



# When less can be more – Setting technology levels in complementary goods markets



Jörg Claussen<sup>a</sup>, Christian Essling<sup>b</sup>, Tobias Kretschmer<sup>c,\*</sup>

<sup>a</sup> Copenhagen Business School, Denmark

<sup>b</sup> ifo Institute for Economic Research at the University of Munich, Germany

<sup>c</sup> LMU Munich, Institute for Strategy, Technology and Organization, Germany

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## ABSTRACT

Higher technological quality often translates directly into higher consumer utility. However, many new products require a complementary product to operate. In such markets, releasing a technologically sophisticated product involves a trade-off as it excludes consumers whose complementary products no longer function with the core product. Firms therefore have to balance product quality against market size. Technological change brings a dynamic perspective to this trade-off as it renders existing technology obsolete but also increases performance of the complementary products, therefore increasing market potential. We study these mechanisms in the empirical context of computer games. In line with our expectations, we find an inverted U-shaped relationship between closeness to the technological frontier and sales revenues as well as differential effects of technological change depending on initial technological quality.

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## 1. Introduction

Choosing the right level of technological quality for new products is both important and difficult (Cooper and Kleinschmidt, 1987; Gjerde et al., 2002), even more so if the technological frontier moves due to technological change (Bhattacharya et al., 1998; MacCormack et al., 2001), sometimes unpredictably so (Mitchell, 1989; Tushman and Anderson, 1986). What a firm is developing right now might be obsolete by the time the product is introduced to the market. This creates incentives to position new products close to the technological frontier (Gjerde et al., 2002; Cooper and Kleinschmidt, 1987; Rindova and Petkova, 2007). As consumers value innovative products, a position closer to the technological frontier therefore usually increases their odds of buying.

However, a position close to the technological frontier might carry disadvantages if demand and industry conditions are not favorable (Ansari and Krop, 2012; Corrocher and Zirulia, 2010; Klenner et al., 2013). Firms have to consider the possibility that a technologically sophisticated and disruptive innovation may only

attract a small portion of potential consumers (Di Stefano et al., 2012; Klenner et al., 2013; Rogers, 2010). If the propensity to purchase a new product is linked to the maturity of the existing market (Corrocher and Zirulia, 2010; Klenner et al., 2013) or if the existing generation's age (Cucculelli and Ermini, 2012) or success (Eggers et al., 2013) are important determinants in the likely success of new products. When choosing their degree of technological sophistication therefore, firms have to consider the current state of the market and its consumers.

This trade-off is accentuated further if a product requires complements that also affect the product's performance (Fabrizio and Hawn, 2013; Matutes and Regibeau, 1988). In many cases, like razors and blades, complements simply provide a constant level of functionality to the core product, while in others the complement itself can have varying degrees of quality and performance and accordingly technological requirements. Consider the computer games industry. A game close to the technological frontier needs a fancy computer to run on. Developing such a game may be risky as high requirements on the complement (the computer) limit the potential market of gamers.

Complements unable to provide the required performance cannot support the core product. Hence, individuals using low-performance complements cannot use high-performance

\* Corresponding author at: Institute for Strategy, Technology and Organization, Kaulbachstr. 45, 80539 Munich, Germany. Tel.: +49 089 2180 6270.  
E-mail address: [t.kretschmer@lmu.de](mailto:t.kretschmer@lmu.de) (T. Kretschmer).

focal products. Managers of innovative products have to weigh up how close to the technological frontier their product should be. Too close means reducing market potential while too far implies that the product may not be attractive to consumers.

To illustrate this, consider two extreme examples. First, take a low-end focal product could be used with any complement on the market – say, the classical computer game Pong could run on any computer, or virtually any mobile phone can send and receive text messages. Anyone could use these products but few do as there are better, more sophisticated alternatives out there. Second, market potential for a cutting edge product is low. An app designed for the latest version of a mobile operating system shuts out all users of older phones that no longer support the new version, while early color TV programmers had to contend themselves with the initially small installed base of color TV set owners. Closeness to the technological frontier translates into high requirements on the complement which only few can provide, and while many consumers would like to, only few can actually use it. Hence, choosing the optimal closeness to the technological frontier (henceforth CTF), taking into account the current set of complementary products (Cabigiosu et al., 2013), matters for new product success.

Changing product characteristics is also often difficult, if not impossible after market introduction; i.e. the absolute level of performance remains constant for the rest of the product life cycle. At the same time, technological change pushes the frontier forward, which has two effects: On the one hand, the focal product becomes technologically less competitive as new product releases closer to the frontier raise the bar. On the other hand, technological change increases performance of the complementary product. Consequently, more consumers have a complement that can support the focal product. While the first effect decreases attractiveness, the latter increases market potential.

To generate insights on the relationship between closeness to the technological frontier, technological change and product success, we address two research questions:

1. Can setting quality too high hurt demand? Specifically, is there an inverted U-shaped relationship between CTF and revenues?
2. Can high-quality products better withstand technological change? Specifically, does CTF moderate the effect of technological change on revenues?

Our empirical setting, the computer games industry, is well-suited for our analysis for several reasons. First, a game's system requirements are a fair measure of closeness to the technological frontier. Second, computer games require a complement, the PC, and have specific requirements on its performance. Third, the computer games industry is subject to rapid technological change. Fourth, pricing in the computer games industry is largely uniform which helps us isolate the effect of CTF on revenues.

Using a rich dataset on the industry and its complementary goods, PCs, we find that games closer to the technological frontier are more successful, but only up to a certain point. In other words, there is an inverted U-shaped relationship between CTF and game revenues. This is because higher system requirements make the game more attractive but reduce market potential. Further, our findings show that technological change has a negative effect on revenues. This captures the effect of decreasing closeness to the frontier eventually leading to obsolescence. However, the effect of technological change turns positive if a game is initially close to the technological frontier. In this case, the market potential increasing effect outweighs the negative effect of obsolescence.

## 2. Theoretical mechanism

Systems of complements are well known. A DVD requires a DVD player, a razor needs blades, and the printer will not print without a cartridge. However, all of these products work once combined with an adequate complementary product and do not have particular requirements on the performance of their complement. Hence, the performance of a DVD is the same for any DVD player.

In addition to these cases of binary fit (it either works or it does not), there can also be a more nuanced relationship between the focal and the complementary product. This is the case if the focal product requires a minimum technological quality of the complementary product and both products can take on many different technological configurations. An example is trailers as the focal product and the cars towing them as the complementary product: trailers have different weights and one has to make sure that the car towing the trailer is powerful enough. Or consider the context we study: computer games as the focal product require computers (complementary product) with enough processing power to support the technological requirements of the game.

For these markets, performance of the focal product is determined by the complement's performance (Fabrizio and Hawn, 2013) in that focal products become more attractive if they are combined with higher performing complements. However, a minimum performance of the complement is required as complements below this threshold cannot support the focal product. For computer games, this is referred to as the minimum system requirements specifying the hardware of the computer. Any system configuration below this threshold cannot support the game. Accordingly, all individuals owning a computer below the minimum system requirements are excluded from consuming the product.

We discuss two important trade-offs affecting these complementary product markets: first, the static trade-off between market potential and product attractiveness and second, the dynamic trade-off between current and future revenues.

### 2.1. Static trade-off between market potential and product attractiveness

Choosing the technological characteristics of a new product is critical. All else equal, closeness to the technological frontier makes a product more attractive. Cooper and Kleinschmidt (1987) and Jain and Ramdas (2005) argue that superior performance is a key success factor for products. However, a position close to the frontier implies increased cost for research and development, reducing the incentives to position a new product close to the technological frontier (Gjerde et al., 2002).

Although various studies find a position closer to the technological frontier to be beneficial (Bartelsman et al., 2008; Cantner et al., 2012; Iacovone and Crespi, 2010), we argue that, in certain complementary goods markets, firms might want to position products away from the technological frontier, even if technological sophistication was costless. This is because being close to the technological frontier excludes consumers. In the markets discussed above, the focal product cannot be used if the complementary product does not provide the required performance. The closer the focal product is to the technological frontier, the closer to the frontier the complement has to be.

This creates a trade-off for firms positioning their new products. If we assume that the distribution of complement performance is exogenously determined for the firm,<sup>1</sup> then getting closer to the frontier reduces market potential. That is because the technological

<sup>1</sup> We can make this assumption if the complementary good is much more expensive than the focal product and replaced by the consumer at a much lower frequency.

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