Effects of Quality Improvement and Upgrading on Software Market Disruption

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ABSTRACT

Digital goods, such as software, are significant elements of the contemporary digital economy. The authors propose a model that characterizes dynamic profit-maximizing competitive pricing strategies of digital goods with network effects. In a two-period game theory model, an incumbent firm has a quality advantage in period 1, but the potential disrupter has a quality advantage in period 2. They analyze pricing strategies and characterize conditions under which the potential disrupter becomes an actual disrupter. They discuss implications for user adoption of digital goods and opportunities for future research.

KEYWORDS

Analytical Model, Competition, Digital Goods, Disruption, Game Theory, Network Effects, Pricing Strategies, Software, Upgrades

1. INTRODUCTION

The growth of software has been associated with the digital transformation of a wide variety of industries from media to transportation and healthcare. Software products, like other digital products, are characterized by interesting economic properties (Economides & Katsamakas, 2006). They are durable goods that tend to have low (or zero) marginal costs, network effects (Bakos & Katsamakas, 2008), and high switching costs associated with learning and data (especially for complex software products such as enterprise applications, e.g. ERP, CRM, etc.).

This paper analyzes strategic interaction in software markets using a game theory model that captures economic properties of software (and related digital goods). The main objective is to characterize how a potential disrupter competes with an incumbent software firm.

We present a framework of dynamic competitive adoption in the software industry. In particular, we consider zero marginal production costs, per-period network benefits and per-period consumer utility from software quality. In our two-period game theoretic model an incumbent firm has a quality advantage in period 1, but the potential disrupter has a quality advantage in period 2. We analyze pricing strategies and characterize conditions under which the potential disrupter becomes an actual disrupter.

First, we analyze competitive adoption in a basic setting, in which old consumers are not allowed to upgrade to the new version in period 2. Second, we analyze the case that first period consumers have the option to upgrade in the second period. Upgrading is a very common practice in software, but its strategic dimensions in the context of quality improvements and network effects is not well understood.

We characterize profit-maximizing upgrading pricing strategies. We derive the conditions under which it is optimal for firms to let old consumers buy the new version, and the conditions under which

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it is profit-maximizing to offer a discounted upgrading price. In the latter case, we find that firms are able to capture the whole upgrading surplus of the old consumers.

We show that the adoption patterns change significantly when upgrading is allowed: In particular, for every first period quality advantage of the old software, there is a second period advantage of the new software such that all consumers adopt the new software in both periods.

2. BACKGROUND

Earlier research closest to our model is the work on dynamic competitive adoption of technologies with network externalities (Katz & Shapiro, 1986). That paper considered a two period setting with two technologies, in which the old technology has a first period marginal production-cost advantage, while the new technology has a second period marginal production-cost advantage. The main goal of the paper was to analyze how technology sponsorship matters. We modify and extend that framework to analyze dynamic competitive adoption in the software industry.

A number of analytical modeling papers have examined various aspects of software pricing. (Jia, Liao, & Feng, 2018) compare selling and leasing pricing models. (Guo & Ma, 2018) examine competition between perpetual software and software as a service. (Wu, Nan, & Li, 2018) analyze freemium in presence of piracy. (Li, Cheng, Duan, & Yang, 2017) analyze enterprise software licensing. (Morgan & Ngwenyama, 2015) examine enterprise software upgrades using a real options perspective. (Wei & Nault, 2013) analyze a “version-to-upgrade” model for experience information goods. (Liu, Cheng, Tang, & Eryarsoy, 2011) and (Ahtiala, 2006) examine software pricing in presence of piracy. (Doğan, Ji, Mookerjee, & Radhakrishnan, 2011) analyze word-of-mouth effects and upgrade design effort of a software monopolist. (Mehra, Bala, & Sankaranarayanan, 2012) examine competition and switching costs in a horizontal differentiation (hoteling) setting. (Zhang & Seidmann, 2010) compare perpetual and subscription licensing under quality uncertainty. (Bala & Carr, 2009) analyze upgrade prices of a monopolist for various levels of user costs. (Zhao & Jagpal, 2009) analyze how market growth may affect software pricing in a monopoly setting. (Choudhary, 2007) compares software quality under perpetual licensing and software as a service. (Kornish, 2001) analyze the existence of an equilibrium pricing strategy of a durable good monopolist under fast sequential innovation. (Ellison & Fudenberg, 2000) analyze when a monopolist may offer excessive upgrades. (Fishman & Rob, 2000) examine conditions under which a durable good monopolist may introduce innovations at a slow rate over time. (Fudenberg & Tirole, 1998) examine upgrades, trade-ins and buybacks for various types of products.

Moreover, empirical papers have provided additional factors affecting software pricing, as well as effects. (Khoo & Robey, 2007) discuss organizational factors surrounding the decisions to upgrade enterprise software. (Khoo, Robey, & Rao, 2011) discuss how enterprise software upgrades may impact stakeholders in an organization. Katsamakas and Georgantzas (2010) explore the concept of disruptive innovation in context of open source software. (Mathew & Nair, 2010) use survey research approach to explore software as a service pricing. (Förderer & Heinzl, 2017) provide empirical evidence that existing users may respond negatively to mobile app updates. (Lehmann & Buxmann, 2009) discuss empirical evidence of software pricing strategies. As early as 1993, users observed that upgrades may make software very costly (Meyer, 1993).

3. MODEL

In this section we develop the basic framework of dynamic competition in software industry.

We consider a duopoly (firms A, B) with two time periods t = 1, 2. In each period, firms decide on the prices p_t, q_t of their software A_t, B_t and then consumers choose their preferred brand (Figure 1). The two software products have different intrinsic qualities α_t, β_t. These parameters capture the functionality, ease of use and other related features of the software products. Qualities are exogenous
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