Technology Readiness Index (Tri): A Multiple-Item Scale to Measure Readiness to Embrace New Technologies

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The role of technology in customer-company interactions and the number of technology-based products and services have been growing rapidly. Although these developments have benefited customers, there is also evidence of increasing customer frustration in dealing with technology-based systems. Drawing on insights from the extant literature and extensive qualitative research on customer reactions to technology, this article first proposes the construct of technology readiness of people and discusses its conceptualization. It then describes a program of research that was undertaken to operationalize the construct, develop and refine a multiple-item scale to measure it, and assess the scale's psychometric properties. The article concludes with a discussion of potential practical applications of the scale and an agenda for additional research aimed at deepening our understanding of technology's role in marketing to and serving customers.

Companies' use of technology in selling to and serving customers is growing at a fast pace. Likewise, customers are dealing with products and services that are becoming increasingly sophisticated from a technological standpoint. As such, the nature of company-customer interactions is undergoing fundamental transformations with far-reaching implications for both companies and customers. For instance, a major consequence of technology's growing role is a commensurate growth in self-service technologies that call for customers to interact with technology-based systems rather than company personnel (Bitner, Brown, and Meuter 2000; Dabholkar 2000; Meuter et al. 2000). Yet, there has been little scholarly research pertaining to people's readiness to use such systems.

This research void is especially critical because the increasing incidence of customers having to serve themselves through technology-based systems is germane not only to service companies but also to goods companies. As Rust (1998) argues, all products are really services, and "most goods businesses now view themselves primarily as services, with the offered good being an important part of the service (rather than the service being an augmentation of the physical good)" (p. 107). In a similar vein, Bitner, Brown, and Meuter (2000), emphasizing the fact that virtually all firms compete on the basis of customer service and service offerings, propose an expanded conceptualization of services that transcends industry boundaries. They also highlight the absence of a technology focus in service encounter research.

Although scholarly research on people's readiness to use technology-based systems is sparse, changes to marketing's traditional domain and structure due technology's expanding role in service delivery have been acknowledged in conceptual frameworks pertaining to this subject.

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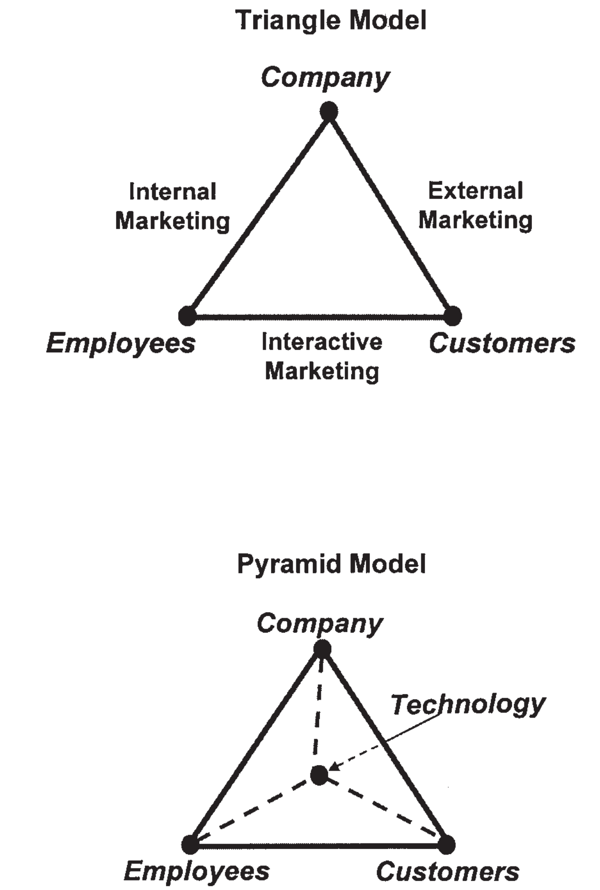
For instance, to highlight the implications of technology-induced shifts in the nature of customer-company interactions, Parasuraman (1996) proposed a "pyramid model" of services marketing. The pyramid model is an extension of the "triangle model" of services marketing, proposed by Kotler (1994) to capture the added complexities of marketing services relative to marketing goods, and is consistent with some of the ideas discussed by Grönroos (1996, 1998). The triangle and pyramid models are shown in Figure 1.

The triangle model underscores the notion that although the marketing of goods occurs primarily in the form of *external marketing*—activities pertaining to the traditional "4 Ps" (product, price, promotion, and place or distribution)—the effective marketing of services requires extra emphasis on two additional forms of marketing: *internal* and *interactive*. Internal marketing is a concept that has been discussed in the services literature for many years (see, for example, Berry 1981). It deals with treating service personnel as internal customers and providing them with appropriate training, support, motivation, and rewards to serve external customers well. Interactive marketing deals with making a good impression on customers during their encounters with service employees.

Both internal and interactive marketing are consistent with the recommendations of Booms and Bitner (1981) who proposed an expanded marketing mix for services by adding three new Ps—people, process, and physical environment—to the traditional 4 Ps. However, these two types of marketing still do not explicitly consider the impact of technology. Because of the rapid infusion of technology into the process through which products and services are purchased and consumed, the triangle model does not completely capture the current complexities of services marketing. To reflect these complexities, the pyramid model incorporates technology as a new dimension into the two-dimensional triangle model and highlights three new links that need to be managed well to maximize marketing effectiveness: company-technology, technology-employee, and technology-customer (Parasuraman 1996).

This article focuses primarily on the technology-employee and technology-customer links in the pyramid model. It has a twofold purpose: (a) to describe the development of the Technology Readiness Index (TRI), a multiple-item scale to assess people's readiness to interact with technology; and (b) to discuss the scale's psychometric properties and potential applications.

FIGURE 1
Triangle and Pyramid Models of Services Marketing



DEFINITION AND IMPORTANCE OF TECHNOLOGY READINESS

The technology-readiness construct refers to *people's propensity to embrace and use new technologies for accomplishing goals in home life and at work.* The construct can be viewed as an overall state of mind resulting from a gestalt of mental enablers and inhibitors that collectively determine a person's predisposition to use new technologies.

Research on the determinants and consequences of adopting new technologies has gone on for decades. The area of telecommunications is a case in point. Scholars started studying telecommunications' affect on and implications for society more than a quarter century ago, when the field was in its infancy relative to what it is today (Short, Williams, and Christie 1976). However, new technologies are now proliferating through various facets of everyday life at a much faster rate than ever before. For instance, whereas the automobile took 55 years to achieve 25% ownership among the population, cellular telephones took only 13 years to reach the same level of ownership (Berry 1999). Ironically, although new technologies have been penetrating the population at increasing rates, ample anecdotal as well as survey-based evidence suggests signs of growing consumer frustration and disillusionment (see, e.g., Alsop 1999; Mossberg 1999). Consider PCs. According to an Arbitron NewMedia survey of 5,500 U.S. households, although home penetration of PCs increased from 29% to 54% between 1995 and 1999, the percentage of adult consumers (ages 16 to 74) who said they were using their home PCs declined from 90% to 53% during the same period ("PC Usage in Homes" 1999). A plausible explanation for the inverse relationship between penetration and use rates is that more recent adopters of new technologies may not be as technology savvy as are early adopters and, therefore, may not be avid users. Another plausible reason is product complexity coupled with a lack of user-friendly instructions and support service. According to Robert McConochie, Arbitron NewMedia's research director, "The patience factor is wearing thin" ("PC Usage in Homes" 1999).

The proliferation of technology-based products and services, and evidence of the challenges and frustrations associated with using them effectively, suggest an urgent need for scholarly inquiries on several important issues: How ready are people to embrace and effectively use new technologies? What are the primary determinants of technology readiness? Is it possible to group people into distinct segments on the basis of their technology readiness, and, if so, do those segments differ meaningfully on demographic, lifestyle, and other criteria? What are the managerial implications for marketing to and serving customer segments that differ on technology readiness? An approach for assessing people's technology readiness, which is this article's principal thrust, is a prerequisite for systematically addressing these issues.

CONCEPTUAL UNDERPINNINGS AND DOMAIN OF TECHNOLOGY READINESS

The extant literature pertaining to adoption of new technologies and people-technology interactions strongly suggests that consumers simultaneously harbor favorable and unfavorable views about technology-based products and services. Mick and Fournier (1998), based on extensive qualitative research on peoples' reactions to technology, identified eight technology paradoxes with which consumers have to cope: control/chaos, freedom/enslavement, new/obsolete, competence/incompetence, efficiency/inefficiency, fulfills/creates needs, assimilation/isolation, and engaging/disengaging. As these paradoxes imply, technology may trigger both positive and negative feelings (e.g., in describing the competence/incompetence paradox, Mick and Fournier, 1998, state that technology can facilitate feelings of intelligence or efficacy, and it can also lead to feelings of ignorance or ineptitude).

Although positive and negative feelings about technology may coexist, the relative dominance of the two types of feelings is likely to vary across individuals. As such, people can be arrayed along a hypothetical technology-beliefs continuum anchored by *strongly positive* at one end and *strongly negative* at the other. Moreover, people's positions on this continuum can be expected to correlate with their propensity to embrace and employ technology (i.e., their *technology readiness*). Insights from a handful of studies that have examined the consumer-technology link are consistent with the hypothesized technology-beliefs continuum and offer support, albeit indirect, for its existence. For instance, studies by Cowles (1989, 1991; Cowles and Crosby 1990) pertaining to interactive media suggest the presence of distinct customer segments with differing perceptions about and acceptance of the media. Likewise, research by Eastlick (1996) revealed that people's attitudes and beliefs about interactive teleshopping were good predictors of their propensity to adopt this mode of shopping. In a study of consumers' evaluations of and intentions to use technology-based self-service options, Dabholkar (1996) found that consumers varied in terms of their beliefs/feelings about the various options and that those beliefs/feelings were positively correlated with intentions to use.

As implied by the foregoing discussion, a combination of positive and negative feelings about technology underlies the domain of technology readiness. Although the positive feelings propel people toward new technologies, the negative feelings may hold them back. The dichotomies in the eight technology paradoxes discussed by Mick and Fournier (1998) reflect general facets of potential drivers and inhibitors of technology readiness. Other studies (e.g., Davis, Bagozzi, and Warshaw 1989; Dabholkar 1994) also have identified specific consumer beliefs and motivations that may enhance (e.g., perceived ease of use, fun) or curtail (e.g., perceived risk) adoption of new technologies. Insights from these studies as well as from preliminary qualitative research formed the foundation for developing a scale to measure technology readiness. The next section provides an overview of the multiple stages of research from which the TRI emerged.

OVERVIEW OF TECHNOLOGY-READINESS RESEARCH PROGRAM

The development of the TRI was a collaborative effort between the author and Rockbridge Associates (a Virginia-based company specializing in service and technology research). This effort involved a multiyear, multiphase research program. The initial phases of the program consisted of qualitative as well as empirical studies commissioned by Rockbridge's clients to understand technology-related attitudes and behaviors of the client companies' customers. Building on insights from these preliminary proprietary studies, the program concluded with the National Technology Readiness Survey (NTRS), a nonproprietary, non-client-sponsored study (underwritten entirely by Rockbridge) for developing a general technology-readiness scale based on responses from a countrywide cross section of adult consumers. The NTRS is the primary focus of the remainder of this article. However, because a number of scale items included in the NTRS came from the preliminary studies, a brief description of the steps that culminated in the NTRS is in order.

Qualitative Research and Generation of Initial Item Pool

Rockbridge had conducted more than a dozen technology-related focus group interviews with customers of companies in a variety of sectors (e.g., financial services, online services, electronic commerce, telecommunications). General themes from these interviews were consistent with the notion that customers have positive feelings as well as apprehensions about technology. Flexibility, convenience, efficiency, and enjoyment are examples of major positive themes that emerged from the focus groups; negative themes included security concerns, risk of obsolescence, impersonalization, and lack of control. The focus group respondents mentioned many specific aspects pertaining to these and other themes that formed the basis for generating scale items to measure technology readiness. This basis was augmented with insights in the literature about attributes for assessing service in general, because several of the technology-related feelings (especially apprehensions) overlap with criteria that customers use in judging service quality (e.g., assurance and empathy [Parasuraman, Zeithaml, and Berry 1988]). Moreover, as Rust (1999) has observed, technology-based interactions and service to customers are intertwined. An initial pool of 44 technology-readiness items was generated from this phase.

A proprietary study commissioned by Sallie Mae, a firm offering a variety of services related to financial assistance for college students, afforded an opportunity for a preliminary evaluation of the 44-item battery. The next section provides an overview of this study and summarizes key insights from it pertaining to technology readiness (details about this study have been discussed by Parasuraman and Colby 1997).

The Sallie Mae Study

The general purpose of this study was to assess Sallie Mae customers' receptivity to and use of various technology-based services. The study involved a survey administered to a representative panel of about 3,000 college students and young professionals (college graduates up to age 35). A total of 1,200 individuals responded (response rate of 40%). Roughly two-thirds of the sample responded by mail, whereas the remainder completed the survey online (no significant differences in response patterns occurred between the two response modes). Respondents answered each technology-readiness item (sample item: "New technology is often too complicated to be useful.") on a 5-point scale: *strongly disagree* (1), *somewhat disagree* (2), *neutral* (3), *somewhat agree* (4), and *strongly agree* (5).

The ratings obtained for the 44 items were subjected to a series of iterative analyses consistent with Churchill's (1979) paradigm for developing scales. An exploratory factor analysis produced five factors with eigenvalues greater than one. Following varimax rotation of the five-factor solution, items with low loadings on all five factors were dropped. For the remaining sets of items (grouped according to the factors on which they had the highest loadings), scale reliabilities (measured by coefficient alpha [Cronbach 1951]) and corrected item-to-total correlations were examined. This analysis identified additional items whose deletion would strengthen coefficient alpha for the corresponding scales. Eliminating these items resulted in a pool of 30 items, which were again factor analyzed to verify if the five-factor structure was still tenable. It was.

Of the five factors, one had just two items, both pertaining to "tangibles" or appearance aspects: "If you use a computer, you prefer attractive graphics on your screen" and "You would not judge the quality of a hi-tech product or service by the attention it pays to graphics or colors" (reverse coded). Moreover, subsequent analyses showed that the tangibles dimension did not correlate with any of the technology-related behaviors or behavioral intentions measured in other sections of the survey. This finding is consistent with results from a recent survey of online shoppers (Hanrahan 1999): Of 10 different online-merchant attributes, "website navigation and looks" had a very weak correlation with the shoppers' likelihood of buying again from the same site (this attribute had the second-lowest correlation, with "product price" having the lowest correlation; "level and quality of customer service" had the highest correlation). Because of this dimension's poor predictive power, and the fact that it was only a two-item measure, it was dropped from the Technology Readiness (TR) scale.

In summary, the condensed scale emerging from this research phase consisted of 28 items clustered into the four categories defined below (all 28 items were included in the NTRS; as such, for the sake of presentation parsimony, the specific items and their factor structure will be presented later when the NTRS is discussed).

1. Optimism (10 items; alpha = .78): A positive view of technology and a belief that it offers people increased control, flexibility, and efficiency in their lives.
2. Innovativeness (5 items; alpha = .82): A tendency to be a technology pioneer and thought leader.
3. Discomfort (8 items; alpha = .79): A perceived lack of control over technology and a feeling of being overwhelmed by it.
4. Insecurity (5 items; alpha = .72): Distrust of technology and skepticism about its ability to work properly.

Of these four dimensions, optimism and innovativeness are drivers of technology readiness, whereas discomfort and insecurity are inhibitors. Additional analyses showed that respondents classified as high, medium, or low based on their scores on each of these dimensions also differed significantly (and in the expected direction) in terms of their use of high-technology products and services. Thus, in addition to being reliable (as evidenced by the high alpha values), the four subscales of the TR scale appeared to be good predictors of technology-related behavior.

Further Testing of the Condensed Scale

Two additional proprietary studies—one for a mortgage bank and another for an online-service provider—offered opportunities for further empirical evaluation of the TR scale, although only to a limited extent (details about this research phase have been discussed by Parasuraman and Colby 1998). Because of questionnaire length and other restrictions imposed by the client companies, only 26 of the 28 items could be included in the mortgage-bank survey, and only 16 items could be included in the online-service survey. Moreover, some of the items had to be reworded slightly to fit the specific study contexts.

Findings from factor analysis of the ratings on the TR items supported the four-factor structure in both studies (although a few items had high cross loadings). However, the reliabilities (alpha values) of the four subscales were generally weaker than in the Sallie Mae study. The reduced number of TR items included in this phase is a plausible explanation for the weaker alpha values. However, audience reactions to presentations based on both this research phase as well as the Sallie Mae study suggested two other shortcomings of the 28-item scale: (a) Many of the scale items were computer or Internet specific rather than pertaining to technology in general, and (b) the proprietary studies involved special samples whose technology-readiness characteristics may not be transferable to the population at large. These deficiencies motivated the design and implementation of the NTRS to develop a more robust and generalizable scale for measuring technology readiness.

THE NTRS

Augmented TR Battery

In response to the concern that the initial scale might be too online specific, a number of new statements were added to broaden the scope and variety of the scale. A reexamination of the transcripts from the technology-related focus group interviews conducted earlier, coupled with brainstorming sessions to identify new attributes that might fit the definitional domains of the four TR dimensions, served as the basis for generating the new items. Thirty-eight new items were added to the 28-item preliminary scale, yielding an augmented battery of 66 statements. Table 1 contains a complete listing of the statements, categorized by dimension. For the sake of presentation convenience and consistency with subsequent tables, the items under each dimension are grouped into two categories: a set of labeled statements retained in the final TR scale (whose development is discussed in the sections below), followed by a set of bulleted statements included in the NTRS but not retained in the final TR scale. Asterisks identify the statements in the preliminary 28-item scale.

Data Collection

A professional research firm specializing in computer-assisted telephone interviewing conducted the fieldwork for the NTRS. The study sample consisted of a national cross section of adults (18 years or older) chosen through random-digit dialing from all over the United States. When no one was available at a telephone number during the initial contact, up to four callbacks were made at different times before replacing the number with another randomly chosen one. A total of 1,000 interviews were completed.

In addition to the 66 TR items, the survey questionnaire contained a variety of questions pertaining to current and potential use of technology-based products and services. It also included questions about respondent demographics. During each telephone interview, the TR statements appeared on the computer screen (one at a time) in a completely random order. Survey participants responded to each question with *strongly agree* (5), *somewhat agree* (4), *neutral* (3), *somewhat disagree* (2), or *strongly disagree* (1).

Data Analyses: Assessment of Factor Structure and Reliability

Table 2 presents orthogonally rotated factor loadings for the preliminary 28-item scale obtained from the Sallie Mae study. This table also shows corresponding loadings from factor analysis of the same 28 items in the NTRS data

TABLE 1
Item Pool Included in the National Technology Readiness Survey (NTRS)

Optimism

OPT1	Technology gives people more control over their daily lives.*
OPT2	Products and services that use the newest technologies are much more convenient to use.*
OPT3	You like the idea of doing business via computers because you are not limited to regular business hours.*
OPT4	You prefer to use the most advanced technology available.*
OPT5	You like computer programs that allow you to tailor things to fit your own needs.*
OPT6	Technology makes you more efficient in your occupation.*
OPT7	You find new technologies to be mentally stimulating.*
OPT8	Technology gives you more freedom of mobility.
OPT9	Learning about technology can be as rewarding as the technology itself.
OPT10	You feel confident that machines will follow through with what you instructed them to do.

- Computers are easier to deal with than people performing the same service.*
- You find you are doing more things now with advanced technology than a couple of years ago.*
- You like the idea of doing business by computer because there is no person to pressure you.*
- People can solve problems more effectively than computers. [reverse scored]
- Society should not depend heavily on technology to solve its problems. [reverse scored]
- People often become too dependent on technology to do things for them. [reverse scored]
- The benefits of new technologies are often grossly overstated. [reverse scored]
- People tell you that you are too optimistic about technology. [reverse scored]
- You find that technology designed to make life easier usually has disappointing results. [reverse scored]
- You want to see the benefits of technology demonstrated before you buy it. [reverse scored]

Innovativeness

INN1	Other people come to you for advice on new technologies.*
INN2	It seems your friends are learning more about the newest technologies than you are. [reverse scored]*
INN3	In general, you are among the first in your circle of friends to acquire new technology when it appears.*
INN4	You can usually figure out new high-tech products and services without help from others.*
INN5	You keep up with the latest technological developments in your areas of interest.
INN6	You enjoy the challenge of figuring out high-tech gadgets.
INN7	You find you have fewer problems than other people in making technology work for you.

- You have avoided trying new high-tech things because of the time it takes to learn them. [reverse scored]*
- You are always open to learning about new and different technologies.
- There is no sense trying out new high-tech products when what you have already is working fine. [reverse scored]

Discomfort

DIS1	Technical support lines are not helpful because they don't explain things in terms you understand.*
DIS2	Sometimes, you think that technology systems are not designed for use by ordinary people.*
DIS3	There is no such thing as a manual for a high-tech product or service that's written in plain language.*
DIS4	When you get technical support from a provider of a high-tech product or service, you sometimes feel as if you are being taken advantage of by someone who knows more than you do.*
DIS5	If you buy a high-tech product or service, you prefer to have the basic model over one with a lot of extra features.
DIS6	It is embarrassing when you have trouble with a high-tech gadget while people are watching.
DIS7	There should be caution in replacing important people-tasks with technology because new technology can breakdown or get disconnected.
DIS8	Many new technologies have health or safety risks that are not discovered until after people have used them.
DIS9	New technology makes it too easy for governments and companies to spy on people.
DIS10	Technology always seems to fail at the worst possible time.

- New technology is often too complicated to be useful.*
- You get overwhelmed with how much you need to know to use the latest technology.*
- With new technology, you too often risk paying a lot of money for something that is not worth much.*
- It is helpful to have a new high-tech product or service explained to you by a knowledgeable person.
- You find it limiting to use high-tech products that are designed to be overly simple. [reverse scored]
- It is not really critical to have a detailed manual for a high-tech product or service. [reverse scored]
- You like to try out all the special features available in a new high-tech product to see what they can do. [reverse scored]
- People miss out on the benefits of technology when they delay a purchase for something better to come out. [reverse scored]
- You feel you are usually in control of new technologies. [reverse scored]
- When you have a problem with technology, you prefer to solve the problem on your own rather than call for help. [reverse scored]
- The hassles of getting new technology to work for you usually makes it not worthwhile.

Insecurity

INS1	You do not consider it safe giving out a credit card number over a computer.*
INS2	You do not consider it safe to do any kind of financial business online.*
INS3	You worry that information you send over the Internet will be seen by other people.*

TABLE 1 Continued

Insecurity	
INS4	You do not feel confident doing business with a place that can only be reached online.*
INS5	Any business transaction you do electronically should be confirmed later with something in writing.*
INS6	Whenever something gets automated, you need to check carefully that the machine or computer is not making mistakes.
INS7	The human touch is very important when doing business with a company.
INS8	When you call a business, you prefer to talk to a person rather than a machine.
INS9	If you provide information to a machine or over the Internet, you can never be sure it really gets to the right place.*
•	Revolutionary new technology is usually a lot safer than critics lead people to believe. [reverse scored]
•	A machine or computer is going to be a lot more reliable in doing a task than a person. [reverse scored]
•	It can be risky to switch to a revolutionary new technology too quickly.
•	If you purchased something from a machine using a credit card, you would usually NOT require a receipt. [reverse scored]
•	If you buy products that are too high-tech, you may get stuck without replacement parts or service.
•	Technological innovations always seem to hurt a lot of people by making their skills obsolete.

NOTE: Labels are shown only for items retained in the final Technology Readiness Index (TRI); bulleted items were included in the NTRS but eliminated during the scale-refinement process. Items with an asterisk at the end were included in the preliminary TR scale developed from the Sallie Mae study. The TRI is copyrighted by Rockbridge Associates and the author; its use requires written permission from the author.

set, as well as coefficient alpha values for the four TR dimensions. A comparison of the results across the two studies shows that the four-factor structure of the preliminary TR scale is reasonably stable. However, a few high cross loadings exist in one or both studies for all four dimensions. Moreover, the coefficient alpha for the insecurity dimension in the NTRS data set is less than the traditionally recommended minimum of .7 (Nunnally 1978).

In light of the aforementioned deficiencies, and because the preliminary scale was augmented in the NTRS to broaden its scope, the data on the full 66-item battery were analyzed using an iterative scale-purification process consistent with Churchill's (1979) paradigm and similar to the one used to obtain the preliminary scale. In accordance with Churchill's recommendation, the process began with the computation of coefficient alpha separately for each of the four sets of items shown in Table 1 (and representing the four a priori dimensions established through the preliminary research phases). The coefficient alpha values ranged from .73 to .78 across the four dimensions; however, the analysis also suggested that deletion of certain items would improve the alpha values for the corresponding dimensions. Deletion of these items and recomputation of alpha values for the reduced sets of items identified a few more items whose elimination would further improve the alpha values. This iterative sequence of steps resulted in a 58-item pool, with alphas for the four subsets of items ranging from .79 to .81.

The reduced pool of 58 items was factor analyzed to verify its dimensionality. A four-factor solution (consistent with the four distinct TR dimensions observed in the previous research phases) was obtained and subjected to varimax rotation. Although the rotated factor pattern was consistent with the a priori four-factor structure, some the items had low loadings (<.3) on all four factors, whereas some others had high loadings (>.5) on more than one factor. These items were eliminated. Moreover, a few items whose highest loadings were on a factor other than the one to which they originally had been assigned were reassigned. The item deletions and reassignments necessitated reexamining the reliabilities of the four subscales. An examination of the coefficient alpha values for the four modified sets of items resulted in a few more item deletions, following which the factor analysis was rerun. The iterative sequence of reliability and factor analyses was repeated (and appropriate item deletions or reassignments made) until no further improvement in alpha values was possible, and the four subscales collectively had a fairly "clean" factor structure and individually had reliability coefficients greater than the minimum recommended value of .7. This process yielded a 36-item scale (referred to hereafter as the TRI) consisting of 10 items for optimism, 7 items for innovativeness, 10 items for discomfort, and 9 items for insecurity. Table 3 presents the factor loadings for the 36 items as well as the alpha values for the four subscales.

Some observations about the content and structure of the TRI are noteworthy. First, the TRI contains 21 (or 75%) of the items in the preliminary scale. These are the labeled items in Table 2 and include 7 items for optimism, 4 items for innovativeness, 4 items for discomfort, and 6 items for insecurity. Thus, the TRI retains a reasonable cross section of items from a scale that had evolved and been tested over multiple earlier phases. Second, the 15 new items in the 36-item TRI attest to the scale's broadened scope (relative to the preliminary 28-item scale). Third, as Table 3 shows, except for the insecurity dimension, the factor-loading pattern for TRI's subscales suggest a less ambiguous dimensional structure than in the case of the preliminary 28-item scale (see Table 2). Three items under the insecurity dimension (INS3, INS6, and INS9), although loading above .3 on that dimension, have somewhat higher loadings on the discomfort dimension. Nevertheless, a decision was made to retain them under in-

TABLE 2
Preliminary 28-Item Technology Readiness (TR) Scale: Factor Loadings After Varimax Rotation

	TR Dimensions							
	Optimism		*Innovativeness*		*Discomfort*		*Insecurity*	
Item	*S.M.*	*NTRS*	*S.M.*	*NTRS*	*S.M.*	*NTRS*	*S.M.*	*NTRS*
OPT1	55	59	—	—	—	—	—	—
OPT2	68	62	—	—	—	—	—	—
OPT3	59	60	—	—	—	—	—	—
OPT4	50	59	50	—	—	—	—	—
OPT5	51	47	—	—	—	—	—	—
OPT6	54	62	32	—	—	—	—	—
OPT7	36	54	44	—	—	—	—	—
•	70	48	—	—	—	—	—	—
•	44	57	32	—	—	—	—	—
•	52	60	—	—	—	—	—	—
INN1	—	32	80	72	—	—	—	—
INN2	—	—	66	62	–32	–38	—	—
INN3	—	34	65	64	—	—	—	—
INN4	—	—	66	68	—	—	—	—
•	—	—	50	47	–48	–52	—	—
DIS1	—	—	—	—	64	63	—	—
DIS2	—	—	—	—	59	50	—	—
DIS3	—	—	—	—	57	52	—	—
DIS4	—	—	—	—	48	60	—	—
•	—	—	—	—	71	67	—	—
•	—	—	–35	–44	63	57	—	—
•	—	—	—	—	49	52	—	—
INS9[a]	—	—	—	—	49	46	45	49
INS1	—	—	—	—	—	—	70	71
INS2	—	—	—	—	—	—	70	65
INS3	—	—	—	—	—	41	62	51
INS4	—	—	—	—	—	—	58	60
INS5	—	—	—	—	31	—	56	55
Cronbach's alpha	.78	.80	.80	.74	.79	.78	.72	.68

NOTE: Item labels correspond to those shown in Table 1. For each dimension, (a) items with just bullet labels correspond to the asterisked bulleted items under that dimension in Table 1 (e.g., the third bulleted item under "Optimism" is "You like the idea of doing business by computer . . . "), and (b) the first and second columns of numbers are from the Sallie Mae (S.M.) study and the National Technology Readiness Survey (NTRS), respectively. All numbers (except in the last row) are factor loadings multiplied by 100. Loadings that are .30 or less are not shown.
a. This item was under the discomfort dimension in the preliminary scale but was reassigned to the insecurity dimension in the final TR scale.

security for two reasons: (a) The reliability analysis results showed that reassigning them to the discomfort dimension would lower the coefficient alpha value for the insecurity dimension to below .7 (with no significant improvement in the alpha value of .75 for discomfort), and (b) the content of the three items—all dealing with *transaction-specific* uncertainties—suggested that they were more similar to the other items under the insecurity dimension than to the discomfort items (which pertain to a more general paranoia about technology).

To further verify the dimensional structure shown in Table 3, a confirmatory factor analysis of a measurement model (with four latent constructs representing the four TRI subscales and the corresponding items for each subscale specified as manifest variables) was conducted using LISREL 8.14. This analysis indicated that the model fit the data reasonably well. Although the model produced a significant chi-square value ($p < .01$), which could be an artifact of the large sample size (Bagozzi and Yi 1988), other goodness-of-fit statistics indicated satisfactory fit (goodness-of-fit index = .91; non-normed fit index = .87; comparative fit index = .88; root mean square residual = .05).

Data Analysis: Assessment of Validity

The high reliabilities and consistent factor structure of the TRI's four dimensions provide support for the scale's trait validity (Peter 1981). However, high reliability coefficients and consistent dimensionality are necessary, but not sufficient, for establishing construct validity (Churchill 1979). To assess a scale's construct validity—the extent to which it fully and unambiguously captures the underlying

TABLE 3
Final 36-Item Technology Readiness (TR) Scale: Factor Loadings After Varimax Rotation

	TR Dimensions			
Item	*Optimism*	*Innovativeness*	*Discomfort*	*Insecurity*
OPT1	62	—	—	—
OPT2	60	—	—	—
OPT3	54	—	—	—
OPT4	54	—	—	—
OPT5	50	—	—	—
OPT6	54	—	—	—
OPT7	57	—	—	—
OPT8	66	—	—	—
OPT9	56	—	—	—
OPT10	53	—	—	—
INN1	—	70	—	—
INN2	—	55	–35	—
INN3	—	63	—	—
INN4	—	65	—	—
INN5	—	61	—	—
INN6	39	56	—	—
INN7	—	52	—	—
DIS1	—	—	66	—
DIS2	—	—	47	—
DIS3	—	—	45	—
DIS4	—	—	62	—
DIS5	—	—	40	—
DIS6	—	—	52	—
DIS7	—	—	45	—
DIS8	—	—	52	—
DIS9	—	—	52	—
DIS10	—	—	48	—
INS1	—	—	—	58
INS2	—	—	—	56
INS3	—	—	45	37
INS4	—	—	—	59
INS5	—	—	—	58
INS6	—	—	39	35
INS7	—	—	—	46
INS8	—	—	—	47
INS9	—	—	52	37
Cronbach's alpha	.81	.80	.75	.74

NOTE: Item labels correspond to those shown in Table 1. All numbers (except in the last row) are factor loadings multiplied by 100. Loadings that are .30 or less are not shown.

unobservable construct it is intended to measure—it must be evaluated further on certain other conceptual and empirical criteria.

The principal conceptual yardstick pertaining to construct validity is face or content validity: Does the scale appear to measure what it is supposed to? Do the scale items capture key facets of the unobservable construct being measured? Assessing content validity is necessarily subjective and involves examining (a) the thoroughness with which the construct's domain was established and (b) the adequacy of the scale items in terms of representing all facets of that domain. As the discussion in earlier sections implies, the TRI meets both these criteria. The scale emerged from an extensive multiphase research program beginning with qualitative research (including a synthesis of the extant literature on consumers' beliefs about technology) to explicate the construct's domain, followed by a series of studies to refine and augment the domain and enhance its robustness.

Empirical evaluation of the scale's construct validity involved examining the association between respondents' TRI scores and their answers to a number of questions pertaining to their experience with and perceptions about technology-based products and services. The NTRS included three sets of such questions:

1. Questions about owning or having in-home access to various technology-based products/services (e.g., cable TV; Internet service). These questions offered three response choices: *currently have*, *plan to get in the next 12 months*, and *no plans to get*.
2. Questions about use of specific technology-based services (e.g., using an ATM; making online purchases). The response choices for these questions were *used in the past 12 months*, *plan to use in the next 12 months*, and *no plans to use*.
3. Questions about perceived desirability of engaging in a variety of "futuristic" technology-based services (e.g., making full two-way video phone calls; using robot checkouts at supermarkets). Respondents rated each service on a 6-point desirability scale (1 = *very undesirable*, 6 = *very desirable*).

The overall purpose of the analyses linking the TRI scores to responses to these questions was to ascertain whether the scores perform as one might expect them to if the TRI is indeed a sound measure of the technology readiness construct. For instance, is the TRI able to discriminate well between users and nonusers of high-technology services? Is the TRI's ability to discriminate stronger for more complex or more futuristic technologies? Is it stronger for technology-based services for which user discomfort and insecurity are likely to be especially germane or pronounced?

Table 4 presents mean TRI scores segmented by ownership of (or subscriptions to) eight different technology-based products/services. These results are from one-way ANOVA (followed by Duncan's multiple-range tests to identify significant differences among the three customer segments). The mean TRI scores do not differ significantly across the three ownership/subscribership categories for the first four products/services (cable TV, direct broadcast TV, answering machine, caller ID). In contrast, at least two of the three customer segments differ significantly for the remaining four. Specifically, customers owning cellular phones are significantly more technology ready than are

TABLE 4
Relationship Between the Technology Readiness Index (TRI) and Having Technology-Based Products and Services

	Ownership/Subscribership Categories		
Technology-Based Product/Service	*Currently Have*	*Plan to Get in the Next 12 Months*	*No Plans to Get*
Cable television service	2.91[a] (724)	2.82[a] (36)	2.80[a] (240)
Direct broadcast television service	2.92[a] (140)	2.95[a] (80)	2.87[a] (780)
Answering machine at home	2.90[a] (789)	2.75[a] (25)	2.81[a] (186)
Caller ID at home	2.89[a] (399)	2.89[a] (84)	2.87[a] (517)
Cellular phone for household	2.96[a] (533)	2.83[b] (115)	2.78[b] (352)
Voice mail at home	3.05[a] (289)	2.97[a] (54)	2.80[b] (657)
Computer at home	3.04[a] (657)	2.74[b] (125)	2.50[c] (218)
Internet service at home	3.12[a] (454)	2.84[b] (184)	2.57[c] (284)

NOTE: The mean values shown are on a 1 to 5 overall TRI scale (numbers in parentheses are sample sizes for the different groups of consumers). Means with the same superscripts are not significantly different; means with different superscripts are significantly different at $p < .05$.

the other two segments. Customers with no plans to obtain a voice-mail service are significantly less technology ready than are those who already have the service or plan to get it in the next 12 months. And, for the two remaining products/services (i.e., computer at home and Internet service at home), the technology readiness scores are significantly different across all three customer segments.

Of the eight technology-based products/services listed in Table 4, the first four are arguably less complex (from an ease-of-use perspective) than the remaining four. Moreover, they do not call for as much technological savvy and user involvement to operate properly; and, as such, user discomfort and insecurity are less likely to be critical issues for them. Therefore, the findings in Table 4 offer some evidence of the TRI's construct validity by demonstrating the scale's ability to discriminate well across different levels of ownership of (or subscriptions to) those products/services for which one might a priori expect consumers' technology readiness levels to be especially relevant.

Table 5 summarizes ANOVA results pertaining to the association between the TRI scores and actual use (as opposed to just ownership/subscribership) of several technology-based services—purchasing a plane/train ticket through a machine, using an ATM, conducting banking transactions over an automated phone system, buying/selling stock/securities online, signing up for a telecommunications service online, purchasing products online—that are likely to be intimidating to customers with a low inherent propensity to embrace new technologies. As the mean TRI scores for the three customer categories imply, except in the case of signing up for a telecommunications service online, users of these services are significantly more technology ready than nonusers who were just planning to use them in the next 12 months, who, in turn, are significantly more technology ready than those who had no plans to use them. This consistent pattern of results lends further credence to the TRI's construct validity.

Table 6 reports ANOVA results pertaining to the desirability—as perceived by high-, medium-, and low-TR customers—of 14 different futuristic or recently introduced technology-based services. For the first five services listed in Table 6, perceived desirability for low-TR customers is significantly lower than that for medium-TR customers, which, in turn, is significantly lower than that for high-TR customers. For the next five services, the desirability scores for medium- and high-TR customers are not significantly different but are both significantly higher than for low-TR customers. For the next three services, although the desirability scores for low- and medium-TR customers do not differ significantly, they both are significantly lower than the scores for high-TR customers. The only service for which desirability scores are statistically similar for all three groups is for the emergency-beacon service (shown last in Table 6). The fact that the perceived desirability of emerging technology-based services differed significantly—and in the predicted directions—across the three TR segments for virtually all of the services listed in Table 6 adds to one's confidence in the TRI's construct validity.

SUMMARY STATISTICS FOR THE TRI AND ITS COMPONENTS

Table 7 contains statistics pertaining to the distribution of respondents' scores on the four components of the technology readiness construct as well as the overall TRI. This table also reports all pair-wise correlations among the TRI and its components.

The results for the four TR components suggest that although people are generally optimistic about technology (mean = 3.84, with a distribution skewed to the right), they also experience a considerable amount of insecurity concerning its role (mean = 4.03, with a distribution skewed to the right). Furthermore, the correlation between these two components, although statistically significant, is weak—the correlation of –.28 implies that the variance shared by the two is less than 9%. Likewise, the correlation of –.30

TABLE 5
Relationship Between the Technology Readiness Index (TRI) and Use of Technology-Based Services

	Use Categories		
Technology-Based Service	*Used in the Past 12 Months*	*Plan to Use in the Next 12 Months*	*No Plans to Use*
Purchased a plane or train ticket through a machine	3.30[a] (97)	3.09[b] (57)	2.82[c] (846)
Used an ATM	2.99[a] (701)	2.79[b] (31)	2.60[c] (268)
Conducted telephone banking using an automated phone system	3.12[a] (377)	2.91[b] (52)	2.72[c] (571)
Bought or sold stock or securities online	3.50[a] (60)	3.24[b] (72)	2.90[c] (677)
Signed up for a telecommunications service online	3.20[a] (50)	3.14[a] (33)	2.95[c] (726)
Purchased online an item costing			
Less than $10	3.36[a] (138)	3.07[b] (80)	2.87[c] (591)
$10 to $100	3.34[a] (213)	3.02[b] (71)	2.82[c] (525)
More than $100	3.34[a] (115)	3.16[b] (66)	2.89[c] (628)

NOTE: Means with the same superscripts are not significantly different; means with different superscripts are significantly different at $p < .05$.

between people's technology-related innovativeness and insecurity is also relatively low, as are the correlations between optimism and discomfort (–.32) and innovativeness and discomfort (–.4). Thus, even technology optimists and innovators apparently experience technology-related anxieties at levels similar to those experienced by individuals who are much less enthusiastic about technology to begin with. This intriguing insight is consistent with the notion of "technology paradoxes" (Mick and Fournier 1998) introduced earlier.

The mean value of 2.88 for the overall TRI is close to the midpoint of the 5-point scale used to measure technology readiness. Moreover, the skewness value of –.01 implies that the distribution of the overall TRI scores is almost perfectly symmetric about the mean. And, although the negative kurtosis (–.19) implies a flatter-than-normal distribution, the fact that its magnitude is close to zero suggests that the distribution does not deviate markedly from a standard normal distribution.

POTENTIAL APPLICATIONS OF THE TRI

The tremendous growth of technology-based products and services, and the increasing rate at which companies are turning to technology to streamline how they market to and serve customers, call for a thorough assessment of customers' technology readiness. As implied by insights from the NTRS, as well as previous studies on people's reactions to technology, customers' propensity to embrace technology varies widely, resulting from an interplay between drivers (optimism, innovativeness) and inhibitors (discomfort, insecurity) of technology readiness. The TRI is a multiple-item scale with sound psychometric properties that companies can use to gain an in-depth understanding of the readiness of their customers (both external and internal) to embrace and interact with technology, especially computer/Internet-based technology.

Examining the TRI scores of a company's current customers can help answer a variety of questions germane to the company's technology strategies and to the effective management of the customer-technology link in the pyramid model (see Figure 1). For instance, what is our customer base's overall level of readiness to interact effectively with technology-based products and services? How does it compare with the technology readiness of the public at large (as measured by, for example, the NTRS)? Are there distinct segments in our customer base that differ in terms of technology readiness? If so, what are the relative sizes of those segments, and do they have any distinguishing demographic, lifestyle, or purchasing characteristics? Answers to these and related questions can provide useful insights pertaining to issues such as the extent to which technology-based systems should be the conduit for customer-company interactions, the types of systems that are likely to be most appropriate, the pace at which the systems should/could be implemented, and the types of support needed to assist customers experiencing problems with technology-based systems.

TABLE 6
Relationship Between the Technology Readiness Index (TRI) and Perceived Future Desirability of Various Technology-Based Services

Technology-Based Service	*Technology Readiness Categories* Low TR (n = 163; mean TR = 2.26)	Medium TR (n = 175; mean TR = 2.89)	High TR (n = 159; mean TR = 3.51)
Maintain a family home page on the Internet	2.74[a]	3.41[b]	3.93[c]
Use a robot check-out at the supermarket	2.37[a]	2.76[b]	3.59[c]
Watch an interactive television show that allows customization of program content	3.21[a]	3.76[b]	3.99[c]
Vote in a local-government referendum from a home computer	3.25[a]	3.72[b]	4.28[c]
Purchase small items like tickets to events over the Internet	3.31[a]	3.87[b]	4.52[c]
Purchase a large item like a car or furniture over the Internet	2.15[a]	2.48[b]	3.15[b]
Make phone call with full two-way video	3.40[a]	4.16[b]	4.50[b]
Send a voice message over the Internet	3.45[a]	4.08[b]	4.39[b]
Visit the World Wide Web through a web TV rather than a computer	3.27[a]	3.74[b]	3.75[b]
Attend an online class that allows electronic information exchange among all parties	3.60[a]	4.16[b]	4.40[b]
Read a book off a CD or the Internet with the aid of a portable electronic viewer	3.12[a]	3.37[a]	3.87[b]
Allow a computer to help diagnose and treat a medical problem	3.17[a]	3.38[a]	3.77[b]
Apply for a large loan over the Internet	2.07[a]	2.31[a]	2.78[b]
Own an emergency beacon for identifying a person's location	3.54[a]	3.63[a]	3.94[a]

NOTE: The TRI categories shown above represent a three-way split of the sample (with approximately equal subsample sizes) based on respondents' scores on the 5-point overall TRI scale. The numbers in each row are mean desirability values based on a 6-point scale (6 = *very desirable*, 5 = *desirable*, 4 = *slightly desirable*, 3 = *slightly undesirable*, 2 = *undesirable*, and 1 = *very undesirable*). Means with the same superscripts are not significantly different; means with different superscripts are significantly different at $p < .05$.

TABLE 7
Summary Statistics for the Technology Readiness Index (TRI) and Its Components

TR Components	*Mean*	*Standard Deviation*	*Skewness*	*Kurtosis*	*Correlation Coefficients*[a] *OPT*	*INN*	*DIS*	*INS*
Optimism (OPT)	3.84	.72	–.93	.98	1.00			
Innovativeness (INN)	3.18	.92	–.12	–.68	.52	1.00		
Discomfort (DIS)	3.46	.72	–.17	–.46	–.32	–.40	1.00	
Insecurity (INS)	4.03	.68	–.69	.01	–.28	–.30	.56	1.00
Overall TRI	2.88	.56	–.01	–.19	.72	.79	–.75	–.69

NOTE: All mean values are on a 5-point scale. The overall TRI score for each respondent was obtained by averaging the scores on the four components (after reverse coding the scores on the discomfort and insecurity components).
a. All correlations are significant at $p < .05$.

The TRI also can be used to assess the technology readiness of internal customers (i.e., employees). As in the case of external customers, gaining a good understanding of the technology readiness of employees is important for making the right choices in terms of designing, implementing, and managing the employee-technology link (see Figure 1). The issue of technology readiness is especially important for contact employees to whom customers may turn for assistance when there are problems with the customer-technology interface. In those situations, satisfactory problem resolution will hinge not only on the contact employees' people skills but also on their technology readiness. Employees who rate high on both interpersonal skills and technology readiness are likely to be much more effective in tech-support roles than are employees who are deficient on either criterion. As such, the TRI can serve as a supplementary screening device, along with traditional people-skills assessments, in selecting personnel for tech-support positions.

DIRECTIONS FOR FUTURE RESEARCH

The findings from the NTRS suggest several avenues for scholarly research aimed at enhancing extant knowledge about technology's role in marketing to and serving customers. Insights about the structure of the technology readiness construct, and the availability of a scale to measure it, should provide an impetus for developing and empirically testing conceptual models in which TR is a core construct. For instance, models positing various antecedents (e.g., demographics, psychographics) and consequences (e.g., satisfaction with products/services, general life satisfaction) of overall technology readiness are worthy of investigation. Examining more detailed models (e.g., ones focusing on the antecedents and consequences of each of the four components of the overall TR construct) is another potentially fruitful avenue for research.

There is also a need for comparative studies of technology readiness across countries and cultures. Do the patterns of TR-related findings for the United States (e.g., the relatively high scores on optimism and insecurity about technology) hold in other countries? If not, in what ways do the findings differ, and what factors (e.g., cultural, socioeconomic) could account for the differences? What are the implications of such differences for multinational companies in which technology plays a major role in interacting with customers? Research-based answers to questions such as these can contribute to international marketing theory and practice.

Yet another direction for future research is to track technology readiness within and across different populations over time and to identify possible reasons for any changes (or lack thereof). Such longitudinal research may reveal important insights about the stability of the construct. A related research priority is to investigate the relative stability of the four individual components of technology readiness. For example, is innovativeness (an apparently intrinsic characteristic of individuals) more stable over time than insecurity or discomfort? Likewise, are certain subfacets within each component more stable than others? Answers to these questions will not only deepen our understanding of the construct but also offer practical suggestions for increasing people's technology readiness.

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