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Market Expansion or Margin Erosion: The Double-Edged Sword of Digital Convergence

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MARKET EXPANSION OR MARGIN EROSION: THE DOUBLE-EDGED SWORD OF DIGITAL CONVERGENCE

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Abstract

Digital convergence enables firms in the computing, communications, and electronic consumer industries to design and launch multifunctional converged products. This presents firms with a significant opportunity for value creation and profit growth. At the same time, the increased substitutability between products supplied by different industry segments heightens competition and poses a significant threat of margin erosion. These conflicting incentives make it difficult for firms in converging industries to make strategic product line and product design decisions.

In our study, we analyze the technological, product, and market factors that have an impact on these decisions and derive conditions under which it is (and is not) optimal for firms to launch converged products that combine the functionalities of products in two different industries. We find that the optimality of including converged products in the product line depends crucially on the synergies arising out of functionality colocation. Further, as technology permits higher levels of product convergence, converged products relegate specialized products to narrow market niches, even when there is some quality degradation from functionality colocation. Overall production and total firm profits tend to increase, although the impact on consumer surplus and total welfare is ambiguous.

1 INTRODUCTION

The term *digital convergence* has been used in the academic and trade literature to refer to a number of distinct, yet related, phenomena. Its most common use has been to describe the coming together of the computing, communications, and entertainment industries, driven by the union of audio, video, and data communications at the content or distribution levels. In a slightly different sense, the term has also been used to describe the tighter and relatively seamless integration of information across different media,[1] as well as the increasing connectivity between different electronic appliances in the home or office.

To define the term more precisely, one needs to separate the salient aspects of convergence. First, underlying the phenomenon is the technology driver: the growing incorporation of common digital or semiconductor technologies in the products of several distinct industries. We refer to this as *digital convergence*. Second, this convergence at the technology level creates increasing overlap in the functionality provided by products and service offerings in these industry segments, such as PDAs and cellular phones, cable TV connections and telephone lines, video game consoles and DVD players, or switches and routers. We refer to

[1]One could refer to this as *information convergence*. The failed cue:cat barcode scanner technology from Digital Convergence Inc. (www.digitalconvergence.com) was based on this idea. See also, IETF's ENUM protocol (www.enum.org) for another interpretation of the same idea.

this as *product convergence*. This disentangles the IT cause (digital convergence) from the business effect (product convergence).[2]

Product convergence is increasingly commonplace in the computing, communications, and consumer electronics industries. PDAs such as RIM's Blackberry 5810 and Handspring's Treo now incorporate cellular telephone functionality with quality levels near those of high-end dedicated handsets. The modern PC itself is the result of the convergence of a large number of distinct functionalities. If the impending launch of a home media center by Digeo (which recently acquired Moxi Media), or of similar products from Microsoft and Sony are successful, one may see a non-PC-centric convergence of the consumer communications functionalities.

These examples illustrate that digital convergence enables firms to make their *specialized* devices more *general-purpose*, through the addition of functionalities provided by products in other distinct product markets. However, the promise of digital convergence is accompanied by a significant threat of profit erosion. Product convergence undermines the tradeoffs between the attributes of distinct product lines, essential for creating product differentiation strategies, and can thereby wipe out secure market niches. The result is increased substitutability between products, even those traditionally considered members of different product markets, and this in turn makes industry boundaries more permeable (Yoffie 1997).

Consequently, firms face crucial product design trade-offs. Do they extend the functionality and scope of their specialized products, trading off increased competition and potential performance degradation for increased customer wallet share? If so, how should they design and price this broader technology product line? There are currently no clear guidelines about the nature of the central trade-off that governs this decision between potential gains from market expansion and the inevitable profit margin erosion from increased competition and substitutability. Our research attempts to shed light on these questions. Specifically, we ask:

- What is the effect of the potential introduction of multifunctional converged products on optimal product lines and designs, customer consumption patterns, profitability, and welfare?

- What are the technological, competitive, and product-related factors that affect these outcomes?

2 OVERVIEW OF MODEL

Our model consists of two overlapping product markets, each of which provides consumers with a set of distinct product functionalities. There is one firm in each market. Each firm may choose to offer a specialized product, which fulfils functionality needs in its own market; a converged product, which combines the functionality of its own market with (partial) functionality of the other market; or both products. The demand side is modeled using the representative consumer approach (Dixit and Stiglitz 1977) with a concave utility function that is separable in the numeraire *Y*. While we have some results for a generic concave utility function, most of our analysis employs a more specific quadratic form:

$$U(q_1, q_2, \ldots, q_n, Y) = \sum_{i=1}^{n} \alpha_i q_i - \frac{1}{2}\left[\sum_{i=1}^{n} q_i^2 + 2\sum_{i=1}^{n}\sum_{j>i} \lambda_{ij} q_i q_j\right] + Y \tag{1}$$

Maximizing utility for the representative consumer yields a linear downward-sloping demand function for each of the three products. The key parameters in this demand system are described briefly below.

- The level of *demand substitutability/complementarity* between the markets $\lambda \in (-1,1)$: This parameter represents the underlying economic relationship between demand in the markets prior to digital convergence, and determines the cross-elasticity of substitution between the two specialized products (as explained in Table 1). Some services such as high-speed Internet access and cable TV are natural substitutes, since demand for both is partially driven by a consumer's entertainment

[2]The term convergence has further been used to refer to the attempts by firms in the affected industries to react to the technological and market transformation by acquiring complementary resources and capabilities through mergers, acquisitions, alliances, and technology partnerships (Deise et al. 2000; Yoffie 1997). Such responses aimed at coping with the business effect (product convergence) driven by the technology cause (digital convergence) can be referred to as *industry convergence*.

needs ($\lambda > 0$). On the other hand, demand for cellular telephones and PDAs may be complementary, since both increase with an increase in the level of mobile work ($\lambda < 0$). The demand for cable TV and wireline telephony is likely to be largely independent ($\lambda = 0$).

- The *relative revenue potential* $\alpha_1,\ \alpha_2 \in (0, \infty)$: The incentive to introduce multifunctional converged products depends on the potential for profits in each market. Firms in saturated industries often look beyond their industry boundaries to find market segments that offer better growth opportunities. Product convergence presents such firms with the opportunity to enter these market segments. For example, relatively slow growth in traditional wireline voice services gives telecommunications firms strong incentives to provide broadband Internet connectivity, enabling them to leverage their "last-mile" ownership in a market with a higher growth potential. Conversely, for firms that are already in large and fast growing segments, the incentives to move into smaller or slowing markets are lower.

- The level of *technological synergy* between colocated functionalities $\boldsymbol{s} \in (0, \infty)$: For certain functionalities, a hybrid device that combines these functionalities is intrinsically more valuable. For instance, combining cellular telephony and personal organization facilitates one-tap calling, a single synchronized address book (cutting out redundant data entry), and a single device to carry around ($s > 1$). However, the device may be more bulky, and resource competition may reduce the performance or battery life of the device ($s < 1$). Combining the functionality of routing and switching into a single device increases performance to near wire-speeds; however, it may reduce overall quality due to the reliance on fewer pieces of highly complex equipment. This parameter influences the induced revenue potential of converged products, as illustrated in Table 1.

- The level of the competing functionality in the converged product $\boldsymbol{r} \in (0,1]$: The extent of the functionality that can be incorporated into a converged product may be limited by the current state of digital technology. Even where technological constraints are not binding, firms may choose to limit the extent or quality level to which the second functionality is provided. We sometimes also refer to r as the *extent of convergence*. This parameter influences both the revenue potential of the converged products, as well as the cross-elasticity of substitution between the specialized and the converged products.

Product 1 and product 2 are the specialized products, and product 3 is the converged product created by adding functionality 2 to specialized product 1. Firm A produces products 1 and 3, while Firm B produces product 2. Table 1 summarizes the remaining specifics of the model.

Table 1. Summary of Remaining Model Variables

Variable and description	Formula
λ_{12}: Slope of price for product 1 (product 2) in quantity of product 2 (product 1)	$\lambda_{12} = \lambda$
λ_{13}: Slope of price for product 1 (product 3) in quantity of product 3 (product 1)	$\lambda_{13} = \dfrac{1 + \lambda r}{1 + r}$
λ_{23}: Slope of price for product 2 (product 3) in quantity of product 3 (product 2)	$\lambda_{23} = \dfrac{\lambda + r}{1 + r}$
α_3: Revenue potential for converged product 3	$\alpha_3 = s(\alpha_1 + r\alpha_2)$
k: Relative revenue potential of the two specialized products	$k = \alpha_2 / \alpha_1$

3 ANALYSIS AND PRELIMINARY RESULTS

In the first phase of our study, we have analyzed the product portfolio choices of firms under an asymmetric technology regime. We assume that the technologies required to design and produce converged products are available in *only one* of the industries. Consequently, only one of the two firms can introduce a converged product in addition to its specialized product, while the second firm supplies only a single specialized product. We term this the *asymmetric convergence game*.

Game structure and equilibrium: The underlying economic model of competition is based on the static multiproduct Cournot game of perfect information. Firms simultaneously choose their product lines and the corresponding quantities, given a level of convergence r. A two-stage game where the extent of convergence r is a symmetric choice variable in the first stage of the game is currently work in progress.

> *Proposition: A unique Nash equilibrium in pure strategies always exists for the asymmetric convergence game with linear demand.*

Sketch of proof: A pure strategy equilibrium exists since the strategy spaces are convex and compact, and the payoff functions are continuous over the entire strategy space while also being concave in their respective strategy spaces (Fudenberg and Tirole 1991). Uniqueness of the equilibrium is established via a graphical analysis of the best-response functions: it is shown that for all points in the parameter space, the best response plane of Firm A (that is, the optimal (q_1,q_3) as a function of q_2) intersects the best-response curve of Firm B—the optimal q_2 as a function of (q_1,q_3)—at exactly one feasible point.

Optimal product portfolios: First order conditions along with non-negativity constraints on quantities yield the following result: for any generic downward sloping demand system, Firm A will always supply both the converged as well as the specialized product, as long as these two products are complementary, that is, so long as $\lambda_{13} < 0$. The outcomes are less straightforward when the specialized and converged products are *demand substitutes*. Since the equilibrium is tractable and unique for the quadratic form of equation (1), optimal product-line choices for the firms under different parameter values can be derived.

Figure 1 illustrates the optimal product portfolios for Firm A under this scenario (Firm B sells only a specialized product in the asymmetric convergence game). When $s < 1$, the converged product is not produced for a large set of parameter values. This is more so when the extent of convergence is low (the lower portion of the figure, where r is low). Supply of the converged product becomes optimal when the extent of convergence is high, but even then, the specialized product will continue to be supplied, unless products 1 and 2 are very close substitutes.

In stark contrast, when $s > 1$, it is never optimal for Firm A to produce only the specialized product. Over a wide range of parameter values, particularly where the functionalities are substitutes, it is optimal to produce only the converged product and discontinue the specialized product altogether. When the functionalities are complementary, both products will be supplied. The desirability of converged products at equilibrium increases as s increases (synergies from functionality colocation go up) or as r increases (the degree of product convergence goes up).

Market outcomes: Figure 2 illustrates typical market outcomes for different degrees of product convergence r. As Figures 2(a) and 2(d) illustrate, the converged product accounts for a significant share of the market. This market share grows with the extent of convergence and (independently) increases with the degree of substitutability between the base functionalities (not shown in Figure 2), thus relegating specialized products to narrow market niches. The competitive effects of the converged product force price and quantity reductions for the specialized products, as shown in Figures 2(a) and 2(b). This naturally depresses Firm B's profits significantly. While Firm A loses profits from cannibalization, market expansion from the converged product more than compensates, as shown in Figure 2(c).

From a welfare perspective, the total quantity consumed (of all three products together) in the marketplace is higher than in the absence of converged products, as are total firm profits. Furthermore, total industry quantity and profit go up as the level of product convergence increases.

4 DISCUSSION AND FUTURE EXTENSIONS

The preceding analysis indicates that digital convergence can significantly alter the competitive landscape for firms. The potentially disruptive nature of convergence has already been observed in the workplace-computing environment, where the function-

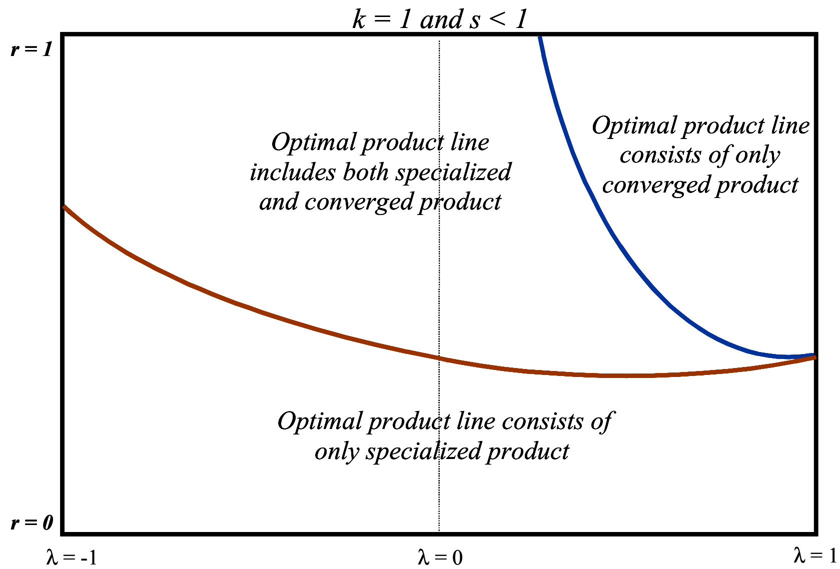

Figure 1(a): Optimal product lines with a loss in value from functionality colocation (s < 1)

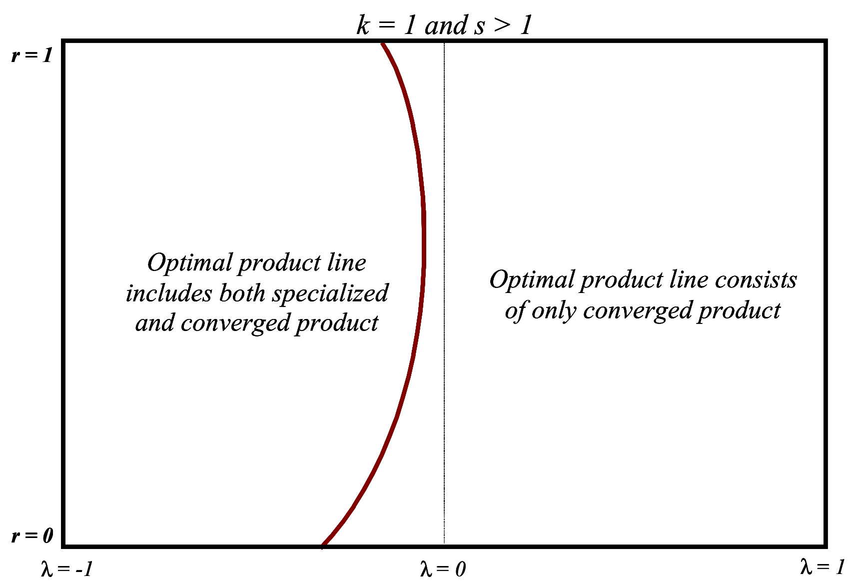

Figure 1(b). Optimal product lines with a gain in value from functionality colocation (s > 1)

The figure depicts the parameter space where different portfolio choices are optimal for Firm A (the firm with the digital convergence technology). The horizontal axes range from purely complementary functionalities ($\lambda = -1$) to purely substitutable ones ($\lambda = 1$). The vertical axis measures extent of convergence, ranging from no convergence ($r = 0$) to complete convergence ($r = 1$). In both figures, relative market size $k = 1$ (the markets have equal revenue potential).

Figure 1. Optimal Product Portfolios for Firm A

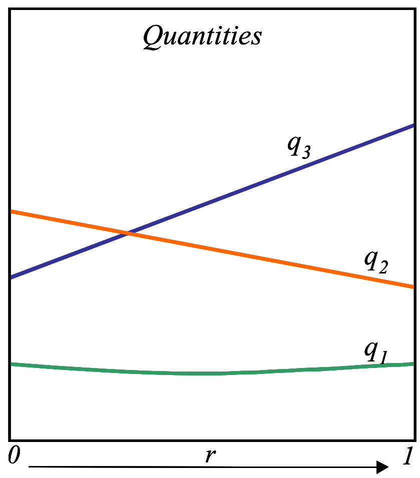

Figure 2(a). Equilibrium Quantities

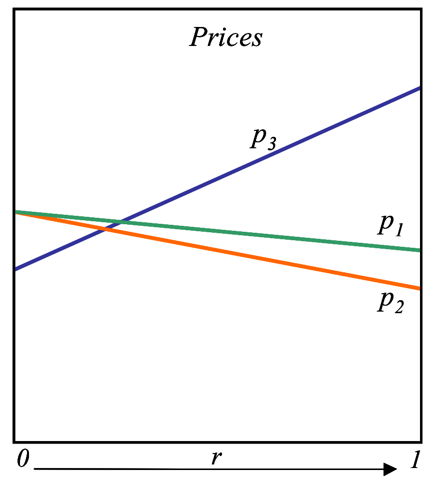

Figure 2(b). Equilibrium Prices

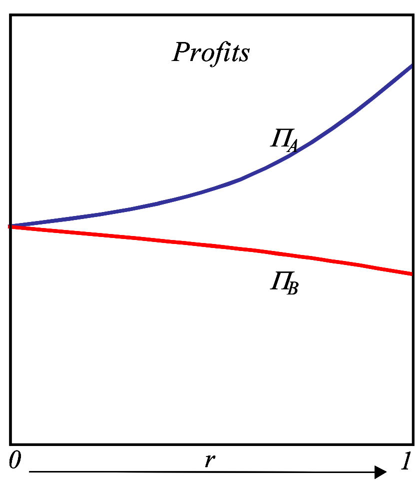

Figure 2(c). Equilibrium Profits

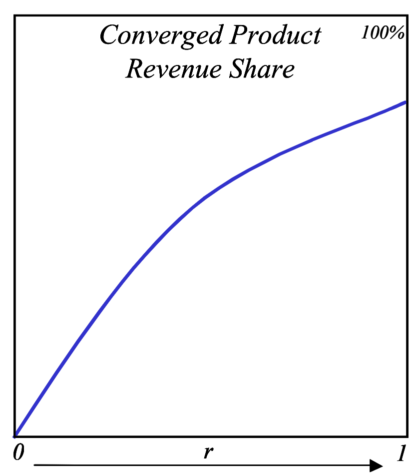

Figure 2(d). Share of Revenue from Product 3

The figure depicts quantities, prices, profits, and market shares of the specialized (product 1 and product 2) and converged (product 3) products, as the extent of convergence *r* goes from 0 to 1. These specific graphs depict a relative market size of $k = 1$ and a low level of complementarity between the base functionalities ($\lambda = -0.25$). At higher levels of convergence, the converged product relegates specialized products to narrow market niches, and the firm with the converged product (Firm A) dominates the market.

Figure 2. Typical Market Outcomes for Different Degrees of Product Convergence *r*

ality of a number of specialized desktop office products (such as electronic word processors, and accounting terminals) has been subsumed into the PC. Our results are supported by the fact that the next new generation of successful converged products has appeared in an industry pair that share a high s value: cellular telephony and PDAs. These are weakly complementary products with a significant technological synergy between the underlying personal communication and organization functions and, as indicated by Figure 1(b), we currently see a significant presence of both specialized and converged products in product lines across these industries. In the home entertainment industries, as the converged products from Digeo and others mature, our results also indicate they could relegate the pure-play digital video recorder and cable modem industries to niche markets, which poses a substantial strategic challenge for firms like TiVo.

Clearly, these results may change when firms are technologically symmetric—while spawning valuable products in the marketplace, it may make it difficult for firms to appropriate this value—or it could cause firms to invest in high-quality specialized products, symmetrically preserving profit margins. The next phase of this research analyzes the symmetric convergence game, where both firms can introduce converged products. We first examine simultaneous choice, and then the case of a technology lead. This analysis is at an advanced stage, and a complete set of results will be presented at ICIS.

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