Marketing High Technology Products: The Role of Product Complexity and Buyer Technological Sophistication

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Abstract

Identifying organizations that are likely to acquire technologically complex products and services has important implications for designing and implementing market segmentation and cross-selling strategies. In this study we propose a framework by which industrial marketers can estimate the likelihood that an organization will adopt complex high technology products, given information on adoption (or non adoption) of related high tech products. The proposed framework combines the "technological sophistication" of the target organization and the "complexity" of the product to design cross selling strategies. The framework is empirically tested with data from 199 organizations in the context of their purchases of telecommunication network products and services.

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INTRODUCTION

The concept of relationship marketing has risen to the forefront of marketing theory and practice in recent years (Berry 1995, Wilson 1995). Among the central issues in relationship marketing is the notion of choice reduction, or the willingness of buyers and sellers to purposefully reduce the number of parties with whom they do business (Sheth and Parvatiyar 1995). An important corollary to the premise of choice reduction is that buyers and sellers would prefer to do *more* business with a smaller set of exchange partners. As a result, organizations are being driven to broaden the scale and scope of business they conduct with each customer. Therefore, the concepts of (i) customer satisfaction, (ii) customer retention, and (iii) customer development are of great significance to the study of relationship marketing.

At the same time that organizations are paying ever greater attention to relationship marketing, they are also inventing new technologies and products at an increasingly faster rate. Organizations are rapidly introducing new technologies in a number of areas like microprocessors and memory chips (e.g., Pentium pro and flash memory chips), telecommunications (fiber optic technology) , software (Windows 97) and medical diagnosis (medical imaging systems). However, to really have an impact on the bottom line, organizations not only need to invent new technologies, but also need to be able to translate their innovations into sales and profits in the marketplace (Robertson 1993).

A greater emphasis on building more substantial relationships with fewer customers, coupled with the rapid pace of new technology development, is placing unique demands on the capabilities and resources of the selling organization (Glazer 1991). For instance, high technology firms spend anywhere between fifteen percent and thirty five percent of revenue on marketing and sales activities, two to three times more than they typically spend on R&D. This level of expenditure makes it critical for firms to develop frameworks for the allocation of marketing and sales resources. In the absence of such frameworks, firms may find that they have targeted customers who are not yet ready to adopt a new technology, or that they have not understood how existing customers will migrate from one technology to the next. Thus the appropriate targeting of marketing and selling efforts is critical to the success of new technology based products, and, in turn, requires an understanding of organizational buyer behavior, particularly the estimation of the likelihood of purchase of the new technology by potential organizational customers (Bunn 1993).

Organizational buying behavior is the decision making process by which organizations establish the need for purchased products and services, and identify, evaluate and choose among alternative brands and suppliers (Webster and Wind 1972). The purchase of new high technology industrial products consists of two sequential decisions, the decision to purchase in the product class and the decision to choose the best possible vendor/brand. Scholars interested in understanding organizational buying behavior (OBB) have developed comprehensive models to predict purchase decisions. Two of the most widely known comprehensive models of OBB were developed by Webster and Wind (1972), and Sheth (1973). The model developed by Webster and Wind elaborates on how buying decisions are affected by environmental, organizational, interpersonal and individual level factors, while the model developed by Sheth focuses on the inputs and outputs in the industrial buying process. However, these comprehensive models are too elaborate to empirically validate in any one study, resulting in a very high ratio of conceptualization to empirical testing in the study of OBB.

Further, much of the empirical work that has been done is coupled only loosely with available conceptualizations. One explanation is the abstractness of most available models which makes them difficult to operationalize (Sheth 1987; Johnston 1981; Anderson, Chu and Weitz 1987). Another reason for the lack of empirical work is the difficulty in collecting data. Surveying one member of the decision-making unit is often considered to provide an incomplete picture (Wind 1978). However, collecting data from the entire decision making unit is very difficult and demanding of the resources as to be impractical. Acknowledging this difficulty in data collection, Zaltman and Bonoma (1987) call for new methodologies to facilitate the study of exchange systems (rather than individuals) as the unit of analysis. Unfortunately, neither the methodologies nor the empirical research have appeared (Anderson, Chu and Weitz 1987).

To address these concerns regarding the need to develop appropriate methodologies to study exchange systems, we propose a framework which predicts the likelihood of purchase of technologically complex products by organizations. Specifically, we investigate how a key organizational characteristic (the buying organization's technological sophistication), interacts with an important product characteristic (the product's technical complexity) to determine the likelihood that an organization will purchase a high technology product. We then validate our model with data collected from 199 organizations in the context of their purchases of telecommunication network products and services.

The primary contribution of this research is to develop a framework that will facilitate an identification of customers who are likely to purchase high technology products. The probability that an organization will purchase a high tech product is a function of both the technical sophistication of the organization and the technical complexity of the product. The proposed framework helps position both customers and products on a latent technological sophistication/complexity dimension. Given a particular level of technical sophistication, the likelihood that an organization will adopt a product is higher for a product that is relatively less complex than a product that is relatively more complex. More "technologically complex" products would require an organization with a higher level of technological sophistication to adopt the product. The proposed model allows for better segmentation, targeting, and lead qualification as it provides an assessment of the likelihood of adopting some high technology product, given information on the adoption of other technological products.

THE PROPOSED MODEL

Organizations typically adopt sets of related high technology products. Therefore, the probability that an organization will adopt a particular high tech product can be conceptualized as a function of both the technical sophistication[1] of the organization and the technological complexity of the product. More formally, the probability that organization j, will adopt the high tech product i, is given by:

$$P_i(\theta_j) = \frac{e^{a_i(\theta_j - b_i)}}{1 + e^{a_i(\theta_j - b_i)}} \qquad (1)$$

Where:

$P_i(\theta_j)$ - Probability that organization j will own product i

θ_j - unobserved technological sophistication of organization j

a_i and b_i - slope and intercept parameter that captures the technical complexity of product i.

Please refer to the appendix for model derivation.

The proposed model captures the interaction between the individual organization's technical sophistication and the complexity of the product to arrive at the probability of ownership of technically complex products. The unobserved technological sophistication of the organization j is captured by a single parameter, θ_j. The higher the technical sophistication of an organization, the higher will be the value of θ_j. The technological complexity of the product i, is captured by two parameters, a slope parameter (a_i) and position parameter (b_i.). The position parameter for product i (b_i.) is defined as the position along the latent continuum which would result in a 50% chance of ownership. As can be seen from equation 1, for an organization with a technical sophistication (θ_j) equal to b_i, the probability of ownership of product i equals 0.5. The position parameter, b_i is directly related to the technical complexity

[1]Technical sophistication of an organization refers to the latent ability of an organization to adopt high technology products. It is based on the prior adoption of other technologies by the organization.

of the product. Products with higher technical complexity will have a higher value of b_i. The slope parameter, a_i, for product i indicates how fast the probability of ownership of product i will drop/increase as the organization's technical sophistication increases/decreases. The higher the value of a_i, the steeper the slope of the curve. The maximum change in ownership probability occurs when the latent technical sophistication θ_j is equal to the intercept parameter b_i. In Figure 1 we illustrate how the likelihood of product ownership of three products with differing technical complexities varies depending upon the 'technical sophistication' of an organization. We term these plots as 'Product Characteristic Curves'.

[Insert Figure 1 about here]

Of the three products, product 1 has the lowest intercept parameter (b_i), followed by products 2 and 3. Note that, for any given level of technical sophistication (θ_j), the likelihood of ownership of product 1 is greater than the likelihood of ownership of products 2 and 3. Also, from the product characteristic curves, it can be observed that the slope parameter for product 3 (a_3) is greater than the slope parameter for product 1 (a_1). The higher the slope parameter, the higher the likelihood of ownership of the product is likely to differ around the midpoints of the product characteristic curve.

DATA

To validate the proposed framework, we chose to study the adoption decision for telecommunication network products and services by large U.S. based companies. The context of telecommunications network products and services was chosen as there are a large number of products and services with a gradation in the level of technical complexity that are considered for adoption. Initially, informal discussions were conducted with 17 managers from different organizations responsible for the oversight of telecommunication networks within their firms. The purpose of these discussions was to identify the telecommunication products that are currently adopted by organizations, and to understand the various factors that are considered important in decision making. These informal discussions lead us to identify 22 products and services that vary widely in their technical complexity. These 22 products are listed in Table 1.

Based on the discussions, a questionnaire was prepared which identified the various telecommunications network products utilized by organizations. The questionnaire was pretested with 12 telecommunication industry executives who participated in an executive education program. Their inputs were taken into account and the questionnaire was accordingly modified. To iron out other possible problems during the actual administration of the survey, the instrument was pilot tested. The questionnaire was mailed to 8 executives who had agreed to participate in the pilot study. One of the authors personally called each of these 8 executives and obtained their responses over the telephone. They were specifically probed about the clarity of the questionnaire and for any problems they had in answering the questions. The data obtained during the pretesting and pilot testing phases were discarded.

The sampling frame for the final survey consisted of a list of the leading 1000 public and private firms in the United States. One-third of these firms were randomly selected for participation in the study. The Chief Information Officer (CIO) of each selected firm was contacted to solicit their firm's participation in the study. If he/she agreed to participate, the questionnaire was faxed to them, and a telephone appointment was set up during which a researcher would contact the CIO to obtain responses to the questionnaire. A total of 212 firms agreed to participate, of which a total of 199 questionnaires were eventually completed.

RESULTS

The parameter estimates of the model proposed in equation 1 were estimated using the maximum likelihood estimation procedure (for details of the estimation procedure please refer to Hambleton and Swaminathan 1985). To empirically evaluate the technological sophistication of the organizations in the sample and the technological complexity of the various products, we estimated the parameters of equation 1using the maximum likelihood procedure implemented in the statistical package MULTILOG (Thissen 1991). The results of the technical complexity, captured by the two parameters (a_i and b_i[2]), of the various telecommunication products and services are reported in Table 1.

[Insert Table 1 about here]

As can be seen in Table 1, the parameters a_i and b_i for the products differ based upon the complexity of the product. The estimates of the intercept parameter b_i is as low as -2.02 for a common toll free 800 number service while the estimate for an 'On-premise Centrex' equipment is 20.08. These estimates indicate that even organizations that are low in 'technical sophistication' are likely to own a toll free 800 number. However only organizations with a high level of technical sophistication are likely to own 'On-premise Centrex' equipment. To

[2] To conserve space, the estimates of technical sophistication of the various organizations are not reported here, but can be obtained by contacting the authors. For these models, we do not apriori expect the parameters to have a value of 0. Hence no t-tests are conducted for the parameters of these item response theoretic models.

illustrate how the likelihood of adoption of different products varies both as a function of the technical sophistication of organizations and the technical complexity of products, let us consider three different organizations with differing levels of technical sophistication. Organization 1 has the lowest level of technical sophistication, organization 2 has a moderate level of technical sophistication and organization 3 has the highest level of technical sophistication. Let us consider three different products with increasing levels of technical complexity--800 number service, Electronic Data Interchange, and ISDN. The likelihood of ownership of these three products by the three organizations can be calculated using equation 1 and the results are given below:

LIKELIHOOD OF OWNERSHIP OF DIFFERENT PRODUCTS
BY DIFFERENT ORGANIZATIONS*

	800 Number Service	Electronic Data Interchange	ISDN
Organization 1	0.371	0.332	0.005
Organization 2	0.941	0.629	0.079
Organization 3	0.999	0.886	0.764

*For calculating likelihood of ownership, the values of technical sophistication used for organizations 1, 2 and 3 are -2.5, 0.5 and 4.2 respectively

As organization 2 has a higher level of technical sophistication than organization 1, for any given product the likelihood of ownership of is higher for organization 2 than for organization 1. In the case of ISDN, the likelihood of ownership of that service is only 0.005 in the case of organization 1, as opposed to 0.764 in the case of organization 3. Hence, it is more profitable for an ISDN provider to target organization 3 (if it already does not own the service) than at organization 1.

DISCUSSION

Increasingly, high technology products require the allocation of significant levels of marketing and sales resources as they are introduced in the market. Indeed, the income statements of high technology firms reveal that most such firms spend 2-3 times as much on sales and marketing as they do on R&D. The model developed and tested in this research helps sellers understand which customers are more likely to purchase a new technology, and thus can be used to guide the allocation of marketing and sales resources for new high technology products and services. The efficiency of personalized selling efforts is dependent on calling on organizations with a higher prior probability of buying the product. According to Poppel (1983), over half the salespersons' time is wasted in calling on low probability prospects who may not be willing or able to buy the product. Thus the model can help industrial marketers increase their efficiency and effectiveness.

The model can also help firms better manage the scale and scope of their relationship with customers. A central tenet of relationship marketing is the notion of choice reduction, or the purposeful selection of a smaller set of business partners. The success of relationship marketing, therefore, is closely linked to better satisfying, retaining, and developing a smaller set of customers. As such, it requires sellers to pay close attention to the needs of buyers, and to greatly expand the scale and scope of their relationship with these customers over time. By providing insights into when customers are likely to be ready to adopt a new technology, the model allows firms to better manage the migration of their customers from one product to the next.

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FIGURE 1 - PRODUCT CHARACTERISTIC CURVE

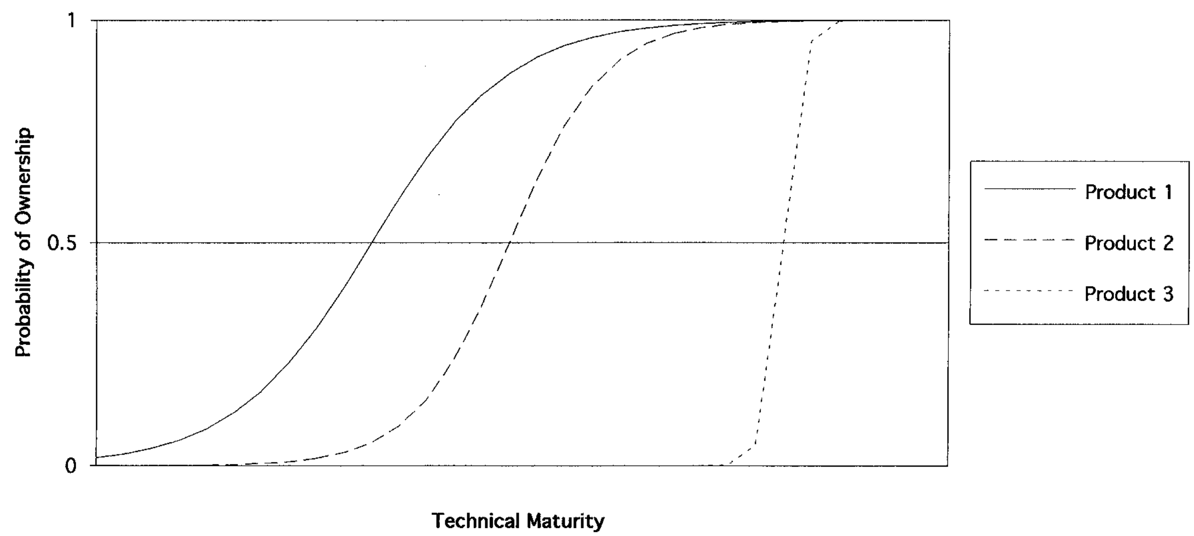

TABLE 1

TECHNICAL COMPLEXITY OF THE DIFFERENT TELECOMMUNICATIONS NETWORK PRODUCTS INVESTIGATED

PRODUCT	Slope Parameter (a_i)	Intercept Parameter (b_i)
1. Electronic Data Interchange	0.41	-0.79
2. Video Teleconferencing	1.73	1.27
3. Dialup Database Services	0.69	-1.69
4. 800 Number Service	1.10	-2.02
5. Outward WATS	0.58	-2.86
6. Videotex	1.76	2.01
7. Voice Mail	1.92	-0.36
8. Electronic Mail	1.22	-1.26
9. Facsimile	1.54	-2.79
10. Cellular Mobile Telephone	1.05	-0.38
11. Custom Calling Service	0.54	1.39
12. PBX	0.43	-5.91
13. Off-premise Centrex	0.95	1.12
14. On-premise Centrex	0.13	20.08
15. ISDN	0.98	3.00
16. Local Area Network	2.20	-1.37
17.Value Added Network	1.28	0.28
18. Foreign Exchange (FX)	1.51	-0.23
19. Microwave	1.31	0.85
20. Fiber Optics	1.64	-.18
21. VSAT	1.05	2.26
22. TVRO Satellite Dish	2.03	1.38
Variance Explained	42%	14%

APPENDIX

MODELING OWNERSHIP OF HIGH TECHNOLOGY PRODUCTS:

The objective of the proposed model is to capture the interaction of the organization's technical sophistication and the complexity of the product in explaining the organizational ownership of technically complex products. Both the technical sophistication of the organization and the technical complexity of the product are latent phenomena. The model we propose helps us to estimates the technical complexity of the product and the technical sophistication of the organization.

Let z_j be the latent technological sophistication of organization j and G_i be the technological complexity of the product i. The log odds of purchasing a product is a function of both the technological sophistication of the organization and the technological complexity of the product.

Log (odds of organization j purchasing product i) = $\frac{z_j}{G_i}$; (A1)

Let $\ln(Z_j) = \theta_j$ and $\ln G_i = b_i$.

Therefore, the odds of organization j purchasing product i is $e^{(\theta_j - b_i)}$; (A2)

The likelihood of organization j, purchasing product i, is given by $\frac{odds}{1+odd}$:

$$P_i(\theta_j) = \frac{e^{(\theta_j - b_i)}}{1+e^{(\theta_j - b_i)}} \qquad \text{(A3)}$$

where $P_i\,\theta_j$ is the likelihood of organization j purchasing product i.

Equation A3 has a single parameter, b_i (referred to as intercept parameter), to capture the technical complexity of the product. This one parameter model can be expanded to include a slope parameter also to capture the technical complexity of the product. The two parameter model is given by: $P_i(\theta_j) = \frac{e^{a_i(\theta_j - b_i)}}{1 + e^{a_i(\theta_j - b_i)}}$. (A4)

(for details of the model development, refer to Hambleton and Swaminathan 1985)