. Specifically, we identify policy-relevant groups present in the baseline regime and compute an average equivalent variation for members of that group under each different policy regime. For example, the second column suggests that those initially uninsured and those privately insured prefer the regime with just private insurance to the baseline regime. In contrast, those individuals initially eligible for Medicare, those initially eligible for Medicaid, and monopolists prefer the baseline regime to the Private Insurance regime. In most cases, the signs of the equivalent variation values match our intuition. For example, it should not be a surprise that individuals eligible for Medicare would prefer a regime in which Medicare is available. As shown in the column for Private Insurance + Medicaid, this decline in well-being for Medicare eligibles is most substantial when these individuals are expected to contribute to Medicaid benefits, or, alternatively, in the Universal Insurance case, also to benefits for those previously uninsured. We might also expect individuals eligible for Medicaid to prefer a regime in which Medicaid is available; the data in the second row of Table 7 confirm that this is so.

Table 7: Equivalent Variation Results for Baseline Groups

	Policy Regimes[a]				
Group	No Insurance	Private Insurance	Private + Medicaid	Private + Medicare	Universal Insurance
Total	1.2919%	0.0545%	−0.0630%	0.1179%	0.3372%
Medicaid Eligible	−0.0767%	−0.0767%	−0.0001%	−0.0767%	−0.0767%
Medicare Eligible	−0.0599%	−1.2698%	−1.4102%	0.1059%	−0.9232%
Uninsured	0.1600%	0.1600%	0.1200%	0.0500%	−0.3200%
Privately Insured	2.2693%	0.2395%	0.0427%	0.1991%	0.8157%
Monopolists	−91.7048%	−6.3633%	−0.2844%	−6.0985%	−6.4595%

[a]All values indicate the percentage change to income available under the base insurance regime consumers would need to receive in order to achieve the same utility as they experience in the indicated regime. Positive values mean the indicated regime is better.

Perhaps surprising is the welfare decline almost every group experiences with the Universal Insurance regime as developed for this model economy. The decline for Medicaid-eligible individuals is understandable because the drug subsidy they receive is lower than in the baseline regime. Individuals initially eligible for Medicare pay a higher tax rate and receive roughly the same drug subsidy, which explains why they are less well off with Universal Insurance. The monopolists sell less of good one (although price rises, total profit falls – see Table 6) thus explaining their preference for the baseline regime. The only individuals to prefer the Universal Insurance regime to the baseline regime are those initially participating in the private insurance program. These individuals receive a slightly lower benefit, but at a much lower cost; the cost of their drug consumption is now spread out over the entire population. The data suggest that the individuals most often identified as likely to benefit from a shift to some sort of universal insurance coverage – those currently uninsured – would, in fact, not really benefit from such a change. It seems, for those initially uninsured, that the consequence of additional taxes needed to finance a universal insurance scheme more than offset the benefit of cheaper prescription drugs. As seen in Table 5, the highest tax rate for universal insurance is 1.6 percent. The uninsured would be required to pay at a rate of 0.483 percent, higher than their combined rates for Medicaid and Medicare.

We next consider the impact of the different policy regimes on different income cohorts in the model population. Table 8 gives equivalent variation statistics under each policy regime for all income deciles. As discussed in the Appendix, the lowest-earning 16.5 percent of the model population are eligible for Medicaid, explaining why the results for the bottom decile and second decile tend to be qualitatively similar to those seen in Table 7 for people initially eligible for Medicaid. Similarly, the results for the third decile are essentially identical to the results in Table 7 for people initially uninsured.

Table 8: Equivalent Variations for Income Deciles

	Policy Regimes				
Decile	No Insurance	Private Insurance	Private + Medicaid	Private + Medicare	Universal Insurance
Bottom Decile	−0.0151%	−0.0151%	0.0000%	−0.0151%	−0.0151%
Second Decile	−0.0481%	−0.0481%	0.0456%	−0.0900%	−0.2309%
Third Decile	0.1600%	0.1600%	0.1200%	0.0500%	−0.3200%
Fourth Decile	2.0688%	−0.1179%	−0.2677%	0.1478%	1.0312%
Fifth Decile	3.3184%	−0.2185%	−0.4554%	0.2287%	1.7211%
Sixth Decile	2.5872%	−0.0400%	−0.2516%	0.2075%	1.0407%
Seventh Decile	2.0264%	0.0853%	−0.1070%	0.1904%	0.5571%
Eighth Decile	1.5553%	0.1809%	0.0039%	0.1774%	0.1851%
Ninth Decile	1.1282%	0.2609%	0.0974%	0.1656%	−0.1285%
Top Decile	0.1085%	0.3043%	0.1918%	0.1163%	−0.4904%
Total	1.2919%	0.0545%	−0.0630%	0.1179%	0.3372%

Middle-income individuals who fall into the fourth through eighth deciles would experience different policy effects from those with the lowest incomes in the economy. All groups would be worse off without public health insurance as seen by the welfare drops they would experience under the Private Insurance regime. For these middle-class Americans, particularly in the fifth decile and sixth decile, universal insurance would improve social welfare. A 1.72 percent increase in income would be required for the fifth decile to be as well off in the baseline regime as they would be under universal insurance. The No Insurance regime benefits middle-income individuals more than others in the economy. The required average income increase for individuals in the fifth decile is 3.37 percent to make them as well off under the baseline regime as in an economy without any pharmaceutical insurance.

The highest-income individuals, those in the top two deciles, benefit from any policy change except for a move to Universal Insurance. Dropping either or both public insurance programs (Medicare and Medicaid) leads to an improvement in their welfare as they are no longer taxed to pay for these programs. Interestingly, dropping the private insurance program, for which they are eligible given their high incomes, is also welfare-improving. It must be that the loss in welfare due to higher effective drug prices is more than matched by a welfare gain resulting from not having to pay a premium for drug coverage. The only regime that would lead to a welfare loss for the highest-income decile, relative to the baseline regime, is Universal Insurance. The percentage drop in income experienced by the top decile is 0.49 percent.

5 Conclusion

In response to the high and rising prices of prescription pharmaceuticals, more and more of their cost is being picked up by private and public prescription drug insurance programs. The pace at which insurance coverage has been extended has been rapid and has not allowed careful thinking about the broader implications of increased coverage, either for the economy as a whole or for specific groups of individuals.

By developing a general-equilibrium model in which consumers are heterogeneous both with respect to income and to need for pharmaceuticals, we are able to shed light on pharmaceutical drug coverage both in terms of overall effect on social welfare and effect on low-income and/or high-need groups. By selecting model parameters based on actual data and to achieve key calibration targets, we are able to generate some preliminary policy conclusions. A primary finding is that while monopolists and the elderly (high-need consumers) benefit from insurance, on average social welfare is higher in an economy without insurance than under the current system of private insurance coupled with public insurance for the low-income and high-need consumers. On average, there is a 1.29 percent income increase required for people to be as well off with all current insurance than if there were no insurance programs. While insurance came in response to high pharmaceutical prices, our model suggests that, in the absence of that insurance, prices would be much lower — although still much higher than marginal cost. Lower demand would be expected without insurance since individuals pay an unsubsidized price for the drug.

Our results indicate additionally that a universal insurance program needs careful consideration before implementation. The proposal in this paper leads to an increase in social welfare relative to the current combination of private and public programs, but it is not seen to benefit those we might expect. Of most concern is the loss in welfare by those who are currently uninsured, since the argument we often hear for universal insurance is that the uninsured are being treated unfairly and need to be protected by a nationwide safety net. In our model, the uninsured experience a welfare decline because the tax they must pay to finance such a program exceeds the sum of their Medicaid and Medicare tax rates in the base-case regime.

Our research is ongoing. We are considering a profit tax on the monopolists to help pay for universal coverage. Moreover, we are in the process of conducting policy analyses for the different regimes to understand the welfare consequences of increasing or decreasing the generosity of various programs.

Appendix

The details of finding values for the data-driven parameters in Table 2 are given here:

a_1 This parameter represents hourly labor productivity in pharmaceutical production. According to the 2006 *Annual Survey of Manufactures*, prepared by the U.S. Census Bureau (2006a), Pharmaceutical Preparation Manufacturing (NAICS 325412) employed 83,453 production workers for a total of 166,564,000 hours during 2006. This means each production worker worked an average of 1995.9 hours during the year. In total, there were 162,948 employees working in this industry. Multiplying 1995.9 times 162,948 gives 325,227,913 total hours worked. Total value added was $112,994 million, which, when divided by total hours worked, gives an average value added per hour worked of $347.43.

Since the early 1980s, the pharmaceutical sector has experienced considerably more inflation than the economy as a whole. Because the ratio a_2/a_1 plays such an important role in the general-equilibrium model, we sought to put both general-equilibrium sectors on an "even playing field" by building in an equal amount of inflation into a_1 and a_2; we did not want to confuse real productivity growth with rising prices. Our approach was to correct $347.43 so that it more accurately reflected real productivity growth. First, we deflated $347.43 to 1982 dollars using the PPI for Pharmaceuticals (1982=100).[25] The 2006 PPI for Pharmaceutical Preparation Manufacturing is 358.79. Then $347.43 / 3.5879 = $96.83 in 1982 dollars. Next, "reinflating" using the PPI for finished goods[26] gives 96.83 times 1.604, so a_1 = $155.32 in 2006 dollars.

a_2 This parameter represents hourly labor productivity in good-2 ("all other goods") production. We approximate a_2 by computing hourly labor productivity in the economy as a whole. For 2006, the Bureau of Economic Analysis reports U.S. GDP was $13,178.4 billion. In July 2006, total nonfarm employment (seasonally adjusted) was 136,172,000.[27] To find the number of

[25] PPI data are available from the website for the U.S. Department of Labor, Bureau of Labor Statistics at http://data.bls.gov/cgi-bin/surveymost?pc; click on Pharmaceutical Preparation Manufacturing to obtain the data.

[26] Available at http://data.bls.gov/cgi-bin/surveymost?wp; use the first series listed.

[27] From the Bureau of Labor Statistics website at http://data.bls.gov/cgi-bin/surveymost?ce. Click on Total Nonfarm Employment Seasonally Adjusted.

hours worked, we first find the number of hours per production worker from the 2006 *Annual Survey of Manufactures* (U.S. Census Bureau, 2006a). For all manufacturing sectors (NAICS 31-33), the total number of hours worked in 2006 was 18,786,191,000 and the total number of production workers was 9,179,071. Dividing hours by workers gives 2046.63 hours per production worker. Given the total nonfarm employment listed above, this suggests there were 136,172,000 times 2046.63 = 278,693,700,400 total hours worked. Dividing GDP by the total number of hours worked gives $a_2 = \$47.34$.

c This parameter indicates the fraction of the population that share ownership of the monopoly that produces good one. In Kelton and Wallace (1995), a single individual had control over all good-one production. In keeping with the idea that monopoly signifies the concentration of power in the hands of a few, we choose to proxy c as the ratio of the number of nonproduction workers in pharmaceutical manufacturing to the number of nonfarm employees in the United States (these individuals are probably benefitting, to varying degrees, from working in a monopoly). The numbers have already been identified above and give a value of $c =$ (162,948-83,453)/136,172,000 = 0.00058. Hence, monopolists have values of $\rho_m \in (0., 0.00058R]$. The role of c in the model is minimal; it does not influence monopoly price, quantity, or profit level.

ρ_{MR} This parameter denotes the value of ρ above which individuals are eligible for Medicare. According to the Kaiser Family Foundation (2007a), there were 22.5 million enrollees in Medicare Part D in 2006. Another Kaiser Family Foundation study reports that another 4.9 million people (as of January 2007) had public prescription-drug coverage other than through Medicare or Medicaid (e.g., the V.A. program).[28] Combined, there were 27.4 million people covered by "Medicare+." According to the U.S. Census Bureau, the total U.S. population in 2006 was 298,754,819.[29] Dividing these two numbers gives 27,400,000/298,754,819 = 0.0917. Hence, $\rho_{MR} = (1 - 0.0917)R = 0.9083R$.

α_p This parameter indicates the minimum value of α for which an individual participates in the private insurance program. According to the Kaiser Family Foundation (2007b), 60 percent

[28] See Kaiser Family Foundation (2007b).
[29] See http://www.census.gov/popest/states/NST-ann-est.html.

of Americans had employer-sponsored health insurance in 2005, with 98 percent of those, or 58.8 percent of the total population, having prescription drug coverage. After subtracting out those on Medicare, and focusing only on the nonmonopolists, we get $\alpha_p = 0.06$ as the solution to

$$\int_{\alpha_p}^{1} \int_{cR}^{R} f(\rho) d\rho f(\alpha) d\alpha = 0.5880. \tag{18}$$

α_{MD} This parameter represents the maximum value of α for which an individual is eligible for Medicaid. According to the Centers for Medicare and Medicaid Services (2007a), there were 45,156,803 individuals enrolled in Medicaid in December of 2006. Another 4,102,338 were enrolled in SCHIP in December of 2006.[30] Thus the fraction of the population receiving medical care via low-income support programs was 49,259,141/298,754,819 = 0.1649. Again focusing only on nonmonopolists, but not excluding people eligible for Medicare (since some people are eligible for both Medicare and Medicaid), this translates to a value of $\alpha_{MD} = 0.025$ after solving the following equation:

$$\int_{0}^{\alpha_{MD}} \int_{cR}^{R} f(\rho) d\rho f(\alpha) d\alpha = 0.1649. \tag{19}$$

δ_{MD} This parameter indicates the portion of pharmaceutical expenses an individual on Medicaid could expect Medicaid to pay. According to the National Pharmaceutical Council, Inc. (2006), Medicaid incurred an average cost of \$60.15 per prescription in 2003. Medicaid subsequently received an average rebate of 24.1 percent, leaving a net cost of \$45.65. The same report indicates that Medicaid co-pays varied across states from \$0 to \$3. Assuming an average co-pay of \$1.50 means Medicaid paid for 96.7 percent of the cost of prescription drugs; hence, we let $\delta_{MD} = 0.967$.

δ_p This parameter indicates the portion of pharmaceutical expenses an individual having private insurance could expect the insurance to cover. According to the Centers for Medicare and Medicaid Services (2008), of the \$216.7 billion in retail sales of prescription drugs in 2006, \$47.6 billion was paid out of pocket, representing 22 percent of the total.[31] Assuming pharmaceutical purchases by the uninsured are negligible, we set $\delta_p = 0.78$.

[30] See Centers for Medicare and Medicaid Services (2007b).

[31] See Table 4 of http://www.cms.hhs.gov/NationalHealthExpendData/downloads/tables.pdf.

δ_{MR} This parameter indicates the portion of pharmaceutical expenses an individual on Medicare could expect Medicare to pay. We set $\delta_{MR} = 0.78$ using the same logic and data as used for δ_p.

δ_{UI} For consistency with the private insurance program and the Medicare program, we set $\delta_{UI} = 0.78$.

λ_1,λ_2 These parameters are derived from the Urban-Brookings Tax Policy Center Microsimulation Model, Table T08-0079. The average effective federal tax rates by quintile found in this table indicate that the lowest quintile faces a rate of essentially zero given the earned income tax credit and other benefits they receive. The second lowest quintile faces an average effective tax rate that is approximately 30 percent of the effective average tax rate for the top three quintiles. Hence, we set $\lambda_1 = 0$ and $\lambda_2 = 0.3$.

References

Center on an Aging Society. 2002. *Prescription Drugs: A vital component of health care.* Georgetown University, Washington D.C. Available at http://ihcrp.georgetown.edu/agingsociety/pdfs/rxdrugs.pdf.

Centers for Medicare and Medicaid Services. 2008. National Health Expenditure Data. Available at http://www.cms.hhs.gov/nationalhealthexpenddata/. Accessed on January 19, 2009.

Centers for Medicare and Medicaid Services. 2007a. "Medicaid Managed Care Enrollment as of December 31, 2006." Available at http://www.cms.hhs.gov/MedicaidDataSourcesGenInfo/Downloads/mmcpr06.pdf.

Centers for Medicare and Medicaid Services. 2007b. "SCHIP Enrollment Reports." Available at http://www.cms.hhs.gov/NationalSCHIPPolicy/SCHIPER/list.asp.

Chotikapanich, D., D. S. P. Rao and K. K. Tang. 2007. "Estimating Income Inequality in China Using Grouped Data and the Generalized Beta Distribution," *Review of Income and Wealth*, **53**, 127-147.

Cline, Richard R. and David A. Mott. 2003. "Demand for a Medicare Prescription Drug Benefit: Exploring Consumer Preferences under a Managed Competition Framework." *Inquiry*, **40**, 169-183.

Elam, Linda. 2007. "Prescription Drugs Under Medicaid." In Fulda, Thomas R. and Wertheimer, Albert I., editors. *Handbook of Pharmaceutical Policy*, 87-108. New York: Haworth Press, Inc.

Goldman, Dana P., Geoffrey F. Joyce and Jesse Dylan Malkin. 2002. "The Costs of A Medicare Prescription Drug Benefit." *Topics in Economic Analysis and Policy*, Vol. 2: Iss. 1, Article 3.

Gross, David J. 2007. "Medicares Prescription Drug Benefit." In Fulda, Thomas R. and Wertheimer, Albert I., editors. *Handbook of Pharmaceutical Policy*, 65-86. New York: Haworth Press, Inc.

Guo, Jeff J. and Kelton, Christina M.L. 2007. "Competition: Brand-Name versus Generic Drugs." In Fulda, Thomas R. and Wertheimer, Albert I., editors. *Handbook of Pharmaceutical Policy*, 395-416. New York: Haworth Press, Inc.

Hoffman, James M., Nilay D. Shah, Lee C. Vermeulen, Fred Doloresco, Penny Grim, Robert J. Hunkler, Karrie M. Hontz and Glen T. Schumock. 2008. "Projecting future drug expenditures—2008," *American Journal of Health-System Pharmacy*, **65**, 234-253.

Kaiser Commission on Medicaid and the Uninsured. 2003. *Medicaid Outpatient Prescription Drug Benefits: Findings from a National Survey, 2003.* Washington, D.C. Available at http://www.kff.org/medicaid/upload/Medicaid-Outpatient-Prescription-Drug-Benefits-Findings-from-a-National-Survey-2003.pdf. Accessed on January 19, 2009.

Kaiser Family Foundation. 2008. *Prescription Drug Trends.* Available at http://www.kff.org/rxdrugs/upload/3057_07.pdf.

Kaiser Family Foundation. 2007a. *MEDICARE CHARTPACK: Overview of Medicare Part D Organizations, Plans and Benefits By Enrollment in 2006 and 2007.* Available at http://www.kff.org/medicare/upload/7710.pdf.

Kaiser Family Foundation. 2007b. *Prescription Drug Trends.* Available at http://www.kff.org/rxdrugs/upload/3057_06.pdf.

Kaiser Family Foundation and Health Research and Educational Trust. 2007. *Employer Health Benefits: 2007 Annual Survey*, Section 9: Prescription Drug Benefits. Available at http://www.kff.org/insurance/7672/upload/76723.pdf. Accessed on January 19, 2009.

Kelton, Christina M. L. and Robert P. Rebelein. 2007. "A General-Equilibrium Analysis of Public Policy for Pharmaceutical Prices," *Journal of Public Economic Theory*, **9**, 285-318.

Kelton, Christina M. L. and Neil Wallace. 1995. *Microeconomics: An Introductory General-Equilibrium Approach*, Unpublished Manuscript, Chapters 7 and 16, available from the authors on request.

McDonald, J. B. 1984. “Some Generalized Functions for the Size Distribution of Income,” *Econometrica*, **52**, 647-665.

McDonald, J. B. and M. R. Ransom. 1979. “Functional Forms, Estimation Techniques and the Distribution of Income,” *Econometrica*, **47**, 1513-1525.

Mulligan, Casey B. 2002. *Economic Limits on “Rational” Democratic Redistribution*, George J. Stigler Center for the Study of the Economy and the State, Graduate School of Business, University of Chicago, Working Paper No. 171.

National Institute of Health Care Management, Research and Educational Foundation. 2002. *Prescription Drug Expenditures in 2001: Another Year of Escalating Costs.* Available at http://www.nihcm.org/ nihcmor/pdf/spending2001.pdf. Accessed on January 19, 2009.

National Pharmaceutical Council, Inc. 2006. *Pharmaceutical Benefits Under State Medical Assistance Programs, 2005/2006 Edition*, Reston, Virginia.

National Pharmaceutical Council, Inc. 2005. *Pharmaceutical Benefits Under State Medical Assistance Programs, 2004*, Reston, Virginia.

Thurow, Lester C. 1970. “Analyzing the American Income Distribution,” *The American Economic Review*, **60**, Papers and Proceedings of the Eighty-second Annual Meeting of the American Economic Association, 261-269.

Urban-Brookings Tax Policy Center Microsimulation Model, Table T08-0079. 2007. Available at http://www.taxpolicycenter.org/numbers/displayatab.cfm?DocID=1818. Accessed on January 19, 2009.

U.S. Census Bureau. 2006a. *2006 Annual Survey of Manufactures.* Available at http://factfinder.census.gov/servlet/IBQTable?_bm=y&-ds_name=AM0631GS101.

U.S. Census Bureau. 2006b. *Current Population Survey*, accessed at http://pubdb3.census.gov/macro/032006/hhinc/new06_000.htm.

U.S. Department of Labor, Bureau of Labor Statistics. 2008. Producer Price Index data from http://data.bls.gov/cgi-bin/surveymost?wp.

Yin, Xiangkang. 2001a. "A Tractable Alternative to Cobb-Douglas Utility for Imperfect Competition" *Australian Economic Papers*, **40**, 14-21.

Yin, Xiangkang. 2001b. "A Model of Shareholder Discounts" *The Economic Record*, **77**, 89-102.