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Movie Theatre Popcorn Pricing, the Physician's Hippocratic Oath, and Health Care Innovation*

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Abstract

Notably lacking in the health care innovation literature is sufficient recognition of the key role that doctors and hospitals play in choosing health care quantity, quality, and in some cases, prices. If providers can freely choose all three, then the profit maximum for a fixed patient type is one in which patient willingness-to-pay (WTP) is maximized, with prices chosen so as to extract the full resulting surplus. This WTP pricing mimics what is found in certain other monopoly settings, such as movie theatre popcorn, in which only high quantity, quality and price combinations are offered. We examine how WTP pricing, quantity and quality choices change with coinsurance and fixed copayment pricing. The Hippocratic Oath, which instructs doctors to maximize patient benefits without regard to costs, is fully consistent with WTP pricing, even with profit-maximization as the provider objective. Extending WTP pricing to health care innovations, we predict the over-adoption of cost-increasing improvements with modest quality improvements, and show that low prices for close substitutes can have little effect on prices charged for innovations, unlike conventional monopoly models. We test model predictions using prices of new drugs using a large US claims dataset and show that time and cross-sectional pricing patterns are consistent with our model.

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Notation

x = quantity of care

q = quality of care

p = price per unit of x

α = share of price p paid by consumer

$B(x, q)$ = consumer benefit from care

$C(x, q)$ = provider cost of care for one patient

N = number of consumers with demand for this service per period

$px - C(x, q)$ = one-period profits to provider from providing care to one consumer

Π = total provider's profit

p^S = supply price = price received by providers

p^D = demand price = price paid by consumers

$\bar{p}$ = price ceiling on supply price received by providers

For the two-step model with innovation:

E = subscript referring to *Established firm*

I = subscript referring to *Innovator*

$\beta B(x, q)$ = consumer benefit from care with an innovating technology

$\lambda C(x, q)$ = provider cost of care for one patient with an innovating technology

F = fixed cost to innovator of developing new technology

I. Introduction

Although moral hazard problems are widely blamed for today's rapidly increasing health care costs, relatively few papers have emphasized that it may be the dynamic effects of insurance on the form of innovation that are the most significant consequences of health insurance coverage (Weisbrod, 1991; Finkelstein, 2007), with cost-increasing innovations with modest improvements in health favored over cost-reducing innovations. Technological change in health care is unlike that occurring in most other industries. This paper attempts to improve our understanding of why.

We offer a new approach for incorporating insurance and physician agency problems into a simple two-stage innovation model. Our key insight is that all too often economists use either price-taking competition or price-setting monopoly models as a starting point for modeling innovation, while the recent agency literature finds that simple competitive or monopoly models do a poor job capturing price, quality, and quantity dynamics in the health care industry. Notable exceptions include McGuire (2000) and Ma and McGuire (2002), discussed further below. We motivate and use a model inspired by McGuire (2000) that highlights how insurance enables providers to oversupply quantity and quality of care for each illness. Insurance also increases profit-maximizing prices desired by providers, or in the case of full insurance, theoretically enables infinite prices without losing customers. Whether prices are set directly by providers or determined by government payers or insurers, even when providers are partially altruistic, their valuation of profit motivates them to extract as much consumer surplus as is allowed by the regulator. We develop a formal model that shows how health insurance may influence providers' preferences for cost-reducing innovations versus cost-increasing innovation even with modest health improvement. Our formal model focuses on a fee-for-service type of payment for providers and it disregards the important insurers' decisions.[1] Starting with the case of a monopoly provider offering a single product with no patient heterogeneity, we show that quality and quantity are always overprovided relative to the social optimum in the presence of generous insurance. What we term "willingness-to-pay pricing" changes pricing and provider adoption of new technologies, and hence changes incentives for innovation in very specific ways that capture important features of new drugs and new medical technologies.

Willingness-to-pay pricing is also closely aligned with the physician's Hippocratic Oath, which instructs doctors to "do no harm" and provide care so as to "maximize patient benefits". We show that if doctors always choose care so as to maximize patient benefits, without regard to their social costs (in the form of higher insurance premiums) then quantity and quality choices will be too high, even with price

[1] Frandsen et al (2018) analyze such insurers' decisions in a context of providers' moral hazard. They show that common agency in the relationship between providers and multiple payers is responsible for the persistent use of the inefficient fee-for-service payments.

ceilings, or pricing delegated to a drug or medical supply producers.

We start with a motivational example intended to capture the idea that consumers often play a minor role in choosing treatment intensity. In many (most?) medical settings, an ill patient gets to choose what provider to see, but after that often plays a minor role in treatment intensity choices: how many minutes of treatment, the numbers of lab tests to perform, how many hospital nursing visits per day, or the number of days of antibiotic or painkillers to receive.[2] These quantity/intensity choices (used interchangeably in this paper) are overwhelmingly made by providers. The patient's expert agent, typically a doctor, chooses these quantities, leaving the patient with an all-or-nothing decision about whether to accept the recommendation or find a new doctor or hospital. In this setting, whether prices are set by providers (as in the US) or by a government (as in other countries), even cost-reducing innovation need not lower prices with WPT pricing.

We organize the paper as follows. We start with a brief overview that motivates our approach and summarizes how it fits in with the existing literature. We then provide an extended example that characterizes well the effects of incentives in health care agency situations with limited competition, using graphical techniques to illustrate key results. Our analytical model first examines the quantity and quality choices of an established technology, before expanding the model to consider the effects of entry by an innovation technology. We then present and test the empirical predictions of our model and how they differ from conventional models using data from the US privately insured population. Our main empirical findings are that in response to increasing insurance in the US in recent years, not only entry prices of new drugs are increasing dramatically, but also levels in early years for each drug cohort. Moreover, quantities per user are also increasing over time for new drugs even as their prices are skyrocketing. We also use regression models to show that new drugs prices are higher in health plans with copayments than in health plans with coinsurance. Our final section discusses public policies toward pricing and regulation of new technologies that might alleviate some of the problems we model.

II. Motivation and key literature

Our main argument is that generous insurance leads to too little investment in cost-reducing innovations, no matter whether physician focus on benefits without regard to costs or not. This argument rests on a series of moral hazard effects that have been developed separately in the literature, but not

[2] Although sometimes consumers do get to express their opinions, for many decisions, particularly inpatient care and really complex and expensive ones, these decisions are delegated to expert agents, their physicians. Choosing to change to a different physician is also very rare Iversen and Lurås 2011; Sorbero *et al* 2003). We examine the interesting case in which consumers are captive to their providers, as has been modeled frequently in the literature (Pauly 1980; Ellis and McGuire, 1986; Klemperer, 1995).

combined in a way that captures their total effect on prices, quantity, and quality of health services, nor their implications for innovation. Starting from a classical demand relationship where the demanded quantity maximizes the consumer's utility at the offered prices, the specific features of health services that modify this basic relationship are as follows.

First, we assume that patients do not choose the quantity and quality of health care services *à la carte*. Instead, expert agents, primarily doctors and hospitals, propose their recommended treatment plan, which is a specified quantity and quality of care at a given price. [3] For most medical decisions, the patient's only decision is whether to accept the treatment or not (McGuire, 2000). The illustration developed in the next section examines the implications of such an all-or-nothing choice. The key difference from the usual demand relationship is that the patient accepts the treatment plan as long as the utility from treatment is higher than without it. Ignoring patient heterogeneity, the provider can fully extract the patient's surplus, as with first-degree price discrimination (Varian, 1989). The corresponding quantity is higher than the one predicted by simple monopoly models. For the usual benefit function with diminishing value of quantity, WTP pricing generates total revenue that can be double that earned in traditional monopoly models, and quantity and quantity are overprovided. WTP pricing means that providers are less constrained when choosing prices and quantity of care, even before adding in insurance coverage.

Second, insurance coverage influences both the demand and the maximum willingness to pay (WTP) for health services. Health insurance is essential for protecting consumers against financial risks, but its effects can be very distorting. Moral hazard is the best-known effect of insurance on demanded quantities: insured individuals are less sensitive to prices and demand more care than uninsured individuals (Arrow, 1967; Pauly, 1968). Moral hazard not only applies to the ordinary demand curve, which captures the marginal WTP, but also to the maximum WTP relationship described above. Because insurance augments the maximum WTP for any offered service, providers have incentives to increase their prices even further than is implied by a price setting monopoly model. Pharmaceutical prices provide a particularly strong example of this phenomenon. Pavcnik (2002) demonstrated empirically that prices decreased in Germany after a 1989 regulatory change in insurance increased the patients' exposure to prices. Jelovac (2015a) provides theoretical insights that distinguish the differential pricing effects of health insurance when prices are negotiated by payers rather than chosen by providers. If consumers pay a coinsurance on the full price of drugs, and pharmaceutical providers choose their own prices, then more generous insurance may simply increase drug prices as reported by Pavcnik (2002), and result in little or no reduction in out-of-pocket payments that are proportional to prices and fees. If providers can balance bills, then supplementary insurance can even increase the out-of-pocket payments of insured people (Jelovac, 2015b). A contrasting

[3] We explore below the case where providers compete for patients, and show similar results in a Hotelling duopoly model.

possibility, shown in Jelovac (2015a), in a theoretical setting is that negotiated prices decrease with the generosity of insurance.

Third, quality increases both the demand and the maximum WTP for a given treatment. Cremer and Thisse (1994) elaborated on how production subsidies can affect quality, which has direct parallels to the effect of health insurance on quality of care. Without insurance, providers typically compete both in price and in quality; however generous health insurance limits the scope for price competition by making demand more inelastic. Providers can then set higher prices, which increase the returns on investments in quality. Quality therefore increases as well. In other words, health insurance increases the scope for non-price quality competition.

Fourth, and this is our main contribution, insurance also influences the adoption of new technologies. Physician lower sensitivity to costs when prescribing treatment means that they will prefer a surplus-increasing new technology regardless of its cost, and avoid cost-reducing innovations unless it also increases benefits to the patient. This argument was implicit in the work of Weisbrod (1991) which extends Ellis and McGuire (1986) to show that retrospective cost-based provider payment encourages the adoption of costly, high-quality innovations of the type we show are favored here. Combining insurance's expansion of demand and willingness-to-pay pricing creates an irresistible incentive for cost-increasing rather than cost reducing technological change. This result usefully complements the conclusions of Ganuza *et al*. (2009) who identify conditions under which the low elasticity of the demand for pharmaceuticals can result in technological innovations with either excessive quality or insufficient quality. However, they do not qualify innovations in terms of cost efficiency as we do. Our results also provides a rationale for the striking empirical results by Howard *et al*. (2015) about the 10 percent annual increase (an average of $8,500 per year) in the average launch price of anticancer drugs, adjusted for inflation and health benefits. Howard *et al*. (2015) report that, despite the impressive scientific knowledge embodied by new drugs, gains in survival times associated with recently approved anticancer drugs are typically measured in months, not in years. Our results also help explain the systematic evidence reported by Hult *et al* (2018) that two-thirds of innovations in health care have quality-adjusted prices that are higher than those of the incumbents.

Our model can be criticized as being overly simplified and unrealistic in thinking of providers as simple profit maximizers, however we also show that our approach of modeling providers as choosing price (p), quality (q), and quantity (x) has greater applicability than might be initially thought. Indeed, doctors are different from many other agents because their training specifically dictates that they focus on patient benefits without paying attention to costs. The Hippocratic Oath, which is at the heart of medical school training, asks doctors both that they "do no harm" and that "the health of my patient will be my first consideration."[4] As such, it is understandable that costs play a minor role in treatment decisions, including the adoption of new technologies. Our model actually results in the same choices p, q and x if instead either a third party medical supplier (e.g, a pharmaceutical company or powerful provider association) gets to choose $p*$ and $q*$ to maximizing profits or providers following the Hippocratic Oath takes decisions to achieve the patient's most desired consumption quantity. We also show that although the solution does differ if providers compete for patients using a Hotelling-style competition, the key findings of the model about quantity and quality being oversupplied with insurance and innovation being distorted, persist.

Our paper offers a unified analysis of how health insurance influences the nature of innovations that are prevalent in health services. We first consider an unregulated setting to develop our main argument. We then analyze how a price ceiling need not prevent the distorting effect of insurance on adopted innovations. Before proceeding, consider the following motivational example.

III. Movie theatre popcorn

Although consumers get to choose which movie theatre to go to, once they make that choice, popcorn is provided by a monopoly in which the theatre is able to achieve the desired triad of high prices, large quantities, and limited choices. Agency theory shows that the combinations offered are not those predicted by a simple monopoly model that allow consumers to choose quantities for a fixed posted price. Instead, as we motivate below, a profit maximizing theatre will offer consumption options along the consumer's all-or-nothing demand curve.

Assume initially that all consumers have the same demand curve for popcorn, that popcorn quality (butter, salt, freshness, etc.) is fixed, and that the marginal cost is zero. Consider Figure 1, in which the solid line presents a stylized demand curve for popcorn by the representative consumer. A monopoly model would have the theatre offer price p^{mon} where the consumer would choose quantity x^{mon} at point G. Theatres can do better than this, however, by only offering the consumption point H, which corresponds to the point where the area of the rectangle going through the origin and point H is just equal to the full area under the demand curve. In the zero marginal cost case, point H corresponds to choosing the utility maximizing quantity of popcorn x^* and then charging the price p^* that extracts the consumer's full consumer surplus. Note that at point x^* it is the consumer's participation constraint that determines quantity, and the profit maximizing

[4] Various versions of the Hippocratic Oath are presented here http://www.aapsonline.org/ethics/oaths.htm. The French Code of Medical Ethics (English version) is linked here https://www.conseil-national.medecin.fr/sites/default/files/code_de_deontologie_version_anglaise.pdf. Extracts from the Boston University School of Medicine and the French Code of Medical Ethics is attached in the Appendix.

price is driven solely by the area under the consumer demand. Because of linear demand curves, the perfectly discriminating monopoly price is the same as the monopoly price, but the quantity demanded is twice as large. Although this doubling obviously follows from using linear demand curve, the key insight is the huge potential for excess quantity if the seller can set both price and quantity.

Now consider the effects of a mandatory popcorn insurance policy that covers fraction 1-α of the price of popcorn, with the consumer paying the remaining fraction α. The dashed demand curve in Figure 1 illustrates this case for $\alpha = 1/2$. Since the consumer only has to pay half of the price, his willingness to pay (the demand price) will be twice as high as before. It is easy to see that the new profit maximum would be characterized by the same $x = x^*$ with the new price twice the original price. More generally, in the absence of interference by a regulator or the entry of a popcorn competitor, the profit maximizing price would be $p = p^*/\alpha$. Increasing insurance generosity by lowering α will increase profits, and supply prices can be an enormous multiple of what a simple monopoly model would predict, even while the demand price paid by the consumer, αp^* , remains the same.

Next let us relax the zero marginal cost assumption and assume that the cost function for popcorn depends on quantity x and quality q: $C(x, q)$. Figure 2 illustrates the popcorn example for the case of an upward sloping (individual) marginal cost curve, but we will soon see that even these costs may not really matter in likely outcomes. The theatre's profit maximization problem then becomes a two-step decision of first choosing quantity x^1 and quality q^1 so that the marginal cost is equal to the consumer's marginal willingness to pay along the relevant demand curve. The profit maximizing price p^1 is then chosen so as to extract the full consumer surplus at point H = (x^1, p^1) with no insurance, and at J = (x^α, p^α) with partial insurance. With a positive marginal cost, increasing insurance coverage will increase the quantity demanded, as insurance reduces the importance of marginal costs and increases the markup of provider prices above them.

As shown in McGuire (2000) and Ma and McGuire (2002), if the regulator imposes a price ceiling, then a reduced supply price for providers at p^{ceil} creates a perverse incentive for the firm to increase quantity to x^{ceil}, which increases profits without losing the consumer, resulting in point K in Figure 2. Further price ceiling reductions or increases in insurance coverage leave the consumer at this corner solution where his participation constraint is binding and total consumer surplus is maximized. At this corner solution, neither prices nor quantities respond to marginal changes in costs. This is ominous about the lack of incentives for cost-reducing innovation: with prices that reflect mainly consumer WTP and not costs, providers have no incentive to recommend, or consumers to choose, a new lower cost innovation.

One last lesson from popcorn sales before moving on to health care and a more formal model. We do observe movie theatres offering more than one size of popcorn. But observant consumers know that the prices charged rarely correspond to a fixed price per unit of popcorn sold (as is true in most market sales, even from a monopoly). Smaller size containers are priced by their differential value from the highest profit sales. In Boston USA, the popcorn small size with half the quantity of the large is sold at only a 12 percent discount from the large, while in Lyon France the small popcorn, which is 75 percent smaller than the large, is discounted only 42 percent. We explore these implications in our empirical section of the paper, which attempts to distinguish price-taking consumer behavior from WTP pricing behavior.

IV. Model incorporating physician agency

Let us now move to a more formal model. Assume initially that there is only one established technology for treating a specific health condition that N identical consumers all have. (Later we allow N to respond to prices.) The resource cost per person and consumer utility from care, are written as $C(x, q)$ and $B(x, q)$, respectively, where x denotes the quantity of care while q denotes the quality of the care. To guarantee interior solutions, we assume that $B(x, q)$ is quasi-concave in x and q and $C(x, q)$ is quasi-convex.[5] Since the fixed costs of developing the established technology is already sunk, we assume without loss of generality that the provider's fixed costs for using the technology are zero. Once insurance is introduced, two prices will need to be distinguished: the demand price, p^D, and the supply price, p^S. Using this notation, patient utility will be

$$U(p^D, x, q) = B(x, q) - p^D x \quad , \tag{1}$$

should he consume health care, or zero otherwise.[6] The provider's profit per patient earned is

$$\Pi(p^S, x, q) = p^S x - C(x, q). \tag{2}$$

In the next three sections, we examine three scenarios for $\{p^D, p^S\}$, all of which assume a monopoly provider paid by fee-for-service prices, in which patients rely on their doctor or hospital and accept treatment decisions without searching for a different provider. Our benchmark scenario approximates conventional insurance by assuming a constant coinsurance rate, $0 < \alpha < 1$, so that $p^D = \alpha\, p^S$. After solving this model,

[5] Specifically this means $B_{xx} \leq 0$, $B_{qq} \leq 0$, $B_{xx} B_{qq} - (B_{xq})^2 \geq 0$, $C_{xx} \geq 0$, $C_{qq} \geq 0$, $C_{xx} C_{qq} - (C_{xq})^2 \geq 0$.

[6] McGuire (2000) adds in an extra adjustment for the reservation utility if the consumer decides to go to a different provider. Although relevant for considerations of total welfare, the demand curve facing an individual seller will already reflect this willingness to go elsewhere, and hence this reservation utility does not need to be subtracted from consumer surplus in our formulation. We discuss below that this opportunity cost of not switching is analogous analytically to a fixed price that does not affect quality and quantity choices unless it affects the marginal purchase decision, which it will rarely be.

we also examine the effects of a binding price ceiling in this constant coinsurance case. Our second scenario assumes the provider must accept a binding regulated price ceiling, $\overline{p^S}$, and that the consumer fee is unrelated to quantity or quality, $\overline{p^D}$. This second scenario approximates that of many health plans in the USA, and in particular most Health Maintenance Organizations (HMOs), in which the consumer price is a fixed dollar amount per day of treatment, which means that on the margin extra intensity (i.e., quantity) is free. Since the demand prices do not reflect quantity or quality, the consumer is in effect fully insured after paying the lump sum amount, $\overline{p^D}$, and hence we call this the full insurance scenario. Our third scenario assumes perfect competition, such that prices are driven down to marginal costs. This scenario is relevant for drugs or medical equipment that are no longer protected by patents and for which consumers or their expert agent providers (e.g, the pharmacist or government) are able to shop around effectively to obtain the lowest price.

A. *Constant coinsurance*

Let's start with the simplest situation: Only one technology is available, and the consumer's price p^D is a constant share α of the price received by the monopoly provider: $p^D = \alpha p^S = \alpha p$. The provider chooses ($p$, x, q) so as to maximize her profits, ensuring that her patient's utility from the treatment is at least the reservation utility without treatment, normalized to zero:

$$\begin{aligned} &\max_{p,x,q} \Pi = N\big(px - C(x,q)\big) \\ &s.t.\quad B(x,q) - \alpha px \geq 0. \end{aligned} \tag{3}$$

The patient's participation constraint is always binding since it is decreasing in price p and the provider's profit is increasing in p. Therefore, we can rewrite the program as:

$$\max_{x,q} \Pi = N\left(\frac{B(x,q)}{\alpha} - C(x,q)\right). \tag{4}$$

The first order conditions for the profit-maximizing price, quantity, and quality satisfy:

$$p^* = \frac{B(x^*,q^*)}{\alpha x^*} \tag{5}$$

$$B_x(x^*,q^*) - \alpha\, C_x(x^*,q^*) = 0 \tag{6}$$

$$B_q(x^*, q^*) - \alpha\, C_q(x^*, q^*) = 0 \tag{7}$$

The provider's profit is decreasing in the co-payment rate α:

$$\frac{\partial \Pi(\alpha, x^*, q^*)}{\partial \alpha} = -N\, \frac{B(x^*, q^*)}{\alpha^2} < 0 \tag{8}$$

It is straightforward to see that if the marginal benefit function B_x is decreasing more rapidly in x and q than the marginal cost, (satisfied automatically by a constant or upward sloping marginal cost of quantity and quality) then the provider's price, quantity and quality of care are all decreasing in α. Generous health insurance is therefore beneficial from the provider's perspective. This is very intuitive: generous insurance increases demanded quantity and quality and makes them less sensitive to price. Price, quantity and quality can thus be higher, and as will be profits.

Result 1.

For an unregulated WTP monopoly provider facing constant coinsurance, the quality, quantity, provider's price and profit are increasing in the generosity of insurance.

Now suppose that the regulator decides to impose a price ceiling $\overline{p}$ such that $\overline{p} < p^*$. The provider's problem then becomes:

$$\max_{x,q} \Pi = N\big(\overline{p}\, x - C(x, q)\big) \tag{9}$$

$$s.t. \quad B(x, q) - \alpha \overline{p} x \geq 0 \tag{10}$$

$$B_x(x, q) \geq 0.$$

Here as before the first constraint implies that the consumer benefits are at least as great as the out of pocket cost, while the second constraint ensures that quantities are not chosen with negative marginal benefits: consumers cannot be induced to consume beyond where their demand curve hits the horizontal axis. Two profit-maximizing solutions are possible, depending upon whether the first or second constraints are binding. For a just barely binding price ceiling, set only slightly below the profit max level, p^*, the first constraint will be binding, quantities and quality will respond to the price ceiling, and the comparative statics correspond to Result 1. With sufficiently generous insurance, this first constraint will always be satisfied, and only the nonnegative marginal benefit constraint will be binding. This second case is far more likely so we focus on it here and state Result 2.

Result 2:

If a binding price ceiling is imposed that is above marginal costs, and insurance is sufficiently generous that the consumer is willing to pay somewhat more for care, which is to say conditions $\overline{p} \geq C_x(x,q)$ *and* $\alpha\overline{p} \leq \frac{B(x,q)}{x}$ *hold, then quantity is determined solely by the horizontal intercept of the consumers demand curve,* $B_x(x,q) = 0$ *and is hence independent of changes in the price ceiling or insurance generosity.*

The effect of price ceilings in the presence of generous insurance seldom receives meaningful attention in the health economics literature on moral hazard. If the price ceiling is well above marginal costs, then quantities (and quality) are set independently of costs and the coinsurance rate, since they are chosen simply so as to maximize quantity demanded. Only when the per item price ceiling is close to marginal costs do costs start affecting quantity and quality decisions.

For completeness it is useful to contrast this WTP solution with the traditional unregulated monopoly case in which the provider chooses only p and q, but not x. Here the consumer chooses quantity to maximize utility $B(x,q) - \alpha px = 0$, so that the monopoly faces demand $p = \frac{B_x(x,q)}{\alpha}$, which for $B(x, q)$ increasing and concave in quantity x, which is traditionally admitted, is always lower than the maximum-WTP demand that we consider throughout, $p = \frac{B(x,q)}{\alpha x}$. The monopoly quantity and quality will satisfy $\frac{B_x(x,q)+xB_{xx}(x,q)}{C_x(x,q)} = \frac{xB_{xq}(x,q)}{C_q(x,q)} = \alpha$, and both be lower than x^* and q^*. For upward sloping marginal cost function, the WTP monopoly price is higher than p^*. The presence of the copayment rate α exacerbates all these differences.

B. *Full insurance or insurance with a fixed consumer copayment*

Next consider the case where the product is still provided by a monopoly, but the consumer pays a fixed total price p^D (which could be zero) for treatment that does not depend on the quantity or quality provided. This situation arises in many settings where the health plan chooses a fixed fee per visit, per day, per hospital admission, or per prescription for the consumer regardless of the intensity, quality or cost of the goods or services provided within each of these units of treatment. Also included are the interesting cases such as in Spain and Canada where many health services are free, and hence $p^D=0$. In these fixed consumer copayment settings, positive prices plausibly affect whether patients seek care, but not their choices of quality and intensity conditional on receiving care. It follows from the results in the previous section with α

= 0 that if providers are allowed to choose prices, then the profit maximizing supply price would be infinite.

Given that infinite prices in response to full insurance are infeasible, price regulation is needed to constrain prices. Although several cases are theoretically possible, we focus here on the empirically plausible case in which the demand price p^D is low so that the consumer is always willing to seek care and accept the recommended quantity offered, and the supply price ceiling $\overline{p^S}$ is high and well above marginal costs. Consistent with the doctors' Hippocratic promise to "do no harm", or perhaps if consumers can actually detect whether excessive care is being provided, we assume that $B_x(x, q) \geq 0$. The problem facing the established firm can be written as follows.

$$\begin{aligned} &\max_{x,q} \Pi = N\left(\overline{p^S}x - C(x,q)\right) \\ &s.t.\quad B_x(x,q) \geq 0 \qquad\qquad \text{patient quantity acceptance} \end{aligned} \tag{11}$$

For the reasons presented in the popcorn discussion, a price ceiling below the profit maximizing price quickly results in a corner solution in which the seller focuses on maximizing the willingness of patients to consume as much of the profitable service as possible. With $\overline{p^S} > C_x(x,q)$, quantity and quality are determined by $B_x(x,q) = 0$, and hence quantity is high, since the marginal costs of quality and quantity must both be positive.[7]

C. Sequential rather than simultaneous choices of p, q, and x

In this paper, we model providers as if they choose the price, quality and quantity of care for their patients, reacting to the insurance generosity and available technology. This is realistic for providers in the US who are able to negotiate their fee levels with individual health plans for individual procedures, but implausible for other settings, such as pharmaceuticals or other medical suppliers, where prices and qualities are set by the medical suppliers. This is particularly true in countries other than the US where these prices and sometimes qualities are exogenous to individual providers. The provider choice of $\{p, q, x\}$ is still interesting in that the solutions to a sequential optimization by two agents is the same as the solution for a single agent if the two have the same objective function, which we state as a Result:

[7] Analytically, this model with full insurance with an infra-marginal fee paid by consumers that does not affect prices on the margin is identical to the fixed outside option for changing providers modeled by McGuire (2000). If consumers plausibly assume that their choices do not affect the value of other providers that they might visit, then quantity and quality choices for the current decision are independent of these choices for all but the marginal consumer just willing to switch providers.

Result 3:

Let $\{p^*, q^*, x^*\}$ *be the solution to the problem* $\max_{p,q,x} \Pi(p, q, x)$

and let $\{p^1, q^1, x^2\}$ *be the solution to the two-stage problem*

$$\max_{p,q} \Pi(p, q|x^2) \ \text{ s.t. } \left\{x^2 \text{is the solution to } \max_{x} \Pi(x|p^1, q^1)\right\}.$$

Then $\{p^*, q^*, x^*\} = \{p^1, q^1, x^2\}$.

This result follows immediately from the first order conditions of the two problems, if the two agents have the same objective function. What this means in words is that the solution to our model with a single agent maximizing profits over $\{p, q, x\}$ is equivalent to the solution where a monopoly medical supplier chooses $\{p, q\}$ so as to maximize its profits knowing that the provider will subsequently choose x in a manner that maximizes the same objective function. Our results also carry over if the provider, not the monopoly technology producer, chooses both x and q, so that only prices are set by the monopolist. Why would a provider have the same objective function as a medical supplier? In general, they should not. But if providers maximize patient benefits net of their after insurance out of pocket costs, without regard to the societal costs of the treatments they recommend, then this satisfies the same first order conditions as the WTP, popcorn pricing, quality and quantity model we use here. More is said about this when we model the Hippocratic Oath below.

D. Consumer heterogeneity

So far we have been assuming identical consumers, so that the number of people being treated, N, is independent of x, q and p^D. Once patient heterogeneity is allowed then not all patients need seek treatment from a single provider. Ma and McGuire (2002) use a duopoly Hotelling formulation of heterogeneity for the constant insurance rate model that uses a structure identical to our formulation, without allowing quality variation. We return to the assumption that $p^D = \alpha p$, and let j index each provider. In this framework the utility of a consumer located $t \in [0,1]$ distance away from Provider j is $[B(x_j, q_j) - \alpha p_j x_j - t\delta]$. As is conventional, we focus on the symmetric equilibrium where $p_1 = p_2 = p$, $x_1 = x_2 = x$ and $q_1 = q_2 = q$, and assume an interior solution in which all patients are treated. The Cournot problem for provider 1 can be written as

$$\max_{p_1,x_1,q_1} \Pi_1 = N_1\big(p_1 x_1 - C(x_1, q_1)\big) \qquad (12)$$

where

$$N_1 = min\left\{\frac{[B(x_1,q_1) - \alpha p_1 x_1] - [B(x_2,q_2) - \alpha p_2 x_2]}{2\delta} + \frac{1}{2}; \frac{B(x_1,q_1) - \alpha p_1 x_1}{\delta}\right\}.$$

Here δ captures the sensitivity of demand to a taste parameter t, provider 1 is assumed to be located at t = 0 with provider 2 located at t = 1, and for simplicity the number of patients in the market is normalized to be 1. Higher values of δ correspond to more inelastic demand functions, since differences in utilities between the two providers matter less, giving providers greater market power. Following Ma and McGuire (2002), we solve for the symmetric equilibrium and we focus on a constant returns to scale cost function so that $C(x,q) = c(q)x$. If providers act as Cournot profit-maximizers over p, x, and q, then the first order conditions for the symmetric equilibrium when firms choose the same price-quantity-quality amounts can be rewritten using our notation to obtain the following solution:

$$\begin{aligned} B_x(x,q) &= \alpha c(q) \\ B_q(x,q) &= \alpha x c'(q) \\ p &= \frac{1}{\alpha x} min\left[max\left[B(x,q) - \frac{\delta}{2}; \frac{B(x,q)+\alpha x c(q)}{2}\right]; \alpha x c(q) + \delta\right] \end{aligned} \qquad (13)$$

These three equations have a clear interpretation. The first equation, parallels that of Figure 2 (point J) and Equation (6) showing that quantity is chosen so that the marginal benefit is equated not to the marginal cost but the insurance adjusted marginal cost. Providers act in the best interests of consumers with regard to quantity decisions achieving their bliss point. The second equation defines profit-maximizing quality. As for quantity, this choice of quality is distorted by insurance parameter α. Quality is indeed increasing with insurance, which parallels the result Cremer and Thisse (1994). The third equation, paralleling Equation (5) says that prices should be priced so as to ensure both that the marginal patient is willing neither to travel to the other provider nor to forego any treatment. Although several special corner solutions are possible, the first term in the third equation is identical to the results in Part A above, except that the travel costs reduce the total value that can be extracted from patients. In Part A, providers only need to worry about losing the marginal patient to no treatment, while here the competing provider may also take away patients. In both cases, insurance increases the optimal prices charged. If benefits constraint binds, then the results are the same as the WTP results in the one provider case, modified by the travel cost adjustment, $(-\delta/2)$.

As would be expected, consumer choice of providers does change the nature of the profit maximizing prices, quantity and quality. As Ma and McGuire (2002) note, these results parallel those of Spence (1975), Ma and Burgess (1993) and others: there is the usual moral hazard of consumption, with insurance inducing too much quantity, and prices reflecting demand elasticities. Since insurance makes demand less elastic, prices are much too high. We introduce quality explicitly rather than interpret quantity as a quality variable, which parallels the insight by Cremer and Thisse (1994): insurance increases quality. The work of McGuire (2000), Ma and McGuire (2002), emphasizing that quantity choices differ dramatically from monopoly model results when both price and quantity are choice variables, has received little attention in the health economics literature. We detect WTP, "popcorn pricing quality, and quantity" choices even in this duopoly model.

E. *Competitive entry in constant reinsurance case*

Although our primary interest is capturing the implications of pricing by imperfectly competitive firms using WTP pricing and quantity setting, it is also interesting to briefly discuss how this differs from the usual competitive case in which supply prices are forced down to competitive levels. This could occur, for instance, for pharmaceuticals or durable medical supplies when a patent expires, the goods are storable, tradeable and quality is uniform. This seems less likely for physician and hospital services where perfect information, storability, and tradability are not possible. We add it in here since it is relevant to the innovator's entry decision: how does an innovator enter a market in which the existing products are competitive, and how does the presence of a competitively-supplied existing product influence the pricing, quality, and quantity decisions of innovators?

Competition can force the supply price down to marginal costs, however it cannot undo the overconsumption caused by insurance. Conditions that will hold at the competitive equilibrium are:

$$\begin{aligned} p^S &= C_x(x,q) && \text{price equal to marginal cost,} \\ B_x(x,q) &= \alpha C_x(x,q) && \text{marginal quantity valued at its insured marginal cost} \\ B_q(x,q) &= \alpha C_q(x,q) && \text{marginal quality valued at its insured marginal cost.} \end{aligned} \tag{13}$$

These conditions are familiar to any competitively supplied good with identical consumers. But does competitive rather than WTP pricing by the established firm deter new entry? That is a key issue to be considered in a setting with entry of innovative technologies.

F. *Innovation results*

Now, we consider a model with two technologies, which may usefully be thought of as pharmaceuticals, lab tests, imaging, or medical procedures. The established technology is indexed by E. An innovator considers developing a new technology, I, where we use I to reflect both the technology and the agent creating this technology. To account for the entry of innovation, we consider the following timing: In the first stage, only the existing technology E exists. In stage 2, providers using E choose quantity, quality and price. In stage 3, a single innovator chooses a technology I. In stage 4, the stylized provider chooses the quantity, quality and price to offer using technology I. In stage 5, providers compare the offerings of E and I and choose which one to recommend to their patients. Note that again patients are passive, and that as in the basic case, it is as if the providers choose the innovators profit-maximizing price.

We characterize the established and innovator's technology by the pair (λ, β), where λ is the cost of the new technology relative to the existing technology and is the β is the benefit to the consumer of the new technology relative to the existing technology. An unambiguous welfare improving innovation is a cost decreasing benefit improving one with $\lambda < 1$ and $\beta > 1$, but we need not restrict anything. The key issue we are interested in is how insurance, WTP pricing, and the Hippocratic Oath changes the innovators willingness to invest in technologies that differ in (λ, β).

In stage 5, the provider chooses whether to use technology E or I. In stage 4, the innovator anticipates this comparison and chooses (p_I, x_I, q_I) so as to maximize profits, ensuring that the patient is at least as well off as with the E technology. Two variants are possible. One is that the provider cares about the patient's utility <u>including</u> out of pocket costs. For the constant coinsurance rate the provider's problem is:

$$\max_{x_I, q_I, p_I} \Pi = N\big(p_I x_I - \lambda C(x_I, q_I)\big) - F$$
$$s.t. \quad \beta B(x_I, q_I) - \alpha p_I x_I \geq B(x_E, q_E) - \alpha p_E x_E.$$

The patient's participation constraint is always binding since it is decreasing in price p_I and the provider's profit is increasing in p_I. Therefore, we rewrite the program as:

$$\max_{x_I, q_I} \Pi = N\left(p_E x_E + \frac{\beta B(x_I, q_I) - B(x_E, q_E)}{\alpha} - \lambda C(x_I, q_I)\right) - F.$$

The first order conditions for the profit-maximizing price, quantity, and quality satisfy:

$$p_I^* = \frac{1}{x_I^*}\left(p_E x_E + \frac{\beta B(x_I^*, q_I^*) - B(x_E, q_E)}{\alpha}\right),$$

$$\beta B_x(x_I^*, q_I^*) - \alpha\lambda\, C_x(x_I^*, q_I^*) = 0,$$

$$\beta B_q(x_I^*, q_I^*) - \alpha\lambda\, C_q(x_I^*, q_I^*) = 0.$$

Here the level of the established firm prices matter. The optimal pricing is such that the innovator can charge an amount over the existing cost that is equal to the difference in patient benefits, inflated by the coinsurance rate. For this equation it does not matter whether the established firm prices E is at its WTP price or whether it is determined through some other process, such as regulation or competition. If p_E is constrained, then low prices for the established good will constrain the innovators price. Alternatively if E is priced at its WTP price, then p_E will satisfy:

$$p_E^* = \frac{B(x_E^*, q_E^*)}{\alpha x_E^*}.$$

Substituting this into the above first order condition defining p_I^* we see that pricing of the new innovation directly depends on the benefits of the new innovation, not on the cost or pricing of the existing technology. This can also be seen by substituting this expression into the innovator's profit objective, which simplifies to:

$$\Pi(x_I^*, q_I^*; \alpha, \beta, \lambda) = N\left(\frac{\beta B(x_I^*, q_I^*)}{\alpha} - \lambda C(x_I^*, q_I^*)\right) - F.$$

This is the same problem as in our basic model, just applied to the innovator's benefit and cost functions.

A second possibility is that the Hippocratic Oath is strictly binding, and the provider cares only about patient benefits without regard to the patient's out of pocket costs. In this case the provider adoption decision is:

$$\begin{aligned} &\max_{x_I, q_I, p_I} \Pi = N\big(p_I x_I - \lambda C(x_I, q_I)\big) - F && \\ &s.t.\ \ \beta B(x_I, q_I) \geq B(x_E, q_E) && \text{Hippocratic Oath} \\ &\qquad \beta B(x_I, q_I) - \alpha p_I x_I \geq 0 && \text{Patient participation constraint.} \end{aligned}$$

It is straightforward to see that in this case if the new technology is strictly more beneficial to patients ($\beta > 1$) than the existing one, then technology I will be chosen by the doctor over E, and WTP pricing, quality and quantity choices are the same as in the basic model.

We have now shown that there are two cases in which prices of an innovator are based on WTP pricing, quantity and quality choices. One is if the established technology is priced at the WTP pricing. The other is where the Hippocratic Oath is binding and such that the provider cares only about benefits and not out-of-pocket costs to the consumer. In this second case, even if the established technology is regulated or priced competitively, then the provider will be able to use WTP pricing for the innovative technology. In both cases,

$$p_I^* = \frac{B(x_I^*, q_I^*)}{\alpha x_I^*}.$$

At the heart of this issue is whether providers recommending treatment value I at its overall value to the patient, or at the incremental value including patient out-of-pocket costs relative to the next best alternative. Economists generally value an innovation at its incremental contribution, but do doctors? Assuming WTP pricing at both the E and I level, the first-order conditions that define the solution show that solution profits are decreasing in both α and λ, and increasing in β. Moreover, the marginal profit from the patient's utility is decreasing in the generosity of insurance:

$$\frac{\partial \Pi(x_I^*, q_I^*; \alpha, \beta, \lambda)}{\partial \alpha} = -N \frac{\beta B(x_I^*, q_I^*)}{\alpha^2} < 0$$
$$\frac{\partial \Pi(x_I^*, q_I^*; \alpha, \beta, \lambda)}{\partial \lambda} = -NC(x_I^*, q_I^*) < 0$$
$$\frac{\partial \Pi(x_I^*, q_I^*; \alpha, \beta, \lambda)}{\partial \beta} = N \frac{B(x_I^*, q_I^*)}{\alpha} > 0$$
$$\frac{\partial \Pi^2(x_I^*, q_I^*; \alpha, \beta, \lambda)}{\partial \alpha \partial \beta} = -N \frac{B(x_I^*, q_I^*)}{\alpha^2} < 0$$

Using the same first-order conditions, we can show that the provider is indifferent between a cost-inflating-high-value innovation (high λ and β and a cost-saving-low-value innovation (low λ and β. Indeed, the iso-profit lines in the (λ, β) space (see Figure 3 below) have a positive slope:

$$\frac{\partial \lambda}{\partial \beta} = \frac{B(x_I^*, q_I^*)}{\alpha C(x_I^*, q_I^*)} > 0$$

The slopes of these iso-profit lines are sensitive to the insurance rate, α (see Figure 4). When health insurance reimbursements are generous, the solution is more sensitive to variations in the value of health than in the cost parameter. The iso-profit lines are therefore steeper in the (λ, β) space. If instead, health insurance is less generous, the iso-profit lines are flatter. We can show that with a generous insurance policy, the provider is more likely to adopt a cost-inflating-high-value innovation (high λ and high β) than a cost-saving-low-value innovation (low λ and low β). With a less generous insurance instead, the provider is likely to prefer adopting a cost-saving-low-value innovation (low λ and low β). In other words, a more generous insurance encourages the adoption of cost-inflating innovations with higher health value while less generous insurance encourages the adoption of cost-saving innovations with lower health value.

Result 4.

With WTP pricing, the provider prefers a new technology that is cost decreasing and health value increasing. The latter is even stronger the more generous the insurance. Having the choice between a cost-inflating-high-health-value innovation and a cost-saving-low-health-value innovation, an innovator is more likely to prefer the former over the latter as insurance becomes more generous.

G. *Discussion of the Hippocratic Oath*

Our results actually hold even in the worst-case scenario, that is, when providers are selfish decision-makers without any concern for their patients' health. We have shown that even a selfish provider prefers a cost-inflating-high-health-value innovation over a cost-saving-low-health-value innovation. Obedience to the Hippocratic Oath naturally reinforces this tendency since it favors health promotion over cost savings, by definition.

Some readers might question the plausibility of the results generated here, since they dismiss our assumption of similarity of objectives between medical suppliers and providers, and insensitivity to societal costs. We attribute this to three key factors. First, the provider's Hippocratic Oath requires doctors to place promoting the health of their patients above all else, and does not include provisions such as "unless a lower cost treatment if feasible without too much harm.[8] We observe with frequency that enormously cost-increasing innovations are adopted with little regard to the cost of the established technology. Howard *et al*. (2015) provide clear evidence of this in the pricing and entry of new anticancer drugs. Hult, Jaffe, and

[8] The French Code of medical ethics contains the statement "My overriding concern shall be to restore, preserve or promote health in all respects, physical and mental, individual and collective." The US uses a wide variety of Hippocratic Oath variations at different medical schools. "Do no harm" is common to many of them. At Boston University Medical School the Oath includes "I will exercise my Art solely for the cure of my patients and the prevention of disease…"

Philipson (2018) document that 75% of more than 6000 innovations over a twenty year period were for price increases, with many of them having negative or merely small quality improvements. A second factor is that the regulated prices allowed are below those desired given generous insurance levels. Perversely, this price ceiling can increase the desire of the provider to increase quantity and quality (McGuire, 2000, Ma and McGuire 2002) as in the popcorn example. Once patient's benefit of treatment is maximized without regard to costs, then there is little incentive for cost reducing innovations to be developed: both the existing and the innovation technologies will have the same value-based supply price, and if anything, prices will be lower for the cost reducing technology. The third consideration is that even if regulators successfully lower prices per unit, the ability of providers to set quantities to partially circumvent this ceiling (increasing x to offset a lower $\bar{p}$) again makes quantity decisions independent of costs.

V. Empirical Implications

The above model generates a variety of predictions that differ from those of a simple monopoly model. These are preliminary thoughts, which also document *ex ante* the types of tests we are in the process of conducting.

H1. New drug prices will be increasing over time because of growing US drug insurance coverage.
H2. New drug quantities per user will increase along with increased insurance, contrary to a monopoly model.
H3. Drug and new technology prices will be higher in health plans with more generous insurance coverage.
H4. Plans that charge a fixed fee rather than a fraction of the drug price will have higher drug and provider prices.
H5. The existence of an existing substitute drug or technology in a market does not constrain the prices of improvements, since the improvement is priced at its WTP price, not its incremental value to consumers.
H6. Drugs are sold at a social cost that is greater than any meaningful number of uninsured consumers would be willing to pay.

Thus far we have conducted analysis that reflect tests of hypotheses H1-H4 and H7. Hypotheses H5 and H6 will require more work and are still in progress.

A. Data

We are using IBM/Watson Truven MarketScan Commercial Claims and Encounter data for 2006-2016, which contains eleven years of insurance claims about 20-50 million commercially insured enrollees age 0 to 64. The enrollees in this data all have employer sponsored health insurance, which on average is relatively generous, and for the most part is for individuals enrolled in large employer health plans. Thus far we have only explored prescription drug claims for this project. For our analysis we excluded: Individuals with capitated health plans or services that include mention of a capitation payment. We excluded records with negative or zero payments or spending on a single claim for over $100,000 (which might be legal settlements or commercial transfers). For pricing calculations we included only claims where quantity (number of packages or months sold) is 1, however for calculating total annual payments per user we used the sum of spending on each drug without regard to quantity sold. The ratio of consumer annual payments for a drug to the price of the first prescription of that particular drug is our measure of "quantity". For this we excluded people who only purchased prescriptions for a specific drug with quantities greater than one. Out of pocket spending was calculated as the sum of deductible, coinsurance and copayment amounts, and we ensured that these costs were also always non-negative. All dollar amounts were deflated using the consumer price index, with 2017 as the base year. Hence spending has already had general inflation removed.

B. Pharmaceutical pricing and relevant policy changes

Understanding our results requires a degree of understanding of how pharmaceuticals are classified, named, and sold. New chemical entities are eligible for a 22-year patent which protects the inventor from entry and competition by other firms. During this patent period the drug is considered a "sole source" drug. Each new chemical must be given both a generic name and a brand name, where the generic name may be the name of the single or set of chemicals included in the drug, and will be available to other firms producing the same drug once the patent expires. Even while a sole source drug the owner of the drug may choose to license out the production of that drug to multiple manufacturers or labelers creating the identical, sole-source drug. Hence multiple suppliers does not necessarily imply multiple competing firms.

Drugs in the United States are assigned a National Drug Code (NDC) which is an 11 alphanumeric character variable.[9] The first segment of the NDC is the labeler code, assigned by the Food and Drug administration, which is any firm that manufactures, repacks or distributes a drug product. The second segment is a product code that identifies the specific strength, dosage form, and chemical formulation of a particular drug. The third segment is the package code, which identifies package forms and sizes. Even while a drug is still covered by a patent, and hence no competing firms are allowed, each drug is already assigned a "generic name" that characterizes the chemical components of that NDC. This generic name may include lists of multiple ingredients. For this paper we focus on average prices, annual usage, and inferred quantities of drugs primarily at the generic name only. This can be confusing in that often the term generic drug is used to describe a new entrant producing an existing drug chemical, competing against the branded patent holder. We use sole source versus competitively sourced drugs to make this distinction. All of the

[9] In Europe and many other countries a different numbering and naming convention is used, mostly called the Anatomical Therapeutic Chemical (ATC) which reflects the active ingredients of drugs. This coding system is quite different in structure.

results shown in this draft of the paper are for prices and quantities of new drug chemicals (i.e., new generic drug names) during the first years after their introduction into the commercial insurance market while still under patent. We call these simply “new drug chemicals”

To understand our analysis it is also important to realize that several national policies have influenced pharmaceutical drug insurance and drug pricing. These are notably:

- 2007 The Medicare program started offering an optional prescription drug benefit through Medicare Part D prescription drug plans. Enrollment was phased in primarily from 2007-2011 while enrollment in the program has now largely stabilized.
- 2010: The Affordable Care Act[10] (ACA) contained hundreds of features, but the most salient are the expansions of family coverage for young adults, expansions of Medicaid coverage in many states, improvements in the Medicare Part D prescription drug insurance, imposition of a excise tax on drug manufacturers with over $5 billion in sales per year, and restrictions on insurance premium to cost rates
- 2014: ACA Marketplace started which encouraged the uninsured to enroll in health plans or face tax penalties. Contributed to a five percentage point reduction in number of uninsured Americans.

C. Results

Results shown are preliminary and illustrative. Much further work is needed.

Figure 5 illustrates that corresponding to the expansion in drug coverage under the Affordable Care Act, there has been an acceleration in the entry year price of new drug chemicals.

Figure 6 illustrates that even after the year of introduction, in recent years drug prices of existing drugs have increased dramatically during the first few years of sales. A simple monopoly does not explain such a rapid increase after the first year of introduction.

Figure 7 illustrates that even as prices of new drugs have been increasing dramatically, the quantity of sales among users (defined as annual spending divided by the cost of the first prescription) has also been increasing This is not explained by a monopoly model but is more consistent with increasing quantities as patients and providers realize the value of new drugs.

Figure 8 illustrates the combined effect of the pricing and quantity escalation for new drugs in early years after new drug introduction, with an acceleration in the last four years.

Figures 9 and 10 illustrate that there is enormous heterogeneity in the pricing across consumers in the US, for two of the highest revenue new drugs (Humira and Enbrel), both used primarily for arthritis conditions.

Table 1 and 2 run two different sets of regressions on an important class in which there has been a lot of recent innovation, immune-suppressants. It shows that drugs are higher in plans when they are free, or subject to a copayment rather than a coinsurance. Enrollees in HMOs which typically constrain choices and negotiate lower prices than FFS and PPO plans, pay lower prices for drugs than those in High deductible

[10] The full name is the Patient Protection and Affordable Care Act of 2010.

and Consumer driven health plans, which do not try to negotiate lower prices. Prices of drugs covered by deductibles and coinsurance are lower than prices of drugs in plans that are free or subject to a fixed dollar amount copayment.

VI. Discussion and policy implications

This paper has developed an analytical framework for thinking formally about the implications of physician agency and insurance on the adoption of insurance. We have shown that a physician is more likely to prefer a cost-inflating-high-health-value innovation over a cost-saving-low-health-value innovation as insurance becomes more generous. This result holds even when we assume that physicians are selfish decision makers. Considering instead either obedience to the Hippocratic Oath naturally reinforces our main result. The pricing of new technologies is not constrained by the low cost of existing technologies as long as any benefit improvement is feasible. Insurance makes it easy for physicians to support very high prices, even while there are few other markets in which this occurs.

Our empirical results from the US find that the prices of new drugs introduced have been increasing dramatically as insurance for drugs has become more generous in recent years. The finding that quantities per user as well as prices have been going up dramatically on existing drugs introduced in prior years is not consistent with a monopoly model of drug pricing and quantities. Further empirical tests of the model prediction are needed.

Our findings suggest new strategies to enable cost-reducing technologies will be needed to change provider and consumer willingness to accept innovations that change the trajectory of health care costs, and can lead to drugs or medical technologies priced at levels that few if any patients would be willing to pay in the absence of generous insurance.

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Figure 1: Profit-maximizing price- and quantity-setting outcomes without (B) and with (C) insurance(α <1) for zero marginal cost case

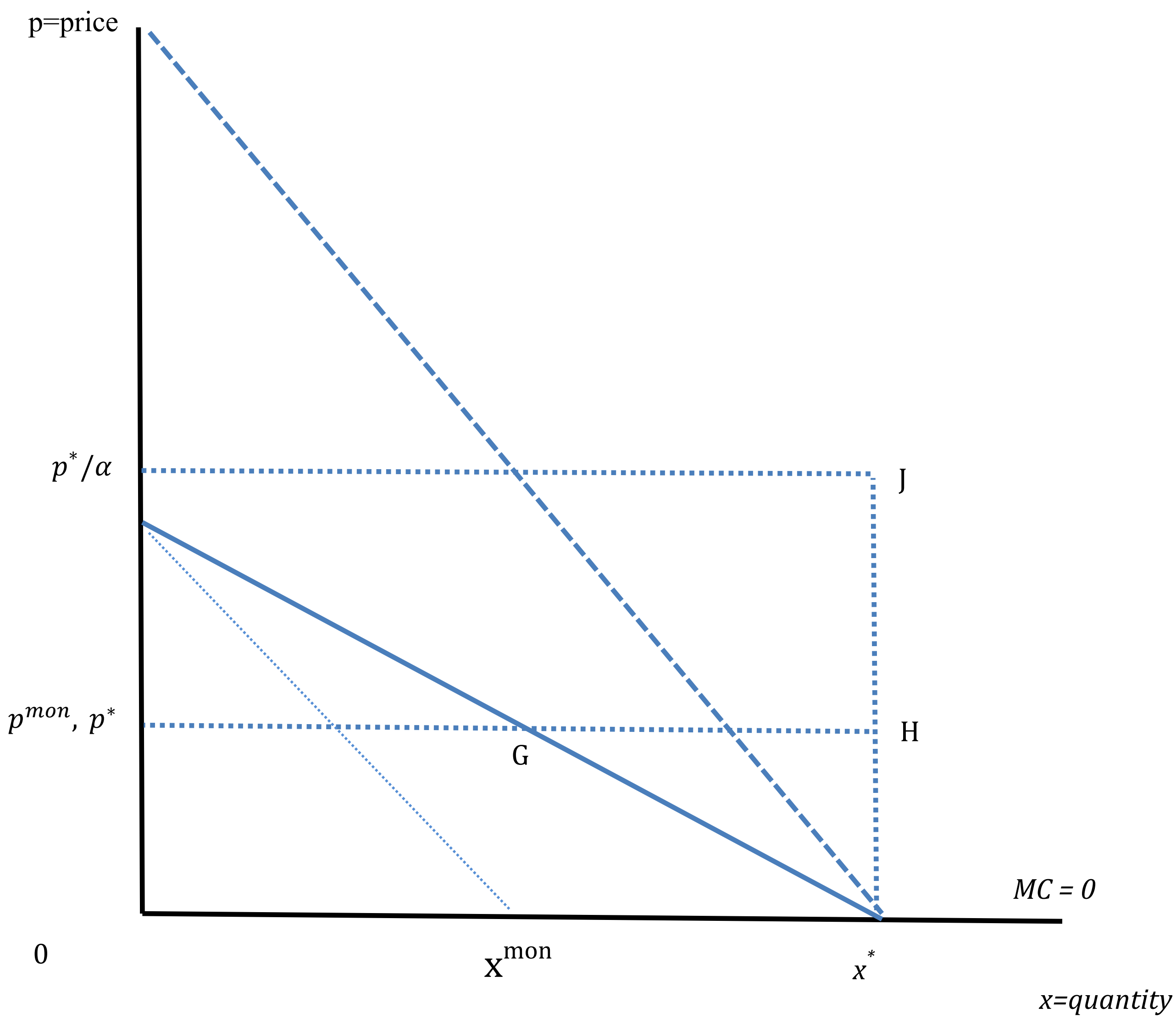


Figure 2: Price and quantity outcomes in four settings: monopoly, no insurance, partial insurance, and partial insurance with a price ceiling

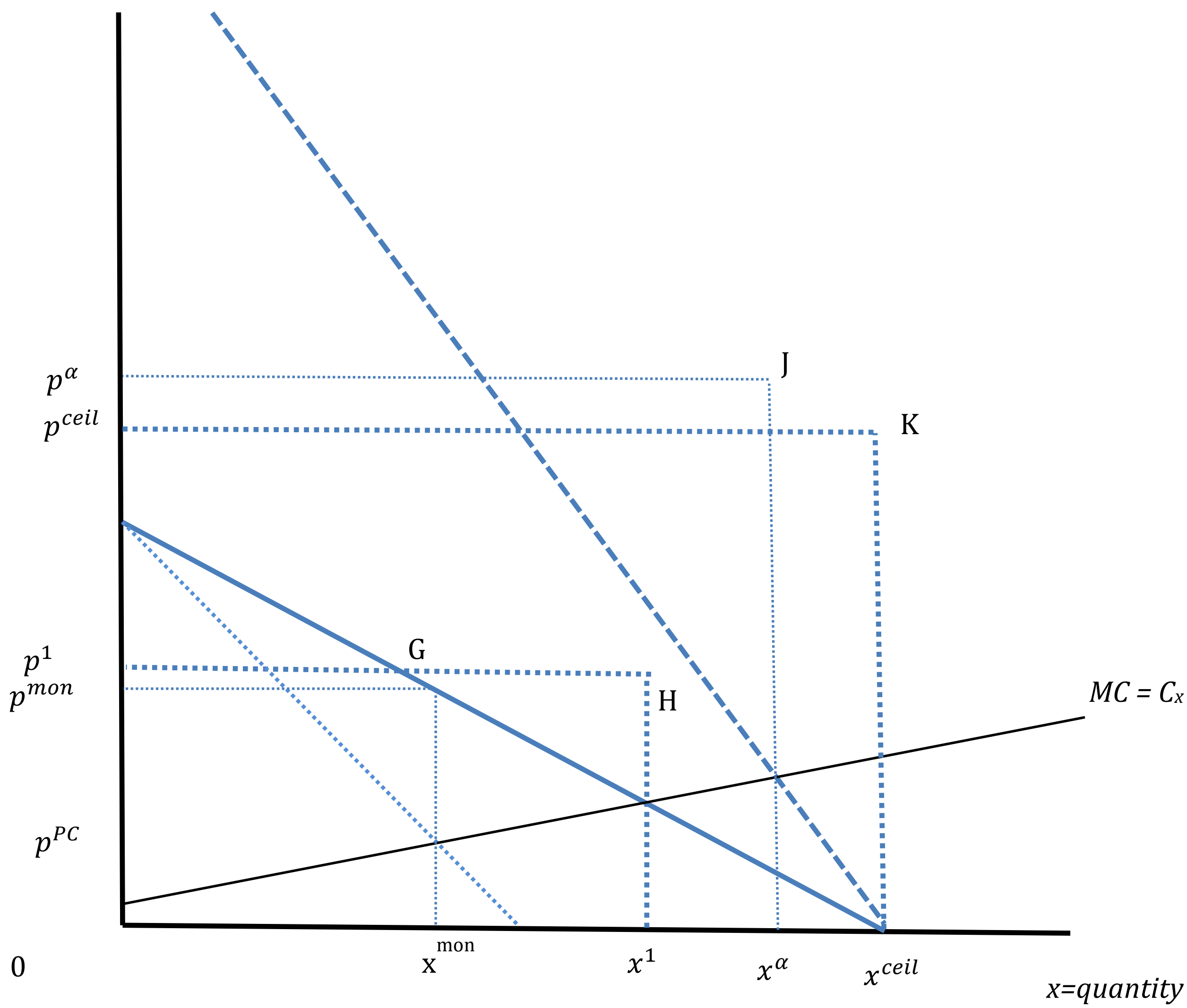
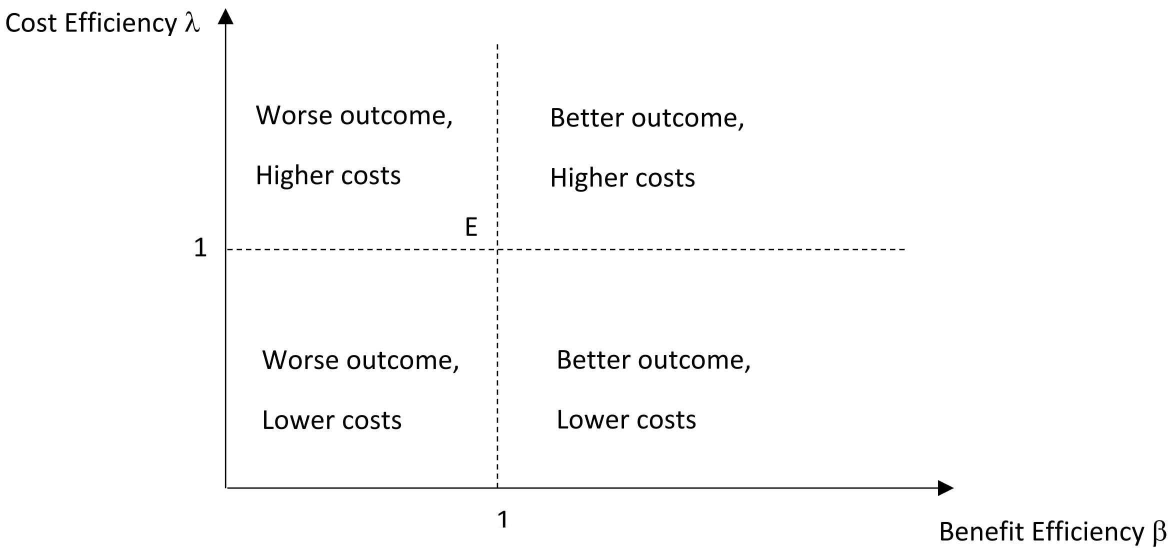
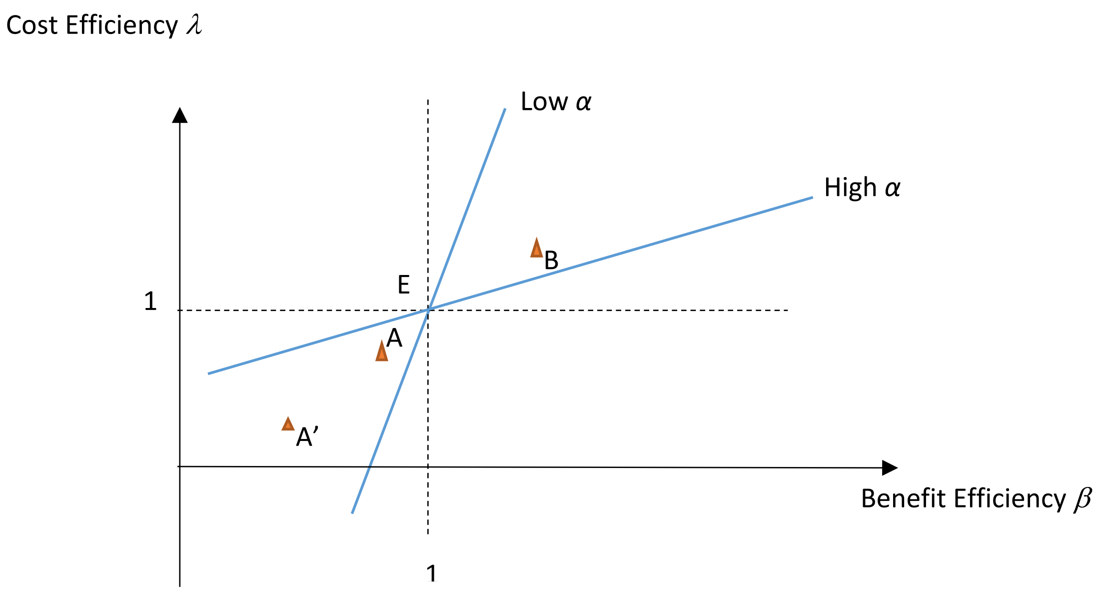


Figure 3: Efficiency relative to existing technology, E



Note: E is the cost efficiency and benefit level of the established technology.

Figure 4: Effect of insurance on innovation profitability based on iso-profitability isoquants



Notes: E is the cost efficiency and benefit level of the established technology.
With low health insurance (high α), the provider prefers point A or A' to point E, and point E to point B while with generous health insurance (low α), point B will be preferred to Point E, which is itself preferred to point A.

Figure 5

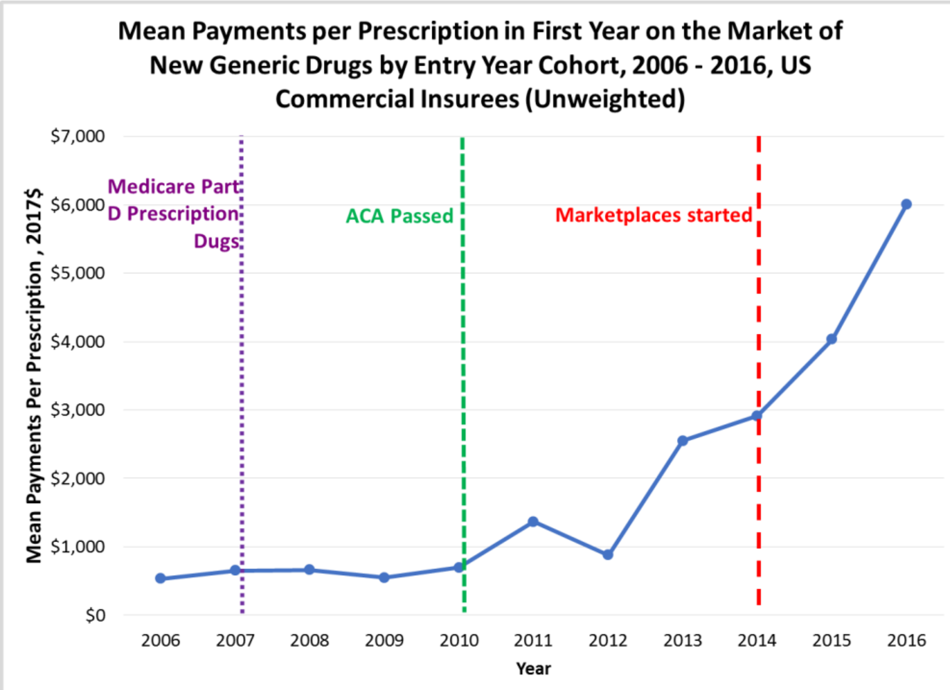


Figure 6

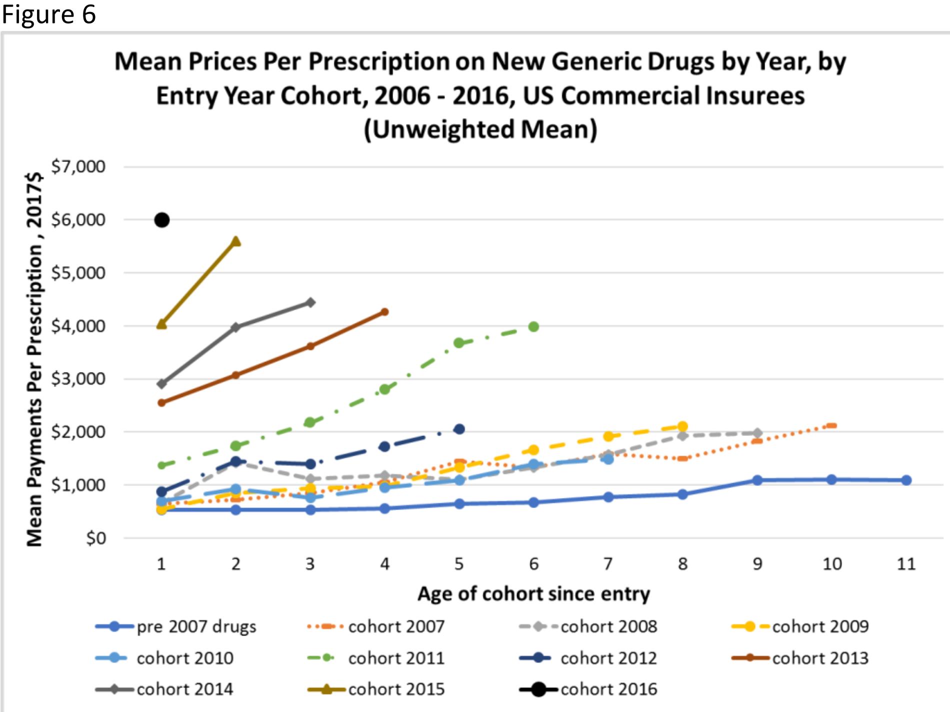


Figure 7

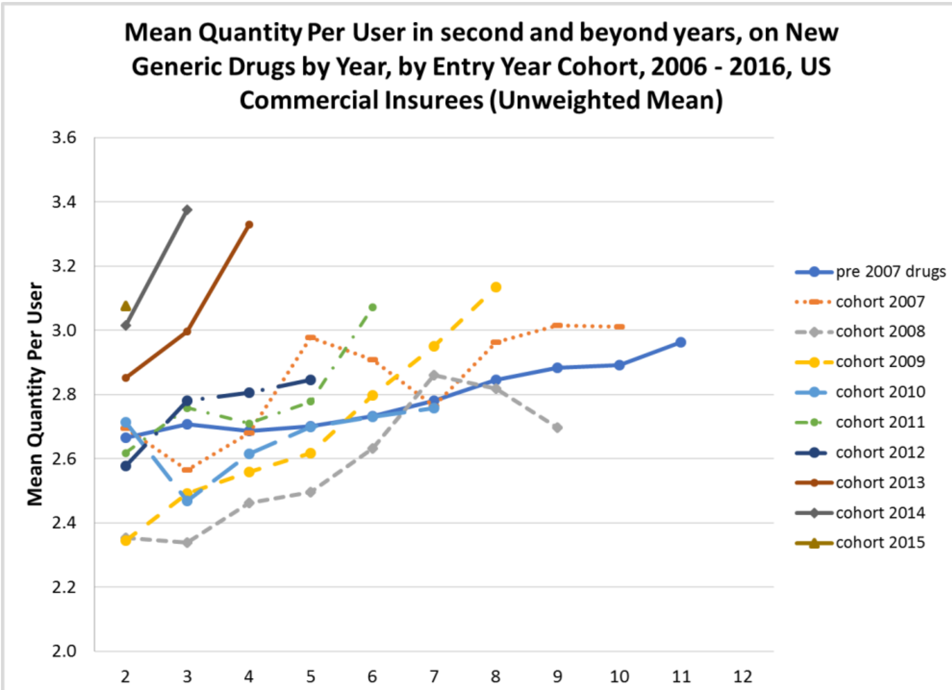


Figure 8

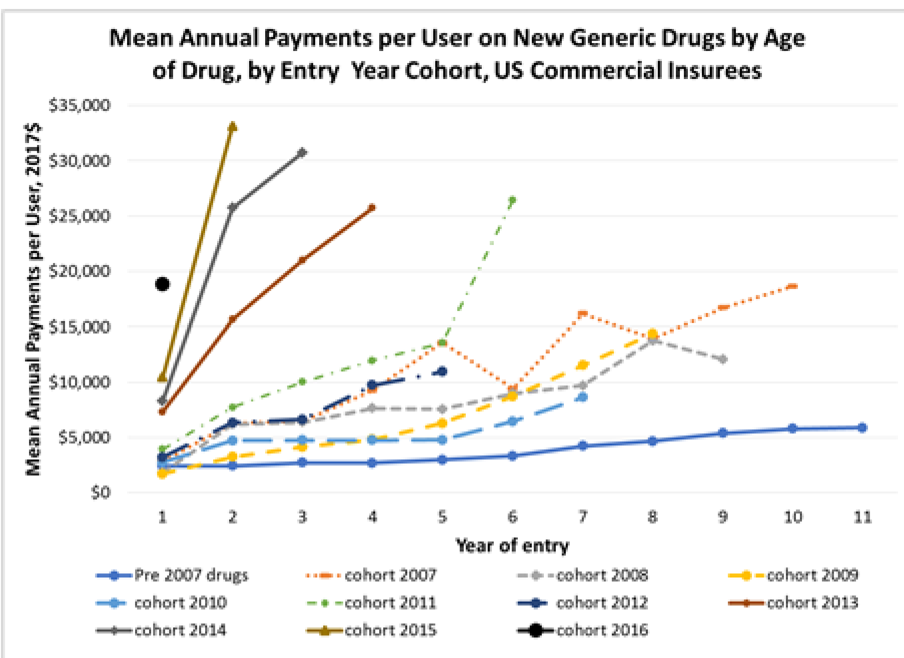


Figure 9

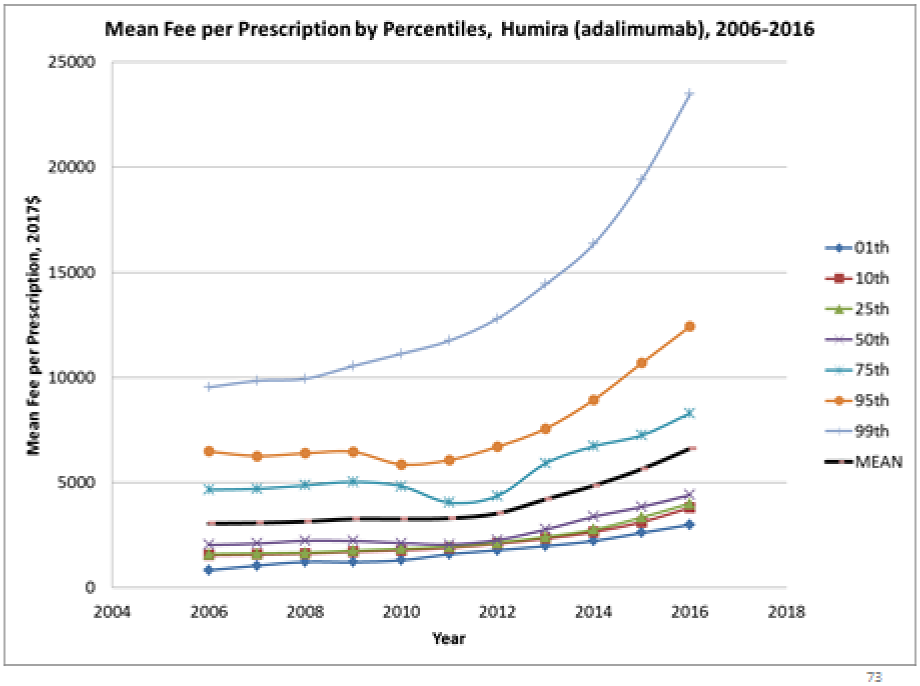


Figure 10

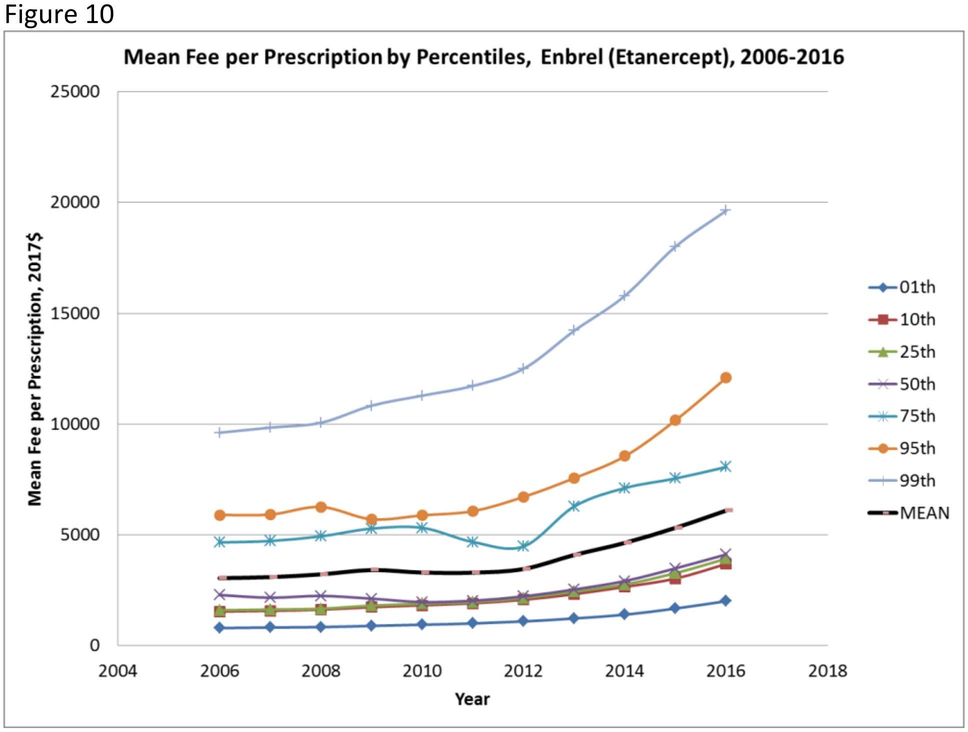


Table 1

Regressions on 34 Generic Drugs in Therapeutic Class: Immunosuppressants, NEC

Plan type	Payment (1)	Ln(payment) (2)	Ln(payment) (3)	Ln(payment) (4)
EPO	-154.584***	-0.088***	-0.018***	
	(6.324)	(0.003)	(0.003)	
HMO	-298.544***	-0.154***	-0.077***	
	(3.809)	(0.002)	(0.002)	
POS	8.832**	-0.046***	0.033***	
	(4.134)	(0.002)	(0.002)	
PPO	-116.400***	-0.085***	-0.015***	
	(3.476)	(0.002)	(0.002)	
CDHP	-2.455*	-0.044***	-0.017***	
	(3.996)	(0.002)	(0.002)	
HDHP (omitted group)	.	.	.	
Any coinsurance	-102.053***	0.012***		0.009***
	(2.791)	(0.001)		(0.001)
Copay no coinsurance	107.550***	0.096***		0.079***
	(2.057)	(0.001)		(0.001)
Deductible only	-261.178***	-0.168***		-0.146***
	(4.968)	(0.002)		(0.002)
Free (omitted group)	.	.		.
Generic drug name (34)	x	x	x	x
Age group (5)	x	x	x	x
Gender of patient (2)	x	x	x	x
Relation to Employee (4)	x	x	x	x
Region (5)	x	x	x	x
State (52)	x	x	x	x
Date year incurred (11)	x	x	x	x

Note: N=8,754,347 for all regressions

Table 2

Regressions on Drugs in Therapeutic Class: Immunosuppressants, NEC

Plan type	Payment (1)	Ln(payment) (2)	Ln(payment) (3)	Ln(payment) (4)
EPO	-135.333***	-0.074***	-0.012***	
	(6.000)	(0.002)	(0.002)	
HMO	-288.327***	-0.138***	-0.068***	
	(3.615)	(0.001)	(0.001)	
POS	26.250***	-0.022***	0.048***	
	(3.923)	(0.002)	(0.002)	
PPO	-98.658***	-0.065***	-0.003**	
	(3.298)	(0.001)	(0.001)	
CDHP	17.631***	-0.020***	0.004**	
	(3.792)	(0.002)	(0.002)	
HDHP (omitted group)	.	.	.	
Any coinsurance	-127.890***	-0.011***		-0.013***
	(2.650)	(0.001)		(0.001)
Copay no coinsurance	92.890***	0.084***		0.068***
	(1.953)	(0.001)		(0.001)
Deductible only	-234.057***	-0.132***		-0.113***
	(4.715)	(0.002)		(0.002)
Free (omitted group)	.	.		.
Generic drug name (330)	x	x	x	x
Age group (5)	x	x	x	x
Gender of patient (2)	x	x	x	x
Relation to Employee (4)	x	x	x	x
Region (5)	x	x	x	x
State (54)	x	x	x	x
Date year incurred (11)	x	x	x	x

Note: N=8,754,347 for all regressions

Appendix

French National Medical Council, FRENCH CODE OF MEDICAL ETHICS,

EDITION OF NOVEMBER 2013, p. 36. https://www.conseil-national.medecin.fr/sites/default/files/code_de_deontologie_version_anglaise.pdf

At the time of being admitted to the medical profession, I promise and swear that at all times I shall act honourably and with integrity.

My overriding concern shall be to restore, preserve or promote health in all respects, physical and mental, individual and collective.

I shall respect all people, their autonomy and their wishes and exercise no discrimination in respect of their social standing or beliefs.

I shall take action to protect them if they are weak or vulnerable or if their integrity and dignity are threatened. Even under duress, I shall not use my knowledge to violate fundamental human rights.

I shall inform my patients of the reasons and the consequences of the decisions I intend to take.

I shall never breach their trust, nor shall I use my power as a doctor to force people to act against their conscience.

I shall give care to the destitute and all those who seek my help. I shall not let myself be guided by the quest for fame or fortune.

In entering peoples' intimate sphere, I shall not divulge the secrets entrusted to me. In entering their household, I shall treat their private affairs confidentially and shall not attempt to corrupt or seduce.

I shall do everything in my power to alleviate suffering. I shall not prolong life out of obstinacy. I shall never deliberately bring about death.

I shall maintain the independence necessary to accomplish my duties. I shall undertake nothing that exceeds my competence, that I shall strive to maintain and perfect in order to more effectively render the services required of me.

I shall assist my fellow doctors and their families in adversity.

May my fellow men and fellow doctors grant me their respect if I remain true to my promises. May I be dishonoured and scorned if I transgress them

https://www.conseil-national.medecin.fr/sites/default/files/code_de_deontologie_version_anglaise.pdf

Boston University Medical School Hippocratic Oath, 2018:

I do solemnly swear by whatever I hold most sacred, that: I will be loyal to the profession of medicine and just and generous to its members; I will lead my life and practice my art in uprightness and honor; I will do no harm; Into whatever home I enter it shall be for the good of the sick and the well to the utmost of my powers; I will hold myself aloof from wrong, from corruption, and from the tempting of others to vice; I will exercise my Art solely for the cure of my patients and the prevention of disease, and will give no drugs and perform no operation for a criminal purpose, and far less suggest such a thing; Whatsoever I shall see or hear of the lives of men and women which is not fitting to be spoken, I will keep inviolably secret; These things I do promise. In proportion as I am faithful to this oath, may happiness and good repute be ever mine; the opposite if I shall be forsworn.