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Choosing price or quantity? The role of delegation and network externalities

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HIGHLIGHTS

- The price/quantity choice is investigated in a duopoly with network effects.
- It can be made by standard firms and by firms delegating market decisions to managers.
- Network effects do not affect the equilibrium choice of non-delegating firms.
- Under delegation they may lead to a unique equilibrium in which both firms choose price.

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ABSTRACT

We consider a differentiated duopoly and endogenise the firm choice of the strategy variable (price or quantity) to play on the product market in the presence of network externalities. We model this choice by assuming both competition between entrepreneurial (owner-managed) firms and competition between managerial firms in which market decisions are delegated from owners to revenue-concerned managers. While network externalities are shown not to alter the symmetric equilibrium quantity choice arising in the no-delegation case, sufficiently strong network effects allow us to eliminate the multiplicity of equilibria under delegation and lead to a unique equilibrium in which both firms choose price.

1. Introduction

In this paper we investigate the role of network externalities (or network effects) in driving the strategic choice between price or quantity competition in a market with differentiated products. Network externalities arise when the utility a consumer derives from joining a network (e.g. telephones, internet) is increasing in the number of users. A considerable body of the Industrial Organization literature has focused on the ways firms can benefit from the presence of network externalities and gain a competitive advantage. Indeed, network effects are shown to be exploited through compatibility strategies enabling firms to capture larger market shares (Katz and Shapiro, 1985), through pricing strategies allowing us to attract a critical mass of adopters and affecting market share dynamics (Cabral et al., 1999; Cabral, 2011) and through strategies affecting consumers' expectations on the network size—e.g., product pre-announcements (Farrell and Saloner, 1986).

All the above literature reveals the importance of both pricing and output choices in the presence of network externalities, and this raises the question whether choosing a price or a quantity contract is the optimal strategy in such contexts.[1] This is the point addressed in this paper. It presents a model of duopolistic competition aiming at capturing the effects of network externalities on firms' strategic decision making. The latter is modelled either as

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[1] The strategic decision between price and quantity of profit-maximising firms has been investigated in several settings in the Industrial Organization theory: see, among others, Singh and Vives (1984), Tanaka (2001) and Tasnádi (2006).

a profit-maximising decision process within owner-managed (entrepreneurial) firms or as a delegation process within managerial firms, in which firms' owners delegate market decisions to professional managers concerned with revenue maximisation (Fershtman and Judd, 1987; Sklivas, 1987). The analysis of the optimal price *vs.* quantity choice in these two strategic environments allows us to highlight the relative role of delegation and network externalities on the equilibrium outcomes.

We show that network externalities do not modify the equilibrium decisions of entrepreneurial firms—the result of Singh and Vives (1984) that quantity is the symmetric equilibrium choice being confirmed independently of the strength of the network effects. On the contrary, when firms are managerial, sufficiently strong network externalities fully reverse this outcome, supporting a unique equilibrium characterised by the symmetric choice of a price contract. This result contrasts with the multiplicity of asymmetric equilibria obtained by Bhattacharjee and Pal (2013) in an alternative framework with network effects and managerial delegation based on relative performance.[2] In their analysis, while delegation generates the absolute irrelevance of the type of contract, price or quantity, offered to customers (Miller and Pazgal, 2001), network externalities alter the relative profitability associated with the different firms' choices, but – independently of their size – leave unsolved the problem of multiplicity of pure-strategy equilibria. Our analysis shows instead that delegation supports, through the adoption of a revenue-based incentive scheme, two symmetric Pareto-rankable equilibria when network effects are zero or sufficiently weak. Strong network effects, however, drive the solution towards the symmetric price choice as a unique equilibrium.

The paper is organised as follows: the model is developed in Section 2, while comments and conclusions are gathered in Section 3.

2. The model

We assume that two technologically identical firms, 1 and 2, offer two varieties of a good characterised by network externalities. The direct and inverse demands for variety i are given respectively by

$$x_i = a + ny_i - p_i + \beta p_j \quad i = 1, 2\, j \neq i \tag{1}$$

$$p_i = \frac{a}{1-\beta} - \frac{x_i}{1-\beta^2} - \frac{\beta x_j}{1-\beta^2} + n\frac{y_i + \beta y_j}{1-\beta^2} \tag{2}$$

where y_i is the expected network size of variety i, $n \in [0, 1)$ measures the strength of the network externality, and $\beta \in [0, 1)$ is a parameter capturing product differentiation.[3] In each firm production takes place at a constant average and marginal cost $c < a/(1-\beta)$.

In the sequel we analyse the choice of the strategic variable (price *vs.* quantity) taken in this market environment by managerial and entrepreneurial firms. In the former case firms' interactions are described by a three-stage game. The type of contract (price or quantity) offered to customers is selected at the first stage by the firm's owner. Market decisions are delegated to a manager whose objective function is a linear combination of profits and revenues:

$$M_i = \theta_i \pi_i + (1-\theta_i)\, p_i q_i = (p_i - \theta_i c)\, q_i \quad i = 1, 2$$

where the parameter θ_i is strategically assigned by each owner to her manager on a profit-maximising basis at the second stage. At the last stage, the two managers compete according to the market variable and the extent of delegation decided by the owners at the previous two stages. By contrast, interactions between entrepreneurial firms are described as a two-stage game in which at the product market stage the profit-maximising owners directly compete according to the variable selected at the first stage.

We solve by backward induction the game with managerial firms, recovering the solution of the game with profit-maximising firms as a special case in which $\theta_i = 1$. The solution for the subgame perfect equilibrium of the whole game requires the solution of the subgames discussed in the following subsection.

2.1. The subgames

The pp subgame. If both firms choose a price contract at the first stage of the game, the resulting subgame is the situation described by Hoernig (2012), recalled here for completeness. At the market stage, given the demand (1) faced by the two firms, profit maximisation for given y_i leads to the following reaction function for any of the two firms:

$$p_i\left(p_j\right) = \frac{a + \theta_i c}{2} + \frac{n y_i + \beta p_j}{2}.$$

By substituting for y_i from (1) after imposing rational expectations ($x_i = y_i$), we obtain the RE reaction functions:

$$p_i^{\mathrm{RE}}\left(p_j\right) = \frac{a + \theta_i c\,(1-n)}{2-n} + \frac{\beta p_j}{2-n}, \quad i = 1, 2,\ j \neq i$$

which yield the following equilibrium prices:

$$p_i^{pp} = \frac{a}{2-n-\beta} + c\,(1-n)\,\frac{(2-n)\,\theta_i + \beta\theta_j}{(2-n)^2 - \beta^2}. \tag{3}$$

It is by anticipating this market outcome that at the second stage each firm formulates its optimal (profit-maximising) response in terms of the delegation parameter, $\theta_i\left(\theta_j\right)$, which can be solved under symmetry, yielding:

$$\theta_1^{pp} = \theta_2^{pp} = 1 + \frac{(a - (1-\beta)\,c)\left(n\,(n-2) + \beta^2\right)}{(1-n)\,(4 - (2+\beta)\,\beta - (2-\beta)\,n)\,c}.$$

The prices set by the two managerial firms playing the *pp* subgame are therefore

$${}_M p_1^{pp} = {}_M p_2^{pp} = \frac{((a+c)\,(2-n) - c\beta)^2}{\beta\,(2-n+\beta) - 2\,(2-n)}$$

while profits are

$${}_M \pi_1^{pp} = {}_M \pi_2^{pp} = \frac{(2-n)\,(a - c\,(1-\beta))^2\left(2-n-\beta^2\right)}{(1-n)\,(4 - (2+\beta)\,\beta - (2-\beta)\,n)^2} \tag{4}$$

where the subscript M denotes the outcomes of managerial firms.

The solution of the subgame with entrepreneurial firms is obtained by imposing $\theta_i = \theta_j = 1$ in (3), which leads to the following equilibrium prices:

$${}_E p_1^{pp} = {}_E p_2^{pp} = \frac{a + c\,(1-n)}{2-\beta-n}$$

and the following equilibrium profits:

$${}_E \pi_1^{pp} = {}_E \pi_2^{pp} = \frac{(a - c\,(1-\beta))^2}{(2-\beta-n)^2} \tag{5}$$

where the subscript E denotes the outcomes of entrepreneurial firms.

[2] The literature of strategic delegation has focused on profit and welfare implications of different types of incentive contracts: those based on revenues, output, relative performance or market shares. The endogenous choice of the type of contract has been studied in Jansen et al. (2009) and Manasakis et al. (2010).

[3] For the consumer's preferences delivering these demand functions, see Hoernig (2012), where a term capturing the network effect is added to a simplified version of Singh and Vives (1984) utility function and is such that utility is higher if expectations are fulfilled, i.e., $x_i = y_i$.