Who Benefits from Pharmaceutical Price Ceilings? Evidence from India*

JOB MARKET PAPER

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Abstract

With the goal of driving down drug costs, governments across the globe have instituted various forms of pharmaceutical price control policies. Understanding the impacts of such policies is particularly important in low- and middle-income countries, where lack of insurance coverage means that prices can serve as a barrier to access for patients. In this paper, I examine the theoretical and empirical effects of one implementation of pharmaceutical price controls, in which the Indian government placed price ceilings on a set of essential medicines. I find that the legislation resulted in broadly declining prices amongst both directly-impacted products and competing products. However, the legislation also led to decreased sales of price-controlled and closely related products, preventing trade that would have otherwise occurred. The sales of small, local generics manufacturers were most impacted by the legislation, seeing a 14.5% decrease in market share and a 5.3% decrease in sales. These products tend to be inexpensive and important for consumer access, but I use novel data to show that they are also of lower average quality. I provide evidence that the legislation impacted consumer types differentially. The benefits of the legislation were largest for quality-sensitive consumers, while the downsides largely affected poor and rural consumers, two groups already suffering from low access to medicines.

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1 Introduction

Globally, both government health departments and patients struggle with high and rising pharmaceutical prices (Abbott, 2017). In low- and middle-income countries (LMICs)[1] this issue is exacerbated by low levels of health insurance coverage, making high drug prices an important impediment to access (Towse et al., 2012). Low-income households living within LMICs are particularly affected by drug prices, not only due to low income and savings levels, but also due to over-reliance on medication for health treatment due to lack of access to medical facilities or trained medical professionals (Hammond et al., 2007). While medicines represent about 30% of total public and private health expenditures in developing countries (World Health Organization, 2011), they comprise between 50-80% of total health spending amongst *low-income* households in these countries (Hammond et al., 2007).

The high prices of originator, on-patent drugs in LMICs has long been a contentious issue, but even when generic drugs are introduced into the market, this has not necessarily been sufficient to achieve affordable prices (Danzon et al., 2015). Large price dispersion often remains amongst generic formulations of the same product, even after mature generic markets develop. This is largely due to what are known as "branded generics" markets, in which producers of generic drugs are able to compete on brand name as opposed to price. While generics are considered non-differentiated products in high-income countries, many LMICs do not require generic manufacturers to conduct bioequivalence trials, which ensure that generic medicines are absorbed in the body in the same strength and timeline as originator products. Furthermore, lax government enforcement of manufacturing standards can lead to inadequate quality-control in the manufacturing process of locally-produced generic medications. In turn, this leads to substandard and falsified medicines on the market – a serious issue in LMICs where studies estimate that 10-15% of medicines are substandard or pure fakes (Bate et al., 2011, 2015). This lack of regulatory assurance creates quality uncertainty in the market, which generic producers may work to overcome by establishing a reputation for quality through a brand name. However, this system of brand-name generics impairs the price competition amongst generic equivalents that otherwise might be expected.

Given the failure of market forces to decrease drug prices and the impact these prices have on consumers, governments have increasingly implemented price-control legislation that covers not only on-patent originator medications, but also generic medications. This study examines the impact of one such imple-

[1] All abbreviations used in this paper are listed in the appendix in Section A.

mentation of price controls, in which the Indian government set market-based price ceilings on a subset of pharmaceutical products, including both on-patent and generic medications. Market-based price controls such as the ones introduced in India have been praised as having potentially important upsides. Not only are they reasonably easy to develop and implement, but also by basing price controls on current market prices they arguably still allow for drug companies to earn a profit, thus may be sustainable in the long term. However, this type of legislation has been criticized as having potentially serious downsides as well. Companies could in theory react to this legislation by discontinuing or lowering production of price-controlled drugs and shifting this manufacturing capacity to more lucrative medications, leading to lower competition or regional shortages. Further, while price controls are enacted to lower medical spending, companies who were ex-ante pricing below the price ceiling are not required to lower their prices, meaning the most price-sensitive consumers do not necessarily benefit. Assessing the empirical effects of price controls in the Indian market can provide important information on the magnitude of both its intended and unintended effects.

In this paper, I measure the impact of pharmaceutical price ceilings on access to medicines in the Indian market. To do so, I first build a theoretical model of the Indian pharmaceutical market with vertically differentiated manufacturers operating in an oligopolistic market. To ensure this model is relevant in the Indian setting, I allow for multiple levels of firm quality or reputation. The predictions of this model are general, such that they would be applicable for a wide range of branded generics markets. To ensure that my theoretical model reflects true market characteristics, I look for actual differences in manufacturer quality and reputation in the Indian market. To do so, I make use of a unique dataset that tests drugs in the Indian market for a wide range of quality characteristics (e.g. correct amount of active pharmaceutical ingredient and disintegration time). I find that about 3-9% of drugs are "substandard" and fail quality tests, however this failure rate differs by producer type. I show that products produced by small, local generics manufacturers are more than twice as likely to fail quality testing as compared to large, exporting generics manufacturers and multinational firms. Average prices in the market reflect this quality differential, as products produced by small, local generics manufacturers are also less expensive than competing products on average.

I then combine a novel data set on the Indian retail pharmaceutical market with data on pharmaceutical manufacturers to test the predictions of my theoretical model. In doing so, I exploit the fact that the price

controls implemented in India were partial in nature by using a difference-in-differences framework to compare changes in outcomes of interest for price-controlled drugs to non-controlled drugs. To ensure that my results are not driven by "spillovers" from medications that received a price ceiling to those that did not, I exclude non-controlled drugs in therapeutic classes where at least one product received a price ceiling. I first examine the impact of the legislation on pharmaceutical prices and retailer mark-up, finding significant decreases in both outcomes post-legislation. I then examine the impact of price ceilings on market sales and find significant decreases in the sales volume of price-controlled and related products post-legislation. As these sales decreases are not driven by companies ceasing production of price-controlled medications, I identify two potential causes of this decrease in sales – a decrease in advertising by pharmaceutical firms and firms exiting sub-markets with high distribution costs, which are generally in rural areas. I present suggestive findings which indicate that both of these factors may contribute to the decrease in sales post-legislation.

A primary concern about price controls is that manufacturers may cease production of price-controlled medications, leading to less competition and potentially shortages. As a last step in this paper, I test whether firms were more likely to exit price-controlled markets after legislation. I find that local generics manufacturers were more likely to exit price-controlled markets after legislation, but multinational firms and exporting generics manufacturers were not. Local generics manufacturers tend to sell inexpensive products, which are important for consumer access. However, these manufacturers are of mixed reputation, and, as I show in the paper, produce medications that are on average lower quality than those produced by competing firms. Thus, the impact on consumer welfare of these firms exiting price-controlled markets is unclear.

There is a large body of evidence on the impacts of pharmaceutical price controls, though most empirical and theoretical evidence is in the context of high-income countries.[2] This literature includes a theoretical discussion of the impacts of pharmaceutical price ceilings in which Cabrales (2003) and Brekke et al. (2011) create theoretical markets of oligopolistic competition in a vertically differentiated pharmaceutical industry and show that lower price ceilings should result in higher market shares for branded medications with

[2]Not only are there economically important market differences between high-income countries and LMICs, but also the price controls tend to take different forms in these markets. Most evidence from high-income countries concerns reference prices, which determine *reimbursement* levels as opposed to directly controlled prices. See for instance, Brekke et al. (2011); Stargardt (2010); Puig-Junoy (2007); Grootendorst and Stewart (2006); Danzon and Ketcham (2004); Pavcnik (2002) and Danzon and Chao (2000), which all discuss the impacts of pharmaceutical reference prices in the high-income country context.

respect to generics. Brekke et al. (2011) also show that even if a price ceiling is only binding on a branded medication, the generic competitors should still react by decreasing prices. This paper expands on these models by allowing for multiple levels of quality or reputation – as may be the case in a branded generics market – and shows that predicted results from high-income countries will continue to hold assuming price ceilings are set sufficiently high.

Despite the growing body of evidence on the impacts of pharmaceutical price controls in high-income countries, there is little known about the impacts of such controls in LMICs. This is an important distinction as the impacts may look very different due to lower levels of insurance coverage, cost-conscious consumers, and a lack of trust in generic medication quality. Where studies on the impacts of pharmaceutical pricing policies in LMICs do exist, the analysis is restricted to a limited geographic area or product space (Bhaskarabhatla et al., 2017; Mohapatra and Chatterjee, 2016; Yang et al., 2013). This paper will contribute valuable empirical evidence on the short-term impact of pharmaceutical price controls throughout India, expanding the analysis to a broad range of affected products to assess whether effects are similar across product types and categories. It will also contribute to the literature on the impacts of government pharmaceutical policy in LMICs more generally (e.g. Chaudhuri et al. (2006); Goldberg (2010); Duggan et al. (2016)).

When debating how best to improve access to medicines in LMICs, it is essential to consider behavioral response by producers to legislated price decreases. While the Indian setting is quite specific, it can more generally provide a setting to study how producers respond to price controls in branded generics markets. This paper shows that the consumer welfare impacts of the legislation are mixed – the legislated price decreases led to pricing spillovers, causing closely related products to decrease their prices as well. However, it also led to exit of low-cost producers from the market, and an overall decrease in sales of price-controlled products, suggesting potential shortages of essential medications.

2 Empirical Setting

This paper examines the impact of price controls implemented in India between 2013 and 2014. The common conception of pharmaceutical price controls are reference prices or price ceilings set by a government insurer for on-patent originator medications. The goals of these price controls are to use payer monopsony

power to lower high medicine prices arising from producer monopoly power and consumer moral hazard due to insurance coverage. India's price controls differ from these in that they largely covered off-patent medications – an economically important difference in that multiple producers are typically active in these price-controlled markets – in a market with low insurance coverage. These price controls address a different market failure – a failure of the market to drive pricing competition amongst generic drugs.

To fully address the background of these price controls, this section proceeds as follows. Section 2.1 presents background on generic pharmaceutical markets globally and then identifies how the generic market in India differs. Section 2.2 presents background about the overall Indian pharmaceutical industry, with specific regards to different producer types that operate in this market. Last, Section 2.3 details the price controls studied within this paper.

2.1 Background on Generic Pharmaceutical Markets Globally and in India

Globally, once branded, originator products lose patent protection, generic competitors can enter the market and compete with these products. To enter the market in high-income countries, generic versions of off-patent proprietary drugs must conduct bioequivalence studies, which are much cheaper than the expensive clinical trials required for proprietary medications. These bioequivalence studies ensure that generic and proprietary medications have the same therapeutic properties – namely that the generic mediation is absorbed in the body at the same rate and in the same amount as the originator product. Bioequivalent products are considered, at least medically, the same and thus many countries allow pharmacists to substitute therapeutically equivalent generic medications in place of more expensive proprietary medications.

As it is relatively inexpensive for generics to come to market, in a competitive market there are often multiple companies producing generic versions of an originator medication. In high-income countries, generics are generally sold as unbranded medications – meaning they are sold by the generic molecule name (e.g. ibuprofen as opposed to the brand, Advil). To save the health system on pharmaceutical costs, countries use different methodologies to encourage generic substitution and pricing competition amongst generics. In the United States, for instance, patients are generally encouraged to accept a generic medication through lower co-pays. Pharmacies are typically paid more to dispense generic medications than branded products, encouraging them to substitute the generic medication. Further, pharmacies are generally paid a fixed amount for dispensing a generic regardless of the amount paid for the generic – thus,

any cost savings on purchasing a cheaper generic medication will accrue to the pharmacy, encouraging them to purchase the cheapest available version. This system both encourages substitution of cheaper generics in place of originator medications, and drives pricing competition amongst generics.

India's generics market operates very differently, and a number of factors dampen price competition that might otherwise occur in a competitive off-patent pharmaceutical market. While India does have a number of unbranded generics in the market, as with many LMICs, it is primarily a branded generics market, meaning generics compete on brand name as opposed to competing solely on price. Additionally, in India pharmacists are not allowed to substitute generic equivalents by law.[3] Further, pharmacies generally receive a percentage of a product's market price as their mark-up. Thus, a pharmacist selling a more expensive product will likely receive a larger payment. The combination of these factors dampens the price competition between different generic brands and between originator and generic products.

Of interest to economists is how branded generics markets can occur in areas where consumers are both highly price-sensitive and largely paying for medications out-of-pocket. One primary reason these markets can exist is lack of confidence in generic bioequivalence and, potentially, manufacturing quality (Danzon et al., 2015; Danzon and Furukawa, 2008). Product brand names can serve as one "counteracting institution" against the impacts of quality uncertainty, providing consumers both a signal of quality and a means to retaliate against low quality products by ceasing future purchase (Akerlof, 1970).

In India, during the time frame of this study, only generics coming to market within four years of the originator drug being approved in India were required to submit bioequivalence studies.[4] However, generics coming to market *after* this four year period only needed permission to manufacture a generic from state licensing authorities, with no bioequivalence studies required. Thus, companies selling generic medicines within India might wait until the four-year period had expired and apply to state licensing boards in the fifth year, waiving the necessity of conducting bioequivalence studies. While companies may have conducted such studies, physicians and patients cannot be sure which generics have gone through bioequivalence tests and which have not. Given India's large export market, it is important to note that generic firms exporting to other markets must follow the manufacturing laws within those countries – thus

[3]Current Prime Minister Narendra Modi has advocated changing this to have physicians write prescriptions with a generic name, allowing pharmacists to prescribe a less expensive product.

[4]The Indian government amended laws in 2017 to make bioequivalence studies mandatory for certain – but not all – classes of generic drugs (Ministry of Health and Family Welfare, 2017). However, this is proactive as opposed to retroactive and does not ensure the bioequivalence of products already on the market.

Indian firms exporting to countries that require bioequivalence trials must conduct these trials for exported products.

A further, closely related, issue is a potential lack of confidence in manufacturing quality due to the presence of low-quality or even fake medicines in the market. This can occur due to lax regulation and enforcement of good manufacturing practices, and leads to quality uncertainty amongst consumers. A mistrust of pharmaceutical quality can logically lead to a branded generics market, as producers can invest in establishing a reputation for quality with patients and physicians. This clearly can dampen pricing competition – if consumers are not confident about the quality of a locally-produced medication brand they are unfamiliar with, then they might not want to purchase this brand even if it is cheaper. While evidence on the prevalence of low-quality medicines is scarce, recent studies have found that about 10-15% of drugs fail quality testing in LMICs, suggesting that substandard medications pose a significant issue in these countries (Bate et al., 2011, 2015). The Indian government presents lower estimates of "non-standard quality" drugs in the Indian market, averaging around 6% of drugs.[5] However, even if incidents of harm due to substandard drugs are rare, if these incidents are publicized in local news, consumers are likely to be aware of them and lack confidence in drug quality.

2.2 Indian Pharmaceutical Market

The Indian pharmaceutical market is the third largest global market in volume and eleventh largest in sales (QuintilesIMS, 2016), valued at $13.8 billion in 2012 (PwC, 2013) and $16.2 billion in 2016 (Care Ratings, 2017). As of 2014, 4.7% of India's GDP was spent on health, 70% of which is from private spending (The World Bank, 2017). Estimates on the percentage of total health spending towards pharmaceuticals in India vary by source, but range from 17-31% of total health spending (Burns, 2014).[6] Of the public expenditure on health, only about 10% goes towards pharmaceuticals – however, there are significant differences by state, with pharmaceuticals comprising less than 2% of public health spending in Punjab and 17% in Kerala (Sakthivel, 2005).

Most medicines consumed in India are produced by the large, local generics manufacturing industry, with multinationals comprising approximately a quarter of sales (additional information about the retail

[5] Table C1 in the Appendix details different estimates, which range from 11% in 2009-2010 to 3.18% in 2014-2016.

[6] However, these estimates may be understated - a 2005 expenditure survey conducted across Indian states found that 61-90% of household out-of-pocket spending on health was spent on pharmaceuticals (Sakthivel, 2005).

market can be found in Section 4.2.). While there are an incredible number of manufacturers within the country – India's National Pharmaceutical Pricing Authority lists 10,563 total registered drug manufacturers in India during 2007 (National Pharmaceutical Pricing Authority, 2007) – over half of local sales are concentrated amongst the twenty largest local generics firms (Aggarwal, 2011). The Indian pharmaceutical industry is also a large exporter of generic medicines, with an estimated $16.8 billion in revenue from pharmaceutical exports in 2016 (Care Ratings, 2017). As such, exports make up more than half of total revenues for the overall Indian pharmaceutical industry.

In India, the retail pharmaceutical supply chain flows from a pharmaceutical manufacturer to a Clearing and Forwarding Agent ("CFA"). The CFA, in turn will sell to stockists (also known as distributors or wholesalers), who in turn sell at a mark-up to retailers (generally pharmacists), who sell at an additional mark-up to consumers. Unique to India is the All India Origin of Chemists and Druggists (the "AIOCD"), a lobbying group for retail pharmacists and wholesalers with significant influence and power. Approximately 90% of pharmacists in India belong to the AIOCD, and the organization works on their behalf to ensure a standardized minimum markup for retail pharmacists and wholesalers in their lobbying organization – generally 20% of retail price for pharmacists and 10% for wholesalers. On top of this negotiated retailer markup, pharmaceutical companies can employ other measures to encourage pharmacists to prescribe their drugs, namely sales representatives and free medication samples.

2.3 Price Control Legislation

India has a long history of regulating the prices of drugs and active pharmaceutical ingredients, dating back to the 1960s.[7] Prior to the legislation introduced in 2013, India already had in place price controls on 95 active pharmaceutical ingredients (also known as "bulk drugs"). Attempts by the government to reform and expand pharmaceutical price controls were met by significant resistance from the local pharmaceutical industry, and with reason – when the Indian government announced an intention to place price controls on essential medicines in 2006, the stock prices of local pharmaceutical firms plunged (Aggarwal, 2011).

Despite industry resistance, India expanded pharmaceutical price controls in 2013, and again in 2014. This study will examine the impact of these two sets of price controls, the timeline of which is available in Figure 1. The first set of price controls were enacted when the Indian government released the 2013 Drug

[7]Figure B1 in the appendix details the history of price controls in India dating back to the mid-1900s.

Price Control Order, giving a local regulatory body, the National Pharmaceutical Pricing Authority, the ability to place price ceilings on formulations of the drugs in India's National List of Essential Medicines. India's National List of Essential Medicines is based on the World Health Organization (WHO)'s List of Essential Medicines, with adjustments based on local market characteristics. As with the WHO List of Essential Medicines, it is common for only certain formulations of a given molecule to be contained on the Indian National List of Essential Medicines.[8] For instance, the 250mg and 500mg dosages of amoxicillin, a commonly used antibiotic, are contained on the National List of Essential Medicines, but another commonly used formulation – the 125mg dosage – is not. The Indian National List of Essential Medicines was first developed in 1996 and is not updated regularly – it was publicly updated in July 2011, and was not updated again until late 2015.

The 2013 Drug Price Control Order did not just place ceilings on essential medicines. It also set retailer markup for price-controlled drugs at 16% for pharmacists and 8% for wholesalers, lower levels than the industry standards of 20% and 10%. This cut in retail margins raised significant furor from the pharmacist lobbying organization, AIOCD. Post-legislation there were wide-spread reports of wholesalers and pharmacists insisting on the standard 10% and 20% markups – forcing at least some producers to meet these demands (The Times of India, 2013).

The National Pharmaceutical Pricing Authority uses market-based mechanisms to set price ceilings, with the rules depending on the number of drugs in a product class. Price ceilings are set using price to retailer, which is the price the pharmacist pays for medication, as opposed to maximum retail price, which is the price the manufacturer prints on the medication package. If there are multiple brands of drugs in a product class, the price ceiling is calculated by first taking the *unweighted* average price to retailer for all drugs with at least 1% market share, and then a 16% retailer markup is added to determine maximum retail price. If a drug is alone in its class, it receives a fixed-percentage price reduction based on the amount price ceilings reduced prices for similar categories of drugs.

In September 2013, the National Pharmaceutical Pricing Authority began publishing and enforcing price ceilings for drugs on the National List of Essential Medicines. However, the process of setting price ceilings proved difficult with the large number of competitors on the market, and thus the National Pharmaceutical Pricing Authority did not announce all price ceilings at the same time, rather announcements

[8]The process of selecting medicines to add to the WHO List of Essential Medicines has been criticized, partially for this reason. See, for instance, Barbui and Purgato (2014).

of price ceilings were made gradually over the following months.

While the 2013 pharmaceutical price controls were anticipated by the pharmaceutical industry, in 2014 the Indian government implemented a second set of price controls that came as a surprise to the pharmaceutical industry. On May 29, 2014, the National Pharmaceutical Pricing Authority issued an internal guideline which gave their organization the right to place price controls on drugs not contained on the National List of Essential Medicines if these controls were in the public interest. The memo justified this right by citing Paragraph-19 of the 2013 Drug Price Control Order which "authorizes the Government, in extraordinary circumstances, if it considers necessary so to do in public interest, fix the ceiling price or retail price of any drug for such period as it deems fit" (National Pharmaceutical Pricing Authority, 2014b). Shortly after, on July 10, 2014, the National Pharmaceutical Pricing Authority announced price controls of an additional 108 formulations of diabetes and cardiovascular drugs not on the National List of Essential Medicines, citing the internal guidelines issued on May 29th of that year. This legislation incensed the Indian pharmaceutical industry, which initially refused to comply with the legislation and fought it in court. On September 29, 2014, courts ruled in favor of the pharmaceutical companies and the National Pharmaceutical Pricing Authority withdrew the May 29th internal guidelines. However, this withdrawal was retroactive and not retrospective. In other words, the price controls issued on July 10th remained in place, however moving forward only drugs on the National List of Essential Medicines could be assigned a price ceiling.[9]

3 Theoretical Impact of Pharmaceutical Price Ceilings

This section presents a theoretical model of the impacts of price ceilings on pharmaceutical prices and sales. It begins with a simple theory of two vertically differentiated firm types – an originator (branded, multinational) firm and a generic firm. This model shows that in reaction to binding price ceiling legislation, that both the originator and generic firms will decrease their price, even if the legislation is only binding for the originator firm. Further, this model shows that the legislation should induce the originator to produce and sell more of their product.

The two firm type scenario is not as relevant in India, which is primarily a "branded generics" market.

[9]India's pharmaceutical industry fought to have the July 10th price controls revoked in court as well, but in this case lost, allowing those controls to remain.

To account for this, this section expands the theory to three firm types: a multinational firm ("multinational firm"), a local exporting firm with a strong reputation ("exporter firm"), and a less well-known, small, local firm ("local firm"). Even in this case, a price ceiling that is binding only on the multinational firm should cause both the exporter firm and local firm to decrease their price and the multinational firm should gain market share given constant quality parameters.

3.1 Two Company Types

3.1.1 Laissez-Faire Market

Traditionally, off-patent pharmaceutical markets are assumed to have two product types – a branded, originator product (referred to here as "originator" products), and a number of less expensive, generic products. There is a perceived quality difference between the originator and generic products – in countries requiring bioequivalence tests, this could be simply to advertising or familiarity – but regardless of the reason, the originator product is able to charge a premium because there are consumers willing to pay that premium.

The perceived quality difference between the originator and generic product is denoted here by θ, where $\theta > 1$. Consumers have different valuations of the drug itself, denoted by τ which is uniformally distributed between $[0, t]$.

The utility of a consumer buying product i is therefore:

$$U_i = \begin{cases} \theta\tau - p_o & \text{if } i = o \\ \tau - p_g & \text{if } i = g \end{cases}$$

where o indexes the originator product, g indexes the generic product, and p_o and p_g are the originator and generic prices, respectively.

A consumer will be indifferent between the branded and generic product when $p_o - p_g = \tau(\theta - 1)$. Assuming an open market, this provides the following demand functions:

$$D_o = \begin{cases} 0 & \text{if } p_o - p_g \geq t(\theta - 1) \\ 1 - \dfrac{p_o - p_g}{t(\theta - 1)} & \text{if } 0 < p_o - p_g < t(\theta - 1) \\ 1 & \text{if } p_o \leq p_g \end{cases}$$

$$D_g = \begin{cases} 1 & \text{if } p_o - p_g \geq t(\theta - 1) \\ \dfrac{p_o - p_g}{t(\theta - 1)} - \dfrac{p_g}{t} & \text{if } 0 < p_o - p_g < t(\theta - 1) \\ 0 & \text{if } p_o \leq p_g \end{cases}$$

It is plausible that the originator and generic manufacturers do not have the same marginal costs. Assuming, therefore, that marginal costs, denoted as c_i, are constant but differ by producer type, producer profits become:

$\pi_i = (p_i - c_i)D_i$

Given these profit functions, a producer's best-response functions in reaction to their competitors price changes are:

$p_o(p_g) = \frac{1}{2}[t(\theta - 1) + p_g + c_o]$

$$p_g(p_o) = \frac{p_o + \theta c_g}{2\theta}$$

It can already be seen here that the best response of a generic product is a price increase (decrease) in response to an increase (decrease) in price by the originator product.

Substituting the best-response functions and solving for the optimal prices under the laissez-faire market provides the following:

$$p_o = \frac{2\theta[t(\theta - 1) + \frac{c_g}{2} + c_o]}{4\theta - 1} \qquad q_o = 1 - \frac{(2\theta - 1)[t(\theta - 1) + c_o] + (\theta - 4)c_g}{(4\theta - 1)t(\theta - 1)}$$

$$p_g = \frac{t(\theta - 1) + 4c_g + c_o}{4\theta - 1} \qquad q_g = \frac{\theta[t(\theta - 1) + c_o] + (\theta - 8)c_g}{(4\theta - 1)t(\theta - 1)}$$

The best-response functions also allow for estimation of the market share of originator products, denoted here as ω:

$$\omega = \frac{D_o}{D_o + D_g} = \frac{1 - \frac{p_o - p_g}{t(\theta - 1)}}{1 - \frac{p_g}{t}} = \frac{2\theta t(\theta - 1) - p_o(2\theta - 1) + \theta c_g}{(\theta - 1)(2\theta t - p_o - \theta c_g)}$$

3.1.2 Price Ceiling Legislation

In India, the price ceiling was binding on the high-priced firm(s) by design, thus we do not need to consider the case of a non-binding price ceiling. Assuming that the price ceiling was binding on just the originator firms, the originator must solve a constrained maximization problem which is a simple modification of the problem above. This leads to the following prices and quantities for originator and generic firms:

$$p_o = \bar{p} \qquad q_o = 1 - \frac{(2\theta - 1)\bar{p} - \theta c_g}{2\theta t(\theta - 1)}$$

$$p_g = \frac{\bar{p} + \theta c_g}{2\theta} \qquad q_g = \frac{\bar{p} - \theta c_g}{2t(\theta - 1)}$$

where $\bar{p}$ is the ceiling price. Though the generic product is not directly impacted by the price ceiling in this situation, their best-response is to decrease their price in response to the originator's legislated price decrease. Even if the price ceiling is binding for both the originator firm and the generic firm, the generic firm's best-response would still be to decrease price below the price ceiling assuming this does not push them below marginal cost.

The legislation will also lead to a quantity response amongst affected firms – assuming prices ceilings are set above marginal cost, the originator product's response to the legislation is an increase in quantity supplied as compared to the laissez-faire market, whereas the generic firm's response is a decrease in supply. Further, it can easily be shown that:

$$\frac{\delta w}{\delta p_b} = \frac{-2\theta^2(t - c_g)}{(\theta - 1)(2\theta t - p_o - \theta c_g)^2} < 0$$

and that the share of the branded product should increase post-legislation.

3.2 Three Company Types

In India, as in many other countries, there is a "branded generics" market, where generic medications compete on brand as opposed to price. Traditionally, generic medicines did not have to run bioequivalence tests to come to market. Thus, while manufacturers may have run such tests, physicians and patients have no assurance that a generic version of an originator product is clinically identical. As a result there are multiple levels of product quality or reputation on the market.

This section shows that even when there are more than two levels of quality all product types will decrease their prices in response to a price ceiling – even if only the originator product is directly impacted. To show this, this section defines a market with three product types - a multinational branded product, a branded-generic produced by a well-known exporting firm, and an unbranded generic produced by a smaller, local firm.

3.2.1 Laissez-Faire Market

Again, consumers have different valuations of the drug itself, denoted by $\tau \in [0, t]$. However, now the perceived quality difference of the multinational drug is notated by α and the perceived quality difference of the exporter drug is denoted by β, where $\alpha > \beta > 1$. Given these parameters, the utility for a consumer buying a product from producer i becomes:

$$U_\theta = \begin{cases} \alpha\tau - p_m & \text{if } i = m \\ \beta\tau - p_e & \text{if } i = e \\ \tau - p_l & \text{if } i = l \end{cases}$$

where m indexes multinational companies, e indexes well-known exporting firms, and l indexes local firms. A consumer will be indifferent between the multinational and exporter product when $p_m - p_e = \tau(\alpha - \beta)$, and will be indifferent between an exporter product and local product when $p_e - p_l = \tau(\beta - 1)$. The multinational and local products will not directly compete, but may indirectly impact each others strategies due to their impacts on the exporter firms.

Again assuming that marginal costs are constant but vary by firm type, producer best-response functions become:

$$p_m(p_e) = \tfrac{1}{2}[t(\alpha - \beta) + p_e + c_m]$$

$$p_m(p_l) = \frac{(\alpha - \beta)p_l + (2\alpha - \frac{5}{2})(t(\alpha - \beta) + c_m) + (\alpha - 1)c_e}{4\alpha\beta - \alpha - 3\beta}$$

$$p_e(p_m) = \frac{(\beta - 1)p_m + (\alpha - \beta)\frac{c_l}{2} + (\alpha - 1)c_e}{\alpha(2 - \frac{1}{2\beta}) - \frac{3}{2}}$$

$$p_e(p_l) = \frac{(\alpha - \beta)p_l + \frac{1}{2}(\beta - 1)[t(\alpha - \beta) + c_m] + (\alpha - 1)c_e}{2\alpha - \frac{3}{2} - \frac{1}{2}\beta}$$

$$p_l(p_m) = \frac{(\beta-1)p_m + 2\beta(\alpha-1)c_l + (\alpha-1)c_e}{4\alpha\beta - \alpha - 3\beta}$$

$$p_l(p_e) = \frac{p_e + \beta c_l}{2\beta}$$

It can already be seen that, under these market conditions:

$$\frac{\delta p_i}{\delta p_j} > 0 \text{ for all } i \neq j$$

In this market setting, the market share of branded products, again denoted as ω becomes:

$$\omega = \frac{t(\alpha-\beta) - p_m + p_e}{(t-p_l)(\alpha-\beta)}$$

3.2.2 Price Ceiling Legislation

Since the price ceiling in India was binding on the high-priced firm(s) by design, we do not need to consider the case of a non-binding price ceiling. If a price ceiling is binding on only the multinational firm, the multinational firm will drop its price to the ceiling price, $\bar{p}$. As in the case with two firms, given its best response function, the exporting firm will drop its price in response to a mandated price decrease for the multinational product. In response to the drop in price amongst the exporting firms, the local firm will drop its price. Thus, even if the multinational firm is the only firm directly impacted by the price ceiling, we would expect all firm types to lower prices.

As $\delta p_e/\delta p_m < 1$, demand for the multinational product should rise post legislation (proof in the Appendix Section E.1). This leads to a corresponding increase in market share as:

$$\frac{\delta w}{\delta p_m} = \frac{(t-p_l)(\frac{\delta p_e}{\delta p_m} - 1) + \frac{\delta p_l}{\delta p_m}(p_e - p_m + (\alpha-\beta)t)}{(t-p_l)^2(\alpha-\beta)} < 0$$

Likelihood of producer exit will increase if the additional pricing pressure caused by the price ceilings creates an unprofitable market or if the firm is capacity constrained and can substitute to more profitable lines of production. This is most likely to be seen for local firms as these were most likely to be pricing at close to marginal cost prior to the legislation. Therefore, even if a price ceiling is binding only on the multinational firm, the additional pricing pressure the local firms face post-legislation might make it more profitable for them to exit the market. As a result, the legislation may lead to a corresponding exit amongst local firms.

3.3 Model Predictions

To summarize, a price ceiling can distort the laissez-faire market equilibrium by lowering prices of not only directly-affected products, but also products priced ex-ante below the price ceiling. Demand for the ex-ante high-priced, high-reputation products will increase, and these products will see an increase in market share. Further, producer exit will not necessarily result unless price ceilings are sufficiently low. However, if low-priced firms were producing at low margins ex-ante, the additional pricing pressure caused by the legislation may lead to increased exit amongst these firms. This set of findings leads to three testable propositions:

Proposition 1: Prices of products will fall amongst multinational, exporter, and local firms post-legislation, even if these products were ex-ante priced below the set price ceiling.

Proposition 2: Multinational products will see both an increase in sales and in market-share post-legislation.

Proposition 3: Producer exit will occur when the additional pricing pressure brought on by the legislation makes it unprofitable to stay in the market. This phenomenon is most likely to be seen amongst products produced by small, local firms.

4 Methodology

The analysis makes use of the fact that the price controls implemented in India were partial in nature to compare sales and pricing of price-controlled drugs to non-controlled drugs. This section will describe the data used in the study, review characteristics of the Indian retail market, and then describe in detail the estimation strategy used to measure the impacts of the price control legislation.

4.1 Data Description

The primary data source used in this analysis is a database of retail sales data obtained from the All India Origin of Chemists and Druggists (AIOCD) Advance Warning Action & Correction System, henceforth referred to as the "AIOCD" data. This data is collected in a joint effort between AIOCD, the national pharmacist trade union, and a private pharmaceutical research company. The data is collected electroni-

cally from a representative sample of AIOCD's member pharmacies and projected to national levels. Given that the data only includes the retail market, it does not cover products sold primarily in hospital settings.

This data is primarily bought and used by private companies to track market trends in the Indian retail pharmaceutical market (AIOCD-AWACS, 2017). While the data is marketed primarily towards private companies, it has previously been used in academic research on the Indian pharmaceutical market (see for instance, Abrol et al. (2016); Mohapatra and Chatterjee (2016); Bhaskarabhatla et al. (2017)). Importantly in this setting, the data also served as one source of data used by the Indian government in setting the price ceilings studied here.

The AIOCD data is available monthly from 2010 to 2015 at the stock keeping unit (SKU) level. It contains information on drug brand name, producing firm, drug dosage and pack size (e.g. 4 pills), in addition to detailed pricing data that includes maximum retail price (MRP), price to retailer, and price to wholesaler for drugs sold in the retail setting.

Data on price ceilings comes from the National Pharmaceutical Price Authority, the government body responsible for regulating pharmaceutical prices in India. The National Pharmaceutical Price Authority publicly lists implemented price ceilings and the date they went into effect (National Pharmaceutical Pricing Authority, 2014a). Generally, price ceilings are published at the dosage strength (e.g. 25 mg) and unit/pack size (e.g. 1 pill or 1 ml) level.

This paper segments producers into three types for analysis: *multinational* companies, large *exporting* firms, which typically export generics to other countries, produce branded generics locally, and generally invest in reputation, and small *local* firms, which often sell in smaller geographic areas, invest little in reputation, and produce a mix of unbranded and branded generics. These firm types will be referred to respectively as multinational, exporting, and local producers throughout the paper. Multinational companies are defined as being headquartered outside of India. To separate the large "exporting" firms from the smaller "local" firms, this paper identifies Indian producers as "exporters" if they have at least one World Health Organization Good Manufacturing Practices (WHO GMP) Plant Approval. Large institutional procurement agencies that operate internationally – such as UNICEF or the Global Fund to Fight AIDS, Tuberculosis, and Malaria – and countries purchasing bulk medicines generally require products to meet WHO GMP standards, thus this classification signifies that a company is likely to export products. This classification is also highly correlated with company size – all of the top 20 companies

operating in India have at least one WHO GMP plant. Data on WHO GMP plant approvals for Indian producers comes from the Central Drugs Standard Control Organization, a department of the Indian government's Ministry of Health & Family Welfare. The department publishes a report "WHO GMP Certified Manufacturing Units for Certificate of Pharmaceutical Products (COPP) in Various States of India" which contains names and addresses of all WHO GMP Certified manufacturers in India (Central Drugs Standard Control Organization, 2015).

To assess whether producer type is actually associated with drug quality, this analysis makes use of a unique set of data from the Food and Drugs Control Administration (FDCA) of India. The FDCA collects a randomized sample of drugs at various points of the drug pipeline (direct from manufacturers, wholesalers, pharmacists, and government hospitals) and tests these drugs for a wide range of quality characteristics. This data is collected over time and includes brand name, batch number, date and location of sample collection, and manufacturer name and location. If a drug fails testing, the FDCA penalizes the producing company, sends a text message to all registered pharmacists with the drug and manufacturer name and batch number, and additionally publishes the manufacturing information for drugs that fail quality testing on a website available to the public for a period of six months.[10]

The data used to determine a company's quality level comes from two sources of FDCA data. The first data source is the full set of drugs which failed FDCA quality control testing between 2010 and 2015, which was scraped over time from the publicly available website. The second source of FDCA data is a set of full testing data – which includes information on drugs that both passed and failed quality testing – for a group of field offices between 2013 and 2014.

4.2 Indian Retail Market Characteristics

The AIOCD data includes data on retail sales from 865 companies and 58,714 different drug brands. Given that there may be multiple stock keeping units (SKUs) for a given drug brand (e.g. there might be a 10-pack and 20-pack of the same brand, which would each present as a separate SKU), there are a total of 103,067 unique SKUs in the data. Despite a large number of competitors in generic markets – the median number of brands in a given market is 5, but the mean is nearly 21 – markets are highly concentrated, as

[10]The current link to this website is available here: http://xlnindia.gov.in/gp_failedsample.aspx.

shown in Table 1. The mean Herfindahl-Hirschman Index (HHI) for firms is 4890[11], with 94% of markets considered to be highly concentrated.

4.2.1 Characteristics of Local, Exporting, and Multinational Firms

Table 2 details retail market characteristics by producer type. While exporting companies make up only 21% of firms operating in the retail segment, they comprise 67% of sales. Multinationals, while only 6% of firms, make up approximately a quarter of sales, and local firms, while vast in number (73% of firms), make up less than 10% of sales. Not each producer type is active in a given product market. An obvious case of this is on-patent medications, where generally only a multinational firm is active. Multinational firms have only entered 38% of Indian product markets, while local and exporter firms have entered 49% and 73% of product markets, respectively. Table 3 details average logged prices, retailer mark-up, monthly sales, and market share by firm type. Though multinationals are in fewer markets than local firms, in the markets they enter they tend to sell more units on a monthly basis and have a higher market share. Prices and retailer markup are highest amongst multinational companies, and lowest amongst local firms. These higher prices are not due solely to the different markets companies choose to enter. Table 4 shows average price ratios for different firm types operating in the same markets. In the same markets, multinational products are priced on average 28% and 29% more than products produced by exporting and local firms, respectively, and products sold by exporting firms are priced 15% more than those produced by local firms.

The pricing differences between firms producing the same medications indicate that consumers perceive some quality difference. However, it is unclear if such quality differences exist in reality. Firms often have multiple manufacturing plants, and these do not always meet the same regulatory requirements. For instance, a manufacturer might have a U.S. FDA approved manufacturing plant, a separate WHO GMP approved plant, and a third manufacturing plant that meets Indian manufacturing requirements, which are generally considered less stringent. While these standards should all guarantee a high-quality product, they require different levels of paperwork and oversight. Thus, even if a manufacturer is capable of producing medications to any regulatory standard, the products they sell in the Indian market may not be meeting

[11]This classification of HHI defines a market at the subgroup level, using the European Pharmaceutical Market Research Association (EPhMRA) guidelines to define a subgroup. A subgroup is generally defined as a molecule or molecule combination, e.g. ibuprofen or ibuprofen and acetaminophen. If the market is expanded to a EPhMRA group level, the average HHI is 3347, with 65% of pharmaceutical markets considered highly concentrated.

the same standards as the products they export.[12]

Table 5 presents results on quality derived from the FDCA data. Of the 865 companies in the AIOCD retail data, 230 show up in the FDCA data. Column (1) presents the average number of times a company's products show up in the data on drug failures collected by the FDCA,[13] and Column (2) presents the average number of times a company's products show up in the sample of FDCA testing data. It is clear that companies are not equally likely to be sampled by the FDCA – Table C2 in the Appendix shows that testing likelihood increases with company size, company type (exporting firms were most likely to be tested), and with average product price. Column (3) shows the ratio of average drug failures to average drug tests for each company type. Local companies have the highest ratio of drug failures to drug tests at 1.8, while exporting and multinationals firms have ratios less than half that size, at 0.89 and 0.67 respectively.[14] It is worth noting that confidence intervals on these figures are quite high, but nevertheless this data does point to differential quality levels between these three firm types.

4.2.2 Characteristics of Price Controlled Products

Approximately 25% of the retail pharmaceutical market in India received a price ceiling (21% in value). Table 6 shows the characteristics of uncontrolled and controlled products. The products generally look similar, however the 2014 price controls took place in more crowded markets (lower HHI), and covered only chronic products. Figure 2 shows pricing, markup, and sales trends for non-controlled products and products given price controls in 2013 and 2014. Pre-trends are similar for each of these groups, and a clear drop in prices can be seen in controlled products after the 2013 legislation was enacted. Figure 3 presents market share over time for local, exporter, and multinational firms. While multinational market share is declining across markets pre-legislation, the market share of multinational firms stabilizes for price-controlled products after the legislation.

Table 7 shows the average markdown required by the legislation for each company type. Multinational

[12] A caveat to this line of reasoning lies in liability laws. While multinational firms often have Indian subsidiaries and operate local manufacturing plants, they are still liable for adverse events under U.S. or E.U. liability laws.

[13] The reasons drugs failed quality testing are available for a subset of the FDCA data. The most common reasons were content assay – which indicates the drug did not have the indicated active ingredient dosage – dissolution, and disintegration time. Additional detail, including all listed reasons and the count of times these reasons were listed, is available in the appendix in Table D3.

[14] These ratios are relatively meaningless, but given that the sample of testing data is approximately 5% of total testing data for the time period, these estimates can be taken to indicate failure rates of 3-9% in actuality. This is in line with other estimates of drug failure rates in India.

firms see the largest required markdowns from ex-ante prices – an average of ₹42 , versus ₹31 for exporter firms and ₹19 for local firms.

4.3 Estimation Strategy

The empirical strategy used in this study will compare changes in outcomes of interest for products placed under price controls as compared to products not placed under price controls. To assign the directionality of the legislation impact and ensure pre-trends will not drive any results from this analysis, the analysis begins with an empirical specification with month-year and treatment group interactions, as shown in Equation 1:

$$log(y_{it}) = \alpha m_t + \lambda d_i + \lambda m_t \times d_i + \mathbf{B}_i + \epsilon_{it} \tag{1}$$

where m_t are month-year fixed-effects, d_i is a fixed effect for price-controlled products, and controls $\mathbf{B}_i$ include drug formulation (e.g. pill, liquid, inhalent), drug pack size (e.g. 10 ml or 10 pills) and its square, firm type, a dummy for chronic drugs, product therapeutic class, and the age of the product launched earliest in a given drug class. Outcomes y_{it} include maximum retail price ("MRP"),[15] retailer markup (inclusive of samples and discounts), and units sold. The coefficient of interest in this equation, λ, represents the interaction between month-year and price-controls. If there are no pre-trends, then λ should be statistically indistinguishable from 0 prior to the initial price control implementation in September 2013. Results for this analysis are shown in Figure 4. The graphs show that pre-trends were similar across products receiving and not receiving price controls. After the beginning of the legislation, noted with red lines in the graphs, prices, retailer markup, and product-level sales begin to decline amongst price-controlled products with respect to non-controlled products.

The assess the overall magnitude of the short-term effect of the legislation on price, retailer markup, and sales units, the main analysis employs a difference-in-differences framework, following the approach of Bertrand et al. (2004). The estimation strategy is shown in Equation 2:

$$log(y_{it}) = \alpha m_t + \lambda s_i + \delta c_{it} + \epsilon_{it} \tag{2}$$

[15]MRP is the central measure of price to consumer, however it is an imperfect measure. MRP is the tax-inclusive price printed on a medication box and is determined by the manufacturer. While the pharmacist can offer discounts below the MRP, this cuts into their margin, which is 20% of the MRP in the retail setting.

where outcomes y_{it} include maximum retail price, retailer markup (inclusive of samples and discounts), and units sold. SKU fixed effects, s_i, control for time-invariant differences between SKUs, and month-year fixed effects, m_t, control for market-wide time effects. The binary variable c_{it} indicates whether a given SKU has been assigned a price ceiling in a given month-year. Thus δ, the coefficient of interest, measures the effect of the price control legislation. Standard errors are clustered at the SKU-level to allow for serial correlation and heteroskedasticity.

Sub-analyses include a regression that is similar to Equation 2, but with an interaction term, as shown in Equation 3.[16]

$$log(y_{it}) = \alpha m_t + \lambda s_i + \delta c_{it} + \omega c_{it} * v_i + \epsilon_{it} \tag{3}$$

with a number of different interaction variables, v_i. The first is a dummy for whether a product is ex-ante priced below the price ceiling. Given that this variable is only available for the treated drugs, for the control group of non-treated drugs, this analysis uses the rules set by National Pharmaceutical Pricing Authority as defined in Section 2.3 to define artificial price ceilings for non-treated drugs. This allows classification of non-treated drugs as being ex-ante below or above this artificial price ceiling. The second interaction variable is a dummy variable indicating whether a given SKU is typically used for a chronic (versus acute) condition. The last interaction term is firm type, with firms classified into three groups: multinational, exporting, and local. A number of robustness tests are shown in the appendix. These robustness tests are discussed in more detail throughout the results section, but include regressions excluding products which exit during the time frame of the study, results excluding low volume products and results run separately by company type.

To identify the impacts of the legislation on originator market share, I estimate the following fractional probit model:

$$E(s_{it}|m, c) = \Phi(\beta + \alpha m_t + \delta c_{it}) \tag{4}$$

where i indexes products, t indexes month-year, m_t denotes month-year, c_{it} denotes an assigned price ceiling, and s_{it} is the market share of originator, exporter, and local firms for a given molecule (e.g. ibuprofen). To estimate this model using panel data, I follow Papke and Wooldridge (2008) in using pooled quasi-maximum likelihood estimation (QMLE) and a generalized estimating equation (GEE) with

[16] As company and product characteristics are time invariant and perfectly correlated with SKU fixed effects, they only enter into the equation as part of the interaction term.

standard errors robust to heteroskedasticity and serial correlation. As in Papke and Wooldridge, I also estimate average partial effects ("APEs") with bootstrapped standard errors. Given that results are very similar, I only present the GEE results within the body of the paper. Alternative specifications for this analysis can be found in the appendix, including a linear specification with fixed effects and a two-period difference-in-difference analysis.

Last, to estimate producer exit, this paper estimates the following probit model at the SKU and product-company levels:

$$E[Y|\beta\mathbf{X}_i] = \beta_0 + \beta_1 c_i + \beta_2 f_i + \beta_3 a_i + \beta_4 \times c_i + \beta_5 a_i \times c_i + \mathbf{B}_i + \epsilon_{it} \tag{5}$$

where c_i indicates a product received a price ceiling, f_i indicates company type, a_i indicates whether a product is for acute or chronic use, and Y is an indicator variable for whether a given SKU or company exits the market after September 2013, when the first legislation was launched. Controls $\mathbf{B}_i$ are product age and drug formulation. In alternate specifications, I add interaction terms between the price ceiling and market concentration, as measured by HHI.

The key identifying assumption in the empirical strategy is that absent the price control legislation, the price-controlled products would have trended similarly to the non price-controlled products. Essential to this identification strategy is avoiding issues of "spillovers" from the medications that received a price ceiling to those that did not.[17] This is particularly important given the design of India's price control legislation, in which only certain drug dosages and formulations received a price ceiling. Therefore, all analyses exclude drugs in controlled therapeutic classes that did not receive a price control because these are particularly likely to see spillover effects from the legislation and thus do not serve as a clean control group. To identify these medications, products are categorized using the European Pharmaceutical Market Research Association (EPhMRA) classification system, with additional sub-groups included for products unique to the Indian market.

[17] This issue of "spillovers" has been raised in other markets with partial price controls – for instance, Marks (1984) provides a discussion of this issue in the context of rent controls.

5 Results

5.1 Testing Proposition 1: Evidence on the Impact of the Price Controls on Market Prices

Proposition 1 from the model predicts that in a vertically differentiated market, all products will decrease their prices in response to a price ceiling, even if the price ceiling is only binding on the high-quality, high-priced firm.

Results of the analysis on the impacts of price ceilings on market prices can be found in Table 9. Column (1), which represents the overall effect of the price ceilings on logged retail price, shows that prices of controlled products dropped by approximately 11.6% as compared to the non-controlled market. Column (2) presents these results with an interaction for chronic versus acute products, and shows that the largest price decreases were amongst acute products. Column (3) shows these same results with an interaction term for company type. As predicted by the model, the three company types all decrease prices in response to the price ceiling. Unsurprisingly, multinational companies have the largest price decreases, as their prices were ex-ante the highest and the price ceilings required the largest markdown for these firms. As an alternative way of looking at these results, Column (4) includes an interaction term for products that were ex-ante priced below the price ceiling. As predicted by the model, even products priced ex-ante below the price ceiling decrease their price in response to the legislation. Results in Appendix F show that these findings are not driven by producer exit and are robust to excluding small SKUs, to using all data, and to running regressions separately for each company type.

Section H in the Appendix analyzes the impact of the legislation on the prices of "spillover" products, which are likely direct competitors of price-controlled products and thus excluded from the main analysis. These results show a small but significant decrease in the prices of spillover products post-legislation, suggesting that the mandated price decreases had wider reaching impacts even on products that were not directly impacted by the legislation.

The results here indicate that Proposition 1 is clearly met. The price control legislation lead to reduced prices not only for directly impacted products, but also for products priced below price-ceilings ex-ante and for competitors of price-controlled products.

5.2 Testing Proposition 2: Evidence on the Impact of the Policy on Relevant Sales and Market Shares

Table 10 presents results on the impacts of price control legislation on logged sales units. As can be seen in Column (1) on the top panel, the overall impact of the legislation on sales is an approximately 4.3% decrease at the SKU-level. Column (2) shows that this is driven by a decrease in sales amongst acute products – products used chronically do not show a change in sales. However, as can be seen in the lower panels, there are significant differences by company type. Sales for local and exporting firms drop significantly after the legislation, by 5.3% and 4.7%, respectively. However, amongst multinational firms, there was no significant drop or growth in sales units overall. Only in chronic markets do product sales increase, whereas there is a significant sales decrease amongst acute products. This runs counter to the predictions of the model, which indicate that the multinational products should see an increase in sales units.

To understand this, it is important to look at the "spillover markets" – in other words to look at potential substitutes for price-controlled products that did not receive a price ceiling. Table 11 aggregates sales to the broader product[18] level – combining sales of both price-controlled and spillover formulations of products – and shows that in product markets where even a portion of products received price ceilings, there is a significant 5.3% decrease in sales post-legislation. This is explained by a lack of an uptick in sales amongst spillover markets – which would be a logical result given the shrinking size of the price-controlled markets. Section H in the Appendix presents results of the effect of legislation on spillover markets alone and shows that even though these markets have significant, though modest, price decreases post-legislation, they do not see a corresponding growth in sales post-legislation. In fact - amongst acute products all firm types see a *decrease* in sales amongst spillover products. Assuming pharmaceutical companies were trying to encourage substitution to non-controlled formulations of price-controlled drugs, there should be an increase in sales amongst these drugs, and empirically this is not evident.

There are two likely explanations for this phenomenon. One of these is firm marketing and promotional expenditures. Optimal advertising levels are dependent on the margins a firm can earn (Schmalensee, 1972). As prices are forced below their laissez-faire levels, firms' margins shrink and thus optimal marketing

[18]For this analysis, I define a product at the molecule or molecule-combination level, regardless of dosage. As an example, all dosage-formations of ampicillin, an antibiotic, would be one product market. However, ampicillin is commonly sold as a combination drug with another antibiotic, cloxacillin - this combination would be a separate product market.

levels are likely to shrink as well. Marketing in this setting can take the form of sales representatives,[19] advertisements, and free samples or discounts to wholesalers and retailers. As most of the products receiving a price control in this setting are not new, innovative medicines, an informational component may arise through demonstrating a product's quality, however it is unlikely to educate a pharmacist or physician about the inherent benefits of the drug itself. If firm marketing is persuasive in encouraging medicine use, and this marketing decreases post-legislation, this may – at least partially – explain the decrease in sales. A corollary can be seen in evidence from high-income countries on total (branded + generic) unit sales after patent expiration. Though generic entry greatly lowers the average price of a drug, which should expand the drug's market size, the arrival of generics also leads to a significant reduction in advertising, which works to counterbalance this effect. This explains why the total volume prescribed for a given drug may actually *decrease* post patent expiration, despite the decrease in average price (Caves et al., 1991).

A second potential explanation for the decreasing sales volume post-legislation may be due to marginal costs rising with volume. Section E.2 in the Appendix provides theoretical evidence that if marginal costs are rising with volume, you may see a decrease in supply after price ceilings are implemented, even if firms are not price takers. Given industry context, marginal costs are often assumed to be constant in the context of pharmaceutical production (for instance, see Brekke et al. (2011) and Cabrales (2003)), however in the Indian market *distribution* costs are likely to increase with volume. Pharmaceutical distribution costs in India are very high – despite significantly lower labor costs, the cost of pharmaceutical distribution in India is two to three times that in the European Union or United States (Langer and Kelkar, 2008). In particular, supply chain costs are very high in rural areas, due to what is known as the "last-mile" problem: the last leg of the pharmaceutical distribution chain in rural India is disproportionately expensive due to sparsely populated villages, lack of paved roads, and dearth of other necessary infrastructure (e.g. cold chain capabilities and health facilities) (Buckley and Gostin, eds, 2013). Even if pharmaceutical firms are not ceasing production of price-controlled products, as the margins on these products are shrinking, either firms or distributors may be pulling price-controlled products from sub-markets with expensive distribution chains – which are most likely to be in rural areas. Exit from rural sub-markets is particularly harmful as these areas already suffer from low access to medicines – rural areas only contribute 21% of pharmaceutical sales in India (Langer and Kelkar, 2008), despite 67% of the Indian population living in rural areas (The World Bank, 2016).

[19] A number of branded generics firms, as well as multinational firms, operate sales forces to promote products.

To assess whether advertising might be driving the decrease in sales, I examine the impact of the legislation on one measure of marketing expenditure, bonus sales, which is the value of free samples given to wholesalers and pharmacists. The first panel in Table 12 shows that bonus sales decrease significantly – by over 50% – amongst price-controlled products after the legislation. The second panel in this table shows that bonus sales decrease for spillover formulations of price-controlled drugs as well, but to a much smaller extent. Table I17 examines the correlation between bonus units as a percentage of sales and sales volume, controlling for SKU and month-year fixed effects. This finds a positive correlation between bonus sales and product sales volume, but this is not causal evidence and there are clear endogeneity concerns. Without causal evidence it is unclear if the decrease in pharmaceutical marketing is causing the decrease in sales post-legislation, but given the significant decline in marketing expenditure, it is one plausible cause.

To assess whether pharmaceutical companies pulled products out of costly rural sub-markets post-legislation, I examine the impacts of the legislation on different subgroups of medications. Prior to the implementation of the price control legislation, rural areas saw increased sales in products likely to be prescribed by primary care physicians as opposed to specialists – e.g. anti-infectives, pain medication, vitamins, and basic respiratory and gastrointestinal medications (Kalsekar and Kulkarni, 2011; India Brand Equity Foundation, 2017). If companies are pulling products from rural markets, then these therapeutic classes should see the largest declines in sales post-legislation. Table 13 shows the main results by therapeutic class. Anti-malarials, anti-infectives, neurological and CNS drugs, analgesics, and vitamins, minerals and nutrients all see a significant decrease in sales post-legislation. With the exception of neurological and CNS medications, these are all classes of medications more commonly used in rural areas prior to implementation of legislation. A second test exploits the lack of cold chain connectivity to rural areas (Samant et al., 2007). Due to lack of infrastructure and cold chain connectivity, products that require specialized storage conditions are less likely to be available in rural markets prior to the legislation enactment. Products with solid dosage formulations, such as pills or tablets, are less likely to require such storage conditions as compared to liquid, injection, or inhalant formulations. Thus if the decrease in sales volume were occurring primarily in rural settings, I would expect "solid" product formations to have the biggest decrease in sales post-legislation. Table 14 shows results analyzing the impacts of price controls on sales separately by drug formulation. This shows that solid formulations of drugs, such as pills and tablets, saw a significant decrease in sales post legislation. Injections saw a semi-significant decrease

in sales post-legislation, while there was no significant change in sales units for inhalants or liquid drug formulations. Though these results are not conclusive, they do provide evidence that the decrease in sales may be driven by producers pulling products out of rural markets due to the increased distribution costs to reach these areas.

While overall sales volume decreases, the second prediction of Proposition 2 – that market share of multinationals will increase post-legislation – is met. Table 15 presents results on the impact of price ceilings on firm market share. The first two columns present results for all products and clearly show that local firms lost significant market share, while multinationals gained significant market share. The market share of exporter firms remained stable. Columns 3 and 4 present the same results for acute products only, while columns 5 and 6 present these results for chronic products only. These show that multinational products gain more in acute markets than in chronic markets. In the appendix, Table J20 shows that these results hold when using a linear specification and Table J19 shows that these results also hold when including spillover products. Thus it is clear that multinational products gained significant market share post-legislation, particularly in acute markets, while local products lost significant market-share.

5.3 Testing Proposition 3: Producer Exit

Proposition 3 indicates that producer exit is not necessarily more likely post-legislation assuming that price ceilings are set sufficiently high; however, if exit does occur it is most likely to be amongst local firms. I test this proposition by examining likelihood of exit post-legislation for price-controlled medications versus non-controlled medications.

Table 16 shows results on the likelihood of producer exit after implementation of price ceilings. Columns (1) and (2) measure exit at the SKU level. These show that local firms are more likely to stop production of a given SKU after the legislation is enacted, however there is no significant impact for exporter or multinational firms. Columns (3) and (4) present the analysis at the company level – an important distinction as companies might produce multiple SKUs for a given product – and tell a similar story. Even at a broader firm level, local firms are more likely to exit a market post-legislation, however there is no significant impact on firm exit for exporter or multinational firms. Columns (2) and (4) show that market concentration does not have a significant impact on firms' decisions to exit after the legislation. Though local firms are of mixed reputation and quality, they produce low-priced medicines that are important for

consumer access – particularly for consumers who are poor or live in rural areas (Dongre et al., 2010). The most price-sensitive consumers, who depend on these low-cost products, are most likely to be negatively impacted by the exit of local firms.

Table G9 in the Appendix presents these same results but this time include "spillover" markets. Given the design of the legislation this distinction is quite important as companies might be able to easily shift production from a drug formulation that has a price ceiling to producing the same drug in a different dosage or formulation that is not controlled. For example, a firm might shift production of 250mg of amoxicillin, which is price-controlled, to production of 125mg of amoxicillin, which is not. These results show that at the broader product level, when including such spillover markets, that local firms do not see a significant increase in exit post-legislation. This indicates that local firms are exiting only price-controlled molecule formulations, but are continuing to produce non-controlled formulations of the same molecule.

It is important to note that these results are all short-term and there may be increased exit in the long-term. If companies are somewhat capacity constrained, then it may become more profitable to exit markets with price ceilings as these companies make decisions to renovate long term assets, such as production facilities, or as they are able to enter new generics markets as medications lose patent protection.

6 Conclusion

When market forces fail to drive down prices in an off-patent pharmaceutical market, countries have increasingly turned to regulating prices with direct price controls. There is limited empirical evidence on the effects of such controls in LMICs where insurance coverage rates are lower and generic competitors are not guaranteed to be bioequivalent to originator medications. This study provides evidence of the impacts of market-based price ceilings on a set of medicines in the Indian retail market. While price ceilings only have a direct effect on high-priced competitors, both theoretical and empirical evidence from the Indian market show that competitive effects may cause even the lowest priced competitors to lower prices. This best-response effect can have a positive impact, even for the poorest consumers, assuming this additional pricing pressure does not cause low-priced competitors to exit the market.

Theory on vertically differentiated markets suggest that price ceilings should increase market share of originator products. Empirically, this is the case in India, as multinationals increase market share in price

controlled markets at the expense of small, local companies. However, counter to theory, multinationals do not significantly increase sales and the total size of the price-controlled markets shrink significantly as compared to the non-controlled markets. Importantly, this decrease in market size spills over to closely related products, suggesting a potentially wider-reaching negative impact of the legislation. While the legislation benefits consumers through lower prices for medications, it also leads to a significant decrease in sales, suggesting that the legislation is preventing trade that otherwise would have occurred. This decrease in sales is likely most harmful for the rural poor as the supply chain costs to reach these consumers are highest, and producers may no longer continue to contract with the wholesalers who serve these populations.

India is unique in that it has a substantial market size and a large, local generics manufacturing industry able to meet most of the country's demand for generic medicines. Not every country has these characteristics. Smaller countries, in particular, might not have a large enough market size to encourage generic manufacturers to either produce locally or import their medicines. While the unique aspects of India's pharmaceutical market make it hard to generalize findings from India to smaller markets, there are two important findings from the Indian market that are more widely applicable. First is that a price ceiling may be effective at reducing all pharmaceutical prices, however this additional pricing pressure may cause low-priced products to exit the market. If a large portion of the market depends on low-priced, locally produced medications this can lead to a net-negative impact for the most at-need consumers. Second, price ceiling legislation may lead to an increased market share for multinational products at the expense of local manufacturers. This could have a major impact on the local generics industry – while the price ceilings may be less binding on local firms, they will face additional pricing pressure and potentially a loss of sales post-legislation. This, in turn, can discourage a local generics industry, which may be critical to ensuring access to medicines.

This study only covers the short-term effects of the price control legislation, but long-term effects are potentially very different. Over time, firms must make choices to pay for maintenance of long-term assets, and may not be willing to pay for the renovation or restoration of these assets if future profits are not sufficiently high. This could cause firms to either exit price controlled markets in the long-term, or to cut production or quality. Potential long-term exit would be exacerbated by reduced incentives to enter price-controlled markets. To sell a product in a state's retail pharmacy market, a firm must pay a high marketing fee. Mohapatra and Chatterjee (2016) find these fees to be highest for small, local firms and

multinational firms. Thus, the pricing pressure placed on small, local manufacturers in conjunction with high costs to market entry may effectively push the cheapest products – which are also arguably of the lowest average quality – out of price-controlled markets.

Producer exit is a major concern of introducing price controls. Foreseeing this issue, India mandated that companies notify and receive approval to withdraw a price controlled product from the market, which may have hampered exit that would otherwise have occurred amongst multinationals. While multinational companies may have pulled certain SKUs from markets, they did not exit the Indian markets at any increased rate after the price control legislation – at least in the short-term. However, the majority of the price controls studied here were on generic products that are relatively inexpensive to produce. In February 2017 India expanded price controls to cardiac stents, mandating that manufacturers and importers "maintain smooth production and supply of coronary stents of all brands." This resulted in two multinational suppliers – Abbott and Medtronic – requesting to withdraw their products from the market, and at least one other multinational company threatening to follow suit. This case highlights the trade-offs between encouraging the entry of innovative products to the Indian market and assuring affordable pricing for consumers. Monitoring long-term impacts of the legislation on not only price-controlled products but also on the launch decisions of multinational producers will provide valuable empirical evidence on these trade-offs.

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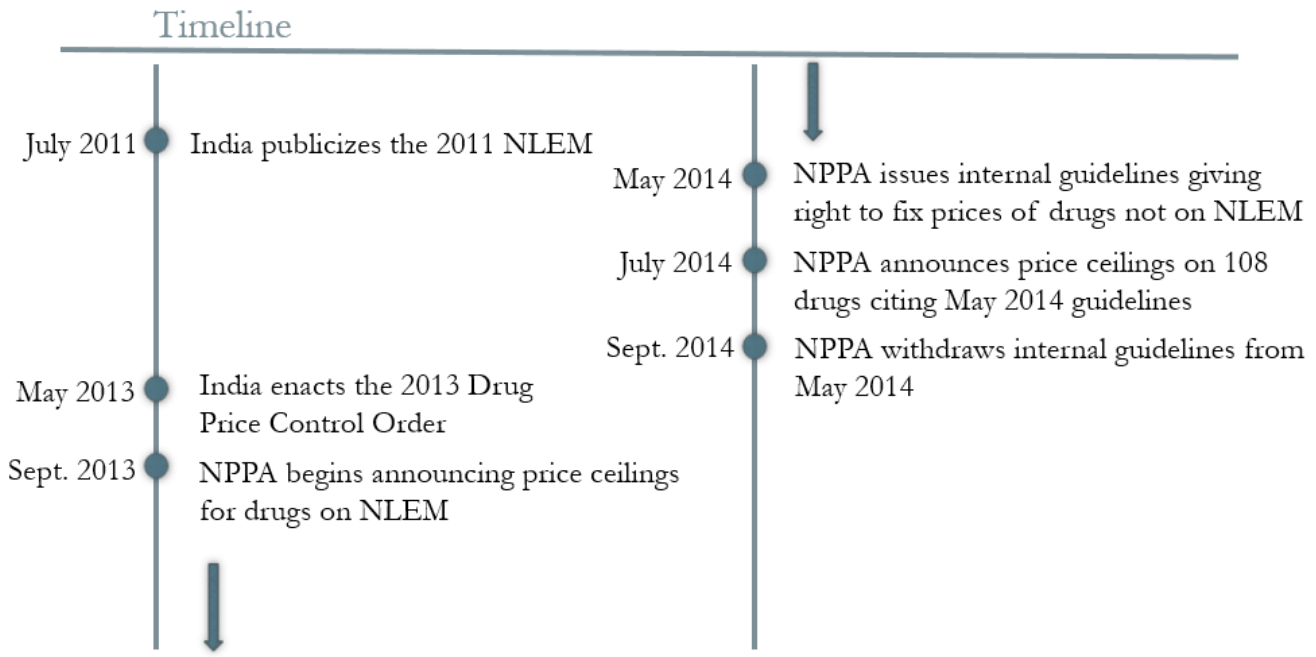
7 Graphs and Figures



† National List of Essential Medicines is abbreviated here as "NLEM." National Pharmaceutical Pricing Authority, the government body responsible for setting price ceilings, is abbreviated here as "NPPA."

Figure 1: Timeline of Price Controls Used in Analysis

Market Concentration Level	Count of Markets	Percentage of Market
Non-Concentrated	52	1.75%
Moderately Concentrated	125	4.21%
Highly Concentrated	2,790	94.03%
Mean HHI	4889.86	
	(3724.16)	

† Markets are defined at the EPhRMA subgroup (generally molecule or molecule-combination) level between 2010 and the implementation of price ceilings in 2013. Definitions of market concentration are those generally used to define market concentration by the U.S. Department of Justice and Federal Trade Commission. These agencies generally consider markets with an HHI over 2,500 to be highly concentrated, and those with HHI between 1,500 and 2,500 to be moderately concentrated.

Table 1: Market Concentration Summary

	Number of Firms		Total Sales in MM (Units)		Total Sales in MM (Value)	
Firm Type	Count	% of Total	Total	% of Total	Total	% of Total
Local	630	73%	9,167	8%	417,312	9%
Exporter	185	21%	74,906	67%	2,976,625	67%
Multinational	50	6%	27,124	24%	1,047,408	24%
Total	865	100%	111,197	100%	4,441,345	100%

† Summary statistics are aggregated from the AIOCD Awacs data between 2010 through 2015. Unit sales presented here are not standardized by dosage.

Table 2: Firm Count and Retail Sales in MM by Firm Type - 2010 Through 2015

	Mean	S.D.	Min	Max
Logged MRP				
Local	4.05	0.88	-4.61	12.71
Exporter	4.23	1.19	-4.61	11.96
Multinational	4.55	1.47	-4.61	12.36
Logged Retailer Markup				
Local	2.50	0.90	-13.86	11.10
Exporter	2.75	1.58	-15.25	11.23
Multinational	3.02	2.28	-14.56	11.67
Logged Sales Units				
Local	6.58	2.25	0.00	15.28
Exporter	7.98	2.55	0.00	17.67
Multinational	8.21	2.77	0.00	16.30
Market Share				
Local	3%	12%	0%	100%
Exporter	9%	21%	0%	100%
Multinational	18%	30%	0%	100%

† Numbers shown here are aggregated from the AIOCD Awacs data between 2010 through 2015. Sales units presented here are not standardized by dosage. Market share is shown at the SKU-level.

Table 3: Summary Statistics by Producer Type

Firm Type	Average # Failures†	Average # Tests*	Ratio of Failures to Tests
Local	0.20	0.11	1.82
	(0.67)	(0.41)	(2.76)
Exporter	1.11	1.25	0.89
	(1.44)	(1.72)	(2.13)
Multinational	0.52	0.78	0.67
	(1.06)	(1.72)	(4.50)

† Average number of failures is measured as the average number of times a manufacturer's products appear in the FDCA "not standard quality" drug data. If a manufacturer does not appear in this data, it is included in the calculation of the average as showing up zero times.
*Average number of tests is the average number of times a manufactuer's products appear in the full sample of FDCA testing data. This sample is approximately 5% of total testing data for this time period.

Table 5: Average Product Failure and Test Rate by Firm Type

	Ratio Multinational-Exporter	Ratio Multinational-Local	Ratio Exporter-Local
MRP	1.28	1.29	1.15
	(0.83)	(0.88)	(0.69)
Markup	1.25	1.37	1.26
	(1.04)	(1.27)	(0.85)
Sales Units	12.21	127.31	195.50
	(32.93)	(381.40)	(693.05)

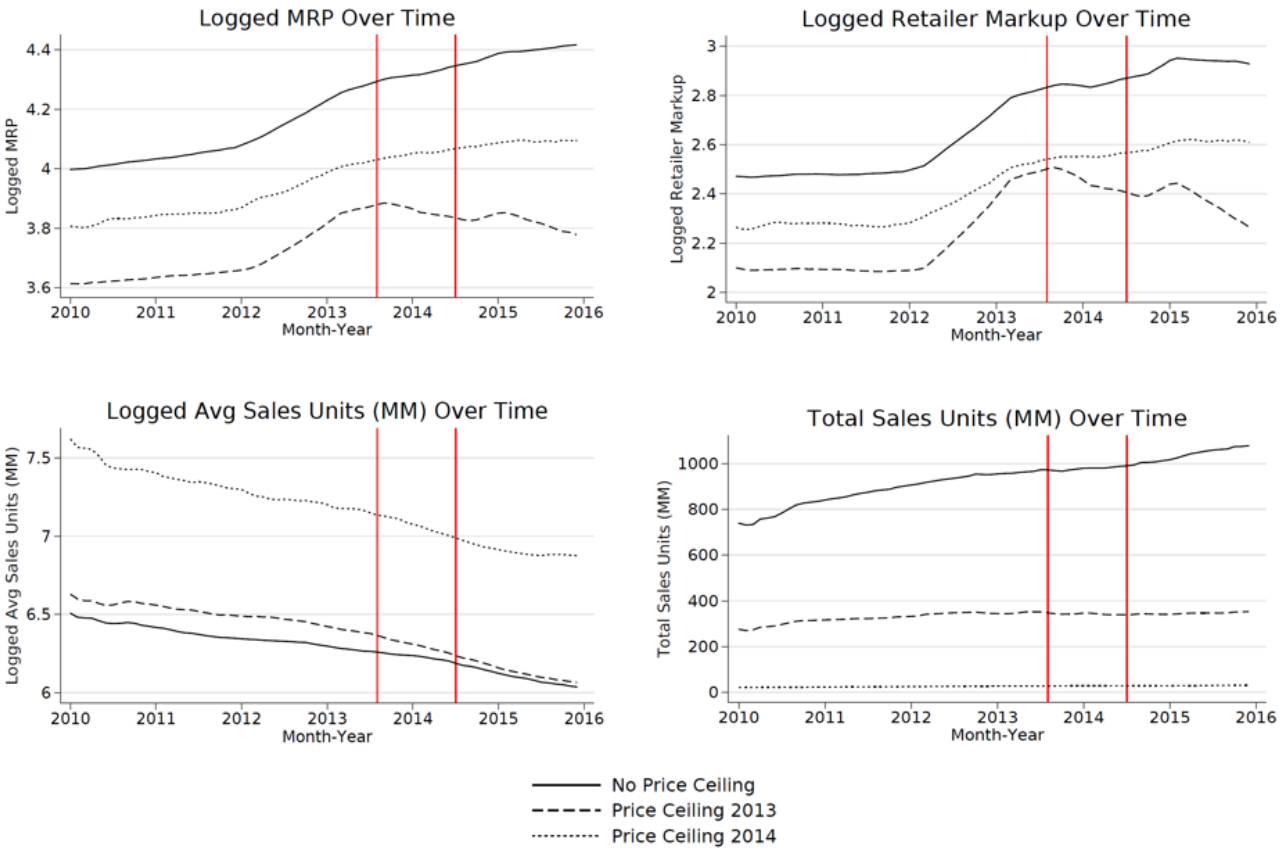
† Numbers shown here are aggregated from the AIOCD Awacs data between 2010 through 2015. Data is Winsorized at 1% to prevent results from being heavily influenced by outliers.

Table 4: Price Ratio by Company Type

Firm Type	No Price Controls	2013 Price Controls	2014 Price Controls
% of Market in Sales Volume	74.81%	22.47%	2.71%
% of Market in Value	78.74%	16.98%	4.28%
% Exporter (Volume)	65.70%	68.41%	76.14%
% Multinational (Volume)	24.94%	27.31%	18.46%
Market Characteristics - Mean and SD			
Logged MRP	4.17	3.76	4.15
	(1.13)	(1.19)	(0.80)
Logged Retailer Markup	2.64	2.27	2.62
	(1.20)	(1.29)	(0.87)
Logged Sales Units	7.47	7.71	8.29
	(2.54)	(2.74)	(2.35)
HHI	3015	3567	1340
	(2365)	(2999)	(613)
SKU Launch Year	2008	2007	2007
	(4.28)	(4.32)	(4.56)
Product Launch Year	2000	1996	2000
	(5.06)	(3.34)	(3.99)
% Chronic	39.68%	31.39%	100%
	(0.49)	(0.46)	(0.00)

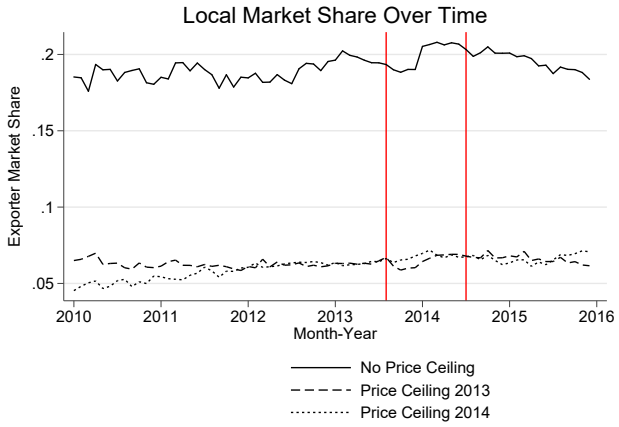
† Statistics sourced from the AIOCD Awacs data for the time period between January 2010 through May 2013, which is when the first waves of price ceilings began. Sales volume and sales units are not adjusted for dosage. All values are unweighted.

Table 6: Characteristics of Price Controlled and Non-Price Controlled Products

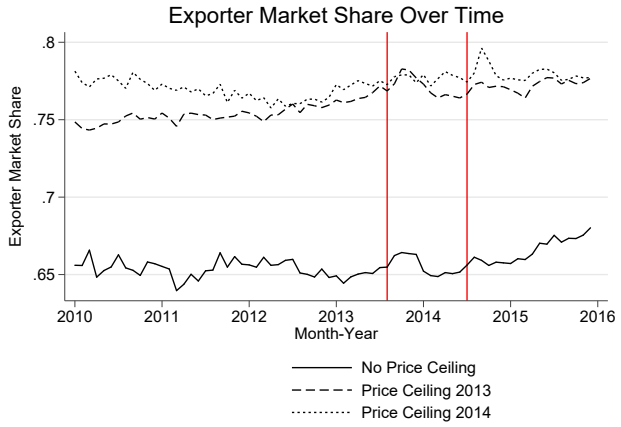


† Data shown here are rolling averages due to seasonal nature of the data. Average sales units are calculated at the SKU-level. Average and total sales units are not adjusted for dosage.

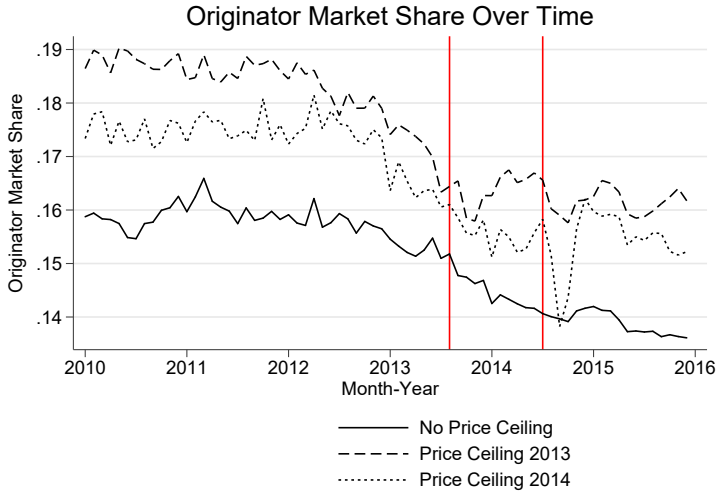
Figure 2: Time Series Trends for Logged MRP, Logged Markup, and Sales Units



(a)



(b)



(c)

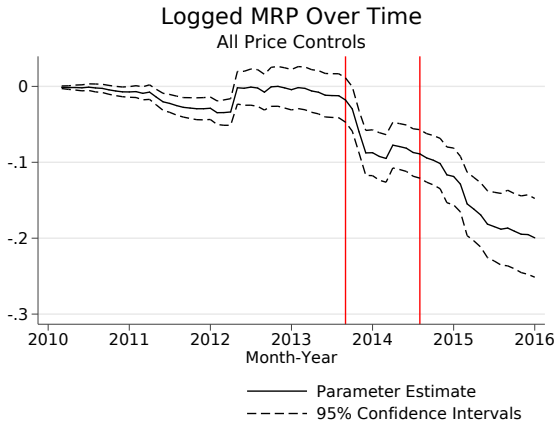
† Market share is calculated at the product level, defined at the EPhMRA subgroup level.

Figure 3: Time Series Trends for Branded, Exporter, and Local Firm Market Shares

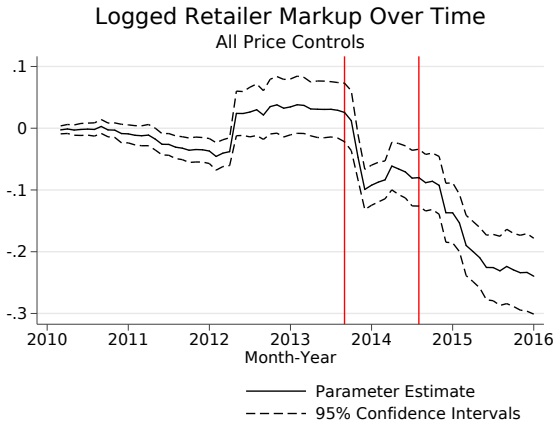
	Local Firm	Exporter Firm	Multinational Firm
	Absolute Markdown		
Overall	4.7	4.2	-6.0
	(36.2)	(57.6)	(65.5)
Above Price Ceiling	-18.8	-30.6	-42.3
	(36.6)	(61.9)	(72.8)
Below Price Ceiling	18.2	23.9	20.9
	(28.2)	(44.2)	(43.1)
	Percentage Difference		
Overall	15.9%	16.2%	5.3%
	(0.55)	(0.58)	(0.50)
Above Price Ceiling	-22.7%	-24.0%	-27.3%
	(0.20)	(0.23)	(0.23)
Below Price Ceiling	38.1%	39.0%	29.4%
	(0.56)	(0.60)	(0.51)

† Markdown is calculated as the ceiling price subtracted by the average SKU market price in the month price ceilings are adopted. Data is Winsorized at 1% to prevent results from being heavily influenced by outliers.

Table 7: Price Markdown by Company Type*



(a)



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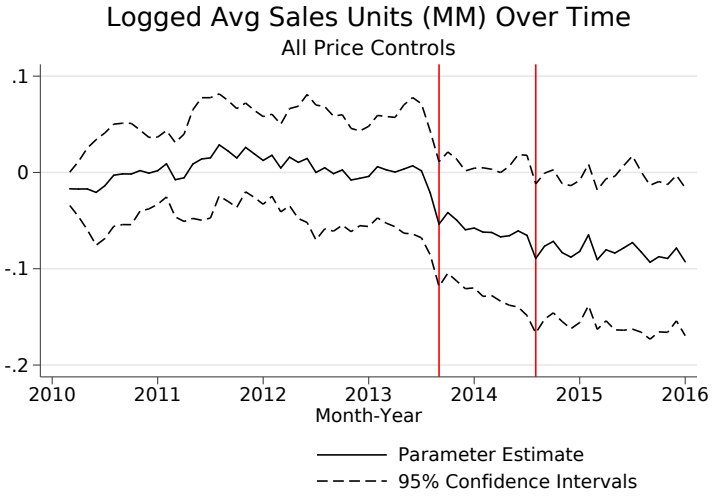

(c)

Figure 4: λ_{it} For Logged MRP, Retailer Markup, and Sales Units

	(1) Main Effect	(2) Chronic Interaction	(3) Company Type Interaction	(4) Price Ceiling Interaction
			Logged MRP	
Price Ceiling	-0.109***	-0.133***	-0.111***	-0.107***
	(0.003)	(0.004)	(0.005)	(0.005)
Chronic × Price Ceiling		0.054***		
		(0.006)		
Company Type				
Exporter × Price Ceiling			0.012^{+}	
			(0.007)	
Multinational × Price Ceiling			-0.054***	
			(0.012)	
Under Ceiling × Price Ceiling				-0.004
				(0.007)
Observations	2,656,065	2,428,764	2,656,065	2,656,065
Adj. R-squared	0.112	0.114	0.112	0.112
			Logged Retailer Markup	
Price Ceiling	-0.148***	-0.180***	-0.162***	-0.144***
	(0.005)	(0.006)	(0.009)	(0.008)
Chronic × Price Ceiling		0.072***		
		(0.009)		
Company Type				
Exporter × Price Ceiling			0.034**	
			(0.010)	
Multinational × Price Ceiling			-0.075***	
			(0.017)	
Under Ceiling × Price Ceiling				-0.007
				(0.010)
Observations	2,497,770	2,422,042	2,497,770	2,497,770
Adj. R-squared	0.0984	0.0995	0.0984	0.0985

† Standard errors are clustered at the SKU level for all regressions shown here. Products from spillover groups are excluded from this analysis.
$^{+}$p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 8: Effect of Price Ceilings on MRP and Retailer Markup

	(1) Main Effect	(2) Price Ceiling Interaction	(3) Chronic Interaction	(4) Company Type Interaction
			Logged MRP	
Price Ceiling	-0.109***	-0.107***	-0.133***	-0.111***
	(0.003)	(0.005)	(0.004)	(0.005)
Under Ceiling × Price Ceiling		-0.004		
		(0.007)		
Chronic × Price Ceiling			0.054***	
			(0.006)	
Company Type				
Exporter × Price Ceiling				0.012^{+}
				(0.007)
Multinational × Price Ceiling				-0.054***
				(0.012)
Observations	2,656,065	2,656,065	2,428,764	2,656,065
Adj. R-squared	0.112	0.112	0.114	0.112
			Logged Retailer Markup	
Price Ceiling	-0.148***	-0.144***	-0.180***	-0.162***
	(0.005)	(0.008)	(0.006)	(0.009)
Under Ceiling × Price Ceiling		-0.007		
		(0.010)		
Chronic × Price Ceiling			0.072***	
			(0.009)	
Company Type				
Exporter × Price Ceiling				0.034**
				(0.010)
Multinational × Price Ceiling				-0.075***
				(0.017)
Observations	2,497,770	2,497,770	2,422,042	2,497,770
Adj. R-squared	0.0984	0.0985	0.0995	0.0984

† Standard errors are clustered at the SKU level for all regressions shown here. Products from spillover groups are excluded from this analysis.
$^{+}$p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 9: Effect of Price Ceilings on MRP and Retailer Markup

	(1) Main Effect	(2) Chronic Interaction
	All Firms	
Price Ceiling	-0.043**	-0.074***
	(0.014)	(0.019)
Chronic × Price Ceiling		0.067*
		(0.026)
Observations	3,205,914	3,101,350
Adj. R-squared	0.0152	0.0153
	Local Firms Only	
Price Ceiling	-0.053*	-0.082**
	(0.024)	(0.030)
Chronic × Price Ceiling		0.055
		(0.048)
Observations	1,058,121	973,956
Adj. R-squared	0.0229	0.0234
	Exporter Firms Only	
Price Ceiling	-0.047**	-0.061*
	(0.018)	(0.025)
Chronic × Price Ceiling		0.033
		(0.033)
Observations	1,828,295	1,810,883
Adj. R-squared	0.0114	0.0115
	Multinational Firms Only	
Price Ceiling	-0.052	-0.154*
	(0.048)	(0.065)
Chronic × Price Ceiling		0.236**
		(0.085)
Observations	319,498	316,511
Adj. R-squared	0.0242	0.0246

† Standard errors are clustered at the SKU level for all regressions shown here. Products from spillover groups are excluded from this analysis.
+p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 10: Effect of Price Ceilings on Logged Sales Units

	(1)	(2)
	Overall Product Market	
	Main Effect	Interaction
Price Ceiling	-0.053*	-0.084**
	(0.024)	(0.032)
Chronic × Price Ceiling		0.070+
		(0.040)
Observations	179,275	179,203
Adj. R-squared	0.00322	0.00324

† Standard errors are clustered at the product level for all regressions shown here.
+p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 11: Effect of Price Ceilings on Sales at Overall Product Level

	(1)	(2)	(3)	(4)
	Main Effect	Local Firms	Exporting Firms	Multinational Firms
	Price-Controlled Products			
Price Ceiling	-0.528***	-0.898***	-0.422***	-0.452***
	(0.035)	(0.078)	(0.040)	(0.127)
Observations	1,520,799	478,842	904,341	137,616
Adj. R-squared	0.274	0.274	0.274	0.327
	Spillover Products			
Price Ceiling	-0.189***	-0.504***	-0.107**	0.085
	(0.034)	(0.074)	(0.039)	(0.117)
Observations	1,521,547	488,266	896,904	136,377
Adj. R-squared	0.277	0.275	0.277	0.340

† Standard errors are clustered at the SKU level for all regressions shown here. Spillover products are excluded from the regressions on price-controlled medications and price-controlled medications are excluded from the regressions on spillover medications.
+p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 12: Effect of Legislation on Bonus Sales

Therapeutic Class	(1) Price Control Effect
Anti-malarials	-0.449**
	(0.158)
Anti-infectives	-0.107*
	(0.045)
Anti-neoplastics	0.257***
	(0.071)
Blood diseases	-0.037
	(0.161)
Cardiac	-0.019
	(0.049)
Dermatological	-0.104
	(0.096)
Gastrointestinal	-0.055
	(0.058)
Gynecological	-0.022
	(0.083)
Hormones	-0.128
	(0.133)
Neurological / CNS	-0.176**
	(0.057)
Opthalmologicals / Otologicals	-0.483
	(0.316)
Others	-0.068
	(0.170)
Pain / Analgesics	-0.204**
	(0.078)
Respiratory	0.055
	(0.088)
Vaccines	-0.066
	(0.166)
Vitamins / Minerals / Nutrients	-0.361***
	(0.053)
Constant	7.735***
	(0.006)

† Standard errors are clustered at the SKU level for all regressions shown here. Spillover products are excluded.
+p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 13: Price Control Effect by Product Subgroup

	(1) Inhalants	(2) Injectables	(3) Liquids	(4) Solids
Price Ceiling	0.073	-0.067^{+}	-0.005	-0.042**
	(0.117)	(0.038)	(0.051)	(0.016)
Observations	39,725	351,489	592,361	2,202,645
Adj. R-squared	0.0213	0.00915	0.0196	0.0178

† Standard errors are clustered at the SKU level for all regressions shown here. Products from spillover groups are excluded from this analysis. Drugs that are classified as an "Other" category are excluded from this analysis.
$^{+}$p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 14: Effect of Treatment by Drug Category on Logged Sales Units

Model:	**Fractional Probit All Products**		**Fractional Probit Acute Products**		**Fractional Probit Chronic Products**	
	Coefficient	**APE**	**Coefficient**	**APE**	**Coefficient**	**APE**
Market Share of:						
Local Firms	-0.558***	-0.145***	-0.531***	-0.146***	-0.571***	-0.135***
	(0.080)	(0.026)	(0.113)	(0.023)	(0.108)	(0.034)
Exporter Firms	0.090	0.033	0.045	0.017	0.130	0.047
	(0.60)	(0.027)	(0.082)	(0.028)	(0.087)	(0.036)
Multinational Firms	0.299***	0.075***	0.367***	0.091***	0.213**	0.055**
	(0.065)	(0.020)	(0.088)	(0.022)	(0.097)	(0.024)
N	180,051	180,051	106,000	106,000	74,051	74,051

† APE standard errors are bootstrapped and all standard errors are robust. Spillover products are excluded from this analysis.
$^{+}$p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 15: Change in Product Market Share by Firm Type - Excluding Spillover Products

	(1) SKU Exit	(2) SKU Exit	(3) Company Exit	(4) Company Exit
Price Ceiling	0.162***	0.176***	0.095*	0.097+
	(0.033)	(0.039)	(0.042)	(0.055)
Chronic	-0.079***	-0.078***	-0.084***	-0.076**
	(0.020)	(0.020)	(0.024)	(0.024)
Company Type				
Exporter	0.049	0.048	-0.048	-0.058
	(0.044)	(0.044)	(0.048)	(0.048)
Multinational	0.166+	0.166+	0.116	0.106
	(0.091)	(0.091)	(0.097)	(0.098)
Market Concentration				
Not Concentrated		-0.041+		-0.077*
		(0.023)		(0.033)
Highly Concentrated		-0.011		0.050*
		(0.017)		(0.025)
Price Ceiling × Chronic	-0.032	-0.034	0.044	0.034
	(0.038)	(0.038)	(0.049)	(0.050)
Company Type				
Price Ceiling × Exporter	-0.103*	-0.105*	-0.127*	-0.139*
	(0.041)	(0.042)	(0.054)	(0.056)
Price Ceiling × Multinational	-0.184**	-0.186**	-0.148+	-0.162*
	(0.060)	(0.062)	(0.079)	(0.078)
Market Concentration				
Price Ceiling × Not Concentrated		-0.031		0.028
		(0.045)		(0.066)
Price Ceiling × Highly Concentrated		-0.007		0.032
		(0.032)		(0.054)
Constant	5.928***	5.499**	-0.174	-0.206
	(1.764)	(1.781)	(2.077)	(2.098)
Observations	96,654	96,654	40,412	40,412

† Standard errors are clustered at the company level. Spillover products are excluded from this analysis.
+p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table 16: Effect of Treatment on SKU and Company Exit

Appendix

A Abbreviations

- CFA: Clearing and Forwarding Agent
- DPCO: Drug Price Control Legislation; the 2013 DPCO initiated the pharmaceutical price caps in India studied in the paper
- EPhMRA: European Pharmaceutical Market Research Association; an organization which has created a standardized classification system for pharmaceutical products used in this paper
- FDCA: Indian Food and Drug Control Administration; the source of my data on drug quality
- HHI: Herfindahl-Hirschman Index; measure of market concentration
- MRP: Maximum retail price; price to consumer listed on medication box
- NLEM: (Indian) National List of Essential Medicines
- NPPA: National Pharmaceutical Pricing Authority; regulatory body that sets pharmaceutical price ceilings
- PCI: Per capita income
- SKU: Stock keeping unit
- WHO GMP: World Health Organization Good Manufacturing Practice certified pharmaceutical production plant

B History of Drug Price Regulation

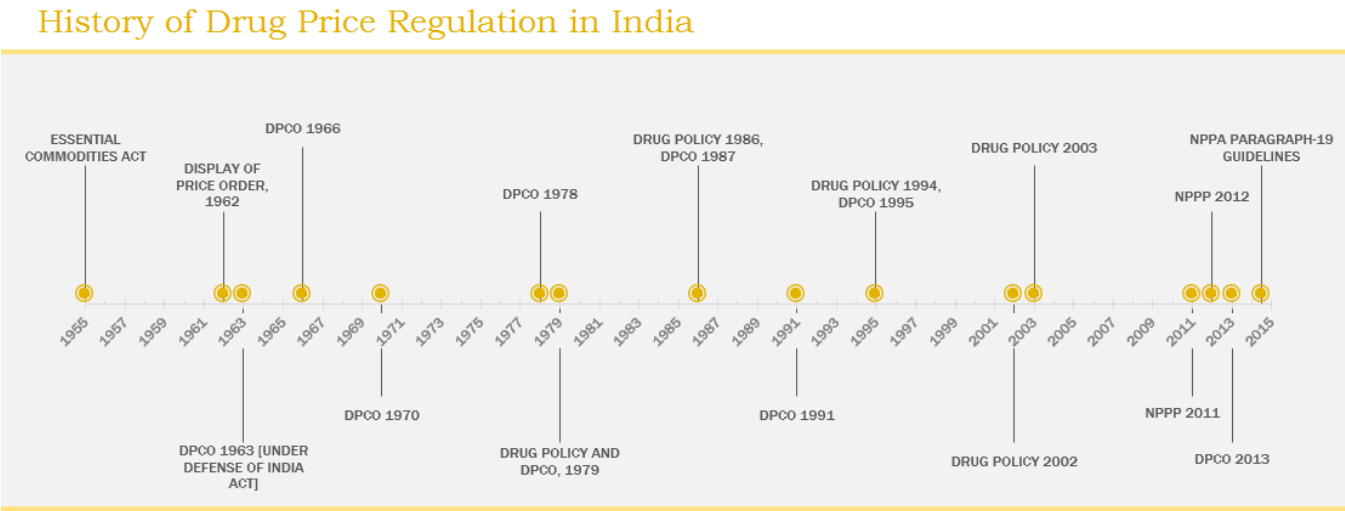

Figure B1: Timeline of Drug Price Regulation in India Between 1955 to Present

In 1955, India established the Essential Commodities Act, which allowed regulators to control prices of consumer products under Section 3. Under the Essential Commodities Act, drug prices have been controlled using a series of Drugs Price Control Orders ("DPCOs"), beginning in 1970. Under a DPCO issued in 1995, India established the National Pharmaceutical Pricing Authority ("NPPA"), an organization which has limited ability to review and fix pharmaceutical prices (Narula, 2015). Under the most recent DPCO, issued in 2013, the NPPA has authority to maintain and expand the National List of Essential Medicines ("NLEM"), a list of medications based off the World Health Organization's list of essential medicines and place drugs on this list under price controls (Narula, 2015).

C Estimates of Not Standard Quality Drugs in India

Year	Estimate	Detail	Source
2009–2010	11%	N/A	Gujarat FDCA
2010–2011	7.11%	N/A	Gujarat FDCA
2011–2012	10.5%	N/A	Gujarat FDCA
2012–2013	5.6%	N/A	Gujarat FDCA
2013–2014	5.8%	N/A	Gujarat FDCA
2014–2015	4.6%	N/A	Gujarat FDCA
2015–2016	4.9%	N/A	Gujarat FDCA
2014–2016	3.18%	3.16% NSQ (3% of retail drugs, 10.2% of government supply chain), 0.0245% Spurious, State-level differences: 0-8.82% of drugs NSQ in retail setting	National Institute of Biologicals

† Estimates from the Gujarat FDCA are sourced from Das (2016). Estimates from the National Institute of Biologicals are sourced from National Institute of Biologicals (2016).

Table C1: Not Standard Quality ("NSQ") Estimates from the Indian Government

C.1 Likelihood of FDCA Testing

Table C2 presents results of a Poisson regression estimating the how often a companies products will be tested by the FDCA. The outcome variable is count of times a companies' products appear in the FDCA testing data, and independent variables include the following company characteristics: logged total sales value, percentage of products priced below the price ceiling, number of unique products a company produces, and company type. I estimate a Poisson regression in place of a negative binomial regression as the dispersion parameter is not statistically different from zero.

	(1)
	FDCA Testing
Logged Total Sales Volume	0.338***
	(0.036)
% of Products Under Ceiling	-2.784***
	(0.782)
# Unique Products	-1.476
	(1.006)
Company Type	
Exporter	1.188***
	(0.213)
Multinational	0.924***
	(0.269)
Constant	-6.303***
	(0.509)
Observations	410

Table C2: Likelihood of a Company's Product Being Tested by the FDCA

D Low-Quality Data Summary Statistics

Reason for Failing	Count	Percentage
Content assay*	143	48.3%
Dissolution	80	27.0%
Disintegration time	29	9.8%
Identification	11	3.7%
Discoloration	10	3.4%
Labeling	8	2.7%
pH	6	2.0%
Particulate matter	6	2.0%
Nil content	6	2.0%
Capping, cracking, or related	4	1.4%
Sterility	4	1.4%
Water / moisture content	4	1.4%
Uniformity of weight	3	1.0%
Missing some active ingredients	3	1.0%
Contains non-listed active ingredient	3	1.0%
Microbial limit tests	2	0.7%
Glass particle	2	0.7%
Sulphated ash	2	0.7%
Refractive Index	1	0.3%
Toxicity	1	0.3%
Salisytic acid test	1	0.3%
Loss on drying	1	0.3%
Total**	296	100.0%

*The mean value of listed active ingredient(s) was 47.4% (st. dev 42.3%), with a range of 0-246.5%.

**A number of drugs failed on multiple categories, thus adding the counts or percentages will not equal the total.

Table D3: Listed Reasons for Failing Drug Quality Testing

E Theory Proofs and Extensions

E.1 Proof that Multinational Firm's Demand Will Rise

Case 1: Only the multinational firm is present in the market

If only the multinational firm is present in the market, the initial demand in the laissez-faire market is:

$$D_m^{lf} = 1 - \frac{p_m}{t}$$

Post-legislation, the multinational firm will lower their price to the ceiling, at price p_c, thus demand becomes:

$$D_m^{pc} = 1 - \frac{p_c}{t}$$

Because $p_c < p_m$ by design, $D_m^{pc} > D_m^{lf}$.

Case 2: Only multinational and exporting or local firms are present in the market

If only multinational and exporting firms are present in the market, their laissez-faire market demand is:

$$D_m^{lf} = 1 - \frac{p_m - p_e}{t(\alpha - \beta)}$$

$$D_e^{lf} = \frac{p_m - p_e}{t(\alpha - \beta)} - \frac{p_e}{t}$$

Post-legislation, the multinational firm will lower their price to the ceiling, at price p_c, and the exporting firm will lower their price in response to the new level: p_e^* thus demand becomes:

$$D_m^{pc} = 1 - \frac{p_c - p_e^*}{t(\alpha - \beta)}$$

where $p_e^* = \frac{p_c}{2(1 + \alpha - \beta)} + \frac{c_e}{2}$

and the change in p_e with respect to p_m is:

$$\Delta p_e(p_m) = \frac{1}{2(1 + \alpha - \beta)} < 1$$

Because $\Delta p_e(p_m) < 1$ it must be the case that $D_m^{pc} > D_m^{lf}$.

If only multinational and local firms are present in the market, their laissez-faire market demand is:

$$D_m^{lf} = 1 - \frac{p_m - p_l}{t(\alpha - 1)}$$

$$D_l^{lf} = \frac{p_m - p_l}{t(\alpha - 1)} - \frac{p_l}{t}$$

Post-legislation, the multinational firm will lower their price to the ceiling, at price p_c, and the local firm will lower their price in response to the new level: p_l^* thus demand becomes:

$$D_m^{pc} = 1 - \frac{p_c - p_l^*}{t(\alpha - 1)}$$

where $p_l^* = \frac{p_c}{2\alpha} + \frac{c_l}{2}$

and the change in p_e with respect to p_m is:

$$\Delta p_l(p_m) = \frac{1}{2\alpha} < 1$$

Because $\Delta p_l(p_m) < 1$ it must be the case that $D_m^{pc} > D_m^{lf}$.

Case 3: All Firm Types are in the Market

If all firm types are present in the market, the initial demand functions in the laissez-faire market are:

$$D_m^{lf} = 1 - \frac{p_m - p_e}{t(\alpha - \beta)}$$

$$D_e^{lf} = \frac{p_m - p_e}{t(\alpha - \beta)} - \frac{p_e - p_l}{t(\beta - 1)}$$

$$D_l^{lf} = \frac{p_e - p_l}{t(\beta - 1)} - \frac{p_l}{t}$$

Post-legislation, the multinational firm will lower their price to the ceiling, at price p_c, and the exporting firm will lower their price in response to the new level: p_e^* thus demand becomes:

$$D_m^{pc} = 1 - \frac{p_c - p_e^*}{t(\alpha - \beta)}$$

where $p_e^* = \frac{(\beta - 1)p_c + (\alpha - \beta)\frac{c_l}{2} + (\alpha - 1)c_e}{\alpha(2 - \frac{1}{2\beta}) - \frac{3}{2}}$

The change in p_e with respect to p_m from laissez-faire pricing is therefore:

$$\Delta p_e(p_m) = \frac{(\beta - 1)}{\alpha(2 - \frac{1}{2\beta}) - \frac{3}{2}} < 1$$

Given $\Delta p_e(p_m) < 1$ it must be the case that $D_m^{pc} > D_m^{lf}$.

E.2 Allowing for Increasing Marginal Costs

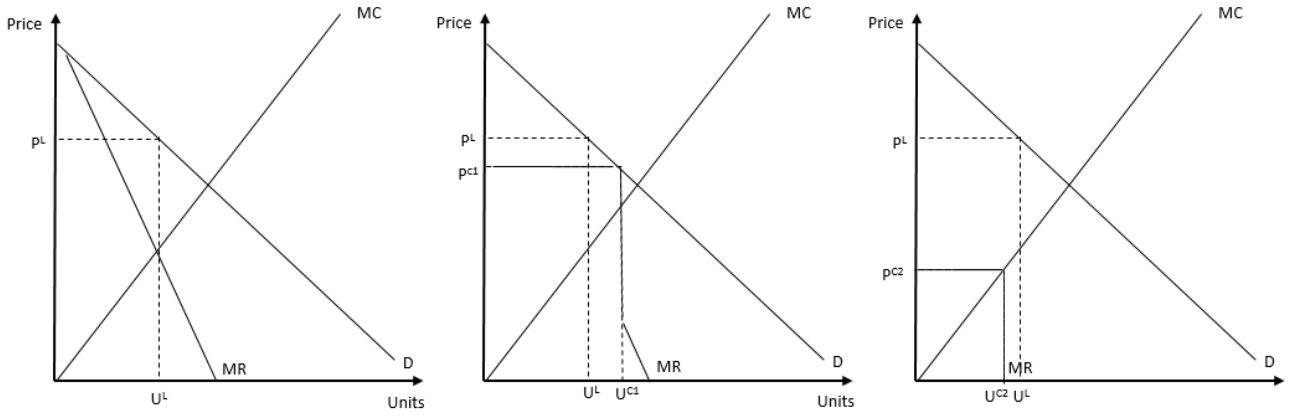

Figure E2: Price Ceilings with Firm Market-Power and Increasing Marginal Costs

Figure E2 shows how price ceilings that are set sufficiently low can lead to a decrease in supply – but not full market exit – after price ceilings are implemented, even for firms with market-power, if marginal costs are increasing in volume. In the first graph P^L and U^L denote the laissez-faire market price and quantity supplied by a monopolist producer. In the second graph, P^{C1} and U^{C1} indicate the prices and quantities supplied at Price Ceiling 1 = P^{C1}. This clearly leads to an increase in supply. In the third graph, the price ceiling is set significantly lower, at P^{C2}. At this, significantly lower price, quantity supplied shrinks to $U^{C2} < U^L$.

F Robustness - Test of Proposition 1

	(1) Main Effect	(2) Price Ceiling Interaction	(3) Chronic Interaction	(4) Company Type Interaction
		Logged MRP		
Price Ceiling	-0.116***	-0.118***	-0.143***	-0.119***
	(0.003)	(0.006)	(0.005)	(0.006)
Under Ceiling × Price Ceiling		0.002		
		(0.007)		
Chronic × Price Ceiling			0.057***	
			(0.007)	
Company Type				
Exporter × Price Ceiling				0.013+
				(0.007)
Multinational × Price Ceiling				-0.058***
				(0.013)
Observations	2,263,423	2,263,423	2,055,980	2,263,423
Adj. R-squared	0.124	0.124	0.128	0.125
		Logged Retailer Markup		
Price Ceiling	-0.159***	-0.162***	-0.193***	-0.171***
	(0.005)	(0.009)	(0.007)	(0.009)
Under Ceiling × Price Ceiling		0.004		
		(0.011)		
Chronic × Price Ceiling			0.075***	
			(0.010)	
Company Type				
Exporter × Price Ceiling				0.033**
				(0.011)
Multinational × Price Ceiling				-0.087***
				(0.019)
Observations	2,106,410	2,106,410	2,050,499	2,106,410
Adj. R-squared	0.107	0.107	0.108	0.107

† Standard errors are clustered at the SKU level for all regressions shown here. Products from spillover groups are excluded from this analysis, as are SKUs that exit the market after May 2013 when the first wave of price ceilings went into place.
+p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table F4: Effect of Price Ceilings on MRP, Retailer Markup, and Sales Units Sold - Excluding SKUs that Exit the Market

	(1) Main Effect	(2) Price Ceiling Interaction	(3) Chronic Interaction	(4) Company Type Interaction
			Logged MRP	
Price Ceiling	-0.041***	-0.035***	-0.049***	-0.059***
	(0.003)	(0.006)	(0.004)	(0.008)
Under Ceiling × Price Ceiling		-0.009		
		(0.007)		
Chronic × Price Ceiling			0.023***	
			(0.007)	
Company Type				
Exporter × Price Ceiling				0.024**
				(0.009)
Multinational × Price Ceiling				0.013
				(0.013)
Observations	1,523,005	1,523,005	1,501,119	1,523,005
Adj. R-squared	0.153	0.153	0.155	0.153
			Logged Retailer Markup	
Price Ceiling	-0.054***	-0.044***	-0.065***	-0.074***
	(0.005)	(0.008)	(0.006)	(0.012)
Under Ceiling × Price Ceiling		-0.015		
		(0.010)		
Chronic × Price Ceiling			0.032**	
			(0.010)	
Company Type				
Exporter × Price Ceiling				0.026*
				(0.013)
Multinational × Price Ceiling				0.015
				(0.018)
Observations	1,520,489	1,520,489	1,498,791	1,520,489
Adj. R-squared	0.123	0.123	0.124	0.123

† Standard errors are clustered at the SKU level for all regressions shown here. Products from spillover groups and SKUs that had less than 1% market share for a given product in the year before relevant price controls were enacted are excluded from this analysis.
+p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table F5: Effect of Price Ceilings on MRP, Retailer Markup, and Sales Units Sold – Products with Greater than 1% Market Share

	(1) Main Effect	(2) Price Ceiling Interaction	(3) Chronic Interaction
		Logged MRP	
Price Ceiling	-0.106***	-0.108***	-0.129***
	(0.005)	(0.009)	(0.006)
Under Ceiling × Price Ceiling		0.004	
		(0.011)	
Chronic × Price Ceiling			0.054***
			(0.011)
Observations	976,362	976,362	763,269
Adj. R-squared	0.127	0.127	0.139
		Logged Retailer Markup	
Price Ceiling	-0.155***	-0.152***	-0.181***
	(0.009)	(0.014)	(0.011)
Under Ceiling × Price Ceiling		-0.005	
		(0.018)	
Chronic × Price Ceiling			0.060***
			(0.018)
Observations	822,374	822,374	760,741
Adj. R-squared	0.0800	0.0800	0.0820

† Standard errors are clustered at the SKU level for all regressions shown here. Products from spillover groups are excluded from this analysis. Only products manufactured by local producers, as defined in Section 4.1, are included.
+p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table F6: Effect of Treatment on Price - Local Products Only

	(1) Main Effect	(2) Price Ceiling Interaction	(3) Chronic Interaction
		Logged MRP	
Price Ceiling	-0.103***	-0.105***	-0.129***
	(0.004)	(0.007)	(0.006)
Under Ceiling × Price Ceiling		0.004	
		(0.009)	
Chronic × Price Ceiling			0.059***
			(0.008)
Observations	1,433,045	1,433,045	1,420,752
Adj. R-squared	0.111	0.111	0.112
		Logged Retailer Markup	
Price Ceiling	-0.133***	-0.139***	-0.166***
	(0.006)	(0.011)	(0.009)
Under Ceiling × Price Ceiling		0.009	
		(0.013)	
Chronic × Price Ceiling			0.073***
			(0.011)
Observations	1,429,898	1,429,898	1,417,700
Adj. R-squared	0.113	0.113	0.113

† Standard errors are clustered at the SKU level for all regressions shown here. Products from spillover groups are excluded from this analysis. Only products manufactured by exporting producers, as defined in Section 4.1, are included.
$^{+}$p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table F7: Effect of Treatment on Price - Exporter Products

	(1) Main Effect	(2) Price Ceiling Interaction	(3) Chronic Interaction
		Logged MRP	
Price Ceiling	-0.168***	-0.123***	-0.176***
	(0.012)	(0.016)	(0.016)
Under Ceiling × Price Ceiling		-0.078***	
		(0.022)	
Chronic × Price Ceiling			0.018
			(0.022)
Observations	246,658	246,658	244,743
Adj. R-squared	0.108	0.109	0.110
		Logged Retailer Markup	
Price Ceiling	-0.234***	-0.158***	-0.266***
	(0.016)	(0.021)	(0.020)
Under Ceiling × Price Ceiling		-0.130***	
		(0.029)	
Chronic × Price Ceiling			0.076*
			(0.030)
Observations	245,498	245,498	243,601
Adj. R-squared	0.0899	0.0908	0.0906

† Standard errors are clustered at the SKU level for all regressions shown here. Products from spillover groups are excluded from this analysis. Only products manufactured by multinational producers, as defined in Section 4.1, are included.
+p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table F8: Effect of Treatment on Price - Multinational Products Only

G Exit Including Spillover Drugs

	(1) SKU Exit	(2) SKU Exit	(3) Company Exit	(4) Company Exit
Price Ceiling	0.162***	0.176***	0.015	0.002
	(0.033)	(0.039)	(0.044)	(0.059)
Chronic	-0.079***	-0.078***	-0.088***	-0.082***
	(0.020)	(0.020)	(0.023)	(0.023)
Company Type				
Exporter	0.049	0.048	-0.046	-0.057
	(0.044)	(0.044)	(0.048)	(0.048)
Multinational	0.166+	0.166+	0.133	0.122
	(0.091)	(0.091)	(0.098)	(0.099)
Market Concentration Not Concentrated		-0.041+		-0.068*
		(0.023)		(0.030)
Highly Concentrated		-0.011		0.060*
		(0.017)		(0.025)
Price Ceiling × Chronic	-0.032	-0.034	0.070	0.062
	(0.038)	(0.038)	(0.055)	(0.055)
Company Type				
Price Ceiling × Exporter	-0.103*	-0.105*	-0.128*	-0.135*
	(0.041)	(0.042)	(0.055)	(0.056)
Price Ceiling × Multinational	-0.184**	-0.186**	-0.153+	-0.162+
	(0.060)	(0.062)	(0.085)	(0.084)
Market Concentration				
Price Ceiling × Not Concentrated		-0.031		0.072
		(0.045)		(0.070)
Price Ceiling × Highly Concentrated		-0.007		0.038
		(0.032)		(0.056)
Constant	5.928***	5.499**	-1.459	-1.549
	(1.764)	(1.781)	(1.981)	(1.992)
Observations	96,654	96,654	44,207	44,207

† Standard errors are clustered at the SKU level for all regressions shown here.
+p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table G9: Effect of Treatment on SKU and Company Exit

H Spillover Group Analysis

	(1) Main Effect	(2) Chronic Interaction	(3) Company Type Interaction
		Logged MRP	
Price Ceiling	-0.023***	-0.032***	-0.024***
	(0.002)	(0.002)	(0.002)
Chronic × Price Ceiling		0.016***	
		(0.002)	
Company Type			
Exporter × Price Ceiling			0.012***
			(0.002)
Multinational × Price Ceiling			0.006
			(0.004)
Observations	2,481,755	2,405,516	2,481,755
Adj. R-squared	0.120	0.122	0.120
		Logged Markup	
Price Ceiling	-0.029***	-0.040***	-0.038***
	(0.002)	(0.003)	(0.004)
Chronic × Price Ceiling		0.021***	
		(0.003)	
Company Type			
Exporter × Price Ceiling			0.014***
			(0.004)
Multinational × Price Ceiling			0.005
			(0.006)
Observations	2,474,599	2,398,871	2,474,599
Adj. R-squared	0.101	0.102	0.101

† Standard errors are clustered at the SKU level for all regressions shown here. Price-controlled products are excluded from this analysis.
+p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table H10: Effect of Treatment on Price and Mark-up of Spillover Products - Broad Definition of Spillover

	(1) Main Effect	(2) Chronic Interaction
	Narrow Product Market	
Price Ceiling	0.042**	0.024
	(0.015)	(0.019)
Chronic × Price Ceiling		0.041
		(0.029)
Observations	3,183,919	3,079,355
Adj. R-squared	0.0146	0.0146
	Broad Product Market	
Price Ceiling	0.001	-0.054***
	(0.009)	(0.010)
Chronic × Price Ceiling		0.129***
		(0.013)
Observations	3,183,919	3,079,355
Adj. R-squared	0.0146	0.0151

† Standard errors are clustered at the SKU level for all regressions shown here. Price-controlled products are excluded from this analysis.
+p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table H11: Effect of Treatment on Logged Unit Sales of Spillover Products - Narrow and Broad Definition of Spillover

	(1) Main Effect Interaction	(2) Chronic
	Local Firms	
Price Ceiling	-0.026***	-0.040***
	(0.002)	(0.003)
Chronic × Price Ceiling		0.023***
		(0.004)
Observations	837,539	775,508
Adj. R-squared	0.138	0.144
	Exporter Firm	
Price Ceiling	-0.022***	-0.027***
	(0.002)	(0.003)
Chronic × Price Ceiling		0.012***
		(0.003)
Observations	1,404,801	1,392,508
Adj. R-squared	0.118	0.118
	Multinational Firm	
Price Ceiling	-0.030***	-0.035***
	(0.005)	(0.006)
Chronic × Price Ceiling		0.014+
		(0.008)
Observations	239,415	237,500
Adj. R-squared	0.113	0.115

Table H12: Effect of Treatment on Logged MRP on Spillover Products By Company Type - Broad Definition of Spillover

	(1) Main Effect Interaction	(2) Chronic
	Local Firms	
Price Ceiling	-0.032***	-0.049***
	(0.004)	(0.005)
Chronic × Price Ceiling		0.027***
		(0.006)
Observations	834,523	772,890
Adj. R-squared	0.0815	0.0838
	Exporter Firm	
Price Ceiling	-0.030***	-0.037***
	(0.003)	(0.004)
Chronic × Price Ceiling		0.016***
		(0.004)
Observations	1,401,792	1,389,594
Adj. R-squared	0.115	0.115
	Multinational Firm	
Price Ceiling	-0.026***	-0.038***
	(0.008)	(0.009)
Chronic × Price Ceiling		0.030**
		(0.011)
Observations	238,284	236,387
Adj. R-squared	0.0930	0.0936

Table H13: Effect of Treatment on Logged Markup on Spillover Products By Company Type - Broad Definition of Spillover

	(1) Main Effect Interaction	(2) Chronic Interaction
	Local Firms	
Price Ceiling	0.031*	-0.023
	(0.014)	(0.016)
Chronic × Price Ceiling		0.110***
		(0.021)
Observations	1,077,665	993,500
Adj. R-squared	0.0219	0.0225
	Exporter Firm	
Price Ceiling	-0.010	-0.057***
	(0.012)	(0.014)
Chronic × Price Ceiling		0.127***
		(0.016)
Observations	1,795,675	1,778,263
Adj. R-squared	0.0109	0.0114
	Multinational Firm	
Price Ceiling	-0.110***	-0.186***
	(0.033)	(0.039)
Chronic × Price Ceiling		0.182***
		(0.047)
Observations	310,579	307,592
Adj. R-squared	0.0231	0.0239

Table H14: Effect of Treatment on Logged Sales Units on Spillover Products By Company Type - Broad Definition of Spillover

I Additional Results from Analysis on Markup and Legislation Effects by Product Category

	(1) Inhalants	(2) Injectables	(3) Liquids	(4) Solids
Price Ceiling	-0.113	-0.098***	-0.136***	-0.101***
	(0.075)	(0.009)	(0.009)	(0.004)
Observations	30,955	271,715	450,075	1,736,604
Adj. R-squared	0.152	0.0622	0.213	0.111

Table I15: Effect of Treatment by Drug Category on Logged MRP

	(1) Inhalants	(2) Injectables	(3) Liquids	(4) Solids
Price Ceiling	-0.107	-0.130***	-0.166***	-0.139***
	(0.109)	(0.014)	(0.015)	(0.005)
Observations	30,948	270,819	448,945	1,731,440
Adj. R-squared	0.127	0.0837	0.118	0.100

Table I16: Effect of Treatment by Drug Category on Logged Retailer Markup

	(1) Main Effect	(2) Local Firms	(3) Exporting Firms	(4) Multinational Firms
Bonus Sales	0.224***	0.162***	0.249***	0.181*
	(0.022)	(0.041)	(0.028)	(0.081)
Observations	2,094,259	718,541	1,173,700	202,018
Adj. R-squared	0.0163	0.0191	0.0134	0.0306

† Standard errors are clustered at the SKU level for all regressions shown here. Price-controlled and spillover products are excluded from this analysis.
+p<0.10, *p<0.05, **p<0.01, ***p<0.001

Table I17: Correlation Between Bonus Sales and Sales Units

	Acute Medications					
	Prior to Price Control Legislation			**Post Price Control Legislation**		
	Ratio MNC-Exporter	Ratio MNC-Local	Ratio Exporter-Local	Ratio MNC-Exporter	Ratio MNC-Local	Ratio Exporter-Local
MRP	1.20	1.28	1.05	1.09	1.08	1.04
	(0.69)	(2.11)	(0.56)	(0.51)	(0.58)	(0.58)
Retailer Markup	1.15	1.37	1.27	1.07	1.25	1.35
	(1.06)	(2.24)	(0.95)	(1.15)	(1.63)	(1.40)
Sales Units	2.71	12.41	16.06	3.16	11.63	15.08
	(7.17)	(19.06)	(19.45)	(8.66)	(20.00)	(19.18)
	Chronic Medications					
	Prior to Price Control Legislation			**Post Price Control Legislation**		
	Ratio MNC-Exporter	Ratio MNC-Local	Ratio Exporter-Local	Ratio MNC-Exporter	Ratio MNC-Local	Ratio Exporter-Local
MRP	1.26	1.34	1.11	1.19	1.27	1.12
	(0.46)	(0.56)	(0.43)	(0.53)	(0.63)	(0.57)
Retailer Markup	1.25	1.42	1.24	1.18	1.33	1.29
	(0.88)	(1.14)	(1.12)	(1.13)	(1.35)	(2.05)
Sales Units	2.95	10.15	11.75	2.86	10.25	12.88
	(8.20)	(16.05)	(16.22)	(7.74)	(17.94)	(17.52)

Table I18: Ratios of MRP, Retailer Markup and Sales Units for Acute and Chronic Products Prior to and Post Price Control Legislation: Price-Controlled Products Only

J Alternative Specifications of Market Share Analysis

J.1 Main Results Including Spillover Products

Model:	**Fractional Probit All Products**		**Fractional Probit Acute Products**		**Fractional Probit Chronic Products**	
	Coefficient	**APE**	**Coefficient**	**APE**	**Coefficient**	**APE**
Market Share of:						
Local Firms	-0.529***	-0.138***	-0.535***	-0.147***	-0.498***	-0.118***
	(0.067)	(0.023)	(0.094)	(0.022)	(0.095)	(0.025)
Exporter Firms	0.116*	0.043+	0.119+	0.045	0.098	0.036
	(0.54)	(0.024)	(0.74)	(0.031)	(0.080)	(0.034)
Multinational Firms	0.256***	0.064***	0.283***	0.070***	0.218***	0.056**
	(0.061)	(0.019)	(0.082)	(0.023)	(0.092)	(0.024)
N	181,305	181,305	106,829	106,829	74,404	74,404

Table J19: Change in Product Market Share by Firm Type - Including Spillover Groups

J.2 Linear Approximation with Fixed Effects

	(1) Local Firm	(2) Exporter Firm	(3) Multinational Firm
		All Data	
Price Ceiling	-0.015***	0.002	0.013***
	(0.002)	(0.004)	(0.004)
Observations	180,051	180,051	180,051
Adj. R-squared	0.00140	0.000948	0.00706
		Acute Products Only	
Price Ceiling	-0.013***	-0.006	0.018*
	(0.003)	(0.007)	(0.007)
Observations	106,000	106,000	106,000
Adj. R-squared	0.00119	0.00148	0.00701
		Chronic Products Only	
Price Ceiling	-0.017***	0.011**	0.007*
	(0.003)	(0.004)	(0.003)
Observations	73,979	73,979	73,979
Adj. R-squared	0.00172	0.000258	0.00702

Table J20: Effect of Legislation on Market Share by Firm Type

J.3 Two-Period Collapsed Difference-in-Difference

In the two-period model, I run two difference-in-difference estimations, separately comparing products receiving price ceilings in 2013 and 2014 to products not receiving price ceilings. In this analysis, I collapse data at the molecule (e.g. ibuprofen) level to two time periods: pre-legislation (Jan 2010-August 2013 for the 2013 legislation and Jan 2010-June 2014 for the 2014 legislation) and post-legislation (September 2013-December 2015 for the 2013 legislation and July 2014-December 2015 for the 2014 legislation). Then, I run a traditional difference-in-differences estimation using a fractional probit model with robust standard errors, as in Equation 6:

$$s_{it} = \gamma post_t + \eta c_i + \tau post_t \times c_i + \epsilon_{it} \tag{6}$$

where c_i indicates a price-controlled product and *post* indicates the post-legislation time period.

	(1)	(2)	(3)
	2013 Legislation	2013 Legislation Chronic Only	2014 Legislation
		Local Firm Market Share	
Post x Price Ceiling	-0.163	-0.291	-0.042
	(0.253)	(0.410)	(0.644)
Post	0.072	0.060	0.067
	(0.060)	(0.097)	(0.060)
Price Ceiling	-0.720***	-0.685*	-1.014*
	(0.177)	(0.268)	(0.461)
Chronic	-0.277***		-0.270***
	(0.062)		(0.064)
Observations	5,520	2,199	5,069
		Exporter Firm Market Share	
Post x Price Ceiling	0.028	0.103	0.077
	(0.153)	(0.257)	(0.331)
Post	0.005	0.006	-0.001
	(0.049)	(0.078)	(0.049)
Price Ceiling	0.311**	0.322+	0.354
	(0.109)	(0.183)	(0.232)
Chronic	0.058		0.054
	(0.050)		(0.052)
Observations	5,520	2,199	5,069
		Multinational Firm Market Share	
Post x Price Ceiling	0.104	0.039	-0.047
	(0.179)	(0.303)	(0.366)
Post	-0.100	-0.082	-0.082
	(0.066)	(0.104)	(0.066)
Price Ceiling	0.001	-0.074	0.237
	(0.129)	(0.222)	(0.256)
Chronic	0.195**		0.219**
	(0.066)		(0.071)
Observations	5,520	2,199	5,069

Table J21: Effect of Legislation on Market Share