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CONVERGING DIGITAL TECHNOLOGIES: AN OPPORTUNITY OR A THREAT?

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Abstract

Increasing similarity in the digital technologies on which products in several distinct industries are based has led to the speculation that products in these industries will converge. Such convergence, while making products more valuable also increases the similarity between products supplied by different industries thereby causing the boundaries between these industries to blur. This presents both a significant opportunity and a grave threat to firms and forces them to alter their business models and strategy to fit the realities of the new environment. In this paper, we model conflicting firm incentives to produce converged products in the presence of converging digital technologies and derive implications for firms' product portfolio and product design choices.

Keywords: Digital convergence, product convergence, technology convergence

Motivation and Research Questions

Digital technology convergence, meaning the increasing incorporation of *common* digital technologies in the products and services of distinct industries, has been shaping the telecommunications and computing industries for some time. The Internet, and the open digital technology standards on which it is based, have accelerated this convergence by an order of magnitude and extended it to embrace almost the entire universe of information based industries such as consumer electronics, media and entertainment - causing the boundaries between these industries to blend or disappear.

Use of digital technologies is increasing the information content in products. This makes products more flexible in terms of satisfying heterogeneous customer needs. It also enables firms to design and market converged products that integrate the functionalities hitherto provided by other products in completely different industry segments. Thus, while traditionally demarcations between different industries as well as firms' competitive strategies have been based on the inherent trade-offs between product attributes, this need no longer be true. Secure product niches with assured revenue streams may therefore become increasingly rare in these industries.

The multifunctional nature of converged products increases the interchangeability between offerings from different industries. As an example, consider the media industry. In the past, tight integration between the type of information and medium of delivery meant that distinct media were tuned to serving different functionalities (e.g. one-to-one vs. one-to-many vs. many-to-many communications). The Internet substitutes for all these with relatively few tradeoffs. Similarly, the same infrastructure and connections into homes/offices can now be used for data and voice communications, as well as audio and video distribution. The end result is a potentially growing degree of overlap or substitutability in the functions that can be performed by different communication networks and information appliances, thereby enhancing the intensity of competition and blurring industry boundaries. In order to survive in this environment firms need to broaden their peripheral vision, as the next most pressing threat may come from outside the industry rather than within it.

In some cases, digital convergence is also reconfiguring entire industry structures. For example, the media industry (which includes content, communication and consumer electronics industries) is undergoing structural transformation from tightly knit

vertical segments to interconnected horizontal layers, much like the PC industry (Mueller 1999). While firms in the media industry of a decade ago often produced their own content, distributed it through their own channels (or networks), dictated what medium (or device) could be used to consume the content and directly billed the consumers, today they are increasingly being forced to focus within one or more of these layers. However, enormous opportunities exist within each layer to broaden the scope of their products and generate multiple revenue streams. This is primarily possible due to the similarity in technologies employed to handle information in each of these layers. These developments make business models such as gatekeeping attractive. If a firm manages to converge and gain control of a horizontal slice in this industry, it can then collect tolls from players in other layers. Microsoft has successfully done this in the PC industry. We see similar attempts in the media industry, particularly in the last layer that is in direct contact with the customers. Firms such as telephone and cable companies are trying to build strong customer ties and grab a larger share of the customer's wallet. Consumer electronics firms are trying to fill a similar role using home media gateways and multi-functional set top boxes such as Moxi Digital's Media Center and Microsoft's Xbox.

The actual introduction of converged products depends on the interaction between technological, competitive and demand factors. While increasingly powerful, cheap and ubiquitous digital technologies needed to drive product convergence are currently available (though some uncertainty exists in terms of standards), such convergence will not be feasible unless both firms and consumers benefit from it. In particular, the supply of converged products to the marketplace will be dictated by firms' incentives to do so. Clearly, digital convergence presents firms in these industries with both a significant opportunity and a grave threat. A great deal depends on the extent to which firms are able to exploit the technologies to provide compelling value to consumers and the extent to which they can design effective business models to appropriate a significant fraction of this value. In this paper, we model the competitive interactions between firms in converging industries under reasonable assumptions about the technological and demand factors. Given the availability of converging digital product technologies, we analyze whether this will lead to the introduction of converged products in the marketplace. We also investigate the resulting effects on prices, firm profits, market shares and social welfare.

A Model of Competition between Converging Products

Firms' product choices in the presence of converging technologies are modeled using a two-stage sequential duopoly game of perfect information. The supply side of the model has two firms A and B, each of which supplies a single distinct product in the base (zeroth) period. Label them products 1 and 2 respectively. Each product satisfies customers' desire for a particular distinct functionality. For the sake of clarity, think of Product1 as a PDA (Personal Digital Assistant or handheld computer) and Product2 as a cellular phone. To abstract away from issues of differentiation and other strategic interaction within an industry itself, and focus on the interaction between converging industries, it is assumed that each sector is represented by a monopolist. While this is an obvious simplification, it is a reasonable representation of industries where a single firm (which we treat as the monopolist) controls the product standards in that industry.¹

Through past R&D, one of the two firms (say FirmA) has a proprietary product technology that makes it feasible for it to introduce a converged product, say Product3. Product3 incorporates all the functionality of Product1 and also integrates some functionality (either a part or the whole) of Product2. Think of Product3 as a PDA-cellphone hybrid device that has all the functionality of a PDA and some functionality of a cellular phone. The extent to which Product3 incorporates the functionality provided by Product2 is termed the degree of convergence (labeled r) and is a decision that FirmA makes in the first stage of the game. The available product technologies might impose some upper bound on this choice of functionality. In the first stage, FirmA also decides the portfolio of products it brings to the market, which could be only Product1 or only Product3 or both. FirmB, which does not have access to this product technology, is passive in this stage of the game. In the second stage of the game, the two firms play a multiproduct Cournot game.

The demand side of the market is modeled using a representative consumer framework (See for instance Dixit and Stiglitz 1977, Matutes and Regibeau 1989) where the entire market is represented using a single utility maximizing consumer. In this framework, the utility function of the representative consumer can be thought of as the composite utility function produced by combining the preferences of a set of heterogeneous consumers. Based on prices, the consumer chooses a basket of products including the quantity of a numeraire product. The numeraire represents the opportunity cost of consuming products in this market or set of markets.

¹Extension to the case of other industry structures is part of future research.

The specific form of the utility function employed is the quadratic utility function (Matutes and Regibeau 1989) that is linearly separable in the numeraire good Y (see (1) below). This means that all income effects fall on the numeraire and hence can be ignored.

$$U(q_1, q_2, q_3, Y) = \hat{a}_i a_i q_i - (1/2)[\hat{a}_i b_i q_i^2 + 2\hat{a}_i \hat{a}_{j>i} L_{ij} q_i q_j] + Y \quad (1)$$

where the q_i terms represent the quantities of product i . Given the quadratic form, this utility function is concave in the product quantities and displays a preference for variety (depending upon the value of b , which is later normalized to 1). Profit maximization by the representative consumer yields a set of linear inverse demand functions for the three products. A number of factors that affect the firms' decisions about product portfolio and product design are considered.

1. **Relative revenue potential for the two functionalities.** The parameters a_i in (1) above become the intercepts in the inverse demand functions and thus are an index of the relative revenue potentials of the products (or the functionalities they provide to consumers). Intuitively, FirmA's incentive to offer Product3 that integrates a large fraction of Product2 functionality will be higher if Product2 has a relatively large revenue potential (a high value of a_2).
2. **The nature of relationship between the two base products.** The L_{ij} terms determine the cross price elasticity and therefore represent the degree of substitutability between products i and j . The relationship between the two industries (the substitutability between base products 1 and 2) is given by the term L_{12} . The substitutability between the converged and the base products is completely determined by L_{12} along with the fraction of Product2 functionality that Product3 integrates. The whole range of relationships from strong complementarity to strong substitutability is considered. In particular, a value of zero for L_{12} means that the two industries are completely independent.
3. **Synergies from functionality co-location:** In some cases, co-locating the two functionalities on a single device may permit consumers to exploit synergies, thus increasing the value of the enhanced product beyond the sum of its parts. For example, getting all your messages (voice, text, rich media, etc.) in a single mailbox on a converged wireless device might have more value than getting the same in separate devices each handling one type of media. On the other hand, in some cases the value from a converged product might be lower than that from the individual specialized products due to dis-synergies in use or resource constraints in the product technology. For instance, integrating PDA functionality on a cell phone may reduce voice quality or drain out the battery faster, thereby reducing the value of having both functionalities on the same device. One would expect that presence of significant synergies strengthens the incentives for FirmA to integrate more Product2 functionality in Product3. The model considers this effect by incorporating a synergy variable 's' into the expression representing the value from Product3 (i.e. a_3).

Analysis and Preliminary Results

The subgame perfect equilibrium of the two-stage game is derived. The second stage of the game is actually comprised of three separate subgames – one each corresponding to a different product portfolio chosen by FirmA (i.e. only Product1; only Product3 or both) in stage 1 of the game. Due to the linearity of the inverse demand functions, the firms' profit functions are quadratic in quantities. Thus the firms' payoffs are continuous and concave on the strategy space ensuring that we have pure strategy equilibria that are unique (except a trivial case which is of little interest to us).

At equilibrium, FirmA's product portfolio choice depends on the relative revenue potential, substitutability between the two base products as well as the degree of synergies derived out of co-locating the two product functionalities. Two forces drive the effect of these factors on firm choices. First, introduction of the converged product into the market increases customer value and causes a **market expansion effect**. At the same time, the resulting higher level of substitutability between the products of the two firms causes a **competition effect**. Most factors affect outcomes by tilting the balance between these two forces.

In the base case, where the relative revenue potentials of the two product markets are equal and there is absence of any synergies (or dis-synergies) in integrating product functionality, the results show that it is never optimal for FirmA to produce Product1 alone, or in other words, it will always introduce the converged product, Product3. Whether it continues to produce Product1 or not depends on the degree of substitutability between the two industry functionalities and the degree of convergence. If the two functionalities are highly substitutable, then it is optimal for FirmA to discontinue producing the specialized base product, Product1. As the degree of substitutability between the two industry functionalities decreases, the market expansion effect alluded

to above, becomes stronger while the competitive effect weakens. Thus, when the two industry functionalities are weak substitutes or complementary, FirmA finds it optimal to supply both products to the market. This is illustrated in Figure 1, where the horizontal axis represents the degree of substitutability ($\lambda_{12} = -1$ for perfect complements and $\lambda_{12} = +1$ for perfect substitutes) between the base products 1 and 2 and the vertical axis represents the degree of convergence ($r = 0$ implies no convergence; $r = 1$ implies complete convergence).

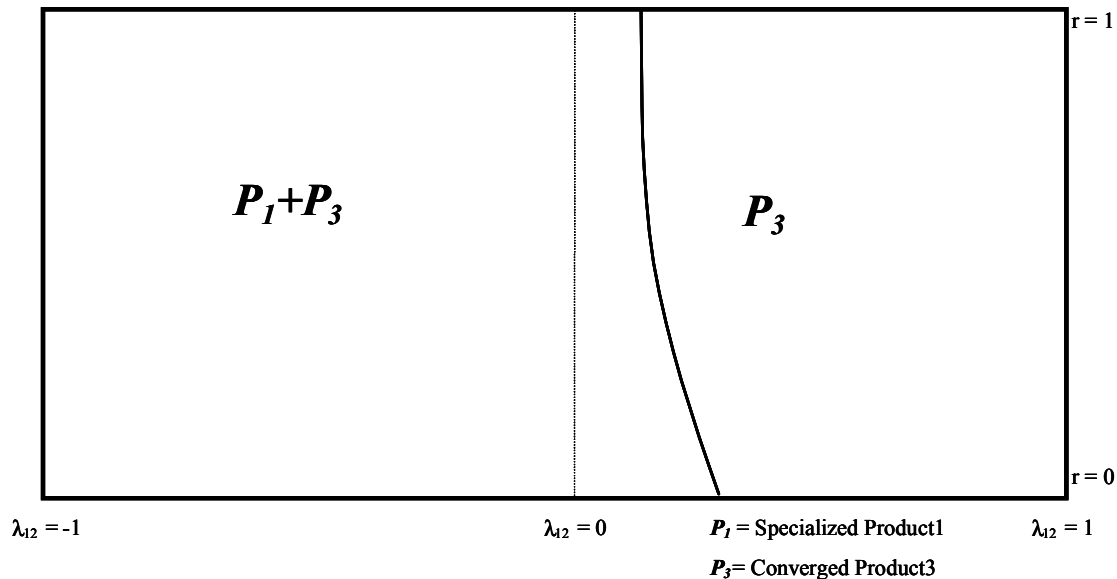


Figure 1. FirmA Equilibrium Product Portfolios

Results also indicate that increasing synergies from co-locating functionalities strengthen FirmA's incentives to introduce the converged product. As a result, even in the presence of mild synergies, the hybrid product is always introduced into the market, irrespective of the market sizes or the relationship between the two industries' product functionalities. Further, as long as these synergies are not too strong, FirmA continues to produce both products. But, if the synergies are high enough, then discontinuing the supply of Product1 is optimal for FirmA. Effect of changing the relative revenue potential of the two product markets depends on the relationship between the two product functionalities. When they are highly substitutable, FirmA continues to produce both products when the two markets are of roughly equal size, but discontinues production of Product1 if the market for Product2 is much larger than that for Product1. When the two industry functionalities are strongly complementary, FirmA benefits from producing both products.

Discussion and Further Extensions

It is clear from the above results that convergence of product technologies does not automatically imply that we will see converged products in the market place. The introduction of converged products depends crucially upon a number of product related, firm related and consumer related factors analyzed in the model.

The model analyzed above can be extended in a number of ways. The immediate extension is to look at the symmetric case where convergent product technologies are not proprietary but are available to both the firms. In this case, the competitive effect will be much stronger than the unilateral convergence analyzed here. However, preliminary analysis of such a model indicates that firms may face a prisoner's dilemma kind of situation and thus product convergence may still be observed. Heterogeneity between the two firms' capabilities may be modeled in terms of differences in investments or costs needed for introducing converged products.

In the current model, the degree of synergies derived from product integration is considered to be exogenous. In reality, this may depend on the extent to which Product2's functionality is integrated into Product3. Lastly, often there is a great deal of uncertainty

in the rate at which consumers adopt a new technology or product. Incorporating such uncertainty into the revenue potential for the converged product will constitute another interesting extension.

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