

Price discrimination and bargaining power in the global vaccine market

Linda Li*

Professor David Ridley, Faculty Advisor

Honors Thesis submitted in partial fulfillment of the requirements for Graduation with Distinction in Economics in Trinity College of Duke University

Duke University
Durham, North Carolina
2013

The Duke Community Standard was upheld in the completion of this thesis.

*Linda Li (linda.li@alumni.duke.edu) graduated with High Distinction in Economics in May 2013. She will be working as an Associate at Deloitte FAS in New York City.

Abstract

Since the 1980s, the market structure of vaccine industry has become increasingly oligopolistic, and in some cases, monopolistic. Alongside these supply trends, we see the emergence and growth of group procurement schemes on the demand side. National governments and international organizations procure vaccines on behalf of end users. Two such organizations are the UNICEF Supply Division and the PAHO EPI Revolving Fund, for which participation is based on income and geography respectively. Consistent with one of the main goals of group procurement, these groups obtain price discounts on vaccines relative to the private sector. This paper seeks to disentangle two possible explanations for this observed price dispersion using vaccine price data over the years 2002-2012 from UNICEF, PAHO, and the U.S. The two explanations are that of price discrimination and bargaining power. Using proxy variables in a fixed effects model, I find that price discrimination does have a significant impact on price discount. I also find support for a bargaining power effect, however, with less certainty, and the existence of supply constraints. These findings have important policy implications for national governments, as well as procurement groups.¹

Keywords: Vaccines; Price discrimination; Bargaining power; Group procurement.

JEL Classification Numbers: I11, I18, L22.

¹The author is grateful to her advisor Professor David Ridley and Professor Michelle Connolly for advice and suggestions, and to Trent Chiang and her Honors Seminar for helpful comments.

1 Introduction

The vaccine market is uniquely characterized as a market in which both buyers and sellers have significant market power. Historically, a few sellers (vaccine manufacturers) have dominated the market, often resulting in a single or small number of manufacturers producing one particular monovalent or combination vaccine². According to Kalorama Information (2008), the top four companies, Merck, Sanofi Pasteur, GlaxoSmithKline, and Wyeth, held 91% of the total market in 2007.

There are a number of reasons for this market structure. In comparison to the market for drug treatments, vaccine markets are far less attractive from the perspective of a profit-maximizing firm. Firstly, vaccines are subject to a winner's curse: the longer the efficacy, the smaller the demand (Danzon, Pereira, & Tejwani, 2005). While drugs extract profits over a lifetime of use and into future generations, vaccines extract profits fewer times over an individual's lifetime and reduce the prevalence of a disease within a population, in turn, reducing its own demand (Kremer & Snyder, 2003). Other reasons for the existence of one or few manufacturers per vaccine include high R&D fixed costs, high liability risks, demand uncertainty, strong barriers to generic entry, and dynamic quality competition (Danzon et al., 2005).

In response to the reduced competition of manufacturers in the vaccine market and the importance of securing an affordable vaccine supply, national governments have traditionally played a large role in vaccine procurement. The U.S. Centers for Disease Control and Prevention (CDC) has traditionally accounted for over half of the U.S. demand for vaccines (Kauf, 1999). In recent years, smaller countries, and low- and middle-income countries, have undertaken efforts to develop group procurement schemes.

Theoretically, group procurement is viewed as a means to increase competition among manufacturers, reduce prices, and increase equity by offering all member countries the same

²A monovalent vaccine is designed to immunize against a single antigen or microorganism. A combination vaccine (also known as a multivalent or polyvalent vaccine) is designed to immunize against two or more strains of the same microorganism, or against two or more microorganisms.

prices regardless of market size or level of development. In addition, it is viewed as a means to increase transparency, ensure quality, and improve supply regularity (DeRoeck et al., 2006). The United Nations Children's Fund (UNICEF) Supply Division began procuring vaccines for countries in 1996 on behalf of the GAVI Alliance, a public-private global health partnership focused on immunization. One criterion for participation is that a country must have a gross national income (GNI) per capita below or equal to the annually set threshold. The 2013 threshold is \$1,550 (as per World Bank data, current U.S. \$, Atlas method³). This restricts participation in UNICEF procurement to primarily low-income countries. Another group procurement scheme, the Pan American Health Organization (PAHO) EPI Revolving Fund, began in 1979. In contrast to UNICEF, PAHO is a regional procurement organization encompassing mostly middle-income countries in the Americas. Today, there are 65 countries who procure their vaccines through the UNICEF Supply Division, and approximately 33 through the PAHO Revolving Fund. Participation in the annual procurement cycle for both purchasing schemes is voluntary for qualifying countries.

We observe significant vaccine price discounts for procurement groups when compared to private sector prices published by the CDC. Over the past decade, the CDC has obtained price discounts of 43% on average over all its vaccines. Even more telling, both UNICEF and PAHO have obtained price discounts of 86-87% on average on its vaccines. Concretely, this means that a vaccine priced at \$100 per dose in the private sector could be obtained by UNICEF or PAHO at approximately \$13-14 per dose.

Based on economic models, there are three possible explanations for this price dispersion: (1) there are different costs for serving different markets, (2) there is third degree price discrimination occurring, and/or (3) there exists differential purchasing or bargaining power (Arnould & DeBrock, 1993). While it is plausible that the first hypothesis of heterogeneous products holds due to differences in packaging, volumes, levels of support, and repurchasing

³The Atlas method is a method used by the World Bank to compare the relative size of economies based on gross national income (GNI) in U.S. dollars. For a detailed description of the method, see <http://data.worldbank.org/indicator/NY.GNP.PCAP.CD>.

agreements, previous empirical tests fail to find support for this argument (Arnould & De-Brock, 1993). These tests rely on the observation that the costs of serving different markets are approximately equal across different vaccines; therefore, statistically different coefficients on vaccine dummies refute this hypothesis. I verify and confirm this result on my data set.

By ruling out the first explanation, I consider the other two - the price discrimination and bargaining power hypotheses. The goal of this paper is to empirically determine the effects of price discrimination and bargaining power on the price discount on vaccines purchased through group procurement schemes, in order to answer the following question: to what extent is the price discount achieved by a group procurement scheme for vaccines attributable to price discrimination and/or increased bargaining power? Though my research focuses on the global market for vaccines, there are many countries excluded from my analysis. Data availability constraints exclude countries not procuring through UNICEF or PAHO (except for the U.S.), such as European and other OECD countries, from my data set.

The rest of the paper is structured as follows: Section 2 presents a review of the relevant literature, Section 3 introduces the theoretical framework, Section 4 describes the data, Section 5 explains the empirical methodology, Section 6 presents the results, and Section 7 concludes.

2 Literature Review

While there is abundant literature on bargaining power and price discrimination, there is not much empirical research on vaccine pricing. One reason for this may be that up until recently, there were little data available on vaccine prices. In 2011, UNICEF made awarded vaccine prices publicly available on its website to promote vaccine price transparency. The paucity of data in this area is further magnified by the lack of transparency on contract prices from both sides of the market, manufacturers and national governments.

Previous empirical research on vaccine pricing has focused primarily on areas for which

there were data available, in particular, the U.S. market. Salkever and Frank (2005) analyze CDC vaccine contracts over the period 1977 to 1992 to determine the contract size-price relationship, finding support for supply constraints in a winner-take-all procurement process. Kauf (1999) tests for the presence of price discrimination and/or bargaining power to explain the observed differences in prices between the private sector and CDC contract. Using longitudinal data, the author finds stronger support for the bargaining power hypothesis. As I seek to extend Kauf's research on these two market features in the context of the global vaccine market, I review some weaknesses of the model.

Firstly, while Kauf proposes price discrimination as an explanation for unexpected coefficient signs on her bargaining power variables, she does not proxy for price discrimination itself. Previous models test for price discrimination by estimating the marginal cost of serving each demand group and taking the ratio of price to marginal cost. Statistically significant differences indicate the presence of price discrimination. The feasibility of using this methodology is limited in the context of the global vaccine market, as data on the marginal costs of transportation and distribution for vaccine manufacturers are not publicly available. One possibility is to use geographic dispersion as a proxy; however, this approach may lack accuracy. Alternatively, the literature proposes another general method to test for the presence of price discrimination; this method uses observed price discounts regressed against a variable hypothesized to affect the elasticity of demand and a group of control variables. According to this model, there is price discrimination if the coefficient on the elasticity measure is significant and of the correct sign (Borenstein, 1991; Joyce, 1990; Kauf, 1999; Kwoka, 1992; Shepard, 1991). I discuss the application of this method in Section 3.

The other weakness present in Kauf's model concerns the use of producer exits as a regressor for price discount. The number of producing firms can be influenced by vaccine prices, posing an endogeneity problem. I seek to address both weaknesses and generalize the methodology for the U.S. vaccine market to the global vaccine market. With the addition of new procurement groups (UNICEF and PAHO) comprised primarily of low- and middle-

income countries into the sample, the range of tiered pricing expands significantly.

3 Theoretical Framework

When firms have market power, they can price discriminate across customer groups, assuming some ability to distinguish among groups and prevent arbitrage across groups. Although the firm structure in the global vaccine market is monopolistic in some cases and oligopolistic in others, I assume a simple monopoly model of price discrimination in which the monopolist can distinguish between consumer groups but not within groups. This accurately describes the operations of procurement groups such as UNICEF, PAHO, and the CDC. The solution of the monopolist's profit maximization problem yields the first-order condition known as the inverse elasticity rule for each market. The condition implies that it is optimal for a monopolist to charge higher prices in inelastic groups and lower prices in elastic groups. It is hypothesized that income affects the elasticity of demand. To the extent that the income of the average individual in a group is representative of the procurement group's willingness to pay, I proxy for the price discrimination effect using group GDP per capita. The prediction is that procurement groups serving populations with lower GDP per capita will obtain greater price discounts. Subsequently, we expect vaccine price discounts to be highest for UNICEF and lowest for the CDC, with PAHO obtaining discounts somewhere in the middle. This model, however, offers no prediction of this effect relative to that of bargaining power.

I present a more formal economic model for bargaining power in the vaccine market developed by Arnould and DeBrock (1993). Assume that there are two buyers in the market - the government (buyer 1) and the private sector (buyer 2). Both can be viewed as intermediaries purchasing on behalf of end users. The public sector maximizes utility $U(x_1, x_2)$ over all immunizations, including those from the private sector, subject to its budget constraint and a zero profit condition. We write the general form of the indirect utility function for

public sector purchases as $V(p_1, p_2)$.

The manufacturer maximizes its profit, π_m . Based on the Nash solution to the bargaining game between manufacturer and government (resulting in p_1 and x_1), the manufacturer then sets the private vaccine market price, p_2 . Formally, the bargaining payoffs for the manufacturer and the government are written as:

$$B_1 = \{[\pi_m(p_1, p_2), V(p_1, p_2)]\} \quad (1)$$

We define a disagreement point, (D_1, D_2) where D_1 and D_2 are the threat points of the government and the manufacturer respectively. If no agreement is reached in the bargaining process, the government obtains indirect utility only from private market end users, $V(p_2)$, and the manufacturer obtains profits only from serving the private sector market, $\pi(p_2)$. The Nash solution to the bargaining game is the p_1 that maximizes the Nash product:

$$p_1^N = \max \pi_m(p_1, p_2)V(p_1, p_2) \quad (2)$$

subject to the disagreement point (D_1, D_2) . In most cases, payoffs for each player increase with the size of their own threat point.

An increase in government bargaining power can be modeled by a relative decrease in the manufacturer's threat point, D_2 . For example, if the public sector requires that all vaccines be purchased through the public purchasing scheme, manufacturers would obtain lower profits from selling exclusively to the smaller private sector market. While D_1 would also decrease, it is reasonable to assume that relative to D_2 , it does not decrease as much. According to this bargaining power model of price dispersion, an increase in government bargaining power allows the government purchasing group to obtain a lower price. This is one of the underlying reasons for pooled procurement. A proxy for bargaining power with population. It can be assumed that a group procuring on behalf of a larger population has a larger threat point, therefore, obtains greater price discounts.

4 Data

I obtain annual data on vaccine prices for the years 2002-2012 from three sources: (1) the UNICEF Supplies and Logistics vaccine price data and vaccine projections, (2) the PAHO Revolving Fund vaccine price lists, and (3) the CDC Vaccine for Children's (VFC) vaccine price lists. The CDC publishes contract prices and private sector prices. The CDC contract prices represent prices established for the purchase of vaccines by immunization programs that receive CDC immunization grant funds (i.e. state health departments, certain large city immunization projects, and certain current and former U.S. territories). Private providers and private citizens cannot directly purchase vaccines through CDC contracts. The CDC reported private sector vaccine prices serve as the benchmark from which I calculate price discounts for procurement groups (UNICEF, PAHO, and CDC). All prices are reported in U.S. dollars. The dependent variable, price discount, does not need to be adjusted for inflation as it is calculated as a ratio (in percent terms).

Due to the divergence of product lines procured through the three procurement groups and the lagged introduction of newer vaccines in developing markets, the number of observations is limited. Observations require matching vaccines procured through groups with those procured by the private sector where data are available. A pure match means that both the group and private sector prices describe the same vaccine in terms of diseases covered, strains, valency, form, and dosage. I obtain 329 pure match observations over the ten year period. In an effort to match previously unmatched observations, I predict vaccine prices using three strategies, in certain cases, in conjunction with one another. Checks for the validity of these strategies are detailed in Section 6.

First, I predict prices for combination vaccines based on prices for its component vaccine parts. For example, PAHO does not procure the HepA-HepB combination vaccine; however, it does procure the HepA vaccine and the HepB vaccine individually. By adding the two prices, I obtain a newly constructed vaccine price for the hypothetical HepA-HepB combination vaccine procured through PAHO to match with data available on the private sector

price of HepA-HepB. I consider the possibility that the predicted prices may be biased due to combination vaccine markups or markdowns by checking for differences between hypothetical combination vaccine prices and observed prices where data are available. Based on a sampling of various vaccines and groups, I find heterogeneous markups/markdowns in which combination vaccines are priced above the hypothetical prediction in some cases, and priced below in others. In light of these findings, I do not adjust for this possible bias. The purpose of this first strategy is to enable a price comparison to be drawn between the benchmark and comparison groups for a pre-existing observed combination vaccine type. Refer to Table 3 in the Appendix for a listing of all newly constructed combination vaccines.

Next, I adjust for quality differences between private sector vaccines and similar vaccines procured through procurement groups. For example, UNICEF and PAHO mainly procure DTP, a combination vaccine for diphtheria, pertussis, and tetanus, while the CDC and the private sector procure DTaP, the same vaccine with an acellular pertussis component. This is an example of the product divergence mentioned earlier; developed markets switch to safer vaccines when available, while developing markets experience a lag in adopting new technologies. In this particular case, I adjust all UNICEF and PAHO DTP prices to predicted DTaP prices by multiplying by a factor. This factor is calculated from a price comparison between DTP and DTaP in the most recent year available in either group. Similar adjustments are made for private sector vaccines to match UNICEF and PAHO vaccines without duplicating data points.

Lastly, I interpolate and extrapolate price data points for missing years. Data interpolation is used for missing points between known points, and data extrapolation is used for back-casting or forecasting from known points. Using Lagrangian interpolation, I fit price data for known years to a polynomial of degree 6 (degree 6 chosen for sufficient capture of up to 8 known data points and ease of calculation), then, predict missing price data within the range known years. In addition, I back-cast and forecast data out to a maximum of 8 years using the rate of price growth in the closest available years if there is an upwards or

downwards trend observed over time. If prices for a given vaccine in a given procurement group appear to be stable, back-casted and forecasted prices are also assumed to be stable from the price of the nearest year.

In total, 184, 177, and 79 observations (not mutually exclusive) are treated by these three strategies respectively. The data techniques described above increase the sample size from 329 to 660 observations with the following group breakdown: 142 UNICEF-private, 259 PAHO-private, and 259 CDC-private, and 142 UNICEF-private observations. Despite the possible data quality concerns raised by this process, there are significant potential gains to increasing the number of vaccine price data matches between the public and private sectors in terms of formulating empirical tests relying on statistical significance.

Data for independent variables, GDP per capita (in current US\$) and total population for the years 2002-2012, originate from the World Bank Databank, which collects data from multiple sources. Information on which countries procure through UNICEF each year is given by the UNICEF Supplies and Logistics GAVI Shipments Archive. In the absence of similar information for PAHO Member country participation in vaccine procurement through the PAHO Revolving Fund, I assume in the data that all Member countries participate every year. We know this to be not true, but introduce the simplification due to data constraints.⁴ Figure 1 presents a visualization of the dependent variable (price discount) over time. Figures 2 and 3 present a visualization of the independent variables of interest (GDP per capita and total population) over time.

⁴According to a policy brief published by the International AIDS Vaccine Initiative (IAVI) in 2008, Mexico and Chile have purchased vaccines directly from manufacturers without using the PAHO Revolving Fund, and Brazil has purchased what it could from national manufacturers before purchasing from the Fund.

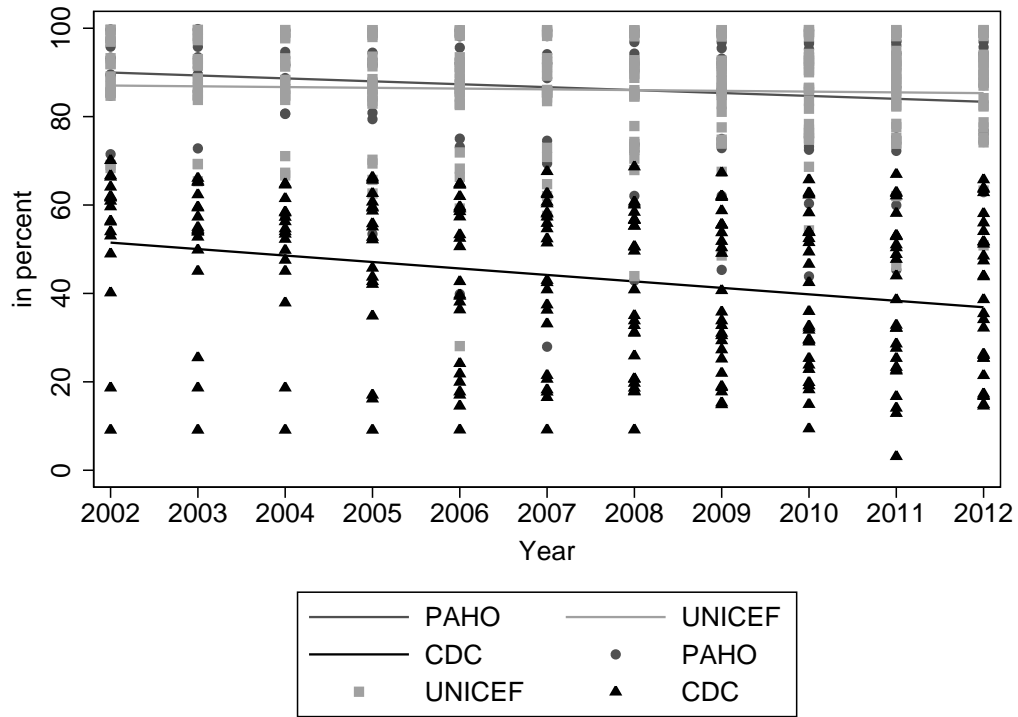


Figure 1: Price Discount Over Time

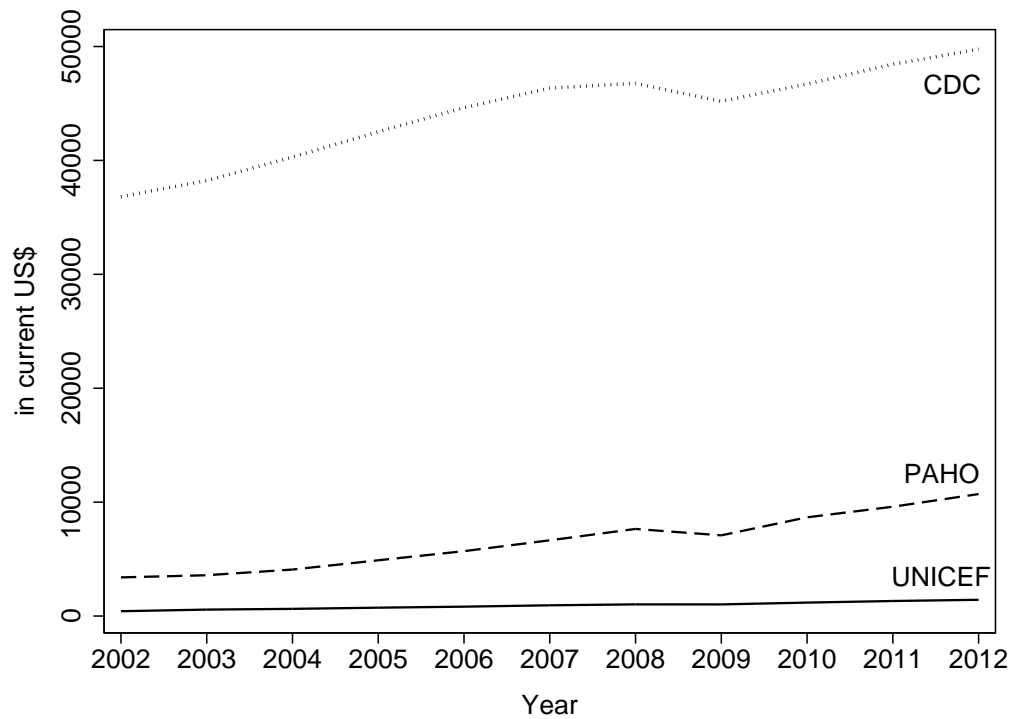


Figure 2: GDP Per Capita Over Time

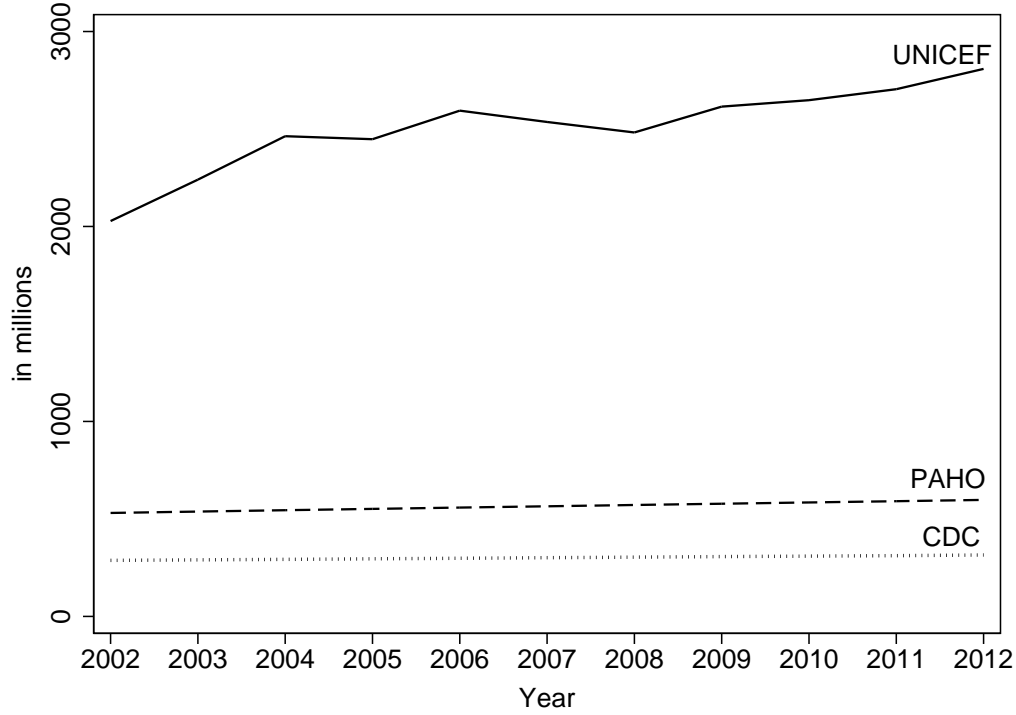


Figure 3: Total Population Over Time

Table 1 presents descriptive statistics of the variables: the number of observations, the mean, the standard deviation, and the minimum and the maximum values. *pd* is the percentage price discount, calculated from the private price (*pprivate*) and the group price (*pgroup*). *gdppercap* is the GDP per capita of the group - the price discrimination measure; *tpop* is the total population of the group - the bargaining power measure. The *unicef*, *paho*, and *cdc* variables are group dummies.

Table 1: Descriptive Statistics

Variable	Definition	Obs	Mean	Std. Dev.	Min	Max
<i>pd</i>	Price Discount (in percent)	660	69.42	25.67	3.17	99.81
<i>pprivate</i>	Private Price (in US\$)	660	44.58	28.35	11.99	142.36
<i>pgroup</i>	Group Price (in US\$)	660	15.00	19.32	0.03	111.96
<i>gdppercap</i>	GDP Per Capita (in current US\$)	660	20524.69	19876.90	426.05	49768.14
<i>tpop</i>	Total Population (in millions)	660	883.16	869.16	287.63	2808.36
<i>unicef</i>	UNICEF dummy	660	0.22	0.41	0	1
<i>paho</i>	PAHO dummy	660	0.39	0.49	0	1
<i>cdc</i>	CDC dummy	660	0.39	0.49	0	1

5 Empirical Methodology

Following the literature on price discrimination and Kauf's empirical specification, I define my dependent variable as the percentage discount between the private sector price and the group procurement price for a given vaccine, procurement group, and year.

$$Price\ Discount = \frac{Benchmark\ Price - Group\ Price}{Group\ Price} * 100 \quad (3)$$

I estimate percentage discount as a function of three variables: (1) group GDP per capita (in current US\$) denoted as $gdppercap$, (2) group total population denoted $tpop$, and (3) group total population squared denoted as $tpop2$. The quadratic term on the bargaining power measure aims to capture possible existence of supply constraints and increasing marginal costs for manufacturers. I control for vaccine components or diseases, group (UNICEF, PAHO, or CDC), and year using dummy variables. I propose the following fixed effects specification for vaccine i in group j in year t :

$$\begin{aligned} pd_{ijt} = & \alpha_{ijt} + \beta_1 gdppercap_{jt} + \beta_2 tpop_{jt} + \beta_3 tpop2_{jt} \\ & + \beta_4 unicef_j + \beta_5 paho_j + \chi_i + \delta_t + \epsilon_{ijt} \end{aligned} \quad (4)$$

where χ_i is the vector of vaccine specific characteristics and δ_t is the vector of time dummies for years 2002-2011 (2012 dropped from the regression as it is the baseline comparison group). For the same reason, the CDC dummy does not appear in the regression. The vaccine specific characteristics include the following components: DTP, HepB, IPV, HepA, Hib, MMR, Td, HPV, Meningococcal disease, Varicella, Pneumococcal disease, and Rotavirus.

A negative and statistically significant estimate of β_1 supports the price discrimination hypothesis, while a positive and significant coefficient β_2 supports the bargaining power hypothesis. It is important to note that these two explanations are not mutually exclusive. Finally, if supply constraints exist, we expect to see a negative estimate for β_3 .

6 Results

The results for the estimation of the fixed effects model on all observations and subsamples are presented below. Subsample 1 omits all observations obtained through hypothetical combination vaccine construction. Subsample 2 omits all observations obtained through price quality adjustments. Subsample 3 omits all interpolated and extrapolated points. Lastly, Subsample 4 is the most restrictive data set, including only pure matches or those observations not treated by the techniques described in the Data Section. I run the regression on multiple subsamples to check the validity of these data techniques.

Table 2: Fixed Effects Model Results, dependent variable Price Discount

	All	Subsample 1	Subsample 2	Subsample 3	Subsample 4
Number of obs	660	476	483	581	329
R-squared	0.7850	0.8010	0.8316	0.8020	0.85
Adj R-squared	0.7759	0.7890	0.8216	0.7924	0.8365
gdppercap	-.0010499**	-.0010302	-.0010258*	-.0005253	.0002669
tpop	.1013269	.1541114	.1652576*	.188337*	.311615*
tpop2	-.0000229*	-.0000344*	-.0000341**	-.0000353*	-.0000555*
unicef	-85.69967	-127.5297	-148.8189*	-179.2139	-276.5404
paho	-18.70385	-27.03967	-29.99004	-18.35414	-12.12448

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels respectively

The signs of the coefficients remain stable throughout the subsamples, except for the coefficient for GDP Per Capita in Subsample 4; however, it is not statistically significant. The coefficient signs corroborate the predictions given by economic theory on price discrimination and bargaining power. A negative coefficient on the price discrimination measure (*gdppercap*) means that as a procurement group’s income rises, its price discount on vaccines shrinks. All else equal, a \$1,000 increase in GDP per capita of the population served by a procurement group results in a 1% decrease in price discount.

The coefficient on the bargaining power measure (*tpop* and *tpop2*) tells us that as the size of a procurement group increases, its price discount on vaccines also increase until a certain point where supply constraints and increasing marginal costs for manufacturers become important. Although the results lack strong statistical significance on some sub-

samples, the coefficient estimate predicts that a population increase of 10 million results in an approximately 1-3% increase in price discount. A statistically significant negative coefficient on the quadratic bargaining power term supports findings in the literature on supply constraints. According to the regression results, the price discounts achieved by group procurement schemes for vaccines are attributable both to price discrimination and bargaining power, and not manufacturer bias towards certain institutions or procurement group bargaining "skill". Almost all coefficient estimates on group dummies are statistically insignificant, therefore, we can say that it is the unique structure of the global vaccine market that explains the price dispersion observed among UNICEF, PAHO, CDC, and the private sector vaccine prices.

Additionally, I explore the possibility of non-uniform effects of price discrimination and bargaining power among the three procurement groups by estimating coefficients for each group. With the addition of interacted variables, all coefficient estimates on price discrimination and bargaining power lose statistical significance. I conclude that the effects of price discrimination and bargaining power are, in fact, the same for all groups.

7 Conclusion

In response to influenza vaccine shortages, there has been recent consideration given to joint procurement through the European Commission (EC). One consideration for policy-makers is what effect this will have on vaccine prices. The findings of this paper demonstrate that price discrimination and bargaining power are quantifiably significant determinants of vaccine price discounts. Though dependent on the precise composition of countries participating in EC procurement, the GDP per capita of the group would fall generally between that of PAHO and the CDC, and the total population is close to that of PAHO. Based on a cursory analysis, I predict that if implemented, the EC procurement group would obtain price discounts on vaccines somewhere between the discounts observed for PAHO and the

CDC in the range of 43-86%. Although this is a wide range, the paper proposes a methodology for estimating price discount with known group composition, and income and population characteristics.

Given that one of the main objectives of pooled procurement in the global vaccine market is securing vaccines at lower costs from manufacturers, it is important for national policy-makers to consider whether joining such an organization is advantageous. On the other hand, international group procurement schemes have an interest in optimizing the composition of their group to achieve the best possible price discount for its Member states. While I do not explore the specific welfare effects of group procurement of vaccines on countries and end users, this is a possible direction for further work.

Additionally, future work should seek to address the role of external financing such as that provided through the GAVI Alliance to low-income countries, on vaccine pricing and discounts. To the extent that the income of the average individual in a group is not representative of the procurement group's willingness to pay, this introduces changes into the manufacturer's profit maximization problem that merit consideration.

Appendix

Table 3: Newly Constructed Combination Vaccines

UNICEF	CDC	PAHO
DTP	DTaP	DTP
*new	DTaP-HepB-IPV	*new
DTP-Hib	DTaP-Hib	DTP-Hib
*new	DTaP-IPV	*new
*new	DTaP-IPV-Hib	*new
	HepA	HepA
	HepA-HepB	*new
HepB	HepB	HepB
*new	HepB-Hib	*new
*new	Hib	Hib
	HPV (bivalent)	HPV (bivalent)
	HPV (quadrivalent)	HPV (quadrivalent)
OPV	IPV	OPV/IPV
	Meningococcal (4 valent)	Meningococcal (2,10 valent)
MMR	MMR	MMR
	MMR Varicella	*new
DTP-HepB	*new	*new
DTP-HepB-Hib	*new	DTP-HepB-Hib
PCV	Pneumococcal (7,23 valent)	Pneumococcal (7,23 valent)
	Rotavirus	Rotavirus
Td/DT	Td/DT	Td/DT
	Tdap	Tdap
	Varicella	Varicella

*new indicates a newly constructed combination vaccine based on addition and subtraction of component parts for which price data are available. A blank indicates the absence of an equivalent vaccine for comparison with the benchmark.

References

A. Ak, J. L. Heier, C. L. Wardell III, O. Ergun, and P. Keskinocak, Improving the Pan American Health Organizations Vaccine Supply Chain, Informs, 2010.

Arnould, R.; DeBrock, L. The Application of Economic Theory to the Vaccine Market. Presented at A Study of the Economic Underpinning of Vaccine Supply. Sponsored by the National Vaccine Program Office and the Centers for Disease Control and Prevention on November 12, 1993 in Washington, DC.

Bjornerstedt, J. and J. Stennek (2001), Bilateral Oligopoly, Working Paper, No.555, IUI, Stockholm.

Borenstein, S. 1991. Selling Costs and Switching Costs: Explaining Retail Gasoline Markets. Rand Journal of Economics, 22: 354-369.

Danzon, P.M., N.S. Periera, S.S. Tejwani. 2005. Vaccine supply: A cross national perspective. Health Affairs. 24. 706-717.

DeRoeck DA, Bawazir SA, Carrasco P, Kaddar M, Brooks A, Fitzsimmons JF, et al. Regional group purchasing of vaccines: review of the Pan American Health Organization Revolving Fund and the Gulf Cooperation Council Group Purchasing Program. Inter J Health Plann Mgmt. 2006; 21: 2343.

Joyce. P. 1990. Price Discrimination in Top Scientific Journals. Applied Economics, 22: 1127-1135.

Kalorama. (2008) Vaccines 2008: World Market Analysis Report, Insights from the Editor. July 2008. [Online]

Kauf, Teresa L., 1999, Price Discrimination and Bargaining Power in the U.S. Vaccine Market, Implications for Childhood Immunization Policy, The Quarterly Review of Economics and Finance 39(2), 249-265.

Kessing, Sebastian; Nuscheler, Robert (2003) : Monopoly pricing with negative network effects: the case of vaccines, Discussion papers // WZB, Wissenschaftszentrum Berlin für Sozialforschung, Forschungsschwerpunkt Markt und Politische ökonomie, Abteilung Marktprozesse und Steuerung, No. SP II 2003-06, <http://hdl.handle.net/10419/51137>

Kremer, M. C. Snyder (2003): "The Revenue Consequences of Vaccines versus Drug Treatments", Harvard University, mimeo.

Kremer M, Williams H. Incentivizing innovation: adding to the tool kit. In Lerner J, Stern S, editors. Innovation policy and the economy. Vol. 10. Chicago (IL): University of Chicago Press; 2010. p. 117.

Kwoka, John E. The Output and Profit Effects of Horizontal Joint Ventures. *Journal of Industrial Economics* (1992).

Salkever, David S., and Richard G. Frank, Economic Issues in Vaccine Purchase Arrangements, National Bureau of Economic Research (Cambridge, MA) Working Paper 5248, 1995.

Shepard, A. 1991. Price Discrimination and Retail Configuration. *Journal of Political Economy*, 99: 30-53.