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A Prescription for Drug Formulary Evaluation: An Application of Price Indexes

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Abstract

Existing economic approaches to the design and evaluation of health insurance do not readily apply to coverage decisions in the multi-tiered drug formularies characterizing drug coverage in private health insurance and Medicare. This paper proposes a method for evaluating a change in the value of a formulary to covered members based on the economic theory of price indexes. A formulary is cast as a set of demand-side prices, and our measure approximates the compensation (positive or negative) that would need to be paid to consumers to accept the new set of prices. The measure also incorporates any effect of the formulary change on plan drug acquisition costs and “offset effects” on non-drug services covered by the plan. Data needed to calculate formulary value are known or can be forecast by a health plan. We illustrate the method with data from a move from a two- to a three-tier formulary.

1. Introduction

For most Americans, health insurance coverage for prescription drug costs consists of a drug formulary describing the required copayment for each covered drug.¹ Spending on drugs accounts for more than 10% of spending on personal health care in the U.S., and until very recently, was growing faster than health care spending overall.² Insurance coverage for drugs is widespread. Virtually all (98%) workers with employer-based health insurance had drug coverage (Kaiser Family Foundation, 2010), and all state Medicaid programs cover drugs. In 2006, in the “largest expansion of a benefit program since the start of Medicare itself,” the new Medicare Part D benefit made highly subsidized prescription drug coverage supplied by private insurers available to Medicare beneficiaries.³ All Part D drug plans use formularies regulated by Medicare.

Existing economic approaches to the design and evaluation of health insurance do not readily apply to coverage decisions in formularies.⁴ The choice of which drugs to cover and their associated pricing involves a number of interrelated factors. Substitutability is often very high among expensive brand-name drugs treating the same condition, and formulary managers choose only some of the available products for preferred formulary placement. For

¹Medicaid enrollees (not also eligible for Medicare) are the major group without coverage by a formulary decided by the payer, though states are free to develop “preferred drug lists” to which special restrictions apply. Federal legislation restricts the formulary strategies by Medicaid plans in exchange for favorable pricing from manufacturers (Scott Morton, 1997).

²In 2007 and 2008, growth in prescription drug spending was lower than growth in health care spending overall. See Hartman, Martin, Nuccio and Catlin (2010).

³See Duggan, Healy and Scott Morton (2008, p. 69).

example, more than 20 brands of statin drugs lower blood cholesterol levels. Three large Medicare Part D plan formularies in California offered only 3, 4 and 5 of these drugs, respectively, on the “preferred brand” tier of coverage with little overlap among the chosen brands by the three plans (Duggan, Healy, Scott Morton, 2008). Substitutability links to a second key feature feeding into formulary decisions: the price a plan pays for a branded drug can depend on formulary placement. List prices for drugs on patent are much higher than marginal cost, and drug manufacturers offer substantial rebates or discounts off list price (e.g. 30%) in exchange for the higher sales volume following from favorable formulary placement.⁵ Finally, drug coverage may affect costs of other health care services. Lower out-of-pocket drug prices encourage compliance with drug therapy, which may reduce hospital or other health care costs, referred to as “offset effects” of drug coverage (Chandra, Gruber and McKnight (2010), Gaynor, Li, and Vogt (2007), Shang and Goldman (2007)).

This paper proposes and applies a new approach to economic evaluation of a change in formulary coverage. We assess the benefits to the members of the plan by estimating how much members would be willing to pay (or have to be compensated) for a formulary change. This dollar value can then be compared to the incremental insurance premium required to pay for the formulary to compute a net value to the plan members. The method can be used to assess the addition of a single or set of drugs to a formulary, or to a comprehensive change in formulary design that alters many prices paid by enrollees. The computation of net value can be done for subgroups within a plan. Our method regards a formulary as a vector of prices for products enrollees purchase. We apply price index theory to evaluate welfare at the alternative price vector – the new formulary.

Section 2 contains some background about drug formularies, and some discussion of the small economics literature bearing on formulary design. This section also makes the distinction between the social value of formulary pricing and the private value to plan members. Section 3 first considers the case of a single drug added to a formulary to illustrate the main ideas, and then applies the theory of price indexes to a formulary to derive a general rule. Our approach incorporates in a natural way any “offset effects” on other covered services in the health plan. In Section 4, we illustrate our method by valuing the formulary change for a subset of the elderly retirees receiving drug coverage from their former employer studied previously by Huskamp and colleagues (Huskamp et al., 2007). Section 5 relates our approach to formulary evaluation to existing approaches based on the cost-effectiveness of drugs. We also discuss limitations of the method and other possible areas of application.

2. Background

2.1 Formulary Tiers, Demand and Supply Prices

The typical drug formulary specifies three tiers of pricing to plan members. Generic drugs (no longer under patent and produced by multiple manufacturers) are on tier 1 and require the lowest copayment. Generics are inexpensive to the plan and are almost always included in coverage. The plan-designated “preferred brands,” still under patent, are on tier 2 and

⁴The central issue addressed in the literature on optimal health insurance is the tradeoff between risk spreading and inefficiency in consumption (Zeckhauser, 1970). Approaches to optimal insurance with multiple goods (Goldman and Philipson, 2007; Ellis and Manning, 2007) capture this tradeoff but the frameworks cannot readily be extended to the many products involved in a drug formulary. Papers on network design are more in the spirit of formulary decisions. Network design can be described in the abstract but the methods are difficult to apply in practice. The perspective of “value-based insurance design” has also been applied to drug coverage. See Chernew, Rosen and Fendrick (2007). Pauly (2010), discussed briefly below, is the closest paper we know of applying the conventional framework to drug insurance. McGuire (2011) contains a recent review of the normative literature on health insurance design.

⁵Berndt, McGuire and Newhouse (2011) link formulary placement to plan acquisition costs within an economic model of imperfect competition among brand drug manufacturers.

require a higher copayment. “Non-preferred brands,” also patent-protected, are placed on tier 3 and require the highest copayment. In 2010, demand (or out-of-pocket) prices averaged \$11 for tier 1 drugs, \$28 for tier 2 drugs, and \$49 for tier 3 drugs.⁶ Some drugs are not included on the formulary, and for these the plan member would have to pay full retail price.

Health plans decide tier placement for branded drugs based on criteria of effectiveness and acquisition costs. The tiered formulary design can move plan members to drugs that are cheaper for the plan when there are multiple therapeutically similar drugs available. Decisions about tier placement translate to sales volume for a manufacturer. By negotiating tier placement along with acquisition price, a plan can often obtain sizeable price discounts and rebates against drug list prices.⁷

Selection incentives may also influence plan formulary decisions. Patterns of drug use make drug coverage an attractive tool for selection by plans. Many prescription drugs are used to treat chronic conditions, with patients on some medications indefinitely. An individual can foresee drugs they are likely to use from one year to the next. In selecting a plan, beneficiaries will consider coverage of medications they take on a regular basis, something a plan may in turn consider when designing a formulary. “Predictability” of a health care service is one of the factors contributing to making coverage a selection device. Another is the correlation with total health care costs, or “predictiveness” (Ellis and McGuire, 2007). Empirical studies confirm that prescription drug use is both positively correlated with total spending and predictable for a given individual over time (e.g., Ellis 1985; Pauly and Zeng 2003; Wrobel et al. 2003). For health plans that cover both prescription drugs and non-drug medical services, “predictiveness” may be an important factor driving selection behavior on the part of the plan. In contrast, stand-alone drug plans (such as those offered to beneficiaries opting for traditional Medicare under Medicare Part D) have no incentive to consider the correlation between prescription drug use and total health care spending. To effect favorable selection, a plan could exclude or place on a non-preferred tier expensive brand drugs or drugs that are used by high-cost patients.

Several demand and supply prices feed into the economic evaluation of formulary decisions. First, there is the full retail price of the drug, the price the consumer would have to pay if he/she purchased the drug independently. Second is the acquisition cost at which the health plan purchases the drug, including any rebates paid by the manufacturer. Finally, there is the out-of-pocket price that the plan sets for the enrollee, which varies by tier. This price could be in the form of a copayment (a flat amount) or coinsurance (a percentage of the plan’s acquisition cost for the drug).

2.2 Normative Economics of Formulary Design

The standard normative paradigm for health insurance coverage is based on a tradeoff between risk spreading (more coverage reduces risk) and appropriate incentives (more coverage increases moral hazard inefficiencies). Although many papers study demand response to drug coverage (e.g., Huskamp et al., 2007; Pauly, 2004), Pauly’s (2010) recent survey is the only paper we know of to apply conventional insurance theory to drug coverage. Consistent with the theory, emergence of drug insurance has appeared in response

⁶See KFF (2010). 78% of employees have formularies with three or more tiers. For average tier pricing, see page 176.

⁷Huskamp, Epstein and Blumenthal (2003) found that when the Veterans’ Administration implemented a national closed formulary, per pill acquisition prices fell between 13 and 36% for some chronic conditions. This study has the advantage of observing actual transaction prices. In many contexts, drug rebates to plans or PBMs are not observed. See also Frank (2001), and Huskamp, Deverka, Epstein et al. (2003, p 2225), Huskamp et al., (2005), and Grabowski and Mullins (1997, p. 535). As Duggan and Scott Morton (2010) put it, “When bargaining with the seller of a patented product, the ability to shift demand to a substitute drug is a powerful negotiating tool.” For an economic model of health plan acquisition costs and the role of formularies, see Berndt, McGuire and Newhouse (2011).

to the financial risk imposed by more use of drugs and higher costs. Cost sharing certainly plays a role in drug insurance, but beyond this, in our view, the conventional approach has limited applicability. There are no studies finding, for example, that demand-side cost sharing and tier placement are driven by demand elasticity.⁸

Other normative frameworks, de-emphasizing risk protection and focusing on incentives and acquisition cost, have been applied to formularies. Olmstead and Zeckhauser (1999) cast the formulary as a “menu-setting problem” in which the health plan decides on which drugs to include and at what prices to maximize average welfare of enrollees subject to a formulary budget. They emphasize that the plan cannot assign drugs to persons but must rely on consumers’ decisions in their own interests. With patient heterogeneity, they show that in general any set of coverage prices will not lead to optimal sorting – a plan must solve a complicated programming problem to choose the drugs and coverage prices that attain the highest expected utility. The connection between formulary coverage and procurement price is not part of their analysis.⁹ Furthermore, the integer programming solution to the menu-setting problem defies easy solution.

Formularies are a form of selective contracting used by managed care plans in contracting with preferred networks of doctors, hospitals, and other suppliers. Selective contracting is a useful tool for a payer (Morrissey, 2008), but characterizing the “optimal network” within a normative analysis is also a complex problem that has not yielded a general, operational solution (McGuire, 2011).

The literature on the “offset effect” of drug coverage, referring to how more (and more clinically appropriate) use of drugs might offset other health care costs (see, e.g., Chandra, Gruber and McKnight, 2010), has implications for drug health insurance design. This perspective implies that the demand-reducing effects of high tier prices should be avoided in formulary pricing for drugs where offsets are likely. Formally, cost offsets could be modeled as a case of insuring products which are substitutes in demand (Goldman and Philipson, 2007). A related literature starts from the observation that many patients may undervalue the benefits of prescription drugs, and the insurance subsidy is a means for correcting underconsumption (Chernew, Rosen and Fendrick, 2007).

In a recent paper, Granlund (2011) uses the concept of “equivalent variation” (EV) to evaluate the welfare effects of a reform to drug pricing in Sweden that encouraged use of generics and increased substitutability between brands and generics. The EV measures the income necessary (at the old prices) to provide consumers with the same benefit as the reform. Following Hausman (1981), Granlund estimates the price and income elasticities necessary to compute EV. An advantage of this approach is that it allows a calculation of welfare beyond the simple price reductions achieved by the reform. Granlund’s method, based on consumer theory, is closely related to what we propose here. As we explain below, to ease application, we simplify demands on econometric estimation, and, to capture an

⁸Even though tier 1 (generic drugs) have the lowest cost sharing, in an economic sense their insurance coverage is less since at a \$5 or \$10 copay, the consumer pays a price equal to or even exceeding the plan’s acquisition cost. Generic coverage is one example of a poor fit with conventional theory.

⁹Some other papers stress this connection. Scott Morton (1997) contains a theoretical and empirical analysis of the role of government regulation of prices Medicaid plans pay for drugs on overall drug prices. Medicaid plans benefit from a “most favored nation” clause that inhibits price cuts to other buyers, such as private managed care. Garcia-Alonso and Garcia-Marinoso (2008) model the interaction between a government agency setting a coverage decisions for a formulary based on cost-effectiveness criteria and a monopoly manufacturer. Various outcomes are possible in their analysis according to the order of moves in the game they set up. Duggan and Scott Morton (2010) is an empirical analysis of national average prices for drugs that shows that the more important is Medicare Part D plans in overall demand, the lower is the average price. They attribute this to the greater bargaining power of the Part D plans in comparison to other buyers.

important element of formulary design choice, incorporate the welfare effects of acquisition price changes.

Frakt, Pizer and Feldman (2011) apply consumer theory in a different fashion to evaluate a formulary, estimating utility and dollar valuation of formulary options by Medicare beneficiaries implied from the choices they make in Medicare Part D. In principle, econometric estimates of willingness to pay for benefit design combinations in a formulary would directly assess value to consumers. In practice though, it is only possible to include very aggregated formulary characteristics (e.g., mean OOP covered).¹⁰ Inferences about consumer valuation of free-standing plans in Part D can thus not be used to assess detailed decisions about tier structure and drug placement.

The literature from the pharmacy benefit management field emphasizes practical rules-of-thumb for assessing formulary performance. From the perspective of a pharmacy benefits manager (PBM), formulary performance can be judged by the extent to which the formulary minimizes prescription drug spending by the plan, which can be achieved through a variety of strategies including encouraging use of generic drugs when available, encouraging use of preferred brands rather than non-preferred brands, maximizing volume-based rebates from manufacturers, and increasing use of mail order (vs. retail) dispensing.¹¹ For example, Roebuck and Liberman (2009), employees of a large PBM, propose the share of prescriptions dispensed as generics (“generic dispensing rate”) and share dispensed by mail-order (“mail-order dispensing rate”) as indicators of formulary performance. The share is an imperfect measure of performance, because a cost-conscious PBM would obviously not be indifferent between two formularies, one with high and one with low costs, but with the same share of generic prescriptions. PBMs use financial incentives for enrollees to encourage use of lower cost medications (e.g., lower copayments for generics and preferred brands, lower copayments for prescriptions filled through mail order programs vs. retail outlets). PBMs often also communicate directly with physicians and patients to influence prescribing behavior. When Zocor (the second-largest selling statin) went generic (simvastatin) in the U.S. in June 2006, health plans aggressively and successfully encouraged physicians and patients to switch from Lipitor (still branded) to simvastatin (Aitken, Berndt and Cutler, 2009). Also, because a PBM may be able to negotiate larger manufacturer rebates for a given drug if the PBM includes few or no therapeutic substitutes for that drug on the preferred tier of the formulary (thus guaranteeing the manufacturer greater sales volume), PBMs have an incentive to list fewer brand drugs in each class on tier 2. Mullins, Palumbo and Saba (2007) develop and apply a “preferred placement index” that measures the share of branded drugs resting on the second (preferred) tier without quantity restrictions. This measure suffers from the same limitation as the other “share” measure mentioned earlier.

2.3 Social Value of Drug Coverage

The social value of the benefits and costs of drug coverage is distinct from the value to plan enrollees, and the best formulary design from a social perspective is different than the best design from the standpoint of the health plan. The cost to a plan of buying a drug is the price set by the manufacturer, whereas the social marginal cost for a branded drug is typically much less. According to Berndt (2002, p.56), the marginal cost of producing an extra capsule or tablet is “nickels, not dollars.” Reducing the price of drugs to patients through

¹⁰See Frakt, Pizer, Frakt (2011), Table II, where they could include just five variables (in addition to the premium) to characterize a formulary. The purpose of their paper is to do a high-level comparison of beneficiary utility in Part D plans against the more restricted formulary used by the Veterans’ Administration. The authors conclude that the additional discounts available to the VA more than make up the loss of utility from fewer drug choices being available.

¹¹Mail-order programs can save dispensing fees for the plan as well as be more convenient for consumers.

insurance therefore tends to move the demand price *towards* marginal cost of production rather than *away from* marginal cost as is typical in health insurance. In other words, rather than creating a moral hazard problem, drug insurance counteracts a monopoly price markup.¹² Health plans, concerned with their private costs, not (the lower) social costs, will therefore tend to offer less drug coverage than is socially optimal.

The full and long-run costs of drugs include research and development. Lakdawalla and Sood (2009) point out that by introducing a wedge between supply and demand prices, coverage leaves supply prices high while reducing demand prices to nearer marginal cost. Plan and social interests, however, diverge here as well. The plan rationally disregards any social benefit from encouraging research and development and seeks as low a procurement price as possible.

Finally, social and private interests diverge with respect to inclusion of drugs on a formulary. A plan gains by leaving a drug off a formulary in order to obtain bargaining power in relation to manufacturers. Lower acquisition prices transfer rents away from manufacturers but are not social savings. The rationale for a formulary is thus a private, not a social, one. All drugs belong on the “socially optimal” formulary. This paper adopts perspective of an integrated health plan (paying for all medical services) in which selective contracting and formulary assignment can increase welfare of plan members.

3. Value and Net Value of a Formulary to Plan Members

3.1 Welfare Framework

We assume consumers evaluate the benefits of health care (drugs and other services covered in the plan) and decide on consumption to maximize utility at prices they face. Alternatively, the “demand” decisions studied here could be regarded as emerging from physician authorization for treatment made in the interest of the patient. Interpreting demand as willingness to pay allows us to figure the premium plan members would be willing to pay for coverage (or changes in coverage) at the prices set in the formulary. This is the value of a formulary to plan members within our framework. We compare consumers’ valuation of a formulary with the incremental premium that would be required to pay for the formulary change. The “net value” of a formulary is then defined as the difference between plan members’ valuation and the incremental premium. Our approach incorporates key features of drug coverage, including multiple price movements (possibly in different directions), demand response, cross-price effects including offsets on other services, and the effect of formulary placement on acquisition prices. The building blocks of value and net value are observable prices and quantities. We conduct the theoretical analysis for a representative plan member.

3.2 Single Drug with Independent Demand

Suppose a plan considers the addition of drug 1 to its formulary, and the demand for this drug is independent of demands for other drugs and other covered services in the plan.¹³ Figure 1 displays demand for drug 1 and the three relevant prices: full or list price, l^1 ; plan discount price, d^1 ; and tier demand price, p^1 . Placement of drug 1 on the formulary reduces the price paid by consumers from l^1 to p^1 , increasing quantity demanded from $q^1(l^1)$ to

¹²Olmstead and Zeckhauser (1999, p.526) observed that formulary coverage can lead to pricing nearer marginal cost of production and attributed the point to a personal communication with Joseph Newhouse. For an earlier paper making a related point, see Crew (1969).

¹³In demand theory no good can be independent of all others because of the budget constraint. (If spending on this good changes, something else has to change.) In the case of a health plan, the premium can change to cover the new plan costs of this service so it is possible for demand for one covered service to be independent of demand of all other covered services in the health plan.

$q^1(p^1)$. We measure the value to the representative plan member of adding drug 1 to the formulary, by the following function:

$$V(l^1, p^1) = (l^1 - p^1) \frac{[q^1(p^1) + q^1(l^1)]}{2} \quad (1)$$

How much income could we take away from a consumer and leave him just as well off with price p^1 as he was with price l^1 ? As we discuss more thoroughly in Appendix A, our proposed value function in (1) closely approximates the answer. Two points are worth mentioning here. First, as Figure 1 shows, our proposed value function $V(l^1, p^1)$ is a linear approximation of the change in the consumer's surplus as a result of the price change of drug 1 from l^1 to p^1 ¹⁴

Second, our proposed value measure weights a price change by the average of the old and new quantity. Taking away income equal to $q^1(l^1)(l^1 - p^1)$ would leave the consumer just able to buy the old quantity at the new price. This weighting of the price change by the original quantity (as is done in the Laspeyre's price index) understates what could be taken away because the consumer will change quantities at the new price (and thereby make himself better off). Alternatively weighting the price change by the new quantity (as is done in the Paasche price index), $q^1(p^1)$, yields the measure of how much income could be taken away as $q^1(p^1)(l^1 - p^1)$. This measure is too great because the consumer would not have purchased $q^1(p^1)$ at the old price. Therefore, the "right" measure of value is somewhere between these two levels of compensation. Our measure, $V(l^1, p^1)$, averages the two.

We now move from value to net value of a formulary change. With the assumption that the demand for drug 1 is independent of the demand for all other drugs and services covered by the plan, the addition of drug 1 to the formulary only affects costs for drug 1. The incremental insurance premium, R , needed to pay for this addition is:

$$R(d^1, p^1) = (d^1 - p^1)q^1(p^1) \quad (2)$$

The net value of adding drug 1 to the formulary, denoted by $NV(l^1, d^1, p^1)$, is simply the difference between value $V(l^1, p^1)$ and the incremental premium $R(d^1, p^1)$:

$$NV(l^1, d^1, p^1) = V(l^1, p^1) - R(d^1, p^1) \quad (3)$$

The net value function above can be useful in several ways. Given a triple of prices (l^1, d^1, p^1) , the net value function tells us whether the addition of drug 1 to the formulary is beneficial to the consumer (when $NV(l^1, d^1, p^1) > 0$). Alternatively, the net value function tells us, from the standpoint of increasing welfare of plan members, the highest (discounted) price the plan should be willing to pay for the drug, d^1 , given the drug's list price, l^1 , and the copay price, p^1 (the d^1 that equalizes net value to zero).

In the simple case just presented, the price of only one drug changed, demand for this drug was independent of other drugs and services in the plan, and the acquisition price did not depend on formulary placement. In the next section we relax all of these assumptions to construct general expressions for value and net value of a formulary change.

¹⁴When the demand curve is linear, the V function is exactly consumer surplus, but consumer surplus itself is an approximation to the change in income needed to keep the consumer indifferent.

3.3 Multiple Drugs and Services

From the consumer's point of view, a formulary change moves prices up or down. Hence, the value to the consumer of a price change for a set of drugs is, in fact, similar to the question of how much would a consumer need to be compensated (or how much he would be willing to pay) as a result of price changes for a set of products. The answer to this question has been extensively studied in the context of "price indexes" or "index numbers" (see, for example, Hausman (2003) and Diewert (1998)). As this literature has demonstrated, the exact answer is easy to state theoretically but hard to observe empirically.¹⁵ However, this literature has also demonstrated that some very good approximations to the exact answer can be easily calculated on the basis of data that are readily available. In what follows we present a simple model, very much in the spirit of the price index literature, to assess willingness to pay for changes in the out-of-pocket prices represented by a formulary change.

Assume a representative plan member uses n services (e.g., drugs, hospital days, physician visits), indexed by i , $i = 1, \dots, n$. Assume that there are two periods, 0 and 1, and let p_t , $t = 0, 1$, be a vector with n elements $p_t = (p_t^1, \dots, p_t^i, \dots, p_t^n)$ denoting the out-of-pocket (OOP) prices paid by the consumer for services $1, \dots, n$, respectively in period t .¹⁶ Let $q(p_t) = q^1(p_t), \dots, q^n(p_t)$ denote the quantities of services $1, \dots, n$ demanded by the consumer when the price vector he faces is p_t . Assume all quantities used are strictly positive at the two price vectors.¹⁷

What is the maximum the consumer would be willing to pay (or the minimum compensation necessary) for the price change p_0 to p_1 ? As shown in Appendix A, the following value function, based on observable p 's and q 's, approximates the maximum amount that the consumer would be willing to pay for the prices to change from p_0 to p_1 :

$$V(p_0, p_1) = \frac{\sum_{i=1, \dots, n} (p_0^i - p_1^i)(q^i(p_1) + q^i(p_0))}{2} \quad (4)$$

Expression (4) is the multiple-good counterpart to (1) and equal to the arithmetic mean of

the Laspeyres' index, $\sum_{i=1, \dots, n} q^i(p_0^i)(p_1^i - p_0^i)$, that weights the price change by original quantities, and the Paasche index, $\sum_{i=1, \dots, n} q^i(p_1^i)(p_1^i - p_0^i)$, that weights by new quantities. As noted in the one-good case, these measures under and overstate the compensation necessary, respectively. In consequence, the average of the two is a workable measure of consumer welfare change.¹⁸

Note that any service i with $p_0^i = p_1^i$ has no effect on the value measure in (4). Cross effects of formulary price changes on other covered services (e.g., "offsets" on hospital care) do,

¹⁵Exact answers require data from hypothetical willingness-to-pay questions or on Hicksian demand functions (which are not found in nature).

¹⁶The subscript t need not be interpreted just as "time." In most applications it will characterize alternative formulary designs considered by plan.

¹⁷No one consumer would use all services, but the representative consumer does.

¹⁸See, for example, Hausman (2003) and Diewert (1998). The geometric mean of the two indexes is referred to as the "ideal" price index. The difference between this and the arithmetic mean is very small in practice (Hausman, 2003). We propose the arithmetic mean for its simplicity and the easy analogy to consumer surplus in the linear demand case shown in the single-drug section above. Use of the arithmetic mean of the pre and post quantities in price indexes dates back to Edgeworth and Marshall. See Diewert (1988) for an historical review.

however, figure into the analysis through the other component of net value – the incremental premium change associated with the formulary change – which we turn to next.

To assess the incremental premium associated with the formulary price change, we need to incorporate acquisition prices. Let $d_t = (d_t^1, \dots, d_t^n)$ be a vector of the (possibly) discounted prices the plan pays for drugs and other covered services $1, \dots, n$. (In the notation here we treat all acquisition prices as “discounted” even though some of these might simply be the “list price” referred to above.) The t subscript allows discounts to depend on formulary placement. The incremental insurance premium, R , required to pay for the change in the prices between period 0 and period 1 is, therefore:

$$R(d_1, p_1, d_0, p_0) = \sum_{i=1, \dots, n} (d_1^i - p_1^i) q^i(p_1) - (d_0^i - p_0^i) q^i(p_0) \quad (5)$$

The incremental premium (5) depends on acquisition prices, d , copayments, p , for all drugs, and all other covered services in both periods. The expression captures two important features of drug formulary purchasing. First, acquisition prices may depend on formulary assignment. The incremental premium (5) allows for $d_0^i \neq d_1^i$ for any drug or service. Generally, favorable formulary assignment is associated with weakly lower acquisition prices.¹⁹ Second, (5) incorporates offset effects. Suppose a move from formulary 0 to formulary 1 improves drug coverage and the resulting higher use of drugs reduces utilization of service number 13, hospital care, so $q^{13}(p_0) > q^{13}(p_1)$. Suppose also that acquisition prices and coverage for hospital care do not change between periods 0 and 1. Expression (5) incorporates the offset effect on the incremental premium as $[q^{13}(p_1) - q^{13}(p_0)][d^{13} - p^{13}]$, the savings in the *plan paid* portion of hospital costs.²⁰

The net value of changing the prices from p_0 to p_1 is simply the difference:

$$NV(p_0, d_0, p_1, d_1) = \frac{\sum_{i=1, \dots, n} (p_0^i - p_1^i)(q^i(p_1) + q^i(p_0))}{2} - \left[\sum_{i=1, \dots, n} (d_1^i - p_1^i) q^i(p_1) - (d_0^i - p_0^i) q^i(p_0) \right] \quad (6)$$

4. An Application: Value of a Move from a Two to a Three-Tier Formulary

Expression (6) depends on prices and quantities a health plan knows (or might reasonably anticipate). The pieces contributing to value, the benefits to the enrollees, we observe in our data of health care claims, but we do not observe actual plan payments to manufacturers that include discounts, rebates and other incentives. The plan of course would know these and could implement the full measure. In our case study, we focus only on the value part (expression (4)) where the ideas we draw from price indices apply. We show how our proposed measure of value can be assessed for an actual formulary design change.

4.1 The Setting

Huskamp et al. (2007) report on the effects of moving from a two-tier formulary (generic and brand) to a three-tier formulary (distinguishing preferred and non-preferred brands),

¹⁹A formulary is thus an example of a “two-sided market” in which the pricing on one side depends on the pricing and demand on the other (Rysman, 2009).

²⁰Intuitively, plan costs (not total costs) are the right measure because consumers value the services being offset, and a measure of this is the OOP they are paying. Glazer and McGuire (2010) discusses how to measure of offset effects in insurance design, developing the argument for why offset effects should be measured in terms of plan costs, not total costs.

which involved changes in copayments within tiers as well. The population was elderly retirees (prior to Medicare Part D drug coverage) of employers whose drug benefits were managed by a large pharmacy benefit management firm. The move to a three-tier formulary increased prices for branded drugs, particularly those assigned to the new third tier of non-preferred brands. The original article reports that plan costs fell, enrollee cost sharing increased, and medication continuation fell slightly for the seven studied classes of drugs used to treat chronic illnesses. In the current paper, we use pre-post data from the largest of the four employee groups from Huskamp et al.²¹ To separate formulary effects from time trends, we designate two of the other employee groups, which maintained a two-tiered formulary and made no other notable changes to formulary design during the period, as comparison plans.²² This difference-in-difference strategy is similar to that employed in the original article. The same PBM administered the formulary for all groups in the data. To increase the comparability between the intervention and control group, we evaluate the change for a selected group of enrollees, those who took at least one drug among the class of drugs for cardiac problems in the pre period.²³ We refer to this as the cardiac group, and examine spending for all medications (not just cardiac medications) used by these individuals.

Our study population is drawn from 47,108 retirees 65 years and older who were continuously eligible for coverage from a state government, their former employer, over the period July 1999 through December 2002. A total of 14,835 of these were in our cardiac group and for whom we value the change in formulary design. Enrollees in this plan could choose to fill their prescriptions at a retail pharmacy (30 or fewer day supply) or through a mail order pharmacy (90-day supply).

In February 2001, the employer increased copayments for drugs as described in Table 1. Only copayments for generic drugs filled at a retail pharmacy were unchanged. Copayments for branded drugs filled at a retail pharmacy that remained on tier 2 increased from \$10 to \$15, and for those that moved to the new tier 3, to \$30. Brand drugs filled through a mail order program experienced the largest copayment increases, from \$5 to \$25 for those remaining on tier 2 and to \$45 for those on the new tier 3. Copayments for generics filled through a mail order pharmacy increased from \$5 to \$10. (Mail-order prescriptions are generally for larger number of pills than prescriptions filled at retail pharmacies (e.g., 90 vs. 30). We define the pre period to be calendar year 2000, and the post period to be calendar year 2002.

4.2 Results

Table 2 contains results for all drugs segmented by tiers in the same manner as Table 1. Initial quantities (prescriptions) are reported for the pre period, and the d-in-d estimate of quantity is listed in the post-period. For example, for tier 1 retail, the d-in-d estimate was derived by comparing the percentage change in number of prescriptions for generic drugs in the intervention plan to the percent change in the comparison plans. In all plans, generics rose more than 5% over this period, but the d-in-d returns an estimate of +5.4% for the change in generics at retail due to the formulary price increases for the branded products in the intervention plan. All branded drugs were subject to a copayment increase as the result of the formulary change, and all groups of branded drugs experienced an estimated decrease

²¹This is "Plan B" from Huskamp et al. (2007). See their Table 1 for more descriptive information about the sample. Our comparison group consists of Plans E and F from the paper.

²²In addition for adjusting for time trends as is common in a difference-in-difference analysis, the comparison group is necessary here because some drugs go off patent over this period, shifting tiers and changing quantities in each tier.

²³We consider drugs in the following classes to be cardiac drugs: angiotensin-converting enzyme inhibitors (ACEs), angiotensin-receptor blockers (ARBs), calcium-channel blockers (CCBs), and statins.

in demand. Drugs were classified according to their tier assignment in the post period in the intervention plan. Quantity reductions on the retail side were relatively small, but much larger for mail order prescriptions, where copayments were raised more. The original (pre) quantities plus the d-in-d estimates yield the post quantities (not shown), so that we have the full set of pre/post prices and quantities that feed into expression (4).

Applying (4), the change in value from the three compared to the two-tier formulary is – \$155.83 per member of the cardiac group. The interpretation: after engaging in whatever pattern of substitution they choose (generics-for-brands, among brands, or retail-for-mail-order, etc.), \$155.83 is the loss in welfare due to the formulary change for the representative member of the cardiac group. Note that the effect of the formulary would be different for other groups of enrollees, and it does not include any change in the insurance premium for this group (and so is not net value).

The formulary change saved money for the plan, though we do not observe actual plan payments net of rebates in claims data and cannot calculate these savings. Overall, assuming the savings are passed on in premium reductions, a group like the cardiac group, with relatively heavy use of drugs, would probably find that premium savings would not compensate for the loss in value. Other groups in the plan, making less heavy use of the pharmacy benefit, are more likely to find the net value of the formulary change to be positive.

5. Discussion

This paper proposes and illustrates the application of a new method for evaluating drug formulary changes based on the economic theory of price indexes. A formulary is cast as a set of demand prices to consumers; a compensating variation measure calculates welfare due to demand-price changes. By recognizing and incorporating formulary effects on acquisition prices and potential offsets for other covered services, our approach incorporates costs as well as benefits of a formulary change. Data needed are simply prices and quantities. All prices would be known to a plan, and all prices but actual acquisition prices are known to researchers with claims data. Quantities in the existing formulary are also in claims. Quantities in the new formulary could either be estimated with data if the change actually happened, or simulated based on experience if the formulary change is being contemplated.

Notably, our approach takes consumer demand as the indicator of welfare. It ignores the value of subsidizing some purchases to “correct” consumer preferences, such as might result, for example, from consumers not appreciating the future effects of compliance with medication intended to manage chronic illness.²⁴ Such a perspective can, however, be grafted on to conventional approaches to assessing consumer benefit in health insurance (Pauly and Blavin, 2008). Cost-effectiveness analysis is another approach to formulary design, one that would be redundant (and even misleading) if demand incorporates benefits.²⁵ If doctor/consumer preferences in drug choices were not regarded as indicative of benefits, some outside standards, however, such as from cost effectiveness analysis would need to be brought to bear. Finally, the risk-spreading effects of formulary choice are also not considered. In a comparison of formulary designs, when the financial risk to plan members doesn’t change much, risk-spreading considerations can be reasonably set aside. Our analysis is also based on another (positive) assumption about demand, that quantity purchased is demand-determined. To the extent that non-price rationing (e.g., quantity

²⁴Generally, this perspective is referred to as “value-based insurance design.” See Chernew, Rosen and Fendrick (2007) and Pauly and Blavin (2008). Newhouse (2006) explicitly discusses drug coverage in relation to irrational noncompliance.

²⁵Our analysis is in effect cost-benefit analysis where benefit is as perceived by consumers.

management) affects quantities of drugs, the application of price index theory would need modification. Use of “shadow prices” in health plan rationing is one way to incorporate supply-side limits within an enrollee demand (Glazer and McGuire, 2002).

Our paper stops short of deriving the “optimal formulary.” One could take our expression for net value, and in the context of particular demands and market conditions on the supply side, derive the tier prices that maximize net value for a given level of premium. This seems to us most worthwhile to do within the context of a particular plan, where the “solution” would be found by iterative simulation methods.

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Appendix A

This appendix shows that our proposed measure of value to the consumer, expression (4) in the text, approximates the consumer's welfare gain from the formulary out-of-pocket price change.²⁶ Let $U(q)$ denote the representative consumer's utility when consuming the bundle $q = (q^1, \dots, q^i, \dots, q^n)$. Let $u_0 = U(q(p_0))$ be the consumer's utility at the initial price vector p_0 . Let $p = (p^1, \dots, p^n)$ be any price vector and let $q_{u_0}(p) = (q_{u_0}^1(p), \dots, q_{u_0}^n(p))$ be the solution to the following problem:

$$\begin{aligned} & \min_{q^1, \dots, q^n} \sum_{i=1, \dots, n} p^i q^i \\ & \text{s.t., } U(q^1, \dots, q^n) = u_0. \end{aligned} \quad (A1)$$

Notice that $q_{u_0}^i(p)$, $i=1, \dots, n$, is the (constant utility) Hicksian demand for drug i , when the price vector the consumer faces is p and utility is kept at u_0 .

Let

$$E(p, u_0) = \sum_{i=1, \dots, n} p^i q_{u_0}^i(p) \quad (A2)$$

$E(p, u_0)$ is an expenditure function, the minimum spending at prices p needed to obtain utility u_0 . Two properties of the expenditure function $E(p, u_0)$ are important:

²⁶The analysis is based on Hausman (1981, 2003).

$$\frac{\partial E(p, u_0)}{\partial p^i} = q_{u_0}^i(p) \quad (A3)$$

$$\frac{\partial^2 E(p, u_0)}{\partial p^i \partial p^j} = \frac{\partial q_{u_0}^i(p)}{\partial p^j} \quad (A4)$$

The consumer's willingness to pay for the prices to change from p_0 to p_1 is:

$$V_{u_0}(p_0, p_1) = E(p_0, u_0) - E(p_1, u_0) \quad (A5)$$

Since $u_0 = U(q(p_0))$, $q_{u_0}(p_0) = q(p_0)$ and, hence, we can write the following approximation:

$$q_{u_0}(p_1) - q(p_0) = q_{u_0}(p_1) - q_{u_0}(p_0) \approx \sum_{j=1, \dots, n} (p_1^j - p_0^j) \frac{\partial q_{u_0}^j(p)}{\partial p^j} \Big|_{p=p_0} \quad (A6)$$

Using the Taylor approximation around the original price vector p_0 and (A3), (A4) and (A6) above it can be shown that:

$$\begin{aligned} E(p_0, u_0) - E(p_1, u_0) &\approx \sum_{i=1, \dots, n} (p_0^i - p_1^i) q^i(p_0) + \frac{1}{2} \sum_{i=1, \dots, n} \sum_{j=1, \dots, n} (p_0^i - p_1^i) (p_0^j - p_1^j) \frac{\partial q_{u_0}^i(p)}{\partial p^j} \Big|_{p=p_0} \\ &= \sum_{i=1, \dots, n} (p_0^i - p_1^i) q^i(p_0) + \frac{1}{2} \sum_{i=1, \dots, n} (p_0^i - p_1^i) \sum_{j=1, \dots, n} (p_0^j - p_1^j) \frac{\partial q_{u_0}^i(p)}{\partial p^j} \Big|_{p=p_0} \\ &\approx \sum_{i=1, \dots, n} (p_0^i - p_1^i) q^i(p_0) + \frac{1}{2} \sum_{i=1, \dots, n} (p_0^i - p_1^i) (q_{u_0}(p_1) - q(p_0^i)) \\ &= \frac{\sum_{i=1, \dots, n} (p_0^i - p_1^i) (q_{u_0}(p_1) + q(p_0^i))}{2} \end{aligned} \quad (A7)$$

If we assume that $q_{u_0}(p_1) \approx q(p_1)$ we get that:

$$V_{u_0}(p_0, p_1) \approx V(p_0, p_1), \quad (A8)$$

where $V(p_0, p_1)$ is our proposed measure of the consumer's willingness to pay for the prices to change from p_0 to p_1 , given in (4). Notice that the difference between $q_{u_0}(p_1)$ and $q(p_1)$ follows from the fact that the former is the compensated (unobserved) demand whereas the latter is the actual observed demand.

We expect $q_{u_0}(p_1) \approx q(p_1)$. The difference between these two demands depends on the income effects associated with the change in prices. Income effects are likely to be ignorable for three reasons. First, OOP expenditures on drugs are a very small share of total spending, and the change associated with a formulary change is even a fraction of this. Shang and Goldman (2007), for example, find that among the elderly with drug coverage, the average income over the period 1992–2000 was \$30,500 (in year 2000\$) and total prescription drug spending was \$817.

Assuming 75% was covered by the health plan OOP spending was about \$200 per year, less than 1% of annual income. Using data from the CPS, Gruber and Levy (2009) find that for the median elderly household, OOP spending on drugs was about 1 % of household budgets. A formulary *change* would therefore represent well less than one percent of spending. For

younger groups, income will be higher and drug spending will be lower, making the income hit of a formulary change even less of an issue.

Second, the demand for health services is income inelastic (Newhouse, 1991), meaning the income effects are low (though some studies of demand for drugs, e.g., Moran and Simon (2006) find higher income elasticities.) Third, premiums actually paid by enrollees could change as a formulary changes. If so, at least in part, compensation is being paid (collected), negating income effects.

Demand for Drug 1

Figure 1.
Demand for Drug 1

Table 1

Two and Three-Tier Formulary Copayments, State Employer

	Two-Tier (Pre)	Three-Tier (Post)
Retail		
Generics	Tier 1: \$5 	Tier 1: \$5
Brands	Tier 2: \$10 	Tier 2: \$15
		Tier 3: \$30
Mail Order		
Generics	Tier 1: \$5 	Tier 1: \$10
Brands	Tier 2: \$5 	Tier 2: \$25
		Tier 3: \$45

Notes: The state employer is Plan B from Huskamp et al. (2007). Mail order prescriptions were typically for larger number of days supplied so were cheaper on a per-pill basis in both the pre and post periods.

Table 2

Quantity Responses to Copayments Changes for Cardiac Group

	Pre		Post		Quantity Impact
	Two-Tier	Quantity	Three-Tier	D-in-D Quantity	
Retail					
Generics	Tier 1: \$5	96,054	Tier 1: \$5	101,240	+ 5.4%
Brands	Tier 2: \$10	77,253	Tier 2: \$15	75,884	- 1.8%
	Tier 2: \$10	33,254	Tier 3: \$30	31,074	-6.6%
Mail Order					
Generics	Tier 1: \$5	34,209	Tier 1: \$10	28,159	-17.7%
Brands	Tier 2: \$5	38,112	Tier 2: \$25	25,156	-34.0%
	Tier 2: \$5	13,232	Tier 3: \$45	11,635	-12.1%

Implied change in value (from expression (4)):- \$155.83 per person