THE MARKET FOR HIGH-QUALITY MEDICINE: RETAIL CHAIN ENTRY AND DRUG QUALITY IN INDIA

Daniel Bennett and Wesley Yin*

Abstract—This study examines the effect of chain store entry on drug quality and prices in India. In contrast to prevailing mom-and-pop pharmacies, chains exploit scale economies in distribution and signaling to offer high-quality drugs at lower cost. We show that chain entry leads to a 5% improvement in drug quality and a 2% decrease in prices at incumbent retailers. Effects are larger for locally distributed drug brands but do not depend on consumer SES. Our findings suggest that in markets with asymmetric information, organizational technologies such as chains can play an important role translating market expansion into higher quality.

I. Introduction

SUBSTANDARD medicines are pervasive in many developing countries (Bate & Boateng, 2007; Gaurdiano et al., 2007). The public health impact of substandard medicine is potentially severe, as these drugs deny patients effective therapy, expose people to toxic impurities, and contribute to pathogenic resistance (Cockburn et al., 2005). Access to effective medicine also has important effects on human capital accumulation, labor supply, earnings, and other economic outcomes (Miguel & Kremer, 2004; Baird et al., 2012).

While drug quality is consistently higher in developed countries (Wertheimer & Norris, 2009; Degardin, Roggo, & Margot, 2014), the relationship between economic development and drug quality is not well understood. In a canonical product market, rising incomes spur demand for high-quality products, which in turn incentivize suppliers to provide these goods. In settings where high-quality production involves fixed costs, market expansion spurs producers to incur these costs and realize scale economies. It is unclear how this process works for products like drugs with imperfectly observable quality (Bate, Jin, & Mathur, 2011). Asymmetric quality information may severely limit the demand for high-quality drugs and thereby dampen supplier incentives to provide high quality.

To explore how income growth translates into improvements in drug quality, this study examines the impact of entry by a high-productivity pharmacy chain on quality and prices in retail drug markets in Hyderabad, India. Using plausibly exogenous entry of chain pharmacies, we find that chain competition leads single-enterprise mom-and-pop pharmacies to lower prices and improve quality. We observe these effects across socioeconomic groups, suggesting that chain entry raises consumer welfare in this case. We assess possible channels for quality improvement and find evidence that firms improve quality by sourcing from better distributors. A chain's entry is itself a product of income growth and market expansion. By establishing its own supply chain, chains incur a substantial fixed cost to safeguard quality. This action is an example of an endogenous sunk cost: a productivity-improving investment that occurs in response to market expansion (Shaked & Sutton, 1990; Sutton, 1991; Ellickson, 2006, 2007). We show that chain pharmacies can help to translate market expansion into higher-quality medicine in developing countries.

This study builds on an extensive literature on the effects of competition on prices and quality. Under full information, studies find that entry causes incumbents to lower prices (Basker, 2005; Jia, 2008; Basker & Noel, 2009). Many studies also examine the effects of competition on product quality (Domberger & Sherr, 1989; Mazzeo, 2003; Matsa, 2011). A distinguishing feature of the retail pharmacy market is the presence of asymmetric information. Consumers have difficulty observing drug quality due to placebo effects and their inability to observe the counterfactual with nonconsumption of the drug. Prices are at best a noisy quality signal (Bate, Jin, & Mathur, 2011). The difficulty observing quality reduces the incentive for firms to respond to competition by raising quality. In theory, competition has ambiguous effects on quality in the presence of asymmetric information (Spence, 1975; Riordan, 1986; Horner, 2002).[1] This study examines whether markets can overcome asymmetric information about quality without regulation.

Our empirical approach exploits the plausibly exogenous entry of a high-productivity pharmacy chain to estimate the impact of entry on incumbent prices and quality. Our data feature a mystery shopper audit of pharmacies, in which auditors purchased two prominent antibiotics, ciprofloxacin and amoxicillin, under realistic conditions. We chose these drugs because of their wide use and public health importance for treating bacterial respiratory and gastrointestinal infections. We then assessed the quality of the drug samples

Received for publication October 30, 2017. Revision accepted for publication February 2, 2018. Editor: Amitabh Chandra.

*Bennett: University of Southern California; Yin: University of California, Los Angeles.

We benefited from helpful comments from Kerwin Charles, Leemore Dafny, Jeffrey Grogger, Seema Jayachandran, Ginger Jin, Jens Ludwig, Dilip Mookherjee, Andy Newman, Chad Syverson, Glen Weyl, and seminar participants at Boston University, BREAD, the Indian Institute of Management Bangalore, the University of California Berkeley, the University of Chicago, the University of Maryland, Northwestern University, the Tinbergen Institute, and Yale University. We thank Pallavi Vyas for excellent research assistance. We gratefully acknowledge the financial support of the Bill and Melinda Gates Foundation, the Center for Health Market Innovations at the Results for Development Institute, the Population Research Center and the Center for Health and the Social Sciences at the University of Chicago, and the Institute for Economic Development at Boston University.

A supplemental appendix is available online at http://www.mitpressjournals.org/doi/suppl/10.1162/rest_a_00758.

[1] Kranton (2003) shows that competition creates an incentive to stock higher-quality products but also increases the risk of losing the future business of dissatisfied customers, so that the net effect is ambiguous. Bjorkman-Nyqvist, Svensson, and Yanagizawa-Drott (2012) find that an NGO offering subsidized authentic drugs can reduce incumbent sales of counterfeit drugs.

The Review of Economics and Statistics, March 2019, 101(1): 76–90

doi:10.1162/rest_a_00758

in a laboratory. We interviewed over 5,200 consumers in study markets, distinguishing between people who had and had not just shopped at sample pharmacies. We also interviewed pharmacists and enumerated the customer traffic at each pharmacy.

We collaborated with a chain pharmacy that was on the verge of expansion in 2010. We collected baseline data in markets where chain executives said they wished to enter. The firm went on to open shops in under half of these markets due to the limited availability of retail space. We resurveyed in all of these markets one year after entry. This situation creates a natural experiment that allows us to estimate the impact of chain entry by comparing entry (treatment) and nonentry (control) markets. Our approach relies on the assumption that treatment and control markets have similar counterfactual trends in quality, prices, and firm performance. Multiple pieces of evidence support this assumption:

- The availability of retail space drove the choice of entry locations. The firm had specific space requirements and a short window for final expansion in Hyderabad. Because the commercial real estate market is decentralized and thin, the firm found only seven sites within this narrow interval for local expansion.
- At baseline, the chain had already entered the more affluent neighborhoods in Hyderabad. The candidate entry markets were the few middle-class neighborhoods it had yet to enter. These markets are more homogeneous than the city as a whole, which limits the threat to validity due to unobserved socioeconomic heterogeneity.
- Treatment and control markets have similar baseline prices, quality, customer traffic, and consumer socioeconomic characteristics according to our assessment of both the means and the distributions of these variables. These results suggest that baseline demographic features did not drive entry decisions among candidate markets.
- A key concern is that unobservable forecasts of consumer demand by the chain or others may have influenced entry decisions. However, we find no statistically significant differences in exogenous socioeconomic trends by treatment status through two years after entry.
- Our estimates are large relative to the effects of socioeconomic trends. Average incomes would need to more than double, and average education would need to increase by over five years in treatment markets to generate the observed quality and price changes. In reality, we do not observe significant changes in income or education in the sample. Any unobservable socioeconomic selection is unlikely to have a stronger effect than these observable SES dimensions.
- We follow Oster (2017) and Altonji, Elder, and Taber (2005) and compute the extent of unobservable selection that would be needed to cause our findings spuriously. Unobservable selection would need to be remarkably strong to generate our findings.

These patterns support the claim that control markets are a plausible counterfactual for treatment markets.

We find that incumbents improved quality and lowered prices in response to chain entry. Compliance with the Indian Pharmacopeia quality standard rose by 5% and prices fell by 2% in treatment markets relative to control markets. Among nonnational drug brands, over which pharmacies have more price and quality flexibility, pharmacopeia compliance rose by 21% and prices fell by 12%. The combination of higher quality and lower prices most likely arose through retail competition rather than other channels. Consumer survey data collected for this study suggest that consumers partially inferred these quality improvements. Next, we assess the market-wide impact of chain entry by incorporating observations from the chain and interacting chain entry with consumer socioeconomic status (SES). We find no effect for this interaction, implying that chain entry improved consumer welfare regardless of SES.

Next, we consider the mechanisms that may underlie this response. Chain entry did not result in measurable substitution from nonnational brands to more expensive and higher-quality national brands. Incumbents did not respond to competition by hiring better-educated staff or altering their staffing. They also did not upgrade storage conditions by installing air-conditioning. Rather, we find that incumbents in entry markets reallocated procurement across distributors by purchasing more stock from fewer distributors, consistent with reoptimizing distributor relationships to procure higher-quality drugs.

II. Background and Predicted Impacts

A. *The Indian Retail Pharmacy Market*

India's pharmaceutical sector produces 13% of global pharmaceutical output (Corporate Catalyst India, 2012). The industry consists of around 250 large national manufacturers and around 8,000 small local manufacturers. Many national manufacturers work to comply with both domestic and international quality standards. India has 74 FDA-approved manufacturing plants, more than any other country besides the United States. National manufacturers advertise heavily to establish brand reputation and strengthen market power. In contrast, local manufacturers produce small batches of common generic medicines, at times incentivizing local doctors and pharmacies to push their products. Regulators struggle to provide effective oversight for the large number of local manufacturers.[2]

[2] The Drugs Control Administration (DCA), the main pharmaceutical regulator in India, oversees both manufacturers and retailers. The DCA has a reputation as an ineffective regulator (*Kashmir Times*, 2009) but appears to limit the flagrant counterfeiting that is reported under even weaker governance (Gaurdiano et al., 2007).

Several factors contribute to heterogeneous drug quality in India. To achieve consistent high quality, manufacturers must invest heavily in quality control equipment and protocols (Woodcock, 2004; Yu, 2008). Quality control is more challenging than procuring pharmaceutical components, which are cheap and available. With summertime temperatures that exceed 40°C, distributors and retailers must safeguard inventory from heat and humidity (Porter, 2013; Waterman, Swanson, & Lippold, 2014). Wholesalers must also safeguard against counterfeiters, who may mix counterfeit and authentic drugs during distribution. Counterfeits imitate the appearance of well-known brands but are not intended to be therapeutic. Because pharmaceutical components are inexpensive, counterfeiters may evade detection by including active ingredients in their products (Newton et al., 2008).[3]

Hyderabad is the fourth largest city in India. Small, independent, single-enterprise mom-and-pop pharmacies predominate there and elsewhere in India. These firms offer most common drugs and rarely require a prescription. Shops are typically small, unenclosed storefronts without air-conditioning. In our data, pharmacies occupy a median of 350 square feet of retail space. Pharmacies usually employ workers without formal training.

Pharmacy markets are hyperlocal, with customers shopping a median of 0.5 kilometers from their homes in our data. Markets in our study contain a median of 24 pharmacies per square kilometer. Pharmacies advertise through prominent storefront signage. Each manufacturer determines a "maximum retail price" (MRP), which appears on the packaging. The wholesale price is tied to the MRP, which restricts the retailer's ability to offer a discount without losing money. However, the MRP varies widely across brands—for example, a ten-tablet strip in our data ranges from $0.46 to $2.00—so pharmacists can lower the price by substituting a cheaper brand.

Conventionally pharmacies obtain inventory from a multilayered distribution market. Retail pharmacies buy from wholesaler distributors, who buy from regional "superstockists," who buy from carry-and-forward agents, who in turn buy from manufacturers. With many agents in the supply chain, low-quality, even corrupt wholesalers can undermine quality with impunity. Hyderabad does not have a centralized wholesale marketplace. Instead, wholesalers deliver inventory directly to shops.

B. The Market for Retail Antibiotics

Consumers have difficulty observing drug quality. The brand, the condition of the packaging, and the expiration dates are imperfect quality signals. Patients also have difficulty gauging the effectiveness of antibiotics based on changes in health because they often use these drugs incorrectly to treat viral infections. While they may not know the quality of specific units of inventory, pharmacists are relatively informed about average quality because they maintain long-standing distributor relationships. A pharmacist can improve drug quality by purchasing different inventory, changing distributors, or improving storage conditions, all of which may raise their costs.

Our audit focuses on ciprofloxacin and amoxicillin, two broad-spectrum antibiotics that are widely used to treat ear, urinary tract, respiratory, and digestive tract infections. Both drugs are sold in blister pack strips of eight to ten tablets. Ciprofloxacin and amoxicillin are suited to a mystery shopper audit because pharmacies stock many brands of these drugs and sell them frequently.

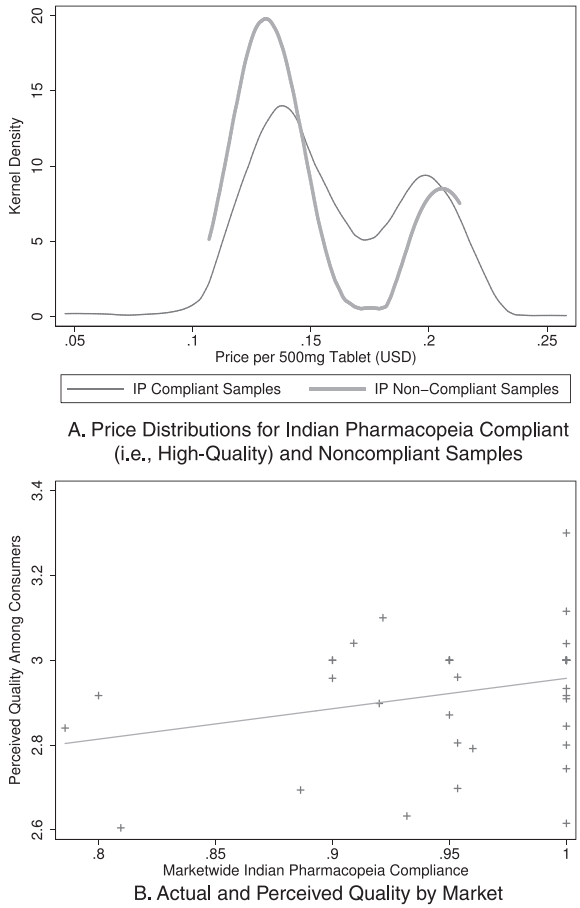
Unlike in conventional product markets, consumers have incomplete information about drug quality (Grigoryan et al., 2007; Eng et al., 2003). We follow Bate et al. (2011) and gauge this information asymmetry hedonically. The price reflects the marginal consumer's valuation of the product, and consumers should be unwilling to pay a premium for quality that they cannot observe. Figure 1A shows the kernel density of price for high-quality and low-quality drugs in our data (described below). High-quality medicine is more expensive on average, which suggests that consumers receive some quality information. The heavy overlap in these distributions indicates that other factors influence price. In particular, the price distributions are bimodal because of the different pricing strategies of national and local brands. Figure 1B directly considers the availability of information through a scatterplot of actual and perceived quality by market. This gradient is positive and significant, but the R^2 of the regression is 0.08, which suggests that consumers perceive drug quality imperfectly.

C. MedPlus Investments and Expansion

Chain pharmacies have expanded rapidly through larger Indian cities in recent years. Chains cater to relatively affluent customers by offering amenities such as air-conditioning and more knowledgeable staff. With over 250 local stores, MedPlus is the largest of three chains operating in Hyderabad during the study period. MedPlus was established in 2008 and grew rapidly in Hyderabad, Chennai, Bangalore, and elsewhere in southern India. The firm markets itself as an inexpensive, high-quality provider. It obtains discounts on inventory by purchasing in bulk and procuring directly from manufacturers, and in turn it offers consumers a 10% discount from the MRP of national-brand drugs. MedPlus also contracts with a few manufacturers to offer an in-house brand as an alternative to the nonnational brands sold at incumbent pharmacies. In fact, MedPlus does not carry any nonnational brand except for its in-house label. Direct purchasing allows MedPlus to offer high-quality medicine by avoiding the quality issues associated with the wholesale market. As we show below, it offers higher-quality drugs, and consumers perceive the chain as higher quality than incumbents.

[3] An extensive literature in public health shows that substandard drugs and counterfeits are pervasive in developing countries (Cockburn et al., 2005; Dondorp et al., 2004; Sow et al., 2002; Taylor et al., 2001).

FIGURE 1.—INDICATORS OF THE NOISY INFERENCE OF DRUG QUALITY



A. Price Distributions for Indian Pharmacopeia Compliant (i.e., High-Quality) and Noncompliant Samples

B. Actual and Perceived Quality by Market

This investment behavior is consistent with endogenous sunk cost (ESC) models, where investments to produce better products are endogenously determined by the degree of market expansion (Shaked & Sutton, 1990; Sutton, 1991). As the market expands, continual investments in integrated production and distribution processes and R&D "shift the technological frontier constantly forward towards more sophisticated products" (Shaked & Sutton, 1990). Ellickson (2006, 2007), Ellickson & Grieco (2013) shows that ESC investments in integration and new distribution systems have spurred the formation of a high-productivity market segment in retail markets such as groceries. The expansion of the retail pharmacy market also aligns with ESC models, in which demand growth creates an incentive for firms to invest in productivity-improving investments.

D. The Impact of Chain Entry in Theory

Chain entry and competition have ambiguous effects on quality in general. Incumbents may respond to competition by either raising or lowering quality and prices, depending loosely on the relative magnitudes of the price and quality elasticities of demand (Dorfman & Steiner, 1954). However, models show that asymmetric quality information mitigates the incentive to improve quality in response to competition. Within a search model, Dranove and Satterthwaite (1992) find that the incentive for firms to offer high quality strengthens as the quality signal becomes precise. With a weak quality signal, the effective quality elasticity of demand is low, and firms have weak incentives to improve quality in response to competition. An effect of competition on quality implies that consumers are at least partially able to infer the quality of the experience good. Bjorkman-Nyqvist et al. (2012) develop a Bayesian learning model that illustrates the potential impact of competition on quality in a setting with sufficiently informed consumers. As with other experience goods, consumers may partially infer quality from their health response to taking the medicine (Nelson, 1974; Farrell, 1981; Chan & Leland, 1982; Shapiro, 1982; Cooper & Ross, 1984; Ross, 1985; Klein & Leffler, 1981; Milgrom & Roberts, 1986). Consumers who do infer quality may also convey the firm's quality to some uninformed consumers, as in Bagwell (1987). In any case, incumbents respond to competition by raising quality if a sufficient share of consumers is informed.

These models generate ambiguous predictions for the impact of competition on quality, but in each case, the response depends on the degree of consumer sensitivity to imperfectly observed quality. As noted, the patterns of our data, as well as those reported in in the literature (Bate et al., 2011; Grigoryan et al., 2007; Eng et al., 2003), indicate that the antibiotics we study are experience goods with imperfect quality inference. For competition to improve quality, an entrant simply needs to exert competitive pressure on incumbents. It is not necessary for firms to signal more effectively or for consumers to infer quality more easily.[4]

III. Data

This study relies on an original data set that measures the quality, price, and performance of retail pharmacies. We surveyed in twenty markets (described below) from May to July 2010 (round 1), one year later (round 2), and in a more limited fashion two years later (round 3). The chain entered seven of the candidate markets between rounds 1 and 2. In section IV, we validate the assumption that entry into candidate markets was plausibly exogenous.

We began by conducting a census of pharmacies within 0.5 kilometer of the center of each market. Within each market, we enrolled the three incumbent pharmacies nearest to where the chain wished to enter, plus two others at random, for a total of 100 incumbent pharmacies. For each sample pharmacy, we conducted mystery shopper audits, drug quality

[4] The chain must have an effective way to signal quality in order for offering high-quality to be optimal. In practice, the chain can signal through advertising and infrastructure investments (e.g., air-conditioning and lighting). Jin and Leslie (2009) show that chains raise quality, but not as much as government-regulated report cards do. The chain may also signal quality through its low prices, consistent with dynamic models of experience goods (Tirole, 1988).

testing, a pharmacy survey, and a customer traffic enumeration in rounds 1 and 2. We also surveyed local consumers about recent drug purchases, drug quality perceptions, demographics, and health. In round 3, we conducted the census, consumer survey, and customer traffic enumeration, but not the pharmacy audit or pharmacy survey. Drug quality and price data are therefore available in rounds 1 and 2 but not round 3. In rounds 2 and 3, we included the newly opened chain pharmacies in the sample.

We audited each pharmacy four times per round in order to stratify by drug and auditor SES.[5] We trained the auditors to follow a set script, which limited variation in dialogue. Auditors were also careful to interact naturally with pharmacists. We explicitly tested for auditor fixed effects by regressing quality and prices on mystery shopper dummies. These fixed effects are jointly insignificant, with a p-value of 0.56 for quality and 0.18 for price. The auditor carried a piece of paper with the drug name written on it (ciprofloxacin or amoxicillin, but with brand unspecified), as would be common of a consumer coming from a medical provider, but allowed the pharmacist to choose the brand.[6] This approach gave the pharmacist latitude to substitute between brands with different quality levels and profit margins. After the purchase, the auditor recorded the transaction price and prepared the drug samples for testing. The laboratory required three strips (thirty tablets) to conduct quality tests, so auditors revisited pharmacies and bought two more strips of the same brand several days later. Audit visits were a tiny fraction of total customer traffic over the sample period.

A laboratory in Delhi tested the drug samples for compliance with Indian Pharmacopeia, the official drug quality standard in India. A sample of ciprofloxacin or amoxicillin complies with Indian Pharmacopeia standards by falling within the official thresholds for active ingredient concentration, dissolution, and uniformity of weight. We conducted tests for all three dimensions of quality. All three measures are continuous, and a drug is compliant if these measures fall within ranges set by pharmacopeia standards. Patients respond to antibiotics in heterogeneous ways, and even small quality deficiencies may have important health impacts for patients who already respond poorly to antibiotic treatment (Drusano, 2004).

Overall, over 96% of the audit samples complied with Indian Pharmacopeia. Among nonnational drugs, only 93% complied with the quality standard. This rate is similar for both antibiotics and is in line with the reported national compliance rate of 91% in 2003 (Sheth et al., 2007). Among substandard samples, 69% failed the active ingredient requirement, 22% failed the uniformity requirement, and 58% failed the dissolution requirement. Appendix figure 2 plots the densities of these components. Quality is optimized at the intended active ingredient dosage and increases monotonically in dissolution and decreases in uniformity of weight. The positive and negative dispersion in active ingredient concentration around 100% reinforces that quality control is an important quality determinant.[7]

Our analysis distinguishes between drugs from national and nonnational manufacturers. Retailers have relatively limited discretion over the quality and price of national brands. Customers are less willing to substitute away from brands with reputations for high quality. Consequently, many national brand manufacturers exercise market power and set wholesale prices so that retailers have slim margins. In contrast, quality is more heterogeneous among local brands, and retailers have more discretion over pricing and brand selection. A research assistant collaborated with laboratory officials to categorize each manufacturer as national, local, or other based on information from manufacturer websites and direct knowledge of large firms. In our analysis, we combine "local" and "other" categories. Since pharmacists selected the brand in our audit, the sample's status as national or nonnational is endogenous. However, a regression of national status on chain entry indicates no effect, as we show in section V.

Our consumer survey is a repeated cross-section that measures demographic characteristics, drug purchases, drug quality perceptions, and health. We enrolled half of the sample from among people who had just visited sample pharmacies ($n = 2{,}602$) and half from among other adults who were present in the area ($n = 2{,}632$). This approach allows us to measure the characteristics of both actual and potential pharmacy shoppers. To enumerate customer traffic, surveyors counted the number of customers entering each pharmacy from 6:00 p.m. to 7:00 p.m. and from 7:30 p.m. to 8:30 p.m. on randomly chosen days. We selected these windows because pilot data indicated that the bulk of customer traffic occurs in the evening.

In spring 2010, MedPlus executives identified eighteen candidate markets they wished to enter. With over 250 stores throughout the city, MedPlus had already entered all of the most affluent markets and nearly exhausted its expansion opportunities. After the 2010 expansion, the firm shifted its focus toward growth in other cities. Between rounds 1 and 2, MedPlus entered seven of the eighteen candidate entry markets. We surveyed in all eighteen markets with the expectation that suitable retail space would not become available in every candidate market and that nonentry markets could serve as controls in this study.

Our budget allowed us to survey two additional markets, which we selected for their similarity to the eighteen candidate markets. The two additional markets have lower socioeconomic status, with 23% lower household income and 1.7 fewer years of schooling ($p < 0.01$ for both

[5] We validated the distinction between high-SES and low-SES mystery shoppers by asking consumer survey respondents to identify the SES of auditors from photographs. Respondents nearly always answered correctly.

[6] Pilot research, including conversations with local pharmacists, doctors, and consumers, indicated that it is normal for customers to request particular compounds and allow pharmacists to suggest a brand.

[7] Limited data indicate that pharmacopeia compliance is much higher in developed countries (Trefi et al., 2007; Bate, Jin, & Mathur, 2013).

variables). We include these markets to improve precision: standard errors are around 15% larger if we exclude these markets. Appendix A.5 shows the results for the eighteen candidate entry markets.

IV. Empirical Strategy

A. Main Empirical Specification

In this section, we estimate the effect of chain entry on incumbent drug quality and prices using a difference-in-difference approach. In the following specification, s indexes the audit scenario, i indexes the pharmacy, m indexes the market, and t indexes the time period:

$$y_{simt} = \beta_1 Post_t + \beta_2 Post_t \times Entry_m + \Omega'_{mt}\beta_3 + \alpha_m + \varepsilon_{simt}. \quad (1)$$

$Post_t$ is an indicator for round 2, and $Entry_m$ is an indicator for entry markets. Market fixed effects, α_m, control for time-invariant market heterogeneity. Some regressions include market demographic and health controls, Ω_{mt}.[8] We cluster standard errors by market, which may lead us to underestimate the standard errors with only twenty markets (Donald & Lang, 2007). Therefore we also report the p-value for each coefficient of interest using Cameron, Gelbach, and Miller's (2008) wild cluster bootstrap.

B. Identification

For our approach to identify treatment effects, unobserved time-varying determinants of quality and other outcomes must be uncorrelated with chain entry. Differential trends in the supply and demand of high-quality medicine in treatment and control markets could violate this assumption. This section discusses contextual and statistical reasons why this assumption is reasonable in this application.

Contextual evidence. According to chain executives, the availability of suitable retail space was the sole determinant of entry among the candidate entry markets. They did not base this decision on any other factors, such as inside knowledge of market growth or price and quality trends. The chain had specific space requirements of 1,000 to 1,200 square feet on the ground level facing a busy commercial street within the specified neighborhoods.[9] The chain was not always able to find available retail real estate that met the size, configuration, and location requirements for one of its stores. The adherence to retail space requirements over the firm's brief expansion phase within Hyderabad led to an arbitrary selection of actual entry locations.

Also, the nature of the chain's expansion strategy limits the potential for selection on time-varying unobservables. According to chain executives, the affluence of the neighborhood was the main characteristic that they used to identify candidate entry markets. At baseline, the firm had already expanded into the most affluent neighborhoods and considered expanding only into a narrow subset of remaining neighborhoods that were sufficiently affluent. These markets are more homogeneous than the city as a whole, which limits the threat to validity from unobservable selection.

Statistical evidence. Chain entry appears to be uncorrelated with unobservable quality and price determinants. Table 1 compares the baseline characteristics of pharmacies, drug samples, and consumers in treatment and control markets. In panel A, audit samples from treatment and control markets have nearly identical prices and quality. The price per tablet differs by \$0.012 ($p = 0.75$), and the rate of Indian Pharmacopeia compliance differs by 0.005 ($p = 0.92$). Samples have similar values for active ingredient concentration and dissolution. Uniformity is somewhat higher in entry markets but does not account for any Indian Pharmacopeia failures in round 1. In panel B, treatment and control pharmacies are comparable in terms of air-conditioning, cleanliness, and customer traffic. The distance to the market center and the number of firms per market are not significantly different across treatment and control markets. These patterns suggest that supply-side factors such as market concentration are not correlated with treatment status.

TABLE 1.—BASELINE CHARACTERISTICS OF TREATMENT AND CONTROL MARKETS

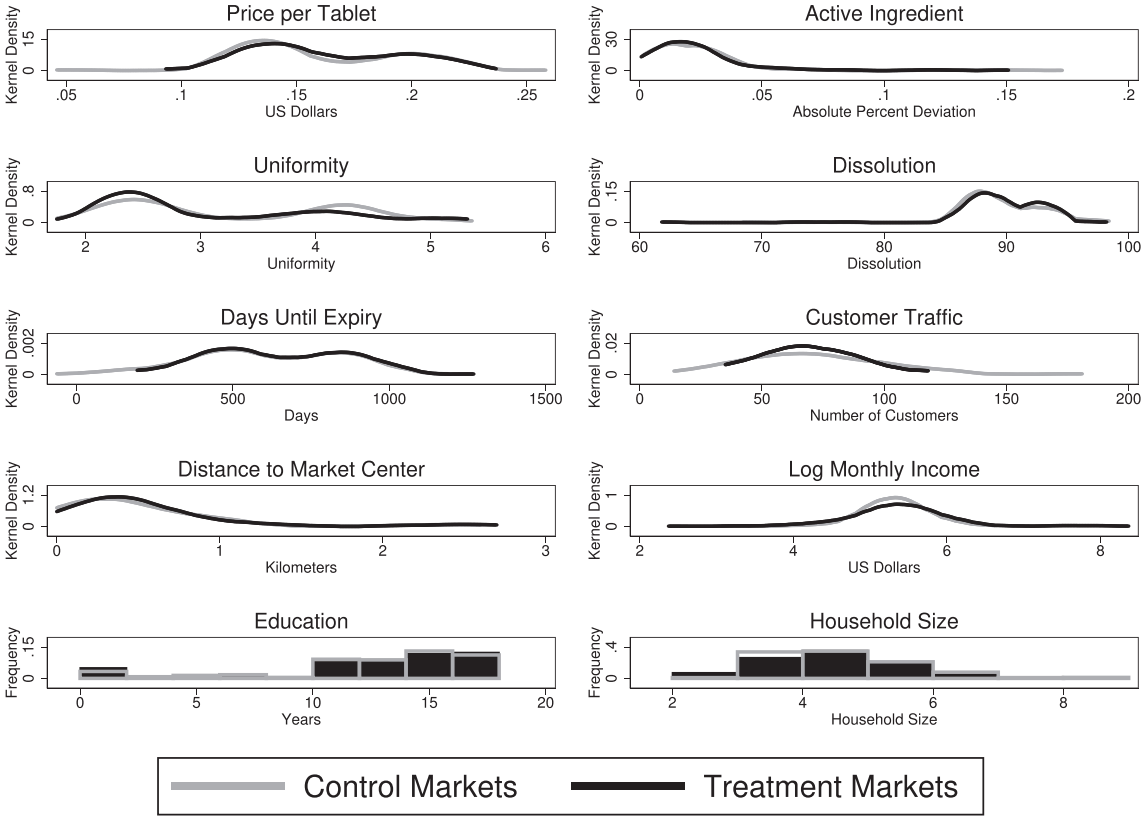
	Control Markets	Treatment Markets
	(1)	(2)
A. Drug sample characteristics		
Price per 500 mg tablet (USD)	0.160	0.162
Complies with Indian Pharmacopeia	0.969	0.971
Active ingredient (deviation from 100%)	0.025	0.023
Uniformity	3.26	3.09*
Dissolution	89.6	89.6
Days until expiry	615	642
Sample size	517	276
B. Pharmacy characteristics		
Air-conditioning	0.16	0.09
Cleanliness (1–5)	4.03	3.97
Customer traffic	71.5	69.5
Distance to market center (km)	0.51	0.56
Number of firms	19.2	14.4
Sample size	65	35
C. Consumer characteristics		
Log monthly household income (USD)	5.30	5.37
Education (years)	12.2	12.0
Household size	4.1	4.0
Scheduled caste/tribe	0.06	0.17***
Owns a vehicle	0.64	0.57
Sample size	317	177

The table compares the means of key drug, pharmacy, and consumer characteristics across treatment and control markets in round 1. Asterisks in column 2 indicate significant differences with column 1. $n = 20$ for number of firms in panel B. *$p < 0.1$, **$p < 0.05$, and ***$p < 0.01$.

[8] Regressions that use pharmacy fixed effects yield very similar estimates. Demographic controls include education, income, household size, caste, and vehicle ownership. Health controls include the prevalence of diarrhea, fever, cough and cold, and injuries. We use the nonshopper sample to calculate market × time averages for all variables.

[9] Commercial real estate markets in Hyderabad are decentralized. Individual brokers maintain proprietary listings that are difficult to search and are based in part on previous client interactions (Das et al., 2013).

FIGURE 2.—BASELINE DISTRIBUTIONS OF NONBINARY CHARACTERISTICS IN TREATMENT AND CONTROL MARKETS



Panel C assesses whether baseline consumer characteristics are correlated with treatment. The panel focuses on the nonshopper sample to avoid selection, although statistics for shoppers are similar. Log income, educational attainment, household size, and vehicle ownership are comparable for treatment and control consumers. Treatment consumers are more likely to belong to a scheduled caste or tribe. The baseline similarity of these demographic characteristics suggests that chain entry is not related to the level of customer demand.

A comparison of means may mask heterogeneity in the distributions of these characteristics. Such heterogeneity may be important if the demand for medicine responds in a nonlinear way to socioeconomic status. For example, holding the mean constant, an increase in the variance in income may increase drug sales if demand is disproportionately concentrated among wealthy consumers. Figure 2 shows the distributions of continuous drug, pharmacy, and consumer socioeconomic variables by treatment status. These distributions tightly overlap. In Kolmogorov-Smirnov tests, uniformity is the only variable out of nine for which the treatment and control distributions are significantly different, with $p \leq 0.10$.

Next, we examine whether treatment and control markets exhibit differential changes in socioeconomic characteristics, which may shift the demand for medicine. We may spuriously attribute the effect of a demand shock to chain entry if the chain selectively enters markets with rising demand for high-quality medicine. Table 2 reports the difference-in-differences for these variables. We do not find significant differences by treatment status in socioeconomic trends between rounds 1 and 2. Moreover, trends in these variables continue to be similar across treatment and control markets through round 3, nearly two years after entry into the treatment markets. The absence of differential trends in these variables supports the claim that entry is uncorrelated with determinants of demand. Appendix table 7 also finds no correlation between chain entry and the composition of customers at incumbent pharmacies.

Finally, patterns in the pharmacy census do not suggest that chain entry is associated with other market trends. Chain entry is not correlated with the preentry closure of incumbent pharmacies, which could otherwise suggest a shift in demand toward high-quality medicine. If unobservable trends make treatment markets more profitable than control markets, we might expect greater nonchain entry in treatment markets. However nonchain entry is similar across treatment and control markets, with an average of 1.14 entrants in treatment markets and 1.15 entrants in control markets between rounds 1 and 2.

TABLE 2.—TRENDS IN SOCIOECONOMIC STATUS FOR TREATMENT AND CONTROL MARKETS

	Rounds 1 and 2			Rounds 1 and 3		
	First Difference		DD	First Difference		DD
	Control	Treatment	(2) – (1)	Control	Treatment	(5) – (4)
	(1)	(2)	(3)	(4)	(5)	(6)
Log monthly household income (USD)	0.05	−0.03	−0.08	−0.15	−0.02	0.13
	(0.07)	(0.15)	(0.15)	(0.06)	(0.12)	(0.13)
Education (years)	0.05	−1.19	−1.23	−2.31	−1.32	0.98
	(0.53)	(0.75)	(0.88)	(0.46)	(0.64)	(0.77)
Household size	0.18	0.18	−0.002	0.85	0.60	−0.25
	(0.19)	(0.17)	(0.24)	(0.16)	(0.14)	(0.20)
Scheduled caste/tribe	0.03	−0.02	−0.05	0.12	0.02	−0.11*
	(0.03)	(0.04)	(0.04)	(0.03)	(0.05)	(0.07)
Owns a vehicle	−0.07	−0.03	0.04	−0.09	−0.04	0.05
	(0.08)	(0.08)	(0.11)	(0.06)	(0.03)	(0.07)
Sample size	970	601	1,571	915	575	1,490

The table compares one-year and two-year trends in exogenous demographic characteristics across treatment and control markets. Columns 1 to 3 compare rounds 1 and 2, while columns 4 to 6 compare rounds 1 and 3. Market-clustered standard errors appear in parentheses. *$p < 0.1$, **$p < 0.05$, and ***$p < 0.01$.

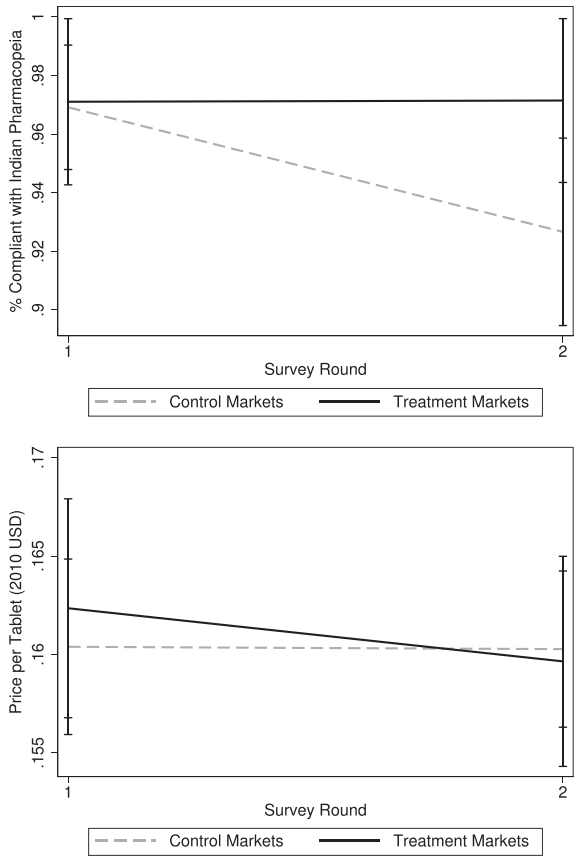
C. *Trends by Treatment Status*

Our estimates are identified through the differential change in price and quality in entry markets relative to control markets. Figure 3 shows this variation by plotting the trends in price and pharmacopeia compliance. After adjusting for inflation, the price of audited drugs in control markets was constant over time, while the price declined by around 2% in entry markets.

The figure shows that quality fell by 5 percentage points in control markets but remained constant in entry markets. Weather differences from round 1 to round 2 most likely explain this pattern. Extreme heat and humidity (particularly in combination) are detrimental to the quality of antibiotics (Waterman & MacDonald, 2010; Peace, Olubukola, & Moshood, 2012; Porter, 2013). These effects, which are nonlinear, motivate the benchmark temperature and humidity thresholds used by international health organizations to safeguard drugs (Kiron, Shirwaikar, Saritha, 2011; Mubengayi et al., 2013).

We obtained peak relative humidity and temperature data for Hyderabad from the National Oceanic and Atmospheric Administration (NOAA). During the data collection, average peak relative humidity was 8.7 points higher for round 2 than round 1 ($p = 0.04$), while daily average high temperatures were 39°C to 40°C during both periods. Based on World Health Organization maximum thresholds for safe storage conditions, the share of audit days with harmful conditions rose from 54% in round 1 to 97% in round 2 ($p < 0.001$). Appendix A.2 discusses these patterns further.

FIGURE 3.—QUALITY AND PRICE CHANGES



V. Main Results

A. *Relative Productivity of the Chain*

A comparison of the chain and control incumbents validates that the chain is a high-productivity firm. Prices are 8% lower ($p = 0.06$) and pharmacopeia compliance is 4 percentage points higher ($p = 0.46$) at the chain. All MedPlus stores are air-conditioned compared to just 12% of incumbents.

B. *The Impact of Chain Entry*

Chain entry had a dramatic effect on incumbents. Table 3 shows the effect of chain entry on log customer traffic and market exit. Customer traffic increased by 25% over two years for control incumbents but stagnated for treatment incumbents. Ninety-six percent of control incumbents who

TABLE 3.—CHAIN ENTRY, CUSTOMER TRAFFIC, AND MARKET EXIT FOR INCUMBENTS

Dependent Variable:	ln(Customer Traffic)		Market Exit	
	(1)	(2)	(3)	(4)
Round 2	0.19***	0.11*	−0.021**	−0.031**
	(0.052)	(0.057)	(0.0099)	(0.015)
Round 2 × entry market	−0.27***	−0.20**	−0.006	0.0064
	(0.069)	(0.083)	(0.016)	(0.021)
Round 3	0.26***	0.20	−0.042***	−0.086**
	(0.045)	(0.20)	(0.013)	(0.033)
Round 3 × entry market	−0.24***	−0.19**	−0.055**	−0.047*
	(0.078)	(0.074)	(0.026)	(0.026)
Market demo and health controls	No	Yes	No	Yes
Wild bootstrap p-value				
Round 2 × entry	0.00	0.13	0.74	0.79
Round 3 × entry	0.01	0.05	0.03	0.12
Proportional selection δ				
Round 2 × entry	–	0.72	–	−0.07
Round 3 × entry	–	0.85	–	0.32
Observations	297	297	1,053	1,053
R^2	0.27	0.29	0.03	0.06

The table shows the impact of chain entry on log customer traffic (columns 1 and 2) and the probability of market exit (columns 3 and 4) among incumbents. Chain entry occurs between round 1 and round 2. Odd-numbered columns exclude market demographic and health controls; even-numbered columns include these controls. Market-clustered standard errors appear in parentheses. All regressions include market fixed effects. *$p < 0.1$, **$p < 0.05$, and ***$p < 0.01$.

TABLE 4.—CHAIN ENTRY AND INCUMBENT DRUG QUALITY

Dependent Variable:	Complies with Indian Pharmacopeia						
Manufacturers:	All		National		Nonnational		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post-entry	−0.042**	−0.077***	−0.0040	−0.053**	−0.15**	−0.23***	−0.14*
	(0.019)	(0.013)	(0.020)	(0.019)	(0.061)	(0.066)	(0.082)
Post-entry × entry market	0.043**	0.063***	−0.016	−0.00074	0.21***	0.24***	0.18**
	(0.019)	(0.017)	(0.024)	(0.021)	(0.071)	(0.050)	(0.082)
Market demo and health controls	No	Yes	No	Yes	No	Yes	Yes
Manufacturer fixed effects	No	No	No	No	No	No	Yes
Wild bootstrap p-value (post × entry)	0.03	0.04	0.51	0.98	0.00	0.11	0.31
Proportional selection δ	–	−31.2	–	0.07	–	−5.00	–
Observations	787	787	525	525	262	262	262
R^2	0.063	0.074	0.062	0.083	0.252	0.348	0.532

The table shows the impact of chain entry on Indian Pharmacopeia compliance of drugs sold by incumbent pharmacies during mystery shopper pharmacy audits. Columns 1 and 2 show results for all drugs, columns 3 and 4 show results for national drugs only, and columns 5 to 7 show results for nonnational drugs only. Market-clustered standard errors appear in parentheses. All regressions include market fixed effects. *$p < 0.1$, **$p < 0.05$, and ***$p < 0.01$.

TABLE 5.—THE IMPACT OF CHAIN ENTRY ON PRICES

Dependent Variable:	ln(Price per Tablet)						
Manufacturers	All		National		Nonnational		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post-entry	0.0051	0.019	−0.015	−0.020	0.051	0.076	0.094
	(0.025)	(0.030)	(0.021)	(0.032)	(0.051)	(0.057)	(0.078)
Post-entry × entry market	−0.024	−0.039	0.018	0.031	−0.11*	−0.14*	−0.14*
	(0.031)	(0.040)	(0.034)	(0.047)	(0.055)	(0.073)	(0.081)
Market demo and health controls	No	Yes	No	Yes	No	Yes	Yes
Manufacturer fixed effects	No	No	No	No	No	No	Yes
Wild bootstrap p-value (post × entry)	0.45	0.47	0.60	0.61	0.06	0.20	0.17
Proportional selection δ	–	−8.15	–	−13.7	–	−4.8	–
Observations	787	787	525	525	262	262	262
R^2	0.108	0.115	0.134	0.139	0.199	0.257	0.662

The table shows the impact of chain entry on the log price per tablet of drugs sold at incumbent pharmacies during the mystery shopper pharmacy audit. Columns 1 and 2 show results for all drugs, columns 3 and 4 show results for national drugs, and columns 5 to 7 show results for nonnational drugs. Market-clustered standard errors appear in parentheses. *$p < 0.1$, **$p < 0.05$, and ***$p < 0.01$.

were present in round 1 remained in round 3, compared to 91% of treatment incumbents. Both results are statistically significant.

For regressions with controls, the table (as well as tables 4 and 5) reports the proportional selection δ based on Oster (2017), as well as Altonji et al. (2005) and Krauth (2016). If unobservables that are positively correlated with these controls influence chain entry, then including the controls should attenuate our estimates. The usefulness of this exercise depends on the explanatory power of the controls.

The δ in Oster's model measures the strength of unobservable selection relative to observable selection. A value of $\delta = 1$ indicates equal selection on observables and unobservables. We report the value of δ that is necessary to negate the observed treatment effect. A large value of δ means that unobservable selection would need to be exceptionally strong to explain the treatment effect.[10] In many cases, such as the main price and quality regressions, including controls increases the treatment effect estimates slightly. δ is negative in these cases, which implies that negative selection on unobservables would be needed to eliminate the effect. Since most plausible sources of bias are positively correlated with the controls, negative values of δ also support the robustness of our estimates.

Regression estimates for drug quality appear in table 4. Columns 1 and 2 use the full sample of drug manufacturers. Column 1, the regression analog of the quality graph in figure 3, shows that chain entry increased pharmacopeia compliance by 4.3 percentage points.[11] This effect rises to 6.6 percentage points after controlling for demographic and health characteristics in column 2. The rest of the table distinguishes between drugs from national and nonnational manufacturers. Columns 3 and 4 show no effect of chain entry on the quality of national brands. In contrast, columns 5 to 7 show a large and significant effect on the quality of nonnational brands: pharmacopeia compliance rose by 20 to 24 percentage points relative to control markets. Effects are significant using either market-clustered standard errors or Cameron et al.'s (2008) wild cluster bootstrapped standard errors. Column 7 shows that including manufacturer (i.e., brand) fixed effects only minimally attenuates the impact on quality for nonnational brands. This result, which we also address in section V, indicates that within-brand variation is the primary source of the quality response.

We analyze the impact of chain entry further by examining the impact on the components of drug quality. Figure 4 shows the change over time in the distributions of both active ingredient concentration and dissolution in treatment and control markets. A similar graph for uniformity (for which we find no effect) is available from the authors. In figure 4A, quality worsened in control markets because mass shifted from the 95% to 100% range to the 85% to 90% range. This leftward shift increased the mass below 90%, the minimum for pharmacopeia compliance. In the lower panel, quality improved in entry markets because mass shifted from the 105% to 115% range to the 95% to 100% range, which reduced high-end failures. In figure 4B, the modal value for dissolution shifted to the right in both treatment and control markets. However, mass in the left tail (which is the source of pharmacopeia failures due to insufficient active ingredient) was eliminated in treatment markets but expanded in control markets.[12] We analyze these effects further in appendix A.1.

Table 5 shows the impact of chain entry on log price. As above, we examine the full sample and then distinguish between national and nonnational drugs. Columns 1 and 2 show an insignificant 2% to 4% effect on price in the full sample. The effect on price for national drugs is also insignificant in columns 3 and 4. However chain entry led to a significant 12% to 15% price decline for nonnational drugs. Columns 6 and 7 decompose this effect into intermanufacturer and intramanufacturer components. The coefficient is the same in both specifications, which suggests that firms reduced prices by offering discounts rather than substituting toward cheaper brands.

The coefficient estimates for income and education in tables 4 and 5 allow us to gauge the likelihood that selection on time-varying unobservables confounds our estimates for drug quality and prices. The effect of income on drug quality is 0.0000028 in the regression in column 2 of table 4 (result not reported). To improve quality by 4.3 percentage points, as we observe, real income would need to increase differentially by $349 per month in real terms in treatment markets, which is more than double the baseline monthly income of $249 and is an order of magnitude larger than the actual change in real income across all study markets over the study period. Similarly, the coefficient on education is 0.0082, meaning that average education would need to increase differentially by 5.3 years in treatment markets to generate the quality result, a nearly 50% increase in educational attainment. In reality, average education does not exhibit a significant differential trend; if anything, it apparently declined slightly over time in (see table 2). We repeat this exercise for the price regressions. Here, too, coefficient estimates for income and education suggest that unrealistic increases in income and education would be needed to generate the observed results. These effect sizes make it unlikely that time-varying unobservables cause our results spuriously.

C. *Consumer Perceptions*

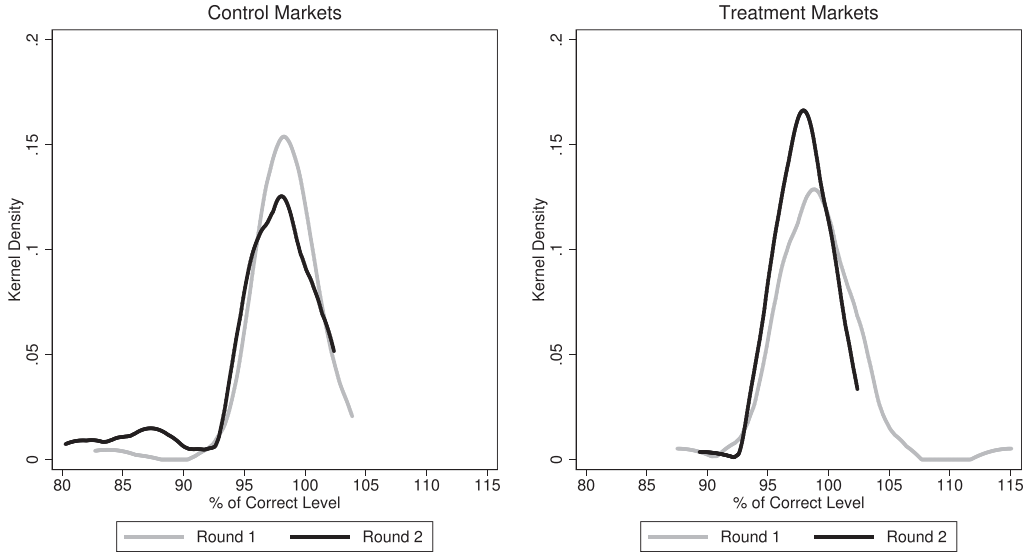
Next we examine the effect of chain entry on perceived quality. Quality competition is profitable only if consumers at least partially perceive quality adjustments and increase demand at firms that improve quality. The consumer survey elicited the respondent's perception of quality on a four-point Likert scale for "nearby pharmacies" and for "national brand" and "local brand" drugs. We limit the sample to nonshopping consumers. Chain entry may have affected the selection of shoppers surveyed, making changes in quality perceptions among shoppers difficult to interpret. Although it is possible that nonshoppers were less informed about drug quality, in practice shoppers and nonshoppers bought

[10] This exercise also requires us to specify the maximum share of the variation in the dependent variable that could arise through selection. We obtain this parameter by regressing each dependent variable on market $\times$ time fixed effects. Our rationale is that these effects capture all market-wide information that the chain could have used to make entry decisions.

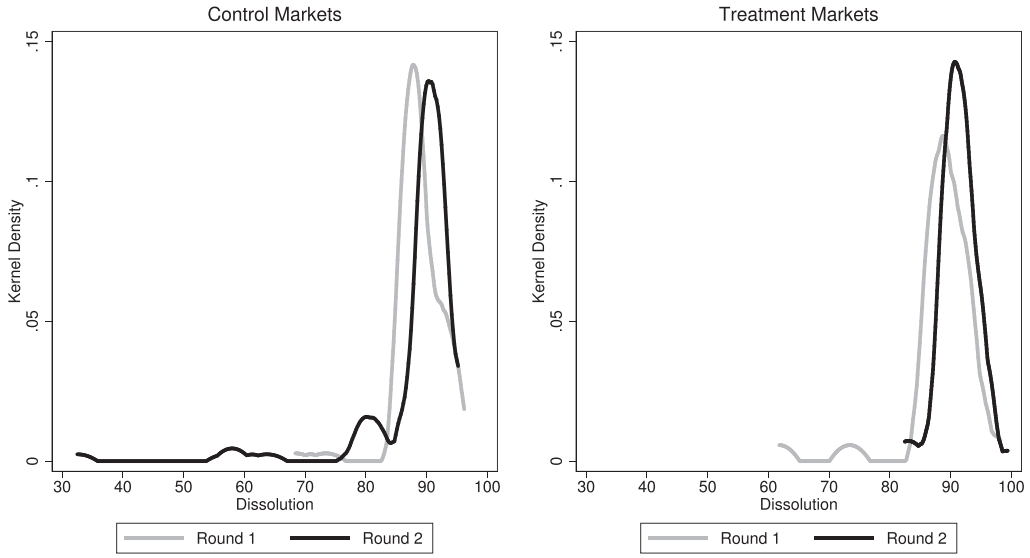
[11] This estimate is based on a change from 8 to 10 total failures in treatment markets and a change from 16 to 41 total failures in control markets.

[12] All of these shifts are significant. Kolmogorov-Smirnov p-values are 0.002 and 0.034 in the left and right panels of figure 5A and are < 0.001 for both panels of figure 5.

FIGURE 4.—CHANGES IN THE DISTRIBUTIONS OF ACTIVE INGREDIENT CONCENTRATION AND DISSOLUTION



A. Density of Active Ingredient Concentration for Nonnational Drugs



B. Density of Dissolution for Nonnational Drugs

medicine with similar frequencies. Estimates for shoppers (available from the authors) closely resemble the estimates for nonshoppers in both magnitude and significance.

Table 6 reports the effect of chain entry on perceived quality. Since there are three consumer survey rounds, we estimate separate effects for rounds 2 and 3. Columns 1 and 2 show a positive and significant effect of chain entry on the perceived quality of nearby pharmacies. Standard errors are smaller and effects are more significant in round 3 because the data from round 2 have a higher intracluster correlation. Estimates become larger once we include demographic and health controls in column 2. Columns 3 and 4 show a generally insignificant effect on the perceived quality of national drugs. These findings are consistent with the small actual impact on quality for these drugs; however, the large coefficient in column 4 suggests that consumers sometimes hold inaccurate perceptions. In contrast, columns 5 and 6 show a large and significant effect for local drugs, which is consistent with actual increases in quality in entry markets over this period.

D. Market-Wide and Distributional Impacts

A welfare assessment of chain entry should incorporate both the presence of the chain and the incumbent response. We report market-wide impact of chain entry, including

TABLE 6.—CHAIN ENTRY AND PERCEIVED QUALITY

Dependent Variable:	Perceived Quality of:					
	Nearby Pharms		National Brands		Local Brands	
	(1)	(2)	(3)	(4)	(5)	(6)
Round 2 × entry market	0.081	0.19	0.19	0.49**	0.37	0.62**
	(0.095)	(0.11)	(0.20)	(0.21)	(0.26)	(0.26)
Round 3 × entry market	0.10**	0.17**	−0.13	0.10	0.28**	0.52***
	(0.046)	(0.065)	(0.10)	(0.16)	(0.14)	(0.13)
Market demo and health controls	–	Yes	–	Yes	–	Yes
Wild bootstrap *p*-value						
Round 2 × entry	0.43	0.20	0.38	0.09	0.20	0.08
Round 3 × entry	0.05	0.00	0.25	0.56	0.05	0.00
Proportional selection δ						
Round 2 × entry	–	−0.43	–	−1.38	–	−32.3
Round 3 × entry	–	−0.76	–	−0.25	–	−3.73
Observations	2,143	2,143	1,677	1,677	1,505	1,505
R^2	0.05	0.05	0.11	0.16	0.19	0.23

The table shows the impact of chain entry on perceived drug quality of drugs sold at incumbent pharmacies. Columns 1 and 2 focus on drugs from nearby pharmacies, columns 3 and 4 focus on national drugs, and columns 5 and 6 focus on nonnational drugs. Market-clustered standard errors appear in parentheses. All regressions include market fixed effects. Dependent variables are measured on a scale of 1 (low) to 4 (high). Estimates are for nonshoppers. *$p < 0.1$, **$p < 0.05$, and ***$p < 0.01$.

TABLE 7.—THE MARKET-WIDE IMPACT OF CHAIN ENTRY

Dependent Variable:	Complies with IP				ln(Price per Tablet)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post-entry × entry market	0.049**	0.068***	0.039	0.054	−0.055	−0.070*	−0.016	−0.058
	(0.022)	(0.021)	(0.034)	(0.037)	(0.035)	(0.035)	(0.040)	(0.041)
High-education customers	–	–	0.018	–	–	–	−0.085	–
			(0.047)				(0.052)	
High-SES mystery shopper	–	–	–	−0.011	–	–	–	0.0062
				(0.064)				(0.036)
Market demo and health controls	No	Yes	No	No	No	Yes	No	No
Wild bootstrap *p*-value								
Post × entry	0.03	0.06	0.27	0.17	0.14	0.13	0.69	0.18
Post × entry × customer education	–	–	0.71	–	–	–	0.13	–
Post × entry × shopper SES	–	–	–	0.88	–	–	–	0.87
Proportional selection δ	–	−8.20	–	–	–	−1.73	–	–
Observations	815	815	815	815	815	815	815	815
R^2	0.06	0.07	0.06	0.06	0.13	0.14	0.14	0.14

The table shows the impact of chain entry on Indian Pharmacopeia Compliance in columns 1 to 4 and log price per tablet in columns 5 to 8 after including observations from the chain and weighting by pharmacy customer traffic. Columns 3 and 7 show the differential impact of chain entry by the pharmacy's proportion of high-education shoppers. Columns 4 and 8 show the differential impact of chain entry by the pharmacy auditor's SES. Market-clustered standard errors appear in parentheses. All regressions include market fixed effects. *$p < 0.1$, **$p < 0.05$, and ***$p < 0.01$.

observations from the seven new chain outlets in round 2, in table 7. We also weight the regressions by customer traffic to account for heterogeneity in pharmacy size. In columns 1 and 2 of table 7, chain entry increased pharmacopeia compliance by 5% to 7%, which is slightly larger than our previous estimate. In columns 5 and 6, chain entry reduced price by 5% to 6%, which is roughly double the impact on prices for incumbents only in table 5, because the chain consistently underprices incumbents.

The remainder of table 7 explores heterogeneous treatment effects by consumer SES.[13] In columns 3 and 4, we compute the average education of each pharmacy's shoppers and distinguish between pharmacies that are above and below the median. Column 3 shows that quality rises differentially (but insignificantly) for pharmacies that serve high-SES customers. With a positive coefficient on $Post_t \times Entry_m$, chain entry also improves the quality of low-SES shops. Columns 4 and 8 exploit the audit stratification by mystery shopper SES to investigate possible SES-based discrimination. The regressions show small and insignificant interactions with auditor SES, which suggests that firms did not discriminate across customers within stores. Therefore, both high-SES and low-SES consumers appear to have benefited from the competitive effects of chain entry.

[13] High-SES consumers may better perceive drug quality and more strongly prefer high-quality medicine. Similarly, low-SES consumers may be more price sensitive, leading to greater price competition for these customers. Firms may cater to consumers of a particular socioeconomic status or may discriminate by treating high-SES and low-SES consumers differently, affecting how incumbents respond to competition.

VI. Mechanisms

A. *Do Effects Operate through Competition?*

Retail competition is the most plausible explanation for our results. Chain entry reduced the demand and increased the elasticity of demand for treatment incumbents. These effects are particularly clear for nonnational drugs, over which firms have the greatest discretion. These effects appear

TABLE 8.—MECHANISMS FOR THE INCUMBENT RESPONSE

	National Brand	Brand Quality	National Brand × Brand Quality	Days Until Expiration	Pharmacist Degree	Number of Workers	Air-Conditioning	Restocking Frequency	Top Distributor Volume
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Post-entry	−0.021	0.0047	−0.016	6.80	−0.12*	−0.031	−0.031	2.62***	−0.61
	(0.069)	(0.0063)	(0.069)	(23.7)	(0.061)	(0.20)	(0.033)	(0.42)	(4.22)
Post-entry × entry market	0.0047	0.015	0.0077	−12.8	0.011	0.0027	0.031	−0.31	19.2***
	(0.088)	(0.011)	(0.090)	(27.4)	(0.085)	(0.30)	(0.033)	(0.68)	(5.79)
Wild p-value (post × entry)	0.96	0.23	0.93	0.65	0.90	0.99	0.34	0.65	0.01
Sample	Drugs	Drugs	Drugs	Drugs	Pharmacies	Pharmacies	Pharmacies	Pharmacies	Pharmacies
Observations	740	740	740	740	198	198	198	198	198
R^2	0.08	0.05	0.08	0.02	0.25	0.32	0.27	0.38	0.27

The table shows the impact of chain entry on the behavior of incumbent pharmacies. Columns 1 to 4 reflect drug inventory choices, columns 5 to 6 reflect staffing choices, column 7 reflects physical investment, and columns 8 to 9 reflect procurement decisions. Market-clustered standard errors appear in parentheses. All regressions include market fixed effects. The sample in columns 1 to 4 excludes brands that are not observed in round 1. *$p < 0.1$, **$p < 0.05$, and ***$p < 0.01$.

to arise through (high-quality) chain competition. In addition to 7 MedPlus stores, an average of 1.15 nonchain stores enter treatment markets and 1.14 nonchain stores entered control markets from round 1 to round 2, an insignificant difference. Estimates (available from the authors) show small and insignificant effects of nonchain entry on quality and price. Moreover, controlling for nonchain entry does not affect our estimates of the impact of chain entry. The chain's impact may be especially large because the chain competes aggressively through price and signals quality effectively.

Appendix A.9 considers three other possibilities in more detail. Chain entry could influence incumbent quality via the wholesale market. However, the wholesale market spans the entire city, and the seven expansion stores are a very small subset of the pharmacies in Hyderabad. Chain entry could also influence the demand for high-quality medicine by shifting consumer perceptions or quality preferences. Appendix table 6 shows that chain entry increased the perceived importance of drug quality among consumers. This mechanism alone cannot explain our findings because greater demand should increase prices. Chain entry may have also affected incumbent prices or quality by changing the selection of incumbent shoppers. However, appendix table 3 shows that chain entry did not influence the demographic characteristics of incumbent shoppers, which casts doubt on this possibility.

B. How Does Quality Improve in Response to Competition?

Next we consider how incumbents improved quality in response to chain competition. Retailers may influence drug quality through any of several channels: substituting toward higher quality or more reputable brands; upgrading their facilities (e.g., by installing air-conditioning) to safeguard their inventories; laying off less-qualified staff and retaining better-trained staff who dispense higher-quality drugs; or modifying their distributor relationships to purchase from more reputable distributors.

Table 8 investigates these possible channels by showing the impact of chain entry on several incumbent drug and pharmacy characteristics. In column 1, chain entry had a small and insignificant effect on the utilization of national brands, which suggests that firms did not respond by substituting toward national brands. Next we approximate brand quality by computing the pharmacopeia compliance rate for each brand in round 1. We then impute brand quality to the actual drug sales in both rounds 1 and 2. Estimates using this approach, which appear in column 2, show that a small and insignificant component of the overall impact on quality arose through substitution across brands. This result is consistent with the estimates in table 4 (columns 6 and 7), which show that brand fixed effects do not explain 75% of the impact on quality for nonnational brands. Column 3 interacts national brand with brand quality to examine whether incumbents shifted specifically toward higher-quality national brands. Again, we do not find evidence of this pattern.

The rest of table 8 assesses whether chain entry influences pharmacy-level quality decisions. Column 4 shows no effect on the probability that the pharmacist has a pharmacy degree, while column 5 finds no impact on the number of employees per shop. These results are inconsistent with pharmacies investing in human capital or laying off the worst-quality workers in order to improve quality. Column 5 shows a small and insignificant effect on the utilization of air-conditioning, which is the primary way firms may safeguard inventories at the store. We also consider the possibility that differences in inventory turnover between treatment and control markets could mechanically generate quality differences irrespective of chain entry. For example, chain entry may have reduced inventory turnover in treatment markets relative to control markets. Depending on how this change influenced the exposure to harsh environmental conditions, this difference could either increase or decrease quality treatment markets relative to control markets. However columns 4 and 7 show no impacts on the days until expiration or the frequency of restocking visits by distributors. The impact of −12.8 days in column 4 is only 2% of the sample mean of 625 days. In contrast, we find significant differences in drug procurement patterns. Column 9 shows a large and significant increase in the volume of drugs purchased from treated incumbents' top three distributors, indicating more selective procurement. Firms concentrated their purchases among fewer distributors, which is striking since earlier results in table 3 indicate

that chain entry significantly decreased customer traffic. In conjunction, these findings suggest that incumbents in this setting improved quality by reoptimizing procurement procedures.

Finally, a comparison of prices and quality among MedPlus and incumbents in entry markets suggests a trade-off between fixed and variable costs of drug quality. Both types of firms had similar drug quality, but the chain had significantly lower prices (estimates available from the authors). These patterns suggest that treatment incumbents were able to come close to the chain in terms of quality, but could only do so at higher cost.

VII. Conclusion

We show that chain entry led to higher quality and lower prices for both incumbent pharmacies in the overall market. This impact was the greatest for nonnational brands, which have the most baseline quality heterogeneity and over which pharmacies have the most discretion. Incumbents apparently increased quality by reoptimizing their distributor relationships rather than substituting across brands or upgrading their infrastructure.

Chain entry in this setting exemplifies the endogenous sunk cost investments of Sutton (1991) and Ellickson (2006, 2007). As markets expand, firms have incentives to make investments that increase market share and lower marginal costs. For retail pharmacies, these sunk costs include actions to create better organizational structures and signal quality. Competition from high-quality entrants in turn encourages incumbents to raise quality.

Our estimates are based on a natural experiment rather than a field experiment. It was not practical in this context to collect the multiple rounds of preentry data that could have helped rule out differential trends. Although multiple pieces of evidence support our identifying assumptions, we cannot completely rule out that confounds, such as differential demand growth beyond our observed measures interfere with our estimates.

While our approach focuses on pharmacy chain entry, other mechanisms may also be relevant. Market expansion could also spur improvements in drug manufacturing and brand competition. The widespread entry of high-quality chains could affect overall quality by forcing low-quality firms out of the market or encouraging wholesalers to offer better drugs. In addition, rising incomes could also lead to more stringent drug quality regulation. Chain entry is one of several ways that economic development may foster drug quality improvements.

In the long run, as the market continues to expand, the Indian retail pharmacy market may be dominated by a handful of high-productivity chains that expand with the market, while coexisting with many smaller lower-productivity shops, as in many developed countries (McKesson, 2012; National Community Pharmacists Association, 2013). The long-run welfare impact of this transition depends on whether there is enough competition so that productivity benefits are shared with consumers.

REFERENCES

Altonji, Joseph, Todd Elder, and Christopher Taber, "Selection on Observed and Unobserved Variables: Assessing the Effectiveness of Catholic Schools," *Journal of Political Economy* 113 (2005), 151–184.

Bagwell, Kyle, "Introductory Price as a Signal of Cost in a Model of Repeat Business," *Review of Economic Studies* 54 (1987), 365–384.

Baird, Sarah, Joan Hamory Hicks, Michael Kremer, and Edward Miguel, "Worms at Work: Long-Run Impacts of Child Health Gains," unpublished manuscript (2012).

Basker, Emek, "Selling a Cheaper Mousetrap: Wal-Mart's Effect on Retail Prices," *Journal of Urban Economics* 58 (2005), 203–229.

Basker, Emek, and Michael Noel, "The Evolving Food Chain: Competitive Effects of Walmart's Entry into the Supermarket Industry," *Journal of Economics and Management Strategy* 18 (2009), 977–1009.

Bate, Roger, and Kathryn Boateng, "Bad Medicine in the Market," *American Enterprise Institute Health Policy Outlook* 8 (2007).

Bate, Roger, Ginger Zhe Jin, and Aparna Mathur, "Does Price Reveal Poor-Quality Drugs? Evidence from 17 Countries," *Journal of Health Economics* 30 (2011), 1150–1163.

——— "In Whom We Trust: The Role of Certification Agencies in Online Drug Markets," *B.E. Journal of Economic Analysis and Policy* 14 (2013), 111–150.

Bjorkman-Nyqvist, Martina, Jakob Svensson, and David Yanagizawa-Drott, "Can Good Products Drive Out Bad? Evidence from Local Markets for (Fake?) Antimalarial Medicine in Uganda," unpublished manuscript (2012).

Cameron, A. Colin, Jonah Gelbach, and Douglas Miller, "Bootstrap-Based Improvements for Inference with Clustered Standard Errors," this REVIEW 90 (2008), 414–427.

Chan, Yuk-Shee, and Hayne Leland, "Prices and Qualities in Markets with Costly Information," *Review of Economic Studies* 49 (1982), 499–516.

Cockburn, Robert, Paul Newton, E. Kyeremetang Agyarko, Dora Akunyili, and Nicholas White, "The Global Threat of Counterfeit Drugs: Why Industry and Governments Must Communicate the Dangers," *PLoS Medicine* 2 (2005), 302–308.

Cooper, Russell, and Thomas Ross, "Prices, Product Qualities, and Asymmetric Information: The Competitive Case," *Review of Economic Studies* 51 (1984), 197–207.

——— "Monopoly Provision of Product Quality with Uninformed Buyers," *International Journal of Industrial Organization* 3 (1985), 439–449.

Corporate Catalyst India, "A Brief Report on India's Pharmaceutical Industry" (Gurgaon, India: Corporate Catalyst India, 2012).

Das, Prashant, Vivek Sah, Divyanshu Sharma, Vinod Singh, and Louis Galuppo, "Real Estate Development Process in India," *Journal of Real Estate Literature* 21 (2013), 271–292.

Degardin, Clara, Yves Roggo, and Pierre Margot, "Understanding and Fighting the Medicine Counterfeit Market," *Journal of Pharmaceutical and Biomedical Analysis* 87 (2014), 167–175.

Domberger, Simon, and Avrom Sherr, "The Impact of Competition on Pricing and Quality of Legal Services," *International Review of Law and Economics* 9 (1989), 41–56.

Donald, Stephen, and Kevin Lang, "Inference with Difference-in-Differences and Other Panel Data," this REVIEW 89 (2007), 221–233.

Dondorp, A. M., P. N. Newton, M. Mayxay, W. Van Damme, F. M. Smithuis, S. Yeung, A. Petit, et al., "Fake Antimalarials in Southeast Asia Are a Major Impediment to Malaria Control: Multinational Cross-Sectional Survey on the Prevalence of Fake Antimalarials," *Tropical Medicine and International Health* 9 (2004), 1241–1246.

Dorfman, Robert, and Peter Steiner, "Optimal Advertising and Optimal Quality," *American Economic Review* 44 (1954), 826–836.

Dranove, David, and Mark Satterthwaite, "Monopolistic Competition When Price and Quality Are Imperfectly Observable," *RAND Journal of Economics* 23 (1992), 518–534.

Drusano, George, "Antimicrobial Pharmacodynamics: Critical Interactions of 'Bug and Drug,'" *Nature Reviews Microbiology* 2 (2004), 289–300.

Ellickson, Paul, "Quality Competition in Retailing: A Structural Analysis," *International Journal of Industrial Organization* 24 (2006), 521–540.

——— "Does Sutton Apply to Supermarkets?" *RAND Journal of Economics* 38 (2007), 43–59.

Ellickson, Paul, and Paul Grieco, "Walmart and the Geography of Grocery Retailing," *Journal of Urban Economics* 75 (2013), 1–14.

Eng, Jodi Vanden, Ruthanne Marcus, James L. Hadler, Beth Imhoff, Duc J. Vugia, Paul R. Cieslak, Elizabeth Zell, et al., "Consumer Attitudes and Use of Antibiotics," *Emerging Infectious Diseases* 9 (2003), 1128–1135.

Farrell, Joseph von Rosthorn, "Prices as Signals of Quality," PhD diss., University of Oxford (1981).

Gaurdiano, Maria Cristina, Anna Di Maggio, Emilia Cocchieri, Eleonora Antoniella, Paola Bertocchi, Stefano Alimonti, and Luisa Valvo, "Medicines' Informal Market in Congo, Burundi and Angola: Counterfeit and Sub-standard Antimalarials," *Malaria Journal* 6 (February 2007).

Grigoryan, Larissa, Johannes G. M. Burgerhof, John E. Degener, Reginald Deschepper, Cecilia Stålsby Lundborg, Dominique L. Monnet et al., "Attitudes, Beliefs and Knowledge Concerning Antibiotic Use and Self-Medication: A Comparative European Study," *Pharmacoepidemiology and Drug Safety* 16 (2007), 1234–1243.

Horner, Johannes, "Reputation and Competition," *American Economic Review* 92 (2002), 644–663.

Jia, Panle, "What Happens When Walmart Comes to Town: An Empirical Analysis of the Discount Retailing Industry," *Econometrica* 76 (November 2008), 1263–1316.

Jin, Ginger, and Phillip Leslie, "Reputational Incentives and Restaurant Hygiene," *American Economic Journal: Microeconomics* 1 (2009), 237–267.

Kashmir Times, "Spurious Drugs' Menace," December 17, 2009.

Kiron, S., Arun Shirwaikar, and Saritha M., "Influence of Storage Conditions on the Potency of Amoxicillin Dispersible Tablets Stores in Hospital and Community Pharmacies in Different Regions of Kerala," *Asian Journal of Pharmaceutical and Clinical Research* 4 (2011), 101–102.

Klein, Benjamin, and Keith Leffler, "The Role of Market Forces in Assuring Contractual Performance," *Journal of Political Economy* 89 (1981), 615–641.

Kranton, Rachel, "Competition and the Incentive to Produce High Quality," *Economica* 75 (2003), 385–404.

Krauth, Brian, "Bounding a Linear Causal Effect Using Relative Correlation Restrictions," *Journal of Econometric Methods* 5 (2016), 117–141.

Matsa, David, "Competition and Product Quality in the Supermarket Industry," *Quarterly Journal of Economics* 126 (2011), 1539–1591.

Mazzeo, Matthew, "Competition and Service Quality in the Airline Industry," *Review of Industrial Organization* 22 (2003), 275–296.

McKesson Corporation, "Retail Pharmacy Trends" (2012).

Miguel, Edward, and Michael Kremer, "Worms: Identifying Impacts on Education and Health in the Presence of Treatment Externalities," *Econometrica* 72 (2004), 159–217.

Milgrom, Paul, and John Roberts, "Price and Advertising Signals of Product Quality," *Journal of Political Economy* 94 (1986), 796–821.

Mubengayi, C. Kalonji, Y. Ramli, M. El Karbane, M. Azougagh, Y. Cherrah, and E. M. Essassi, "Study of the Accelerated Stability of Amoxicillin Made in DR Congo," *Journal of Chemical and Pharmaceutical Research* 5 (2013), 126–132.

National Community Pharmacists Association, "NCPA Financial Digest" (2013).

Nelson, Philip, "Advertising as Information," *Journal of Political Economy* 82 (1974), 729–754.

Newton, P. N., Facundo M. Fernández, Aline Plançon, Dallas C. Mildenhall, Michael D. Green, Li Ziyong, et al., "A Collaborative Epidemiological Investigation into the Criminal Fake Artesunate Trade in South East Asia," *PLoS Medicine* 5 (2008), 209–219.

Oster, Emily, "Unobservable Selection and Coefficient Stability: Theory and Evidence," *Journal of Business and Economic Studies*, https://doi.org/10.1080/07350015.2016.1227711.

Peace, Nwokoye, Oyetunde Olubukola, and Akinleye Moshood, "Stability of Reconstituted Amoxicillin Clavulanate Potassium under Simulated In-Home Storage Conditions," *Journal of Applied Pharmaceutical Science* 2:1 (2012), 28–31.

Porter, William R., "Degradation of Pharmaceutical Solids Accelerated by Changes in Both Relative Humidity and Temperature and Combined Storage Temperature and Storage Relative Humidity (T× h) Design Space for Solid Products," *Journal of Validation Technology* 19 (2013), 1–22.

Riordan, Michael, "Competition with Experience Goods," *Quarterly Journal of Economics* 101 (1986), 265–280.

Shaked, Avner, and John Sutton, "Multiproduct Firms and Market Structure," *Rand Journal of Economics* 21 (1990), 45–62.

Shapiro, Carl, "Information, Product Quality, and Seller Reputation," *Bell Journal of Economics* 13:1 (1982), 20–35.

Sheth, Prafull, Brijesh Regal, Madhulika Kaushal, Kaustav Sen, and D. B. A. Narayana, "Extent of Spurious (Counterfeit) Medicines in India," SEARPharm Forum technical report (2007).

Sow, P. S., T. S. N. Gueye, E. Sy, L. Toure, C. Ba, and M. Badiane, "Drugs in the Parallel Market for the Treatment of Urethral Discharge in Dakar: Epidemiological Investigation and Physicochemical Tests," *International Journal of Infectious Diseases* 6 (2002), 108–112.

Spence, A. Michael, "Monopoly, Quality, and Regulation," *Bell Journal of Economics* 6 (1975), 417–429.

Sutton, John, *Sunk Costs and Market Structure: Price Competition, Advertising, and the Evolution of Concentration* (Cambridge, MA: MIT Press, 1991).

Taylor, R. B., O. Shakoor, R. H. Behrens, M. Everard, A. S. Low, J. Wangboonskul, R. G. Reid, and J. A. Kolawole, "Pharmacopoeial Quality of Drugs Supplied by Nigerian Pharmacies," *Lancet* 357 (2001), 1933–1936.

Tirole, Jean, *The Theory of Industrial Organization* (Cambridge, MA: MIT Press, 1988).

Trefi, Saleh, Veronique Gilard, Myriam Malet-Martino, and Robert Martino, "Generic Ciprofloxacin Tablets Contain the State Amount of Drug and Different Impurities Profiles: A 19F, 1H and DOSY NMR Analysis," *Journal of Pharmaceutical and Biomedical Analysis* 44 (2007), 743–754.

Waterman, Kenneth C., and Bruce C. MacDonald, "Package Selection for Moisture Protection for Solid, Oral Drug Products," *Journal of Pharmaceutical Sciences* 99 (2010), 4437–4452.

Waterman, Kenneth C., Jon T. Swanson, and Blake L. Lippold, "A Scientific and Statistical Analysis of Accelerated Aging for Pharmaceuticals. Part 1: Accuracy of Fitting Methods," *Journal of Pharmaceutical Sciences* 103 (2014), 3000–3006.

Wertheimer, Albert, and Jeremiah Norris, "Safeguarding against Substandard/Counterfeit Drugs: Mitigating a Macroeconomic Pandemic," *Social and Administrative Pharmacy* 5 (2009), 4–16.

Woodcock, J., "The Concept of Pharmaceutical Quality," *American Pharmaceutical Review* 7 (2004), 10–15.

Yu, Lawrence X., "Pharmaceutical Quality by Design: Product and Process Development, Understanding, and Control," *Pharmaceutical Research*, 25 (2008), 781–791.