To Regulate or to Deregulate? The Role of Downstream Competition in Upstream Monopoly Vertically Linked Markets

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To regulate or to deregulate? The role of downstream competition in upstream monopoly vertically linked markets

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Abstract

This paper attempts to cast light to the relationship between Cournot-Bertrand controversy and monopoly regulation. To this purpose, we use a simple model of a vertically linked market, where an upstream regulated natural monopoly is trading via two-part tariff contracts with a downstream duopoly. Combining our results to those of the existing literature on deregulated markets, we argue that when the downstream competition is in prices, efficiency dictates regulating the monopoly with a marginal cost based pricing scheme. However, this type of regulation leads to significant welfare loss, when the downstream market is characterized by Cournot competition.

JEL classification: L43; L51

Keywords: Bertrand; Cournot; Marginal cost pricing; Regulation; Vertical relations

1 Introduction

Utilities such as energy, water supply and telecommunications and certain modes of transport such as rail, all include natural monopoly characteristics (i.e., electricity transmission, gas distribution, local loop telecommunications, etc.) arising from pervasive economies of scale and scope (Armstrong & Sappington, 2006). These characteristics mean that competition

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is unlikely to develop, or if it develops, it will be uneconomic because of the duplication of assets. As explained by Borenstein (2002), Mulligan and Tsui (2008), Acemoglu and Robinson (2013) inter alia, in order to prevent this result, the standard approach of policy making from governments is to develop strong regulatory capabilities so that they can police the revenues and costs of production of the privatized utility firms and protect consumers from monopoly exploitation. At the same time, there needs to be commitment on the part of government to the regulatory rules to establish credibility on the part of the investors that the regulatory rules will bring about the intended outcome. Where regulatory credibility is weak or absent, private investment decisions will be adversely affected.

While there is an extensive literature examining the Cournot-Bertrand controversy in the context of vertically linked markets where trading occurs through linear or non-linear wholesale prices contracts (Correa-López & Naylor, 2004; Correa-López, 2007; Arya et al., 2008; Mukherjee et al., 2012; Chirco & Scrimitore, 2013; Alipranti et al., 2014; Manasakis & Vlassis, 2014), the interdependency between the nature of the downstream competition and the upstream monopoly regulation is usually ignored by the existing literature. More specifically, Yanez (2002), investigates the spillover effects from price regulation of a single product that is a substitute in consumption and vertically related to the product of another regulated industry such as electricity. Armstrong and Sappington (2006) study the choice between regulated monopoly and unregulated competition, highlighting the role of imperfect information. They argue that the appropriate choice between the two regimes is strongly affected by certain technological and demand characteristics such as the regulator's resources, the efficiency of tax systems and capital markets, and the strength of other prevailing institutions. Moreover, Sappington (2006) argues that when vertically integrated providers are present (i.e., telecommunications industry) the entrant's decision to make or buy critical production inputs may be largely insensitive to the price of these inputs. Lastly, Bergantino et al. (2011), explore the effectiveness of price and quality cap regulation where a (regulated) incumbent competes with his (unregulated) rivals under two regimes accounting for the Nash-Cournot and the Stackelberg framework respectively.

In this paper, we study the role of downstream competition in a regulated upstream natural monopoly. A novel aspect of our analysis is that we allow for a two-part tariff marginal cost based pricing scheme and we consider the role of its nature, when the monopoly is regulated or deregulated. One additional key aspect of our analysis is that we take into account downstream competition and its intensity (Cournot or Bertrand). We address a number of research questions such as: Is it preferable to regulate upstream natural monopolies (utilities), with a two-part tariff marginal cost based pricing scheme? Does upstream regulation stimulate total welfare? What is the role of the nature of downstream competition? We show that the answer to all these research questions depends solely on the type of downstream competition. If downstream rivals compete in quantities, then regulation is not preferred from the viewpoint of welfare when a two-part tariff is charged by the monopolist (this is the usual pricing scheme in utility companies - see for example Joskow, 2014; Viscusi et al. 2005; Newbery, 2002; Brown & Sibley, 1986). However, when the downstream market is characterized by price competition, marginal cost pricing is the ideal choice.

Our result has important policy implications for a number of markets with natural monopoly characteristics such as gas and electricity markets. Specifically, gas market is divided into five relevant market segments: a) the extraction/production of gas (i.e., upstream market), b) the transportation of gas via high pressure pipelines (i.e., transmission market), c) the transportation on medium and low pressure pipelines (i.e., distribution market), and finally, d) the storage of gas and e) the supply of gas to customers (i.e., downstream market).[1] In an empirical study, Davis and Muehlegger (2010), showed that in the market of the US natural gas distribution, which has natural monopoly characteristics with high fixed and low marginal costs (Newbery, 2002; Davis & Muehlegger, 2010), the ideal regulatory pricing of a marginal cost-based two-part tariff holds only for industrial customers. On the other hand, residential and commercial customers pay per-unit prices higher than the marginal cost alongside with a fixed monthly fee. According to Davis and Muehlegger (2010) this pricing policy leads to a huge welfare loss. Given the fact that industrial customers of natural gas (e.g. refineries, electricity generation, steel industry, cement industry, car industry, etc.) operate in markets characterized by quantity competition due to capacity constraints (Cabral, 2000; Motta, 2004), whereas commercial and residential customers mostly, compete, in prices, our results indicate that regulation is imposed to the wrong market segment. In other words, the price charged to commercial customers should be regulated with a marginal cost pricing rule, whereas the charges of industrial customers should be deregulated.

The rest of the paper is structured as follows: The model and the equilibrium analysis under regulated and deregulated monopoly are presented in the next two sections. Section 4 compares the results and discusses the policy implications. A robustness analysis is conducted in section 5. Finally, section 6 concludes.

[1] It is worth mentioning that the gas supply market can be further divided into several sub-segments: i) supply of gas to dealers (including the local distribution companies), ii) supply of gas to gas-powered electricity plants, iii) supply of gas to large industrial customers, iv) supply of gas to small industrial and commercial customers, and v) supply of gas to household customers (Fafaliou & Polemis, 2009).

2 The model

Our setting follows that of Alipranti et al. (2014). We consider a vertically linked market with an upstream monopoly U, and two downstream firms D_1 and D_2. Monopolist's production is used as input by downstream firms in one-to-one proportion. The cost of buying this input is the only cost faced by the downstream firms. The marginal cost of the upstream monopolist is constant and equals $c > 0$.

Firms play a two-stage game. In stage one, the upstream monopoly bargains simultaneously and separately with its downstream clients over the terms of a two-part tariff contract consisting of a fixed tariff F and a per unit charge w (wholesale price). The bargaining between U and D_i's (with $i = 1, 2$) follows the standard Nash bargaining model. In stage two, the downstream firms compete in quantities (Cournot competition) or prices (Bertrand competition) after observing each other's contract terms (i.e., w and F) from the first stage. In the above-described environment, multiple equilibria can arise due to the multiplicity of the beliefs that the downstream firms can form when they receive out-of-equilibrium offers (McAfee and Schwartz, 1994). We avoid this problem by assuming immunity of the contract between U and D_i to a bilateral deviation of U with D_j, holding the contract with D_i constant (see Horn & Wolinsky, 1988; Cremer & Riordan, 1987; O'Brien & Shaffer, 1992; Milliou & Petrakis, 2007; Milliou & Pavlou, 2013; Alipranti et al., 2014). In order to guarantee the existence of a pure strategy pairwise proof equilibrium we make the following assumption: $\beta \geqslant \bar{\beta}(\gamma) \equiv \frac{\gamma^3}{(2-\gamma)(2-\gamma^2)}$, where $\beta \in (0, 1]$ is the bargaining power of the upstream firm and $\gamma \in (0, 1)$ is the rate of substitution between the products of the downstream firms.

Following Singh and Vives (1984) the inverse and the direct demand functions for downstream firm i are:

$$p_i = a - q_i - \gamma q_j \tag{1}$$

$$q_i = \frac{a - p_i - \gamma(a - p_j)}{1 - \gamma^2} \tag{2}$$

where $i, j = 1, 2$ (with $i \neq j$), a is a positive constant, p_i and q_i are the price and quantity of D_i, respectively. Finally, we assume that $a > c$.

3 Equilibrium analysis

In this section we examine the equilibrium conditions under two different regimes: a) when the upstream monopoly is regulated via a two-part tariff where the wholesale price is fixed to marginal cost and b) when the upstream monopolist trades with its downstream rivals for both the wholesale price and the fixed tariff.

3.1 Regulated monopoly

We assume that the regulator imposes marginal cost pricing on the upstream monopoly. In this case, the equilibrium wholesale prices under both downstream Cournot (w_i^{C*}) and Bertrand competition (w_i^{B*}) will be equal to $w_1^{C*} = w_2^{C*} = w_1^{B*} = w_2^{B*} = w^* = c$.

It can be easily shown that the equilibrium output and price under the two different modes of downstream competition[2] are:

[2]Where the superscripts C and B denote Cournot and Bertrand downstream competition, respectively.

$$q_i^{C*} = \frac{a-c}{2+\gamma} \tag{3}$$

$$p_i^{C*} = \frac{a+c(1+\gamma)}{2+\gamma} \tag{4}$$

$$q_i^{B*} = \frac{a-c}{(1+\gamma)(2-\gamma)} \tag{5}$$

$$p_i^{B*} = \frac{a(1-\gamma)+c}{2-\gamma} \tag{6}$$

The equilibrium downstream and upstream profits for each mode $M = C, B$ of downstream competition are:

$$\Pi_{D_i}^{C*} = [q_i^{C*}]^2 - F_i^{C*} \tag{7}$$

$$\Pi_U^{C*} = 2(w^* - c)q_i^{C*} + F_i^{C*} + F_j^{C*} = F_i^{C*} + F_j^{C*} \tag{8}$$

$$\Pi_{D_i}^{B*} = (p_i^{B*} - c)q_i^{B*} - F_i^{B*} \tag{9}$$

$$\Pi_U^{B*} = 2(w^* - c)q_i^{B*} + F_i^{B*} + F_j^{B*} = F_i^{B*} + F_j^{B*} \tag{10}$$

The equilibrium fixed fee F_i^{M*}, solves the following Nash product:

$$F_i^{M*} = \arg\max_{F_i} [\Pi_U^M(F_i, F_j^{M*}) - d(F_j^{M*})]^{\beta} [\Pi_{D_i}^M(F_i)]^{1-\beta} \tag{11}$$

where $d(F_j^{M*}) = (w^* - c)q_j^{mon} + F_j^{M*} = F_j^{M*}$, q_j^{mon} is the downstream monopoly quantity (disagreement point for U. It is the case where an agreement is not reached between U and downstream firm i and thus downstream firm j becomes a monopoly).

Solving (11), we get the equilibrium value of the fixed fee for each mode of downstream competition.

$$F_i^{C*} = \frac{\beta(a-c)^2}{(2+\gamma)^2} \tag{12}$$

$$F_i^{B*} = \frac{\beta(a-c)^2(1-\gamma)}{(2-\gamma)^2(1+\gamma)} \tag{13}$$

Using (3), (5), (6), (12), (13) and (7)-(9), we obtain the equilibrium upstream and downstream profits:

$$\Pi_{D_i}^{C*} = \frac{(1-\beta)(a-c)^2}{(2+\gamma)^2} \tag{14}$$

$$\Pi_U^{C*} = \frac{2\beta(a-c)^2}{(2+\gamma)^2} \tag{15}$$

$$\Pi_{D_i}^{B*} = \frac{(1-\beta)(1-\gamma)(a-c)^2}{(2-\gamma)^2(1+\gamma)} \tag{16}$$

$$\Pi_U^{B*} = \frac{2\beta(1-\gamma)(a-c)^2}{(2-\gamma)^2(1+\gamma)} \tag{17}$$

From (14)-(17), we note that the industry's profits are divided between the upstream monopoly and the downstream firms according to the relative bargaining power of each side.

Comparing the above results, we end up to the following Propositions:

Proposition 1. *Under regulated upstream market, the final prices are higher (lower) under Cournot (Bertrand) competition while the opposite holds for the equilibrium output.*

Proof. Taking the difference $p^{C*} - p^{B*} = \frac{(a-c)\gamma^2}{(2+\gamma)(2-\gamma)} > 0$. Similarly, $q^{C*} - q^{B*} = \frac{-(a-c)\gamma^2}{(2+\gamma)(1+\gamma)(2-\gamma)} < 0$ □

Proposition 2. *Under regulated upstream market, the equilibrium downstream and upstream profits are higher (lower) under Cournot (Bertrand) competition.*

Proof. The difference between the downstream profits is $\Pi_{D_i}^{C*} - \Pi_{D_i}^{B*} = \frac{2(1-\beta)(a-c)^2\gamma^3}{(2+\gamma)^2(1+\gamma)(2-\gamma)^2} > 0$. In the case of the upstream market, we have $\Pi_U^{C*} - \Pi_U^{B*} = \frac{4\beta(a-c)^2\gamma^3}{(2+\gamma)^2(1+\gamma)(2-\gamma)^2} > 0$ □

Proposition 3. *Under regulated upstream market, consumers' surplus and total welfare are lower (higher) under Cournot (Bertrand) competition.*

Proof. Consumers' surplus is given by $CS^{M*} = (1+\gamma)[q_i^{M*}]^2$ while total welfare is equal to $TW^{M*} = CS^{M*} + \Pi_U^{M*} + 2\Pi_{D_i}^{M*}$.[3] Given that $q^{C*} - q^{B*} < 0$ it follows that $CS^{C*} < CS^{B*}$. Moreover, $TW^{C*} - TW^{B*} = \frac{(\gamma^2+2\gamma-4)(a-c)^2\gamma^2}{(2+\gamma)^2(1+\gamma)(2-\gamma)^2} < 0$ □

[3] Total welfare is usually expressed as a weighted sum of consumers' surplus and firms' profits (see for example Cowan (2001)), i.e., $TW = CS + b * \Pi$, where TW denotes total welfare, CS denotes consumers' surplus, Π denotes firms' profits and $0 < b \leq 1$. In our analysis b is set equal to 1. However, it can be easily shown that our main findings hold for $0 < b < 1$.

Similar to conventional wisdom, Proposition 1 informs us that competition in prices is more competitive than competition in quantities. In other words, Cournot competition yields higher prices and lower output than Bertrand competition. In this case, under a regulated two-part tariff pricing scheme based on the marginal cost of the upstream monopoly, the downstream firms are less efficient under Cournot competition. As a consequence, they charge higher prices and they produce a smaller quantity than under Bertrand competition. According to Proposition 2, downstream profits are higher under Cournot than under Bertrand competition. This is due to the fact that the negative impact of the aggressiveness of competition on profits dominates the higher fixed fee charged in Cournot's case. Finally, Proposition 3 informs us that under a regulated two part-tariff regime, a market with Bertrand competition is more efficient than a market with Cournot competition. The higher consumers' surplus under Bertrand competition is enough to dominate the higher upstream and downstream profits in the Cournot case (see Proposition 2) and hence total welfare is higher under Bertrand competition. Overall, it turns out that in a regulated vertically linked market with upstream monopoly and trading with non-linear contracts, Bertrand competition is more socially desirable than Cournot competition.

Given Propositions 1, 2 and 3, it turns out that two-tier industries in which the upstream market is perfectly competitive (i.e., upstream marginal cost pricing) are to a major extent equivalent with one-tier industries where Bertrand is more efficient than Cournot competition. In this respect the fixed fee charged by the upstream monopolist does not affect the driving force (see next subsection) of our findings.

3.2 Deregulated monopoly

Alipranti et al. (2014) showed that the main results of subsection 3.1 are reversed when the upstream monopoly is deregulated (by a marginal cost based two-part tariff pricing scheme) and therefore is free to negotiate its wholesale prices. More specifically, their findings can be summarized in the following proposition.

Proposition 4. *In a deregulated upstream monopoly trading via two-part tariffs with two downstream rivals, Cournot downstream competition is more efficient (in the sense that it is characterized by higher consumers' surplus and total welfare) than Bertrand downstream competition.*

The driving force of Alipranti et al. (2014) result is the so-called *commitment problem* (see, among others, Hart & Tirole, 1990; Saggi & Vettas, 2002; Rey & Verge, 2004 and de Fontenay & Gans, 2005). The commitment problem is generated by the fact that the upstream monopoly negotiates via non-linear pricing with its downstream competing rivals separately, not publicly. This in turns yields to an opportunistic behavior by the upstream monopoly since the latter has the incentive to offer a lower wholesale price to D_i than to D_j. This will lead to an increase in the level of market share of D_i and its profitability which will then be transferred upstream by the monopoly through a higher fixed fee to D_i. It is worth emphasizing that the inability of the upstream monopoly to publicly commit to specific contract terms to all downstream customers due to the existence of secret negotiations between the two vertically linked segments of the market (i.e., upstream monopoly and downstream oligopoly) prevents U from inducing the maximum overall industry profits (Alipranti et al., 2014). In other words, the existence of the commitment problem will lead each D_i, to an anticipated opportunistic behavior by its upstream monopoly supplier, and thus an offer that maximizes the industry's overall profits would have to be turned down (Rey & Verge; 2004, de Fontenay & Gans, 2005; Alipranti et al., 2014). It is argued that the fact that competition in quantities is characterized by strategic substitutionality, whereas competition in prices by strategic complementarity, intensifies the opportunistic behavior of the upstream monopolist in the former case, leading to lower wholesale prices which in turn enable downstream firms to produce more efficiently under Cournot than under Bertrand competition (i.e., the commitment problem is more intense when downstream firms compete in quantities). It can be easily noted that this difference in the intensity of the commitment problem between the two modes of downstream competition disappears under regulation due to the fixed (at the marginal cost level) wholesale prices set by the regulator. Therefore, similar to Singh and Vives (1984), the competition is fiercer under Bertrand than under Cournot leading to Propositions 1, 2 and 3.

4 Regulated vs. deregulated upstream monopoly

In this section we compare the equilibrium outcomes under the two different regimes.

Alipranti et al. (2014) assume without loss of generality that marginal cost is zero both upstream and downstream. The corresponding results with respect to the equilibrium quantities and the total welfare in their context (where subscripts reg and $wreg$ denote the existence of regulated and deregulated upstream monopoly, respectively) under a non-zero marginal cost c for the upstream monopolist are

$$q_{wreg}^{C*} = \frac{(a-c)(2-\gamma)}{2(2-\gamma^2)} \tag{18}$$

$$q_{wreg}^{B*} = \frac{(a-c)(2+\gamma)}{4(1+\gamma)} \tag{19}$$

$$TW_{wreg}^{C} = \frac{(a-c)^2(2-\gamma)(6-\gamma-3\gamma^2)}{4(2-\gamma^2)^2} \tag{20}$$

$$TW_{wreg}^{B} = \frac{(a-c)^2(2+\gamma)(6-\gamma)}{16(1+\gamma)} \tag{21}$$

Proposition 5. *It is efficient to regulate (deregulate) an upstream natural monopoly via a marginal cost-based two-part tariff if the downstream competition takes place in prices (quantities).*

Proof. Given that consumers' surplus is equal to $(1+\gamma)$ times the square of the equilibrium quantity, if $q_{reg}^{B*} > q_{wreg}^{C*}$ and $q_{wreg}^{B*} > q_{reg}^{C*}$, then $CS_{reg}^{B} > CS_{wreg}^{C} > CS_{wreg}^{B} > CS_{reg}^{C}$ ($q_{wreg}^{C*} > q_{wreg}^{B*}$ has been proven by Alipranti et al. (2014)). This is true since $q_{reg}^{B*} - q_{wreg}^{C*} = \frac{(a-c)\gamma^2(1-\gamma)}{2(1+\gamma)(2-\gamma)(2-\gamma^2)} > 0$ and $q_{wreg}^{B*} - q_{reg}^{C*} = \frac{(a-c)\gamma^2}{4(1+\gamma)(2+\gamma)} > 0$. Similarly, if $TW_{reg}^{B} > TW_{wreg}^{C}$ and $TW_{wreg}^{B} > TW_{reg}^{C}$, then $TW_{reg}^{B} > TW_{wreg}^{C} > TW_{wreg}^{B} > TW_{reg}^{C}$ ($TW_{wreg}^{C} > TW_{wreg}^{B}$ has been proven by Alipranti et al. (2014)). This is true since $TW_{reg}^{B} - TW_{wreg}^{C} = \frac{(a-c)^2\gamma^2(8-3\gamma^2)(1-\gamma)^2}{4(1+\gamma)(2-\gamma)^2(2-\gamma^2)^2} > 0$ and $TW_{wreg}^{B} - TW_{reg}^{C} = \frac{(a-c)^2\gamma^2(8-\gamma^2)}{16(1+\gamma)(2+\gamma)^2} > 0$ □

Proposition 5 is illustrated in Table 1.

[Table 1 about here]

Table 1 illustrates our findings for different values of γ. The second (third) and the fourth (fifth) columns illustrate the case of downstream Cournot (Bertrand) competition under regulated and deregulated upstream monopoly , respectively. We assume the following functional forms and parameter values: $a = 1$, $\beta = 0.6$ and $c = 0.08$ [The value of β is approximated based on Draganska et al. (2010), while the value of c is based on Davis & Muehlegger (2010)]. The values of γ are those used by Correa-López (2007). In general, parameter values were chosen so as to generate realistic results.

Our findings have important implications for the type of policies imposed by the National Regulatory Authorities (NRAs) on natural monopolies such as network industries (electricity, natural gas distribution segments, telecommunications networks, etc.). We argue that when downstream Bertrand competition is present, by applying a non-linear pricing mechanism leading to a marginal price equal to marginal cost, the NRAs increase the level of production and eliminate the deadweight loss associated with the existence of the (upstream) monopoly. In such cases (e.g., commercial and residential customers of natural gas) the NRAs can efficiently allow the monopolist to recoup its fixed costs by charging fixed fees that do not depend on the level of production (Davis & Muehlegger, 2010). On the other hand, when downstream Cournot competition is present (e.g., industrial customers of natural gas) and customers are paying both a fixed monthly fee and a price per unit equal to marginal cost of the upstream monopoly, our findings reveal that a two-part tariff pricing scheme leads to significant welfare loss. In other words, in the imposition of a two-part tariff marginal cost pricing scheme, the regulatory authorities should indeed take into account the nature of downstream competition. Our results indicate that the NRAs should be skeptical on the type of regulation in the two-tier industries. Similarly, they indicate that it is important in the evaluation of an effective regulatory scheme that the downstream rivals compete in prices rather than quantities because otherwise different policy implications could be drawn.

5 Linear pricing

To further check for the robustness of our findings, we consider the case where the upstream monopolist trades with the downstream firms via linear contracts. By dropping F (the fixed tariff) and conducting the same analysis as above, we get the following equations:

$$CS^{C}_{lwreg} = \frac{(1+\gamma)(2-\beta)^2(a-c)^2}{4(2+\gamma)^2} \tag{22}$$

$$TW^{C}_{lwreg} = CS^{C}_{lwreg} \times \frac{\beta(1+\gamma)+2(3+\gamma)}{1+\gamma} \tag{23}$$

$$CS^{B}_{lwreg} = \frac{(a-c)^2[\gamma^3(1-\beta)(1-\gamma)-2(\beta+\gamma)+\beta\gamma(1-\gamma)+4]^2}{(1+\gamma)(2-\gamma)^2[\gamma^3(1-\beta)(1-\gamma)-2\gamma(1+\beta\gamma)+4]^2} \tag{24}$$

$$TW^{B}_{lwreg} = CS^{B}_{lwreg} \times A \tag{25}$$

$$CS^{C}_{lreg} = (1+\gamma)\left(\frac{a-c}{2+\gamma}\right)^2 \tag{26}$$

$$TW^{C}_{lreg} = (a-c)^2\frac{(3+\gamma)}{(2+\gamma)^2} \tag{27}$$

$$CS^B_{lreg} = (1+\gamma)\left(\frac{a-c}{(1+\gamma)(2-\gamma)}\right)^2 \quad (28)$$

$$TW^B_{lreg} = \frac{(a-c)^2(3-2\gamma)}{(1+\gamma)(2-\gamma)^2} \quad (29)$$

where $A = [\gamma^3(1-\beta)(1-\gamma)-2(\beta+\gamma)+\beta\gamma(1-\gamma)+4][12+2\beta-(14+\beta)\gamma-(7\beta-4)\gamma^2+(3+\beta)\gamma^3+(1-\beta)\gamma^4(2\gamma-5)]$ and subscripts $lreg$ and $lwreg$ denote the existence and the absence of regulation in the upstream monopoly, respectively. It can be easily shown that 26-29 are equivalent to those generated in the case of non-linear marginal cost pricing (section 3.1). Given this result and by performing tedious calculations, we get $CS^B_{lreg} = CS^B_{reg} > CS^C_{lreg} = CS^C_{reg}$, $CS^B_{lreg} > CS^B_{lwreg} > CS^C_{lwreg}$, $CS^C_{lreg} > CS^C_{lwreg}$, $TW^B_{lreg} = TW^B_{reg} > TW^C_{lreg} = TW^B_{reg}$, $TW^B_{lreg} > TW^B_{lwreg} > TW^C_{lwreg}$ and $TW^C_{lreg} > TW^C_{lwreg}$. Figures 1-6 illustrate the validity of the previous inequalities.[4] Moreover from the aforementioned inequalities and the discussion in section 4, it follows that $CS^C_{wreg} > CS^C_{lwreg}$ and $TW^C_{wreg} > TW^C_{lwreg}$.

[Figures 1 to 6 about here]

The absence of the fixed fee in the case where trading occurs via linear contracts, eliminates the commitment problem and leads to results consistent with conventional wisdom (Bertrand competition is more efficient than Cournot competition).

Furthermore, the level of consumers' surplus and total welfare remain unchanged under marginal cost pricing regardless of the type of the tariff charged by the upstream monopoly (i.e., linear or non-linear). More specifically, when trading occurs via linear contracts, the

[4] We use figures instead of algebraic expressions for reader-friendly purposes.

fixed tariff representing the profits of the monopoly under non-linear tariffs is distributed to the downstream firms. However, this change does not alter the final results.

In conclusion, the dilemma of regulation presented in section 4 does not exist under linear contracts; efficiency dictates regulation of the upstream monopoly regardless of the type of the downstream competition.

6 Concluding remarks

In this paper we investigate whether the decision of regulating or deregulating an upstream monopoly is based on the nature of the downstream competition (Cournot vs. Bertrand). To this purpose, we use a simple model of a vertically linked market, where an upstream regulated monopoly is trading via two-part tariff contracts with a downstream duopoly. Our findings indicate that the nature of downstream competition in vertically linked markets with an upstream natural monopoly constitutes an important signal for the regulator. We show that monopoly regulation consisting of a non-linear marginal cost based pricing scheme is efficient under downstream Bertrand competition and inefficient under downstream Cournot competition. Our findings suggest that the regulatory authorities' decisions of whether or not they should regulate a market with upstream natural monopoly characteristics should depend, among other things, on the nature of downstream competition. We have to stress however, that the aforementioned results are not necessarily robust to alternative assumptions regarding the upstream market structure and/or the contracting procedure/contract type. For example when the upstream monopolist trades with downstream firms via linear contracts then the type of the downstream competition does not affect the decisions of the regulator. This implies that the results regarding the comparison of Cournot and Bertrand competition depend on the specific features of the vertically linked markets. Furthermore, the important policy implications of our results call for further investigation through empirical research.

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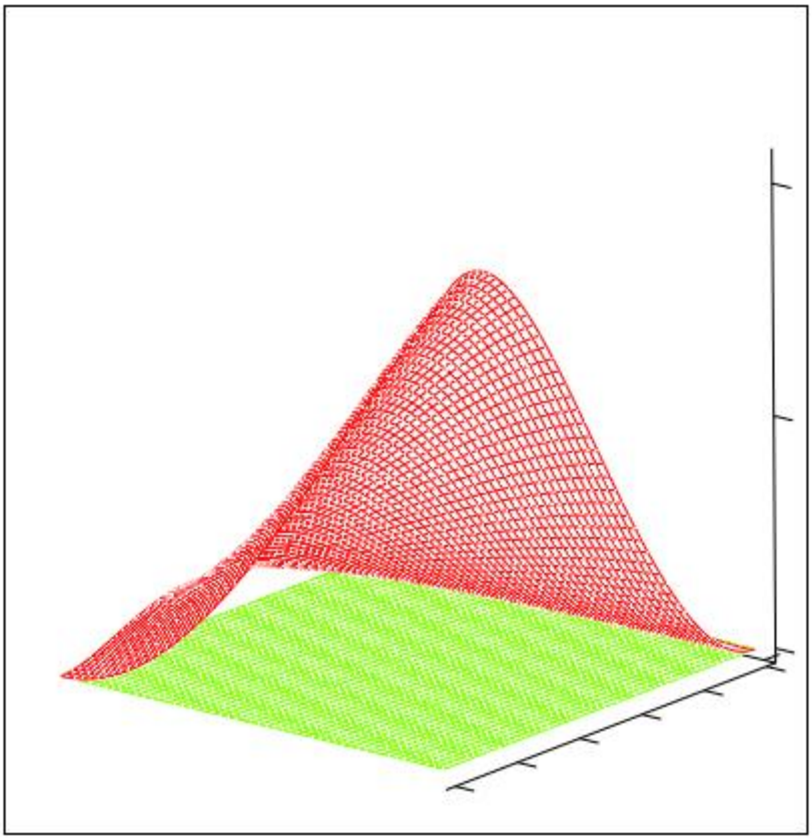
Table 1: Nature of downstream competition and regulation

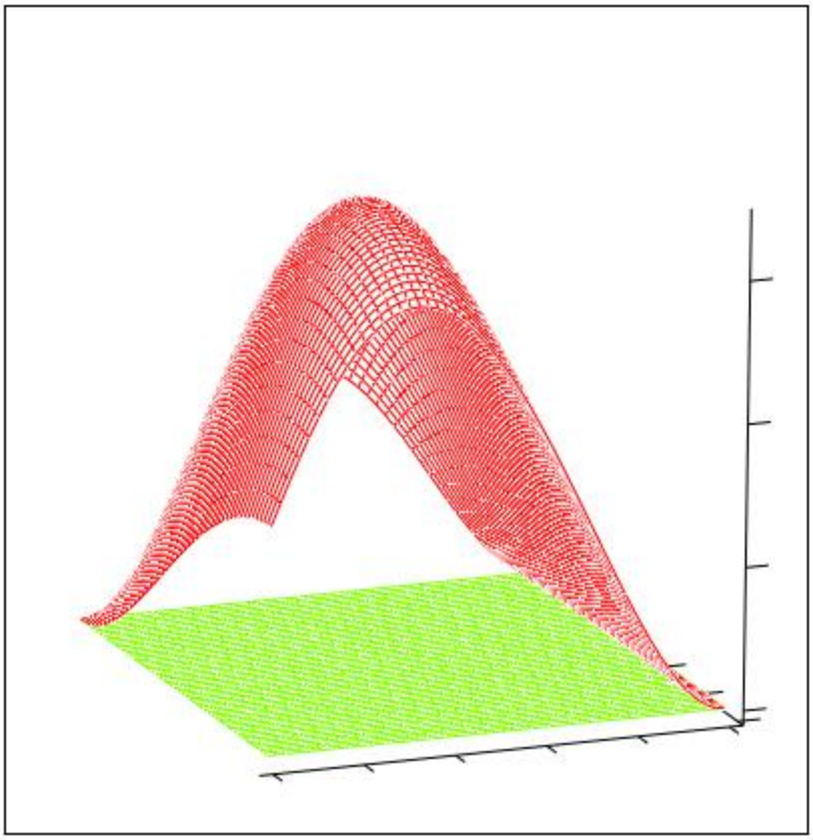
	Regulation		**Deregulation**	
	Cournot	*Bertrand*	*Cournot*	*Bertrand*
$\gamma = 0.3$				
CS	0.208	0.225	0.218	0.215
TW	0.528	0.541	0.535	0.533
$\gamma = 0.5$				
CS	0.203	0.251	0.233	0.220
TW	0.474	0.502	0.492	0.485
$\gamma = 0.8$				
CS	0.194	0.327	0.297	0.230
TW	0.410	0.457	0.450	0.428

Figure 1: Consumers' surplus – Bertrand vs. Cournot downstream competition



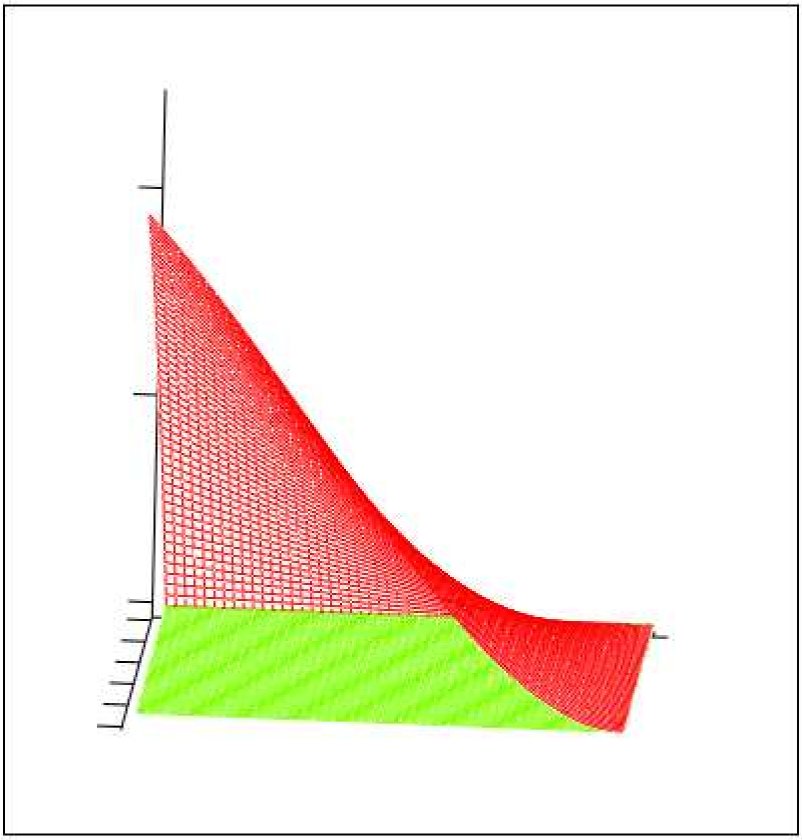
Note: $CS^{B}{}_{lwreg} - CS^{C}{}_{lwreg}$ gives a result of the form $(c-a)^2 \dfrac{y(\beta,\gamma)}{g(\beta,\gamma)}$ with $g(\beta,\gamma) > 0$. $y(\beta,\gamma)$ (red surface plot) is depicted in the vertical axis and $\beta \in (0,1]$, $\gamma \in (0,1)$ in the horizontal axes. The green surface plot is the zero hyperplane.

Figure 2: Total welfare – Bertrand vs. Cournot downstream competition



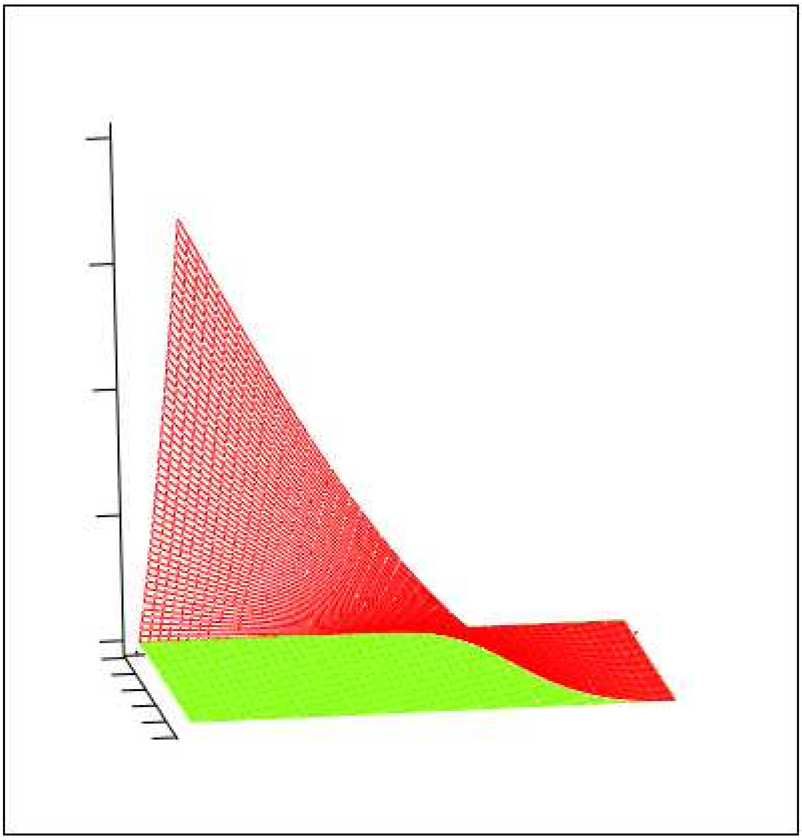
Note: $TW^{B}{}_{lwreg} - TW^{C}{}_{lwreg}$ gives a result of the form $(c-a)^2 \dfrac{y(\beta,\gamma)}{g(\beta,\gamma)}$ with $g(\beta,\gamma) > 0$. $y(\beta,\gamma)$ (red surface plot) is depicted in the vertical axis and $\beta \in (0,1]$, $\gamma \in (0,1)$ in the horizontal axes. The green surface plot is the zero hyperplane.

Figure 3: Consumers' surplus – Regulated vs. deregulated upstream monopoly with Bertrand downstream competition.



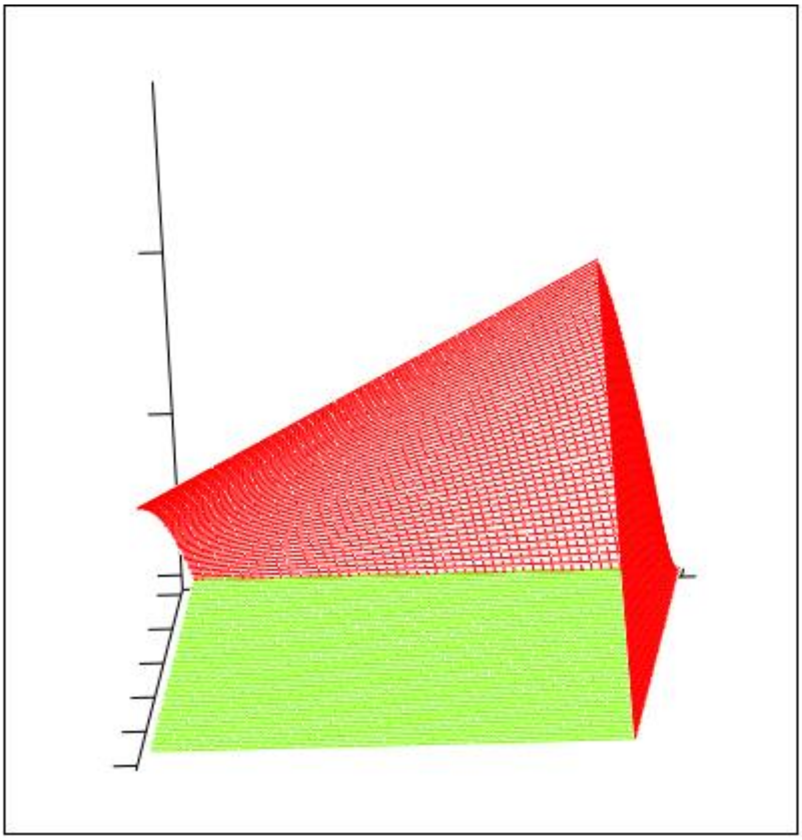
Note: $CS^{B}{}_{lreg} - CS^{B}{}_{lwreg}$ gives a result of the form $(c-a)^2 \dfrac{y(\beta,\gamma)}{g(\beta,\gamma)}$ with $g(\beta,\gamma) > 0$. $y(\beta,\gamma)$ (red surface plot) is depicted in the vertical axis and $\beta \in (0,1]$, $\gamma \in (0,1)$ in the horizontal axes. The green surface plot is the zero hyperplane.

Figure 4: Total welfare – Regulated vs. deregulated upstream monopoly with Bertrand downstream competition.



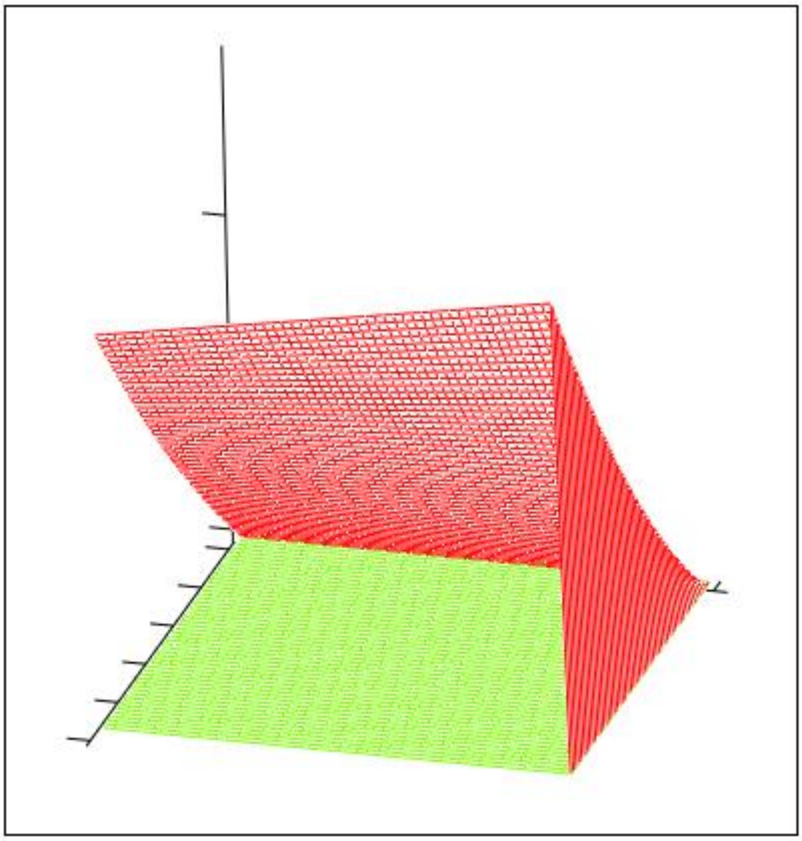
Note: $TW^{B}{}_{lreg} - TW^{B}{}_{lwreg}$ gives a result of the form $(c-a)^2 \dfrac{y(\beta,\gamma)}{g(\beta,\gamma)}$ with $g(\beta,\gamma) > 0$. $y(\beta,\gamma)$ (red surface plot) is depicted in the vertical axis and $\beta \in (0,1]$, $\gamma \in (0,1)$ in the horizontal axes. The green surface plot is the zero hyperplane.

Figure 5: Consumers' surplus – Regulated vs. deregulated upstream monopoly with Cournot downstream competition.



Note: $CS^{C}{}_{lreg} - CS^{C}{}_{lwreg}$ gives a result of the form $(c-a)^2 \dfrac{y(\beta,\gamma)}{g(\beta,\gamma)}$ with $g(\beta,\gamma) > 0$. $y(\beta,\gamma)$ (red surface plot) is depicted in the vertical axis and $\beta \in (0,1]$, $\gamma \in (0,1)$ in the horizontal axes. The green surface plot is the zero hyperplane.

Figure 6: Total welfare – Regulated vs. deregulated upstream monopoly with Cournot downstream competition.



Note: $TW^{C}{}_{lreg} - TW^{C}{}_{lwreg}$ gives a result of the form $(c-a)^2 \dfrac{y(\beta,\gamma)}{g(\beta,\gamma)}$ with $g(\beta,\gamma) > 0$. $y(\beta,\gamma)$ (red surface plot) is depicted in the vertical axis and $\beta \in (0,1]$, $\gamma \in (0,1)$ in the horizontal axes. The green surface plot is the zero hyperplane.