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European Journal of Operational Research 192 (2009) 621–633
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
www.elsevier.com/locate/ejor

O.R. Applications

The optimal pace of product updates

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Received 20 July 2005; accepted 28 September 2007
Available online 13 October 2007

Abstract

Some firms (e.g. Intel and Medtronics) use a time-pacing strategy for product development (PD), introducing new generations at regular intervals. If the firm adopts a fast pace (introducing frequently), it prematurely cannibalizes its old generation, incurring high development costs, while if it has a slow pace, it fails to capitalize on customer willingness-to-pay for improved technology. We develop a model to gain insight into which factors drive the pace. We consider PD cost, the diffusion rate (coefficients of innovation and imitation), the rate of margin decline, and the degree to which a new generation stimulates market growth. We find that a faster pace is generally associated with faster diffusion, a higher market growth rate and faster margin decay. Not so intuitively, we find that relatively minor differences in the development cost function can significantly impact the pace.
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Keywords: OR in research and development; New product introduction; Diffusion; Time-pacing; Clockspeed

1. Introduction

Consider a firm such as Intel that periodically updates its product line with a new generation of product. For example, since the introduction of the early 4004 microprocessor, Intel has typically introduced a new generation every three to four years as shown in Fig. 1.[3] Each new technologically-advanced generation revitalizes the product line, initially commanding a relatively higher price. But then the price begins to decay as the new generation diffuses through the market, displacing the previous generation. As it ages, the new generation itself eventually becomes ripe for replacement.

Many electronic products are similarly updated at relatively regular intervals, including items such as computer components, printers and other peripherals, digital cameras, and cell phones. From a customer's perspective, these products seem to improve at a somewhat regular pace, as new generations of products are repeatedly introduced. Eisenhardt and Brown (1998) refer to this type of product development (PD) strategy as time pacing. The pacemaker company Medtronics has benefited from a time-pacing strategy (Christensen, 1997): Uncertainty was reduced and requests for revisions to product features during the design process were essentially eliminated. This allowed the design and launch process to remain on schedule, even though the time-paced schedule did not specify the products to be developed, only the timetable. A notion similar to that of the pace of new product generations is that of industry clockspeed as discussed by Fine (1998) and by Mendelson and Pillai (1999): a fast pace contributes to a fast clockspeed.

The pace at which a company introduces new product generations is an important but complex decision for the firm. For example, say Intel has just introduced a new

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[3] We recognize that the pace is not exactly constant. Market conditions have changed significantly since 1970 and the pace that was optimal then would not necessarily be optimal today. However, it appears that Intel does use some form of time pacing for planning purposes.

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doi:10.1016/j.ejor.2007.09.043

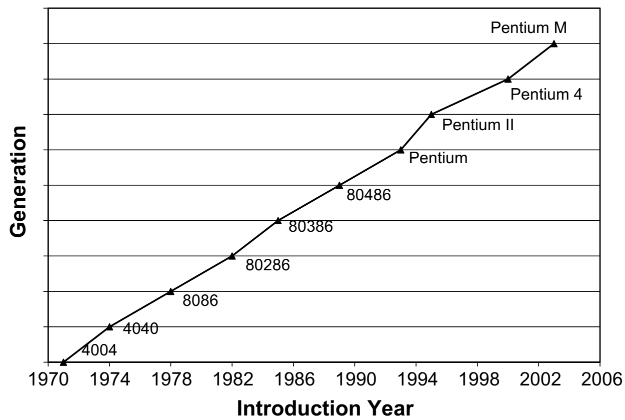

Fig. 1. Intel's new product development launch history (Intel, 2007).

generation of microprocessor. It then needs to decide whether to introduce the next generation microprocessor next year, in two years, or at some point further down the road. If it goes for an early introduction, it may incur high costs (in PD, for example) and it may prematurely cannibalize sales of its previous generation. If it waits too long, it may fail to capitalize on customer willingness-to-pay for more advanced technology in addition to the possibility that competitors may (further) infiltrate the market (in other words, the margins on the existing product may have fallen significantly). Additionally, the existing product sales may decline due to market saturation. Thus it is unclear: How frequently should the firm introduce a new generation?

Our contribution is to analyze the pacing decision considering a wide range of factors including the costs (both out-of-pocket and opportunity costs) of introducing the next generation either too early, or too late. Specifically, we focus on the interaction between: (1) the PD cost curve (considering both shape and scale parameters); (2) the new product diffusion characteristics (innovation and imitation parameters); (3) the growth in potential market size; and (4) the rate of decline in profit margin after a new generation's introduction. We have chosen these factors because they directly or indirectly address the issues related to introducing too early or too late and discuss each factor briefly below. Due to the analytical complexity of the model, we proceed to study the optimal pace of product updates numerically. To simulate a broad array of environments, we consider five levels for each of the six parameters used in a full-factorial experiment – parameter levels are based on previous empirical work within the field as detailed in Section 4. Using an exhaustive numerical search, we find the optimal pace in each of the 15,625 runs, and statistically analyze the results to determine the effects of each parameter on pace and profits.

The first parameter examined is PD cost, which we assume is convex. Others have similarly assumed that "crashing" is costly while extensively long development times also lead to inefficiencies in PD – see Morgan et al. (2001), Bayus (1997) and Graves (1989). Introducing too early may cause excess PD costs due to more frequent introductions and possibly crashing costs. On the other hand, introducing too late may decrease PD costs overall, but may increase the PD costs per introduction. Although PD cost might typically represent less than 5% of the total product revenues over a generation's life (Ulrich and Eppinger, 2004), our results show that seemingly relatively minor differences in the PD cost curve can significantly impact the optimal pace.

Second, to model the diffusion process we follow the multi-generation model of Norton and Bass (1987), where we similarly assume the overall market size grows incrementally over time (or remains constant). To the best of our knowledge we are the first to consider how the coefficients related to the rate of diffusion (i.e. the Bass (1969) coefficients and the growth rate of the market between generations) impact the time-pacing decision. This is significant given the vast empirical evidence supporting the Bass model of diffusion (Norton and Bass, 1992). If a firm introduces too early, it may cannibalize the previous generation too quickly, not taking advantage of market growth. If it waits too long, sales may have slowed considerably as the product has already diffused through the market. We find the Bass coefficients of innovation and imitation are some of the most important determinants of the pace. Specifically, if there is not a sufficient base of customers of the innovator type, then the pace will be slow. But once this base of innovators exists, the pace will be increased by either innovators or imitators.

Lastly, we assume the profit margin for a given generation of product declines exponentially over time – see Carrillo (2005), Krishnan et al. (1999), Bayus (1997), and Smith and Reinertsen (1991). Here introducing too early forgoes potential profit margin from the previous generation, while introducing too late results in sales of the previous generation at small margins. The rates of growth in market size and of decay in profit margin are effectively surrogates for such factors as the rate of technological change, the rate of change in customer willingness-to-pay, and the competitive nature of the market. For example,

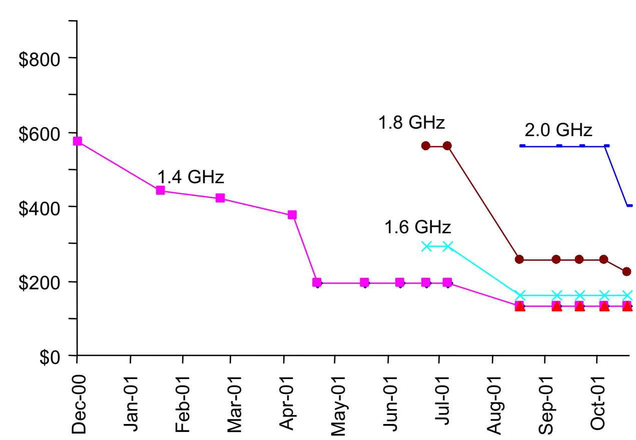

Fig. 2. Price decay after introduction of an Intel microprocessor (Dataquest, 2003).

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