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THE WELFARE EFFECTS OF PUBLIC DRUG INSURANCE

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ABSTRACT

Rewarding inventors with inefficient monopoly power has long been regarded as the price of encouraging innovation. Public prescription drug insurance escapes that trade-off and achieves an elusive goal: lowering static deadweight loss, while simultaneously encouraging dynamic investments in innovation. As a result of this feature, the public provision of drug insurance can be welfare-improving, even for risk-neutral and purely self-interested consumers. In spite of its relatively low benefit levels, the Medicare Part D benefit generate $3.5 billion of annual static deadweight loss reduction, and at least $2.8 billion of annual value from extra innovation. These two components alone cover 87% of the social cost of publicly financing the benefit. The analysis of static and dynamic efficiency also has implications for policies complementary to a drug benefit: in the context of public monopsony power, some degree of price-negotiation by the government is always strictly welfare-improving, but this should often be coupled with extensions in patent length.

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I Introduction

Patents encourage innovation by awarding inefficient monopoly power to inventors. This leads to the familiar trade-off between inducing innovation, and ensuring the efficient utilization of invented goods. Public prescription drug insurance provides a way out of this dilemma, because it helps decouple the price consumers pay from the price innovators receive. By subsidizing co-insurance for drugs, public insurance encourages utilization, but without necessarily compromising innovators' prices, profits, and incentives for research. As such, public insurance can simultaneously promote static and dynamic efficiency, which are often at odds.

The social value of publicly provided drug insurance is typically thought to derive from its insurance value, and the value of care provided to less affluent groups. However, its static and dynamic efficiency effects imply that public drug insurance is valuable to *risk-neutral, self-interested consumers*. We demonstrate this point theoretically, and the data suggest that it is of considerable quantitative importance. Even though Part D is not a particularly generous insurance plan, it generates an annual value of $3.5 billion in static deadweight loss reduction, and $2.8 billion in additional innovation. The total value of $6.5 billion is within 13% of median estimates for Part D's social cost. Part D is nearly welfare-improving, even ignoring the aspects of the program typically thought to generate its entire social value.

Taken as a whole, the Part D legislation — like many public prescription drug insurance programs — addresses more than just insurance for prescription drugs. While prescription drug insurance per se enhances welfare, the auxiliary provisions of the Part D program rest on shakier conceptual foundations. Two provisions in particular bear on its efficiency effects. First, the original legislation forbade the government from using its newfound buying power to negotiate

prices. This was motivated by concern that price-negotiation could lower pharmaceutical profits and dampen innovation incentives. Second, and in stark contrast, the legislation also placed limits on the ability of innovators to "game" the patent system by acquiring extended patent protection. Many pharmaceutical companies use a variety of strategies to extend monopolies and block the entry of generic competitors; the Medicare Modernization Act placed explicit restrictions on such behavior.

The prohibition on price-negotiation is likely to be welfare-decreasing, even in a dynamic sense.[1] In particular, some degree of price-negotiation is always welfare-improving. The argument is a familiar application of the "second-best" principle: it is welfare-enhancing to distort an efficient margin slightly, as long as it reduces distortion along another, inefficient margin. While patents distort consumer utilization, the innovator is nonetheless able to maximize his static profits with respect to price. Initially, therefore, small deviations from the optimal monopoly price have no impacts on monopoly profits, or on incentives for innovation. In contrast, they strictly lower the degree of deadweight loss from under-utilization by consumers. As a result, some degree of price-reduction enhances the efficiency of utilization, but has no deleterious effects on innovation, at least on the margin. The recent proposal in Congress to begin price-negotiation may thus rest on sounder economic footing than the original legislation.

The case for or against "patent-gaming" is not nearly as clear-cut, but there is an important interaction between the two provisions. Somewhat surprisingly, the recent push to negotiate

[1] While the current Congress has passed legislation that could end up overturning the prohibition on price-negotiation, it remains in place as of this writing. The Medicare Prescription Drug Price Negotiation Act of 2007 (H.R. 4) requires the Secretary of the Department of Health and Human Services to negotiate prescription drug prices for Medicare Part D starting in 2008. This has not yet been signed into law.

prices actually undercuts the economic case for limiting patent-gaming. The key is the well-known result that the dynamically optimal patent is long, but "narrow," in the sense that it awards a negligibly small per-period profit over an infinitely long period of time (Gilbert and Shapiro, 1990; Klemperer, 1990) . There is an important analogy between prescription drug policy and this principle of optimal patent design. Patent-gaming can be thought of as a *de facto* means of increasing patent length (albeit at some social cost). In contrast, price-negotiation reduces profits at a given point in time, and thus serves to "narrow" patent width. Since it is welfare-improving to simultaneously lengthen patents and narrow market power, it is similarly welfare-improving to couple patent-gaming with price-negotiation. This is precisely the opposite of the way the original Part D legislation was configured.

In this paper, we analyze the welfare economics of the Medicare Part D program, with special attention to its provisions for drug insurance, price-negotiation, and patent-gaming. We begin with some relevant background material, and then present our analysis in three parts. Section III presents a simple theoretical model that demonstrates the welfare effects of Medicare Part D, as well as the approach to calculating them. Section IV uses the theoretical model to quantify the welfare effects of the program. Finally, Section V analyzes how the passage of Part D affects optimal innovation and procurement policy.

II The Medicare Part D Program

Design and Benefits of Medicare Part D

Medicare Part D subsidizes the costs of prescription drugs for Medicare beneficiaries and was introduced by the passage of the Medicare Prescription Drug, Improvement, and Modernization Act of 2003 (MMA). Beneficiaries can obtain the Medicare Drug benefit through two types of

private plans: beneficiaries can join a Prescription Drug Plan (PDP) for drug coverage only, or they can join a Medicare Advantage plan (MA) that covers prescription drugs (MA-PD). Beneficiaries are required to make premium payments to obtain Part D coverage. However, premiums are highly subsidized. Medicare Part D covers roughly 75% of the costs.

Medicare Part D establishes a standard drug benefit that Part D plans may offer. The standard benefit is defined in terms of the benefit structure and not in terms of the drugs that must be covered. In 2007, this standard benefit requires payment of a $265 deductible. The beneficiary then pays 25% of the cost of a covered Part D prescription drug up to an initial coverage limit of $2400. Once the initial coverage limit is reached, the beneficiary is subject to another deductible, commonly known as the "Donut Hole," in which they must pay the full cost of drugs. When total out-of-pocket expenses on formulary drugs for the year, including the deductible and initial coinsurance, reach $3850, the beneficiary then reaches catastrophic coverage, in which he or she pays a 5% coinsurance. In practice, Part D plans might deviate from this standard benefit but they must offer coverage that is equivalent to or better than the standard benefit in actuarial terms. The law also stipulates that employers sponsoring prescription drug coverage for retirees can receive a federal subsidy if the coverage is at least actuarially equivalent to the standard Medicare drug benefit. Employers would receive a 28% subsidy to their portion of the individual retiree's drug costs between $250 and $5,000. Finally, Medicare Part D also provides more generous insurance and additional subsidies to low-income beneficiaries. Currently, dual-eligible (eligible for both Medicare and Medicaid) beneficiaries constitute the majority of the beneficiaries receiving low income subsidies as they are automatically enrolled in Part D plans.

Role of Price Negotiations

One of the controversial features of the MMA was it did not allow Medicare to negotiate prices directly with pharmaceutical companies. Many critics regard this as poor stewardship of tax dollars, while those in favor argue that price-negotiation could dampen innovation incentives by lowering pharmaceutical profits. However, this original legislation might be overturned by the Medicare Prescription Drug Price Negotiation Act of 2007 (H.R. 4). This bill, passed earlier this year by the House of Representatives, would require the Secretary of Health and Human Services to negotiate directly with manufacturers to lower covered Part D drug prices, beginning in 2008. This would reverse the MMA prohibition against federal negotiation of drug prices. The status of the bill remains uncertain, as of this writing. In April of 2007, an attempt to force a Senate vote on the bill was blocked (Marre, 2007). For his part, President Bush has consistently promised to veto it if passed (Espo, 2007).

MMA and Patent-Gaming

Patent-gaming refers to activities of pharmaceutical companies to extend monopolies and block entry of cheaper generics in markets for blockbuster drugs near patent expiration. The most common tactic is to file a lawsuit against a generic competitor for infringement of a patent on the original product.[2] Under the Drug Price Competition and Patent Term Restoration Act of 1984

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[2] Another tactic is to file multiple patents with the FDA after a potential generic entrant applies for FDA approval, and then to sue the new entrant for the infringement of these later patents. Such lawsuits have triggered multiple but staggered 30-month delays. For example, the manufacturers of Paxil, a blockbuster antidepressant, received 5 staggered 30-month extensions delaying the approval of generics by 65 months. Still other tactics include the conduct of clinical trials in children, for which the Hatch-Waxman act guarantees six months of market exclusivity, or introducing new versions of a patented product that differ only in dosage, appearance or indications for use. For example, Eli Lilly (the manufacturer of the antidepressant Prozac), introduced Sarafem, a new drug chemically identical to Prozac but colored pink and lavender instead of green. Sarafem got more than 2 years of market

(commonly known as the Hatch-Waxman Act) the filing of any lawsuit—no matter how frivolous—triggers an automatic 30-month delay in the introduction of generics.[3] An FTC study found that brand name companies sued the first generic entrant and triggered the automatic 30-month extension for 72% of the drugs analyzed in the study. The study also found that, for cases resolved in the courts, generic entrants prevailed 73% of the time (FTC, 2002). The MMA imposed limits on patent-gaming by stipulating that brand name companies could not get more than one 30-month extension for lawsuits filed against generic entrants. The law also allows the generic applicant to assert a counterclaim to de-list a patent related to the brand name drug. This further discourages branded companies from such patent-extension strategies.

III The Welfare Effects of Stand-Alone Public Drug Insurance

We first analyze the welfare effects of extending insurance, without any additional provisions. This analysis distills the key welfare effects of drug insurance alone. It demonstrates one of the unique features of such insurance: its potential to lower deadweight loss and raise monopoly profits, simultaneously. It can achieve this outcome by partially decoupling the consumer's price from the revenue earned by the monopolist.

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exclusivity, because it was approved for treating premenstrual depression, anxiety and irritability (whereas Prozac was approved for major depression), and an additional 6 months extension because it was tested in clinical trials for children (Angell, 2004).

[3] Drug Price Competition and Patent Term Restoration Act of 1984, Pub. L. No. 98-417, 98 Stat. 1585 (codified at 21 U.S.C. § 355 (1994) and 35 U.S.C. § 271(d)-(h) (1994)) ("Hatch-Waxman Act").

Static Implications

The provision of drug insurance can reduce deadweight loss, because co-payments below the monopoly price increase utilization by consumers. Define $D(p)$ as the demand function, $P(Q)$ as inverse demand, MC as the constant marginal cost of production, and p_m as the equilibrium monopoly price. The social surplus generated by competitive provision of the good is given by:

$$SS_c \equiv \left(\int_0^{D(MC)} P(Q)dQ - MC * D(MC) \right) \quad (1)$$

In the absence of insurance, deadweight loss in the branded pharmaceutical market is social surplus under competition, minus social surplus under monopoly:

$$DWL \equiv SS_c - \left(\int_0^{D(p_m)} P(Q)dQ - MC * D(p_m) \right) \quad (2)$$

Now suppose that the government offers prescription drug insurance. Specifically, suppose the government covers the share $(1-\sigma)$ of the market price, and leaves the consumer with the co-insurance rate σ. If the government continues to pay the monopoly price for pharmaceuticals, the actuarial cost of the insurance is $p_m(1-\sigma)D(\sigma p_m)$. From a purely static point of view, this cost is simply a transfer from the government to the pharmaceutical industry.[4] The welfare effects emerge from the change in quantity induced by this policy.

Of course, Part D could impact the monopoly price charged for pharmaceuticals. The government may use its newfound monopsony power to negotiate prices downward, or

[4] Later, we include the deadweight cost of public funds, which is so far absent.

monopolists may exploit the subsidy to consumers and choose to raise prices. We discuss these possibilities later. For now, we analyze the welfare effects of the program, given some arbitrary post-Part D monopoly price, $p_m^{'}$.

Deadweight loss is a function of what the government pays monopolists, and offers consumers in terms of co-insurance. This relationship can be expressed as:

$$DWL(p_m^{'}, \sigma) \equiv \left(\int_0^{D(MC)} P(Q)dQ - MC * D(MC) \right) - \left(\int_0^{D(\sigma p_m^{'})} P(Q)dQ - MC * D(\sigma p_m^{'}) \right) \quad (3)$$

Ultimately, what matters for deadweight loss is simply $\sigma p_m^{'}$, the price faced by consumers. The welfare effect of lowering the consumer price — either by lowering the co-insurance or by lowering the price paid to monopolists — is given by:

$$-\frac{dDWL}{d\sigma p_m^{'}}|_{p_m^{'},\sigma} = D'(\sigma p_m^{'})\left(\sigma p_m^{'} - MC\right) \quad (4)$$

From a static point of view, lowering the price paid by consumers always lowers deadweight loss, as long as $\sigma p_m^{'} > MC$, or that consumers continue to face a price that is at least as large as marginal cost. Empirically, this assumption seems to hold for Medicare Part D. Marginal cost is typically estimated to be 20% of the branded drug price (Caves, Whinston, and Hurwitz, 1991; Grabowski and Vernon, 1992; Berndt, Cockburn, and Griliches, 1996). In contrast, the average coinsurance rate under Medicare Part D is currently about 62%, well above marginal cost.[5]

[5] This number was calculated by the authors using the Medical Expenditure Panel Survey (MEPS) data described later. Appendix A presents a formal proof that the anticipated percentage change in co-insurance rate (along with the elasticity of demand) is a sufficient predictor of the change in utilization, even with a nonlinear benefit design.

There is one remaining loose end: to show that Part D will always raise consumption, once we account for the behavioral response of innovators. Part D may induce innovators to raise their monopoly price, but never by so much as to reduce quantity below its initial level. For a percentage subsidy s, a firm with constant cost faces the profit function:

$$(1+s)p(q)q - MC * q \tag{5}$$

This has the first-order condition

$$p'(q)q + p(q) = \frac{MC}{1+s}, \tag{6}$$

which makes clear that a subsidy is equivalent to a reduction in marginal cost. As such, subsidies will always raise quantity.

Dynamic Implications

The original intent of Medicare Part D was to provide drug insurance without affecting prices paid to innovators. Earlier, we showed that drug insurance improves static welfare by lowering deadweight loss. We now show that this original aspect of Part D induces more innovation, and increases dynamic social surplus.

Let I denote industry investment in research, and let $g(I)$ denote the probability of discovery with $g'(I) > 0$ and $g''(I) < 0$. In other words, R&D investment raises the probability of new drug discovery, but in a concave fashion. Suppose the innovator enjoys a patent monopoly for T periods after the discovery and will make zero profits thereafter. If the firm discounts the future at the rate r, it invests in research in order to maximize the present value of expected profits:

$$\Pi(I) = g(I)\left[\int_0^T e^{-rt}\pi(\sigma, p_m)dt\right] - I \qquad (7)$$

By the envelope theorem, stand-alone drug insurance raises the expected profits of innovators, because $\frac{d\pi}{d\sigma} < 0$. It will also induce more innovation. The privately optimal level of innovation is given by:

$$g'(I) = \frac{1}{\left[\int_0^T e^{-rt}\pi(\sigma, p_m)dt\right]} \equiv \frac{1}{\Pi^m(\sigma, p_m, T)} \qquad (8)$$

The marginal product of research is the reciprocal of monopoly profits, Π^m and, by extension, of patent length (Nordhaus, 1969). Therefore, since reductions in co-insurance raise profits, they must also stimulate innovation.

Define $I_{pat}(\Pi^m)$ as the level of investment induced by monopoly profits Π^m. Expected social surplus can be written as:

$$S(T, p_m, \sigma) \equiv g(I_{pat}(\Pi^m))\left[\int_0^\infty e^{-rt}SS_c dt - \int_0^T e^{-rt}DWL(\sigma p_m)dt\right] - I_{pat}(\Pi^m) \qquad (9)$$

The marginal value of introducing stand-alone drug insurance is given by:

$$S_\sigma|_{\sigma=1} = I_\pi \Pi_\sigma^m \left\{ g'(I)\left[\int_0^\infty e^{-rt}SS_c dt - \int_0^T e^{-rt}DWL(p_m)dt\right] - 1\right\} + g\left[-\int_0^T e^{-rt}DWL'(p_m)\,p_m dt\right] < 0 \qquad (10)$$

The term in curly braces is strictly greater than unity, because total social surplus from the innovation must be strictly larger than the innovator's profits.[6] Therefore, the first term is negative. This measures the value of drug insurance as a stimulant to innovation. The second term is negative, because $p_m > MC$, implying that deadweight loss will rise with a higher price. This is the value of insurance in mitigating deadweight loss.

Notice the important presumption that the profits of innovators do not exceed social surplus. Clearly, this condition always holds in a completely private market, even one afflicted by moral hazard in insurance provision (Lakdawalla and Sood, 2006). Intuitively, consumers would never voluntarily pay more than their consumer surplus for a drug in a spot market, and they would never pay more for an insurance policy than the expected value of its covered treatments. Public subsidies for employer-provided health insurance make it theoretically possible that profits could exceed social surplus. However, given the estimated rate of surplus-appropriation by innovators (see the discussion beginning on page 25), this would require extremely large transfers. It is even less likely among the elderly population, where prescription drug insurance was relatively uncommon.[7]

However, another more controversial question concerns whether there is currently too much or too little innovation, or equivalently, how much innovators ought to be able to appropriate. In the standard model, innovators ought to appropriate the full value of social surplus, which is

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[6] In theory, distortions like subsidies for health insurance could result in profits being higher than social surplus. However, we later document empirical evidence confirming social surplus is larger than profits.

[7] As of 2003, 60% of the aged (65+) population had no drug insurance, or insurance that was less generous on average than the standard Part D benefit.

impossible in the absence of price-discrimination. Some economists have pointed out that patent races, public subsidies, and other imperfections can alter this result, sometimes substantially. Others have emphasized the extremely low rates of social-surplus appropriation by innovators.[8]

Resolving this controversial question lies beyond the scope of this paper, but we can interpret our analytical results, regardless of whether innovation is too high or too low. If, as in the standard case, innovation is too low, Part D has a direct welfare benefit, without any auxiliary provisions. This is the analysis presented above. If in fact there is *too much* innovation, the direct effects of Part D on innovation reduce social welfare. However, this adds additional value to price-negotiation or similar measures to limit, or even reduce, the profits of innovators. In this case, a Part D program coupled with price-reductions that hold innovator profits constant would be strictly welfare-improving.[9] The rest of the analysis is presented from the point of view of the standard model, that there is too little innovation; the possibility of "over-innovation" is discussed further in Section V, when we consider the benefits of price-negotiation.

Public Financing and Deadweight Cost

In the analysis above, we abstracted from the costs of public-financing. When the government has access to an efficient lump-sum tax mechanism, it does not matter whether insurance is publicly or privately financed. Clearly, the deadweight costs of public financing play a substantial role in the optimal policy configuration. However, in this section, we show that they

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[8] For contrasting views in the context of pharmaceuticals, see Garber, Jones, and Romer (2006), compared with Philipson and Jena (2006). In a broader context, see Shapiro (2007), compared with Nordhaus (2004).

[9] Such a scheme would also be feasible, since innovators have already revealed their willingness to operate at today's profit levels.

do not change the basic conclusion that some public financing of drug insurance is welfare-improving —deadweight costs merely change the optimal *level* of financing. When deadweight costs of taxation rise, the optimal degree of public financing falls, but some public subsidy for drug insurance is always optimal, because of its value as a deadweight-loss reduction device.

Paying more money out of the public treasury, as opposed to private pockets, incurs social cost. This has two effects. First, providing insurance to the uninsured becomes less beneficial, on balance. Second, it now becomes strictly costly to attract the currently insured to a public plan with the same co-insurance rate. In the absence of deadweight costs, public subsidies for insurance premia represent a pure transfer to such people. With deadweight costs, this transfer imposes net costs on society.

In spite of these costs, some degree of subsidization remains optimal. Intuitively, providing a small subsidy to the uninsured always provides some positive benefit, because of the reduction in deadweight loss. Moreover, the cost of "crowd-out" (i.e., attracting currently insured consumers to a less generous public plan) is initially zero, because in an unsubsidized equilibrium, they strictly prefer their more generous private plans.

This intuition can be seen most easily by calculating the optimal degree of subsidy, given a public co-insurance rate σ and a private co-insurance rate σ_p. Specifically, suppose that there are $\overline{N}$ initially uninsured consumers, and $\bar{I}$ privately insured consumers. Without loss of generality, we assume that the insured consumers are all identical, and all have policies with co-insurance rate σ_p.

Define s as the share of the consumer's premium that is publicly financed. Define $N(s)$ as the number of uninsured consumers choosing the public drug plan at the premium subsidy s, and define $I(s)$ as the number of insured consumers doing the same.[10] The social marginal cost of public funds is μ: for example, if raising \$1 of revenue introduces \$0.50 of deadweight loss, we say that $\mu = 0.5$. Finally, $D(p)$ is per person demand at the price p. We assume this is uniform across people, but relaxing this assumption leaves the analysis unchanged. The social cost of a publicly financed drug benefit offering co-insurance rate σ is thus:

$$DWC = s\mu D(\sigma p_m)(1-\sigma)p_m\left[N(s)+I(s)\right] \tag{11}$$

The total reduction in deadweight loss for all consumers is given by:

$$N(s)\int_{D(p_m)}^{D(\sigma p_m)} P(q)dq + I(s)\int_{D(\sigma_p p_m)}^{D(\sigma p_m)} P(q)dq \tag{12}$$

The optimal degree of public financing maximizes deadweight loss reduction, net of social cost, according to:

$$\max_s \left\{ N(s)\int_{D(p_m)}^{D(\sigma p_m)} P(q)dq + I(s)\int_{D(\sigma_p p_m)}^{D(\sigma p_m)} P(q)dq \right\} - s\mu D(\sigma p_m)(1-\sigma)p_m\left[N(s)+I(s)\right] \tag{13}$$

The first-order condition for the optimal subsidy can be written as:

[10] Both I and N also depend on the co-insurance rates σ and σ_p, but since we regard these as fixed, we do not explicitly consider them.

$$N_s \int_{D(p_m)}^{D(\sigma p_m)} P(q)dq + I_s \int_{D(\sigma_p p_m)}^{D(\sigma p_m)} P(q)dq - s\mu D(\sigma p_m)(1-\sigma) p_m \left[N_s + I_s\right] - \mu D(\sigma p_m)(1-\sigma) p_m \left[N + I\right] \leq 0 \quad (14)$$

To show that the optimal value of s exceeds zero, it suffices to show that the marginal return to s is strictly positive when $s = 0$. Without subsidies, neither insured nor uninsured consumers will choose the public drug benefit; otherwise, they would have chosen such an insurance policy in the private market. Therefore, evaluated at zero, the marginal return to public financing is given by:

$$N_s \int_{D(p_m)}^{D(\sigma p_m)} P(q)dq + I_s \int_{D(\sigma_p p_m)}^{D(\sigma p_m)} P(q)dq > 0 \quad (15)$$

If $MC < \sigma \leq \sigma_p$, both terms are strictly positive. If $\sigma > \sigma_p$, the first term is strictly positive, and the second term is zero. To see this, observe that $I_s(0) = 0$. Intuitively, insured consumers will not switch to a less generous plan, absent a strictly positive subsidy. Therefore, since $I(s)$ will be uniformly zero for all s below some strictly positive $s^* > 0$, its derivative must be zero at $s = 0$.[11]

Two other points follow from the first-order condition for public financing. Not surprisingly, the optimal degree of public financing is lower when the marginal cost of public funds μ is higher. In addition, the degree of public financing is *higher* when the deadweight loss from monopoly is higher. Indeed, for competitive markets with $p_m = MC$, there are no static grounds for the

[11] More formally, there exists some $s^* > 0$ such that insured consumers are exactly indifferent between the public and private plans: a strictly positive subsidy is required to compensate the insured consumers for their partial loss of coverage. Therefore, $I(s) = 0$, for all $s \leq s^*$; this implies that $I_s(0) = 0$.

public financing of health insurance. Arguments would need to be made on the conventional bases of insurance value, altruism, or merit goods.

IV Calibrating the Welfare Effects

In this section, we calculate—in a "back-of-the-envelope" fashion – the welfare impacts of Medicare Part D. We consider both the static and dynamic benefits of increased drug consumption and the associated increase in pharmaceutical innovation induced by Medicare Part D. We also estimate the social costs of financing this benefit due to deadweight loss from increased taxation. We exclude dual eligibles from the analysis as they already receive generous public prescription drug insurance from Medicaid. The introduction of Medicare Part D does not substantially change the generosity of insurance for dual eligibles; all it does is transfer insurance from Medicaid to Medicare Part D.

The net benefits of Part D can be calculated according to the following equation:

$$NB = Enrollees * (PC\ Static\ Benefit) + (Dynamic\ Benefit) - (Deadweight\ Cost) \quad (16)$$

In words, the net benefit of the program is equal to: the number of enrollees multiplied by the per capita static benefits to those enrollees, plus the dynamic benefit of the program, minus the deadweight costs of financing. The first term embodies the utilization effects on enrollees, the second the innovation effects, and the third the social cost of funding premiums and employer subsidies. Appendix B provides a summary of the calculations involved in calibrating the static benefits, dynamic benefits and dead weight costs of Part D. A more detailed exposition of this calibration is provided below.

Part D Enrollees and Non-Enrollees

We need to estimate both the number of enrollees, and the number of non-enrollees eligible for the employer subsidy payment. The latter group affects the financial cost of the program, if not the static welfare benefit. We used data from the 2003 Medical Expenditure Panel Survey (MEPS) to estimate these quantities.

Methods

The Medicare Modernization Act classifies an individual's private prescription drug coverage as "creditable" or "non-creditable." Broadly speaking, "creditable coverage" is private insurance that is actuarially at least as generous as Medicare Part D. Individuals without creditable coverage are required to enroll in Part D within 63 days of being eligible, or face a late enrollment penalty if and when they enroll. Those with creditable coverage are not subject to this penalty provision. Moreover, if a firm provides a Part D-eligible employee with creditable coverage, that firm is entitled to a 28% subsidy on their portion of the individual retiree's drug costs between $250 and $5,000.

In our calculations, we assume that there are no costs of switching to Part D. Therefore, everyone without creditable coverage (i.e., less generous than Part D) switches to the program. We also assume that people with creditable coverage refuse to switch.[12] Evidently, therefore, we need to identify individuals with and without "creditable coverage." To do so, we use actual

[12] This assumption has less transparent foundations. Clearly, people with very generous coverage fail to switch, but the effects for people with marginally more generous coverage are theoretically unclear. On the one hand, the subsidy of the Part D premium suggests that some may switch to Part D. On the other hand, employers could pass along the subsidy they receive for privately insuring a worker who is still employed, which may fully counteract the value of the premium subsidy. We adopt the simple assumption of no-switching, because it best matches actual enrollment data, as shown in Table 1.

prescription drug expenditures observed in the MEPS,[13] and calculate the average co-insurance rate generated by the individual's current plan (or lack thereof), and by the standard Medicare Part D benefit. Those whose average co-insurance rate is lower under Part D are classified as having no creditable coverage, and vice-versa. Appendix A presents a formal proof that the average co-insurance rate is a sufficient predictor of value for an insurance plan, even one with a nonlinear benefit design.

Estimates

Using the MEPS sampling weights we estimate that, excluding dual eligibles, 36 million beneficiaries would be eligible for Medicare Part D. Next, for each MEPS respondent we then calculate the average coinsurance for prescription drugs under 2 scenarios: (1) their current coverage; or (2) enrollment in the standard Medicare Part D benefit, described earlier. Based on this analysis, we identify individuals with and without creditable coverage. We estimate that 59% of eligible respondents, or roughly 21 million beneficiaries, have no creditable coverage. We assume all these individuals enroll in Part D.

The remaining 15 million already have more generous insurance compared to the standard Part D benefit and are assumed not to enroll in Part D. Based on information about the source of coverage in MEPS we estimate that roughly 26% of beneficiaries have creditable insurance from an employer or union, which would then receive the employer subsidy instituted by Medicare Part D. Finally, 14% of beneficiaries have creditable insurance from other sources such as

[13] Notice that we calculate the effective co-insurance rate from current spending. This is equivalent to calculating the first-order welfare effect of switching to Part D. Individuals with a positive first-order welfare effect will benefit, and vice-versa.

Veterans Administration, Indian Health Service and state pharmaceutical assistance programs. The employer subsidy is not paid in these cases.

As a validity check, we compared our enrollment estimates to the actual enrollment rates reported by the Department of Health and Human Services (HHS), both of which appear in Table 1. The HHS estimates show that, as of January 2007, and excluding dual eligibles, 36 million beneficiaries were eligible for Medicare Part D. Of these, 21 million were estimated to have no creditable coverage prior to Part D.[14] The remaining 15 million had creditable coverage from employer/union or from other sources such as Veterans Administration, Indian Health Service and state pharmaceutical assistance programs (Kaiser Family Foundation, 2007). These numbers are quite similar to the estimates we derived from analysis of the MEPS.

Table 1: Prescription Drug Coverage Sources Among Medicare Beneficiaries.

	HHS Estimates		MEPS Estimates	
	Population (mil)	**Percent**	**Population (mil)**	**Percent**
Coverage Type				
Enrolled/No creditable Coverage	21	59%	21	59%
Creditable Employer Coverage	10	28%	9	26%
Others with Creditable Coverage	5	13%	5	14%
Total	36	100%	36	100%

[14] Of the 21 million beneficiaries, 17 million enrolled in Part D and the remaining 4 million continued to have no creditable coverage. We assume that, over the long-run, these remaining 4 million respondents will switch into the more generous coverage afforded by the Part D program. If not, this incomplete take-up rate would lower the welfare benefits of the program.

Static Benefits

The next step is computing the static benefit enjoyed by enrollees in Part D. Using a linear approximation to demand, the benefit associated with a particular change in price and quantity is simply the size of deadweight loss reduction "triangle," or $\frac{1}{2}(-\Delta p)(\Delta q)$—one half times the reduction in price, times the increase in quantity. This benefit can be equivalently written using the anticipated percentage changes in price and quantity, along with the elasticity of demand. Appendix A presents a formal proof that the anticipated percentage change in co-insurance rate and elasticity of demand are sufficient predictors of change in utilization, even with a nonlinear benefit design.

Assuming that the price paid to the manufacturer does not change,[15] some simple algebra yields the equivalent formulation of the static benefit for an enrolling consumer:

$$SB = \frac{1}{2}\left[\frac{(\sigma_{ND} - \sigma_D)}{\sigma_{ND}}\right]\left[\frac{(\sigma_{ND} - \sigma_D)}{\sigma_{ND}} e\right] OOP_{ND} \qquad (17)$$

The terms σ_D and σ_{ND} are the average share of price paid by the consumer with and without Part D, respectively. OOP_{ND} is the out of pocket prescription drug expenditure of the consumer under the status quo, and e is the elasticity of demand. To calculate the static welfare impact of Medicare Part D, we need empirical estimates of: (1) The percentage change in price to the

[15] This assumption matches the available empirical evidence. For example, Lichtenberg and Sun (2007) use data from a large retail pharmacy before and after introduction of Medicare Part D and find that Medicare Part D had a negligible impact on overall prices paid to manufacturers but a significant impact on prices faced by consumers.

consumer induced by Medicare Part D, (2) the elasticity of demand for prescription drugs, and (3) the out of pocket costs of purchasing prescription drugs.

Percentage Change in Price

We calculate the percentage price change that enrolling consumers would enjoy if they took up the program by computing — for each elderly consumer in MEPS — the difference in average coinsurance between: (1) status quo insurance, and (2) an insurance plan with the features of the standard Medicare Part D benefit described earlier. We calculate this percentage change in price for each MEPS respondent estimated not to have creditable coverage. Respondents with creditable coverage are assumed not to enroll in Part D and thus experience no change in price. Based on these calculations the average percentage change in coinsurance for those without creditable coverage due to the standard Medicare Part D benefit was estimated to be 30.1%.

Price Elasticity of Demand

Long-run generic prices (assumed to be equal to marginal cost) are approximately 20% of the prices charged for the corresponding on-patent drug (Caves, Whinston, and Hurwitz, 1991; Grabowski and Vernon, 1992; Berndt, Cockburn, and Griliches, 1996). Thus we assume that the mark-up on pharmaceutical prices is roughly 80%. The standard theory of monopoly would then imply, based on a 80% mark-up by monopolists, a price elasticity of uninsured demand around 1.25, or the inverse of the markup.

However, the above elasticity is not the relevant one for insured patients who face copayments, rather than manufacturer prices (Chandra, Gruber, and McKnight, 2007). Thus, for the insured consumers we use elasticity estimates that rely on changes in patient cost sharing among the insured elderly population. For example, Chandra, Gruber and McKnight (2007) estimate the

price elasticity of prescription drugs among the elderly by studying a policy change that raised patient cost-sharing for retired public employees in California. Their estimates of price elasticity range from 0.5 to 1.5.[16] We take the midpoint of their range, and assume that the price elasticity is 1.0 among the insured elderly population. Based on these estimates of the elasticity of demand and percentage change in price the average percentage change in number of prescriptions for those without creditable coverage was estimated to be 34.5%.

Out-of-Pocket Costs

The out of pockets costs of purchasing drugs are available directly from MEPS. For those without creditable coverage, out-of-pocket costs are estimated to be $1,302.

Results

Based on these estimates, we estimate the aggregate static benefit of Medicare Part D to be $3.5 billion or $99 per eligible beneficiary. There is wide variation in the per capita benefit enjoyed by beneficiaries depending on insurance coverage, or lack thereof, prior to the introduction of Medicare Part D. Since insurance coverage is highly correlated with income, the poor enjoy greater benefits than the rich. For example, we estimate the per capita benefits to be $116 for those with incomes less than $15,000 per year, $94 for those with income between 15,000 and 50,000, and $46 for those with incomes greater than $50,000. Similarly, beneficiaries in poor self-reported health and those with higher prescription drug costs also enjoy greater benefits. Those reporting their general health to be "poor" enjoy per capita benefits of $190, those

[16] They also do not find significant variation in price elasticity of prescription drugs by age, income, and health status.

reporting "good" health enjoy per capita benefits of $109 and those reporting "excellent" health only receive $51 in per capita benefits.

Dynamic Benefits

Since Medicare Part D likely increases pharmaceutical company profits, it has the dynamic benefit of inducing additional innovation. We can estimate the value of this induced innovation just as we estimated the static value of the program.[17] First, we maintain the assumption (inherent in the original MMA legislation) that Part D continues to forbid price-negotiation, and that pharmaceutical firms will continue to receive the monopoly prices set before Medicare Part D (p_m). However, firms do experience an increase in demand for their products due to the reduction in price for consumers after the introduction of Medicare Part D.

Step 1: Change in Pharmaceutical Revenues

For a given consumer, the percentage change in total drug expenditures is equal to the percentage increase in the quantity of drugs consumed, $\frac{(\sigma_{ND} - \sigma_D)}{\sigma_{ND}} e$, which is calculated as above.

Assuming manufacturer prices have been so far unaffected by Part D, the percentage change in quantity is equal to the percentage change in revenues for innovators. The average percentage change in price for all eligible beneficiaries was estimated to be 17.9%. This estimate combined with the elasticity estimates implies an average percentage increase in drug expenditures of 20.5%.

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[17] We are proceeding under the standard assumption that there is too little innovation, because innovators cannot capture full social surplus. In Section V, we discuss how Part D could be configured for maximal welfare benefit, if in fact there is over-innovation in the status quo.

Step 2: Creation of New Chemical Entities

The increase in pharmaceutical revenue will induce more R&D and innovation. The number of new drug introductions induced by Part D will depend on the elasticity of new drug introductions with respect to pharmaceutical revenues. Acemoglu and Linn (2004) estimate that the elasticity of non-generic drug approvals with respect to revenues is roughly 3.5. We use this elasticity and the estimate of change in pharmaceutical revenues to calculate the percentage change in the number of new chemical entities (NCEs). The baseline rate of NCE introduction is assumed to be 32 NCEs per year. This is the average number of NCEs introduced per year during the period 1995 to 2004 as reported in the FDA Orange Book. Applying the estimated percentage change to this baseline level yields the absolute number of new drugs projected from the passage of Part D.

Step 3: Innovator's Private Value of New Chemical Entities

The next step is to compute the annual private value of these additional drugs to their innovators. In general, it is quite difficult to compute the expected value of the *marginal* drug directly, because it is hard to identify the marginal drug and just as hard to identify *expected* value. However, it is easier to calculate the actual marginal cost of bringing an additional drug to market. Theory suggests that this marginal cost ought to be equal to the expected marginal private value of an additional drug.[18] Di Masi et al. (2003) estimate that the marginal research and development cost of bringing an NCE to market is $939 million in year 2006 dollars. To annualize this cost, we use a standard empirical estimate of the annual cost of capital in the

[18] Grabowski et al (2002) provide empirical evidence that the theory is consistent with the data in the pharmaceutical industry.

pharmaceutical industry, of 12% per year.[19] Therefore, the annualized marginal cost of bringing an NCE to market is expected to be (0.12)*($939m) = $113 million. This then yields our estimate of the annualized marginal expected private benefit.

Step 4: Marginal Social Value of New Chemical Entities

The last step is to infer the marginal social value, which theory predicts will exceed the private value to the innovator (although see the caveat in footnote 17). To estimate the social return, we must estimate the fraction of social surplus captured by the innovator. Several estimates are available from the literature. Based on data from 1948 to 2001, for example, Nordhaus (2004) estimates that innovators capture just 2.2% of the total present value of social returns to innovation. In a pharmaceutical context, Philipson and Jena (2006) use data from over 200 published studies of healthcare innovations to estimate the distribution of surplus-appropriation by pharmaceutical innovators. They find that the median producer share of social surplus is 17%, the first quartile is roughly 10% and the third quartile is roughly 25%. To be conservative, we assume that innovators are able to capture as much as a quarter of the social surplus from pharmaceutical innovation. This parameter yields an estimated social rate of return on pharmaceutical R&D investments of 48% per year, four times the estimated private return. This suggests that the annual social value of the marginal drug is equal to ($113 million)/(0.25) = $452 million.

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[19] The latest estimates of the cost of capital by industry are available online at http://pages.stern.nyu.edu/~adamodar/. Based on these data, we estimate the cost of capital for the pharmaceutical industry to be 12% per year. This estimate of cost of capital is similar to estimates of private rate of return on R&D investments in the pharmaceutical industry (Grabowski, Vernon, and DiMasi, 2002).

Gross Static and Dynamic Benefit of Part D

Using the methods described in Step 1 we estimate that Medicare Part D would increase pharmaceutical sales by $15 billion per year. Given baseline pharmaceutical sales of $275 billion in the US in 2006, this corresponds to a 5.4% increase. The 3.5 innovation elasticity from Acemoglu and Linn (2004) then implies that the number of new drugs per year would increase by roughly 19%, or 6.1 NCEs. Earlier, we calculated an annual social value of $452 million for the marginal additional drug, which yields a gross dynamic benefit of $2.8 billion annually. Combining the dynamic with the static benefit yields a gross risk-neutral welfare benefit for Medicare Part D of $6.3 billion annually.

Deadweight Costs of Financing Medicare Part D

It remains to compare the aggregate benefits of Part D with its social cost. The program itself is just a costless transfer. However, since it is publicly financed, there are deadweight costs associated with its financing.

The actuarial cost of the Medicare Part D insurance for a beneficiary who enrolls in the standard Part D plan is simply:

$$s\left[Total\_Exp(1-\sigma_D)+(1-\sigma_D)Total\_Exp\frac{(\sigma_{ND}-\sigma_D)}{\sigma_{ND}}e\right] \qquad (18)$$

s is the subsidy provided by Medicare Part D and is estimated to be 75%. The first term in the square brackets is the actuarial cost of the benefit under the initial demand for pharmaceuticals and is simply the total cost of prescription drugs times the plan share of costs. The second term is the actuarial cost of the additional demand induced by Medicare Part D and is equal to the

change in total drug costs times the plan share of costs. As discussed earlier, the percentage change in total drug costs, $\frac{(\sigma_{ND} - \sigma_D)}{\sigma_{ND}} e$, is simply the percentage change in price to consumers induced by Part D times the elasticity of demand. All the above quantities can be easily estimated from available data. Using data from the MEPS, we estimate average total drug costs for MEPS respondents without creditable coverage who are likely to enroll in Medicare Part D to be $1,537. As discussed earlier, we can also calculate the price change consumers would enjoy if they took up the program; price-elasticities of demand for pharmaceuticals (taken from the literature) then imply the associated increase in drug costs. Similarly, the costs of providing the employer subsidy (28% of costs between $250 and $5000) can be estimated easily using data on prescription drug expenditures for those with creditable employer/union provided insurance. The results show that for those receiving the premium subsidy, Medicare costs are $893 per enrollee and for those receiving the employer subsidy, Medicare costs are $584 per enrollee. These estimates are similar to those obtained by HHS. For example, the average premium for a Part D plan was roughly $27 per month or $327 per year. Since Medicare subsidizes premiums by 75%, Medicare costs of providing the premium subsidy equal $985 ($327*3) per year. Similarly, HHS estimates indicate that the cost of employer subsidy was $549 per beneficiary receiving the subsidy (Kaiser Family Foundation, 2007).

The true social cost of the program is the deadweight cost associated with paying the actuarial cost out of public funds. While there is debate in the public finance literature on the magnitude of deadweight loss, we use a conventional estimate — that each additional dollar spent on

Medicare Part D generates 30 cents of deadweight costs due to increased taxation (cf, Jorgenson and Yun, 2001).[20]

Based on these estimates, we estimate the deadweight costs of financing Medicare Part D to be $7.2 billion per year, 87% of which is covered by the risk-neutral benefits of the program. This analysis reveals that conventional estimates of demand, dynamic benefit, and deadweight loss yield the surprising result that Part D insurance is nearly "break-even" for a society of risk-neutral and self-interested consumers.

V Drug Insurance and Innovation Policy

The previous section characterized the direct welfare benefit of Medicare Part D. The passage of a public prescription drug insurance program — welfare-improving or not — also has important indirect effects, by changing the socially optimal rewards for innovation, and thus the optimal public policy toward innovation. We consider the optimal configuration of innovation policy, with a focus on two policy instruments in particular. First, the government could potentially use its bargaining power to influence prices paid to innovators. Second, it can increase or decrease de facto patent length by regulating patent-gaming. We show that using both these instruments in conjunction with public drug insurance can allow the government to achieve first-best utilization and innovation. Of course, there may be significant informational or political constraints to pursuing the first-best policy. Therefore, we go on to show that it is always strictly welfare-improving to negotiate prices down to some degree, and we derive the conditions under

[20] Different authors have suggested that the number could be as high as $1 of deadweight loss for each $1 of public spending (cf, Feldstein, 1999).

which the government should tighten or loosen patent enforcement. As is often the case, the exact degree of price negotiation or patent enforcement requires the estimation of the key trade-offs outlined below.

The First-Best Benchmark

In addition to the co-insurance rate, suppose the government can also set a price paid to innovators, and a de facto patent length. Since the government is not perfectly free to dictate terms to innovators, define Π^R as the minimum profits innovators will accept. The government now solves:

$$S^R(T, p_g, \sigma) = \max_{T, p_g, \sigma} g(I_{pat}(\Pi^m))\left[\int_0^\infty e^{-rt} SS_c dt - \int_0^T e^{-rt} DWL(\sigma p_g) dt\right] - I_{pat}(\Pi^m) \quad (19)$$
$$s.t. \Pi^m \geq \Pi^R$$

This has the first-order conditions:

$$I_\pi \Pi_T^m \left(g'(I)\left[\int_0^\infty e^{-rt} SS_c dt - \int_0^T e^{-rt} DWL(\sigma p_g) dt\right] - 1\right) - g(I) e^{-rT} DWL(\sigma p_g) + \lambda \Pi_T^m = 0$$
$$I_\pi \Pi_p^m \left(g'(I)\left[\int_0^\infty e^{-rt} SS_c dt - \int_0^T e^{-rt} DWL(\sigma p_g) dt\right] - 1\right) - g(I) \int_0^T e^{-rt} dt DWL'(\sigma p_g)\sigma + \lambda \Pi_p^m = 0$$
$$I_\pi \Pi_\sigma^m \left(g'(I)\left[\int_0^\infty e^{-rt} SS_c dt - \int_0^T e^{-rt} DWL(\sigma p_g) dt\right] - 1\right) - g(I) \int_0^T e^{-rt} dt DWL'(\sigma p_g) p_g + \lambda \Pi_\sigma^m = 0$$

If the government knows all the parameters of the problem, and can freely adjust its policy instruments, it can always achieve the first-best outcome. Given the conventional result that first-best innovation requires profits equal to total social surplus, the family of first-best policy solutions satisfies:

$$\sigma p_g = MC$$
$$D(\sigma p_g)(p_g - MC)\left(1 - e^{-rT}\right) = SS_c$$

The first condition guarantees efficient utilization in the goods market. The second ensures that the innovator earns the total social value of his invention. Under these conditions, deadweight loss is zero, and $g'(I)\left[\int_0^\infty e^{-rt} SS_c dt - \int_0^T e^{-rt} DWL(\sigma p_g) dt\right] = 1$.

If the first-best is achieved, the constraint on price-negotiation would fail to bind, since profits would be higher than monopoly profits. As such, we can solve for the optimal policy configurations using the two equations above:

$$\sigma = \frac{D(MC)MC}{\frac{SS_c}{1 - e^{-rT}} + D(MC)MC}$$
$$p_g = \frac{SS_c}{(1 - e^{-rT})D(MC)} + MC \qquad (20)$$

Notice that, for any nonzero value of T, this yields a co-insurance rate strictly between zero and one, a strictly positive price, and positive profits.

This analysis proceeded from the standard case under which monopoly profits are less than their first-best level. This result would fail in the case where there is over-innovation prior to the drug insurance policy enactment. In this case, reducing prices has the additional advantage of reducing wasteful innovation. However, it is no longer clear that the innovator will accept the first-best level of profits, if this is less than monopoly profits. The government's degree of negotiating leverage becomes crucial. It may or may not be possible for the government to

induce innovators to accept the first-best level of profits. As such, the second-best solution would involve profits equal to Π^R.

The discussion above presumes that the first-best policy parameters are known to policymakers. In practice, this may be too much of a simplifying assumption in a world with many drugs, and heterogeneous consumers. Nonetheless, the first-best configuration provides us with intuition about how to achieve welfare improvements. The aim is to reduce deadweight loss without paying too high a price in terms of deadweight loss due to foregone innovation. On page 34, we formalize this intuition and characterize a simple policy configuration that always achieves a welfare-improvement, even if not the first-best outcome.

Price-Negotiation

Provided that consumers face prices above marginal cost, some degree of price-negotiation is always welfare-improving. Recall that $S(T, p_m, \sigma)$ is total social surplus, for patent length T, price p_m, and co-insurance rate σ. At the monopoly price, the marginal return to price-reduction is always positive:

$$\frac{dS^R}{dp_g}\Big|_{p_m} = I_{\pi}\Pi_p^m\left(g'(I)\left[\int_0^{\infty} e^{-rt}SS_c dt - \int_0^T e^{-rt}DWL(\sigma p_m)dt\right] - 1\right) - g(I)\int_0^T e^{-rt}dtDWL'(\sigma p_m)\sigma + \lambda\Pi_p^m \quad (21)$$

At the privately optimal monopoly price,[21] profits are maximized, and the envelope theorem implies that $\Pi_p^m = 0$. Therefore, the value of an initial price-reduction simplifies to:

$$\frac{dS^R}{dp_g}|_{p_m} = g(I)\int_0^T e^{-rt} dt DWL'(\sigma p_m)\sigma \qquad (22)$$

Since deadweight loss is minimized when the consumer faces a price equal to marginal cost, the marginal return to price-reduction is strictly positive if and only if $\sigma p_m > MC$.

The usual intuition of the second-best applies here. There are two interconnected margins of decisionmaking: profits and utilization. It is not optimal to leave the margin of profits undistorted, while leaving utilization distorted. Therefore, a government that has the leverage to lower prices ought to do so, at least to some degree.

Note, however, that this does not justify an unlimited amount of price-negotiation. Inframarginal reductions in the price will tend to be costly, because they lower profits, innovation, and expected surplus.[22] In addition, the returns to price-negotiation — and thus the optimal degree of price-negotiation — may fall with the generosity of the drug benefit, because it lowers deadweight loss, and increases the cost in terms of foregone profits. From an inframarginal perspective, the policymaker must balance the welfare gains from greater utilization, against the costs of lost innovation. Note that, for any chosen price-discount, both these quantities are estimable using the methods presented above, where we estimated the impact

[21] This applies to the optimal price that obtains under any co-insurance and patent regime.

[22] This reasoning might change if the initial level of innovation is too high.

of consumer price-reduction on deadweight loss, and the impact of pharmaceutical revenues on innovation.

Patent Gaming and Patent Length

Finally, we examine the qualitative impact of drug insurance on the optimal degree of patent protection. Drug insurance affects the social return to patent protection according to:

$$\frac{dS^R}{dT} = I_{\pi}\Pi_T^m\left(g'(I)\left[\int_0^{\infty} e^{-rt} SS_c dt - \int_0^T e^{-rt} DWL(\sigma p_g)dt\right] - 1\right) - g(I)e^{-rT} DWL(\sigma p_g) + \lambda\Pi_T^m \quad (23)$$

The drug benefit has two competing effects on this expression. First, it raises innovation. This lowers the marginal benefit of patent-extension, by virtue of diminishing returns to innovation. More formally, when I rises, $g'(I)$ falls, as does the return to patent-extension. On the other hand, it also lowers deadweight loss, which reduces the marginal social cost of longer patents. That is, when DWL falls, the marginal return rises. In general, therefore, the introduction of drug insurance has uncertain effects on the optimal patent length.

However, the interaction between price-negotiation and patent-extension is clearer. Aggressive price-negotiation is actually complementary with more generous patent-extension policies. The government should thus seek to "give back" to innovators in the form of longer patents, even as they "take away" per-period profits by paying lower prices. To see this, observe that if prices fall, so do profits and the level of innovation. This raises the return to stimulating innovation, and raises $\frac{dS^R}{dT}$ as well.

Suppose the government negotiates prices such that profits, and innovation, are held constant at their monopoly levels. In this case, the only parameter changing in equation 23 would be deadweight loss, which falls. Reductions in deadweight loss increase the optimal patent length, because monopoly power is cheaper to society. Therefore, if price-negotiation eliminates the positive impact of drug insurance on profits, it should be coupled with longer patents.

It is not clear that the optimal level of price-negotiation ought to drive down profits to their original level. However, our analysis implies that one *welfare-improving* policy configuration is: public drug insurance, price-negotiation to hold profits fixed at their initial level, and longer patents. The first two components of this strategy lower deadweight loss and hold innovation constant. According to equation 23, they also increase the optimal patent length. Relaxing restrictions on patent-gaming may be a practical way to achieve longer patents, if the cheaper and more direct method of granting longer patents is politically infeasible.

VI Conclusion

Part D would nearly pay for itself, even if it provided no insurance value, and served no redistributive purpose. This is a rather surprising result, considering that the program itself was designed primarily to provide insurance, and to provide drugs to poorer groups. In the design of the benefit, a great deal of attention was paid to traditional "insurance" issues of adverse selection and moral hazard, but less effort was devoted to understanding the risk-neutral efficiency effects on utilization and innovation. Our analysis suggests that the pure efficiency effects are quantitatively important.

Our analysis also reveals some surprising conclusions about the auxiliary provisions of Part D. First, the original legislation prohibited the government from negotiating prices. We showed that

this prohibition is inefficient. In fact, some degree of price-negotiation is strictly welfare-improving. Banning price-negotiation may be useful if the regulator is unable to commit to an optimal degree of negotiation, but instead seeks low prices at any cost. However, even in this case, legislative limits on price-negotiation would make more sense than a total legislative prohibition.

Second, price-negotiation is often thought of as being a complement to limits on patent-gaming. Both are thought to be means of curtailing "excessive" pharmaceutical profits generated by the new drug benefit. Surprisingly, however, the two legislative approaches are more substitutable than complementary. By lowering profits, price-negotiation actually lowers the cost of patent-extension, and thus *lowers* the return to limits on patent-gaming. When patent monopolies earn fewer per-period rents, longer patents become cheaper means of encouraging innovation. Therefore, price-negotiation — if it succeeds politically — should likely be coupled with more tolerance for patent-gaming and other forms of de facto patent-extension activity by innovators.

The economic case for the Part D benefit, and its auxiliary provisions, is quite a bit different than it may initially appear. The public provision of drug insurance can have significant efficiency benefits, as can some degree of price-negotiation.

Appendix A

Consider a health insurance plan that has a deductible of X dollars and offers a coinsurance of c for expenditures above the deductible. Consider an uninsured consumer with total expenditure E_1, where $E_1 > X$. Assume that the elasticity of demand is e.

The objective is to predict total expenditures, E_2, for this consumer when he or she enrolls in the health insurance plan with this non-linear benefit structure. First, note that the change in expenditures is the same as the change in quantity, because we assume prices paid to the manufacturer do not change. The consumer price does change, and it does so in a non-linear fashion, because it depends on the level of expenditures. Following the standard theory of demand, total expenditure when the consumer enrolls in this health insurance plan is given by:

$$E_2 = X + (E_1 - X) + (E_1 - X)(1 - c)e$$

The above equation shows that for the first X dollars in expenditures there is no change in demand as the consumer is below his or her deductible and therefore does not experience any change in price. For the next E_1-X dollars the consumer faces a percentage price reduction of 1-c. Therefore, the percentage change in demand or expenditures for this region is simply the percentage change in price times the elasticity of demand.

In the paper, we argue that the percentage change in coinsurance and elasticity of demand are sufficient predictors of the percentage change in utilization. In other words, we argue that the percentage change in total expenditures in this scenario can also be calculated by simply multiplying the percentage change in coinsurance times the elasticity of demand. Calculated this way, expenditures when the consumer enrolls in the health plan are given by:

$$E_2' = E_1 + E_1 e\left(\frac{1-\bar{c}}{1}\right)$$

Where, $\bar{c}$ is the average coinsurance when enrolled in the health plan:

$$\bar{c} = \frac{X + c(E_1 - X)}{E_1}$$

After substituting for $\bar{c}$ in the above equation, some simple algebra yields:

$$E_2' = X + (E_1 - X) + (E_1 - X)(1 - c)e$$

Hence, we get that $E_2' = E_2$.

A corollary of the above result is that the percentage change in coinsurance is a sufficient predictor of whether the consumer would benefit from insurance. A negative percentage change in average coinsurance or decrease in coinsurance implies an increase in use and thus an increase in static welfare.

Appendix B

Welfare Effects of Medicare Part D

Enrollment in Part D

	Population	**Estimation Notes**
(1) No creditable Coverage/Enrolled	21 million	MEPS respondents for whom status quo coverage is less generous than Part D.
(2) Creditable Employer Coverage	9 million	MEPS respondents with employer coverage more generous than Part D.
(3) Other Creditable Coverage	5 million	MEPS respondents with employer coverage more generous than Part D.
Total	36 million	Total Medicare eligible population as represented by MEPS.

Static Benefit of Part D:

	Mean or Amount	**Estimation Notes**
(4) % change in price for those who enroll	30.1%	% change in average coinsurance experienced by MEPS respondents without creditable coverage if they enrolled in the standard Part D benefit.
(5)% change in quantity for those who enroll	34.5%	Mean[Row (4)*elasticity]
(6) Out of pocket expenses	$1,302	Based on MEPS
(7) Static benefit for those who enroll	$167	Mean[0.5*Row(4)*Row(5) *Row(6)]
(8) Total static benefit	**$3.5billion**	Row(7)*Row(1)

Dynamic Benefit of Part D:

	Amount	**Estimation Notes**
(9) Dollar change in pharma revenues	$15 billion	Row(5)*Row(1)*Drug Expenditures from MEPS
(10) % change in pharma revenues	5.4%	Row(9)/Total Pharma Sales in 2006 ($275 billion)
(11) % change in number of new drugs	19%	Row(10)*Innovation Elasticity (3.51)
(12) Number of new drugs	6.1	Row(11)*Average number of new drugs per year (32)
(13) Private return per new drug	$113million	Cost of R&D per drug(939million)*private return

(14) Social return per new drug	$452million	Row(13)/Ratio of private return to total returns (0.25)
(15) Total Dynamic Benefit	**$2.8billion**	Row(14)*Row(12)
Dead Weight Costs of Financing Part D:	**Mean or Amount**	**Estimation Notes**
(16) Average drug expenditures for those who enroll	$1,537	Mean drug costs of MEPS respondents without drug coverage
(17) % change in expenditures for those who enroll	34.5%	Mean[Row (4)*elasticity]
(18) Actuarial costs of Part D benefit	$19.0billion	Based on row(16), row(17), percent subsidy, and average coinsurance in Part D. See text for exact formula
(19) Costs of employer subsidy	$5.2billion	28% of mean costs between $250 and $5,000 of MEPS respondents with creditable employer provided coverage
(20)Total costs of Part D insurance and employer subsidy	$24.2billion	Row(18)+Row(19)
(21) Dead weight costs of Part D insurance and employer subsidy	**$7.2billion**	0.30*Row(18)

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