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# Pricing of new pharmaceuticals and price regulation in India*

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**Abstract**

How does restricting a firm's ability to raise prices in the future affect the introductory price of new products? This paper considers this question for new molecules launched in the Indian pharmaceutical market. The empirical results from the Indian market show higher launch prices for originators of chronic drugs that were introduced after the regulatory announcement. However, there appears no significant effect on competitor prices. I show that these findings align with a theoretical framework where originators of repeat purchase products increase introductory prices. While the originator secures a higher second period price, the competitor offers significant price cuts to capture new consumers. Overall, these results suggest that regulation delays welfare gains from new drugs, as initially more consumers are left out. The significance of this finding depends on the importance of these new introductions.

JEL codes: I18, L13, L65
Keywords: Regulation, oligopoly, price setting, pharmaceuticals

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# 1 Introduction

In the presence of switching costs, originator firms offer low introductory prices and later increase them while serving 'locked-in' consumers (Gabszewicz et al., 1992). In this paper, I examine how this pricing behaviour is likely to change if there is a restriction on subsequent price increase. This is examined in the case of the Indian pharmaceutical market.

India introduced a cap on annual price increases for pharmaceuticals in 2013. For those products that were not under a select list of essential drugs, annual prices could be raised no more than 10%.[1] This paper analyzes the effect of this regulation upon new non-patented pharmaceuticals launched in India between 2007-16. The results suggest that originators of new molecules respond to this regulation by increasing introductory prices of chronic drugs.

Building upon earlier work by Gabszewicz et al. (1992), I show the originator firm's price response to regulation. I demonstrate that when the originator anticipates competitive entry in the second period, they maximise their joint profit by raising the introductory price. This leaves more consumers not served in the first period, which the competitor gains by offering a significant price cut. These predictions correspond to the scenario for repeat purchase goods, such as chronic ailment drugs. For such products, experienced consumers may face switching costs. Importantly, these results are driven by an assumption of heterogeneity in consumer switching costs and myopic consumers. In the presence of uniform adoption costs and forward looking consumers, price regulation encourages originator firms to keep low launch prices to expand current demand (Ridley and Zhang, 2017).

Subsequently, these predictions are tested on the data from the Indian pharmaceutical sector. The effect of the regulatory announcement in 2013 is identified through the effect on originator and competitor pricing of chronic ailment drugs.[2] Data from the Indian pharmaceutical market seems a good choice for examining the impact of price regulation in the presence of switching costs for several reasons. Firstly, since prescriptions are typically generated by brand name in India, switching costs may be the only source of product differentiation

[1] Essential drugs here refer to those included in the National List of Essential Medicines (NLEM), 2011.

[2] Originator here refers to the first mover that launches a new molecule in India. This is not related with the innovator/patent holding firm. In the present sample, none of the molecules have valid patents in India (which can be either because the product doesn't qualify for product patent or a patent was never enforced by the innovator).

among sequentially entering branded generics.[3]

Additionally, the data allows for another source of variation across firms that were previously exempt from regulation. In 2007, a relevant government department sent out a notice whereby it encouraged manufacturers to contain prices changes within 10 percent. However, the notice also mentions that a list of large manufacturers would be created and their price changes will be monitored.[4] Thereby, smaller manufacturers that are not exempt from monitoring post 2013, would likely be affected more by the regulation. The difference-in-differences estimation results reveal that the originator's launch prices are higher for chronic drugs after the regulatory announcement. I also find that if the regulatory cap is non-binding upon those previously exempt, they likely increase their prices to meet the cap. I further expect competitors to price below the originator, but do not find significant results for this.

The main contribution of this study is to examine the effect of price regulation in the presence of some form of switching costs. When there is competition among brands of the same molecule, consumers may experience varying degrees of risk aversion due to uncertainty regarding the quality of brands they have not previously tested. Even though generics are required to establish bioequivalence with respect to the originator's product[5], and follow safety and quality assurance upto the regional regulatory standards, it can often take time for generic adoption to pick up pace. These costs are more pronounced for long term consumers, such as those who purchase chronic ailment drugs. Such risk aversion results in brand loyalty, which the originator is able to leverage, and increase its subsequent prices. This paper shows that price cap regulation mitigates the market power of the originator upon 'locked in' consumers. This would appear to benefit the consumers in the long run, however in the short term more consumers are left out. Earlier research suggests that price ceiling component of DPCO 2013 led to lower overall prices, and the benefits of the legislation were higher for quality sensitive consumers (Boswell-Dean, 2019).

The role of such switching costs has been examined in a sequential entry game absent any price regulation, by Gabszewicz et al. (1992). They show that a pure strategy equilibrium can exist where the originator sets a low launch

[3]Most firms market a molecule under their unique brand name. The idea of prescribing by generic name has been encouraged in recent years, but this is not a mandatory requirement as yet, and there are no generic substitution laws in place.

[4]See appendix A for further details.

[5]Bioequivalence implies that the generic drug performs in the same manner as the originator product. This is usually shown by comparing the time it takes for the drug to reach the bloodstream as well as, its concentration in the bloodstream.

price to soften price competition in the second stage. Their argument is that the effect of brand loyalty for the originator firm's product need not discourage entry, but instead encourage the competitor to compete for the experienced consumers. I extend their model by re-examining the launch price that maximises the originator's joint profit if they were faced with a constraint on price increases. The intuition for firm's incentive to set higher launch prices stem from being able to secure a higher second period price. Ridley and Lee (2020) show that similar incentives may be at work when medicine reimbursements based on lagged prices drive up launch prices. Additionally, while Gabszewicz et al. (1992) do not address the role of consumer surplus, this paper provides a comparison of consumer welfare outcomes in the unconstrained case with the one where there is a constraint.

The overall picture reflects on how inflationary caps might prove counter-intuitive if they reduce consumer welfare in the short run, due to originator's higher introductory prices. Prices can become a barrier to access in settings where majority of the burden of health expenditure is borne out of pocket by patients.[6] The extent to which these immediate losses are critical depends upon, whether new introductions are significant improvements over existing alternatives. However, it should be noted that the present results are driven by the assumption of uniform distribution of consumer switching costs/risk aversion. Subsequent extensions of this work, could consider how these predictions alter if there was a fraction of consumers, denoted by $\lambda$, which have high risk aversion. One might expect with higher proportion of risk averse consumers, the loss to the originator from an increased intensity of price competition is greater.

The analysis in this paper is related with several literatures. First, this paper relates with previous works on the impact of restricted price increases on introductory prices of pharmaceuticals. In a regulated market, originators set higher launch prices irrespective of the degree of novelty (Ekelund and Persson, 2003) and command higher prices when faced with greater demand uncertainty (Shajarizadeh and Hollis, 2015). Abbott III (1995) considers the likely impact of introducing a restriction on price increases in the US, and expects that initial prices of new pharmaceuticals will be set at higher levels. However more recently, Ridley and Zhang (2017) show that this would not be the outcome with forward looking consumers. In that case, by lowering launch prices originators expand current demand and are able to to commit to lower future prices.

[6] As of 2018, the out of pocket expenditure in India is 63% of current health expenditure (World Health Organisation, 2021)

However, all of the aforementioned consider originator pricing in the monopoly period. The present study is closest in analysis to Ridley and Zhang (2017), but my results contrast theirs when the role of consumer heterogeneity in switching costs/risk aversion and generic entry are accounted for.

Second, this paper is related with the strand of literature on the impact of various mechanisms of price regulation on brand and generic prices of existing products. With reference pricing, brand prices decrease more with generic competition (Pavcnik (2002), Brekke et al. (2011)). Dubois and Lasio (2018) show that when there is a brand preference, price cap regulation intensifies competition between brand and generic drugs, and this hurts generic firms. Unlike earlier works that consider regulation of reimbursement prices, the present study considers prices that are not subject to any reimbursements. Moreover, by taking a sample of newly launched drugs, this paper examines the impact of the regulation upon the pricing over the life cycle of the originator's product.

Third, this paper adds to the theoretical literature on heterogeneous switching costs and their impact upon competition. The present work builds upon the insights of Gabszewicz et al. (1992) on consumer learning costs that lead to originator's first mover advantage in a sequential entry game. More recent literature has considered the impact of the size of switching costs upon competition. While duopolists increase first period prices with switching costs, only when switching costs are not too large (Ruiz-Aliseda, 2016), but more consumers with low switching costs make entry costlier for the competitors (Biglaiser et al., 2013).

Finally, earlier work shows that the price ceiling component of DPCO 2013 leads to reduced prices and sales for existing drugs on the market (Boswell-Dean, 2019). But another appears to indicate that firms engage in price coordination to evade price control (Bhaskarabhatla et al., 2017). However, this, to the best of my knowledge, is the first study that considers the impact of the regulation of price increases in the Indian market.

In the following section, the hypotheses are presented. Section 3 deal with data and descriptive analysis. Next, the empirical framework is detailed in section 4 and the regression results are summarized in section 5. The final section concludes with a discussion of the results.

## 2 Hypotheses

**Model set up** Consider a two period model. In the first period, an originator brings a new pharmaceutical into the market at price, $p_{O1}$. In the absence of patent protection on the drug, the competitor enters in the period 2 and both firms play a noncooperative game in price strategies. The originator sets price $p_{O2}$, and the competitor, $p_{C2}$. It is assumed that there no cost differences between the two firms and there is no cost to entry.

In the model, consumers are myopic, and those who purchase the product in the first period are experienced consumers in the second period. Where prescriptions are generated by brand names, once consumers in period 1 have tried the product they are unlikely to switch to a different brand, even if the competitor's product is identical. This stems from risk aversion of consumers, which in turn might arise from the lack of confidence in the substitutability among different brands of the same molecule.[7] This has been observed in the context of patented pharmaceuticals where consumers retain their loyalty with originator brands even after generic entry (Frank and Salkever, 1997). Consumers differ in their degree of risk aversion, and higher risk aversion results in consumer inertia ($\alpha$). A high value of $\alpha$ corresponds to a low level of inertia. The consumers are taken from a uniform distribution of $\alpha$ such that $\alpha \in [0, 1]$.

This framework is based upon the study by Gabszewicz et al. (1992) which presents a model for pricing in the event of sequential entry with consumer learning costs. They show that the competitor has two possible strategies that depend upon the originator's introductory price. One where they serve new consumers, as well as some of the experienced consumers, alternatively they serve only experienced consumers. Figure 1 below depicts the two possibilities. When the originator sets a high introductory price, their best reply curve ($R_O^B$) intersects the lower segment of the competitor's best reply curve ($R_C$) at $E1$. The competitor responds by serving both experienced and inexperienced consumers in the market. In an alternate scenario, the originator could charge a low introductory price and the competitor would serve only the experienced consumers. This scenario is depicted by the intersection of the originator's best reply function ($R_O^A$) with the upper segment of the competitor's best reply function($R_C$) at $E2$. Further, they show that it is the latter equilibrium at which the originator's joint profit is maximised. The critical value at which the competitor

[7] Alternatively, this can also be viewed as prescriber risk aversion. Doctors can be risk averse as well, and may continue to prescribe the brand that was given previously.

switches between the two strategies is given by $p_{O2} = \frac{p_{O1}}{\sqrt{2}-1}$. The key steps of the model by Gabszewicz et al. (1992) have been solved and are presented in appendix B.

**Price constraint** Presently, I expand their model further to account for the impact of price caps on prices, profits and consumer welfare. I show that when there is a constraint, there is no ambiguity in the competitor's strategy. This is shown by adding the assumption that the originator can set the second period price to a maximum of 10% of the previous price. This implies $p_{O2} \leq 1.1p_{O1}$, therefore $p_{O2} \geq \frac{p_{O1}}{\sqrt{2}-1}$ will never be the case (see Figure 1). Hence, the competitor will serve both the experienced and inexperienced consumers and the new equilibrium will be at $E3$. The detailed steps are presented in appendix B.2.

Table 1: Results: Prices and Profits

| | Without constraints | | With constraints | |
|---|---|---|---|---|
| | Prices | Profits | Prices | Profits |
| First period | $P_{O1} = 0.1v$ | $\pi_{OT} = 0.45v$ | $P_{O1} = 0.38v$ | $\pi_{OT} = 0.40v$ |
| Second period | $P_{O2} = 0.6v$ | | $P_{O2} = 0.42v$ | |
| | $P_{C2} = 0.3v$ | $\pi_{C2} = 0.09v$ | $P_{C2} = 0.20v$ | $\pi_{C2} = 0.08v$ |

Without the constraint, the result shown here is the one in equilibrium.

In the absence of any constraint, originator can avoid aggressive competition in period 2 by choosing a low introductory price. However, since there is a constraint, the originator will charge a higher launch price in order to be able to maintain a higher period 2 price. The total profit earned by the originator in the absence of the constraint, is approximately 11% higher than the overall profit earned when the constraint binds (see Table 1). Notably, the competitor's profit is also lower in the presence of the constraint.

**Consumer Welfare** Next, the impact on consumer surplus is examined. Gabszewicz et al. (1992) do not compute consumer surplus, and I compare the surplus from the unconstrained equilibrium vs the constrained equilibrium.

The total utility gained by each consumer in both periods is considered.

While the experienced consumers can either purchase from the originator in both periods, or from the originator in the first and the competitor in the second period. On the other hand, the inexperienced consumers only purchase in the second period from the competitor.

The utility function $U$ for consumer $h$, who may be experienced ($e$) or inexperienced ($n$), purchases from firm $i$ at time period $j$:

$$U_{hij} = \begin{cases} U_{eO1} + U_{eO2} = \alpha v - P_{O1} + v - P_{02}, & if \frac{P_{O1}}{v} \leq \alpha \leq 1 - \frac{P_{O2} - P_{C2}}{v} \\ U_{eO1} + U_{eC2} = 2\alpha v - P_{O1} - P_{C2}, & if 1 - \frac{P_{O2} - P_{C2}}{v} \leq \alpha \leq 1 \\ U_{nC2} = \alpha v - P_{C2}, & if \frac{P_{C2}}{v} \leq \alpha \leq \frac{P_{O1}}{v} \\ 0, & otherwise \end{cases}$$

The consumer surplus(CS) is calculated by integrating over the values of $\alpha$ and the results are presented in Table 2. It appears that overall welfare is lower in the constrained scenario. The originator's launch price is higher under the constraint, which suggests a higher number of inexperienced consumers in the second period. Some of these inexperienced consumers are served by the competitor when the price is lower than that of the originator's price. Although it appears as if inexperienced consumers would benefit from constraints on price increases. However, there are more inexperienced consumers who are not served at all (for details, see appendix 4).

Table 2: Results: Consumer Welfare

| Without constraints | | | With constraints | | |
|---|---|---|---|---|---|
| Experienced | Inexperienced | Total | Experienced | Inexperienced | Total |
| $0.72v$ | 0 | $0.72v$ | $0.664v$ | $0.0051v$ | $0.6691v$ |

These results are driven by the distributional assumptions about consumer inertia and based on that the following five predictions emerge from this model. However, only the first three among these are empirically tested in the following section:

**Prediction 1**: Launch prices of originator are higher after the regulation.

**Prediction 2**: Originator's price increment in the second period is lower after the regulation.

**Prediction 3**: Launch prices for competitor are lower than the originator's launch price after the regulation.

**Prediction 4**: Profits of both the originator and competitor will be lower under the regulation.

**Prediction 5**: Consumer surplus is lower under the regulation.

# 3 Data and Descriptives

The parent dataset is a product-level monthly sales data from April 2007-November 2016. The data is compiled by AIOCD AWACS, a pharmaceutical market research organization which is a joint venture between All Indian Origin Chemists and Distributors (AIOCD), the largest organization of pharmacy retailers in India, and Trikaal Mediinfotech Pvt Ltd. This dataset is disaggregated to the level of individual pack, and provides information on sales value, quantity sold and product level information such as drug type (tablets, capsules, syrups, etc.), strength of dosage, pack size, therapy group, class, whether it is for acute or chronic ailments, etc. This represents 85-90% of the total market. Since this data is collected at the level of stockists, some drugs may not feature in the data if they were not in supply or scantily supplied to limited pharmacies. The dataset provides information at product level, which is a specific brand, dosage strength (100, 200 mg) and pack level (10 capsules, 20 tablets, etc.). Each product identifies a unique brand, strength and pack combination and is called a stock keeping unit (SKU). So a given firm can supply multiple SKUs of the same molecule with variations in strengths and/or pack size.

For the purpose of examining launch prices of new drugs, a subset of the data that includes molecules that were launched 2007 onwards is taken. This data is aggregated annually at the level of SKUs since the regulation caps annual price increases. The price variable is constructed using a ratio of total aggregate sales value for each SKU to the total volume for each year.

Of a total of 370 new molecules launched in India after 2007, 188 are mo-

nopolies i.e., where there are no alternate brands for such molecules.[8] Also, 102 molecules were launched between 2013-16. The originator is defined as a firm which is the first brand to enter the molecule market and all of the different SKUs launched by the first brand are considered the originator. The sample is limited to consider the case for molecules that were launched as unique originator brands (i.e, there was no simultaneous entry of two or more firms) and consider the first competitor in the relevant molecule market. An originator can have multiple SKUs in the same entry year, which is often the case as a firm attempts to launch different doses and pack sizes for diverse patient needs. Hence, different samples are generated to ensure that each originator has one observation. One way to do so is to only consider those molecules where originator and competitors have one SKU each. Another strategy is to match the formulations between originator and competitor firms and retain only the matched SKU. Finally, if there are multiple matches, the earliest SKU launched is chosen and where they are still overlaps, the largest dose/pack size is retained.

In the following analysis, originator launch prices are normalised using a substitute price index. To do so, Ekelund and Persson (2003) use a weighted average of the prices of all substitutes, using individual market shares as weights. I use this method to generate price indexes for launch prices of the originator firm, where weights are taken as the market shares of each molecule in the therapy group it belongs to. Accordingly, the originator launch price for molecule $i$ which belongs to group $k$ in year $t$ is written as the following:

$$RP_{it} = \frac{P_{it}}{P'_{jt}} \tag{1}$$

$RP_{it}$ is the weighted relative launch price of molecule $i$ at launch year $t$;
$P_{it}$ is price of molecule $i$ at launch year $t$;
$P'_{jt}$ is weighted price of substitutes $j$ of molecule $i$ at launch year $t$, given by the following:

$$P'_{jt} = (\sum_{\substack{j=1 \\ i,j \in k}}^{n} w_{jt} P_{jt}) / (\sum_{\substack{j=1 \\ i,j \in k}}^{n} w_{jt}) \tag{2}$$

$P_{jt}$ is price of molecule $j$ at the time when molecule $i$ is launched;

[8] The absence of competitors could also be a matter of censoring in our data.

Table 3: Summary of launch prices for originator before 2013

| | Acute Prior | | Chronic Prior | |
|---|---|---|---|---|
| | mean | sd | mean | sd |
| Originator's Launch Price | 6.47 | 26.23 | 3.67 | 16.92 |
| RP | 1.29 | 1.57 | 1.43 | 1.78 |
| Observations | 139 | | 129 | |

$w_{jt}$ is the market share of molecule $j$ in group $k$ at the time that molecule $i$ is launched

In Figure 2, the originator's launch price (adjusted for inflation) over time is shown. From the figure, the price appears to be increasing in the period after the regulatory announcement.

[Figure 2 here]

The originator's mean launch price for acute ailment vs chronic drugs prior to the regulation is compared in Table 3. The originator launch price appears higher for acute ailment drugs, but the relative price (RP), i.e. launch price normalised to price of existing substitutes, appears to be lower for acute drugs. In either case, the difference in the means is not statistically significant. However, when we compare the relative price before and after the regulation only for chronic drugs, the price is significantly higher after the regulation (Figure 3). In the next section, I examine the impact of the regulation upon originator launch as well as follow-on pricing strategies, and competitor's entry pricing using a difference-in-differences estimation.

[Figure 3 here]

# 4 Empirical specification

The data is a repeated cross section and the originator introductory prices are estimated as per equation 3 below. The dependent variable here is LNRP, which is the log of RP, as defined previously. The main independent variable here is the indicator variable that takes a value of 1 if the molecule was launched after 2013. Next, there are two treatment groups to be considered. Following from the theoretical framework, repeat purchase drugs such as those for chronic

ailments, are more likely to be have had lower introductory prices in the absence of regulation. The second treatment is identified from the policy itself. As mentioned previously, prior to 2013, there was some indication that firms that met a certain set of criteria would be required to keep annual price increases to a limit of 10% and would be monitored for the same. If a given product of a firm met the following criterion, it would be subject to the monitoring:

1. Annual turnover of the formulation exceeds 10 million INR and;
2. Share of the formulator is atleast 20% in the formulation segment or is one of the top 3 medicines in the group.

In 2013, when the new regulation came in, there were no size based exemptions and all products were subject to monitoring. It is therefore expected that the effect of the regulation would be stronger upon firms which were, prior to 2013, exempt from monitoring. In order to identify these group of previously not-monitored firms, their existing portfolio of products is considered. It can be expected that if a firm met the criterion for its existing products, it would most likely meet the criterion for its new products as well (if they already have strong marketing and distribution networks they are more likely to be successful in their new product launches as well). So for each firm, for all products introduced before 2007, I evaluate their turnover and share in 2007 (which is the first year of the present dataset). The affected group would be the firms which never meet the monitoring criterion for any of their old products. Based on the foregoing, out of 125 firms that launch products as originators, 60 had not been monitored previously.

Other controls include log of inter-molecular substitutes (greater number of substitute molecules should put downward pressure on launch prices) and whether the drug is a combination of two or more active pharmaceutical ingredients (combinations of existing drugs may be less novel and hence are likely to have lower launch prices). Finally, drug category (injectables, liquids, inhalants and others) and therapy class effects are also included in some specifications.

$$\begin{aligned} LNRP_i =& \beta_0 + \beta_1 After_i + \beta_2 After_i * T_i + \beta_3 T_i \\ &+ \beta_4 Combination_i + \beta_5 LNSubstitutes_i \\ &+ \beta_6 \eta_i + \epsilon_i \end{aligned} \tag{3}$$

where:

$LNRP$: the natural logarithm of the $RP$ ( for each molecule $i$ at launch)

$After$: dummy variable that takes value 1 if the originator launches their product between 2013-16

$T$: treatment is Chronic (which takes value 1 if the molecule is for chronic ailments) and Not-monitored (takes value 1 if the originator firm was not previously subject to monitoring)

$Combination$: dummy variable which takes value 1 if the molecule is a combination of two or more active ingredients

$LNSubstitutes$: log of number of substitute molecules (within the same group of drugs) active at the time the originator launches their product

$\eta$ includes therapy class and formulation fixed effects

The second prediction on follow-on prices of originators is tested using a similar empirical specification, with the dependent variable now being the $\frac{P_{O2}}{P_{O1}}$ as per our model. This is a measure of the price increase by the originator in the period when the competitor enters relative to the monopoly scenario. The independent variables for this specification remain the same as in the case of launch price regressions, except the inclusion of length of delay in competitor's entry.

For the third prediction on competitor's launch price, the empirical specification is given in equation 4. The dependent variable is analogous to $\frac{P_{C2}}{P_{O1}}$ in the model, i.e., the competitor's introductory price relative the originator's price in the preceding period. It is expected that if the competitor does not enter within the very next period after the originator's launch, their launch price would be based upon the originator's price in the period before. The independent variables now capture the effect of this length of entry delay. For the treatment effect, however, only chronic drug indicator is considered. The reason for this being that not-monitored firms as originators are more likely to be affected by the regulation, however the competitors themselves are affected

by the originator's strategy and other market conditions.[9]

$$\begin{aligned} LNP_{C2i} =& \beta_0 + \beta_1 After_i + \beta_2 After2013_i * T_i + \beta_3 T_i \\ &+ \beta_4 Combination_i + \beta_5 Delay_i \\ &+ \beta_6 \eta_i + \epsilon_i \end{aligned} \tag{4}$$

where:

$LNP_{C2i}$: the natural logarithm of the ratio of launch price of competitor to price of the originator in the previous period

*Delay*: the length of time between the originator and competitor's entry

# 5 Results

In Table 4 below reports the results from the DID specification of originator launch prices. In the first two columns of Table 4, originator's launch price regressions with a single treatment group are reported. It is appears here, that after the regulation, launch prices increase more for chronic ailment drugs, but there is no significant effect upon not monitored firms. The last two columns include the triple difference estimator when both treatment groups, chronic drugs and not monitored firms, are considered together. If not monitored firms are now affected by the regulation, it is expected that their launch prices for chronic drugs are higher. It is observed that the overall effect of the regulation for chronic drugs is still significant at 10% in the last two columns. In fact, when both therapy and formulation fixed effects are included, the magnitude of the coefficient for chronic drugs is almost identical to the single treatment case in the first column. For not monitored firms, the launch prices of new products after the regulatory announcement are higher, but this effect is non-significant. The triple difference coefficient, though positive, is not significant either. This result suggests that originator firms respond to regulation by introducing chronic drugs at higher prices. But, previously not-monitored firms appear to be setting introductory prices similar to those before the regulation.

Among the control variables, new combination drugs are more likely to have lower launch prices since the individual constituent molecules may be already available in the market. This is evident in the negative and significant coefficient

[9] So far, it has been assumed that there is no direct effect of the regulation on competitor strategy. This is discussed further in the concluding section.

for combinations in the first column. While in other columns the significance of this variable is not evident, it should be noted that both, the magnitude of the coefficient and the p-value in the last column are not very different from that in the first column. In the last column, a negative and significant effect of log of substitutes is also visible. This suggests a late mover disadvantage; within a therapy class later entrants are only able to compete if they offer a discount over existing substitutes.

[Table 4 here]

Next, based on the hypothesis, it is expected that in response to the originator's changed price strategy, the competitor would offer a discount while introducing chronic ailment drugs. The results from the DID specification for competitor's launch price regressions in Table 5. The dependent variable here includes real prices, i.e. they have been adjusted for inflation using the wholesale price index (WPI). Note that the variable $After$ captures the effect of the regulation upon those competitor drugs where the originator launched their product after the regulatory announcement. The effect of the actual year of competitor product launch is estimated by including time dummies. In the first two columns the sample includes only those molecules where the competitor and originator have matching SKUs, but the first column does not include formulation fixed effects. Whereas, the last column reflects the results from a sample of all molecules where a competitor is present. The launch prices of competitor products are lower following the regulation in all estimations, but the relevant coefficient is significant only in the full sample. Though it is expected that competitors of chronic drugs should offer their products at a discount after the regulation, but this treatment effect is not significant in the matched sample case. Moreover, in the last column this effect is positive. It is likely that in the full sample some competitors launch their products that are different from the originator's, and so the former compete through product differentiation rather than prices.

In the full sample, the coefficient for combination drugs is positive and significant. Where firms launch combination products, they likely have previously launched the individual molecules. For such products, competitors may not find it lucrative to offer a discount to capture new consumers, given consumers may still purchase molecules separately. With delayed entry by competitor the expected effect is lower prices, though the coefficient appears non significant.

[Table 5 here]

Finally, if the regulatory price cap is binding, it is expected that the increment in the originator's second period prices would be lower. In Table 6 below the results from originator's follow-on price regression are presented. The dependent variable are inflation adjusted follow-on prices. Of the three columns in this table, the first two include chronic as the only treatment group, and the last column has both treatment groups. There is also variation in inclusion of therapy class and formulation fixed effects across the three columns. It is evident that in all three columns that the follow-on prices are significantly higher if the molecule was launched after 2013. For chronic drugs the regulation leads to a smaller increase in second period prices, but this effect is not significant. On the other hand, previously not monitored firms decrease the extent of price increase in response to the regulation, as seen in the negative and significant coefficient in the last column. But these firms are likely to keep chronic drug prices higher, if the regulatory cap was not binding upon them. This is evident in the positive and significant coefficient of the triple difference estimator. Additional controls, such as competition from new molecules and combination drugs lower follow-on prices, but do not have a significant effect. Finally, the longer the delay in entry by the competitor, the lower the extent of price increase by the originator. This is likely to be the case because the originator's price level is closer to the duopoly price in later periods. However, this too is not a significant effect in our results.

[Table 6 here]

These results align with our model predictions that originators may set higher launch prices for chronic drugs in response to a restriction on price increases. In following period when the competitor enters, originator prices should reduce for chronic drugs. This is because the regulatory cap is expected to bind upon these set of products. However, I do not find this effect to be significant. On the other hand, previously not monitored firms are now affected by the upward price rigidity. The positive effect of the triple difference indicates the regulatory cap is not binding upon chronic drugs of not monitored firms. Therefore, with the regulation these firms increase the follow-on prices for chronic drugs. In summary, originator firms respond to the regulation by increasing launch prices for chronic drugs, but also increase second period prices if the regulatory cap was not binding. For the competitors, there appears limited evidence of the regulation leading to lower overall launch prices and no significant effects for chronic drugs. If competitors launch slightly differentiated products com-

pared to the originator, the nature of competition may shift away from one that is based on prices. An additional limitation could come from fewer molecules that experienced competitive entry (47.8%) in our overall sample. As a further robustness check, the competitor and originator follow-on prices are estimated using different measures of inflation- overall WPI versus sector-specific WPI. The main results appear unchanged. This is discussed further in appendix C.

# 6 Conclusion

This paper is a study of the impact of regulation of price increases upon pricing of new non-patented pharmaceuticals. To provide a theoretical basis for this, I extend the model by Gabszewicz et al. (1992) to examine the effect of price regulation on firm pricing strategy, when consumers are myopic and incur switching costs. The model shows that when there is a restriction on price increases, originator firms maximise their joint profits only when the launch prices are higher and this intensifies price competition. The launch prices are higher because firms want to ensure a higher second period price.

The empirical results from the Indian pharmaceutical market substantiate the model predictions for originator's launch prices. I create a quasi-experiment from a new price regulation that was announced in India in 2013. This effect of the regulation appears to be positive and significant for chronic drugs, where there are switching costs. I also find that if the regulatory cap is non-binding upon products of not monitored firms, they increase their second period prices to meet the cap. Further, an increased intensity of price competition in the duopoly period was expected, however, I do not find significant results for this. This might be due to the limitation of few molecules with competitors in the present data.

On the one hand, price cap regulation mitigates the market power of originators on experienced consumers, while infusing greater price competition for new consumers. This enables welfare gains for consumers in the long run, as Abbott III (1995) suggests, they may benefit from overall lower price levels under the regulation. However, in the immediate term, some consumers may likely be left out from the market due to higher launch prices. Whether these immediate losses are critical would further depend upon, the extent to which these new introductions are significant improvements over existing alternatives.

Subsequent extensions to the theoretical framework could consider the im-

pact of different distributional assumptions regarding consumer heterogeneity. Further research could also examine the impact of the regulation on follow-on prices of competitors. Since competitors are also subject the price constraint, there may be an additional stage of the game to consider their response. For the present study, sufficient empirical data was not available to examine follow-on competitor prices.

# References


Abbott III, T. A. (1995). Price regulation in the pharmaceutical industry: Prescription or placebo? *Journal of Health Economics*, 14(5):551–565.

Bhaskarabhatla, A. (2018). *Regulating Pharmaceutical Prices in India: Policy Design, Implementation, and Compliance*. Springer.

Bhaskarabhatla, A., Chatterjee, C., Anurag, P., and Pennings, E. (2017). Mitigating regulatory impact: the case of partial price controls on metformin in India. *Health Policy and Planning*, 32(2):194–204.

Biglaiser, G., Crémer, J., and Dobos, G. (2013). The value of switching costs. *Journal of Economic Theory*, 148(3):935–952.

Boswell-Dean, E. (2019). Who benefits from pharmaceutical price controls? Evidence from India. *CGD Working Paper 509, Washington,DC:Center for Global Development*. Available at https://www.cgdev.org/publication/who-benefits-pharmaceutical-pricecontrols-evidence-india.

Brekke, K. R., Holmas, T. H., and Straume, O. R. (2011). Reference pricing, competition, and pharmaceutical expenditures: Theory and evidence from a natural experiment. *Journal of Public Economics*, 95(7-8):624–638.

Dubois, P. and Lasio, L. (2018). Identifying industry margins with price constraints: Structural estimation on pharmaceuticals. *American Economic Review*, 108(12):3685–3724.

Ekelund, M. and Persson, B. (2003). Pharmaceutical pricing in a regulated market. *Review of Economics and Statistics*, 85(2):298–306.

Frank, R. G. and Salkever, D. S. (1997). Generic entry and the pricing of pharmaceuticals. *Journal of Economics & Management Strategy*, 6(1):75–90.

Gabszewicz, J., Pepall, L., and Thisse, J.-F. (1992). Sequential entry with brand loyalty caused by consumer learning-by-using. *The Journal of Industrial Economics*, 40(4):397–416.

Pavcnik, N. (2002). Do pharmaceutical prices respond to potential patient out-of-pocket expenses? *RAND Journal of Economics*, 33(3):469–487.

Ridley, D. B. and Lee, C. Y. (2020). Does medicare reimbursement drive up drug launch prices? *Review of Economics and Statistics*, 102(5):980–993.

Ridley, D. B. and Zhang, S. (2017). Regulation of price increases. *International Journal of Industrial Organization*, 50:186–213.

Ruiz-Aliseda, F. (2016). When do switching costs make markets more or less competitive? *International Journal of Industrial Organization*, 47:121–151.

Shajarizadeh, A. and Hollis, A. (2015). Price-cap regulation, uncertainty and the price evolution of new pharmaceuticals. *Health Economics*, 24(8):966–977.

World Health Organisation (2021). Global health expenditure database. `https://apps.who.int/nha/database/ViewData/Indicators/en`. Last accessed 2nd October 2021.

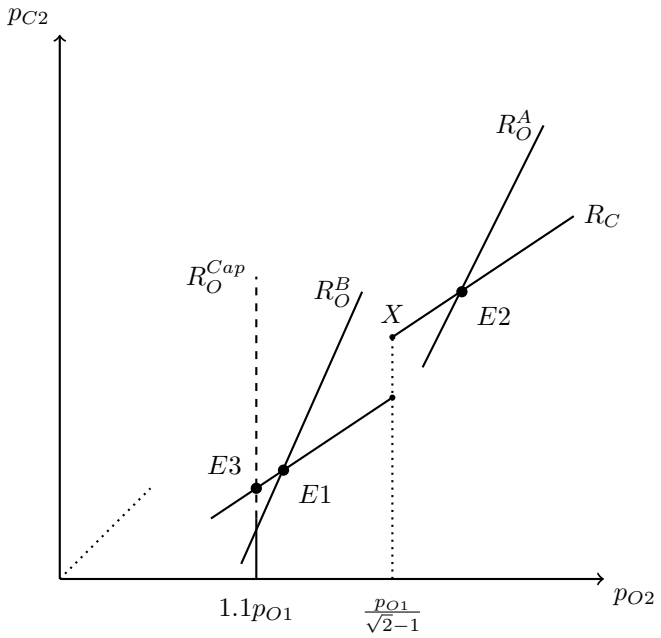


Figure 1: Firms best reply functions when the constraint binds (amended from Gabszewicz et al. (1992))


Figure 2: Originator's launch prices

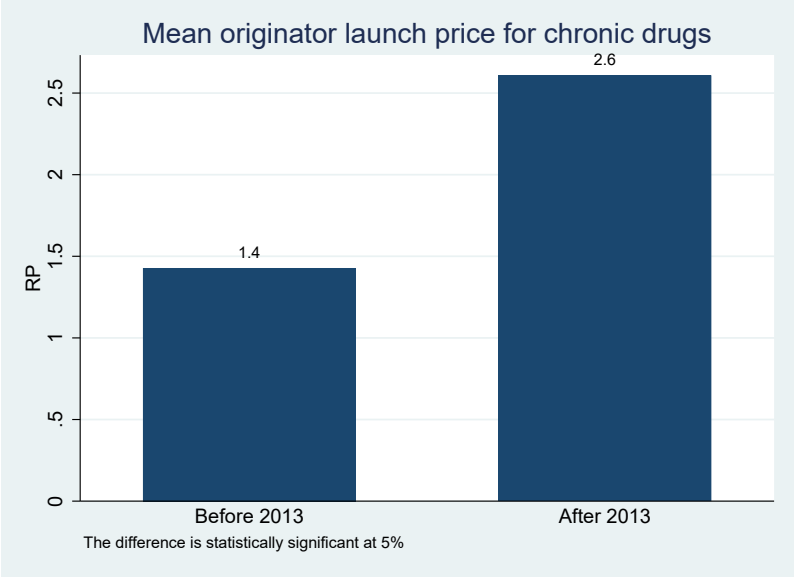


Figure 3: Originator price measured as RP defined above i.e.,weighted relative launch price of molecule

Table 4: Originator Prices - DID

| | Chronic | Not Monitored | Both | Both |
|---|---|---|---|---|
| After 2013=1 X Chronic=1 | 0.460** | | 0.425* | 0.466* |
| | (0.199) | | (0.244) | (0.252) |
| After 2013=1 X Not-monitored=1 | | 0.235 | 0.219 | 0.233 |
| | | (0.179) | (0.247) | (0.253) |
| After 2013=1 X Chronic=1 X Not-monitored=1 | | | 0.176 | 0.166 |
| | | | (0.348) | (0.352) |
| After 2013=1 | -0.132 | 0.066 | -0.160 | -0.201 |
| | (0.135) | (0.121) | (0.183) | (0.190) |
| Chronic=1 | 0.022 | 0.147 | 0.063 | 0.063 |
| | (0.122) | (0.109) | (0.128) | (0.129) |
| Log of Substitutes | -0.060 | -0.053 | -0.064 | -0.067* |
| | (0.039) | (0.041) | (0.040) | (0.040) |
| Combination | -0.160* | -0.111 | -0.115 | -0.156 |
| | (0.096) | (0.090) | (0.088) | (0.096) |
| Not-monitored=1 | | -0.199 | -0.102 | -0.116 |
| | | (0.121) | (0.164) | (0.166) |
| Chronic=1 X Not-monitored=1 | | | -0.247 | -0.244 |
| | | | (0.228) | (0.229) |
| Constant | -0.487 | 0.013 | 0.067 | -0.454 |
| | (0.366) | (0.170) | (0.171) | (0.369) |
| r2 | 0.108 | 0.084 | 0.102 | 0.119 |
| N | 370 | 370 | 370 | 370 |
| Therapy_Effects | Yes | Yes | Yes | Yes |
| Formulation_Effect | Yes | No | No | Yes |
| Sample | All | All | All | All |

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Competitor Prices - DID

| | | Matched sample | |
|---|---|---|---|
| | Matched sample | All fixed effects | All molecules |
| After 2013=1 | -0.107 | -0.122 | -0.385* |
| | (0.214) | (0.252) | (0.198) |
| Chronic=1 | -0.032 | 0.061 | -0.186 |
| | (0.145) | (0.137) | (0.142) |
| After 2013=1 X Chronic=1 | -0.015 | -0.010 | 0.123 |
| | (0.164) | (0.212) | (0.177) |
| Delay in Entry | -0.043 | -0.047 | -0.009 |
| | (0.040) | (0.044) | (0.032) |
| Combination | | 0.172 | 0.208** |
| | | (0.104) | (0.087) |
| Constant | -0.186 | -0.245 | -0.567** |
| | (0.163) | (0.213) | (0.230) |
| r2 | 0.278 | 0.336 | 0.256 |
| N | 119 | 119 | 217 |
| Launchyear_Effect | Yes | Yes | Yes |
| Therapy_Effects | Yes | Yes | Yes |
| Formulation_Effect | No | Yes | Yes |
| Sample | Matched | Matched | All |

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Is the increase in second period prices lower among originators?

| | Chronic | Chronic | Both |
|---|---|---|---|
| After 2013=1 X Chronic=1 | -0.012 | -0.044 | -0.086 |
| | (0.036) | (0.044) | (0.055) |
| After 2013=1 X Not-monitored=1 | | | -0.185** |
| | | | (0.085) |
| After 2013=1 X Chronic=1 X Not-monitored=1 | | | 0.206** |
| | | | (0.099) |
| After 2013=1 | 0.075*** | 0.103*** | 0.139*** |
| | (0.029) | (0.034) | (0.045) |
| Chronic=1 | -0.009 | -0.020 | -0.010 |
| | (0.025) | (0.019) | (0.020) |
| Change in substitutes | -0.005 | -0.008 | -0.007 |
| | (0.006) | (0.005) | (0.005) |
| Delay in Entry | -0.010 | -0.012 | -0.015 |
| | (0.012) | (0.011) | (0.011) |
| Combination | 0.005 | -0.032 | -0.035 |
| | (0.027) | (0.031) | (0.032) |
| Not-monitored=1 | | | 0.106 |
| | | | (0.066) |
| Chronic=1 X Not-monitored=1 | | | -0.117 |
| | | | (0.079) |
| Constant | -0.044 | -0.078** | -0.073** |
| | (0.029) | (0.035) | (0.037) |
| r2 | 0.079 | 0.260 | 0.288 |
| N | 177 | 177 | 177 |
| Therapy_Effects | No | Yes | Yes |
| Formulation_Effect | No | No | Yes |

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

# Appendices

## A Note on India's pharmaceutical regulation

Pharmaceuticals in India have been under some form of price regulation since the 1960s, with the most recent change in 2013 which involved a shift from cost based to a market based regulation.[10] The main idea behind this regulatory change was to control prices of essential drugs, while being independent of any other policy to promote the growth of the pharmaceutical industry or improving institutional frameworks for ensuring access to medicines. This regulation, called the Drug Price Control Order, has two components to it. One is an absolute price ceiling based on lagged prices, upon a select list of essential drugs. For these drugs, annual price increases are capped at the wholesale price index for the year. The other component requires that annual price increases for all remaining drugs are limited to 10%.

In 2007, the relevant government departments circulated a notice and encouraged manufacturers to keep price changes within a 10% limit. But they also mentioned that firms will be shortlisted when the price increase exceeds this limit and annual turnover of the formulation exceeds INR 1 crore (10 million). Further, the market share of such a formulation should be at least 20% or it is one of the top 3 formulations in the group. Should it be found that that the price changes are beyond the prescribed limit for such firms, the manufacturers would then be asked to voluntarily reduce prices. Although this suggests that the 10% inflation rule was already in the works prior to 2013, it may be argued that since this regulation was not in the DPCO 1995 (the previous price regulation), it may not be legally binding prior to 2013. Moreover, the criteria of large firms being monitored seemed to indicate that there were exemptions. Nevertheless, as per DPCO 2013, there are no exemptions based on manufacturer size, and all manufacturers are required to reduce prices should they exceed the cap of 10% in a 12 month period. Further, the penalty being that the manufacturer shall be liable to deposit the overcharged amount along with interest from the date of increase in price.

[10] For a detailed summary of pharmaceutical price regulation in India, see Bhaskarabhatla (2018)

# B Theoretical model

## B.1 Gabszewicz et al. (1992)'s model

Here I present the original model by Gabszewicz et al. (1992). They show consumer heterogeneity is in learning costs, i.e., consumers vary in their attitude towards trying a new product. Such learning, if brand specific, dissuades the consumer with high learning costs from switching to the competitors product. In the present study, this is interpreted as risk aversion to moving to a new brand that may be due to the uncertainty regarding the substitutability of the two products. Both mechanisms generate brand loyalty for the originator's product. Additionally, they also show the case for learning that is not brand specific. However this case is not considered for the present purposes since in the context of pharmaceuticals, as previously mentioned, risk aversion to switching brands is typically observed.

The key steps of the original model by Gabszewicz et al. (1992) are shown below. They consider $\alpha$ to be learning costs that the consumer has to incur in trying a new product and such learning costs may be brand specific.

The intrinsic value of the product, $v$, and income $I$, are assumed to be the same for each consumer. For consumers with low learning costs, the utility gained from first time they consume the product may be higher. So for consumer $\alpha$, total utility derived from consuming one unit of the good is given by: $\alpha v + I - p$. The multiplicative form of $\alpha$ is consistent with vertical product differentiation models.

Demand functions:

- Originator's demand in period 1 is given by

$$D(p_{O1}) = 1 - \frac{p_{O1}}{v}$$

This is arrived at from the demand of the marginal consumer who is indifferent between buying or not buying in period 1.

$$\alpha v + I - p_{O1} = I$$

$$\alpha v = p_{O1}$$

- Originator's demand in the second period :

  The demand from the experienced consumer who is indifferent between buying from originator or competitor;

$$v - p_{O2} = \alpha v - p_{C2}$$

$$(1 - \alpha)v = p_{O2} - p_{C2}$$

$$D_O = \frac{v - p_{O1} - p_{O2} + p_{C2}}{v}$$

  In equilibrium, the following condition always holds: $p_{O2} \geq p_{C2}$. This is because, in the simultaneous game in the second period, the originator would not charge a price lower than that of the competitor. If they did so, then the competitor would be left with zero profits and hence they would charge an even lower price to capture all the consumers.

- Competitor's demand in the second period:
  Case A: When competitor serves only the experienced consumers who have low learning costs then, $p_{C2} \geq p_{O1}$.

$$D_C^A = \frac{p_{O2} - p_{C2}}{v}$$

  Case B: When the competitor serves new inexperienced consumers and experienced consumers who have low learning costs then, $p_{C2} < p_{O1}$.
  The inexperienced consumer who is indifferent between buying from competitor or not buying at all:

$$\alpha v + I - p_{C2} = I$$

  Total demand for the competitor therefore is:

$$D_C^B = \frac{p_{O2} - 2p_{C2} + p_{O1}}{v}$$

*Equilibrium Analysis*

Solving by backward induction.

*Second period*

Competitor maximises their profits :

$\pi_C = p_{C2} D_C$ which results in the following best response function for both scenarios:

$\tilde{p}^A_{C2} = \frac{p_{O2}}{2}$ if competitor serves only experienced consumers

$\tilde{p}^B_{C2} = \frac{p_{O2}+p_{O1}}{4}$ if competitor serves both experienced and inexperienced consumers.

When does the competitor switch from one strategy to the other;

$$\pi^A_C = \pi^B_C$$

where $\pi^A_C = p^A_{C2} D^A_C$ if demand corresponds to case 1
and $\pi^B_C = p^B_{C2} D^B_C$ if demand corresponds to case 2.

Therefore,

$$\tilde{p}^A_{C2} \frac{(p_{O2} - \tilde{p}^A_{C2})}{v} = \tilde{p}^B_{C2} \frac{(p_{O2} - 2\tilde{p}^B_{C2} + p_{O1})}{v}$$

Using the competitor's best response functions above, this can be solved to obtain the following result.

$$p_{O2} = \frac{p_{O1}}{\sqrt{2} - 1} \tag{5}$$

At the outset the originator cannot know the strategy of the competitor in the simultaneous second period game, but knows that they can manipulate the competitor's strategy choice through their own introductory price. The above condition shows that if $p_{O2} \geq \frac{p_{O1}}{\sqrt{2}-1}$ then the competitor will serve only experienced consumers (because profit from case A is higher), else both.

Next, the originator will only serve experienced consumers in period 2 and therefore by maximising their profits ( $\pi_O = p_{O2} D_O$) the following best response function is arrived at:

$$\tilde{p}_{O2} = \frac{p_{C2} - p_{O1} + v}{2} \tag{6}$$

If competitor goes with strategy A, i.e. serves only the experienced consumers in the market then mutually solving the best response functions of both players results in the following:

$$p^A_{O2} = \frac{2(v - p_{O1})}{3} \tag{7}$$

Alternatively, the competitor chooses strategy B and serves both experienced and inexperienced consumers. In this case, mutually solving the best response functions of both firms results in the following solution;

$$p^B_{O2} = \frac{4v - 3p_{O1}}{7} \tag{8}$$

*First period*

Originator maximises their joint profits of period 1 and period 2

$$p_{O1} D_1 + p_{O2} D_2$$

In case competitor's strategy is A:

$$\pi^T_O = p_{O1}(1 - \frac{p_{O1}}{v}) + \frac{4(v - p_{O1})^2}{9v}$$

Setting

$$\frac{\partial \pi^T_O}{\partial p_{O1}} = 0$$

the following is obtained:

$$p^A_{O1} = \frac{1}{10} v = 0.1v$$

Hence, $p^A_{O2} = \frac{6}{10} v = 0.6v$ & $p^A_{C2} = \frac{3}{10} v = 0.3v$

In case competitor's strategy is B:

$$\pi_O^T = p_{O1}(1 - \frac{p_{O1}}{v}) + \frac{(4v - 3p_{O1})^2}{49v}$$

Then;

$$p_{O1}^B = \frac{5}{16}v = 0.31v$$

Hence, $p_{O2}^B = \frac{7}{16}v = 0.44v$ & $p_{C2}^B = \frac{3}{16}v = 0.19v$

Gabszewicz et al. (1992) develop both cases and show that the profit from case A is higher than the profit from case B. Therefore, in equilibrium, the originator sets a low introductory price and thereby ensures that the competitor chooses strategy A and serves only experienced consumers.

### B.2 Optimisation problem in a regulated market

Equilibrium with a 10% price constraint is arrived at in the following way.

The originator's profit maximisation function in the second period looks like the following:

$$L = p_{O2}D_{O2} + \lambda(1.1p_{O1} - p_{O2})$$

Applying the Kuhn Tucker conditions, results in the following best response function;

$$p_{O2} = \begin{cases} 1.1p_{O1} & if \;\; 0 \leq p_{O1} \leq \frac{5}{16}(v + p_{C2}) \\ \frac{v + p_{C2} - p_{O1}}{2} & otherwise \end{cases}$$

If the constraint does not bind, then the best response function remains the same as in the unconstrained case. However, if the constraint binds then $p_{O2} = 1.1p_{O1}$. In a graphical representation of the same in Figure 1 shown earlier, the originator's best response function is now given by $R_O^{Cap}$, which is the unconstrained best response function until $p_{O2} = 1.1p_{O1}$, after which the curve is vertical.

Mutually solving the originator's best response function with that of the

competitor's , $\tilde{p}^B_{C2} = \frac{p_{O2}+p_{O1}}{4}$, gives the following solution:

$$p_{C2} = \frac{21}{40}p_{O1} = 0.53p_{O1}$$

This results in a new equilibrium at $E3$ (see figure 1) where the competitor serves both experienced and inexperienced consumers.

In period 1, the originator maximizes the joint profit from both periods:

$$\pi^T_O = p_{O1}D_{O1} + p_{O2}D_{O2}$$

$$\pi^T_O = p_{O1}(1 - \frac{p_{O1}}{v}) + \frac{11}{10}p_{O1}[1 - \frac{63}{40v}p_{O1}]$$

and taking a partial derivative with respect to $p_{O1}$ results in;

$$p_{O1} = \frac{420}{1093}v = 0.38v$$

Hence, $p_{O2} = 0.42v$ & $p_{C2} = 0.20v$

Next, it is shown that once the inflation constraint is imposed and is binding upon the originator, there is no alternate scenario that corresponds to an equilibrium. The equilibrium for the originator and competitor is given by:

$$p^*_{O2} = \frac{11}{10}p_{O1} \tag{9}$$

$$p^*_{C2} = \frac{21}{40}p_{O1} \tag{10}$$

I first prove that for the originator there exists no other price other than one in equation 9, that is as profitable. In equilibrium, the originator serves only experienced consumers in period 2. So the possible deviation for the originator is to undercut the competitor in period 2 and serve some inexperienced consumers. If the originator deviates to some price, $\tilde{p}_{O2}$ such that $\tilde{p}_{O2} = p^*_{C2}$,[11] then the profit is given by:

$$\tilde{\pi}_{O2} = \frac{v^2 - p^2_{O1}}{7v}$$

[11] If the originator lowers the price but remains above $p_{C2}$ then it still does not gain any inexperienced consumers. On the other hand, if the originator sets a price below the competitor's price, the competitor can further lower it's price and gain all the inexperienced consumers. Hence, the originator could deviate to the competitor's price.

Profit corresponding to the price in equation 9 is

$$\pi_{O2} = \frac{11}{10} p_{O1}[1 - \frac{63}{40v} p_{O1}]$$

$$\tilde{\pi}_{O2} - \pi_{O2} = 4451 p_{O1}^2 - 3080 v p_{O1} + 400 v^2$$

.

Comparing the two profits is clear that $\tilde{\pi}_{O2} - \pi_{O2} > 0$ only if $p_{O1} > 0.52v$ or $p_{O1} < 0.17v$.

However, Gabszewicz et al. (1992) show that equilibrium in pure strategies can exist only if $p_{O1} \leq \frac{2}{5}v$. Moreover, the originator's best reply curve intersects the competitor's best reply curve at point X in Figure 1, if introductory price is $\hat{p}_{O1} = \frac{2v}{3\sqrt{2}+5}$. Hence, the originator's introductory price, if high, should be within $\hat{p}_{O1} \leq p_{O1} \leq \frac{2}{5}v$. Since deviation corresponds to prices outside this range, this shows that deviation is not profitable for the originator.

Now let us turn to the competitor. The competitor's response is given by equation 10 above. The competitor could consider the following two deviations:

1. Either the competitor's launch price is higher than that of the originator's launch price, which then implies that the competitor serves only experienced consumers.

2. The competitor charges a price so low, that the originator loses all their consumers in period 2.

Let us consider the first scenario. The competitor could charge a price $\tilde{p}_{C2} > p_{O1}$ such that it maximises the following profit function:

$$\tilde{\pi}_{C2} = \tilde{p}_{C2}(\frac{p^*_{O2} - \tilde{p}_{C2}}{v})$$

which results in:

$$\tilde{p}_{C2} = \frac{4v - 3p_{O1}}{14}$$

This corresponds to the following profit:

$$\tilde{\pi}_{C2} = \frac{121 p_{O1}^2}{400v}$$

Competitor's profit for price corresponding to equation 10 is:

$$\pi_{C2} = \frac{882 p_{O1}^2}{1600 v}$$

Comparing the two profits it can be seen that $\tilde{\pi}_{C2} < \pi_{C2}$ always holds.

In the second scenario, the competitor can charge an extremely low price and capture the entire market from the originator such that the demand looks like the following;

$$1 - \frac{p_{O2}^* - \tilde{p}_{C2}}{v} = \frac{p_{O1}}{v}$$

which shows that

$$\tilde{p}_{C2} = \frac{-10v + 12 p_{O1}}{10}$$

The above expression implies that the competitor can have a positive price only if $p_{O1} > \frac{5}{6}v$. This is not possible for an equilibrium in pure strategies which requires $p_{O1} \leq \frac{2}{5}v$. Hence, it is proved that there is no profitable deviation for the competitor.

### B.3 Welfare effect in a regulated market

Figure 4 below represents the market with consumers distributed across values of $\alpha$ between 0 and 1. In this figure, inexperienced consumers, in the absence of any constraints, are denoted by the segment $n1$. The segment of inexperienced consumers in the scenario with inflation constraints is denoted by $n2$, and those with $\alpha$ values between 0.2 and 0.38, are served by the competitor in period 2. However, all those consumers with $\alpha < 0.2$ are not served at all. Also, the experienced consumers, lose surplus due to the higher launch price of the originator. Overall, the consumer surplus is lower in the constrained scenario.


Figure 4: Distribution of inexperienced consumers served with and without constraints

## C Sensitivity checks

In order to empirically estimate follow-on prices, I adjust the prices for inflation. As per DPCO 2013, for essential drugs, the upward price revisions are linked with the movements in wholesale price index (WPI). For this purpose, the national regulator considers the overall WPI published the the Office of Economic Advisor annually. Adjusting prices for new non-essential drugs using overall WPI suggests that follow-on prices of new products are decreasing over the product lifecycle (Figure 5). Alternatively, I consider the WPI for drugs and medicines, and find that follow-on prices are increasing over time (Figure 6). To the extent, which price index may be correctly reflecting price changes, I estimate the competitor and originator follow on price regressions based on both indices (Tables 7 and 8 ). In Table 8, when both treatments are included the triple difference variable loses significance, however the p-value is only slightly above 10%. Other than this, our core results remain unchanged across both price indices.

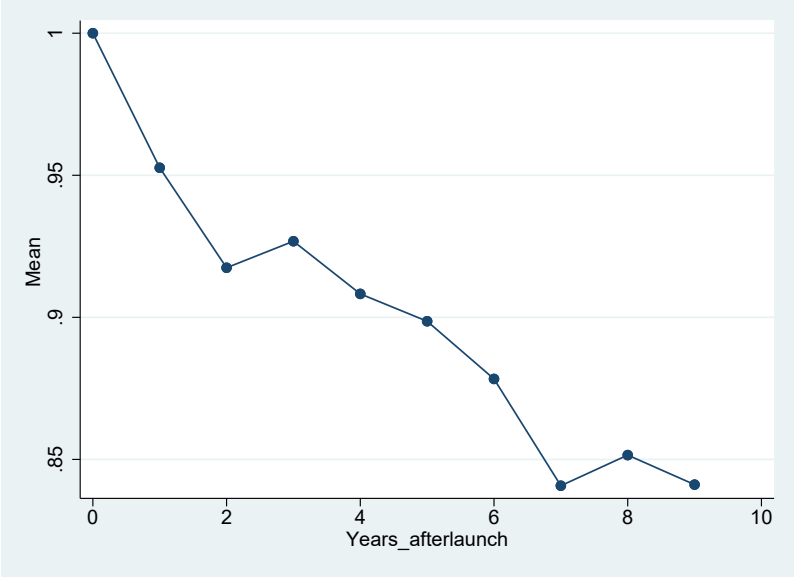


Figure 5: Normalised prices of the originator - overall inflation

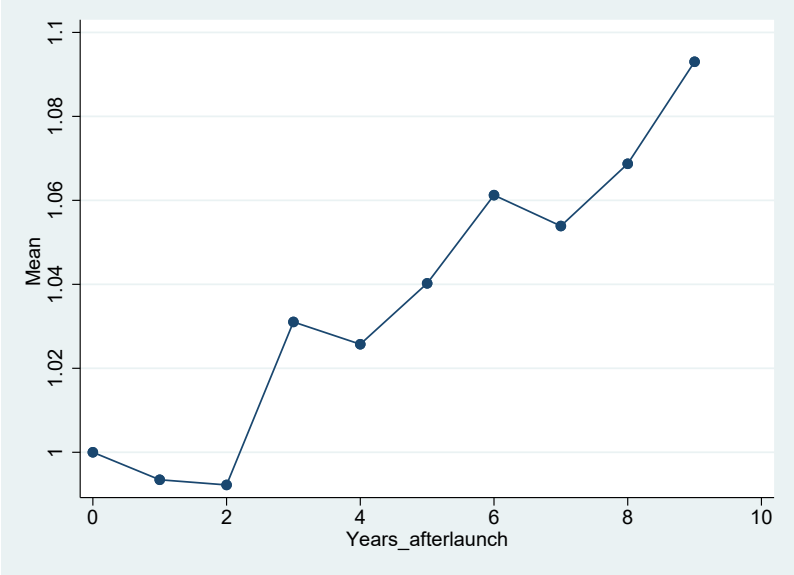


Figure 6: Normalised prices of the originator - sector inflation

Table 7: Competitor Price - Alternate WPI

| | | | |
|---|---|---|---|
| After 2013=1 | -0.161 | -0.044 | -0.454** |
| | (0.220) | (0.261) | (0.194) |
| Chronic=1 | -0.037 | 0.066 | -0.190 |
| | (0.145) | (0.134) | (0.141) |
| After 2013=1 X Chronic=1 | -0.022 | -0.025 | 0.125 |
| | (0.162) | (0.210) | (0.173) |
| Delay in Entry | -0.056 | | -0.023 |
| | (0.040) | | (0.032) |
| Combination | | 0.151 | 0.206** |
| | | (0.102) | (0.086) |
| Constant | -0.137 | -0.282 | -0.518** |
| | (0.163) | (0.185) | (0.227) |
| r2 | 0.271 | 0.309 | 0.265 |
| N | 119 | 119 | 217 |
| Launchyear_Effect | Yes | Yes | Yes |
| Therapy_Effects | Yes | Yes | Yes |
| Formulation_Effect | No | Yes | Yes |
| Sample | Matched | Matched | All |

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Second period prices for originators - Alternate WPI

| | Chronic | Chronic | Both |
|---|---|---|---|
| After 2013=1 X Chronic=1 | -0.006 | -0.034 | -0.064 |
| | (0.032) | (0.038) | (0.050) |
| After 2013=1 X Not-monitored=1 | | | -0.175** |
| | | | (0.082) |
| After 2013=1 X Chronic=1 X Not-monitored=1 | | | 0.153 |
| | | | (0.093) |
| After 2013=1 | 0.020 | 0.049* | 0.081** |
| | (0.025) | (0.028) | (0.040) |
| Chronic=1 | -0.006 | -0.022 | -0.016 |
| | (0.025) | (0.019) | (0.019) |
| Change in substitutes | -0.003 | -0.006 | -0.005 |
| | (0.006) | (0.006) | (0.005) |
| Delay in Entry | 0.014 | 0.011 | 0.009 |
| | (0.011) | (0.010) | (0.010) |
| Combination | 0.012 | -0.021 | -0.026 |
| | (0.026) | (0.031) | (0.032) |
| Not-monitored=1 | | | 0.113* |
| | | | (0.065) |
| Chronic=1 X Not-monitored=1 | | | -0.099 |
| | | | (0.077) |
| Constant | -0.030 | -0.055 | -0.048 |
| | (0.029) | (0.034) | (0.035) |
| r2 | 0.020 | 0.212 | 0.246 |
| N | 177 | 177 | 177 |
| Therapy_Effects | No | Yes | Yes |
| Formulation_Effect | No | No | Yes |

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

# References


Abbott III, T. A. (1995). Price regulation in the pharmaceutical industry: Prescription or placebo? *Journal of Health Economics*, 14(5):551–565.

Bhaskarabhatla, A. (2018). *Regulating Pharmaceutical Prices in India: Policy Design, Implementation, and Compliance*. Springer.

Bhaskarabhatla, A., Chatterjee, C., Anurag, P., and Pennings, E. (2017). Mitigating regulatory impact: the case of partial price controls on metformin in India. *Health Policy and Planning*, 32(2):194–204.

Biglaiser, G., Crémer, J., and Dobos, G. (2013). The value of switching costs. *Journal of Economic Theory*, 148(3):935–952.

Boswell-Dean, E. (2019). Who benefits from pharmaceutical price controls? Evidence from India. *CGD Working Paper 509, Washington,DC:Center for Global Development*. Available at https://www.cgdev.org/publication/who-benefits-pharmaceutical-pricecontrols-evidence-india.

Brekke, K. R., Holmas, T. H., and Straume, O. R. (2011). Reference pricing, competition, and pharmaceutical expenditures: Theory and evidence from a natural experiment. *Journal of Public Economics*, 95(7-8):624–638.

Dubois, P. and Lasio, L. (2018). Identifying industry margins with price constraints: Structural estimation on pharmaceuticals. *American Economic Review*, 108(12):3685–3724.

Ekelund, M. and Persson, B. (2003). Pharmaceutical pricing in a regulated market. *Review of Economics and Statistics*, 85(2):298–306.

Frank, R. G. and Salkever, D. S. (1997). Generic entry and the pricing of pharmaceuticals. *Journal of Economics & Management Strategy*, 6(1):75–90.

Gabszewicz, J., Pepall, L., and Thisse, J.-F. (1992). Sequential entry with brand loyalty caused by consumer learning-by-using. *The Journal of Industrial Economics*, 40(4):397–416.

Pavcnik, N. (2002). Do pharmaceutical prices respond to potential patient out-of-pocket expenses? *RAND Journal of Economics*, 33(3):469–487.

Ridley, D. B. and Lee, C. Y. (2020). Does medicare reimbursement drive up drug launch prices? *Review of Economics and Statistics*, 102(5):980–993.

Ridley, D. B. and Zhang, S. (2017). Regulation of price increases. *International Journal of Industrial Organization*, 50:186–213.

Ruiz-Aliseda, F. (2016). When do switching costs make markets more or less competitive? *International Journal of Industrial Organization*, 47:121–151.

Shajarizadeh, A. and Hollis, A. (2015). Price-cap regulation, uncertainty and the price evolution of new pharmaceuticals. *Health Economics*, 24(8):966–977.

World Health Organisation (2021). Global health expenditure database. `https://apps.who.int/nha/database/ViewData/Indicators/en`. Last accessed 2nd October 2021.