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Innovation and 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. Prescription drug insurance escapes that trade-off and achieves an elusive goal: lowering static deadweight loss, without reducing incentives for 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*. The design of insurers' cost-sharing schedules can either reinforce or mitigate this result. Schedules that impose higher consumer cost-sharing requirements on more expensive drugs help ensure that insurance subsidies translate into higher utilization, rather than pure increases in manufacturer profits. Moreover, some degree of price-negotiation with manufacturers is likely to be welfare-improving, but the optimal degree depends on the size of such transactions costs, as well as the social cost of weakening innovation incentives by lowering innovator profits. These results have practical implications for the evaluation of public drug insurance programs like the US Medicaid and Medicare Part D programs, along with European insurance schemes.

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. 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 drug purchase for consumers, publicly provided drug insurance encourages utilization, but without necessarily compromising innovators' prices, profits, and incentives for research. Such programs can simultaneously promote static and dynamic efficiency, which are often at odds.

While these basic forces are powerful, translating them into practice requires attention to several specific benefit design and industrial organization issues. First, the cost-sharing schedule offered to manufacturers must mitigate their natural incentive to raise their prices in response to more generous drug insurance. Drug insurance will improve static efficiency if, at the monopolist's margin, increases in the manufacturer price impose greater out-of-pocket costs on consumers. Intuitively, price *increases* should be less well-insured. In practice, such arrangements are widespread in private health insurance markets.

Second, while the results are robust to a variety of market features, they may be hindered by prohibitions on price-discrimination. The pharmaceutical market embeds powerful barriers to resale that facilitate price-discrimination, even across individual insurance plans. However, public drug insurance legislation sometimes limits discrimination by tying together the prices charged to public and private insurers. Limits on price-discrimination do lower costs (and deadweight loss) for the publicly insured, but have the opposite effect on those outside the

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public program (Scott Morton, 1997; Duggan and Scott Morton, 2006). Similar results obtain when manufacturers have enough market power to affect the number of enrollees in the program.

Finally, there are *always* gains to leveraging insurer market power against pharmaceutical manufacturers, to obtain price-concessions on the margin. The social value of inframarginal price-negotiation depends on its transactions costs, and upon the right balance between the static benefits of lower prices, and the possible costs of weakened innovation incentives.

In this paper, we analyze the welfare economics of public drug insurance. Section II presents the benchmark model that demonstrates the key welfare effects of public drug insurance provision. Section III develops a number of extensions and characterizes the limitations of the benchmark results. Finally, Section IV concludes with a discussion applying our results to existing public drug insurance programs and possible reforms.

II. The Welfare Effects of Public Drug Insurance

Suppose the government offers a premium subsidy for those who wish to take up insurance that covers all available drugs. For simplicity, assume that people either have no drug insurance, or are insured through this government program.¹ In our benchmark case, each drug is provided by a monopolist while under patent, and a competitive market otherwise.² Finally, a representative insurer stands in for a perfectly competitive insurance market, or a public-sector insurer that sets actuarially fair prices. The government offers a percentage subsidy s , so that insureds pay the fraction $(1 - s)$ of the actuarially fair premium. The government also chooses a design for the consumer cost-sharing schedule, so that consumers pay the price $g(p)$ out-of-pocket when a manufacturer sells its drug at the price p , and $g(p) < p$. The number of insureds I depends on the subsidy rate, s , the generosity of the program, g , and the vector of all prices charged by firms. Normalize the total number of consumers to be one, so that $I + U = 1$, where U represents the number of uninsureds.

Determination of Deadweight Loss

Define $D^z(p^z)$ as the per capita demand function for drug z , $P^z(Q^z)$ as inverse demand, MC^z as the constant marginal cost of production, and p_M^z as the equilibrium monopoly price without insurance. For simplicity, suppose these are identical across drugs and suppress the superscripts.

The social surplus generated by competitive provision of the drug is given by:

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

If the off-patent market is competitive, deadweight loss in the patented market is given by:

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

With government-provided and subsidized insurance, this deadweight loss becomes:

¹This abstracts from the issue of “crowd-out,” whereby increase in public insurance coverage reduces private insurance coverage (Cutler and Gruber, 1996). As long as crowd-out is imperfect, it affects only the magnitude of our predictions, but not their direction or intuition.

²The appendix shows how our results generalize to the cases of monopolistic competition and oligopoly.

$$DWL \equiv SS_c - (1 - I(s, g, \vec{p}_M, \vec{p}_I)) \left(\int_0^{D(p_M)} P(Q) dQ - MC * D(p_M) \right) - I(s, g, \vec{p}_M, \vec{p}_I) \left(\int_0^{D(g(p_I))} P(Q) dQ - MC * D(g(p_I)) \right)$$

The vectors $\vec{p}_M$ and $\vec{p}_I$ represent prices charged for all drugs, to the uninsured and insured, respectively. Note that, in the benchmark case, the firm can price-discriminate between the uninsured and insured. In this case, it is straightforward to show that it will continue to charge the standard monopoly price p_M to the uninsured, as long as no single firm has the power to affect the number of insureds. We relax several of these assumptions later.

The social gain to subsidizing insurance can be calculated as:

$$-\frac{dDWL}{ds} = -\frac{dI}{ds} \left\{ \left(\int_0^{D(p_M)} P(Q) dQ - MC * D(p_M) \right) - \left(\int_0^{D(g(p_I))} P(Q) dQ - MC * D(g(p_I)) \right) \right\}$$

This gain is strictly positive so long as $MC \leq g(p_I) < p_M$.

Static Welfare Implications

In the market for prescription drugs, marginal cost is sufficiently low that $MC \leq g(p_I)$ for most drugs and benefit designs.³ Therefore, the set of welfare-improving insurance subsidy policies is the set of cost-sharing schedules such that $g(p_I) < p_M$. One trivial approach to improving welfare would be to set a constant copayment k such that $MC \leq k < p_M$. To avoid breaking the government's budget, this would require some other type of restraint on manufacturer prices, such as price-negotiation or direct price controls.

Consider the non-trivial case in which g is increasing, and the cost-sharing schedule itself restrains manufacturer price hikes. We derive a simple and practical set of schedules such that public insurance subsidies reduce deadweight loss, or $g(p_I) < p_M$. To rule out the absence of insurance, we assume $g(p) < p$ for all nonzero p . We also assume insurance weakly raises marginal revenue, or $D(g(p)) + (p - MC)D'(g(p))g'(p) \geq D(p) + (p - MC)D'(p)$, $\forall p$.

To build intuition, consider copayment schedules g that are continuously differentiable in p . While uncommon outside pure co-insurance, this case is pedagogically instructive; later, we generalize to cases with discontinuities. The sufficient condition for an increase in utilization is that $g'(p_M) \geq 1$: For every one dollar increase in the manufacturer price, the consumer pays at least one extra dollar. Effectively, price *increases* are uninsured. This is similar to the widespread strategy of private insurers, who often shift expensive drugs into less generous tiers of coverage (Goldman et al., 2006).

Define π_I as per capita profits earned by the monopolist on each insured consumer, and π_U as per capita profits on the uninsured.

$$\begin{aligned}\pi_I &= (p_I - MC)D(g(p_I)) \\ \pi_U &= (p_M - MC)D(p_M)\end{aligned}$$

³Marginal cost in the pharmaceutical industry is typically 10–20% of the uninsured monopoly price (Caves et al., 1991). For most observed benefit designs, co-payments for branded drugs are not lower than this. Exceptions may occur for high marginal cost products, like specialty drugs, or unusually generous insurance plans.

Since insurance does not lower marginal revenue, it will always be true that $p_I \geq p_M$. Make the change-of-variables, $p_O = g(p_I)$, so that $\pi_I = (p_I(p_O) - MC)D(p_O)$. Continuing with our assumption that no single firm can affect I , profit-maximization implies:⁴

$$\frac{d\pi_I}{dp_O} = \left(\frac{1}{g'(p_I(p_O))} \right) D(p_O) + (p_I(p_O) - MC)D'(p_O) = 0$$

$$\frac{d\pi_U}{dp_M} = D(p_M) + (p_M - MC)D'(p_M) = 0$$

We can rewrite the first condition, without altering the equilibrium, as:

$$\frac{d\pi_I^*}{dp_O} = D(p_O) + (g'(p_I(p_O))p_I(p_O) - g'(p_I(p_O))MC)D'(p_O) = 0$$

Since $p_I \geq p_M$, it will be true that $g'(p_I) \geq 1$. Therefore, since $p_I > p_O$,

$$g'(p_I(p_O))(p_I(p_O) - MC) > (p_O - MC)$$

This implies that $\frac{d\pi_I^*}{dp_O} < D(p_O) + (p_O - MC)D'(p_O)$, and that for arbitrary values of p , $\frac{d\pi_I^*}{dp} < \frac{d\pi_U}{dp}$. Assuming that the profit functions are globally concave, it follows that, for the optimal choices p_M^* and p_O^* , $p_M^* > p_O^* = g(p_I^*)$.

The argument generalizes to discrete schedules, such as tiered copayments. Define the set of discrete copayments $\{\sigma_1, \sigma_2, \dots, \sigma_N\}$, and the associated pricing thresholds $\{p_1, p_2, \dots, p_N\}$, where $g(p) = \sigma_i, \forall p \in [p_i, p_{i+1}]$.⁵ Denote by σ_I and p_I the optimal copayment and price under insurance. It is trivially true that $\sigma_I < p_M$ if $p_N < p_M$, so assume there exists j such that $p_j \leq p_M < p_{j+1}$. The analogous condition for insurance to increase utilization is:

$$p_k - g(p_k) \leq p_{k-1} - g(p_{k-1}), \forall k \geq j$$

Intuitively, this condition ensures that the consumer's share of the cost, $p - g(p)$, weakly rises with price increases beyond p_M . It guarantees that $\sigma_I \leq p_M$.⁶ The proof is in the appendix, which also generalizes our results to the cases of monopolistic competition and oligopoly.

The government has a number of options for *implementing* the required benefit design. First, it could benchmark the copayment to the marginal cost of production and negotiate prices with manufacturers on a case-by-case basis, as is the case in Europe (Sood et al., 2008). As a variant on this, it could ensure that $g'(p) \geq 1$ for all $p \geq MC$, but this would result in a less generous benefit than may be desired. Second, it could benchmark the shape of g to the observed p_M

⁴Technically, we also require $g'(p) > 0$, to ensure the existence of $\frac{d\pi_I}{dp_O}$. When we analyze the case of discrete copayment schedules below, we relax this assumption to the set of *weakly* monotonic schedules.

⁵By combining the analysis from this section and the preceding one, it is straightforward to generalize to the case of a continuously varying schedule with particular points of discontinuity.

⁶For the discrete case, it is impossible to rule out the case of $p_M = \sigma_I$ without further assumptions. As a simple example of how the knife-edge case might obtain, suppose the copayment schedule were $\{\sigma_1, \sigma_2 = p_M\}$, where $g(p) = \sigma_1$, for all $p < 0.001 p_M$.

charged to the uninsured, but this would create incentives for distorting p_M . Finally, it could leave g to be negotiated between private insurers and drug manufacturers, as in the US Medicare Part D program. Insurers have private incentives to limit manufacturer price increases, and the capability to do so if they have market power of their own. In the case of Medicare Part D, insured consumers do currently face lower out-of-pocket prices than they would face in the uninsured market (Duggan and Scott Morton, 2008).⁷

Dynamic Implications

The envelope theorem implies higher profits among the insured. Therefore, subsidizing insurance raises profits and induces more innovation, assuming subsidies are expected to persist. Let R denote industry investment in research, and $\varphi(R)$ the probability of discovery, where $\varphi'(R) > 0$ and $\varphi''(R) < 0$.⁸ Suppose the innovator enjoys a patent monopoly for T periods after the discovery but makes zero profits thereafter. The function $\Pi(g, s)$ measures total per-period profits for the firm, given the benefit design g and the subsidy rate. If the firm discounts the future at the rate r , the privately optimal level of innovation is given by:⁹

$$\varphi'(R) = \frac{1}{\left[\int_0^T e^{-rt} \Pi(g, s) dt \right]}$$

The marginal product of research is the reciprocal of the present value of profits (Nordhaus, 1969). Therefore, since insurance subsidies raise profits, they also stimulate innovation.

Define $R_{pat}(\Pi)$ as the level of research investment induced by monopoly profits Π .¹⁰ Expected social surplus can be written as:

$$ES(s; g) \equiv \varphi(R_{pat}(\Pi(g, s))) \left[\int_0^\infty e^{-rt} S S_c dt - \int_0^T e^{-rt} DWL(g, s) dt \right] - R_{pat}(\Pi(g, s))$$

Taking the design of the public drug benefit as given, the total (static plus dynamic) marginal value of public subsidies for insurance is given by:

$$ES_{s|s=0} = R_{pat} \Pi_s \{ \varphi'(R) \left[\int_0^\infty e^{-rt} S S_c dt - \int_0^T e^{-rt} DWL(g, s) dt \right] - 1 \} + \varphi \left[- \int_0^T e^{-rt} \frac{d(DWL)}{ds} dt \right]$$

The first term in the expression is the dynamic value (if any) of insurance subsidies as a stimulant to innovation; the second is the value of static deadweight loss-reduction. In the previous section, we demonstrated that — for appropriately designed programs — static deadweight loss falls with increases in insurance. Therefore, the second term in the square brackets will be weakly positive, and strictly positive under the conditions described earlier.

⁷Duggan and Scott-Morton (2008) show that — for Medicare Part D — $p_O < p_M$, and $p_I < p_M$. The latter condition is possible evidence of insurer market power, as discussed below.

⁸For simplicity we assume that probability of discovery is just a function of R&D investments. In practice, probability of discovery might depend on a variety of factors such as the scientific difficulty of progress and skill of the scientific workforce. We abstract away from these factors as they do not change with the introduction of a drug benefit and are exogenous in the short run.

⁹This result holds under pure monopoly. Later, we consider the alternative cases where innovation may be socially excessive.

¹⁰It may be true that some innovation takes place in the absence of positive profits, but our results will hold even if $R_{pat}(0) > 0$, so long

as $\frac{\partial R}{\partial \Pi} > 0$.

The first term will also be weakly positive, if total social surplus from innovation is weakly larger than profits. This will certainly be true with a single innovator, well-informed consumers and no subsidies for innovation (Lakdawalla and Sood, 2006). Well-informed consumers would never pay more for an innovation than its value to them. However, it *might not* be true, after we introduce imperfections such as imperfect consumer information, tax-subsidies for health insurance, public subsidies for basic research, spillover effects of innovation and competition among innovators. In this case, innovation may be socially excessive.

There is significant controversy as to whether the current level of innovation is excessive or insufficient. On the one hand, some economists have emphasized the extremely low rate of social surplus-appropriation by innovators. Others have argued that patent races, public subsidies, and other imperfections can alter this result, sometimes substantially.¹¹

Resolving this question lies beyond the scope of this paper, but our analytical results are meaningful in either event. If innovation is too low, prescription drug insurance has a direct welfare benefit by stimulating it. If, on the other hand, there is too much innovation, the government has incentives to limit or reduce innovator profits through, for example, the exercise of insurer market power, or other rules such as tighter patent-restrictions (reductions in T).

Public Financing and Deadweight Cost

It should be understood that all the welfare effects calculated above abstract from the costs of publicly financing a benefit. Public subsidies for drug insurance must generate enough benefit to outweigh the marginal social cost of funds (cf, Browning, 1976; Feldstein, 1999).

III. Extensions

Price-Negotiation and Insurer Market Power

In the benchmark case, public and private insurers exercised no market power, but in practice, market power is often used to extract price discounts. Absent transactions costs, some negotiated discount from the manufacturers' optimal prices always improves welfare. To illustrate, suppose the government can costlessly exercise market power and obtain a uniform discount δ for all drugs. Insured consumers pay the prices $\bar{p}_I - \delta$. Expected surplus in each drug market is:

$$ES(s, \delta; g) \equiv \varphi(R_{pat}(\Pi(g, s, \delta))) \left[\int_0^\infty e^{-rt} S S_c dt - \int_0^T e^{-rt} DWL(g, s, \delta) dt \right] - R_{pat}(\Pi(g, s, \delta))$$

The optimality of *some* price-negotiation follows from $DWL_\delta < 0$ and $\Pi_\delta|_{\delta=0} = 0$. Intuitively, marginal price changes do not affect profits, since manufacturers price their products optimally. However, such price changes lower deadweight loss, due to the presence of monopoly distortion.

To derive $DWL_\delta < 0$, define SS_U as per capita social surplus in the uninsured market for a particular drug, and SS_I as per capita surplus among the insured. We then have:

¹¹For 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). Also see the work by Boldrin and Levine (<http://www.dklevine.com/general/intellectual/against.htm>) for the related view that patents are not necessary for innovation.

$$\frac{dDWL}{d\delta} = \frac{dI}{d\delta} [SS_U - SS_I] - I(s, g, \vec{p}_M, \vec{p}_I - \delta) \left(\frac{dSS_I}{d\delta} \right)$$

If drug and insurance demand strictly respond to prices, then $\frac{dI}{d\delta} > 0$ and $\frac{dSS_I}{d\delta} \geq 0$, where strict inequality obtains when g is strictly rising at p_I . Moreover, for an appropriately configured

$dDWL$ benefit, $SS_I > SS_U$. These conditions are sufficient to imply that $\frac{dDWL}{d\delta} < 0$.

To show $\Pi_{\delta}|_{\delta=0} = 0$, observe that per period profits for a single drug are:¹²

$$\Pi(g, s, \delta) = \max_{p_I, p_M} I(s, g, \vec{p}_M, \vec{p}_I - \delta) \pi_I(p_I - \delta, g) + (1 - I(s, g, \vec{p}_M, \vec{p}_I - \delta)) \pi_U(p_M)$$

Ignoring the effects of price-negotiation on the prices of other drugs, $\frac{d\Pi}{d\delta}|_{\delta=0} = 0$ by the envelope theorem, since the firm chooses p_I to maximize profits. *Incorporating* those effects,

$\frac{d\Pi^z}{d\delta}|_{\delta=0} = (\pi_I^z - \pi_U^z) \sum_{y \neq z} \left(-\frac{dI}{dp_I^y} \right) > 0$, for every drug z . In other words, if a marginal reduction in prices of all drugs raises I , then the marginal impact on profits is positive. Inframarginally, however, price-negotiation is very likely to depress profits, due to the concavity of π_I in p_I .

This analysis implies only that *some* degree of price-negotiation improves net welfare. The unchecked exercise of insurer market power *may* become harmful, since inframarginal increases in δ may eventually lower profits and thus innovation. However, extensive price-negotiation becomes a compelling policy choice if innovation is well above its social optimum. In this case, publicly subsidized drug insurance becomes a tool for expanding insurer market power — by making available the negotiating leverage of the government — and thus driving the rewards for innovation down to its socially optimal level.

The absence of transactions costs is also crucial to the result's generality. If the government must incur costs in establishing a price-negotiation mechanism, or allowing greater insurer market power, the result would be more deadweight loss.

Horizontal Market Power

Previously, we assumed no manufacturer could influence I through its pricing decisions, but there may be cases where a particular firm sells a very widely used drug, which give it the power to influence incentives for program participation. Suppose a drug is so widespread that its prices affect incentives to enter the program. Define P_M, P_I , and P_O as the uninsured, insured, and out-of-pocket insured prices, respectively, where the capital letters distinguish these quantities from the analogous quantities, p_M, p_I , and p_O , from the benchmark model in which firms cannot affect I . When manufacturers can influence I , they have incentives to induce entrance into the insurance program, in the sense that $P_M > p_M$ and $P_I < p_I$.

In particular, the manufacturer solves the problem:

¹²Here we reintroduce the superscripts, for clarity.

$$\max_{P_O, P_M} I(s, g, \vec{P}_I(\vec{P}_O), \vec{P}_M) \pi_I^*(P_O) + (1 - I(s, g, \vec{P}_I(\vec{P}_O), \vec{P}_M)) \pi_U(P_M)$$

The first-order conditions are:

$$\begin{aligned} [P_M]: \frac{\frac{dI}{dP_M}}{I(s, P_I(P_O), P_M)} (\pi_I^*(P_O) - \pi_U(P_M)) + \frac{d\pi_U^*}{dP_M} &= 0 \\ [P_O]: \frac{\frac{dI}{dP_O}}{I(s, P_I(P_O))} (\pi_I^*(P_O) - \pi_U(P_M)) + \frac{d\pi_I^*}{dP_O} &= 0 \end{aligned}$$

By the envelope theorem, per capita profits are strictly higher among the insured population,

so dI long as $g(P_I) < P_I$. Moreover, it is true that $\frac{dI}{dP_M} > 0$. Therefore, at the optimal value of

P_M^* , it must be true that $\frac{d\pi_U^*}{dP} \big|_{P_M^*} < 0$. Comparing this to the benchmark equilibrium, the concavity

of π_I^* implies $P_M^* > P_M^*$, since $\frac{d\pi_I^*}{dP} \big|_{P_M^*} = 0$. An analogous argument implies that $P_O^* < P_O^*$. Horizontal market power benefits the insured at the expense of the uninsured, but the net effect on utilization and deadweight loss is ambiguous. If desired, the government could eliminate this behavior by restricting the number of insureds, I through tighter eligibility guidelines.

Price Discrimination

The benchmark case allowed price-discrimination between the publicly insured and others. In practice, such discrimination is made feasible by the difficulty of reselling drugs. Medicare Part D provides an example of a program in which prices charged to the publicly insured may differ.¹³ However, in some circumstances (e.g., the US Medicaid program), public schemes explicitly prohibit such price-discrimination, or at least tie public prices to prices charged elsewhere. Limits on price-discrimination operate quite similarly to horizontal market power for manufacturers, by increasing prices for the uninsured and reducing them for the insured.

Suppose the monopolist now faces the problem:

$$\begin{aligned} \max_{P_O, P_M} I(s, g, \vec{P}_I(\vec{P}_O), \vec{P}_M) \pi_I^*(P_O) + (1 - I(s, g, \vec{P}_I(\vec{P}_O), \vec{P}_M)) \pi_U(P_M) \\ \text{s.t. } P_I \leq P_M \end{aligned}$$

We can interpret this as a rule that the government always gets a price at least as low as that charged outside the program.¹⁴ This rule limits the price charged to public insureds, but raises the price charged to those outside the program; in addition, it increases the number of public insureds by making the public program relatively more attractive.

Limits on price-discrimination affect deadweight loss through three channels: increasing P_M , decreasing P_I , and increasing I . In that respect, the consequences are identical to the case of horizontal market power: there are more insureds; the insured benefit; the uninsured lose; the

¹³As summarized by Frank and Newhouse (2008), there are both practical impediments and aids to the bargaining leverage enjoyed by Part D insurers. On the one hand, they do not enjoy unlimited leverage due, for example, to political constraints on excluding drugs from formularies. On the other hand, they enjoy enhanced leverage due to their unique ability to exclude their own negotiated prices from Medicaid's calculated "best-prices."

¹⁴This formulation is also equivalent to one of equal pricing, so long as $g(P_I) < P_I$, since the latter implies $P_I \leq P_M$ always binds.

net consequences for welfare depend on which of these effects predominates. The similarity with this case is not accidental, since, from a broader perspective, limiting price discrimination is also a case of market power, but exercised by a public insurer. Some exercise of market power improves welfare at the margin, but deadweight or transaction costs — in this case the impact on those outside the public insurance scheme — may dominate this welfare-improvement.

Comparison to Alternative Policy Options

Public drug insurance can be configured to reduce deadweight loss without reducing innovation incentives, but other creative schemes have been devised to do this as well, such as rewards for innovators or public provision of innovation (Kremer, 1998; 2000b; a). From a purely pragmatic point of view, subsidies for drug insurance are by far the most common in practice, with the possible exception of public financing for *basic* research. As a result, less “start-up cost” is required in order to use it as a vehicle for improving innovation delivery.

To be fair, however, all three options face practical challenges. For rewards, the optimal level of the reward is difficult to calculate before the innovation is discovered, in spite of creative approaches to recovering it (Kremer, 1998). Similarly, heavy public-sector involvement in the innovation process creates agency costs, by divorcing the innovation decision from its financial returns. Finally, while public subsidies for drug insurance are often observed, the complexity of real-world schemes illustrates practical challenges: programs that partner with the private-sector must contend with incentives for adverse selection or other types of “gaming,” while publicly administered insurance schemes impose agency costs of their own.

One organizing difference across these options is the greater scope for private-sector involvement in a publicly subsidized drug benefit. While rewards for innovators could be offered by groups of consumers (e.g., health insurers), implementation through governments or international organizations seems more plausible. On the other hand, the US health care system provides working models of public subsidies for private health insurers.

Naturally, private-sector involvement has costs and benefits. On the one hand, it decreases the flexibility of the government, which must account for behavioral responses. On the other, using market forces to set prices reduces bureaucratic burden and agency cost, and may result in more efficiency. In addition, shifting cost onto the private sector may lower the publicly financed cost. For instance, under the first-best reward scheme, the government pays inventors the full value of their optimal compensation. Under first-best insurance, copayments equal marginal cost, and total premiums equal the full value of optimal compensation. If the government can mandate the optimal benefit design and achieve full insurance with partial premium subsidies, it is liable for less than the full value of optimal compensation.

IV. Conclusions

Public drug insurance provides a means of decoupling consumer prices from manufacturer prices. This feature allows it to function as a mechanism for reducing static deadweight loss without harming incentives for innovation. Indeed, we have shown how it can be used as a tool to move innovation in any direction desired. Therefore, while insurance in the non-drug marketplace is often thought to encourage over-use, insurance for prescription drugs may instead serve as a corrective to substantial under-utilization. It is important to note the heterogeneity in the way public prescription drug insurance is implemented in the real world. In that respect, our analysis sheds light on several real-world programs.

Medicare Part D provides subsidized prescription drug insurance to US Medicare beneficiaries. One unique feature of Part D is the role of the private sector: Medicare specifies a standard

drug benefit, and requires only actuarial equivalence for private plans. These plans typically design benefits so as to limit incentives for manufacturer price increases, by “tiering” expensive drugs into higher co-insurance rates (Kaiser Family Foundation, 2008). Perhaps as a result, Part D seems to have had a positive impact on drug utilization *and* on revenues (Lichtenberg and Sun, 2007; Duggan and Scott Morton, 2008).

Drug insurance through the US Medicaid program is a useful comparator. Medicaid requires that it receive the best-available private price, and thus limits the price-discrimination that manufacturers enjoy within Medicare Part D. Duggan and Scott-Morton (2006) show that this rule substantially increases prices for drugs with higher Medicaid market share. They find that a ten percentage-point increase in the Medicaid market share is associated with a ten percent increase in the average price of a prescription. This complicates Medicaid’s welfare effects.

Single-payer drug insurance schemes in Europe most resemble the benchmark case of a publicly designed and subsidized benefit. However, unlike Medicare, European governments negotiate prices with manufacturers. Therefore, while European consumers face lower prices, manufacturers also receive less revenue (Sood et al., 2008).

These examples indicate that the implementation of public drug insurance varies widely in ways that bear upon our analysis. Policymakers may choose, for example, to tune benefits for greater increases in utilization through judicious benefit design, or lower increases in manufacturer profits, by means of aggressive price-negotiation. Regardless of the specific implementation, drug insurance provides a unique policy lever for managing deadweight loss associated with patents, and one that is in widespread use throughout the developed world.

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Mathematical Appendix

Discrete Copayment Schedules

As throughout the text, define $p_M = \arg \max_p \{D(p)[p - MC]\}$. Conditional on a copayment level σ_l , define the profit-maximizing price in the insured market as:

$$\mu_l = \arg \max_{p_l \leq p < p_{l+1}} \{D(\sigma_l)(p - MC)\}$$

The profit-maximizing manufacturer price in the insured market can then be defined as μ_i , where:

$$i = \arg \max_{l \in \{1, \dots, N\}} \{D(\sigma_l)(\mu_l - MC)\}$$

Finally, define $\mu_j = \arg \max_{\mu_l \in \{\mu_1, \dots, \mu_N\}} \{D(\mu_l)(\mu_l - MC)\}$, which represents the profit-maximizing price in the uninsured market, when the monopolist is constrained to use the set of discrete pricing options. Without loss of generality, assume $\mu_j \leq p_m < \mu_{j+1}$; the other possible case is $\mu_{j-1} < p_m < \mu_j$.

Proposition

If $\mu_k - \sigma_k \leq \mu_{k-1} - \sigma_{k-1} \forall k \geq j$, then $\sigma_i \leq \mu_j \leq p_m$.

Proof

Suppose that $\sigma_i > \mu_j$. This implies that $\mu_i - \sigma_i \leq \mu_{i-1} - \sigma_{i-1}$. As a result,

$$D(\sigma_i)[\mu_i - \sigma_i] < D(\sigma_{i-1})[\mu_{i-1} - \sigma_{i-1}]$$

Moreover, since $\sigma_i > \mu_j$, and profits in the uninsured market are a decreasing function of price beyond μ_j , we know that

$$D(\sigma_i)(\sigma_i - MC) \leq D(\sigma_{i-1})(\sigma_{i-1} - MC)$$

The two preceding equations imply that

$$D(\sigma_i)(\mu_i - MC) < D(\sigma_{i-1})(\mu_{i-1} - MC)$$

However, this violates the optimality of μ_i in the insured market. QED

Monopolistic Competition and Oligopoly

Our benchmark analysis presumed the case of monopoly, but our results can be extended to the cases of monopolistic or oligopolistic competition among innovators. The monopolistic competition case is the simpler of the two. The results in this case follow trivially, since a monopolistic competitor behaves like a monopolist, insofar as it faces downward-sloping demand and does not take prices as given. The one difference is that monopolistic competition limits the firm's ability to raise prices, since the monopolistic competitor faces a more elastic demand curve. From a dynamic point of view, monopolistic competition may (or may not) result in a level of innovation that is socially excessive. The implications of this case are discussed in the text.

Next consider a duopoly model with heterogeneous products. We analyze the case of Bertrand competition, although the form of competition is not essential. Profits in the insured and uninsured markets for firms A and B are:

$$\begin{aligned}\pi_{A,I} &= (p_{A,I} - MC)D(g(p_{A,I}), g(p_{B,I})) \\ \pi_{A,U} &= (p_{A,U} - MC)D(p_{A,U}, p_{B,U})\end{aligned}\quad (1)$$

As in the text, assume that insurance weakly raises the marginal revenue of each duopolist, and that $g'(p) \geq 1$, $\forall p \geq p_{A,U}, p_{B,U}$. To simplify the algebra, set marginal costs to zero. Equilibrium prices in the uninsured market are determined by the intersection of reaction functions for firms A and B :

$$\begin{aligned}p_{A,U} &= -\frac{D(p_{A,U}, p_{B,U})}{D_1(p_{A,U}, p_{B,U})} \\ p_{B,U} &= -\frac{D(p_{B,U}, p_{A,U})}{D_1(p_{B,U}, p_{A,U})}\end{aligned}\quad (2)$$

Similarly, equilibrium prices in the insured market are determined by the intersection of reaction functions for firms i and j . The equilibrium conditions take the form:

$$\begin{aligned}p_{A,I} g'(p_{A,I}) &= -\frac{D(g(p_{A,I}), g(p_{B,I}))}{D_1(g(p_{A,I}), g(p_{B,I}))} \\ p_{B,I} g'(p_{B,I}) &= -\frac{D(g(p_{B,I}), g(p_{A,I}))}{D_1(g(p_{B,I}), g(p_{A,I}))}\end{aligned}\quad (3)$$

Define $p_{A,O}$ and $p_{B,O}$ as the consumer's out-of-pocket costs for A and B , respectively. Since $p_{A,I} \geq p_{A,U}$, it is true that $g'(p_{A,I}) \geq 1$. Moreover, $p_{A,I} > p_{A,O}$. Therefore, $g'(p_{A,I}) p_{A,I} > p_{A,O}$, and similarly $g'(p_{B,I}) p_{B,I} > p_{B,O}$. Therefore, reaction functions in the insured market always satisfy the following inequalities:

$$\begin{aligned}p_{A,O} &< -\frac{D(p_{A,O}, p_{B,O})}{D_1(p_{A,O}, p_{B,O})} \\ p_{B,O} &< -\frac{D(p_{B,O}, p_{A,O})}{D_1(p_{B,O}, p_{A,O})}\end{aligned}\quad (4)$$

Comparing these inequalities to the reaction functions for the uninsured market implies that $p_{A,O} < p_{A,U}$ and $p_{B,O} < p_{B,U}$. Therefore, as in the model with a monopolist provision of public insurance will weakly reduce static deadweight loss.

The argument for increased profits and innovation is as before: The envelope theorem implies that profits are higher among the insured population; this results in more innovation, since higher overall profits raise the return to innovation.