



An evolutionary stable strategy for retailers selling complementary goods subject to indirect network externalities



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ABSTRACT

A two-population evolutionary game model is constructed for retailers and used to investigate the effect of indirect network externalities (INEs) and product complementarity on the strategic choice of marketing objective of the retailers. The results show that their strategic choice of marketing objective is correlated with market reservation price (MRP) when the strength of the INE is low. When the MRP is low, the retailers tend to adopt a strategy of profit maximization. As MRP increases, low-cost retailers adopt a strategy of revenue maximization instead of profit maximization to maximize revenue at an earlier stage than high-cost retailers. However, when the strength of the INE is high, retailers only choose a strategy of revenue maximization as their marketing objective. The probability that a retailer uses a revenue maximization strategy increases as the strength of the INE grows, and product complementarity increases, when there is an equilibrium between two pure marketing objective strategies. An optimal preference ratio for retailers may exist when the strength of INE is found to be not large enough. Numerical examples reveal that the degree of preference of retailers to maximize profit is shown to be negatively correlated with both INE and product complementarity. On the other hand, their profits are positively correlated with both of these factors.

1. Introduction

As marketing objectives determine the direction of development of an enterprise, enterprises have to dynamically choose suitable marketing objectives, depending on the dynamic environment present, so as to maintain their competitive advantage. It is well known that two possible marketing objectives involve pursuing maximum profit or maximum revenue. Of the two, pursuit of profit maximization is considered to be the most common marketing objective of enterprises. As a result, traditional economic theories usually suppose profit maximization is their decision goal. However, enterprises also pay close attention to their revenue. For instance, enterprises usually maximize their revenue and evaluate their business performances according to their annual revenue. At the same time, their preference is to release data relating to their revenue and revenue growth in order to reveal their performance and promote their reputation through advertising and propaganda. By so doing, they aim to attract more consumers and thus extend their market share.

The Conference Board, based on an investigation into 558 CEOs around the world, recently found that 37.5% of people consider their primary challenge is to find ways to realize stable sustainable revenue

growth. This proportion is even larger in China where it amounts to 53.8% (Rudis, 2006). Hence, it is clear that pursuit of revenue maximization must also be deemed an important enterprise behavior. The topics of how to adjust marketing objectives in response to a dynamically changing complex environment (so as to acquire long-term competitive advantage), and how to select marketing objectives for a diverse range of economic scenarios, have aroused a considerable amount of interest in academic and business circles.

In this work, we consider the topics outlined above for an economic scenario involving product complementarity and network externality. ‘Complementary goods’ are ones whose rates of consumption are dependent on each other. Consumers acquire greater utility using two such products *simultaneously* compared to the sum of the utility acquired using each *individually* (Bhaskaran and Gilbert, 2005). Examples include products such as computer hardware and software, computer operating system and application software, etc. Such products have demands that are obviously correlated: increasing the price of one of the products reduces the demand for its complementary product (and, conversely, decreasing the price increases demand for the complementary product). Therefore, enterprises selling complementary products need to adjust their ordering plans and marketing

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objectives to account for demand change induced by product complementarity. Previous studies have mainly focused on the pricing of complementary products (Gabszewicz et al., 2001; Mukhopadhyay et al., 2011). However, Xiao and Yu (2006a) did take into account the effect of product complementarity on retailers' strategic choice of marketing objectives. Unfortunately, their research failed to include network externality.

'Network externality' is essentially a demand-side economy of scale in the process of increasing installed user-base and is a typical characteristic that distinguishes a network economy from traditional economies. The concept was initially proposed by Katz and Shapiro (1985). Essentially, the idea is that the utility derived by a consumer increases as the number of consumers purchasing the same, or compatible, products (services) increases. They also proposed that complementary products will produce an *indirect* network externality (INE), which influences product value by increasing the number of consumers purchasing complementary products. For instance, a consumer's decision to buy a Windows operating system is not just affected by the value of the Windows operating system itself. Rather, it is also influenced by its network value (i.e. the large number of other users) and the intensity of the INE effect due to Microsoft's Office application software, which is complementary with Windows. This highlights the fact that the presence of INEs increases the willingness of consumers to buy complementary products. That is, INEs can influence a consumer's decision by changing their expectation of the market scale of complementary products. As a result, retailers have to take the effect of change in market demand caused by an INE into account. Their response is to adjust their pricing decisions and order quantities as well as the way in which they realize their profit (that is, should they aim for profit maximization or revenue maximization?). Accordingly, new characteristics and rules need to be found to determine the decisions made by retailers as they account for INEs. The problem of determining the retailers' strategic choice of marketing objectives, and their ways of realizing a profit in response to INEs, thus constitutes a new and important field of academic study.

In this study, we explore the strategic choices of retailers in two vertically-integrated supply chain systems under a scenario involving both product complementarity and INE using an indirect evolutionary game approach. The results show that the retailers' selection of marketing objective is correlated with market reservation price (MRP) when the strength of the INE is small. As MRP rises, low-cost retailers tend to use a revenue maximization strategy in place of profit maximization strategy at an earlier stage than high-cost retailers. That is, profit maximization is converted to revenue maximization. However, when the INE has a strong effect, all retailers prefer to adopt revenue maximization strategy as their marketing objective. When there is a mixed equilibrium of two pure strategies of marketing objective coexisting, the probability that retailers adopt a revenue maximization strategy increases with rising INE strength and product complementarity.

The rest of the paper is organized as follows. In Section 2, we review studies in the literature that are of relevance. Section 3 describes the evolutionary game model for retailers and Section 4 illustrates the evolutionary stable strategies (ESSs) adopted by retailers under different conditions. Section 5 considers an extended model of hybrid strategies. Section 6 verifies and analyses the theoretical results obtained from numerical examples and Section 7 presents our conclusions and proposed direction of future research.

2. Literature review

One area of the literature of interest to our research is that related to marketing objectives. Determining the appropriate marketing objective for a firm has become a practical problem of some importance and has been well studied in the literature. Baumol (1967) considered maximizing sales revenues subject to certain profit constraints as a

typical marketing goal for oligopolies, and pointed this out mainly because the salaries and earnings of top managers are positively correlated with sales. Barros (1995) found that private owners and the public owner (i.e. government) both like to design contracts for marketing objectives that are based on a linear combination of profit and sales revenues as this induces their managers to deviate from profit maximization. Yang et al. (2008) considered enterprises in the tourism supply chain and investigated their strategic choice between profit and revenue maximization. They concluded that enterprises choosing a revenue maximization strategy gain more market share and profit than those choosing profit maximization. However, the theme-park operator in the upstream end of the supply chain prefers hotels and travel agencies to maximize revenue. Donder and Roemer (2009) endogenized a firm's objectives as a function of the bargaining weights of two different factions, one composed of the firm's owners and one composed of the managers. These factions tend to maximize the profit and revenue, respectively. Oppen et al. (2012) analyzed 1555 turnover cases in listed, state-owned firms in China. They discovered that the turnover in CEOs was negatively related to the sales revenues of key businesses, rather than profits. Moreover, their statistical results showed that state shareholders actually placed more emphasis on sales revenue generation than profitability when monitoring their CEOs. Yang et al. (2014) studied price competition for retailers who simultaneously maximized the probability of achieving their profit and revenue targets. Most of the studies mentioned above were conducted under competitive market conditions, that is, the situation in which the firm's decisions are strategic substitutes. In this paper, we examine the implications of marketing objectives on equilibrium outcome under complementary market conditions.

Research on network externality is another area of the literature of interest to our study. This is quite an extensive area of research and is mainly concentrated on optimizing: the pricing strategy (Cabral et al., 1999; Cabral, 2011), innovation strategy (Vencatachellum and Boivin, 2002; Banerjee, 2013; Xing, 2014), technology compatibility decisions (Baake and Boom, 2001; Chen and Chen, 2011), sales channel strategy (Viswanathan, 2005; Liu et al., 2015), price and quantity competition strategy (Chirco and Scrimatore, 2013), investment strategy (Liao and Chen, 2014), and so on. These studies are focused on competitive enterprises producing substitute goods with direct network externality. However, in reality, indirect network externality derived from complementary goods is also a fairly common occurrence (e.g. computer hardware – software, CD title – CD player, etc.).

Economides (1996) adopted product complementarity as the source of network externality, and discussed the incentive an exclusive holder of a technology has to share it with competitors in a market with network externalities. Gupta et al. (1999) examined INE in the operation mode of a newly adopted product, and presented a conceptual and operational model for the evolution of the digital television market. Basu et al. (2003) used a hedonistic price approach to study the INE accrued from the effect of compatible complements on product attributes in the CD industry. They showed that INE effects that vary with the product's attributes are likely to help product managers and designers rethink their pricing strategies. In the current work, we use our model to investigate the effects of INEs on a retailer's choice between revenue maximization and profit maximization.

There is some work in the literature on evolutionary games that is also related to the contents of this paper. Bester and Güth (1998) developed an evolutionary approach to explain whether altruistic preferences are evolutionarily stable. It turns out that profit maximization may not always be an evolutionarily stable strategy. Güth and Peleg (2001) used indirect evolutionary game theory to study the conditions under which profit maximization survives. Xiao and Yu (2006a) discussed retailer strategy (profit vs. revenue maximization) in the situation where manufacturers offer differentiated goods. They showed that whether or not equilibrium corresponds to an evolutionarily stable strategy depends on the type of strategic interaction

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