Welfare Effects of Public Procurement of Medicines: Evidence from Ecuador

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Abstract

This article evaluates the welfare implications of a public procurement program, where the Ecuadorian government procures medicines used for cancer treatment and distributes it to patients for free with the aim to benefit the poor. Using a unique dataset on Ecuador's pharmaceutical market, we estimate a structural model of demand and supply, and focus on two research questions related to this program. First, we consider a targeting strategy commonly implemented in various developing countries, where patients below a given income threshold qualify for the free drug. We compare this with a simpler drug distribution mechanism where every patient is a potential recipient of the free drug and the patients are served on first-come-first-serve basis. Our results show that the poor patients do self-select into the program, and the first-come-first-serve strategy does benefit the poor more compared to the relatively rich. However, the targeting strategy does a much better job in serving the poorest patients. Second, we study the supply side implications of this program. Our counterfactual exercises show that when the government procures low-cost drugs and provides them for free, it distorts the supply side incentives, and hence, market prices of similar low-cost drugs may increase by about 8% in response. Prices of the high cost drugs remain mostly unaffected. Therefore, the policy may end up negatively affecting near-poor patients that did not qualify for the free government drug.

Key Words: Government procurement, Pharmaceutical markets, Developing economy, Consumer welfare, Targeting

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1 Introduction

Access to drugs is a contentious issue in the context of developing and underdeveloped countries, where limited access has excluded many patients from the benefits of pharmaceutical innovations. This is especially crucial in case of life-saving drugs (e.g. cancer drugs), where high prices impose significant economic burdens on poor consumers. Governments in less-developed countries undertake various public welfare programs aimed at the poorer sections of the population in order to ensure that they have access to life-saving drugs. Under such programs, the below-poverty-line patients receive drugs at subsidized prices (even at zero cost).

However, implementing such income-based programs in developing countries can be a challenging task, as the potential recipients may lack credible income records (Alatas, Banerjee, Hanna, Olken, and Tobias (2012))[1]. Consequently, there is an increased emphasis on targeting strategies that do not rely directly on observing incomes. As an alternative strategy, the government may choose to procure a stock of low-cost generic version drugs[2] and provide those to patients on first-come-first-serve basis until the stock is over. This simple strategy will be an effective distribution mechanism if the poor patients self-select into the welfare program, consume the free generic drug, and rich patients choose to opt for branded drugs by buying those from the market.[3] The efficacy of this mechanism in serving the poorest depends on the heterogeneity of consumer preferences for branded and generic drugs that varies among rich and poor patients.

Additionally, implementation of a public welfare program may involve supply side implications. On the one hand, providing subsidized medicine unambiguously benefits the below-poverty-line consumers and increases their consumer welfare. However, this policy may have unintended consequences through supply side interactions. Under this program, the poorest among all consumers have access to the free medicine and hence are much less likely to buy those medicines from the market. If the low-income consumers are also highly price sensitive, the residual demand curve that the firms face is less elastic as a result of this policy. As a consequence, entry by the government and provision of free medicine for the poor may lead to firms charging higher prices in equilibrium. The extent of price increase

[1]Most of the potential recipients of the free drug in developing countries typically work in the informal sector and may lack verifiable records of their earnings.

[2]In our context, Ecuador government procures low-cost generic version of the medicine for free distribution. This is also common practice in other developing countries as this keeps the procurement costs of the government low. For example, under the 'Jan Aushadhi' scheme implemented by Indian government, generic version of the drugs are sold to the consumers at a subsidized price.

[3]Several theoretical and empirical studies in the existing literature recognize self-selection mechanisms as an effective way to design targeted aid programs. For example, see Nichols and Zeckhauser (1982), Besley and Coate (1992), Alatas, Purnamasari, Wai-Poi, Banerjee, Olken, and Hanna (2016)) among others.

in response to this policy depends on the level of government provision, and the elasticity of substitution among products in the market. The resulting price increase may lead to lower consumer welfare for the near-poor (i.e. above-poverty line) consumers who do not qualify for the welfare program. Hence, the overall effect of the policy on consumer welfare is an empirical question that we address in this paper by examining the effects of a drug procurement policy in Ecuador while accounting for firms' incentives to adjust their product prices in the market.

Our analysis is carried out in the context of drugs that are used for breast cancer treatment. Breast cancer is one of the most common types of cancer in the 40-60 age group and is the twelveth most common cause of death among females in Ecuador. Our dataset records sales and prices of four different types of molecules used to treat breast cancer between 2007 and 2014.[4] Since we observe consumer choices as well as the price setting behavior of the firms, we can ask: 'would low-income patients self-select and choose the government drug if the government enters the market and provides a generic drug for free?' 'What would have happened to equilibrium drug prices and consumer welfare if the government offered free medicine to below-poverty-line consumers?' To answer these questions, we take a structural approach and estimate a model of supply and demand where product prices are endogenously determined. Specifically, we allow heterogeneity in price sensitivity among consumers by flexibly modeling price coefficient as a function of consumer income. We recover marginal costs for drug production using equilibrium first-order conditions resulting from firm's profit maximization.

Our demand estimates reveal the presence of heterogeneity across different consumers in terms of demand characteristics such as price sensitivities and willingness to pay. In particular, high income consumers are much less price sensitive compared to low income consumers. The high price sensitivity of low income consumers implies that introduction of free medicine by the government would lead to significant substitution away from other products available in the market.

With demand and supply estimates in hand, we perform two counterfactual policy simulations. In our counterfactual world, the government procures a generic drug offered in the market and provides it to the cancer patients at zero cost.[5] Our first counterfactual exercise considers a targeted drug distribution strategy based on income, and compares it with a first-come-first-serve mechanism. The former (targeted drug distribution strategy) provides free drugs to the consumers who earn below a given income threshold. It therefore requires

[4] The government of Ecuador started providing the generic drug in 2015. Hence in our sample, we do not observe government entry. Please refer to section 2 for detailed discussion.

[5] Procurement of generic version of cancer drug is consistent with the government policy in Ecuador, since the generic version keeps the cost of procurement low, see section 5 for more details.

detailed information on consumer incomes, and hence may be difficult to implement in the informal developing country setting. Under the latter (first-come-first-serve strategy), any patient irrespective of her income may choose the free government drug until the stock of free drug is available. This is simple and easy to implement. Our analysis reveals that the low income consumers do self-select into the welfare program, and hence the first-come-first-serve policy benefits the low-income section of the society more compared to the relatively rich. Our simulation exercise shows that the consumers with higher income would opt for the products offered in the market even when the free government drug in available in their choice sets. This is driven by the heterogeneity in consumer preferences, as high income consumers are less price sensitive and derive higher utility from branded drugs even when they have access to the free government drug. However, we can not conclude that the first-come-first-serve policy dominates the targeting policy, as targeting directs the benefits of the welfare program more effectively among the poorest.

In our second counterfactual policy simulation, we allow the firms to adjust the equilibrium prices in response to the government entry. The government decides the income threshold, and provides free medicine to the consumers whose incomes fall below the threshold. Hence, the consumers below poverty line may choose to buy a drug offered in the market and pay the market price or opt to receive free medicine from the government program. The government provides a generic version drug for free under its program. Note that, if the preferences for product variety dominates the price effect, then a consumer may choose to opt for the market product even when the free government drug is available in her choice set. All other consumers who do not qualify for the government drug choose from the range of products available in the market conditional on buying a product.

In our analysis, we fix the income threshold at different levels and compute the equilibrium prices as well as the distribution of consumer welfare. Our counterfactual simulations reveal that the public procurement program leads to an increase in the aggregate consumer welfare. The welfare effects are heterogeneous among consumers. The low-income consumers being highly price sensitive, choose the free government drug in most of the cases and enjoy significant increases in consumer surplus. However, the choices made by the low-income consumers renders the residual demand curves faced by the firms relatively inelastic. Our exercise shows that the firms would increase prices in response to the government entry. In particular, the firms with low-priced generic products would increase prices by around 8%. Therefore, the near-poor patients (i.e., the poor patients right above the income threshold) are more likely to buy the low-priced products, and are most negatively affected by the public policy. The rich consumers who used to opt for branded products are not affected by the policy as the prices of the branded products is not affected due to entry of the government. Our flexible demand and supply model captures those differential effects by allowing heterogeneity across consumers.

Our article relates to two sets of research literature. First, this paper contributes to an active literature on government intervention and targeted social safety net programs for addressing the poorest section of the society (for example, see Bokhari, Gai, and Gottret (2007), Alatas, Banerjee, Hanna, Olken, and Tobias (2012), Alatas, Purnamasari, Wai-Poi, Banerjee, Olken, and Hanna (2016), Chatterjee, Kubo, and Pingali (2015), Duggan, Starc, and Vabson (2016), Polyakova and Ryan (2019) among others). The majority of studies conducted in developing countries have focused on the demand side of the targeting mechanism, by considering the role of consumer behavior in the adoption of a welfare program. Our study contributes to this literature by highlighting the supply side implications of the targeting policy, its effects on the firm behavior and its implications for consumer welfare.

Second, we also contribute to the growing literature on pharmaceutical product market in developing countries.[6] Chaudhuri, Goldberg, and Jia (2006) study the Quinolones antibiotic segment in India, and investigate the welfare implications of patent policy while allowing firms to adjust prices. Dutta (2011) also addresses welfare implications of patent policy by allowing firms to respond to policy changes. Duggan, Garthwaite, and Goyal (2016) estimates the price effects of pharmaceutical product patents in the context of India. Similarly, Mohapatra and Chatterjee (2018) studies the price control policy and its effect of drug availability across various regions in India. Our work complements this literature by estimating the price effects as well as the consumer welfare effects of a public procurement program aimed at helping the low-income consumers.

The rest of the article is organized as follows: Section 2 describes Ecuadorian health system, and the data. Section 3 presents the framework for analysis. Section 4 discusses estimation details and the results from estimation. Section 5 explains the set up of our counterfactual exercises and reports results from counterfactual analysis. Section 6 concludes.

2 Context and Data

Our study is conducted in the context of drugs that are used for treatment of breast cancer in Ecuador. In Ecuador, breast cancer is the twelfth most common cause of death among

[6] A large existing literature models pharmaceutical market in developed countries (e.g.: Ching (2010a), Arcidiacono, Ellickson, Landry, and Ridley (2013), Bokhari and Fournier (2013), Dubois, De Mouzon, Scott-Morton, and Seabright (2015), Shapiro (2016), Dubois and Lasio (2018), Shapiro (2018) to mention a few. Please refer to Ching, Hermosilla, and Liu (2019) for an excellent survey). Consumers in developed countries have access to health insurance market, while majority of the consumers are uninsured in a developing country. Therefore, modeling the decisions in developing country markets is different from developed country markets.

females, with more than 32.7 cases per 100,000 inhabitants. The treatment protocol of a patient diagnosed with early stage breast cancer consists of a combination of surgery, radiation treatment as well as chemotherapy to remove carcinogenic tissues to prevent the cancer tumor from growth. If the cancer is estrogen receptor positive, the patients are prescribed with hormonal therapy for a period of five years after the surgery, in order to minimize the probability of a reactivation of the disease. The molecules we study in our analysis (Tamoxifen, Anastrozole, Exemestane and Letrozole) are prescribed as part of the hormone treatment therapy recommended for most estrogen-receptor positive cancer patients.[7]

We obtained our primary data from the IMS Health Ecuador. Our data records sales as well as revenue at the stock-keeping-unit (SKU) level between 2007 and 2014 for the four different molecules used for treatment of breast cancer (Tamoxifen, Anastrozole, Letrozole and Exemestane). We define a quarter as a market.[8] According to the World Health Organization (WHO), the hormone treatment therapy prescribes a daily dosage of 20mg for an average adult. We use this information to convert the number of units for different presentations into number of daily dosages. Additionally, we collect data regarding incidence and the total number of diagnosed breast cancer cases from the reports published by Ecuadorian Health Authority. The total number of breast cancer cases converted in number of daily dosages serves as market size in our analysis. Table 1 reports the variations in the SKU level prices across products observed in our data. Table 2 reports the corresponding product market shares.

[Table 1 about here]

[Table 2 about here]

Molecule 'Anastrozole' is sold by two firms Astrazeneca and Medicamenta. While the branded version sold by Astrazeneca is priced at 7.7 USD per pack, the generic version of the molecule is sold by Medicamenta at a price of 3.2 USD. The cheapest alternative Tamoxifen is sold by two firms (Astrazeneca and Medicamenta) and are priced at close to 1 USD per 20mg. Tamoxifen also enjoys the highest market share among the products sold in the market. Molecule Letrozole is sold by Novartis and is priced at around 4 USD per pack. Similarly, molecule Exemestane is only sold by Pfizer at an average price of 3.85 USD per one unit. Since all the four molecules are imported from foreign countries, the corresponding exchange rate plays a role in determining the cost of import and hence the

[7]These medicines are classified as either estrogen-receptor modulator (SERM) or aromatase inhibitor (AI).

[8]For each year from 2008 to 2014, we observe data for all four quarters (28 quarters in total over seven years). We observe only the last quarter data for 2007, hence we end up with 29 markets in our analysis.

market price. Anastrozole molecule is imported from Brazil, Exemestane is imported from Italy, Tamoxifen is imported from Switzerland, and Letrozole is imported from Mexico. We collect data regarding daily exchange rates from the Ecuadorian Central Bank and use the quarterly average official exchange rate in our analysis. Finally, to construct empirical income distribution, we collect data regarding the individual income from the National Institute of Statistics and Census of Ecuador.

Next, we briefly discuss the Ecuadorian healthcare system and the provision for drug procurement. Ecuadorian constitution defines access to health services as a fundamental right mandated by the state. Since majority of the Ecuadorian population do not have any form of health insurance, paying for healthcare expenses can be challenging for poor patients.[9] Given this, the Ecuadorian government prepares a list of essential medicines, and conducts Corporate Reverse Drug Bidding (also known as SICM) to procure the essential drugs at minimum cost (Acosta, Basto, Fonseca, Durán, Vargas, et al. (2018)). The first procurement bidding to supply drugs for two years was conducted in 2011 with the goal to procure drugs starting from January 2012. Although under this program, the government planned to procure low-cost generic breast cancer drugs, due to problems in planning and execution, less than 10% of the proposed amount (amounting to less than 1% of the total sales in the market) was actually procured over the two years. This led to the termination of the program in 2013. The first successful drug procurement auction and distribution of generic drugs took place in 2015 where the government procured low-cost drugs through competitive bidding and distributed those among consumers.[10] Given that our sample ends in 2014, we do not observe the entry of the government in the dataset.[11] Therefore, we use a structural approach and estimate a model to uncover the underlying factors that affect the decisions of the consumers as well as the behaviors of the firms prior to the entry of the government. We can then use the estimated model to simulate the entry of government, study the welfare implications of this program and evaluate alternative allocation mechanisms. Now we describe the structural model in detail.

[9] According to a report by the Pan American Health Organization, in 2008, about 19% of the population was covered by the civil and armed force social security system and about 3% were covered by private health insurance. Reference: http://www1.paho.org/hq/dmdocuments/2010/Health_System_Profile-Ecuador_2008.pdf

[10] See the chapter V in the document titled 'Public Access to Quality Medicines: Public Procurement as a Mechanism to Guarantee the Right to Health' for detailed discussion on 2015 procurement mechanism and its improvements over 2011 system. Link: https://subastademedicamentos.compraspublicas.gob.ec/pdf/SERCOP_Public_access.pdf

[11] Since the government procurement amount in 2012 was a very small part of the entire market, we ignore the presence of government during that period.

3 Framework for Analysis

In this section we describe the model used to analyze the effect of government procurement on demand, prices and consumer surplus. We first describe the demand model and then explain the supply side of the market.

3.1 Demand Model

We use a random utility discrete choice model to estimate the demand for cancer drugs in Ecuador, which incorporates consumer heterogeneity in the valuation of products offered in the market. Similar discrete choice modeling has been used in Ching (2010b), Dunn (2012), Björnerstedt and Verboven (2016), and Dubois and Lasio (2018) among others, to estimate demand in pharmaceutical drug markets.

A quarter is defined as a market. There are L_m patients, $i = 1, \cdots, L_m$ in a given market m. Each patient chooses one out of $J_m + 1$ differentiated products offered in the market denoted by $j = 0, \cdots, J_m$. Good 0 is the outside good or no-purchase alternative. Each patient maximizes the following indirect utility function, describing the utility derived by patient i for product $j = 1, \cdots, J$:

$$U_{ijm} = \underbrace{X_{jm}\beta + \xi_{jm}}_{\delta_{jm}} + \underbrace{[-\exp(\alpha + \sigma_p \text{income}_{im})]\, p_{jm}}_{\mu_{ijm}} + \epsilon_{ijm} \tag{3.1}$$

In the above specification, X_{jm} is a K-vector of product characteristics that are observed by the econometrician. We include a constant term, and dummy variables for the molecules in the X_{jm} specification. We also include a time trend to capture the change over time in the valuation of the outside option. Additionally, we include the interaction of time trend with the brand dummy to flexibly capture the variation in the valuation of a brand over time. The term ξ_{jm} is a demand shifter that is unobserved by the econometrician. Price is denoted by p_{jm}. Household specific variables include ($\text{income}_{im}, \{\varepsilon_{ijm}\}_{j\in J_m}$): income_{im} denotes the patient's household specific income and is drawn from the empirical income distribution in Ecuador. ε_{ijm} denotes the IID (across patients and products) utility shifter and is assumed to follow an Type-I Extreme Value distribution.

We allow price sensitivity to vary across households depending on the level of income. In the specification $[-\exp(\alpha + \sigma_p \text{income}_{im})]$, α captures the mean price sensitivity, and σ_p captures the variation in price sensitivity across households depending on income levels. In particular, a negative value of σ_p would imply that households with lower income are also more price sensitive. Capturing heterogeneity in price sensitivity among patients depending on the level of income is crucial for our analysis. As highlighted by Frank and Salkever

(1997) and Grabowski and Vernon (1992), the supply side effects of government provision will primarily depend on the heterogeneous price sensitivities of the households operating in the market.

We the define the utility provided by the outside option by:

$$u_{i0m} = \varepsilon_{i0m} \tag{3.2}$$

Following the specifications used in Berry, Levinsohn, and Pakes (1995), and Nevo (2000) the indirect utility can be split into two terms.

$$\begin{aligned} \delta_{jm} &= X_{jm}\beta + \xi_{jm} \\ \mu_{ijm} &= [-\exp(\alpha + \sigma_p \text{income}_{im})] + \epsilon_{ij} \quad \forall j = (0, \cdots, J_m) \end{aligned} \tag{3.3}$$

The model predicted aggregate market share of product $j \in J_m$ is given by

$$s_{jm} = \int \frac{exp(\delta_{jm} + \mu_{ijm})}{1 + \sum_{k \in J_m} exp(\delta_{jm} + \mu_{ijm})} dP_D \tag{3.4}$$

where P_D denotes the joint distribution of income among households.

3.2 Oligopoly supply model

The oligopoly model serves two purposes. First, in combination with the demand parameters, it enables one to uncover the marginal costs prior to the government's entry. Second, based on the demand parameters and uncovered marginal costs, it can be used to predict the price effects of the government welfare program.

Each firm f owns a portfolio of products F_{fm} in market m. Its total variable profits are given by the sum of the profits for each product $k \in F_{fm}$:

$$\Pi_{fm}(\vec{p}) = \sum_{k \in F_{fm}} (p_{km} - c_{km}) s_{km}(\vec{p}) M \tag{3.5}$$

where c_{kM} is the constant marginal cost for product k and $s_{km}(\vec{p})$ is corresponding market share, now written as a function of the $J \times 1$ price vector $\vec{p}$. The profit maximizing price of each product $j = 1, \cdots, J$ should satisfy the following first-order condition:

$$s_{jm}(\vec{p}) + \sum_{k \in F_{fm}} (p_{km} - c_{km}) \frac{\partial s_{km}(\vec{p})}{\partial p_{jm}} = 0 \tag{3.6}$$

Note that, while a price increase for a product k directly raises profits proportional to current demand $s_{jm}(\vec{p})$, it lowers the product's own demand, which lowers profits proportional to the current markup. Additionally, it raises the demand of the other products in the firm's portfolio, which partially compensates for the reduced demand of the own product. If the first-order conditions hold for all products $j = 1, \cdots, J$, a multiproduct Bertrand-Nash equilibrium obtains.

To write this system of J first-order conditions in vector notation, define the $J \times J$ matrix θ^F as the firms' product ownership matrix, a block- diagonal matrix with a typical element $\theta^F(j,k)$ equal to 1 if products j and k are produced by the same firm, and 0 otherwise. Let $s(\vec{p})$ be the $J \times 1$ vector of market shares, and $\Delta(\vec{p}) = \partial s(\vec{p})/\partial p'$ be the corresponding $J \times J$ Jacobian matrix of first derivatives. Let $\vec{c}$ be the $J \times 1$ marginal cost vector. Using the operator $\odot$ to denote element-by-element multiplication of two matrices of the same dimension, we have

$$s(\vec{p}) + (\theta^F \odot \Delta(\vec{p}))(\vec{p} - \vec{c}) = 0 \tag{3.7}$$

This can be inverted to give the following expression:

$$\vec{p} = \vec{c} - (\theta^F \odot \Delta(\vec{p}))^{-1} q(\vec{p}) = 0 \tag{3.8}$$

which decomposes the price into two terms: marginal cost and a markup, which depends on the own- and cross- price elasticities of demand.

We model the log of marginal cost for a drug j in a market m to depend linearly on the observed cost shifters, w_{jm} and on an additive error term ω_{jm}

$$\log(c_{jm}) = w_{jm}\gamma + \omega_{jm} \tag{3.9}$$

where γ is the parameter vector to be estimated. Since these drugs are products with well-known technologies, we assume marginal cost to remain unchanged with level of production. We include molecule dummies for all 4 molecules to capture the cost differences across molecules. Since all these products are imported from foreign countries, fluctuations in the exchange rate act as a key contributor to the variations in the (local) marginal cost for these molecules. We have information about the country of origin from where a molecule is imported. Hence, we also include the interaction of molecule dummy with the origin country's exchange rate in w_{jm}.

4 Estimation and Results

The estimation of demand and marginal costs is similar to that in Berry, Levinsohn, and Pakes (1995). We construct moments using equations (3.3) and (3.9), and estimate the parameters using the Generalized Method of Moments. Endogeneity of price arises in this framework as the firm observes ξ_{jm} while deciding on prices. Hence, to estimate the model it is necessary to specify a reasonable set of instruments. Since all those molecules are imported from foreign countries, the country specific exchange rate affects the cost of import and hence is correlated with price. Therefore, we use one period lagged exchange rate for countries of origin as an instrument for price. Under the exclusion restrictions that the fluctuations in cancer drug market is independent of exchange rate fluctuations, exchange rate is a valid instrument for price. Following Berry (1994), Berry, Levinsohn, and Pakes (1995), we use characteristics of other firms as additional instruments. Further, we construct two measures of firm presence to capture popularity of a firm in other close therapeutic categories and use those as instruments. In our data, we observe firms selling not only drugs to treat breast cancer, but also sales of drugs used to treat other forms of cancer. We construct revenue share of a firm in other related cancer drugs as well as weighted average of prices of drugs offered by each firm in other forms of cancer and use those as instruments. Firm presence captures the popularity of a firm in the cancer drug market. We expect that if a firm is popular in those related categories, then the firm may also enjoy more brand-recognition and trust among the consumers and doctors in the drug for breast cancer, therefore may charge a higher mark up. Under the assumption that the long-run popularity is independent of the short run demand shocks, these firm presence measures act as valid instruments.

Before reporting the results from the BLP model, we first present the demand estimates from the logit model. Table 3 report estimates from OLS estimation where we estimate the demand model ignoring endogeneity, and from 2SLS estimation where we allow endogeneity and instrument for price.

[Table 3 about here]

The estimated price coefficient in the OLS model is negative, but not significantly different from 0 reflecting the bias induced by endogeneity of price. Once we instrument for price, the price coefficient becomes negative and significant. Table 4 documents the results from estimation of the full model.

[Table 4 about here]

Note that in our specification, the price coefficient takes the form $[-\exp(\alpha + \sigma_p * \text{income}_i)]$, where α is the mean price sensitivity and σ_p captures the heterogeneity in price sensitivity that varies with household income. The estimated mean price coefficient is positive and significant, while the coefficient of income is negative and significant, implying that the price sensitivity of a patient decreases as the income of the household increases.

[Figure 1 about here]

Figure 1 plots the histogram of the price coefficient as a function of consumer income. There are two key points to note here. First, all price coefficients are negative and bounded away from zero. Second, there is a tail to the left implying that consumers are highly heterogeneous in terms of price sensitivity. To gain more insight into consumer heterogeneity, we plot the price coefficients with respect to income. The plot is given in figure 2.

[Figure 2 about here]

As evident from the figure, the price coefficient monotonically decreases as income decreases. This heterogeneity is crucial in understanding the supply side responses when the government enters the market. This suggests that the poor consumers being highly price sensitive may self-select into the welfare program and consume the free drug. Additionally, when the government entry caters to the poorest section of the market, the remaining individuals with relatively higher income have comparatively lower sensitivity for price. Given this, firms may re-optimize their pricing strategy and the new equilibrium prices may be higher than the pre-government entry prices.

The result from marginal cost estimation is reported in table 5. The marginal cost of production of Tamoxifen is the lowest while estimated marginal cost of Anastozole is the highest among the molecules considered. The median markup of the products sold comes up to around 0.71 USD while median lerner's index $((price - mc)/price)$ is estimated to be 23%. Next, we use our demand and marginal cost estimates to perform the counterfactual exercises by allowing the government's entry to provide free drugs in the market.

5 Counterfactual Exercise

We use the estimated model, and simulate the provision of free drug where the government procures one of the drugs offered in the market and provides it at zero cost. The Ecuadorian government spends close to 7% -12% of its GDP on public purchases of medicine, which amounts to USD 250-350 million worth of annual transactions in the public drug market. Therefore, to minimize the cost of acquisition, the policy statement encourages the procurement of low-cost generic medicines. To quote the policy document,

"The State will promote the production, importation, commercialization, dispensing and sale

of generic medicines with emphasis on the essentials. Its use, prescription, dispensation and dispensing is mandatory in public health institutions."[12]

Consistent with the policy statement, in our counterfactual simulations, we allow the government to procure a generic version of the cancer drug and offer it for free to the patients. In particular, in our exercise, we simulate the entry of 'Taxus Tablet 20 Mg X 30' at zero price into the market.

We carry out two counterfactual policy simulations. First, we consider a target-based distribution mechanism where only the consumers below a certain income threshold qualify for the free drug. We compare it with a simpler drug distribution mechanism that serves the patients on first-come-first-serve basis, and evaluate the extent to which the low-income consumers self-select into the welfare program. In our second counterfactual exercise, we study the supply side implications of the government program and compute the equilibrium market prices and overall distribution of consumer welfare in response to the government entry.

5.1 A comparison of the drug distribution mechanisms

Targeted income-based social welfare program has been widely used in less-developed countries as a means to provide safety-net to the low-income section of the population (Coady, Grosh, and Hoddinott (2004)). Under income-based drug distribution program, the government fixes an income threshold and the patients whose income fall below the threshold value qualify for the free drugs. However, implementing such income-based programs can be a challenging task in the less-developed countries, as large sections of the potential recipients typically work in the informal sector and hence may lack verifiable records of their earnings. Consequently, there is an increased emphasis on targeting strategies that do not rely on directly observing incomes. As an alternative strategy, the government may choose to procure a stock of low-cost generic version drugs and provide those to patients on first-come-first-serve basis until the stock is over.

A simple example would make things clear. Suppose the government sets the income threshold such that the income of the bottom 30% of the population falls below the threshold. Then under the targeting strategy, those low-income consumers qualify for the free drug and may choose to avail the benefits of the program. On the other hand, under the first-come-first-serve mechanism, any patient, irrespective of her income level may opt for the government drug. However, the government stock is limited and can serve only 30% of the population (as we have assumed in our example). Therefore the allocation of this stock is

[12] Reference: Corporate Reverse Drugs Bidding (WHO website) Link: https://www.who.int/phi/3-DanielLopezSalcedo.pdf

done on first-come-first-serve basis. Note that, the first-come-first-serve mechanism is easier to implement and does not require any information regarding the consumer income. This simple strategy will be an effective distribution mechanism to serve the poorest, if the low-income patients self-select into the welfare program and consume the free generic drug, while the rich patients choose to consume the branded drugs by buying those from the market.

In order to understand the extent to which the market sorts the patients into the welfare program under the first-come-first-serve system, we simulate the consumer choices in this counterfactual world and compare it with the choices made by the consumers in the base case where the targeting mechanism is implemented. In our simulation exercise, the government procures 'Taxus 20 Mg X 30' tablet packs. We fix the stock of procurement at 30% of the market size.[13] The drugs are provided to the consumers at zero cost. Note that, while the price of the government drug is set at zero, other non-price product characteristics of the government drug is identical to the observable characteristics of 'Taxus 20 Mg X 30' tablets available in the market.

Under targeting mechanism, the low-income patients whose income fall in the bottom 30% of the income distribution qualify for the free drug.[14] We carry out the following steps to simulate the consumer choices under targeting. First, we draw a random sample of consumers from the empirical income distribution, where the number of consumers (the sample size) is equal to the size of the market. Under targeting mechanism, the patients with income below the 30th percentile choose from among 8 products offered in the market (7 products are offered in the market at market price, 8th product is provided by the government) and the outside option. The consumers whose income is above 30-th percentile do not qualify for the free drug and choose among 7 products sold in the market and the outside option. For each consumer and for each product available in her choice set, we draw an i.i.d. random shock from the extreme value type-1 distribution. Given the estimated utility parameters, product characteristics, level of consumer income and consumer-product specific random shocks, we can compute the utility that a consumer derives from each product by following the functional form in (3.1). The consumer then chooses that product which derives the maximum utility. We draw large number of random samples[15] from the empirical income distribution, repeat each of those steps for every drawn sample and record the choices made by the consumers.

Next we compute the consumer choices under the first-come-first-serve mechanism. Under

[13]We choose the stock at 30%, as this is close to the proposed procurement amount by the Ecuadorian government.

[14]This implies that in our counterfactual exercise, we put the income threshold at 30-th percentile of the income distribution.

[15]In practice, we draw 1000 random samples in our counterfactual exercise.

this mechanism, each patient is a potential recipient of the benefit of the program. Since the procurement stock can serve only a subsection of the population (in this case 30%), the order of arrival of the patients into the market plays an important role in determining access to the free drug. The patients who arrive early in the sequence will have the option of free drug in their choice set, while the patients who arrive after the stock is over will not have the option to choose the free government drug. Given that the size of the market is close to 120 thousand, the number of possible arrival sequences of the patients is extremely large (in the order of magnitude of 10^{100}) and hence it is computationally impossible to implement. To address this, we resort to a simulation based exercise and draw a large number of random sequences for a given sample. In practice, we draw 1000 different random arrival sequences for each sample. For a given sample of consumers drawn from the income distribution, for a given sequence, we compute the utility that a consumer derives from each product by following the functional form in (3.1). We then allow consumers to make their choices following the order in the sequence. A consumer chooses the product that derives the maximum utility in her choice set. The choice set of the first patient in the sequence includes the 7 products offered in the market, the free government drug and the outside option. We allow the government free drug to be included in the choice set of the patients until the stock is over (that is 30% of the population have chosen this option). The patients in the sequence that arrive after the stock of government drug is over, choose among 7 choices offered in the market and the outside option.[16]

While simulating the consumer choices we consider two different situations. In the first case, we assume that the government drug comes with zero cost to the patients. Implicitly this assumes that, in addition to zero monetary cost, the drugs available under public health system are easily accessible, consumers have perfect information about drug availability, and hence the consumers do not face other non-monetary costs while consuming the drug. However in developing countries, free drug provision is often associated with various complications such as long waiting time, lack of healthcare workers and limited access to drugs due to unavailability (Chaudhury, Hammer, Kremer, Muralidharan, and Rogers (2006), Banerjee, Deaton, and Duflo (2004)). Therefore, often in developing countries, relatively high-income consumers opt for purchasing drugs from the private market instead of relying on the government sources.[17] To take this into account, we consider a situation

[16] It is important to note here that, while implementing this counterfactual exercise, we have assumed away any strategic supply side responses, i.e. we have assumed that the firms in the market would keep charging the pre-government entry drug prices and would not update the equilibrium prices in response to the government entry. We will consider the supply side implication in the next exercise.

[17] Private providers enjoy a high market share in many low-income countries. According to the data from the Demographic and Health Surveys (DHS), 50 percent of households seeking pediatric outpatient care in Africa and 70–80 percent in India visit the private sector with little variation over the 20 years that these

where we assign a negative utility shock to a consumer when she chooses the free government drug. We allow the the magnitude of the shock to be positively correlated with the level of income of the consumer, so that the individuals with higher income derive more negative utility from the free government drug. In practice, we draw i.i.d. random numbers from log-normal distribution (with mean 0 and variance 1). The negative of the random number is denoted as the utility shock for the free government drug. We sort the sample of utility shocks. The consumer with the highest income is assigned the most negative shock, the consumer with second highest income is assigned the second most negative shock and so on. The consumer with lowest income gets the smallest (least negative) shock in our simulation. We compute the utility that a consumer derives from each of the products in the choice set, and the consumer chooses the product that derives the maximum utility.

[Table 6 about here]

The results from our counterfactual exercise are reported in table 6. As the table suggests, 34.2% of the consumers who get the free government drug under targeting policy also get the free drug under first-come-first-serve strategy. When we add non-monetary costs involved in the public provision of the drug, the fraction increases to 38.2%. Note that, under targeting, every consumer in the bottom 30% of the population (by income) benefits from the public program. According to our calculations, under first-come-first-serve policy, close to 34-38% of those beneficiaries (from the lowest 30% segment of the income distribution) enjoy the benefits of the free drug.

[Figure 3 about here]

[Figure 4 about here]

Which sections of the population do benefit from the public welfare program under the first-come-first-serve mechanism? We plot the income distribution of the beneficiaries under this scheme and report those in figures 3 and 4. In figure 3, we plot the case where we assume zero cost of government drug and in figure 4 we plot the case where the public provision involves a non-monetary cost. Each bar in the diagram responds to the fraction of consumers who benefit under the first-come-first-serve mechanism and belong to a specific decile in the income distribution. The graphs suggest that the market does sort the consumers on the basis of income into the welfare program, and hence compared to the high-income segment of the population, the low-income consumers benefit more from the welfare program. Note that, since consumers are drawn randomly, on average, consumers from each decile have an

surveys have been collected (See Grépin (2014), and Das, Holla, Mohpal, and Muralidharan (2016)) equal probability of arriving early in the sequence and getting the free government drug in their choice set. This implies if consumer preferences are homogeneous (i.e., each decile of the income distribution have similar preferences for the free drug), then on an average from each income segment equal number of consumers will opt to consume the free drug.[18] However, as our results show, consumers with lower income are more likely to self-select and consume the free drug, while the consumers with higher income would opt for the products offered in the market even when both have equal probability of having the government product in their choice set. This is driven by the heterogeneity in consumer preferences, as high income consumers are less price sensitive and hence derive higher utility from branded drugs even when the free government drug is available in their choice set. As figure 4 shows, under the first-come-first-serve mechanism, out of all the patients who consume the free government drug, less than 8% have incomes that belong to the top 20 percentile in the income distribution. Similarly, close to 62% of the free drug is consumed by the patients whose incomes fall in the bottom half of the income distribution. This suggests that although less effective compared to the targeting policy, the first-come-first-serve policy does benefit the poor section of the population more compared to the relatively rich. Ecudaorian government's current policy of drug distribution involves a first-come-first-serve strategy. Our analysis shows that implementing the targeting policy instead can certainly direct the benefits of drug allocation for the low-income segment of the population more effectively compared to the current mechanism.

5.2 Supply-side Effects of the Government Entry

Our second counterfactual exercise is aimed at quantifying the price effects as well as the effects on consumer welfare when the government provides a medicine free of cost to a set of patients whose household income falls below a certain income threshold. We are interested in two key aspects while studying the entry of the government. First, we quantify the heterogeneous price responses of branded and generic products in the market when the government provides a generic drug at zero price. Second, we quantify the variations in the price responses with varying levels of the income threshold as the number of low income consumers who qualify for free medicine varies in a market.

We fix the threshold level by allowing a specific fraction of households to qualify for free medicine. For example in our analysis, if threshold is fixed at 30%, then the households in the bottom 30% of income distribution qualify for free government medicine. Given a threshold level and conditional on choosing an inside product, the qualifying patients choose among 8

[18] Hence, under homogeneous preferences, each of the bars in the diagram would be close to 10%.

products: 7 products that are offered in the market at market price and the product provided by the government (in our analysis, 'Taxus Tablet 20 Mg X 30' with zero price). Consumers who do not qualify for free medicine (consumers above income threshold), choose among the 7 observed products and pay the market price (conditional on buying an inside product). In our analysis, we vary the level of income threshold from 5% to 65%, (specifically, 5%, 10%, 15%, 20%, $\cdots$, 65%) and allow different fractions of low income households to qualify for government provision.

Given that a fraction of low income consumers have access to the free government drug, the profit maximization problem of each firm is defined as follow:

$$\Pi_{jm} = \max_{p_{jm}} \Big[(p_{jm} - c_{jm})s_{jm,nq}M_{nq} + (p_{jm} - c_{jm})s_{jm,q}M_q\Big] \tag{5.1}$$

In the above expression, M_{nq} represents the number of patients who do not qualify for free government medicine. On the other hand, M_q represents the number of patients that qualify for the government provision and hence have the option of choosing the government provided free drug among other options in their choice set. For example, if the threshold is fixed at 30%, then the bottom 30% households in the income distribution will be included in M_q while rest 70% of the market is denoted by M_{nq}. In the expression (5.1), $s_{jm,nq}$ represents the share of product j in the consumer segment who does not qualify for free government drug in market m, while $s_{jm,q}$ represents j's share among consumers who qualify for the government provision. Hence in our counterfactual analysis, we allow the possibility that the low income households (below threshold) can still buy a drug offered in the market. The corresponding market shares are given by:

$$\begin{aligned} s_{jm,nq} &= \int \frac{\exp(\delta_{jm} + \mu_{ijm})}{1 + \sum_{k \in J_m} \exp(\delta_{jm} + \mu_{ijm})} dP_{Dnq} \\ s_{jm,q} &= \int \frac{\exp(\delta_{jm} + \mu_{ijm})}{1 + \sum_{k \in J_m} \exp(\delta_{jm} + \mu_{ijm}) + \exp(\delta_{gov} + \mu_{i,gov})} dP_{Dq} \end{aligned} \tag{5.2}$$

In the expression (5.2), P_{Dnq} denotes the conditional income distribution of the households who are above income threshold (do not qualify for free government drug) while P_{Dq} denotes the income distribution of the low income households who qualify for the free drug. As is clear in the expression, the only difference between the individual probabilities come from the additional option (free government drug) that the low income consumers face while making the choices. Following the specification (3.3), δ_{gov} is identical to the mean utility a consumer generates from the product 'Taxus Tablet 20 Mg X 30' in a given market, while zero price implies $\mu_{i,gov}$ equals to zero for all consumers who qualify for the free drug.

We derive the first order conditions for each product from the firm's profit maximization problem and use those to solve for the equilibrium market prices under the government provision. For a given income threshold, the first order condition for a product j in market m is given by

$$(p_{jm} - c_{jm}) \left[\frac{\partial s_{jm,nq}}{\partial p_{jm}} M_{nq} + \frac{\partial s_{jm,q}}{\partial p_{jm}} M_q \right] + s_{jm,nq} + s_{jm,q} = 0 \tag{5.3}$$

In the system of equations (5.3), the partial derivatives, $\frac{\partial s_{jm,nq}}{\partial p_{jm}}$, and $\frac{\partial s_{jm,q}}{\partial p_{jm}}$ are obtained by differentiating the share equations as specified in (5.2) using the demand model. Given the estimated marginal costs from (3.8), we derive the new equilibrium prices for a given income threshold. In our empirical implementation, we use the last three quarters of our sample to derive the results for our counterfactual exercises. For each income threshold level (5%, 10%, 15%, $\cdots$, 65%), we draw 1000 random samples from the empirical income distribution and solve equilibrium prices for each sample and report the average equilibrium price.

The price effects of government entry for the products offered in the market at various income threshold levels are documented in figure 5 and figure 6. In our counterfactual exercises, the government offers the product 'Taxus Tablet 20 Mg X 30' for free to low income consumers below a given income threshold. As the figure 5 demonstrates, varying the level of income threshold has the maximum effect on the equilibrium prices of Taxus tablets (Taxus Tablet 10Mg X 30 and Taxus Tablet 20Mg X 30).

[Figure 5 about here]

In addition to Taxus tablets, we observe some price increases for Nolvadex tablets. The entry of government has negligible effects on other high priced products sold in the market. Note that as documented in table 1, the Taxus tablets (both 10 Mg and 20Mg) are the cheapest alternatives available in the market followed by Novadex 10Mg Tablet. Figure 6 documents the percentage change in the equilibrium prices of the products offered in the market as income threshold varies.

[Figure 6 about here]

Our counterfactual exercise shows that, depending on the level of threshold, Taxus tablet prices may go up by 5% to 8%. Since the low income consumers right above income threshold (those that do not qualify for free medicine), are more likely to purchase the cheaper alternatives, a price rise may affect their consumer welfare in a negative way. Government entry has no effect on the high income consumers who are more likely to buy the high priced branded alternatives.

Why do Taxus prices go up when government provides the Taxus 20Mg tablets for free to low income consumers? Note that, as our demand estimates suggest, low income consumers are also the most price sensitive consumers in the market. Hence prior to the entry of the government, conditional on buying, the low income consumers were more likely to buy the Taxus tablets as these were the cheap alternatives available in the market. After the government enters and offers Taxus tablets for free to a fraction of low income patients at the bottom of the income distribution, the most elastic consumer segment that used to purchase Taxus tablets will substitute to the free Taxus tablets provided by the government. Given this, the residual demand faced by Taxus (from the remaining low income patients) is less elastic, as those consumers are relatively higher income consumers compared to the bottom fraction. Therefore, the re-optimized equilibrium price of Taxus goes up in response to the government's entry. Note that a naive (and misleading) way of interpreting the price effect of government entry can be to conclude that entry leads to more competition and hence should lead to lower prices. However, as our analysis shows, heterogeneity among consumers, may actually lead to increased prices in response to entry. Our differentiated random coefficient demand model that captures the flexible substitution patterns across different products offered in the market, along with consumer heterogeneity play a key role in deriving these price responses in the counterfactual exercise.[19]

We follow Williams (1977), and Small and Rosen (1981) to compute the surplus for consumer i under government entry with new equilibrium prices and compare it to the consumer welfare at the observed prices where no government entry has taken place. The consumer surplus for a low-income patient that does not qualify for the free government drug is given by

$$CS_{im,nq} = \frac{1}{\alpha_i}\left[\gamma + \ln\left[1 + \sum_{k=1}^{J_m} \exp\left(v_{ijm,nq}\right)\right]\right] \tag{5.4}$$

The consumer surplus for a low-income patient that does qualify for the free government drug is given by

$$CS_{im,q} = \frac{1}{\alpha_i}\left[\gamma + \ln\left[1 + \sum_{k=1}^{J_m} \exp\left(v_{ijm,q}\right) + \exp(v_{gov})\right]\right] \tag{5.5}$$

In the above expressions, α_i stands for the price coefficient for individual i. Similarly, $v_{ijm,q}$, and $v_{ijm,nq}$ stand for the deterministic component of utility for consumer i when i qualifies for

[19] Note that, in our counterfactual exercise, we do not allow entry and exit of existing firms and products. It is possible that in the event of Government entry, existing firms may exit the market, or withdraw some of their products which may also affect equilibrium prices and consumer welfare. The reader can refer to Eizenberg (2014), Wollmann (2018), Fan and Yang (2019), Mohapatra and Chatterjee (2018) to see more examples of such analysis.

free drug and does not qualify for free drug respectively, and is equal to utility for consumer i net of the idiosyncratic ε term. We integrate out over consumer heterogeneity to obtain aggregate consumer surplus.

The variations in the aggregate consumer surplus for different levels of income threshold are documented in figure 7.

[Figure 7 about here]

The bottom solid line plots total consumer welfare prior to government entry. The dotted line plots the total consumer welfare after the government enters and a fraction of consumers qualify for free medicine in the market. For every level of income threshold, the total consumer surplus exceeds the consumer surplus under no government entry. This suggests that the gain in consumer welfare due to provision of free drugs exceeds the loss in consumer welfare due to higher prices for every level of income threshold. Additionally, as more consumers are included in the program and qualify for free medicine, the consumer welfare monotonically increases.[20]

The distributional effects of government entry on consumer welfare is documented in figures 8, 10, 9, and 11. Figure 8 and figure 9 plot the percentage deviation in consumer surplus for the consumers below the income threshold when the threshold covers bottom 30% and bottom 20% consumers in the income distribution respectively. Similarly, Figure 10 and 11 document the the distribution of percentage deviation in consumer surplus for the consumers above the income threshold in the corresponding cases.

[Figure 8 about here]

As documented in the figure 8 and in 9, low income consumers below the threshold level who qualify for free medicine register a large gain in consumer surplus. As expected, the gain in consumer surplus increases monotonically as income of the household goes down, and the least income consumers receives the highest benefit from this program.

[Figure 9 about here]

This large increase in consumer welfare from lowest section of income distribution contributes to the overall increase in the consumer surplus. However, the consumer surplus of all consumers does not go up unambiguously. In particular, as reflected in figures 10 and 11, the consumer surplus of consumers right above the income cutoff are the most negatively affected.

[20]Note that, this is a partial equilibrium analysis, and we do not consider the general equilibrium effect which may take into account the negative welfare effects of higher government spending, such as higher tax rates.

[Figure 10 about here]

Due to the rise in the equilibrium prices in response to government entry, the generic products (Taxus tablets) also raise their prices. Since low income consumers close to the income threshold who do not qualify for free drugs are also more likely to buy the low priced generic products, higher prices for those drugs have a negative consumer welfare effect on those consumers.

[Figure 11 about here]

As income increases, and the price sensitivity goes down, the consumer welfare loss also decreases. So, high income consumers are not affected by the government entry. The heterogeneity among consumers indicates that although the overall benefit of the policy is positive, the unintended consequence of the policy negatively affects the consumers at the bottom segment of the income distribution right above the income threshold.

Public welfare programs in various developing countries link the benefits provided to a consumer to its observable characteristics such as the level of income. As argued in Akerlof (1978), this 'tagging' mechanism may improve the efficiency of public spending by providing the benefits to the most needy recipients. As we infer from our analysis, the government's policy to provide free drugs to low income consumers does achieve its goal by providing significant consumer surplus gain for low income consumers. However, our analysis also present an interesting aspect that as an unintended consequence of the policy, the near-poor will end up paying more for the drugs compared to the case where government does not enter.

6 Conclusion

This article studies the welfare effects of a public medicine procurement program in the context of a developing country like Ecuador using a structural model. We consider a targeted drug distribution strategy based on income that provides free drugs to the consumers who earn below a given income threshold. We compare this mechanism with a first-come-first-serve strategy, where any patient irrespective of her income, may choose the free government drug until the stock of free drug is available. The former (Income-based targeting) requires detailed information on consumer incomes, and hence may be difficult to implement in the informal developing country setting, while the latter (first-come-first-serve mechanism) is simple and is easy to implement. Our analysis reveals that the low income consumers do self-select into the welfare program, and hence the first-come-first-serve policy does benefit the low-income section of the society more compared to the relatively rich, even though the targeting policy directs the benefits of the welfare program more effectively among the poorest.

Our welfare analysis shows that the provision of free medicine to the poor consumers leads to an increase in the aggregate consumer welfare. As the procurement level increases, the overall aggregate consumer welfare unambiguously increases. The consumers below poverty line who receive the drugs for free enjoy significant increases in consumer surplus. However, the welfare change is heterogeneous across consumers. In particular, consumer surplus for low-income consumers right above the income threshold (the near-poor consumers) may decrease due to the supply side responses. This is because the market prices of low-cost drugs may increase by about 8%, while the prices of high cost drugs remain mostly unaffected. Our results show that supply side incentives may distort the goals of the program and may lead to unintended consequences by hurting the consumers right above the income threshold. Therefore, the policy designer needs to take this account while implementing the program. One proposed solution can be to regulate the prices of the generic drugs that cater mostly to poor consumers. Other solutions like providing income specific subsidies or direct benefit transfers may lead to better outcomes which we propose for further research.

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7 Tables and Diagrams

Table 1: Descriptive Statistics: Prices across Products

Brand	Product Description	Molecule	Price (in USD)			
			Mean	S.d.	Min	Max
Astrazeneca	Arimidex Tablet 1 Mg X 28	Anastrozole	7.72	0.69	5.69	9.13
	Nolvadex Tablet 10 Mg X 30	Tamoxifen	0.81	0.09	0.67	1.05
Medicamenta	Taxus Tablet 10 Mg X 30	Tamoxifen	0.50	0.02	0.46	0.58
	Taxus Tablet 20 Mg X 30	Tamoxifen	0.98	0.04	0.71	1.04
	Trozolet Tablet 1 Mg X 28	Anastrozole	3.28	0.22	3.21	4.86
Novartis Pharma	Femara Tablet 2.50 Mg 30	Letrozole	4.12	0.33	3.33	4.94
Pfizer	Aromasin Tablet 25 Mg X 30	Exemestane	3.85	0.51	3.13	5.33
No. of Observations: 200; No. of Markets: 29						

Notes: This table records the prices for products sold in the market in USD. The product description refers to the description of the stock-keeping-unit (SKU).

Table 2: Descriptive Statistics: Market Share across Products

Brand	Product Description	Molecule	Market Share (in %)			
			Mean	S.d.	Min	Max
Astrazeneca	Arimidex Tablet 1 Mg X 28	Anastrozole	2.6	1.0	0.0	5.0
	Nolvadex Tablet 10 Mg X 30	Tamoxifen	12.6	4.9	0.2	26.5
Medicamenta	Taxus Tablet 10 Mg X 30	Tamoxifen	36.0	10.9	0.0	49.8
	Taxus Tablet 20 Mg X 30	Tamoxifen	32.4	8.2	9.9	67.2
	Trozolet Tablet 1 Mg X 28	Anastrozole	1.1	1.1	0.0	3.8
Novartis Pharma	Femara Tablet 2.50 Mg 30	Letrozole	7.9	3.2	2.2	18.5
Pfizer	Aromasin Tablet 25 Mg X 30	Exemestane	7.3	7.9	0.2	42.7
No. of Observations: 200; No. of Markets: 29						

Notes: This table records the percentage market shares for products sold in the market. The product description refers to the description of the stock-keeping-unit (SKU).

Table 3: Descriptive Results, Logit Demand

Variable	**OLS**	**2SLS**
Price	-0.28	-1.13***
	(0.21)	(0.35)
Constant	-5.77***	-5.71***
	(0.35)	(0.36)
Dummy Exemestane	0.50***	0.99***
	(0.13)	(0.21)
Dummy Letrozole	0.90***	1.02**
	(0.35)	(0.37)
Dummy Tamoxifen	2.49***	2.77***
	(0.36)	(0.39)
TimeTrend×Medicamenta Dummy	0.44***	0.41***
	(0.08)	(0.08)
TimeTrend×Novartis Dummy	-0.43***	-0.26**
	(0.08)	(0.10)
TimeTrend×Pfizer Dummy	-0.26***	-0.24***
	(0.07)	(0.08)
TimeTrend	-0.25***	-0.14
	(0.10)	(0.11)
No. of Markets	29	29
No. of Observations	200	200

Notes: Standard errors in parentheses, $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 4: BLP estimates

Variable	**BLP**
Non-Linear Parameters	
Mean Price Sensitivity	4.50***
	(1.10)
Price × Income	-4.62***
	(1.34)
Linear Parameters	
Constant	-0.40
	(1.70)
Dummy Exemestane	1.19***
	(0.14)
Dummy Letrozole	0.52
	(0.38)
Dummy Tamoxifen	2.46***
	(0.38)
TimeTrend×Medicamenta Dummy	0.65***
	(0.13)
TimeTrend×Novartis Dummy	-0.11
	(0.09)
TimeTrend×Pfizer Dummy	-0.42***
	(0.09)
TimeTrend	-0.06
	(0.10)
No. of Markets	29
No. of Observations	200

Notes: Standard errors in parentheses, ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 5: Marginal Cost Parameter estimates

Variable	**OLS**
Dummy Anastrozole	0.90***
	(0.03)
Dummy Exemestane	0.85*
	(0.46)
Dummy Tamoxifen	-0.75***
	(0.07)
Dummy Letrozole	0.14
	(0.2)
Brazil Exchange Rate	1.85***
× Dummy Anastrozole	(0.09)
Italy Exchange Rate	0.20
× Dummy Exemestane	(0.34)
Switzerland Exchange Rate	-7.9***
× Dummy Tamoxifen	(2.22)
Mexico Exchange Rate	1.08***
× Dummy Letrozole	(0.19)
Median markup	0.71
Median(p-mc)/p	0.23
No. of Markets	29
No. of Observations	200

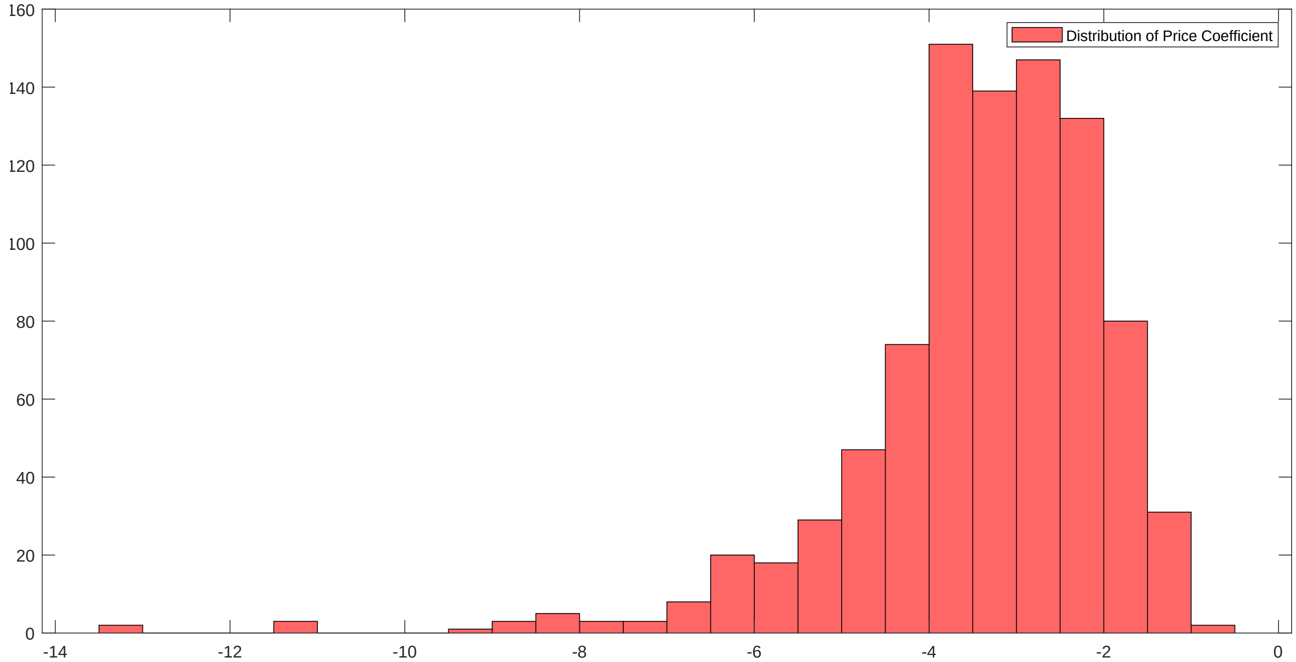
Notes: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6: Results from Counterfactual Exercise

	Fraction of consumers under targeting who would also get the free drug under market allocation
Zero cost for Govt drugs	34.2%
Non-zero cost for Govt drugs	38.3%

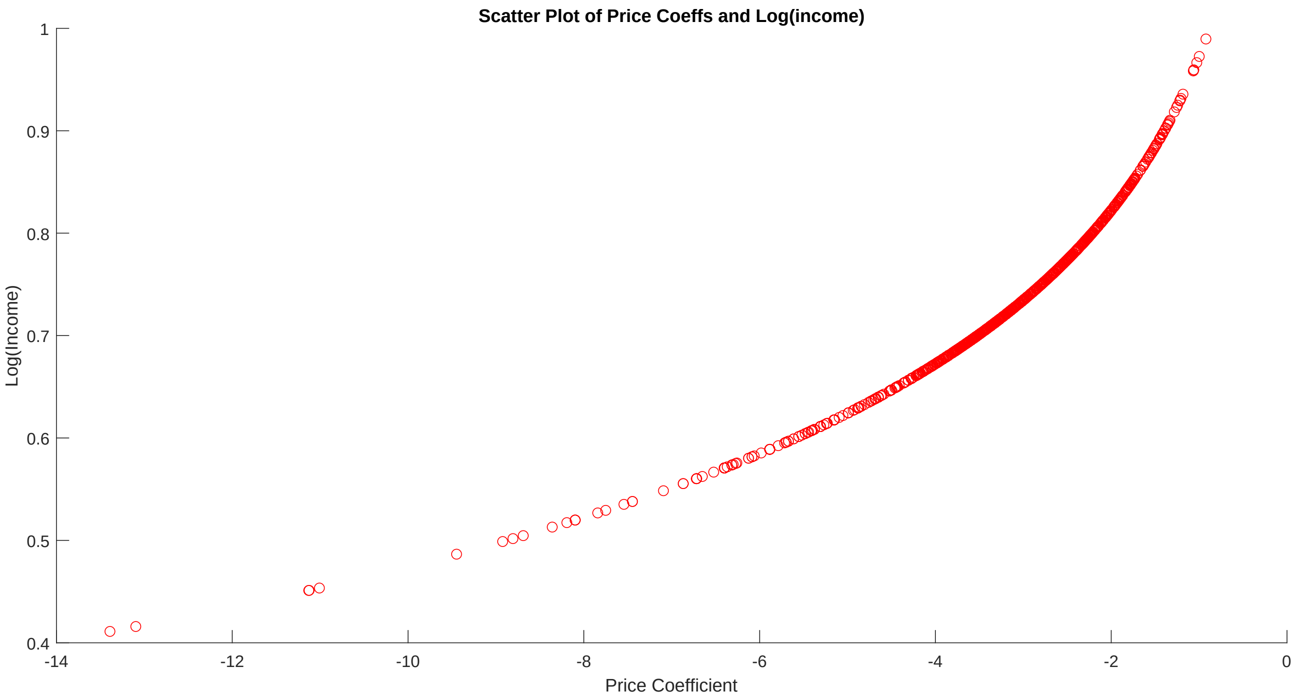
Notes: This table reports the results from counterfactual exercise and computes the fraction of consumers who benefit from free drug under targeting who would also get the drug under market allocation. See the discussion in section 5 for detailed explanation.

Figure 1: Histogram of Price Coefficients



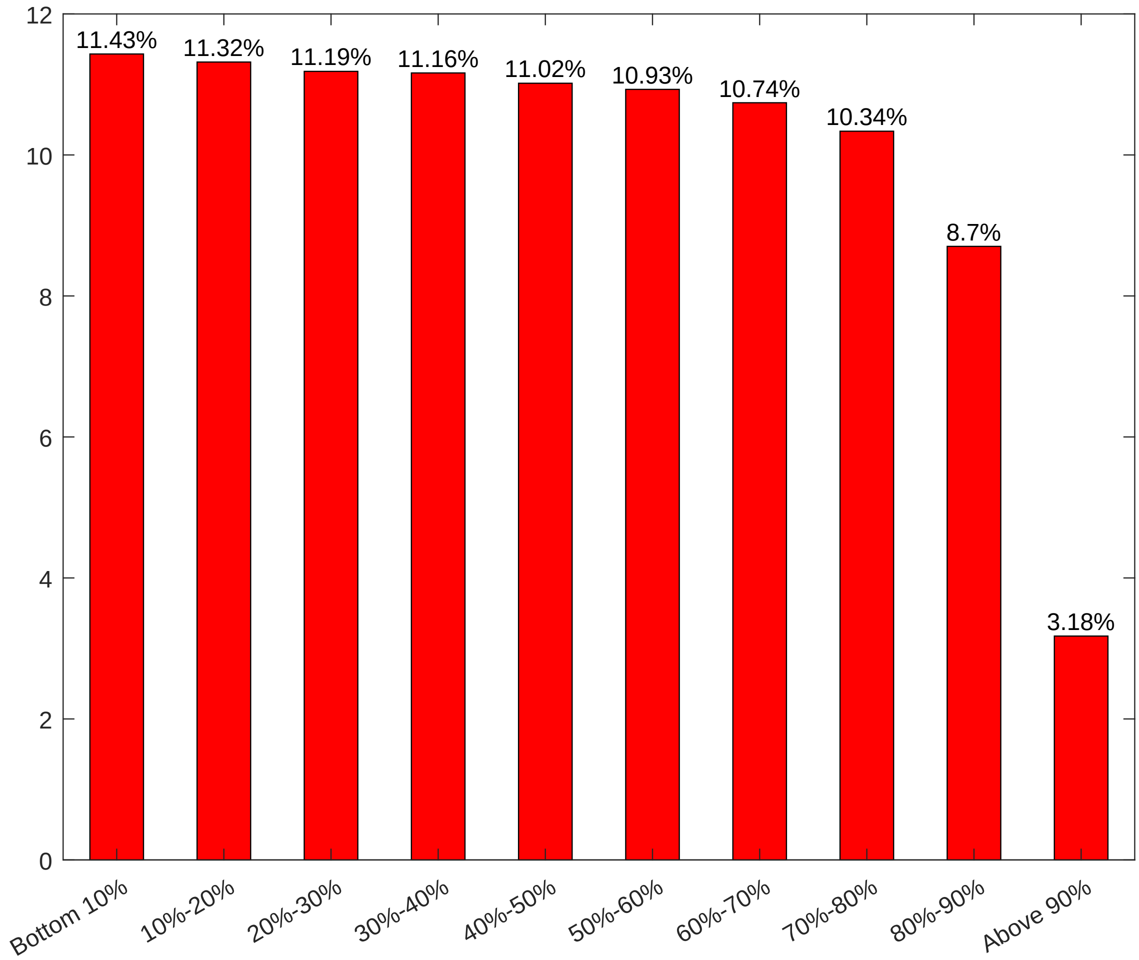
Notes: This graph plots the histogram of estimated price coefficients. Price sensitivities among consumers vary with Income.

Figure 2: Scatter Plot of Price Coefficients with respect to Income



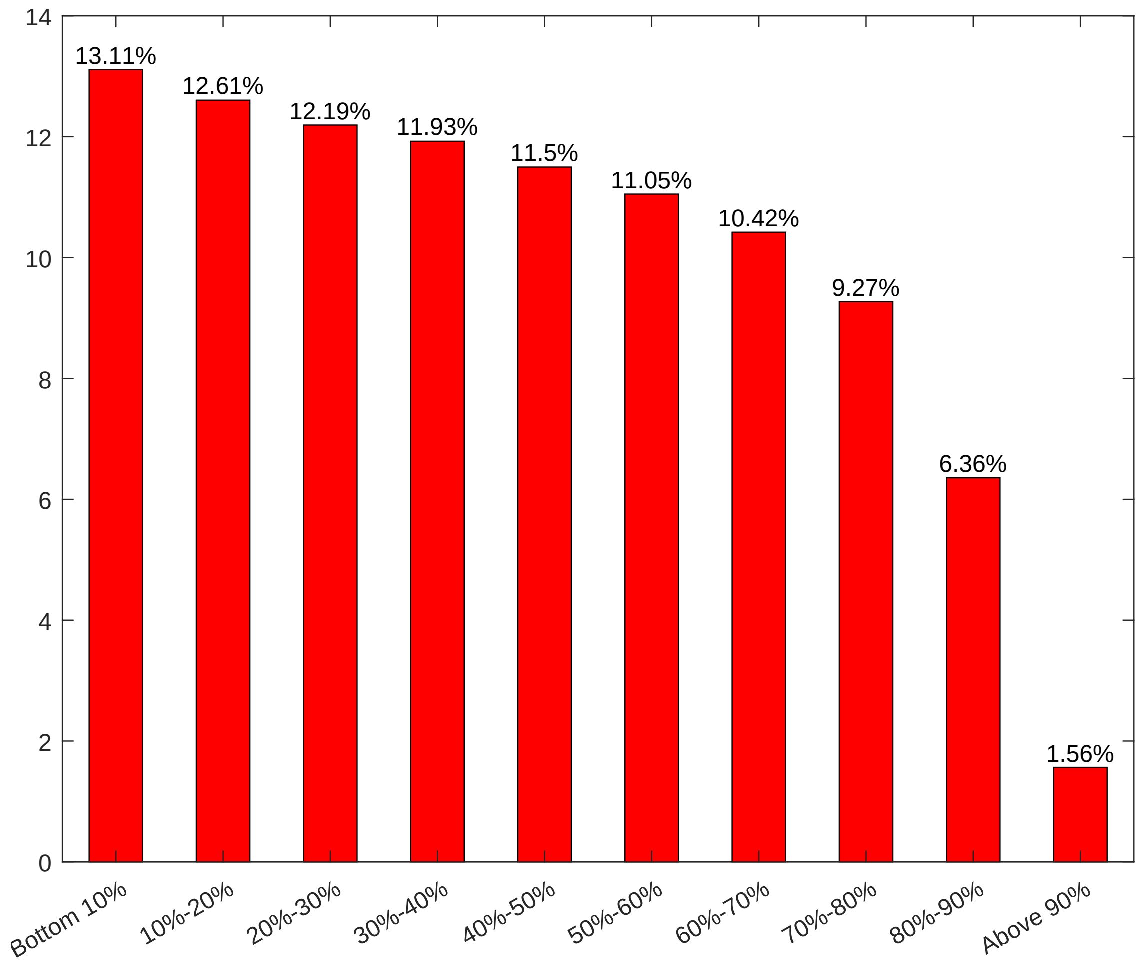
Notes: This table plots the estimated price coefficient in the x-axis and the log of income on the y-axis. As income increases, the estimated price coefficient is less negative.

Figure 3: Counterfactual Result: Income Distribution of Consumers Who Benefit from Free Drug



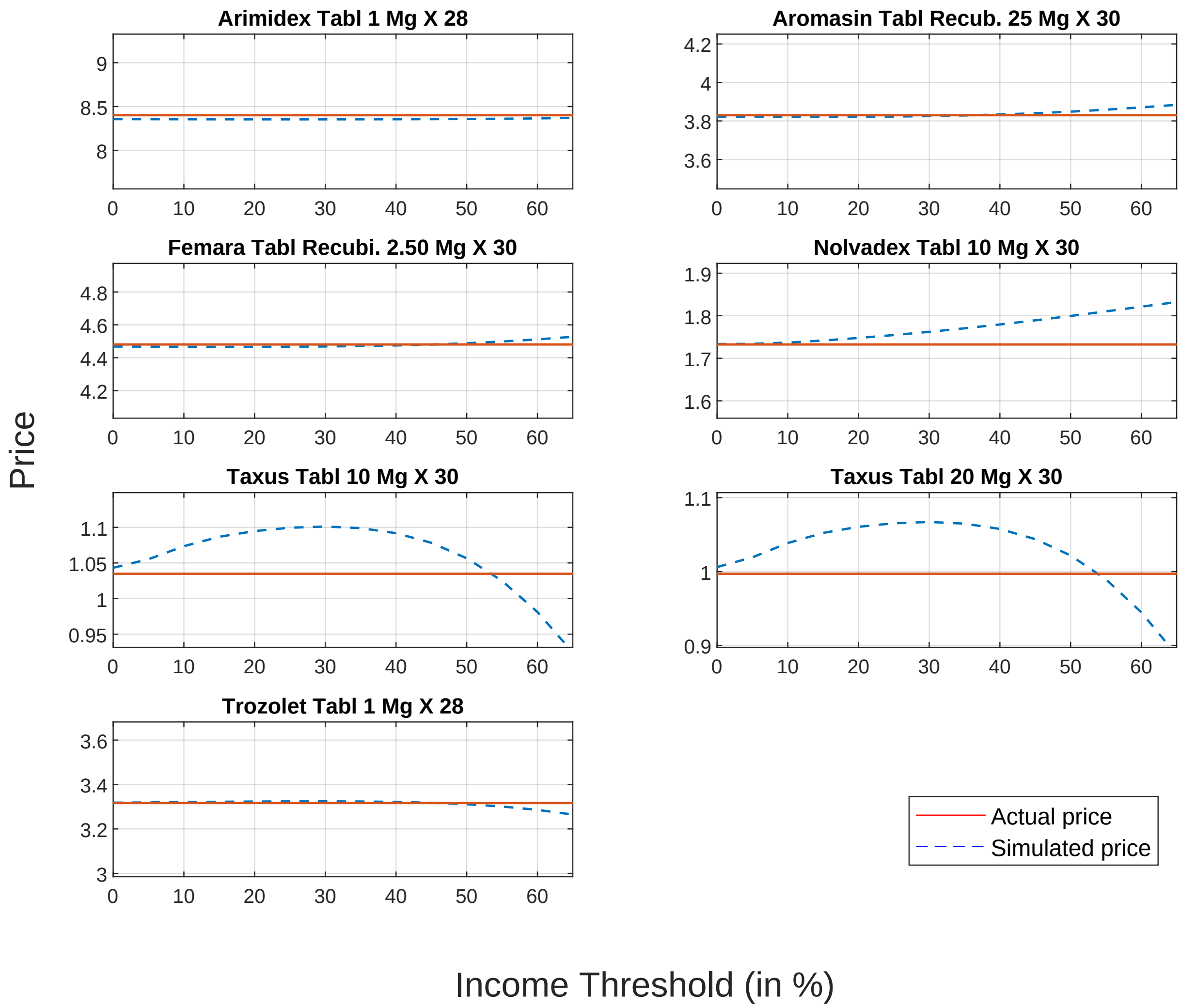
Notes: This figure plots the income distribution of consumers who benefit from the free drug provision. The X-axis plots the different deciles in the income distribution. The Y-axis plots the percentage fraction of consumers who get free drug and belong to a specific decile.

Figure 4: Counterfactual Result: Income Distribution of Consumers Who Benefit from Free Drug



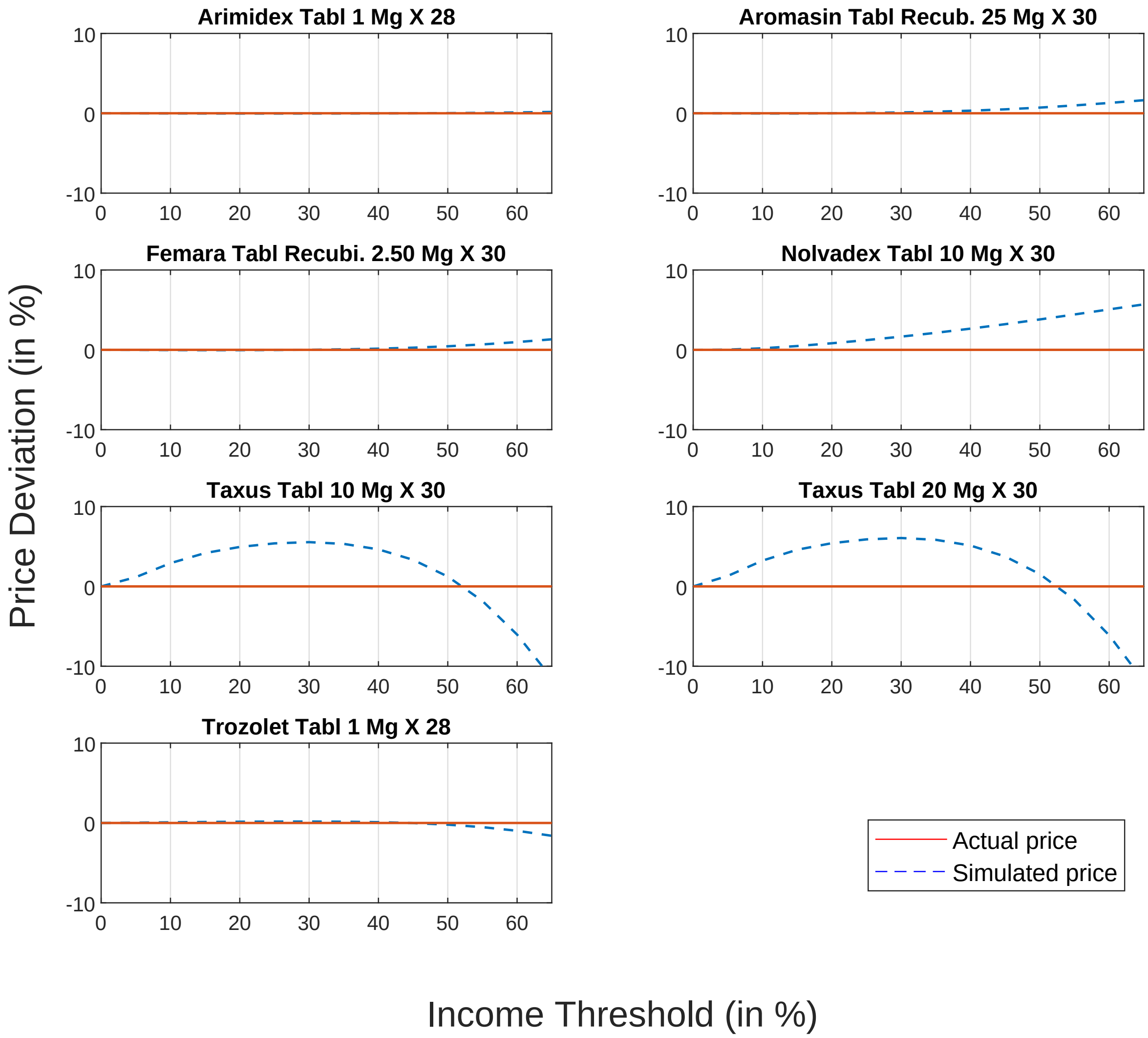
Notes: This figure plots the income distribution of consumers who benefit from the free drug provision. The X-axis plots the different deciles in the income distribution. The Y-axis plots the percentage fraction of consumers who get free drug and belong to a specific decile. Compared to figure 3, in figure 3, consumers incur a cost while consuming government drug (see the discussion in section 5 for details).

Figure 5: Counterfactual Result: Price variation with level of Income Threshold



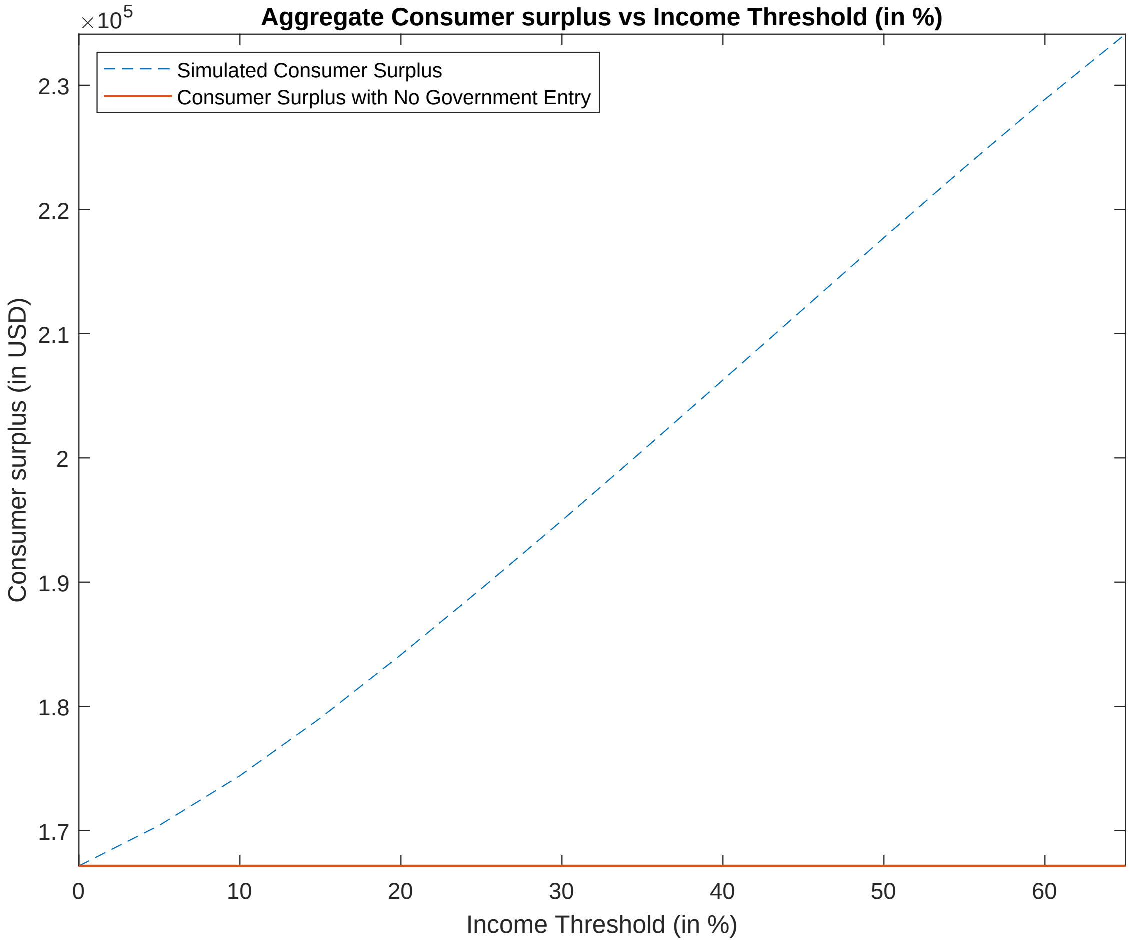
Notes: This figure plots equilibrium prices for each of the seven products offered in the market when government enters the market and offers drugs for free to low income patients below a level of threshold. We plot income threshold in x-axis which varies from 0% to 65%. Corresponding equilibrium price for each product is plotted in the y-axis.

Figure 6: Counterfactual Result: Price Deviation (in %) with level of Income Threshold



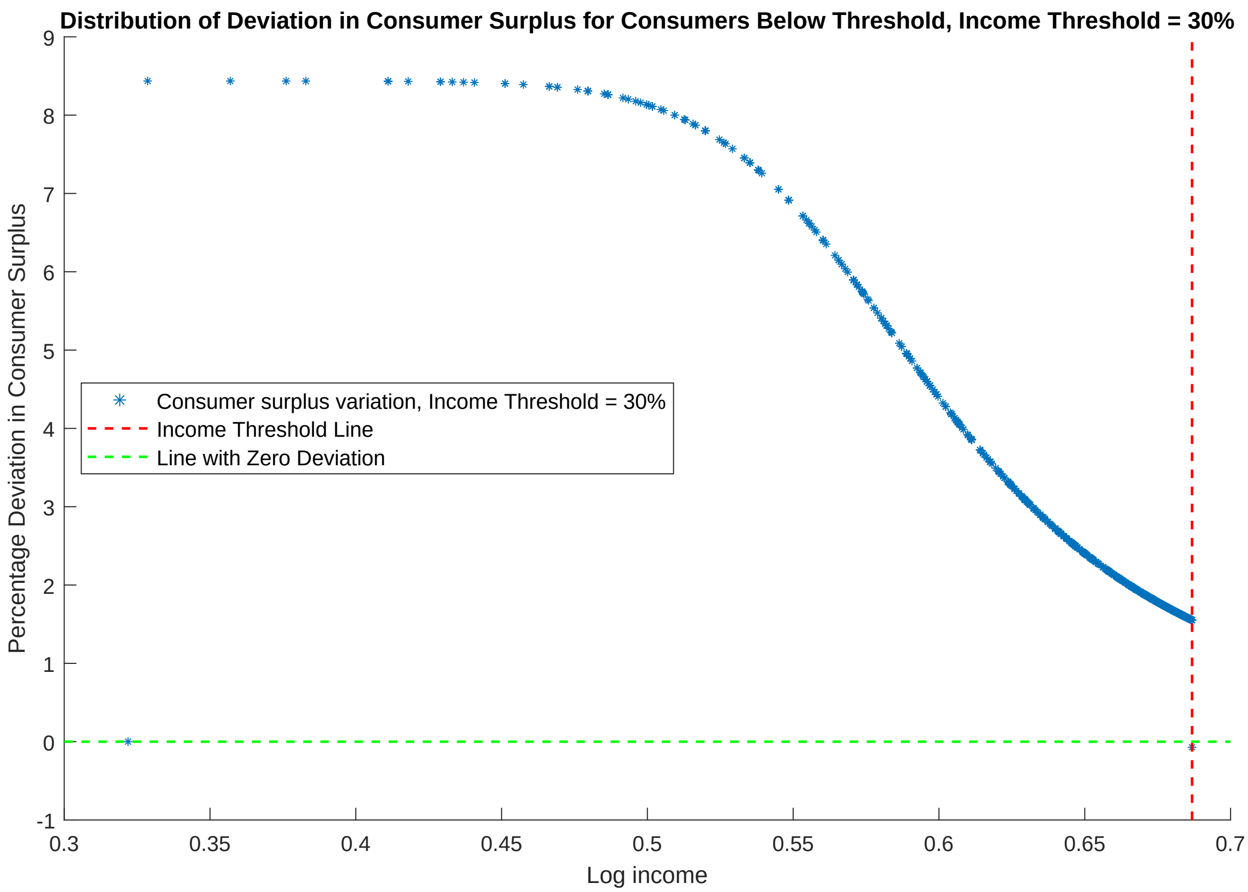
Notes: This figure plots percentage deviation of equilibrium price for each of the seven products offered in the market when government enters the market and offers drugs for free to low income patients below a level of threshold. We plot income threshold in x-axis which varies from 0% to 65%. Corresponding equilibrium price deviation for each product is plotted in the y-axis.

Figure 7: Counterfactual Result: Aggregate Consumer Surplus variation with level of Income Threshold



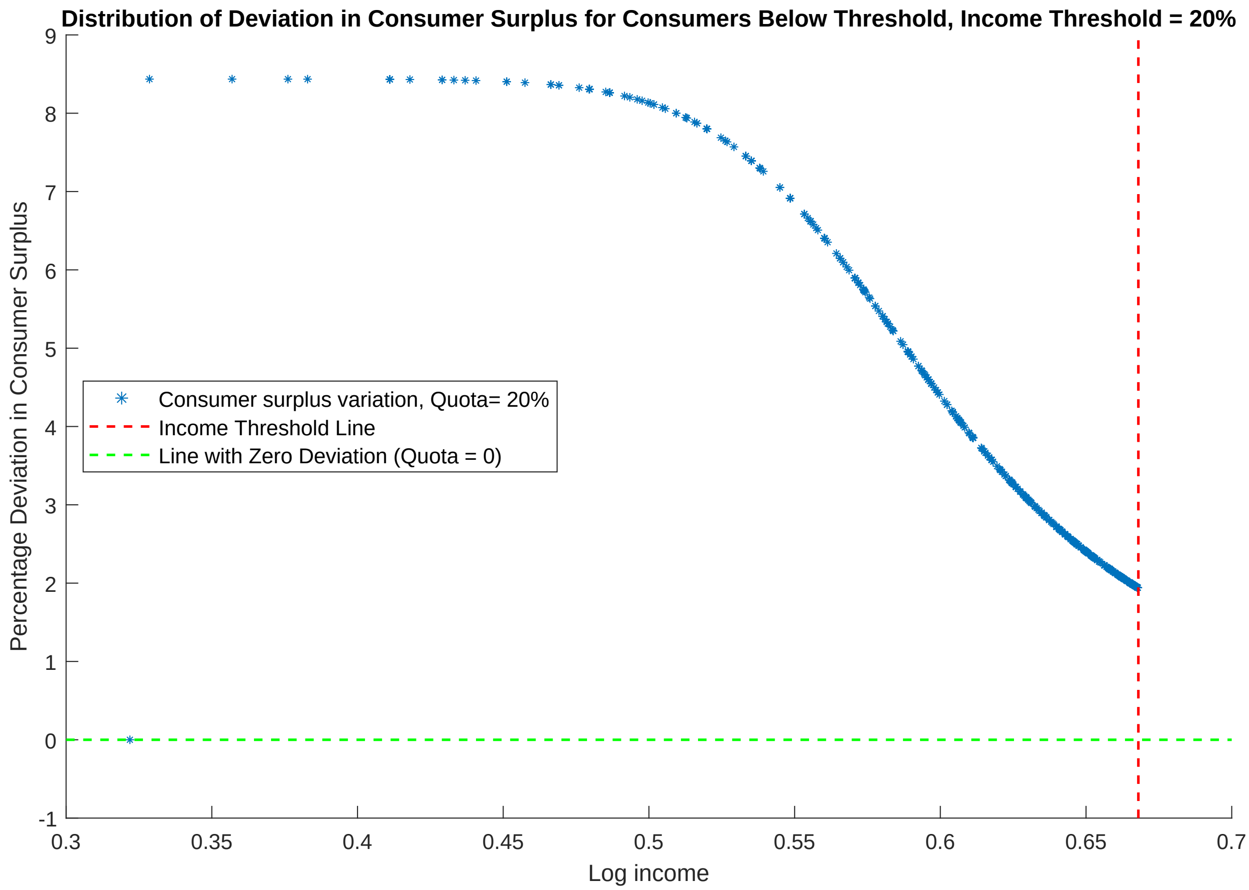
Notes: This figure plots aggregate consumer surplus for different income threshold levels when government enters the market and offers drugs for free to low income patients below a level of threshold. We plot income threshold in x-axis which varies from 0% to 65%. Corresponding aggregate consumer surplus (in USD) is plotted in the y-axis.

Figure 8: Counterfactual Result: Distribution of Consumer Surplus wrt Income



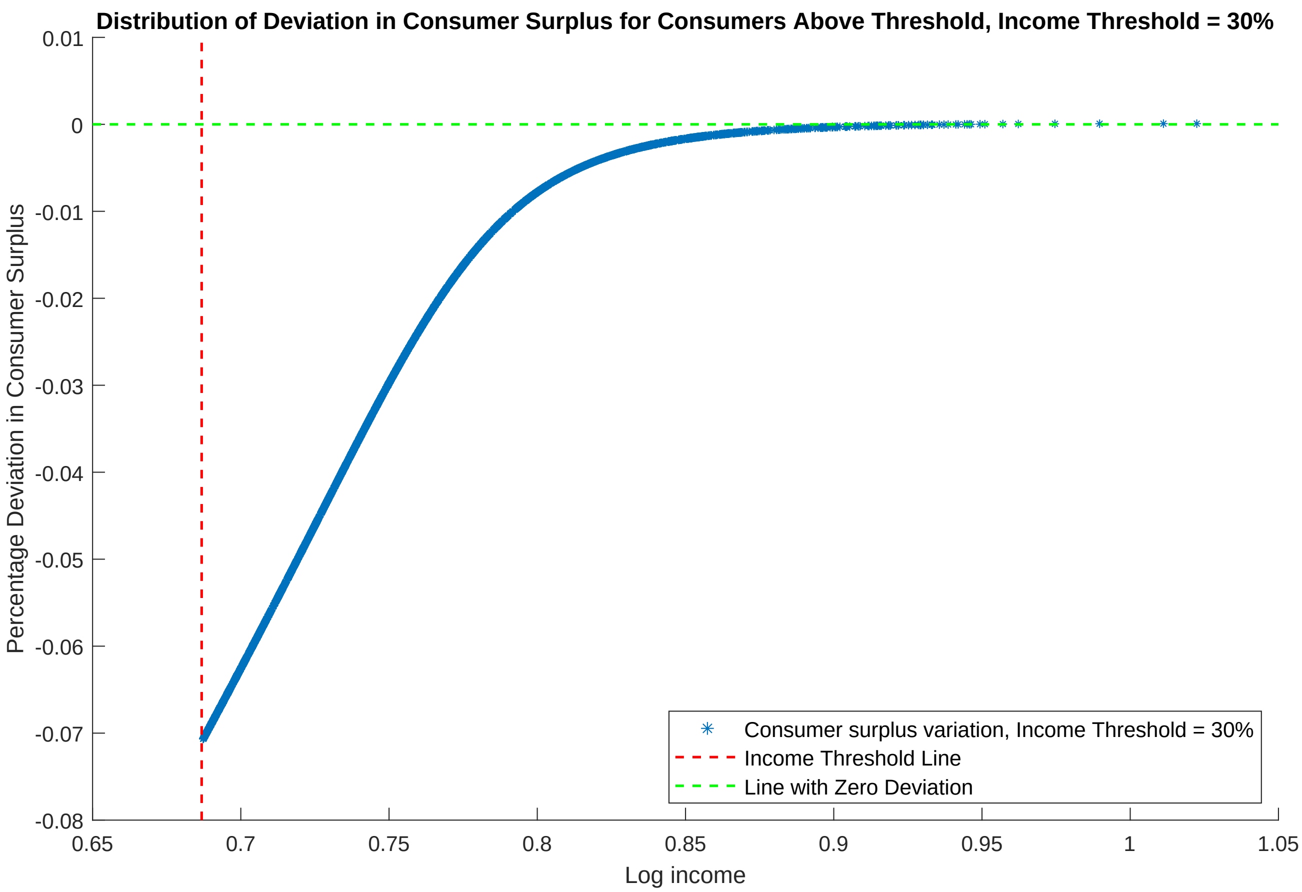
Notes: This figure plots the percentage deviation in consumer surplus in y-axis and log income in x-axis for consumers below income threshold where income threshold is set at 30% (bottom 30% patients in the income distribution). The horizontal green line shows the line of zero deviation, hence, any point to the north of this line is positive deviation. The vertical red line shows the income threshold line.

Figure 9: Counterfactual Result: Distribution of Consumer Surplus wrt Income



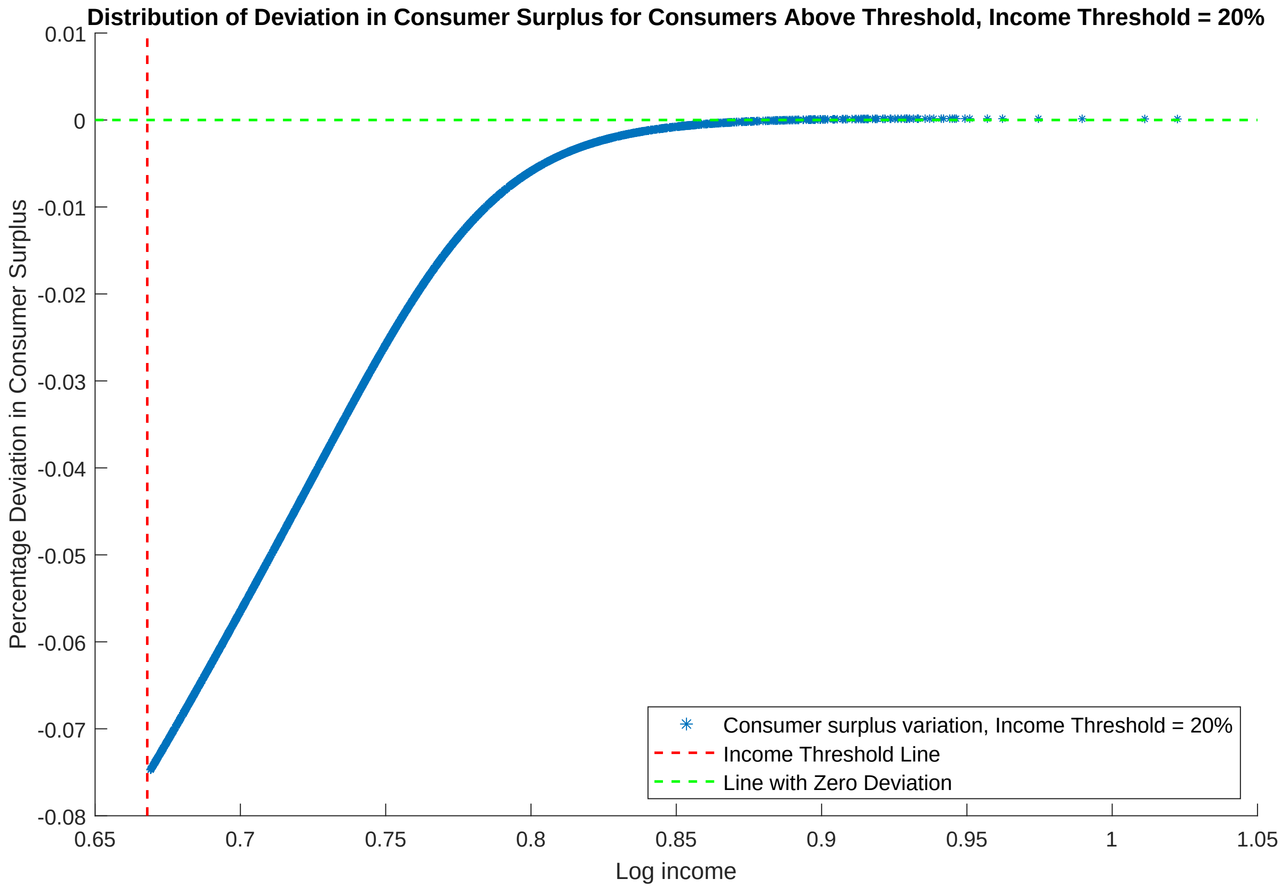
Notes: This figure plots the percentage deviation in consumer surplus in y-axis and log income in x-axis for consumers below income threshold where income threshold is set at 20% (bottom 20% patients in the income distribution). The horizontal green line shows the line of zero deviation, hence, any point to the north of this line is positive deviation. The vertical red line shows the income threshold line.

Figure 10: Counterfactual Result: Distribution of Consumer Surplus wrt Income



Notes: This figure plots the percentage deviation in consumer surplus in y-axis and log income in x-axis for consumers above income threshold where income threshold is set at 30% (top 70% patients in the income distribution). The horizontal green line shows the line of zero deviation, hence, any point to the south of this line is negative deviation. The vertical red line shows the income threshold line.

Figure 11: Counterfactual Result: Distribution of Consumer Surplus wrt Income



Notes: This figure plots the percentage deviation in consumer surplus in y-axis and log income in x-axis for consumers below income threshold where income threshold is set at 20% (top 80% patients in the income distribution). The horizontal green line shows the line of zero deviation, hence, any point to the south of this line is negative deviation. The vertical red line shows the income threshold line.