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## Full Length Article

# Beyond the more the merrier: The variety effect and consumer heterogeneity in system markets<sup>☆</sup>

Li Sun<sup>a,\*</sup>, Surendra Rajiv<sup>b,1,†</sup>, Junhong Chu<sup>c,2</sup><sup>a</sup> Zayed University, P.O. Box 19282, Dubai, United Arab Emirates<sup>b</sup> Philind Motion Pictures Private Limited, 1004 B, Hill Grange, Hiranandani Estate, Thane (W) 400607, India<sup>c</sup> NUS Business School, BIZ 1, 8-34, 15 Kent Ridge Drive, Singapore 119245, Singapore

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## ABSTRACT

Research in indirect network effects has simplistically treated complementary product variety as the *total number* of complementary products (e.g., game titles in video game markets). This assumption of equi-differentiation ignores differences across genres or product categories. Furthermore, since consumers with differential preferences for variety enter the market at different stages, consumer heterogeneity in preference for variety in complementary products may evolve as the market develops. We propose a model that recognizes these previously ignored, but important, demand characteristics, and empirically investigate the effects of breadth and depth of software variety on consumer hardware adoption in the fifth-generation video game market. We find that early adopters seek variety across a wide spectrum of game genres, and that late adopters are interested only in action-oriented games and have no interest in strategy-oriented games unless they are so-called “superstars.” Our findings imply that effective variety planning should be built along both dimensions, instead of simply assuming that more is better. Our policy simulations demonstrate that variety planning is as critical as entry timing to the success of platform companies in system competition, and is one of the reasons for PlayStation’s winning the battle against Nintendo64. In addition, the boosting effect of a new title on hardware sales perishes quickly, so it is important to have a cascade strategy to guarantee a continuous supply of complementary software.

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## 1. Introduction

Many consumer electronic devices have become platforms for daily communication, office work, or entertainment activities when powered by frequently updated applications and content. For instance, smartphones enable consumers to make phone calls, play games, check email, and enjoy web-based services. Video game consoles are hardwired with an operating system with which consumers can play different genres of games. The hardware/platform and software together form a system

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\* Corresponding author. Tel.: +971 44021440.

E-mail addresses: [li.sun@zu.ac.ae](mailto:li.sun@zu.ac.ae) (L. Sun), [surendra.rajiv@gmail.com](mailto:surendra.rajiv@gmail.com) (S. Rajiv), [bizcj@nus.edu.sg](mailto:bizcj@nus.edu.sg) (J. Chu).

<sup>1</sup> Tel.: +91 9619569666.

<sup>2</sup> Tel.: +65 65166938.

<sup>†</sup> Prof. Surendra Rajiv has passed away. He had been and will continue to be a great source of inspiration for us.

(Binken & Stremersch, 2009); the hardware by itself has little or no value to consumers unless it is supported by a variety of complementary software.

Many system markets, especially those in the information technology (IT) industry, are subject to indirect network effect (Katz & Shapiro, 1985, Shapiro and Varian 1999, Sriram et al., 2015), which causes consumer demand for a platform to depend on the supply of complementary products, and vice versa. Platform providers may not have enough resources to produce all complements in-house, or find it economically more efficient to outsource. Therefore, we often observe a large number of independent content providers or third-party software developers who work with specific platforms, which distinguishes system markets from traditional multiproduct markets. Many empirical studies have examined the existence and strategic implications of the indirect network effect on various digital economies, such as DVDs (Dranove & Gandal, 2003), television advertising (Wilbur, 2008), video games (Dubé, Hitsch and Chintagunta 2010, Liu, 2010), and online consumer-to-consumer platforms (Chu & Manchanda, 2015).

Home video games have been accepted as a canonical example of system markets whose growth is primarily driven by the indirect network effect. However, findings on this effect are mixed. While the majority of studies report significant and positive effects in line with economic theory, some have found it to be insignificant (Stremersch, Tellis, Franses, & Binken, 2007) and contend that hardware adoption is driven by “superstar” software (Binken & Stremersch, 2009). This intriguing discrepancy impels us to reexamine the characteristics of the indirect network effect more closely, so as to provide better guidance for marketing management and policy making.

We believe that at least two factors contribute to this inconsistency. First, how is complementary product variety measured? Indirect network effect literature has been criticized for its overly simplistic measure of software variety, which reveals only the total number of variants (Binken & Stremersch, 2009). A measurement that accounts for the characteristics of complementary products might alter the significance of overall indirect network effects. Second, how is consumer heterogeneity handled? When variety-seeking behaviors for complements differ among platform users, the strength of the indirect network effect at a market level might not be stable if the composition of consumers changes over time. In that case, the statistical significance of such an effect is insufficient to warrant the conclusion that software variety has little influence on the adoption of compatible hardware. In this study, we investigate these potential factors' relationship to the indirect network effect.

In system markets, consumers' variety-seeking behavior for complementary products is the micro-foundation for the existence of the indirect network effect (Chou & Shy, 1990, Church and Gandal 1992, Church, Gandal, & Krause, 2008). However, in most empirical studies (e.g., Dranove & Gandal, 2003, Dubé et al. 2010, Liu, 2010), variety is simply measured as the total number of software titles, overlooking the differences in content. Although this measure helps establish a direct link between variety-seeking behavior at the micro (individual) level and the indirect network effect at the macro (market) level, it ignores the fact that complements that serve different functions or offer different contents have varying degrees of importance in decisions about hardware adoption, and therefore the measure cannot suggest how to manage the variety of complementary products in order to accelerate platform adoption. We must instead examine software variety and consumer preference in a more nuanced way than simply assuming that more is better.

To make clear distinctions between variety-seeking behavior and the indirect network effect, we define *variety-seeking behavior* as individual consumers who prefer platforms with a greater variety of complementary products. Therefore, the utility function is assumed to monotonically increase with the variety of complements. In comparison, the *indirect network effect* is the market outcome of variety-seeking behavior when both increasing returns to scale for the production of complements and free entry to the software market are present; these are necessary requirements for the indirect network effect (Chou & Shy, 1990; Church et al., 2008). Accordingly, we use *variety effect* in our discussion of the structure of consumer preference, and *indirect network effect* for the overall outcome at the market level.

We propose a two-level construct that captures both the breadth and depth of variety. *Breadth* refers to the number of complementary product genres, because genres reveal the main theme or basic gameplay experience without going into detail and allow consumers to choose more easily by understanding the content's diversity (Agre, 1998). *Depth* refers to the number of game titles within each genre. These definitions are similar to those in the retailing literature of assortment management, where breadth of assortment is the number of product categories and depth is the number of stock keeping units in a particular category (Dhar, Hoch, & Kumar, 2001; Mantrala et al., 2009). Note that Binken and Stremersch (2009) examine the vertical (quality) differentiation of software and find strong superstar effects in game console adoption, whereas our definitions focus on horizontal differentiation between genres; therefore, our study complements theirs and enriches the literature in an important way.

As for the role of consumer heterogeneity, diffusion literature has shown that different consumer cohorts tend to adopt a new technology at different stages of the product's lifecycle (Rogers, 1983), and consumer heterogeneity can be critical to the growth of new technology (Bemmar, 1994; Song & Chintagunta, 2003). In system markets with a large variety of complements, the likelihood of heterogeneity in variety seeking is high and could be another reason for consumers to adopt a system at different periods. In the literature on network effect, however, consumers are assumed to be homogeneous in such behavior (Clements & O'hashi, 2005; Nair, Chintagunta, & Dubé, 2004). When the market is stable (or static), this may be sufficient to capture the overall network effect, but it provides little insight on differences in consumer preferences for complementary products, let alone guidance for platform companies seeking to match product offerings to consumer preferences. Furthermore, this approach becomes problematic when we study the adoption process throughout the platform lifecycle, during which the composition of different types of consumers may change. Therefore, even with market data, it is important to account for consumer heterogeneity when studying preference for variety.

Our approach to consumer choice has a number of advantages. It accommodates segment-specific variety-seeking behavior that eventually rolls up to market demand for hardware. It accounts for unobserved consumer heterogeneity, while keeping track of

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