Economic Modelling 50 (2015) 168–178

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/ecmod

Price limits and corporate investment: The consumers' perspective☆

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ARTICLE INFO

Article history:
Accepted 20 June 2015
Available online 10 July 2015

Keywords:
Real option
Investment
Price cap
Consumer welfare

ABSTRACT

This paper uses a real-option model to examine how a price cap affects a regulated firm's investment timing/capacity decision and the resulting consumer welfare. The model is too complex to allow for closed-form solutions, hence the results are derived numerically. We show that optimal investment size is an increasing function of price cap, and optimal investment trigger is initially decreasing and subsequently increasing in price cap, hence there is a unique price cap that minimizes investment trigger. The resulting consumer welfare is initially increasing and subsequently decreasing in price cap, thus there is also a unique price cap that maximizes consumer welfare. These two price caps are generally different, and can be substantially different in certain cases; therefore, accelerating investment will not necessarily make consumers better off. Also, increasing (decreasing) the price cap results in a slight (large) reduction in consumer welfare, which implies that consumers are paradoxically better off with a too-high price cap than a too-low price cap. The central message of the paper is that consumers and consumer advocates should be interested in the price-cap setting process, since the price cap impacts consumer welfare, sometimes in unexpected ways.

1. Introduction

A number of monopolistic industries are subject to governmental price limits, to prevent corporations from exploiting their monopoly power (Baldwin et al., 2012).[1] Examples of such industries are electric utilities, water, gas, telecommunications, and insurance. While these may not comprise the majority of industries in the corporate sector, they are nevertheless an important segment. As pointed out by Spiegel and Spulber (1994, p. 424), the utility industry alone accounted for about 6% of the GNP of the USA and over 18.8% of the total business expenditure for new plant and equipment in 1989.

This paper examines how a price limit or cap affects an unlevered firm's investment decision, and the resulting impact on consumer welfare. Using a real-option model of investment, we show that a price cap can have a significant effect on both the timing and size of a company's investment. Since price caps are to be found in monopolistic industries, the firm's investment decision can in turn have a significant effect on consumer welfare.

Our model generates the following main results. First, the optimal investment size is an increasing function of price cap, but it increases at a declining rate until it flattens out to a constant size. Second, the optimal investment trigger is initially decreasing and subsequently increasing in price cap, hence there is a unique price cap that minimizes the investment trigger. Third, consumer welfare is initially increasing and subsequently decreasing in price cap, hence there is a unique price cap that maximizes consumer welfare. However, these two unique price caps are generally different (possibly very different, depending on the parameter values); thus, encouraging investment will not necessarily be best for consumers, contrary to some earlier papers. Finally, the effect of price cap on consumer welfare is generally asymmetric; that is, a lower price cap will result in a sharp fall in consumer welfare, but a higher price cap will result in a gradual fall. The practical implication is that a too-low price cap is likely to hurt consumers more than a too-high price cap.

The rest of the paper is organized as follows. Section 2 reviews the existing literature and clarifies the contribution of this paper. Section 3 analyzes the price-cap-regulated firm's investment (size and timing) decision, and Section 4 derives an appropriate consumer welfare function. Section 5 presents the results of the model, and Section 6 concludes.

☆ I acknowledge helpful comments and suggestions from three anonymous reviewers, which helped improve the paper. I also thank the Editor S. Mallick for his guidance and suggestions.

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[1] Price control can be viewed as a redistribution of wealth from corporations to consumers. Micheli and Schmidt (2015) show that price control (rent control in their example) dominates other forms of wealth redistribution such as transfer payments. It is therefore not surprising that price control is a popular means of limiting excessive profits of monopolies.

http://dx.doi.org/10.1016/j.econmod.2015.06.014

2. Literature review

From the company's perspective, the important issue is how to modify its investment policy in the presence of a price cap.[2] A few papers use the real option model to determine the optimal investment policy under a price cap. Dixit (1991) shows that, for a competitive firm, a price cap raises the investment trigger and thus has a negative effect on investment. Roques and Savva (2009) and Dobbs (2004) show, for an oligopoly and a monopoly respectively, that setting the price cap equal to the competitive entry trigger price results in the lowest investment trigger and thereby maximizes investment. None of these papers, however, look at investment size or capacity.

From a consumer's perspective, the important issue is how a price cap will affect consumer welfare. The direct effect of a price cap will be to increase consumer welfare, since it limits how much consumers have to pay per unit of the good. However, there could be an indirect negative effect via the investment effect, since price caps are used in monopolistic industries. This indirect effect is explicitly incorporated in our model. Evans and Guthrie (2012) examine the effect of price cap on total welfare (consumer welfare plus producer welfare) when the firm makes incremental investments and the regulator adjusts the price cap continuously.

Our paper differs from the existing literature in the following ways. First, existing real-option models (Dixit, 1991; Dobbs, 2004; Roques and Savva, 2009, etc) not consider investment capacity or consumer welfare, unlike our paper. Second, while Evans and Guthrie (2012) consider economic welfare, their model maximizes total welfare (or an equally-weighted combination of consumer and producer welfare), which is not consistent with observed regulator behavior (Dasgupta and Nanda, 1993; Evans et al., 2008; Florio, 2013, etc).[3] Third, none of the above-mentioned papers consider the firm's capacity choice when investing. While some investments are indeed incremental in nature, there are many that are "lumpy" one-time decisions, where incremental additions to capacity are not possible (Bar-Ilan and Strange, 1999; Dangl, 1999). This "lumpy" investment is incorporated in our paper, where the size or capacity of the investment, and its effect on consumer well-being, are explicitly taken into account.

To summarize, the existing price cap literature examines the effect of price cap on investment timing, and on total welfare (consumer plus producer) with incremental investment and continuous price cap adjustment. There is no research on the effect of price cap on the joint investment timing/capacity decision or on consumer welfare for lumpy investment. This is the gap our study aims to fill.

3. A model of investment timing and capacity

3.1. Basic model assumptions

The monopolistic firm consists of a plant which produces q units of the output, which are sold at a price of \$p per unit. As in Roques and Savva (2009), Dobbs (2004), and Evans and Guthrie (2012), we assume there are no operating costs. The output quantity cannot exceed the plant capacity Q, while the output price cannot exceed the price cap $\bar{p}$; hence both price and quantity are constrained, $p \le \bar{p}$ and $q \le Q$. The firm determines both p and q optimally, subject to the above constraints, based on the realization of the demand function below.

As is common in the real-option literature (Aguerrevere, 2003; He and Pindyck, 1992; Kandel and Pearson, 2002), the demand for the product is given by a linear inverse demand function:

$$p_t = y_t - \theta q_t \tag{1}$$

where p is the output price per unit, q is the output level, y is a continuously-varying stochastic exogenous parameter that represents the strength of demand. The state variable is y, which introduces uncertainty in the model and can be interpreted as the relative strength of the demand side of the market. When y increases, demand is stronger and price p is higher for a given q. Therefore, revenues and profits are both increasing functions of y.

The parameter θ is a non-negative constant representing the slope of the linear demand function (or price sensitivity to output quantity). It can be viewed as "price responsiveness" or elasticity coefficient,[4] or a measure of monopolistic market power. For $\theta = 0$, the demand is infinitely elastic and if the company raises the price at all, sales will fall to zero; thus, $\theta = 0$ means the firm has no market power and the output price is exogenous. For large θ, demand is inelastic and the company can raise price without a significant drop in sales, hence a large θ signifies substantial market power.

We also make the standard assumption (Aguerrevere, 2003; He and Pindyck, 1992; Kandel and Pearson, 2002, etc) that y evolves continuously as a geometric Brownian motion:

$$dy/y = \mu dt + \sigma dz \tag{2}$$

where μ and σ are the expected growth rate and volatility, respectively, of y; and z is a standard Wiener process. We assume $r > (2\mu + \sigma^2)$; this condition is required to ensure meaningful project values (see Section 3.2).

The cost of investing in the project is an increasing function of plant capacity Q, and is given by cQ^{η} (where $\eta \ge 1$), as in Bar-Ilan and Strange (1999). The investment is irreversible, in that the company cannot recoup any part of the sunk investment cost, even though it can terminate operations and exit the industry if business conditions deteriorate sufficiently. Also, depreciation is ignored in the model.

The price cap of \$$\bar{p}$ per unit of output is assumed to be exogenously set by the regulator, and the firm takes it as given. All cash flows are discounted at the constant risk-free rate of r, consistent with the real-option literature (Aguerrevere, 2003; Dixit, 1991; Dobbs, 2004; Evans and Guthrie, 2012; Roques and Savva, 2009, etc).

3.1.1. Operating levels

Absent constraints, operating level will be chosen to maximize the instantaneous profit, which (since there are no operating costs) is given by: $\pi(q) = pq = (y - \theta q)q$. Setting $d\pi/dq = 0$, we get the optimal output level as a function of the state variable y:

$$q_t = y_t / 2\theta \tag{3}$$

and the corresponding price from Eq. (1):

$$p_t = y_t / 2. \tag{4}$$

Thus, the unconstrained optimal profit stream is $q_t p_t = (y_t)^2 / 4\theta$ per unit time. However, when y rises sufficiently, the price cap will become binding (at $y = 2\bar{p}$, from Eq. (4)) or the capacity constraint will become

[2] Price limit is a form of wealth expropriation (from corporations), and it has been shown that wealth expropriation can have a significant negative effect on corporate investment (Ochoa et al., 2015). Therefore, it is important to account for the effect of price limit on the firm's investment policy.

[3] The reason price caps are used in the first place is to ensure that consumer interests are protected, hence maximizing consumer welfare should be the primary objective of the regulator (Baldwin et al., 2012; Iozzi, et al., 2002). However, corporate or producer welfare is also important because investors require adequate returns, without which future investment will be negatively impacted. Thus, the literature generally views the regulator as maximizing a weighted combination of consumer welfare and corporate welfare (Florio, 2013; Dasgupta and Nanda, 1993; Spiegel and Spulber, 1994, etc). But these weights vary widely and are determined largely by political and other non-economic factors, such as regulatory capture, lobbying, societal attitudes towards wealth redistribution, elected versus appointed regulators, degree of regulatory capture, etc (Baldwin et al., 2012, Besley and Coate, 2003; Florio, 2013). Also, a proper study of the regulator's price cap decision would need to take into account the role played by corporate leverage decisions in influencing the regulator (Bortolotti et al., 2007; Dasgupta and Nanda, 1993). Hence the regulator's objective function is beyond the scope of this paper, and we focus on the magnitude of consumer welfare, and how it is affected by a price cap.

[4] The elasticity of demand for the demand Eq. (1) is $p / (\theta q)$.