Price of a Life: An Application of Value-Adjusted Utility Theory to Pharmaceutical Pricing Policies

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1 Introduction

At the core of consumer theory in economic consumer theory is utility, the subjective measure of satisfaction or usefulness gained through the consumption of a good or service. Utility's subjective nature is key, as it reflects the varying values and preferences of individual consumers and maximization of this value is the objective in rational consumer decision-making. Producer decisions, however, are not typically thought of as relying on utility maximization. The assumption is that firms operate without considering subjective preference, maximizing profit rather than utility. This paper applies Value-Adjusted Utility Theory, a particular theory that removes the distinction between profit-maximizing supply-side decisions and utility-maximizing consumer choice through the creation of a single utility function that can be used for any decision-maker. Through application of this theory to a case study of the pricing practices pharmaceutical companies under specific conditions, I demonstrate the process of supply-side decision-making through the VAU framework, as well as some potential uses of this theory to optimize decision-making over time. Following this introduction, the paper proceeds with a review of the literature surrounding Value-Adjusted Utility theory and relevant research on the pharmaceutical industry. The next section will detail the data used to select and analyze the case study, followed by a deeper analysis of the proposed utility function and its application to economic decision-making. The paper concludes with an analysis of the results of those methods, and the larger policy recommendations that come about as a result.

2 Literature Review

Utility is a widely studied concept within economics and various other disciplines, with nuanced distinctions made by different authors and different schools of thought. This paper stems largely

from the conception of utility set out by Peter Fishburn in his 1968 survey of utility theories. He characterizes utility theories as sets of theorems derived from the axiomatic preference/indifference relationships between decision alternatives within a set [1]. This paper centers around a utility theory that Fishburn would categorize as "prescriptive", or concerned with the normative applications of utility theory which draw conclusions about how agents ought to act. Though there are countless prescriptive utility theories, each with their own assumptions and interpretations, this paper applies the particular prescriptive theory advanced by Yaseen Mozaffar in his forthcoming paper, "Value-Adjusted Decision-Making: A Unified Utility Theory for Both Sides of a Market" [12].

As is typical for prescriptive utility theories, Value-Adjusted Utility Theory is a mechanism for rational economic decision-making, through maximization of a utility function. There are, however, some key departures from the conventions of utility theory. Most applicably to this paper, rather than a typical utility function, which is subject to an exogenous resource constraint, a VAU function recognizes that possession of resources has its own utility, so budgets are simply treated as another source of utility, as savings/profit or debt. In addition to providing a mechanism for valuations of utility more precise than an ordered list of preferences, this allows the utility function to be applied to producers through manipulation of a profit function. Another notable characteristic of VAU is that it categorizes all sources of utility as either resource adjustments (how a decision affects availability of time, money, or materials for the agent) or quality of life adjustments (how a decision affect overall welfare in the world).

Illustration of the applications and implications of this theory on producer choice requires a subject that is as unrestrained by external factors as possible, to ensure that a firm's observed behavior is indeed a choice. In addition, for the sake of a comprehensible example, an ideal subject would have observable behavior that draws as direct a line between a quality of life adjustment and

a resource adjustment. On both counts, the pharmaceutical industry is uniquely suited to serve as a case study. For one, many pharmaceutical companies operate as monopolies for certain products, which removes market forces that would typically alter the conditions of profit maximization. In her survey of the relationship between American intellectual property law and pharmaceutical companies, Lara Glasgow shows that pharmaceutical patents grant monopoly power that is functionally untouched by antitrust regulation, allowing them to price patent-protected products at any point, irrespective of market conditions[2]. Importantly, she details a number of strategies employed and loopholes exploited by pharmaceutical manufacturers to extend the life of their patents long past the point where the costs of the product's research and development have been recouped[2]. This strengthens the case that certain pharmaceutical companies can pursue elective pricing strategies, making the industry suitable for this analysis.

Furthermore, prescription drugs provide an unusually clear relationship between producer resource adjustments and quality of life because consumption of pharmaceuticals are often the difference between life and death, not just some subjective measure of how satisfied someone is with their circumstances. This is reflected in a RAND review of empirical literature on the price elasticity of prescription drugs. Although different studies generated different results, each one found prescription drugs to be firmly inelastic, as low as -0.05 [3]. Although the precise price elasticity is unknown for a particular drug or type of drug, the effects are not. Nicole Rende notes that the markets for particularly critical drugs may reach a state of "demand-supply inflexibility", wherein consumption is deemed so important to consumers that price elasticity is functionally 0, allowing virtually unrestrained price gouging [6]. Coleen Cherici, Patrick McGinnis, Wayne Russell further explore the relationship between price markups and how critical a drug is for those who need it. Their analysis found that among 416 medicines used for "emergencies and serious conditions,"

were marked up an average 650% from market pricing and that the drugs deemed ”most critical” could be marked up as high as 4533% [11]. These percentages are not perfectly applicable to this paper because the particular study was focused on drug shortages caused by gray market supply chains, not monopolies, but nonetheless, the causal link between the necessity of a drug and the propensity to price gouge sufficiently illustrates the directness of the relationship between pharmaceutical resource adjustment and quality of life adjustments. Finally, a paper headed by Andrew Wilper found that lack of insurance could be causally linked to approximately 45,000 deaths per year among American adults under the age of 64 [4]. Again, while not directly about monopolistic pricing, this paper still firmly establishes a relationship between inability to pay for healthcare and resulting deaths.

Taken together, this base of literature produces an inescapable conclusion that certain profit-maximizing pharmaceutical companies electively price patent-protected, life-saving drugs at levels that can be directly linked to some amount of deaths due to inability to pay. With that conclusion drawn, this paper will proceed to apply Value-Adjusted Utility Theory to pharmaceutical pricing, in order to explore the tradeoff being made between profitability and welfare.

3 Data

In order to properly apply VAU, a subject more precise than ”certain pharmaceutical companies” is required. The process of isolating such a subject is detailed here. I began with the California Office of Health Planning and Development’s dataset of 2019 Prescription Drug Wholesale Acquisition Cost (WAC) Increases[9]. This data originated in California because California is the only state to mandate reporting of this information, but every company that sells in California is required to

report, so it is unlikely that any major drug manufacturers were excluded from this data. WAC is not reliably indicative of the price that consumers pay for a particular drug, so these data were far from sufficient, but it was nonetheless valuable as a starting point after extensive cleaning. Additionally, limiting the sample only to drugs that increased in price strengthened the degree to which a pricing decision could be attributed to company choice by removing any drug that may have been subject to some factor forcing that company to lower its prices (such as a demand shock or loss of overall profitability).

I began by removing unnecessary variables from the dataset, leaving only information necessary for identifying the drug and company that produces it. I then filtered all but "single source drugs" (drugs only produced by a single company with no generic counterparts) out of the dataset, as well as any drug with a patent expiry date that has already passed, or was N/A (meaning there was not a patent on the drug). This restricted my sample to only patent-protected drugs over which a company held a monopoly. I then manipulated the NDC variable (a unique ID number reflecting the manufacturer, drug, and packaging of the drug) into a new ID variable which reflected only the drug ID without the other two elements. This allowed me to remove the duplicates of identical drugs that were packaged at different doses and quantities. Next, the average price paid by an American customer for a course of each medication was retrieved from GoodRX, along with the condition(s) the drug was meant to treat [10].

The dataset was then further restricted by comparing the target condition to the Lancet's data on mortality by disease, and removing any drug that treated only conditions that did not appear in the set (meaning that they are not meaningfully associated with mortality)[5]. Also removed from the sample was any drug that only treated symptoms, rather than a particular disease, to avoid double-counting the effects of a drug that treated a disease that causes those symptoms. The final

restriction on the dataset was to remove any drug made by a company with a negative net income, because a company that is not profitable cannot freely make decisions while remaining viable.

The drugs remaining in the dataset now are unique, patent-protected, life-saving medications created by profitable companies. This is the closest approximation of purely elective decision-making that can be isolated with the available data. From here, a distinction needed to be made between ”life-saving” and ”life-extending” drugs; the majority of the drugs left in this dataset were used to mitigate the impact of a disease, but not actually cure it. While a metric of lifetime added could theoretically be calculated from such drugs, such a metric fails to create an intuitive enough relationship between profit and welfare to properly illustrate the tradeoff. The dataset has now been restricted just to five electively priced drugs which lower the probability of its consumer dying from a particular condition. With incidence data from the Centers for Disease Control and mortality differentials from clinical trials retrieved from the National Institutes of Health, I am able to examine the decision-making of these pharmaceutical companies through the lens of Value-Adjusted Utility[7][8]. Table 1 displays all relevant information for these five drugs.

4 Empirical Methods

The principles of Value-Adjusted Utility Theory were applied in two distinct ways to the case of elective pharmaceutical pricing decisions. Both stem from the general case of the Value-Adjusted utility function[12]:

$$U(x) = \sum v_1 \int_0^x u_1 x \, dx + v_2 \int_0^x u_2 x \, dx ... + v_n \int_0^x u_n x \, dx \tag{1}$$

where U is the utility received from taking action x (if the decision is simply whether or not to act) or from taking x units of action (if an action can have different effects based on the level

of action), and each u is the marginal utility of the a single outcome of the action either in terms of resources or quality of life, weighted by v, which is a numerical representation of the relative importance of that outcome for the agent, such that the set of values for v for the entire function sum to 1. Any decision made is represented as choosing the value of x which maximizes Ux. For the purpose of practical application to the pharmaceutical case, this function can be modeled using the following simplified form [12]:

$$U(x) = (v)u_{R+}x + (1-v)u_{QoL+}x - (v)u_{R-}x - (1-v)u_{QoL-}x \tag{2}$$

In this case, we hold marginal utility constant and reduce the potentially infinite outcome terms to just the sum of the positive effects of the action minus the negative effects of the action. For simplicity in this case, we can refer to the resource terms as ”money” and the quality of life terms as ”lives” or ”welfare.” Therefore, the value adjustment reflects the relative importance of wealth accumulation and human life in the opinion of the agent. The decision in question is the price at which a firm elects to price a life-saving medication. Because firms like the pharmaceutical companies are profit-maximizing agents, we assume that they weight monetary terms with a value of 1, creating a utility function that is entirely defined as the difference between revenue gained and costs incurred. In other words, the Value-Adjusted Utility function of a purely profit-maximizing firm is identical to its profit function.

Suppose now we reverse the weights on the utility function such that quality of life is weighted at 1 and profits become a non-factor. The pharmaceutical pricing strategies can be thought of as a discrete choice model between the two extremes of value adjustments. The quality of life-weighted counterfactual model displays the outcome if the firms were to price their product at $0 so that anyone who needs the drug would be able to access it. The firm would then be forgoing a

monetary gain equal to the number of people afflicted with the target condition multiplied by the average price of the drug. So long as this value is less than or equal to the net income of a firm, that firm could choose to price their product at $0 without sacrificing anything other than shareholder profits.

5 Research Findings

A typical discrete choice model seeks to estimate the probability of an actor selecting each option. In the case of these pharmaceutical companies, however, this is unnecessary; the option to maximize profit has already been selected in each case. The purpose of framing these pricing decisions as a matter of discrete choice is to demonstrate that the extreme values of value-adjustment (and therefore all of the values in between them) are viable strategies for these firms. Table 2 displays the outcome of the counterfactual model, in which pharmaceutical companies only consider quality of life in their pricing decisions, as well as some of the implications of its comparison with the status quo of profit maximization. The number of lives saved by this decision is calculated as the number of Americans afflicted with the target condition, multiplied by the difference in mortality between those treated with the drug in question and those treated with the next best option. Forgone Profits is the amount of money that a firm would lose if their drug was priced at $0 instead of the Average Price and everyone afflicted "purchased" a course of the drug. Put another way, this value is the amount of profit gained by the firm's current price point rather than at $0. For each of these drugs, the forgone profits were well below the threshold of the manufacturer's net income. Because net income is calculated as the revenue remaining after the value all expenses are deducted, these forgone profits would not affect the firm's research budget, or in any way reduce

their ability to continue producing medication. There would simply be less money to be circulated among shareholders and executives in the form of dividends and bonuses. This is true even in the case of Novartis, as the sum of forgone profits for all three electively-priced drugs are below the net income threshold. By dividing the foregone profits by the number of lives that would be saved by making their drug freely available, therefore, we estimate how many dollars these firms have gained for each person they have chosen not to save from the target condition.

The model has two uses. First, given reliable valuations, can be used to make decisions, just like the average utility function. Second, more importantly, can be used to reverse engineer valuations from decisions that have already been made. In the test case, we found that Novartis valued human life this much (insert table here). Test variance for statistical significance. Significance indicates that there is some factor making a difference in valuation outcomes between different drugs.

6 Conclusion

The Value of a Life estimated in this paper is unlikely to be accurate. The mortality differential for target conditions was calculated using point estimates rather than confidence intervals, and they were drawn from limited sample sizes from clinical trials. Furthermore, while the heavily restricted selection of drugs under consideration approximated elective decision-making as closely as possible, there is no way to prove that those pricing decisions were in fact unaffected by market conditions or other factors, or that pricing pharmaceuticals at $0 would not cause some quality of life tradeoff. Finally, of course, the Value-Adjusted Utility function was simplified to the point where even a complete data set would produce inaccurate results. Indeed, the extreme variation for the values of life calculated for the three Novartis entries implies that at least two of those estimates

are incorrect estimations of the firm's value of life. None of this, however, is central to the purpose of this paper. The accuracy of the particular dollar value estimated as the price of a life is far less important than the fact that a value could be estimated in the first place.

Under the typical assumptions of economic producer theory, firms are treated as value-neutral, objective decision-makers, for whom pure profit-maximization is not only an acceptable framework for action, but unquestioningly assumed to be "correct". Through the application of Value-Adjusted Utility to the case of pharmaceutical pricing and simple modeling techniques to demonstrate that profit maximization can be a choice rather than a necessity, I argue that profit maximization as a corporate objective is anything but value-neutral. Ultimately, decisions justified as purely "economic" (as are most corporate choices) entails the imposition and acceptance of a value system that treats societal welfare as a non-issue, sometimes at a cost of thousands of human lives each year. The widespread acceptance of pure profit maximization as the correct objective for a firm means that firms are never made to confront their effect on quality of life, except in cases where it can adversely affect profits, such as through legal action or negative press coverage. This theoretical utility framework illustrates that, irrespective of whether or not anyone acknowledges the quality of life cost of profit-maximization, that cost is incurred to a degree that is significant and measurable.

The only policy recommendation that stems from this analysis is for economic decision-makers to interrogate their values, and in particular challenge the assumption that profit maximization is sufficient to absolve firms of the impacts of their actions. It is quite possible that even widespread re-imagining of such values would produce no tangible changes to the economy. A pharmaceutical executive may be confronted with the fact their pricing decisions have implicitly valued a human life at $22,000 and not feel compelled to change, but at the very least they would lose the

opportunity to pretend that they have never considered the human cost of their choices. It is also possible, however, that if annual reports and stock trackers were to include the number of people killed or harmed by the actions of a firm, giving the decision-makers at that firm no choice but to think about their impact, there might be more thought given to the inevitable tradeoff between pure profit-chasing and the cost it incurs.

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Figures and Tables

Drug	Company	Net Income	**Target Condition**	Number Afflicted (est.)	Untreated Mortality	Treated Mortality
Pradaxa	Boehringer Ingelheim	9.9 billion	AFib-related stroke	2,200,000	8.10%	6%
Eliquis	Bristol-Myers Squibb	4.92 billion	AFib-related stroke	2,200,000	15.00%	9%
Entresto	Novartis	12.611 billion	Chronic Heart Failure	6,500,000	1.11%	0.90%
Tasigna	Novartis	12.611 billion	Chronic Myelogenous Leukemia	58,000	3.94%	3.54%
Gilenya	Novartis	12.611 billion	MS Relapse	250,000	20%	17%

Table 1: Drug and Disease Info

Drug	Company	Net Income	Forgone Profits	Lives Saved	**Value of a Life**
Pradaxa	Boehringer Ingelheim	9.9 billion	$1,101,362,000.00	4,615	**$238,648.30**
Eliquis	Bristol-Myers Squibb	4.92 billion	$3,366,500,000.00	8,800	**$382,556.80**
Entresto	Novartis	12.611 billion	$1,185,800,000.00	16,250	**$72,972.31**
Tasigna	Novartis	12.611 billion	$1,225,400,000.00	1,044	**$1,173,755.00**
Gilenya	Novartis	12.611 billion	$4,303,000,000.00	195,000	**$22,066.67**

Table 2: Counterfactual Analysis