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Wholesale pricing and evolutionary stable strategies of retailers under network externality

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ABSTRACT

This study aims to investigate the mechanism of influence between the strategic choice of the marketing objective of retailers and the wholesale pricing of the manufacturer in a market with network externality by developing an evolutionary game model for a one-population of retailers and an optimisation decision model of the wholesale pricing of the manufacturer. Using these models we analyse the influence of network externality on the evolutionary stable strategy (ESS) of the retailers' marketing objectives, the wholesale pricing of the manufacturer, and the profits of nodal enterprises. The results show that the strength of network externality affects the decisions of the manufacturer with regard to wholesale pricing, thereby influencing the evolution of the marketing objectives of retailers. When the strength of network externality is found to be low, the manufacturer is supposed to set a high wholesale price to prompt retailers to take a profit maximisation strategy (*P* strategy). When the strength of network externality is moderate, a moderate wholesale price would be set by the manufacturer. Under this condition, the marketing objective of retailers is evolved to stable co-existence of profit, and revenue, maximisation. While when network externality exhibits a high strength, the manufacturer is expected to set a low wholesale price and therefore retailers change the marketing objective to revenue maximisation strategy (*R* strategy). When the market position of retailers is low, increasing network externality cannot generate more profits. On the contrary, affected by the decisions of the manufacturer with regards to wholesale pricing, retailers lose more profits, while the profit of the manufacturer increases. With the improvement of the bargaining power of retailers, the wholesale price and profit of the manufacturer decrease; however, a large network externality can make up a part of the profit losses of the manufacturer caused by the improved bargaining power of retailers.

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1. Introduction

In a market environment with dynamic competition, choosing a suitable marketing objective is of great importance to the development of enterprises as it determines the orientation of the business activities of enterprises at each stage. Profit maximisation and revenue maximisation are two different marketing objectives. The former is most commonly seen in enterprises and it is generally supposed in traditional economic theories that enterprises pursue profit maximisation. However, in reality, enterprises also generally maximise their revenue and evaluate their operating performance based on the revenue and its growth rate. It is found, in an investigation by the Conference Board to 658 Chief Executive Officers (CEOs) across the world that 37.5% of these CEOs regard it as a primary challenge to realise the sustainable and stable growth of op-

erating revenue. While within the scope in China, this proportion rises to 53.8% (Rudis, 2006). Therefore, seeking revenue maximisation is another important marketing objective for enterprises. In addition, existing studies indicate that enterprises adopting profit maximisation as their marketing objective in a competitive environment do not always acquire more profits than those applying revenue maximisation (Schaffer, 1988; Xiao & Yu, 2006a,b). This is because, compared with profit maximisation, revenue maximisation is more aggressive without considering the operating cost in decision-making but when seeking a larger market share. So, how do enterprises change their marketing objectives according to the dynamic and complex changes in market environment or how to choose the marketing objective when faced with different management scenarios? These topics have caused extensive concern in academic and business circles.

We study the above topics under the management scenario of network externality and supply chain. In the supply chain, the strategic choice of the marketing objective for enterprises is inevitably affected by horizontal and vertical enterprise decisions.

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For example, in the two-level supply chain composed of one manufacturer and two retailers, when the downstream retailer chooses the marketing objective, it is influenced by the strategic choice of the retailer in the same industry and the upstream manufacturer. In return, the decisions of the manufacturer can also be affected by the strategic choice of the marketing objective of the retailers. Then, in such long-term competitive interaction, can retailers obtain a higher profit from seeking profit maximisation or revenue maximisation? How can the manufacturer make the marketing objective selected by retailers more conducive to themselves through pricing decisions? These problems have been discussed in previous studies under different supply chain management scenarios (Xiao & Chen, 2009). However, these studies fail to consider the management scenario of network externality.

Network externality, as a typical characteristic that distinguishes a network economy from traditional economic theories, is essentially a demand-side economy of scale in the process of increasing the installed user-base. It was initially proposed by Katz and Shapiro in 1985 and defined such that the utility of consumers improves with the increasing number of consumers purchasing the same, or compatible, products (service). Typical commodities include: mobile phones, facsimile equipment, software and hardware for computing, etc. According to the definition, in addition to the influence of the value of commodities, the purchase decisions of consumers are also influenced by the network value composed of the user scale of commodities and the strength of network externality. Therefore, the presence of network externality promotes the willingness of consumers to pay so that it can affect the purchase decisions of consumers by influencing their expectations of the market scale of products. Under this condition, retailers have to take the influence of the change in market demand caused by network externality into account and adjust the decisions of price and order quantity as well as the ways of realising a profit, that is, profit maximisation or revenue maximisation. Similarly, the manufacturer can also observe this change in market demand and thereby adjust the wholesale price so as to induce retailers to adopt more beneficial operating strategies. Accordingly, under network externality, new characteristics and rules are supposed to be found in the decisions of the manufacturer and retailers. Thus, it becomes a new, important, academic problem to study the relationship between the choice of marketing objective or the ways for the profits of retailers and the pricing decisions of the manufacturer.

By using evolutionary game theory, we explore the relationship between the strategic choice of marketing objective of retailers, and the pricing decisions of the manufacturer under network externality in a two-level supply chain system consisting of one manufacturer and one population of retailers. The following questions are mainly discussed: (1) the conditions for the evolutionary stability of pure-strategy equilibrium (profit maximisation and revenue maximisation) and mixed-strategy equilibrium; (2) the method how the manufacturer set the wholesale price under the condition that they have known the ESS of retailers; and (3) the influences of network externality on the decisions of the manufacturer for the wholesale price and the ESS of retailers as well as the profit of nodal enterprises. Our results show that network externality can affect the decisions of the manufacturer for wholesale pricing, thereby influencing the evolution of the marketing objective strategy of retailers. With increasingly strong network externality, the profit of the predominant manufacturer grows accordingly, while those of the subordinate retailers decrease. The improvement of the bargaining power or market position of retailers decreases the wholesale price and profit of the manufacturer, while the network externality (at higher strength) can make up a part of the profit losses of the manufacturer.

The rest of this paper is organised as follows: Section 2 reviews relevant studies, Section 3 describes the proposed models and presents the demand function of retailers, while the balance of the single duopoly game equilibrium of retailers is analysed in Section 4, Section 5 shows the ESS of retailers under different wholesale prices, Section 6 presents the decision model for the optimal wholesale price of the manufacturer, Section 7 verifies and analyses the theoretical results using numerical examples, and in the last section, the conclusions are summarised, along with recommendations for subsequent research directions.

2. Literature review

Previous literature related to this study mainly concern three topics: the influence of network externality on the competitive strategy, competitive decisions of enterprises under the marketing objective of non-profit maximisation, and the strategic choice of the marketing objective of profit maximisation or revenue maximisation.

We mainly pay attention to the influence of network externality on the competitive strategy. Baake and Boom (2001) analysed the influence of the strength of network externality on the market equilibrium based on the vertical differentiation model. Their findings show that when vertically differentiated products present network externality, the quality difference of products mitigates price competition among manufacturers. Prasad, Venkatesh, and Mahajan (2010) discussed the impact of network externality on the choice of the pure bundling, or mixed bundling, of products. Their results suggest that, when two kinds of products both show strong network externality, adopting pure bundling is more conducive to making profit. When strong network externality is merely found in one product, selecting mixed bundling is more profitable. Cheng, Liu, and Tang (2011) studied the influence of network externality on the compatibility strategy of proprietary software and open-source software. They discovered that under the effect of network externality, the compatibility with the software produced by competitors goes against the suppliers of proprietary software, but helps open-source software communities. After studying the optimal pricing strategy of enterprise resource planning (ERP) systems for sellers, Hajji, Pellerin, Léger, Gharbi and Babin (2012) suggested that sellers consider the dynamic pricing and network structure before entering a market. Implementing a suitable dynamic pricing strategy is obviously superior to a fixed price strategy and a dynamic pricing strategy containing fixed variables. By analysing the influence of network externality on the management delegation of enterprise owners, Hoernig (2012) found that enterprise owners would adopt more aggressive contracts to stimulate managers into seizing market share with a strong network externality. Chirco and Scrimatore (2013) discussed the effects of network externality on the selection of price strategy and quantity strategy under the management delegation of enterprise owners. They found that the price strategy is the only equilibrium strategy in the market with sufficient strength of network externality. By investigating the strategic choice of whether, or not, to provide an on-line service, Etzion and Pang (2014) found that when the service offered has network externality, the strategic choice depends on the decisions and service quality of competitors. Based on relative performance targets, Pal (2015) studied the influence of positive network externality on price strategy and quantity strategy. He discovered that under the effects of positive network externality, there are two pure-strategy Nash equilibria, that is, (quantity strategy, price strategy) as well as (price strategy, quantity strategy), and a mixed-strategy equilibrium of these two pure strategies. Liu, Li, and Kou (2015) investigated the impact of network externality on the marketing channel strategy and versioning strategy of information products. The results revealed that when network

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