2021-05-13

When the truth hurts: ordinary selling price regulation in a monopoly

Sahragardjooneghani, Babak

UNIVERSITY OF CALGARY

When the truth hurts: ordinary selling price regulation in a monopoly

by

Babak Sahragardjooneghani

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF ARTS

GRADUATE PROGRAM IN ECONOMICS

CALGARY, ALBERTA

MAY, 2021

Abstract

How does restricting firms to communicate a truthful ordinary selling price affect pricing and profits when some consumers are uncertain about product quality? In this thesis we analyze a two-period monopoly model to study the welfare effect of ordinary selling price (OSP) regulation. In the model, quality is observed by informed consumers who buy in the first period. However, consumers who arrive in market in the second period are not able to discern quality, but must infer it indirectly through prices. We first characterize the necessary conditions for OSP regulation to make the first-period price informative for second-period consumers. We show that OSP regulation has no effect when the proportion of uninformed consumers is high. This means regulation is ineffective when it would be most useful. We then compare the equilibrium outcome when OSP is effective to the equilibrium outcome in an unregulated environment. A simple welfare measure indicates that restricting firms to communicate a truthful first-period price has no effect on the uninformed consumers' expected surplus, but does create a deadweight loss from deceptive pricing in the first period. This deceptive pricing occurs because OSP regulations provide incentives for a low-quality firm to charge a high initial price when doing so enables it to earn excess profits in the second period.

Acknowledgements

My sincerest gratitude goes out to my research supervisor, Dr. Aidan Hollis, not only for sharing his extensive academic knowledge but also for his endless support during my MA program. It was a great privilege and honour for me to work and study under his guidance. I will always be extremely thankful for what he has offered me.

I would also like to thank all the faculty in the Department of Economics at the University of Calgary. They gave me a solid economic knowledge and cultivated me to be a more strong and more positive person.

I am grateful to my parents for their love, care and sacrifices for educating me and preparing me for the future. Above all, I would like to thank my wife, Nastaran, for her love, and constant support, and for keeping me sane over the past few months.

I would like to dedicate this thesis in loving memory of the Flight PS752 passengers, especially sixteen alumni of Sharif University of Technology.

Table of Contents

List of Tables

Acronyms

OSP	Ordinary Selling Price
No OSP	Having No Ordinary Selling Price regulation in effect

Chapter 1

Introduction

The most common sign in almost any store is "Sale", usually followed by "20% Off!" or some other declaration of how much the buyer can "save" by making a purchase immediately instead of at the ordinary price. Apparently shoppers are attracted by the opportunity to score a deal. What is clear from the common use of this strategy, and its appeal to consumers, is that a price reduction can signal *something* about how the new, reduced transaction price offers better value for the consumer. What it signals, of course, is usually unclear. Sometimes reduced prices are put onto racks of slightly shopworn items whose value is genuinely compromised. In the majority of cases, however, the "sale!" declaration is supposed to identify a temporary opportunity to get a quality good at under the usual selling price.

It is apparent that "50% off" only means something if the store did not inflate the price by 100% the previous day in anticipation of the price reduction. Certainly, some retailers seem to have a strategy of having high usual prices so that they can then put everything in the store on sale. Do they actually sell any meaningful quantity at those higher prices? If not, the "sale" is a mirage. Consumers who understand this should, of course, simply be interested in the actual transaction price they face, not the hypothetical amount of the discount from a notional ordinary price. A naive consumer – if any such creature exists – might be impressed by the price reduction, and in principle could rush to take advantage of the opportunity.

Some governments, including Canada's, have passed regulations to protect these naive consumers, by requiring retailers not to use fictitious "ordinary selling prices". Under subsections 74.01 (2) of the Competition Act, it is "reviewable conduct" if a firm makes a false representation as to the ordinary selling price of an item. In particular, a representation about the ordinary price may be misleading if the seller has "not offered the product at that price or a higher price in good

faith for a substantial period of time recently before or immediately after the making of the representation." The Act also requires that the seller have sold a "reasonable" volume of the product at that higher price, a standard which is probably more difficult to interpret and to police.

In this paper, we examine the effect of ordinary selling price regulation on the behavior of the firm in a monopoly setting, when the quality of the product is known only to the firm and to a slice of the consumer population. The crucial question here is "How do consumers acquire information?" The literature proposes two answers to this question. One strand of models, such as Bagwell and Riordan (1991) and Armstrong and Chen (2020), assume that an exogenous proportion of consumers are informed. This could arise because of consumers' previous experience with similar goods. These informed consumers might provide incentives for sellers to price honestly and send a credible signal to uninformed consumers. However, another strand of models, such as Wolinsky (1983) and Milgrom and Roberts (1986), assume that consumers can strategically choose to pay the cost of quality monitoring or the cost of getting another piece of information. We follow the former definition of informed consumer in our model.

In the model analyzed, we apply the Competition Act's time test requirement where firms are required to sell their good for a substantial period of time to define the "ordinary" price. Since our objective is to study the effect of this regulation on the firm's behaviour and on consumer responses, we adopted some classic assumptions into a two-period monopoly model, and compare the market outcome with and without this regulation in a monopoly model. This model is a modified extension of Bagwell and Riordan (1991)'s "Hind-sighted Consumer" model, in which there are informed consumers, who can costlessly identify product quality, and uninformed consumers, who cannot. Our extensions to their model to consider ordinary selling price regulations requires several important modifications. In Appendix 1, we show that as long as the consumer populations who enter the market in different periods have same distribution of taste and information, ordinary selling price regulations have no effect on the market outcome. Hence, we modified their model

in two aspects; we assume that all uninformed consumers enter the market in the second period. Furthermore, we assume that the monopolist produces either low- or high-quality goods, and that both types of good have a linear downward-sloping demand. We borrowed the first assumption from Armstrong and Chen (2020) to depict a plausible situation in which the low-quality producer has incentives to deceive the uninformed consumers.

When there is no OSP regulation, from the consumer perspective any claim about the ordinary price is only ”cheap talk”. However, when this regulation is in effect, it is costly to claim high quality, so a natural intuition about OSP regulation is that it would result in a “fairer” equilibrium outcome. Although a deceptive ordinary price claim might seem unfair, the analysis in this thesis suggests that protection against such deceptive practices is not always a good option. Using a two period monopoly model with information asymmetry we show that the information attached to a credible ordinary price might result in a worse outcome for consumers, compared to a world in which the ordinary price is just ”cheap talk”. This arises because, in a regulated environment, low-quality firms may have incentive to charge a high regular price in the interest of signaling high quality to the uninformed consumer. This high regular price, however, destroys surplus.

The structure of the paper is as follows. In Section 2, we provide a short review of related literature. Section 3 provides a monopoly model and results. Section 4 concludes briefly. Supplementary material, including complex formulas and proofs, is contained in the Appendix.

Chapter 2

Literature Review

Many retailers post a higher "regular price" alongside the "Discounted" or "Sale price" in the store. A firm can have several reasons to communicate a higher regular price alongside the sale price. One reason to is to signal quality through the ordinary price and persuade consumers to happily buy a high-quality product at a lower price. Some experimental studies such as Kamen and Toman (1971) and Buzzell (1972) suggest that when consumers are not sure about the quality of a product, they tend to interpret high prices as a signal of higher quality.

Some empirical studies such as Ngwe et al. (2019) argue that both the actual offer price and the referenced price are interpreted by consumers as signals of quality. They found that reporting a higher regular price is an influential tool to persuade consumers to stop shopping around and buy immediately. Urbany et al. (1988) found in two experimental studies that not only a plausible regular price but also an exaggerated ordinary price can increase the consumer's willingness to purchase a certain good and stop searching for a better deal.

The question of how prices convey information about product quality from an informed agent to an uninformed agent was first discussed in the risky assets market. Kihlstrom and Mirman (1975) show that prices perfectly transmit information from informed agents to the uninformed market observer, when there is a one-to-one relationship between the market price and uninformed agent's expectations. This one-to-one correspondence guarantees that prices are accurate reflections of what knowledgeable consumers know about the market environment, and consequently, signal the true state of the world to the uninformed price observer. Analysing a market with two risky assets, Grossman and Stiglitz (1976) argue that when information is inexpensive and the proportion of agents who choose to become informed is sufficiently high, then prices at least partially reveal knowledgeable consumers' information. However, when the number of informed agents is

increasing in the market, the utility of acquiring information decreases, so fewer consumers choose to get informed. Hence, such a one-to-one relation exists if and only if the cost of information is zero. Since this is not possible in the real world, they argue that the information of knowledgeable agents is not fully conveyed through the price system.

In one of the first attempts to model the signaling role of prices in strategic interaction between the firm and uninformed consumers, Milgrom and Roberts (1986) investigate the signalling role of price when a monopolist introduces a new product into the market and all consumers are uninformed about product quality. They argue that a truly high-quality firm may be more willing than a low-quality imitator to charge a higher price because of its higher cost. They conclude that, if the the cost differences among qualities are sufficiently high, then a price sufficiently higher than the full-information price can effectively signal product quality.

Bagwell and Riordan (1991) argue that not only the cost asymmetry between firms, but also the presence of informed consumers in the market, provides incentives for a high-quality firm to signal its type by charging a high price. Using a multi-period monopoly model where the proportion of uninformed consumers is exogenous and increasing over time, they argue that if the proportion of informed consumers is sufficiently high, then there exists a separating equilibrium in which the high-quality monopolist can signal its type by charging a high price. In their model, there are two types of consumers: a proportion of consumers are informed about product quality before purchasing and the remaining consumers only observe prices and update their beliefs based on their expectations. They conclude that when a monopolist is introducing a good in the market, it can signal quality through a price higher than the full-information monopoly price at the beginning, but as the number of informed consumers in the market increases, the cost of signaling via higher price increases and eventually the market ends up at the monopoly price.

Judd and Riordan (1994) study a monopoly model, where, unlike the previous models, there is not a perfect correlation between cost and quality. They define quality as the final utility that

consumers enjoy and show that if consumers have some private information about product quality, which is not observable by the firm, then the monopolist is able to signal its private information about product quality even in the absence of cost asymmetries.

Studying the effect of price on the consumer perception of quality is not limited to markets with one seller. Chan and Leland (1983) argue that when it is costly to search, depending on the distribution of search costs, price might convey partial information about product quality. Using a differentiated duopoly model, Daughety and Reinganum (2007) argue that, in a market with several producers and two vertically differentiated products, if there is enough horizontal differentiation between the unobserved potential difference in quality, then there exists a unique symmetric equilibrium in which higher price signals higher quality. Janssen and Roy (2010) argue that firms use high prices as a signal of quality even if the market is competitive. Using a Bayesian model of oligopoly competition with two product qualities, they argue that when firms privately possess information about their product quality, and are identical in every aspect except product quality, a fully revealing equilibrium involves mixed strategies where low type firms use a mixed strategy and earn positive profits, while high-quality firms choose a high price to signal their higher quality.

Despite the high volume of research in price signaling in a competitive market, the literature has little to say about the effect of ordinary selling price (what they term "reference price") regulation on consumer beliefs and market outcomes. In a recent article by Armstrong and Chen (2020), the authors study the effect of a reference price, when a monopolist is selling its product at a discounted price. They study three different scenarios: when the firm is restricted to communicate a truthful reference price, when the firm can communicate a false earlier price but consumers know this fact, and when the firm can make this false claim but consumers naively believe that the firm is honest. They show that when the quality of the product is exogenous, and the firm is initially uninformed about its product quality, restricting the firm to communicate a truthful earlier price

results in a higher initial price, and therefore results in a worse outcome for the society. We obtain the same results but our approach is different from their work at least in three respects. First, we assume the firm is informed about its type and hence knows the exact cost of taking a deceptive action. Second, we assume that second period consumers only observe the communicated first-period price, but do not know the volume of sales in the first period. In our model, uninformed second-period consumers use Bayesian updating, based on their priors about the probability of the firm being exogenously high-quality and observations of price in the first period. These different assumptions result in different conclusions; like Armstrong and Chen (2020), our model predicts a higher expected initial price when OSP regulation is in effect. But despite their conclusion that a regime with OSP regulation results in a lower expected surplus for the second-period consumer, our results suggest that, on average, OSP has no effect on the Bayesian rational uninformed consumer's expected surplus in the second period. In addition, the construction of our model make it possible to not only study the effect of OSP regulation on social welfare but also derive the necessary condition for this regulation to affect uninformed consumers' beliefs.

Chapter 3

Monopoly Model

3.1 The Model

This chapter presents a model in which a monopolist signals quality through the use of an "ordinary selling price". We consider a monopolist that is privately informed of its own type. The firm's type is the quality of its product and can be high (H) or low (L). This type is stable from one period to the next; a firm cannot change its type. To be able to incorporate a Bayesian update of beliefs, we assume that the probability ρ of producing the high-quality product is randomly chosen by nature and is common knowledge. The marginal cost of producing either quality of product is constant over time. For the sake of simplicity, we assume the marginal cost of the low-type firm is equal to that of the high-type firm and is normalized to 0. The monopolist sells its product in two periods, and its objective is to maximize total expected profits.

There is a unit mass of consumers. Proportion λ arrives in the market in the first period, and $1-\lambda$ in the second period. If the characteristics of consumers who arrive in the market in different periods are the same, then there is no point in signalling an ordinary price. In this case, the consistency of beliefs and sequential rationality require firms to stick to the same strategy in both periods, as shown in Appendix A. Hence, for any regulation about ordinary selling price to be meaningful, consumers who arrive in the market in the first period are assumed to have characteristics different from those of second-period consumers.

To incorporate asymmetry in our model, we have borrowed one assumption from Armstrong and Chen (2020) and applied it into our model. We assume that all informed consumers, whom we might label "keen early adopters", enter the market in the first period and are able to distinguish H from L at no cost. For example, these are the types of consumers who avidly follow every iPhone update. Second-period consumers cannot discern H from L; however, they may *infer*

quality through observation of prices.

Furthermore, we assume consumers who enter the market in the same period have heterogeneous willingness to pay, based on their type. Type θ consumers have reservation price θV_i for good i, where $i = L, H$, $V_H > V_L$, and θ is uniformly distributed between 0 and 1, and this distribution is common knowledge. To help set intuition, we might think of θ as being like consumer income, which varies across consumers of all types. In order to provide enough incentives for the low-quality firm to benefit from second period consumers' lack of information, we assume that the high-quality product's full-information price is strictly higher than the maximum willingness to pay for the low-type product, that is $\frac{V_H}{2} > V_L$.

Given these assumptions, if the firm offers a high quality product, the informed consumers in the first period choose to buy one unit if and only if

$$P_{H1} \leq \theta V_H. \tag{3.1}$$

Similarly, if the firm is of low quality, these informed consumers buy if and only if

$$P_{L1} \leq \theta V_L. \tag{3.2}$$

This results in linear downward-sloping demand for whichever product is available in the first period.

The second-period consumers, however, are not able to distinguish between different product types based on observation of the product. We assume they have homogeneous prior beliefs which are based on the probability drawn from nature ρ. As long as there is no informative communication, second-period consumers assign probability ρ to the likelihood that the monopolist is a high-quality producer. However, an informative communication can affect their beliefs and consequently their willingness to pay for the monopolist's product. We assume that the firm can signal product quality via both the current price P_{2i} and the claimed first-period price (or "ordinary

selling price") P_{1i}. The second-period consumers observe these prices and update their belief functions $\rho(P_{1i}, P_{2i})$ based on Bayes' rule. If (V_H, V_L, λ) is such that consumers expect the monopolist to send the same signal independent of its type then $\rho(P_{1i}, P_{2i}) = \rho$, and if the signal chosen by the monopolist depends on its type then $\rho(P_{1H}, P_{2H}) = 1$ and $\rho(P_{1L}, P_{2L}) = 0$. The second period consumer of type θ chooses to buy the product if and only if

$$\theta\left[\rho(P_{1i}, P_{2i})V_H + (1 - \rho(P_{1i}, P_{2i}))V_L\right] \geq P_{2i}$$

Depending on the regulatory environment and parameter space, the first-period price might – or might not – affect second-period consumers' beliefs. What does matter in ordinary selling price regulation is the informative effect of the ordinary selling price on the optimal strategy chosen by the firm as well as its effect on the second-period (uninformed) consumers' information partition. To characterise, these effects we now study the Bayesian Nash equilibrium in two different environments; first, when there is no ordinary selling price regulation in effect, and second, when the authority requires the firm to truthfully communicate its ordinary (*i.e.* first-period) selling price. When there is no OSP regulation, we assume that the firm need not be honest about the price actually charged in the first period.

3.2 Equilibrium with no OSP regulation

We first assume that the uninformed consumer receives signal (P_{1i}, P_{2i}) and updates her belief in the absence of OSP regulation. It is obvious that in this case the firm can choose the first-period optimal price, without considering the effect on decisions by second-period consumers. The reason is the firm has the option to choose the first component of the signal sent to the second-period consumer (*i.e.* P_{1i}) at no cost, even if it is not a truthful price. Hence, when there is no OSP regulation, firms always charge the optimal full-information price in the first period; if the type of firm is L then it charges price $\frac{V_L}{2}$ and if the type of firm is H it charges $\frac{V_H}{2}$. However, the firm's optimal behaviour

in the second period depends not only on V_H and V_L but also on the consumers' beliefs. We now characterise possible equilibrium scenarios in the second period.

Let us first assume that there exists a separating equilibrium in which the high-type firm offers a price strictly higher than that of the the low-type firm. If the profit to the high-type firm in this hypothetical equilibrium is higher than the profit to the low-type firm, then the low-type firm can profitably deviate and charge the high-type's price and vice versa. Hence, when there is no OSP regulation the necessary condition to have a separating equilibrium is that both types of firms earn same profit. We now search for existence of such an equilibrium under our assumptions.

Lemma 1: In the absence of OSP regulation, if there exists a separating equilibrium in the second period, then in this equilibrium $P_{2L} = \frac{V_L}{2}$.

Proof: Suppose $P_{2L} \neq \frac{V_L}{2}$, and consumers believe that the firm is the low-type *i.e* $\rho(P_{1L}, P_{2L} = 0$. Consumers already believe $\rho(P_{1L}, P_{2L}) = 0$. Since beliefs function is weakly positive, for any out of equilibrium receiver $\rho(P_{1L}, \frac{V_L}{2})$ is at least as high as $\rho(P_{1L}, P_{2L}) = 0$. Thus, deviation to price $\frac{V_L}{2}$, does not worsen the consumers' beliefs about the firm's type.On the other hand, $\frac{V_L}{2}$ maximizes the low-type firm's profit when consumer believes it is a low type. consequently, as long as $P_{2L} \neq \frac{V_L}{2}$, this deviation is strictly profitable. Hence, in any fully revealing equilibrium, $P_{2L} = \frac{V_L}{2}$.■

Lemma 2: In the absence of OSP regulation, in a separating equilibrium, if there is any, $P_{2H} \geq \frac{V_H}{2}$.

Proof: Suppose that there exists a separating equilibrium in which a firm of type H charges price $P_{2H} < \frac{V_H}{2}$, and assume that consumers' beliefs even out of the equilibrium path are a weakly increasing function of prices. Thus, increasing the price to the full information optimal price does not decrease the consumers' beliefs about the probability that the firm is a high type, while it will result in the maximum possible profit for the high-type firm given that consumers believe the firm is the high-type. However, if $P_{2H} > \frac{V_H}{2}$, given that beliefs are a weakly increasing function of

prices, if the firm deviates and charges the full-information price, it may result in less favourable beliefs and consequently less profit for the firm.■

Using Lemmas (1) and (2) we now show that a separating equilibrium is not possible under our assumptions. We showed that in any possible separating equilibrium the profit to the low-type firm should be equal to the profit to the high type firm. Let us suppose the high-type firm's price in the separating equilibrium is P_H. Considering Lemma 2, this price should be weakly greater than high-quality product's full-information price, and the profit to the high-type firm charging price P_H should be equal to that of the low-type firm in a separating equilibrium, *i.e.* $\frac{V_L}{4}$.

$$\frac{V_L}{4} = \frac{V_H - P_H}{V_H} P_H \tag{3.3}$$

A separating equilibrium is possible if and only if equation (3.3) has a root which is weakly greater than $\frac{V_H}{2}$ and strictly lower than V_H. However, assuming $V_H > 2V_L$, this equation's root $P_H = V_H(\frac{1}{2} \pm \sqrt{1 - \frac{V_L}{V_H}})$ can never lie between $\frac{V_H}{2}$ and V_H. Hence, under our assumptions, there does not exist a separating equilibrium in the absence of OSP regulation.

Claim 1: When there is no OSP regulation, the only possible equilibrium is a pooling equilibrium at which the monopolist sends signal $(\frac{V_H}{2}, \frac{\rho V_H + (1-\rho)V_L}{2})$ independent of its type.

Proof: We showed that when there is no OSP regulation, under our assumptions, there does not exist a separating equilibrium. For a Bayesian rational consumer who knows the cost of production for both types of firm is equal, this means the best strategy of firms in the second period is independent of its type. Hence, exposed to any signal, the expected value of product for the Bayesian rational consumer of type θ is $\theta[\rho V_H + (1-\rho)V_L]$. Given this belief, the best strategy of both type of firms is to charge price $\frac{\rho V_H + (1-\rho)V_L}{2}$ in the second period and communicate an ordinary price equal to the high-type full information price $\frac{V_H}{2}$. A reasonable assumption that supports this equilibrium is that the off-equilibrium receivers know that cost and benefits of sending any signal

is the same for both types of firm, so any signal other that $(\frac{V_H}{2}, \frac{\rho V_H+(1-\rho)V_L}{2})$ offers no additional information. This implies that beliefs are not affected by such signals. ■

With no OSP in effect, consumers and firms earn full-information surplus in the first period

$$E[CS_{1N}] = \lambda[\rho\frac{V_L}{8} + (1-\rho)\frac{V_H}{8}]$$

$$\Pi_{i1N} = \lambda[\frac{V_i}{4}]$$

Thus the total expected surplus in first period is equal to $\lambda[\rho\frac{3V_L}{8} + (1-\rho)\frac{3V_H}{8}]$.

Given the above, in the second period, both types of firms act the same and earn equal profit

$$\Pi_{i1N} = (1-\lambda)\frac{\rho V_H + (1-\rho)V_L}{4}.$$

Consumers' expected surplus in the second period is

$$E[CS_{1N}] = (1-\lambda)[\rho\frac{V_L}{8} + (1-\rho)\frac{V_H}{8}].$$

We now consider how outcomes differ if ordinary selling price regulations are in place.

3.3 Regulated Equilibrium

Let us assume that the firm is restricted to communicate the true price charged in the first period to second-period consumers. Then, considering the fact that all consumers are informed in the first period, uninformed consumers expect the firm to communicate either $\frac{V_H}{2}$ or $\frac{V_L}{2}$ as the only two possible prices in the first period. Since there is a one-to-one correspondence between each of these full information prices and the each of the quality levels, the Ordinary Selling Price communication is equivalent to the situation in which the firm claims quality V_i.

With OSP regulation in place, if a low-quality firm claims V_H, it has already paid the cost of

dishonesty, which is equal to the profit loss of not choosing the low-type optimal price in the first period. If the low-type firm charges price $\frac{V_H}{2}$ instead of $\frac{V_L}{2}$ in the first period, its profit loss is equal to

$$\begin{cases} \lambda \frac{V_L^2-(2V_L-V_H)(V_H)}{4V_L}, & \text{if } \ V_H < 2V_L \\ \lambda(\frac{V_L}{4}), & \text{if } \ V_H + \geq 2V_L \end{cases}$$

Since we assume, $V_H \geq 2V_L$, the cost of signalling V_H for the low type firm is equal to losing all sales in the first period, *i.e.*, $\lambda(\frac{V_L}{4})$. However, the cost of signalling V_H for the high type firm is 0. These different signalling costs might attach more credibility to the firm's ordinary selling price claim and consequently result in a refinement of the consumer information partition.

If consumers observe ordinary price $\frac{V_L}{2}$ (or equivalently a claim of quality V_L), then they certainly believe that the product is a low-quality product. However, if they receive a signal containing $\frac{V_H}{2}$, they know that the low-type firm might still have an incentive to pay the cost of pretending to be a high-type firm in the first period (that is, receiving zero sales) and enjoy the benefit of its deception in the second period. Hence, when it is possible consumers update their beliefs based on Bayes' rule , considering prices in both periods and taking into account this possible incentive.

Pooling equilibrium

Suppose consumers believe that a low-type firm will choose to pretend to be a high type with probability χ. If $\chi = 1$, then consumers know that both types of firm send the same signal in the second period regardless of the actual state of the world. This equilibrium is possible if and only if, given consumer beliefs, cheating yields a strictly higher payoff to the low-type firm than honesty and the high-type firm does not have a strictly profitable deviation.

If the low-quality firm finds it profitable to pretend to be a high-quality firm, and charges price $P_P > \frac{V_L}{2}$ then the consumer will buy the product if

$$\theta[\rho(\frac{V_H}{2}, P_P)V_H + (1-\rho)(\frac{V_H}{2}, P_P))V_L] \geq P_P.$$

Knowing that $\chi = 1$, Bayesian rational consumers' posterior beliefs after receiving signal $(\frac{V_H}{2}, P_P)$ are the same as their priors, $\rho(V_H, P_H) = \rho$. Thus, the consumer of type θ chooses to buy if and only if

$$\theta[\rho V_H + (1-\rho)V_L] \geq P_P$$

Consequently, a cheating low-quality firm's demand, which is equal to a high type firm's demand in the pooling equilibrium, in the second period is

$$D(P_{1H}, P_P) = (1-\lambda)[1 - \frac{P_P}{\rho V_H + (1-\rho)V_L}]$$

Solving for the firm's maximization problem, the best response of the low-quality firm is to choose a second-period price

$$P_P = \frac{\rho V_H + (1-\rho)V_L}{2}$$

which yields an expected second-period payoff of

$$\pi_C = D(P_{1H}, P_P) \times P_P = \frac{1-\lambda}{4}(\rho V_H + (1-\rho)V_L).$$

If π_C is strictly higher than the profit of an honest low-type firm, then the low-type firm always chooses to cheat. The payoff to an honest low-quality firm is

$$\pi_H = \lambda \frac{V_L}{4} + (1-\lambda)\frac{V_L}{4}.$$

Hence, cheating is a strictly dominant strategy for a low-type firm if

$$\frac{1-\lambda}{4}(\rho V_H + (1-\rho)V_L) > \lambda \frac{V_L}{4} + (1-\lambda)\frac{V_L}{4} \tag{3.4}$$

or

$$\frac{\lambda}{1-\lambda} < \rho \frac{V_H - V_L}{V_L}. \tag{NC1}$$

If the proportion of uninformed consumers is sufficiently high such that (NC1) is satisfied, then cheating is a strictly dominant strategy for the low type firm. Since by assumption costs are type-independent and both firms claim the same level of quality the best response of firms in the second period is also type-independent. Given this, it is reasonable to assume that consumers beliefs are unchanged as long as (NC1) holds even if they observe a price other than P_P in the second period. This means that under (NC1),sending signal $(\frac{V_H}{2}, P_P)$ is the best choice for both type of firms and neither the low-type nor the high-type has incentive to deviate from this optimal strategy. Thus, the only possible equilibrium is a pooling equilibrium where both types of firm signal $(\frac{V_H}{2}, P_P)$ and second-period consumers' posterior beliefs are the same as their priors. The second-period outcome is unchanged from the non-regulated environment. The only difference is that now, if the state of the world is such that $i = L$, then no transaction occurs in the first period. Thus, ordinary selling price regulation, in this case, can erode the first-period consumer expected surplus by $\frac{V_L}{8}$. In addition, the low-type firm chooses to bear the cost of imitation which is equal to the profit of an honest low-type firm in the first period, *i.e.*, $\frac{V_L}{4}$. Thus the total welfare loss due to regulation is $\frac{3V_L}{8}$.

Claim 2: When the proportion of uninformed consumers is sufficiently high such that (NC1) holds, OSP regulation has no effect on second-period equilibrium. However, it provides incentives for the low-type firm to charge a (deceptive) high price in first period and consequently erodes total surplus by $(1-\rho)\frac{3\lambda V_L}{8}$.

Separating equilibrium

We now characterise the possibility of a fully revealing equilibrium, where the signal sent by each firm is type-dependent and consumers believe that $\chi = 0$. What matters in a fully revealing

equilibrium is the low-type firm's incentives to imitate the high-type. Given consumers' beliefs, the profit to an honest low-type firm in a fully revealing equilibrium is

$$\pi_L(\frac{V_L}{2},\frac{V_L}{2}) = \lambda\frac{V_L}{4} + (1-\lambda)\frac{V_L}{4}$$

If the low-type firm deviates and deceptively claims to supply a high-quality product, then given that consumers believe $\rho(\frac{V_H}{2},\frac{V_H}{2}) = 1$, the cheater low-type will earn

$$\pi_L(\frac{V_H}{2},V_H 2) = (1-\lambda)\frac{V_H}{4}$$

Hence the necessary condition for this fully revealing equilibrium to be sustained is that the low-type firm earns strictly higher profit when it chooses to price honestly. This condition is guaranteed if

$$\frac{\lambda}{1-\lambda} > \frac{V_H - V_L}{V_L}. \tag{NC2}$$

If (NC2) holds then the profit to an honest low-type firms is strictly higher than the maximum possible profit to a low-type firm under the most favorable beliefs, *i.e.*,$\Pi_L(\frac{V_L}{2},\frac{V_L}{2}) > \Pi_L(\frac{V_H}{2},P_{2L})$, for any P_{2L} that satisfies $\rho(\frac{V_H}{2},P_{2L}) = 1$. Thus even the most favorable off-equilibrium beliefs provide no incentive for the low-type firm to deviate. On the other hand, strategy $(\frac{V_H}{2},\frac{V_H}{2})$ maximizes the high-type firm's profit function when consumers believe it is the high type. Consequently, regardless of beliefs, any deviation is strictly less profitable for the high-type firm as long as (NC2) is satisfied. Thus, when the proportion of informed consumers is sufficiently high such that (NC2) holds,firms charge the full information prices in both periods.In this case, there is a one-to-one correspondence between real state of the world and the signal sent by the monopolist in each state. Consequently, the first-period price perfectly transmits information from informed consumers to uninformed ones.

It is clear that when (NC2) holds, regulation has no effect on the first period-price. However, in the second period, it results in a separating equilibrium which was not possible in the absence of OSP regulation. That is, in the second period, firms will choose full-information separating prices rather than the pooling price that arose in the absence of OSP regulation. Hence if the firm is the low type, regulation results in a better outcome; while if firm is the high type, regulation might be destructive for social welfare. To derive the expected welfare effect of OSP regulation overall, we can compare fully separating equilibrium expected outcome against that of the pooling equilibrium. With OSP regulation, the second period consumers' surplus and total surplus are respectively

$$E[CS_R] = (1-\lambda)[\rho(\frac{V_H}{8}) + (1-\rho)\frac{V_L}{8}]$$

$$E[S_R] = (1-\lambda)[\rho(\frac{3V_H}{8}) + (1-\rho)\frac{3V_L}{8}]$$

In an unregulated environment, both types of firm have $\frac{1-\lambda}{2}$ units of demand and charge price $P_P = \frac{\rho V_H + (1-\rho)V_L}{2}$; hence the firm earns profit $(1-\lambda)\frac{\rho V_H + (1-\rho)V_L}{4}$ independent of its type. However, consumers' surplus in the second period depends on the firm's type. If the firm type is low,

$$E[CS_{NL}] = (1-\lambda)\int_{\frac{1}{2}}^{1}(\theta V_L - \frac{\rho V_H + (1-\rho)V_L}{2})d\theta = (1-\lambda)[\frac{V_L}{8} - \frac{\rho(V_H - V_L)}{4}],$$

which is strictly lower than consumers' surplus in a regulated environment. However, if the firm is the high-type, then second period consumer surplus in the absence of OSP regulation is strictly higher than that of regulated environment:

$$E[CS_{NH}] = (1-\lambda)\int_{\frac{1}{2}}^{1}(\theta V_H - \frac{\rho V_H + (1-\rho)V_L}{2})d\theta = (1-\lambda)[\frac{V_H}{8} + \frac{(1-\rho)(V_H - V_L)}{4}].$$

Thus, the second period consumer's expected surplus in the absence of OSP regulation is

$$E[CS_N] = (1-\rho)CS_{NL} + (\rho)CS_NH = (1-\lambda)[\rho(\frac{V_H}{8}) + (1-\rho)\frac{V_L}{8}].$$

which is exactly equal to the expected surplus in regulated environment. Considering the firm's profit in the second period, we can conclude that regulation, even when it provides incentives for the low-type firm to price honestly, has no effect on *total* welfare or on uninformed consumers' expected surplus:

$$E[S_N] = E[S_R] = (1-\lambda)[\rho(\frac{3V_H}{8}) + (1-\rho)\frac{3V_L}{8}].$$

Claim 3: When (NC2) holds, OSP regulation provides incentives for the low-type firm to honestly signal its type. In this case, prices perfectly transmit informed consumer's knowledge to the uninformed consumer. However, this transmission of information has no effect on the expected social welfare and consumer surplus. If the firm's type is low then OSP is beneficial for uninformed consumers, while if the firm's type is high, regulation results in a worse outcome for consumers.

We characterised equilibrium outcome when the low-type monopolist has a strictly dominant strategy; we showed that if (NC1) holds, then cheating is the dominant strategy for low-type. In contrast, under (NC2), pricing honestly strictly dominates deception. We now study the low-quality firm's behaviour when neither (NC1) nor (NC2) holds, *i.e.*, when $\frac{V_H - V_L}{V_L} \geq \frac{\lambda}{1-\lambda} \geq \rho\frac{V_H - V_L}{V_L}$. We call this condition (NC3) for the reminder of this paper.

Since the low-type firm has only two possible actions and no strictly dominant strategy, the only possible equilibrium in this case is a mixing strategy. Suppose there exists an equilibrium where the low-type firm chooses to pretend with probability $0 < \chi < 1$ and charges price P_X. Knowing this, exposed to signal that contains ordinary price $\frac{V_H}{2}$, consumers believe

$$\rho(\frac{V_H}{2}, P_X) = \frac{\rho}{\rho + \chi(1-\rho)} > \rho$$

Given consumers' beliefs, the best strategy of a high-type firm and a cheating low-type firm is to choose

$$P_X = \frac{1}{2}[\frac{\rho}{\rho+\chi(1-\rho)}V_H + \frac{\chi(1-\rho)}{\rho+\chi(1-\rho)}V_L]$$

We are now led to find the value of χ for which the low-type firm is indifferent between signalling $(\frac{V_H}{2}, P_X)$ or sending the honest signal $(\frac{V_L}{2}, \frac{V_L}{2})$. Given consumers' beliefs, the profit of an honest low-type firm is

$$\pi_H = \lambda\frac{V_L}{4} + (1-\lambda)\frac{V_L}{4} = \frac{V_L}{4}$$

while the profit to a deceptive low-type firm is

$$\pi_X = \frac{(1-\lambda)}{4} \times \frac{\rho V_H + \chi(1-\rho)V_L}{\rho+\chi(1-\rho)}.$$

Solving for $\pi_H = \pi_X$, this equation results in the probability χ that equalizes profit from either possible action:

$$\chi = \frac{\rho}{1-\rho}[\frac{(1-\lambda)V_H - V_L}{\lambda V_L}]$$

Since $\rho\frac{V_H-V_L}{V_L} \leq \frac{\lambda}{1-\lambda} \leq \frac{V_H-V_L}{V_L}$, χ lies between 0 and 1. Thus, in a regulated environment, when the proportion of informed consumers is such that neither (NC1) nor (NC2) is satisfied, there exists a Bayesian Nash Equilibrium in mixed strategies in which the high-type firm signals $(\frac{V_H}{2}, P_X)$, and the low-type firm signals $(\frac{V_H}{2}, P_X)$ with probability $\frac{\rho}{1-\rho}[\frac{1-\lambda}{\lambda}(V_H - V_L) - 1]$ and $(\frac{V_L}{2}, \frac{V_L}{2})$ with complementary probability. If consumers observe ordinary price $\frac{V_L}{2}$ the certainly believe that the firm is the low type. However, if they observe ordinary price $\frac{V_H}{2}$ consumers believe the probability that the firm is high type is $\frac{\lambda V_L}{(1-\lambda)(V_H-V_L)}$. Considering the fact that a high type firm's profit in the second period is identical to a low-type imitator, it is sensible to assume that consumers stick to these beliefs even if they observe any second-period price other than P_X when the firm chooses first-period price $\frac{V_H}{2}$. Given this assumption there is no profitable option open to both types of firms. Thus, we have a unique Bayesian Nash equilibrium with a mixing strategy, where the high

type always charges price P_X, while the low type mimics this strategy with probability strictly smaller than 1 and prices honestly with complementary probability.

We now discuss the welfare effect of OSP regulation when the low-type firm chooses a mixing strategy. The first-period price is independent of OSP regulation, unless the firm type is low and firm chooses to cheat. The probability of having a deceptive low-type firm is $(1-\rho)\chi$. Thus, the expected loss in total surplus due to regulation in the first period is $(1-\rho)\chi\frac{3V_L\lambda}{8}$. In the second period, both types of firms always face demand $\frac{1-\lambda}{2}$ independent of the regulatory environment. Thus the total surplus in the second period does not depend on regulation. However, OSP results in the transfer of surplus between consumers and the firm, depending on the firm's type. The low-type firm's gain (which is equal to the consumers' loss) owing to regulation is

$$\Delta\pi_L = \frac{1}{2}[\chi(P_x - P_P) + (1-\chi)(\frac{V_L}{2} - P_P)].$$

The gain to the high-type firm due to charging a strictly higher price in regulated environment is

$$\Delta\pi_H = \frac{1}{2}[P_x - P_P]$$

Thus the total change in expected profit to firms due to regulation – which exactly balances regulation's effect on consumers surplus – is

$$E[\Delta\pi] = -E[\Delta CS] = \frac{1}{2}\big[\rho(P_x - P_P) + (1-\rho)[\chi(P_x - P_P) + (1-\chi)(\frac{V_L}{2} - P_P)]\big]$$

$$= \frac{1}{4}\big[\rho V_H + (1-\rho)\chi V_L + (1-\chi)(1-\rho)V_L - \rho V_H - (1-\rho)V_L\big] = 0$$

Hence, when (NC3) is satisfied, OSP regulation has no effect on the second-period consumer expected surplus, but probabilistically decreases first-period consumer surplus.

Chapter 4

Discussion

This thesis has explored the effect of "ordinary selling price" regulation on the optimal behaviour of the firm and its effects on consumer and total surplus in a monopoly context. We summarize the effect of OSP regulation on equilibrium prices in two possible states of the world in Tables 4.1 and 4.2. The key results are in Table 4.2, in conditions NC2 and NC3, that the low-type firm charges a deceptive high price in the first period only when OSP regulation applies.

With no OSP regulation, any "ordinary selling price" claim is just "cheap talk" from the consumer's perspective, and consumers update their beliefs only based on the second-period price. However, restricting firms to communicate a truthful price makes it costly for a low-quality monopolist to deceive the uninformed consumer. Thus, when this regulation is in effect, the uninformed consumer, who updates her beliefs based on Bayes' rule, might end up having a refined information partition. Our model suggests that this scenario is possible only when the proportion of uninformed consumers in the market is sufficiently low. The interpretation of this result is that, if the objective of OSP regulation is to prevent false claims, then it is most effective when it is least useful – since the number of uninformed consumers must be low for it to work. Furthermore, our results suggest that, even when OSP is effective in deterring strictly false claims about price, it can result in a worse outcome for society. This arises if OSP regulation requires the firm to report only

Table 4.1: OSP regulations effect on high-quality product price

Condition	**OSP**		**No OSP**	
	First period price	Second period price	First period price	Second period price
(NC1)	P_H	P_P	P_H	P_P
(NC2)	P_H	P_H	P_H	P_P
(NC3)	P_H	P_X	P_H	P_P

$P_H > P_X > P_P > P_L$

Table 4.2: OSP regulations effect on Low-quality product price

Condition	**OSP**		**No OSP**	
	First period price	Second period price	First period price	Second period price
(NC1)	P_H	P_P	P_L	P_P
(NC2)	P_L	P_L	P_L	P_P
(NC3)	P_H or P_L	P_X or P_L	P_L	P_P

$P_H > P_X > P_P > P_L$

its true price, not how many sales it made. Thus, a low-quality producer that seeks to pretend to be high-quality to uninformed consumers may charge a high price in the first period (while making zero sales). This deception thus causes a deadweight loss from excessive pricing in the first period, with no compensating benefit to society in the second period. The underlying cause of inefficiency is that the regulation covers only one dimension of firm behaviour – price – which creates a costly opportunity for deception. If the firm were required to report its true quality, or its price *and* quantity sold, then the inefficiency would be eliminated. Presumably the appeal of reporting price is that it is easily observed and interpreted by consumers and regulators. Unfortunately, just because a variable is easily observed does not make it a useful signal. In the model proposed in this thesis, the neutral effect of OSP on the second period consumer arises from the assumption of symmetric cost of production. This is a reasonable assumption when the difference between the costs,*i.e.* $C_H - C_L$, is small enough relative to the difference between maximum reservation price for each products,*i.e.* $V_H - V_L$. While a formal analysis is beyond the scope of this thesis, easing this assumption could result in social gains in the second period when OSP is effective in inducing honesty. However, this happens only if the number of second period consumers is sufficiently small. Thus, even with cost asymmetry the positive effect of OSP regulation can be negligible compared to it's harmful effect.

While the model nominally describes a situation in which there are informed consumers in the first period and uninformed consumers in the second, it can also be seen as a description of a more general situation in which the monopolist sells to both informed and uninformed consumers. Ordinary selling price regulation, which is intended to protect uninformed consumers, simply re-

quires that the firm not offer a lower price to informed than uninformed buyers. Exactly the same unintended side effects would arise in such a situation.

In this model, ordinary selling price regulation is either useless or positively harmful. One might ask, given this result, whether it has a place in antitrust laws such as the Canadian Competition Act. To be sure, more analysis is certainly required before eliminating it. But the analysis in this thesis suggests that courts should, at least, be hesitant about applying penalties for violations of ordinary selling price regulation; it also suggests that governments should consider whether ordinary selling price regulations need further refining or perhaps elimination.

Bibliography

M. Armstrong and Y. Chen. Discount pricing. *Economic Inquiry*, 58(4):1614–1627, 2020. doi: https://doi.org/10.1111/ecin.12774. URL https://onlinelibrary.wiley.com/doi/abs/10.1111/ecin.12774.

K. Bagwell and M. H. Riordan. High and declining prices signal product quality. *The American Economic Review*, 81(1):224–239, 1991. ISSN 00028282. URL http://www.jstor.org/stable/2006797.

. Buzzell, Robert D. (Robert Dow). *Marketing : a contemporary analysis*. New York : McGraw-Hill, 2d ed edition, 1972. ISBN 978-0-07-009477-2. 1964 ed. published under title: Marketing, an introductory analysis.

Y.-S. Chan and H. Leland. Prices and qualities in markets with imperfect information: A search model. 04 1983.

A. Daughety and J. Reinganum. Competition and confidentiality: Signaling quality in a duopoly when there is universal private information. *Games and Economic Behavior*, 58(1):94–120, 2007. URL https://EconPapers.repec.org/RePEc:eee:gamebe:v:58:y:2007:i:1:p:94-120.

S. J. Grossman and J. E. Stiglitz. Information and Competitive Price Systems. *American Economic Review*, 66(2):246–253, May 1976. URL https://ideas.repec.org/a/aea/aecrev/v66y1976i2p246-53.html.

M. C. Janssen and S. Roy. Signaling quality through prices in an oligopoly. *Games and Economic Behavior*, 68(1):192–207, January 2010. URL https://ideas.repec.org/a/eee/gamebe/v68y2010i1p192-207.html.

K. L. Judd and M. H. Riordan. Price and quality in a new product monopoly. *The Review of Economic Studies*, 61(4):773–789, 1994. ISSN 00346527, 1467937X. URL http://www.jstor.org/stable/2297918.

J. M. Kamen and R. J. Toman. "psychophysics of prices": A reaffirmation. *Journal of Marketing Research*, 8(2):252–257, 1971. ISSN 00222437. URL http://www.jstor.org/stable/3149774.

R. E. Kihlstrom and L. Mirman. Information and market equilibrium. *Bell Journal of Economics*, 6(1):357–376, 1975. URL https://EconPapers.repec.org/RePEc:rje:bellje:v:6:y:1975:i:spring:p:357-376.

P. Milgrom and J. Roberts. Price and advertising signals of product quality. *Journal of Political Economy*, 94(4):796–821, 1986. ISSN 00223808, 1537534X. URL http://www.jstor.org/stable/1833203.

D. Ngwe, K. J. Ferreira, and T. Teixeira. The impact of increasing search frictions on online shopping behavior: Evidence from a field experiment. *Journal of Marketing Research*, 56(6):944–959, 2019. doi: 10.1177/0022243719865516.

subsections 74.01(2) of the Competition Act. https://www.competitionbureau.gc.ca/eic/site/cb-bc.nsf/eng/03125.html.

J. E. Urbany, W. O. Bearden, and D. C. Weilbaker. The effect of plausible and exaggerated reference prices on consumer perceptions and price search. *Journal of Consumer Research*, 15(1):95–110, 1988. ISSN 00935301, 15375277. URL http://www.jstor.org/stable/2489175.

A. Wolinsky. Prices as signals of product quality. *Review of Economic Studies*, 50(4):647–658, 1983. URL https://EconPapers.repec.org/RePEc:oup:restud:v:50:y:1983:i:4:p:647-658.

Appendix A

Appendix A

If the first and second period consumer population have the same distribution of information and taste, then the optimal strategy of a type i firm (P_{1i}, P_{2i}) satisfies $P_{1i} = P_{2i}$. Thus, there is no value to the firm in communicating OSP.

Proof: Suppose first-period consumers update their beliefs after observing the first-period price, while the second-period consumers realization is based on both the first- and the second-period prices. Suppose that the firm's optimal strategy (P_{1i}, P_{2i}) is type-dependent. In this case, the expected profit of the high-type firm is

$$\pi_H(P_{1i}, P_{2i}) = \lambda[\frac{V_H - P_{1i}}{V_H} P_{1i} + \frac{V_H - P_{2i}}{V_H} P_{2i}] + (1-\lambda)[\rho(P_{1i}) \frac{V_H - P_{1i}}{V_H} P_{1i}$$
$$+\rho(P_{1i}, P_{2i}) \frac{V_H - P_{2i}}{V_H} P_{2i}] + (1-\lambda)[(1-\rho_1(P_{1i}))P_{1i} \frac{V_L - P_{2i}}{V_L}$$
$$+(1-\rho(P_{1i}, P_{2i})) \frac{V_L - P_{2i}}{V_L} P_{2i}]$$

Since all agents are sequentially rational, if the firm's best strategy reveals its type in the second-period, it must do so in the first period. Thus, $\rho(P_{1i}) = \rho(P_{1i}, P_{2i}) = 1$

$$\pi(P_{1i}, P_{2i}) = \lambda[\frac{V_H - P_{1i}}{V_H}(P_{1i}) + \frac{V_H - P_{2i}}{V_H} P_{2i}]$$

$$+(1-\lambda)[\frac{V_H - P_{1i}}{V_H} P_{1i} + \rho(P_{1i}, P_{2i})) \frac{V_H - P_{2i}}{V_H} P_{2i}]$$
$$\rightarrow \pi(P_{1i}, P_{2i}) = \frac{V_H - P_{1i}}{V_H} P_{1i} + \frac{V_H - P_{2i}}{V_H} P_{2i}$$

The profit is the sum of two separable functions of P_{1i} and P_{2i}. Since these two functions are

exactly the same, the best choice of price is the same for both periods.

Now, suppose there exist a pooling equilibrium in which the high-type firm's strategy (P_{1i}, P_{2i}) fully reveals the firm's type and maximizes its profit. In this case, $\rho(P_{1i}) = \rho(P_{1i}, P_{2i}) = \rho$, and the firm's profit is

$$\pi(P_{1i}, P_{2i}, \rho(P_{1i}), \rho(P_{1i}, P_{2i})) = \lambda[\frac{V_H - P_{1i}}{V_H} P_{1i} + \frac{V_H - P_{2i}}{V_H} P_{2i}]$$
$$+(1-\lambda)[\rho \frac{V_H - P_{1i}}{V_H} P_{1i} + \rho \frac{V_H - P_{2i}}{V_H} P_{2i}] + (1-\lambda)(1-\rho)[P_{1i} \frac{V_L - P_{2L}}{V_L}$$
$$+ \frac{V_L - P_{2i}}{V_L} P_{2i}]$$

This is again a separable function of P_{1i} and P_{2i}, and is a sum of two identical functions. Hence, the firm should charge the same price in periods 1 and 2. Similarly, we can show that this is true for the low-type firm.