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SPOTLIGHT ARTICLES

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Technological Evolution and Radical Innovation, Sood, Ashish and Tellis, Gerard J., Journal of Marketing 69(3):152–168 (2005).

Based on limited theoretical and scattered empirical support and some circular definitions of technology, a central premise of the literature on technological evolution is that performance of a new technology begins below that of an extant technology, intersects the existing technology's performance once, and ends at a higher plateau. This yields the technological S curve that plots performance of a technology on the y-axis against time on the x-axis.

For managers, this suggests that improvement in a mature technology's performance is typically costly, short lived, and little. It is therefore suggested that managers abandon the maturing technology and adopt a new one and that the appropriate time to do so is during the inflection point of the S curve, following which performance improves at a declining rate until maturity.

Using new definitions of technological change and data from 14 technologies from four markets, this study instead discovered that evolution follows a step function, with sharp performance improvements following long periods of no improvement and paths of rival technologies sometimes either crossing more than once or not at all.

This study's definition of technology is in terms of a technology's intrinsic characteristics rather than the traditional focus on a technology's effects (e.g., revolutionary, disruptive, discontinuous). The latter approach is problematic in that if these effects are used to predict market outcomes (i.e., performance), researchers risk circular logic in asserting premises that are true by definition. The authors define a technology platform (TP) as a new technology founded on scientific principles different from those of existing technologies (e.g., compact disks used a new platform, laser technology, to write or read data rather than the prior technology that used magnetism). This research focused on TP rather than on either what the authors call component innovation—use of new parts or materials within the same TP (e.g., magnetic tape floppy disk and zip disk use differing components or materials, though they are both based on the platform of magnetic recording)—or design innovation, which is reconfiguration of the linkages and layout of components within the same technological platform (e.g., floppy disks have grown smaller over the past several decades, although each size was based on magnetic recording). Concern was with the progress of a technology along a primary dimension, that is, one critical to customers when the innovation emerges (e.g., resolution in monitors and printers).

There exists no single, strong, and unified theory for the S curve, although the emerging and most compelling explanation lies in the technology life cycle, whose three stages emerge from the interplay of firms and researchers over the life of the technology:

(1) Introduction stage: A new technological platform progresses in performance slowly at first because (a) the technology is not well known and might not attract researchers' attention and (b) basic but important bottlenecks must be overcome before any new TP can be translated into practical and meaningful product performance improvements (e.g., the laser beam required much time and effort to achieve the safety and miniaturization required to use it as a surgical tool).

(2) Growth stage: With continued research, the TP crosses a threshold following which it progresses rapidly. This stage typically begins with the emergence of a dominant standard around which product characteristics and consumer preferences coalesce, stimulating research on the new TP and leading to improvement in its performance. Also, publicity draws a large number of researchers to study the new platform, leading to rapid performance advances and growing sales and profits that provide additional support for research.
(3) Maturity stage: Progress occurs slowly or reaches a ceiling because of limits to technology performance improvements, because the focus shifts from product to process innovation, because of less incentive for incumbent firms to innovate due to fears of obsolescence or cannibalization from a competing platform, and because of limits of scale (i.e., things become impossibly large or small) or system complexity (i.e., things become too complex to work flawlessly).

On the basis of the preceding explanation, hypotheses were derived regarding various aspects of technological evolution (indicated in parentheses):

- H_1 (shape): Technological progress on a primary dimension follows a single S-shaped growth curve. This is the conventional wisdom in the literature.
- H_2 (path): When a new technology is introduced, its performance is lower than that of the old technology.
- H_3 (Path): When a new technology reaches maturity, its performance is higher than that of the old technology.
- H_4 (Path): The performance path of a pair of successive technologies intersects once when the new technology surpasses the old technology in performance.

The existing literature, both theoretical and empirical, suggests these three hypotheses dealing with the path of technological change on a primary dimension because performance of successive technologies each follows an S curve. Sometime during an old technology's life, a new technology emerges, making slow initial progress on the primary dimension. However, it eventually enters its growth phase and improves rapidly, whereas the previous technology improves much more slowly even though major commitments are made to develop products using the old technology. Consequently, a point is reached when the new technology crosses the old technology in performance. This pattern of intertechnology competition produces overlapping S curves, with each new S curve starting below but ending above the old curve.

These first four hypotheses regarding shape and path of technological change on a primary dimension were all rejected, whereas the next four concerning the pace of technological transition were all accepted.

- H_5 (pace): The time interval between successive introductions of a new technology decreases over time. More rapid innovation is based on empirical research and is explained by greater resources being devoted to research and development (R&D) every year, an increasing number of countries and people involved in this research each year, and progress in one field (e.g., computers) enabling greater efficiencies in another area (e.g., materials design).
- H_6 (pace): The time interval between successive improvements in performance of a given technology decreases over time.
- H_7 (pace): The percentage increase in performance, calculated relative to the previous year, increases over time. A number of empirical studies provide support for H_6 and H_7.
- H_8 (Source): Primarily small entrants introduce platform innovations. Empirical studies support H_8. Small firms and new entrants are often ridiculed and ignored by incumbents initially but subsequently become successful with the new technology's progress. Prior studies suggested many reasons for large incumbents failing to introduce innovations, including incumbents' technological inertia, complacency, arrogance, and unwillingness to cannibalize their current products. However, H_8 was not supported in this research.

The research methodology entailed collecting data via the historical method. Sample categories were data transfer (as utility), computer memory, desktop printers, and display monitors (all consumer electronics). Technical data were collected on product performance for various technologies at different stages in their evolution, found in sources such as technical journals, industry publications, R&D organizations' white papers, and annual reports of industry associations.

H_1 on the S-shaped technological performance improvement curve was rejected, with only 4 of the 13 technologies studied exhibiting S-shaped growth. Instead, the authors discovered for 9 of the 13 technologies long periods of static performance interspersed with abrupt jumps in performance, suggesting irregular step functions, each approximating an S curve.

A performance jump appears largest following a long plateau of no improvement.

Also rejected were H_2, H_3, and H_4 on the path of technological change. New technologies can enter above—most do so—or below the performance of existing technologies. Also, many new technologies never improved on the old technology, whereas others enjoyed brief periods of dominance over the old technology before the old technology regained dominance. The performance curves of a pair of competing technologies rarely exhibit a single crossing as suggested by H_4. Consequently, it would be unwise for an incumbent to scan for competition only among technologies performing worse than its current technology.

H_5, H_6, and H_7 on the pace of technological change were all supported, suggesting that the pace of technological transition and the number of new technologies increase over time. There is declining duration between introductions of successive new technologies and declining duration between successive improvements in each technology.

H_8 on the source of new technologies was rejected; only one platform innovation was introduced by a small entrant, whereas the other 13 came from large companies. This might be because in recent decades, innovation has become far more complex, and so the deeper pockets of larger firms enable incumbents to maintain state-of-the-art facilities to conduct research. Furthermore, incumbency provides them with opportunity and resources for developing and introducing platform innovations.

It is also noteworthy that this research contradicts prior studies showing that certain secondary dimensions—notably functionality, reliability, convenience, and cost—become successively and systematically important as technology evolves. However, this study found that each new technology introduces a sequence of random, seemingly unpredictable secondary dimensions as a new basis of competition while competing on the primary dimension.

Several important implications for managers are offered. First, analysts expecting a single S curve might wrongly conclude that a technology has matured at the first performance plateau and would suggest prematurely abandoning the old technology. Second, the continuous emergence and steady growth of most new technologies suggest the danger of a firm relying on the status quo. Because of technology's ever-increasing pace, vigilance for the emergence of new technologies coupled with efforts to improve the old technology can help an incumbent compete. Third, an attack from below is a viable threat: Many new technologies start by offering low performance but later threaten existing technologies by improving at a much faster pace. What were initially niches can grow into mass markets and eventually displace the old technology. Fourth, secondary dimensions of competition can threaten incumbents, who therefore need research to identify technological solutions to improve the old technology's value and to identify market segments that value the old technology's contributions. Alternatively, incumbents should explore R&D dimensions on multiple dimensions to react appropriately to entrants' threats. Fifth, first-mover advantages might not endure because entrants introduce even more innovations than do incumbent firms.

Drivers of Brand Extension Success, Volckner, Franziska and Sattler, Henrik, Journal of Marketing 70(2):18–34 (2006).

Brand extensions—the use of well-known brand names to introduce new products both within and beyond the original product category—are one of the most frequently used branding strategies. Nonetheless, the high failure rates of many such launches have led to a stream of research on determinants of brand extension success factors.

Two key issues remain unresolved by this research. First, little is known about the success factors' relative importance in driving brand extension success. Second, prior research only investigated the direct effects of the potential success factors (i.e., independent variables) on brand extension success (i.e., dependent variable) without testing the potential interactive indirect, or mediating, effects among the success factors in influencing brand extension success. This omission might have caused faulty interpretation of the significance and relative importance of these success factors.

This article extended this prior research by addressing three issues: (1) the significance and relative importance of the drivers of brand extension success, done by simultaneously examining 10 success factors, considering the direct main effects of each of the 10 success factors on brand extension success; (2) the indirect mediating effects of one success factor on another success factor; and (3) the indirect moderating effects of interactions between the success factors. The latter two issues were examined via application of a structural equation analysis to test three

conceptual models of extension success determinant, the complexities of which are beyond the scope of this review.

The conceptual framework for the authors' comprehensive model of brand extension success was derived from both published research as well as discussions with managers. Regarding the first issue, the direct determinants of brand extension success, a systematic literature review was undertaken of 45 empirical studies over 15 years, most of which used hypothetical brand extensions. Most of these studies employed consumer surveys requesting respondents to rate success factors (i.e., the independent variables) and extension success (i.e., the dependent variable) on rating scales. This literature review uncovered 10 potentially relevant success factors; the authors call them "potentially relevant" because there were many success factors yielding mixed results across studies. Additionally, expert interviews were conducted with senior brand managers in major German fast-moving consumer goods companies and with researchers in several German university marketing departments. Almost all experts agreed that these 10 factors are all relevant to brand extension success, and none of them identified any additional factors.

The resulting 10 success factors believed to directly and positively drive brand extension success were grouped into four categories as follows:

- Parent-brand characteristics
  (1) Quality, or strength, of the parent brand
  (2) Successful history of previous brand extensions, such as high number of previous successful brand extensions, high variability among product types offered by the parent brand, and low quality variance among previous brand extensions
  (3) High consumer parent-brand conviction
  (4) High consumer parent-brand experience
- Extension's marketing context
  (5) High marketing support, such as advertising support and firm competence
  (6) High retailer acceptance
- Relationship of parent brand to extension product
  (7) High fit between the parent brand and the line extension, such as high global similarity, high ability of parent brand owner to produce a product in the extension product class, and high relevance of the extended associations to the extended product
  (8) Low linkage of the utility of the parent brand to product attributes of the original product category
- Extension's product category characteristics
  (9) Low perceived risk of unknown brands
  (10) High consumer innovativeness
- Concerning the second issue under investigation, the indirect mediating effects of one success factor on another success factor, i.e., structural relationships among the success factors, the following positive relationships were anticipated based on prior research:
  (11) Quality, or strength, of the parent brand and retailer acceptance
  (12) Marketing support and retailer acceptance
  (13) History of previous brand extensions and consumer parent-brand conviction
  (14) Consumer parent-brand experience and consumer parent-brand conviction
  (15) Marketing support and fit between the parent brand and the extension product.
- Additionally, other relationships were anticipated based on interviews with brand managers and university researchers, who were given a description of the 10 success factors and asked to point out possible structural relationships among the factors and to give a reason for each. The following positive relationships were specified by over 25 percent of these experts:
  (16) Parent-brand conviction and perceived quality of the parent brand
  (17) History of previous brand extensions and perceived quality of the parent brand
  (18) History of previous brand extensions and retailer acceptance
  (19) Perceived fit between the parent brand and extension and retailer acceptance
- Experts expected one negative relationship:
  (20) The perceived risk of unknown brands and consumer innovativeness
- Concerning the third issue studied, the moderating effects or interactions between the successes factors, the following relationships were expected based on the literature review:
  (21) A positive interaction between the fit variable and the quality of the parent brand, i.e., the positive effect of the quality of the parent brand on extension success increases as the level of perceived fit increases
  (22) A positive interaction between the history of successful previous brand extensions and the quality of the parent brand, i.e., the positive effect of higher levels of parent-brand quality on extension success increases as the number or success of previous brand extensions increases

(23) A negative interaction between the fit variable and the number of successful previous brand extensions, i.e. the negative effect of low levels of fit on extension evaluations diminishes as the number or success of previous brand extensions increases

- Additionally, based on expert opinion from a group discussion of three senior brand managers and three researchers, positive interactions were expected between the following:

(24) The fit variable and parent-brand conviction

(25) Marketing support and retailer acceptance, i.e., consumer advertising positively influences extension success, provided that the product is available in retail stores.

The research design consisted of a questionnaire administered to 2,426 people living in Germany via door-to-door interviews. Respondents were administered multiple-item measures for extension success (i.e., perceived extension quality) and for success factors for 22 parent brands on the German fast-moving consumer goods market, with three extensions each (i.e., 66 brand extensions), each of which is among the top 100 sales-generating brands launching at least five extensions within the past four years and which achieved high awareness ratings in a pretest.

Results of model testing showed that 9 of the 10 factors significantly influence brand extension success (factor 8, low linkage of the utility of the parent brand to product attributes of the original product category, was not significant) and that the relative importance varied substantially across the success factors. In order of importance, the major contributors to driving brand success were fit between the parent brand and extension product, which was by far the most important contributor, marketing support, parent-brand conviction, retailer acceptance, and parent-brand experience. The authors highlight the overwhelming importance of fit compared with other brand extension factors in light of the fact that this study used real brand extensions, whereas previous researchers attributed the strong impact of fit to the use of hypothetical brand extensions.

In addition, several important structural relationships among success factors were verified. These were retailer acceptance and fit (12), parent-brand experience and parent-brand conviction (14), and marketing support and fit (15), although the impact of these structural relationships on extension success was small relative to the direct effects of the success factors. Further, statistically significant effects were found for two interaction terms: the interaction of fit and the parent brand quality (21) and the interaction of fit with parent-brand conviction (24), although the contribution of the two interaction terms was small relative to the main effects of the success factors.

These findings should help managers to divide the large number of potentially relevant success factors into essential factors (i.e., fit, marketing support, parent-brand conviction, retailer acceptance, and parent-brand experience) and less relevant or unimportant factors (i.e., history of previous brand extensions, consumer innovativeness, linkage of the utility of the parent brand to specific product attributes, and moderating effects).

The authors offer suggestions for how managers can influence the five most important success factors:

- Fit between parent brand and extension product: Consumers will probably infer judgments of fit and consistency when an advertisement illustrates how parent-brand attributes improve the extension's ability to provide benefits. Repeated exposure to advertisements evoking appropriate parent-brand associations can assist consumers in establishing linkages between the brand and the extension product.
- Marketing support: This is especially important since it is under a company's direct control and can be influenced in the short term, subject to budgetary restrictions.
- Parent-brand conviction and parent-brand experience: Although often managers cannot influence these two factors in the short or medium term since they both relate to the parent brand's specific characteristics, the findings suggest that building customer-based brand equity or acquiring strong brands are favorable strategies because they represent a prerequisite for the successful leveraging of an existing brand to reap a financial benefit. Managers overseeing a brand portfolio can select an appropriate brand that performs favorably on these factors.
- Retailer acceptance: Backing the product with trade and slotting allowances plus consumer advertising can be helpful in gaining retailer acceptance.