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An Updated and Streamlined Technology Readiness Index: TRI 2.0

A. Parasuraman[1] and Charles L. Colby[2]

Abstract

The Technology Readiness Index (TRI), a 36-item scale to measure people's propensity to embrace and use cutting-edge technologies, was published in the *Journal of Service Research* over a decade ago. Researchers have since used it in a variety of contexts in over two dozen countries. Meanwhile, several revolutionary technologies (mobile commerce, social media, and cloud computing) that were in their infancy just a decade ago are now pervasive and significantly impacting people's lives. Based on insights from extensive experience with the TRI and given the significant changes in the technology landscape, the authors undertook a two-phase research project to update and streamline the TRI. After providing a brief overview of technology readiness and the original TRI, this article (a) describes the multiple research stages and analyses that produced TRI 2.0, a 16-item scale; (b) compares TRI 2.0 with the original TRI in terms of content, structure, and psychometric properties; and (c) demonstrates TRI 2.0's reliability, validity, and usefulness as a customer segmentation tool. The article concludes with potential applications of TRI 2.0 and directions for future research.

Keywords

technology readiness, technology adoption, technology use, TRI, TR-based segments

Introduction

The Technology Readiness Index (TRI), a 36-item scale to measure "technology readiness"—defined as "people's propensity to embrace and use new technologies for accomplishing goals in home life and at work"—was published over a decade ago (Parasuraman 2000, p. 308). Since then, technology has revolutionized service delivery in virtually every service category. The magnitude of change is evident in the growth and penetration statistics of foundational technologies. As of 2013, 2.7 billion people worldwide had Internet access, with global penetration growing from 7% in 2000 to 39% in 2013 (Brahima 2013). Growth in mobile technology is even more prolific, with mobile cellular subscriptions worldwide growing from 2.3 billion in 2005 to 6.8 billion in 2013 (Brahima 2013). Another example of increasing connectivity is social media—Facebook had 1 million subscribers worldwide in 2004, 350 million in 2009, and over 1 billion in 2012 (Yahoo! Finance 2012).

The impact of these technologies in the service domain is evident in statistics tracked in the United States since 1999 by the National Technology Readiness Survey (NTRS).[1] In the financial services category, for instance, while just 30% of consumers with Internet access checked bank account information online in 1999, 51% did so in 2004, and 76% in 2012. Similar technology-induced growth trends are evident in other categories such as investing, travel, online education, e-government, health care and "Customer to Customer (C2C)"commerce.

Technology-triggered transformation in services is likely to accelerate in the future because current technologies are increasing rapidly in speed, capacity, connectivity, functionality, and ease of use, while potentially groundbreaking innovations are still nascent. The Consumer Electronics Association identified five important future technologies likely to significantly affect service delivery and consumption: (1) increased linking of physical objects across billions of nodes, (2) driverless vehicles, (3) digital health care, (4) robotic technology, and (5) empowerment of consumers as curators of digital content (Chisholm et al. 2013). These technologies will have major implications for service providers, customers, and employees. For instance, the billions of interconnected nodes will enable ultimate service personalization through continually responding to real-time information about customers and their environments. Driverless vehicles will free up a substantial block of time and create a new service delivery channel (the vehicle). Digital health care will present opportunities wrought by wearable devices, robotic aids, telemedicine, and so on. Robots will open a revolutionary frontier that could upset traditional

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customer-employee relationships. And, media service providers must adopt new business models to survive as their audience takes control of content.

For service providers, customers, and employees, the technology revolution has caused tension between the positive aspects of increased value and the negative aspects of having to learn and develop trust in new methods of doing business. Previously, *managers* in service firms may have been preoccupied with the challenge of converting a bricks-and-mortar distribution system into one with electronic, self-service interfaces. But going forward, as technology revolutionizes services, managers must cope with more complex challenges associated with delivering innovative service experiences, while ensuring that customers are receptive to those experiences, and potential adverse effects on employees are minimal.

Customers also face trade-offs associated with trying to get maximum value from technology-based service options without encountering frustration or failure. To illustrate, a music consumer who subscribes to a service like iTunes™ will have convenient access to a vast array of music and videos, but will have to master the skills of downloading and managing content; or, a patient needing a lifesaving procedure could forgo travel to a hospital, but must learn to trust a remotely controlled robot.

Likewise, *employees*, especially customer-facing employees, must feel confident about and comfortable with new technology-based service options; otherwise, their morale and productivity may decline. Understanding employees' reactions to cutting-edge technologies is as critical as understanding customers' reactions. Thus, the importance and practical relevance of the Technology Readiness (TR) construct will continue to grow, commensurate with rapidly evolving technologies.

Conceptual Underpinnings and Domain of Technology Readiness

The original TRI was anchored in literature on adoption of new technologies and people-technology interactions. A brief recap of that literature would be helpful. As summarized in Parasuraman (2000), Mick and Fournier's (1998) seminal work, based on extensive qualitative research on peoples' reactions to technology, identified eight technology paradoxes (e.g., freedom/enslavement, assimilation/isolation, efficiency/inefficiency), implying that technology may trigger both positive and negative feelings. Based on Mick and Fournier's findings, and insights from previous studies in the context of interactive media (Cowles and Crosby 1990), teleshopping (Eastlick 1996), and self-service technologies (SSTs; Dabholkar 1996), Parasuraman argued that the relative dominance of positive and negative feelings about technology would vary across people and cause corresponding variations in people's propensity to embrace and employ new technologies. Other studies (e.g., Davis, Bagozzi, and Warshaw 1989) also have identified specific consumer beliefs and motivations that may enhance (e.g., perceived ease of use, fun) or curtail (e.g., perceived risk) new technology adoption.

Contemporaneous with and subsequent to the TRI's development, other scholars have examined the advantages and drawbacks of new technology-based systems and their implications for fostering consumer acceptance. For instance, Hoffman, Novak, and Peralta (1999) discussed the need and strategies for bolstering consumer trust in e-commerce, which was still nascent and hence cutting edge at that time. Alluding to the technology paradoxes uncovered by Mick and Fournier (1998), Bitner (2001) elaborated on the challenges vis-à-vis consumer and employee acceptance of technology-based service systems. Meuter et al. (2003, 2005) posited and empirically examined associations between consumers' technology-related characteristics (e.g., technology anxiety) and their usage of SSTs.

Since the TRI's publication, the pace of technological change has accelerated, with the advent of advances such as high-speed Internet access, mobile commerce, social media, and cloud computing. Against this backdrop, and informed by over 12 years of experience using the TRI, the authors initiated the development of an updated and streamlined TRI 2.0. To distinguish the original TRI from TRI 2.0, hereafter the former is referred to as TRI 1.0.

The remainder of this article first offers a brief overview of the technology readiness construct and the 36-item TRI 1.0. It then discusses (a) the motivation for developing TRI 2.0 and the multiphase process employed in doing so, (b) TRI 2.0's psychometric properties and summary statistics vis-à-vis those of TRI 1.0, and (c) a TR-based segmentation of consumers using latent class analysis (Magidson and Vermunt 2003). The article concludes with TRI 2.0's potential applications and some future research directions.

The Structure of Technology Readiness and TRI 1.0

Technology readiness represents a gestalt of mental motivators and inhibitors that collectively determine a person's predisposition to use new technologies (Parasuraman 2000). The construct is multifaceted, comprising four dimensions:

- Optimism—a positive view of technology and a belief that it offers people increased control, flexibility, and efficiency in their lives.
- Innovativeness—a tendency to be a technology pioneer and thought leader.
- Discomfort—a perceived lack of control over technology and a feeling of being overwhelmed by it.
- Insecurity—distrust of technology, stemming from skepticism about its ability to work properly and concerns about its potential harmful consequences.

Of the four dimensions, optimism and innovativeness are "motivators," contributing to TR, whereas discomfort and insecurity "inhibitors," detracting from it. Moreover, the four dimensions are relatively distinct, meaning that an individual can possess different combinations of technology-related traits, sometimes leading to a paradoxical state that consists of strong motivations tempered by strong inhibitions.

TRI 1.0 consists of 36 belief statements, each with a fully anchored 5-point scale (*strongly disagree* = 1 to *strongly agree* = 5). Of the 36 statements, 10 measure Optimism, 7 measure Innovativeness, 10 measure Discomfort, and 9 measure Insecurity. Thus, TRI 1.0 provides dimension-specific as well as overall measures of TR.

TR is an individual-level characteristic that does not vary in the short term nor does it change suddenly in response to a stimulus. Higher TR levels are correlated with higher adoption rates of cutting-edge technology, more intense usage of technology, and greater perceived ease in doing so (e.g., see Kuo 2011; Lin and Chang 2011; Massey, Khatri, and Montoya-Weiss 2007).

The Technology Readiness Research Program

TRI 1.0's development was a collaborative effort between the authors and Rockbridge Associates (a Virginia-based market research company specializing in technology and services issues). As part of an ongoing research program on TR, the authors have conducted multiyear surveys of the U.S. adult population (these are the NTRS mentioned previously), derived normative measures of TR from the survey data, and monitored technology behavior trends. Data from the 1999 NTRS were used in developing, fine-tuning, and validating TRI 1.0 (Parasuraman 2000). Subsequent NTRS studies included TRI 1.0 as well as measures of technology-related behaviors, intentions, and preferences.

To date, the authors have provided academic licenses for TRI 1.0's use to 127 researchers in 30 countries, where it has often been translated into local languages. Almost a third (29%) of the applications have been in the United States, but other countries with many users include Germany (9%), Malaysia (6%), Turkey (6%), United Kingdom (6%), China (5%), India (5%), Brazil (4%), Canada (4%), Philippines (4%), and South Africa (4%). Most of the studies involved business-to-consumer contexts (41%), but a good number were in business-to-business (30%) and educational (29%) contexts. TRI 1.0's applications span a variety of services, attesting to the proliferating influence of technology in the service domain. A longitudinal analysis of the academic license requests suggests that TRI 1.0's early applications were in sectors that were early adopters of technology-based service delivery models, including financial services and retailing. The applications then spread to government and nonprofit services, and more recently to health care.

Motivation for Developing TRI 2.0

The collective experience from over a decade of TRI 1.0's use in the NTRS and other studies surfaced some key issues that provided the impetus for updating the scale. The feedback from other researchers came through a LinkedIn TR forum as well as through personal communications. The issues included a need to (a) reassess scale statements referencing contexts that were no longer innovative, (b) examine and incorporate relevant implications of a changing technology environment, and (c) make the instrument more parsimonious.

An inherent challenge with a scale that measures technology attitudes is that the technologies themselves change over time, the pace being particularly fast in the realm of service delivery technologies. Scale items that refer to specific technologies to make the statements meaningful and clear to respondents risk losing their relevance if the referenced technologies become obsolete or commonplace. Perhaps because of this, the overall TRI as measured by the NTRS tended to shift gradually upward over time. For example, an abbreviated 10-item version of TRI 1.0 that Rockbridge tracked averaged 100 in 1999, but reached 103 in 2009. Though this change was relatively minor, the trend signaled that some scale items might be losing their relevance. For example, for the item "I do not consider it safe to do any kind of financial business online," the percentage of NTRS respondents that *strongly* or *somewhat* agreed was 58% in 1999, 50% in 2004, and 38% in 2009. Because online financial services were becoming increasingly common in the United States, the item became less relevant and contributed to the TR index's upward drift. Other TRI 1.0 items contained words such as "machine," "computer," and "computer program" that were becoming outdated.

Another issue was that many formative technologies of today were in their infancy in 1999. Examples include smartphones, wireless Internet services, social media, home videoconferencing, and cloud applications. In addition, new issues were emerging in societal conversations about technology, including concerns about social dependency and distraction. There was a need to ensure that the TR index captured contemporary technology-related themes to ensure its continued relevance.

Finally, a commonly expressed concern was that the 36-item index was too long. The benefit of having an extensive item battery was that it offered psychometrically sound measures of the four distinct TR dimensions. However, many researchers seeking permission to use the scale were only interested in measuring overall TR, as just one construct in comprehensive multiconstruct frameworks. They therefore needed survey space to measure other constructs and opted to use the concise 10-item version mentioned previously. Consequently, the question arose as to whether a shorter version of the TR index—one that could measure overall TR as well as its four components without sacrificing reliability and validity—could be developed through a rigorous scale development process. Recently, Lin and Hsieh (2012) derived a 16-item TR scale from the original 36-item scale and empirically verified its reliability and validity in contexts involving the use of SSTs. However, their research effort was primarily empirical and focused solely on condensing the original scale by eliminating items. It did not involve updating the scale by adding new items or modifying current items to address the changing technology environment and to capture emerging technology themes.

Development of TRI 2.0

The cumulative experience of the authors' and other researchers' use of TRI 1.0 provided preliminary ideas about the types of changes the instrument needed. To augment and flesh out those ideas, the authors undertook additional exploratory research. This qualitative phase was followed by an extensive quantitative research phase to refine TRI 1.0 and assess the refined scale's psychometric soundness.

Qualitative Research Phase

The exploratory phase of TRI 2.0's development consisted of an interactive discussion with consumers using a virtual data collection forum, OpinionPond™ (Woodall and Colby 2011). The OpinionPond forum mirrors a social media discussion, allowing consumers to post comments and respond to others' comments in a user-friendly, graphically attractive environment. A representative sample of U.S. adults (age 18 and older) was recruited from an online panel to participate in the discussion. The sample was prescreened and balanced to include a mix of consumers by gender (half male), age, education (at least a fourth had no college), employment status (at least half were employed), and technology readiness (at least one quarter scored low based on a short list of 6 items). A total of 61 respondents participated in a 1-weeklong discussion. The research team monitored the discussion and posted follow-up questions to seek clarification and stimulate further discussion when necessary.

A principal objective of the OpinionPond discussion was to obtain information about motivators and inhibitors underlying the adoption and use of cutting-edge technologies. Another objective was to identify unique traits that might help differentiate consumers who adopt at different stages of a technology's life cycle. A final objective was to identify what consumers consider to be "cutting edge" in terms of products, services, and behaviors. Consistent with TR's definition, the discussion topics addressed both the personal and occupational spheres of technology adoption and use.

During the weeklong discussion period, respondents were asked to comment at least twice on several technology-related topics to generate relevant information for modifying TRI 1.0, as well as for ensuring that the survey instrument contained an adequate number of questions about (a) personal, demographic, and occupational characteristics that might be potential correlates of technology adoption and use and (b) contemporary tech-oriented behaviors (in order to validate TRI 2.0). Specifically, the following open-ended questions were posted on the forum and participants were asked to comment on them:

- What's cutting-edge technology at home? (To generate examples of technologies for personal use)
- What's cutting-edge technology at work? (To generate examples of technologies for work use)
- What motivates you to try new technology? (To uncover underlying beliefs that contribute to technology adoption and use)
- What makes you hesitant to try new technology? (To uncover underlying beliefs that inhibit technology adoption and use)
- What is it about you in particular that influences the extent of your technology use? (To identify personal characteristics, such as demographics and lifestyle, that could affect technology use)

Forum participants were also given an opportunity to pose questions about pertinent issues not covered in the discussion.

This research phase produced a rich data set of 317 comments (about 5 per respondent). To assimilate the results and identify technology themes, the research team convened a brainstorming session that included four analysts who helped moderate the forum and one of the authors (who monitored the forum but did not moderate). Before the brainstorming, the team reviewed the comments (maintained in a spreadsheet) and a memorandum summary prepared by the lead moderator. During the brainstorming, the team identified important themes related to technology drivers, technology inhibitors, technology behaviors, and technology correlates.

Insights from the exploratory research reaffirmed broad themes from previous technology readiness research suggesting that a combination of positive and negative beliefs influences technology behavior. Themes emerging from the forum discussions mapped on to the four TRI 1.0 dimensions fairly well. For instance, technology motivators that forum participants discussed (e.g., improved quality of life through greater freedom, control, and mobility; technology's ability to connect people to their social networks and to the world at large) corresponded to themes in the optimism dimension. Technology inhibitors emerging from the forum corresponded to themes in both the discomfort and insecurity dimensions (e.g., a lack of confidence in using technology, risks and perceived costs, concerns with security and privacy). However, one negative theme not apparent in the original research was a concern that technology had a potentially dehumanizing effect. This effect manifested itself in forum participants' comments about overdependence on technology, a diminished quality of personal relationships, and a tendency to become distracted (to a point that is potentially dangerous). Table 1 summarizes common themes derived from the forum discussions and provides illustrative quotes.

The forum discussions also offered insights about correlates and consequences of technology adoption. Participants identified what they believed were factors that correlated with receptiveness to new technologies. Their comments confirmed several characteristics already identified in past TR research, including age, occupation, and education. More important to the next research phase was identifying technologies consumers consider to be "cutting edge," an area that by definition continually changes. In the personal sphere, forum participants mentioned new digital technologies, such as smart devices, eBooks, wireless connectivity, and video chats. In the occupational sphere, they described technologies that potentially change the space and time structure of the workplace, such as becoming an e-mail-dominant workplace, using portable devices, and videoconferencing.

After completing the exploratory research, the authors reviewed the 36 items in TRI 1.0 and identified potential

Table 1. Illustrative Comments by Respondents in Qualitative Research Phase.

Theme	Quote
Technology motivators	
Improved quality of life	Saving time is usually what motivates me to upgrade or try new technology
Social influence	My friends and coworkers have a huge influence on my decisions to try new technologies
Staying connected	We're all over the world and we now have the closest thing to living next door . . .
Feeling empowered	. . . having an iPhone increases my confidence and decreases my stress when I am traveling . . .
Being entertained/ amused	Love the fact that I can take my phone or iTouch and entertain my daughter at a restaurant . . .
Technology inhibitors	
Lack of confidence	I was afraid to try different things because I felt if I screwed it up, I could not fix it . . .
Dependency	Why do we feel the need to sit on Facebook and Myspace for hours?
Security and safety	. . . I sometimes am alarmed at spam mail I receive after merely visiting a website
Risk of early adoption	. . . if it's a new product out sure there will be bugs and there will be updates for the product and that's why I'll wait a bit . . .
Cost barriers	The high cost of acquiring these [technologies] is actually very discouraging

refinements in the form of (a) wording changes to current scale items and (b) additional items to capture contemporary themes. The wording changes were intended to update questions to reflect how consumers describe technology currently and/or to make items less dependent on a specific type of technology (that has or will become obsolete). Of the original 36 items, 11 were updated and 25 were deemed appropriate and left unchanged. The following are examples of item rewordings:

Optimism Statement:
Original: "I like *computer programs* that allow me to tailor things to fit my own needs."
Reworded: "I like *technologies* that allow me to tailor things to fit my own needs."
Discomfort Statement:
Original: "There should be caution in replacing important people tasks with technology because new technology *can break down or get disconnected*."
Reworded: "There should be caution in replacing important people tasks with technology because new technology *is not dependable.*"
Insecurity Statement:
Original: "I worry that information I *send* over the Internet *will be seen by other people*."
Reworded: "I worry that information I *make available* over the Internet *may be misused by others*."

Apart from wording changes, 9 new items reflecting contemporary themes emerging from the exploratory phase were added. Collectively, these items captured new issues underlying technology adoption (including freedom to choose locations, distraction, impacts on relationships, dependency, and social pressures) as well as ways consumers viewed technology in their lives, with more nuance on personal and work influences. Examples of the newly added items include the following:

Technology adoption motivators

- Technology makes me more productive in my personal life.
- Communications technology and the Internet help people build stronger relationships.

Technology adoption inhibitors

- People are too dependent on technology to do things for them.
- Too much technology distracts people to a point that is harmful.

Table 2 presents the full battery of 45 TR items included in the survey employed in the quantitative phase. The table identifies 16 items that subsequently comprise TRI 2.0 (these items have new reference labels in the first column; items without reference labels in this column were eliminated during the scale refinement process). The table's last column shows the original reference labels (from Parasuraman 2000) for the 36 TRI 1.0 items. The 9 newly added items are identified as such in the last column.

Quantitative Research Phase

The quantitative phase consisted of a mail and an online survey of a representative cross-section of U.S. adults (ages 18 or older). The survey's core consisted of the 45 TR statements with the same fully anchored 5-point agreement scale used in TRI 1.0 (*strongly/somewhat disagree*, *neutral*, *somewhat/ strongly agree*). The survey also included:

- 33 behavioral items concerning ownership and use of, or intent to purchase, a variety of innovative technology-based products and services; these items included 13 consumer behaviors, 5 occupational behaviors, 4 behaviors that could be personal or work related, and 11 social media behaviors;
- 31 items concerning Internet-based activities such as e-commerce transactions and/or the use of e-services (e.g., online banking);
- 9 demographic questions concerning type of community, homeownership, children in the household, gender, ethnicity, age, education, and income;
- 7 work-related questions concerning occupation, employment status, and whether the employment was technology related.

In the mail survey, the 45 technology readiness statements were randomized twice (i.e., two questionnaire

Table 2. 45 TR Items in the 2012 National Technology Readiness Survey (NTRS).

TRI 2.0 (NTRS 2012)[a]	Scale Item (2012 Wording)	TRI 1.0 (NTRS 1999)[b]
Optimism		
OPT1	New technologies contribute to a better quality of life	New item
OPT2	Technology gives me more freedom of mobility	OPT8
OPT3	Technology gives people more control over their daily lives	OPT1
OPT4	Technology makes me more productive in my personal life	New item
•	Technology gives people more freedom to live and work where they please	New item
•	I like technologies that allow me to tailor things to fit my own needs	OPT5
•	Technology makes me more efficient in my occupation	OPT6
•	I like the idea of doing business online because I am not limited to regular business hours	OPT3
•	I feel confident that technology-based systems will follow through with what I instruct them to do	OPT10
•	Products and services that use the newest technologies are much more convenient to use	OPT2
•	I rely on technology to keep up to date on topics I care about	New item
•	Communications technology and the Internet help people build stronger relationships	New item
Innovativeness		
INN1	Other people come to me for advice on new technologies	INN1
INN2	In general, I am among the first in my circle of friends to acquire new technology when it appears	INN3
INN3	I can usually figure out new high-tech products and services without help from others	INN4
INN4	I keep up with the latest technological developments in my areas of interest	INN5
•	I enjoy the challenge of figuring out high-tech gadgets	INN6
•	I find I have fewer problems than other people in making technology work for me	INN7
•	I prefer to use the most advanced technology available	OPT4
•	I find new technologies to be mentally stimulating	OPT7
•	Learning about technology can be as rewarding as the technology itself	OPT9
Discomfort		
DIS1	When I get technical support from a provider of a high-tech product or service, I sometimes feel as if I am being taken advantage of by someone who knows more than I do	DIS4
DIS2	Technical support lines are not helpful because they don't explain things in terms I understand	DIS1
DIS3	Sometimes, I think that technology systems are not designed for use by ordinary people	DIS2
DIS4	There is no such thing as a manual for a high-tech product or service that's written in plain language	DIS3
•	It is embarrassing when I have trouble with a high-tech gadget while people are watching	DIS6
•	If you provide information to a technology-based system, you can never be sure it really gets to the right place	INS9
•	It seems my friends are learning more about the newest technologies than I am	INN2
•	There should be caution in replacing important people tasks with technology because new technology is not dependable	DIS7
•	I do not consider it safe to do business online	INS2
•	Technology always seems to fail at the worst possible time	DIS10
•	Many new technologies have health or safety risks that are not discovered until after people have used them	DIS8
•	If I buy a high-tech product or service, I prefer to have the basic model over one with a lot of extra features	DIS5
•	In my circle of friends, people are admired more if they own the latest gadgets	New item
Insecurity		
INS1	People are too dependent on technology to do things for them	New item
INS2	Too much technology distracts people to a point that is harmful	New item
INS3	Technology lowers the quality of relationships by reducing personal interaction	New item
INS4	I do not feel confident doing business with a place that can only be reached online	INS4
•	I worry that information I make available over the Internet may be misused by others	INS3
•	The human touch is very important when doing business with a company	INS7
•	When I call a business, I prefer talking to a person rather than interacting with an automated system	INS8
•	Whenever something gets automated, you need to check carefully that the system is not making mistakes	INS6
•	Any business transaction you do electronically should be confirmed later with a separate communication	INS5
•	New technology makes it too easy for governments and companies to spy on people	DIS9
•	I do not consider it safe to provide personal information over the Internet	INS1

Note. Technology Readiness Index (TRI) 1.0 and TRI 2.0 are copyrighted by Rockbridge Associates and the authors; their use requires written permission from the authors.
[a]Labels in the left column are shown only for items retained in the final (revised) TRI 2.0; bulleted items without labels were included in the NTRS but eliminated during the scale refinement process. [b]Items with labels in right column were included in the original scale; the labels correspond to those in Parasuraman (2000).

versions were created) and the sample was split evenly between the two to minimize order effects. The mail survey was administered by Readex Research, a professional marketing research firm, to a representative sample of 2,500 U.S. residential postal addresses. To encourage response, a prenotification postcard was mailed to each household. The subsequent mail kit included a cover letter, a postage-paid return envelope, and a US$1 bill. Questionnaire recipients were offered the choice of responding online, but nearly all who responded returned their completed questionnaires by mail. A total of 354 usable questionnaires were returned for a response rate of 14%.

The online survey was administered to a census-balanced sample of U.S. adults recruited from an online panel maintained by Survey Sampling International (www.surveysampling.com). In this version, the 45 TR statements were fully randomized. To account for inattentive survey respondents, a control question was included that required carefully reading the question to answer correctly. Respondents who failed on this question or who completed the survey within an unrealistically brief period were removed from the sample. The online survey yielded a total of 524 usable questionnaires.

The number of questions in the online survey was greater than in the mail survey, where space was limited; for example, only 23 online behaviors were captured in the mail survey, and the mail survey did not include social media questions. The subsequent analyses were based on items contained in both versions. The combined sample of 878 respondents from both surveys included 51% females and 49% males. The median age was 51 years, with 21% being 18–34 years, 16% 35–44 years, 22% 45–54 years, 18% 55–64 years, and 23% 65+ years.

The reliance on two sampling frames helped balance the demographic mix in the sample. The mail survey respondents tended to be older (median age 56) and more male (57% male), while the online sample tended to be younger (median age 47) and more female (44% male). Even after combining the mail and online samples, the survey sample differed in some respects from data reported by the U.S. Census Bureau's Current Population Survey (CPS). The sample was very close to the U.S. adult population on gender mix (49% male vs. 48% in the CPS), but skewed toward being older (42% age 55+ vs. 34% in the CPS), and toward being more educated (39% had a 4-year college degree or above vs. 29% in the CPS). To check for potential nonresponse bias, the data were subsequently weighted by gender, age, and education, and the results were compared with and without weighting for the critical measures obtained from the survey (TRI 2.0 and a TR-based segmentation, described subsequently). The differences were negligible, confirming that nonresponse bias did not impact the findings.

Assessment of Factor Structure, Reliability, and Discriminant Validity

The analyses employed in developing TRI 2.0 mirrored those used in developing TRI 1.0. The first step was to assess the general data structure across the 45 TR items using principal components analysis with Varimax Rotation of the factor loadings. A scree plot of Eigenvalues for different numbers of components affirmed a four-factor solution, with the incremental variance explained by additional factors being relatively small. The four-factor solution, shown in Table 3, explained 44% of the variance across the items. The 45 items by and large grouped around the same four dimensions as in TRI 1.0, with the reliability coefficients (Cronbach's αs) for the 4 item clusters ranging from .68 to .90. Thus, even though some new technology belief themes emerged that were not prevalent over a decade ago, they still seemed to fit well within TRI 1.0's dimensional structure and were likely reflective of changes in emerging technologies rather than any fundamental shift in people's mind-set underlying their adoption and use of new technology-based offerings.

A second factor analysis (using the same procedure as in the first step) was conducted on just the 36 statements from TRI 1.0. Again, a scree plot confirmed a four-factor structure, mirroring the four dimensions in the original scale. The resulting solution explained 46% of the variance in the items. Table 4 shows the factor loadings for the items (in the columns labeled "2012"). The table also shows the loadings for the same items from the 1999 NTRS reported in Parasuraman (2000). With few exceptions the factor-loading patterns across the 2012 and 1999 surveys are consistent, attesting to the temporal stability of the TR index's dimensional structure. The reliability coefficients for the four dimensions are also consistently good, ranging from .77 to .86 in 2012 and.74 to .81 in 1999.

Because a third of the items were reworded, it is perhaps not surprising that 7 of the items in the new factor analysis did not correspond to the same dimensions as in the original TR index, while the remaining 29 matched their original dimensions. Specifically, of the 7 innovativeness items in the 1999 survey, 1 shifted to discomfort; of the 10 optimism items, 3 shifted to innovativeness; of the 9 insecurity items, 2 shifted to discomfort; of the 10 discomfort items, 1 shifted to insecurity. It is noteworthy that, with the exception of the 1 innovativeness item (INN2) in the 1999 survey that shifted to discomfort in 2012, the remaining six shifts occurred either within motivator dimensions (three from optimism to innovativeness) or within inhibitor dimensions (two from insecurity to discomfort and one from discomfort to insecurity). Thus, even the small number of shifts are consistent with the fundamental motivator-inhibitor conceptual structure of TRI 1.0. However, the fact that certain items shifted between positive and negative dimensions, even taking into account changes in wording, suggests an opportunity for improving the index by making it more parsimonious and enhancing its discriminant validity.

Additional analyses were conducted to derive a more parsimonious scale by eliminating items from the augmented list of 45 existing and new items. The primary criteria guiding these analyses focused on ensuring sufficient reliability for the four TR dimensions, while simultaneously limiting each dimension to as few items as possible, and preserving the index's dimensional structure. The authors began by dropping items that from the outset had ambiguous loadings and low communality,

Table 3. Preliminary 45-Item TR Scale.

	TR Dimensions			
Item	Optimism	Innovativeness	Discomfort	Insecurity
OPT1	69	—	—	—
OPT2	73	—	—	—
OPT3	68	—	—	—
OPT4	68	—	—	—
•	63	—	—	—
•	64	—	—	—
•	70	—	—	—
•	63	—	—	—
•	57	—	—	—
•	54	37	—	—
•	65	—	—	—
•	49	—	—	—
INN1	—	76	—	—
INN2	—	73	—	—
INN3	—	72	—	—
INN4	48	59	—	—
•	35	71	—	—
•	36	64	—	—
•	48	59	—	—
•	53	49	—	—
•	38	37	—	—
DIS1	—	—	63	—
DIS2	—	—	54	31
DIS3	—	—	53	—
DIS4	—	—	40	33
•	—	—	59	—
•	—	—	44	48
•	—	—	49	-45
•	—	—	32	53
•	31	—	38	48
•	—	—	—	46
•	—	—	—	47
•	—	33	—	—
•	33	33	41	—
INS1	—	—	—	60
INS2	—	—	—	54
INS3	—	—	—	61
INS4	—	—	—	56
•	—	—	—	60
•	—	—	—	58
•	—	—	—	50
•	—	—	—	54
•	—	—	—	48
•	—	—	—	54
•	—	—	—	52
Cronbach's α	.90	.88	.68	.86

Note. Factor loadings after Varimax rotation. Item labels correspond to those in Table 2. For each dimension, items with just bullet labels correspond to the bulleted items under that dimension in Table 2 (e.g., the third bulleted item under "Optimism" is "Technology makes me more efficient in my occupation."). All numbers (except in the last row) are factor loadings multiplied by 100. Loadings with absolute value .30 or less are not shown.

suggesting they did not contribute much to the overall index. An example of such a problematic item, identified in the qualitative research phase, was "In my circle of friends, people are admired more if they own the latest gadgets." The authors then selectively removed items from each of the four dimensions based on their item-to-total correlations, communalities, and impact on reliability. After identifying a shorter list of potential scale attributes, the authors assessed the convergent and discriminant validity of attribute lists through confirmatory factor analysis using AMOS. After several rounds of item deletions and analyses to verify reliability and factor structure, the iterative procedure converged on a 16-item solution.

Table 5 shows the factor structure of the final 16-item TRI 2.0, with 4 items for each dimension. Of the 16 items, 11 were in TRI 1.0, while 5 are new (2 in the optimism dimension and 3 in the insecurity dimension). The four-factor solution explains 61% of the variance across the 16 items. All dimensions meet the minimum reliability threshold: The lowest reliability (Cronbach's α) is .70 for discomfort and the highest is .83 for innovativeness. TRI 2.0's factor structure is also distinct: The items load cleanly on their respective dimensions (with just one exception all cross-loadings are .30 or less) and all loadings are strong (.59 or higher).

To further verify the dimensional structure in Table 5, a confirmatory factor analysis of a measurement model (with four latent constructs representing the four subscales, and the corresponding items specified as manifest variables) was conducted using AMOS. Although the model produced a significant χ^2 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 = .95; nonnormed fit index = .92; comparative fit index = .94; root mean square residual = .06). The scale was also assessed for common method bias by introducing a common latent factor (CLF) to capture overlapping variance among the manifest variables (see Williams, Hartman, and Cavazotte 2010). The scale performed well with none of the standardized regression weights changing substantially between the models with and without the CLF.

An important benefit of TRI 1.0 and the revised TRI 2.0 is the ability to measure TR's four dimensions. A decade of experience with TRI 1.0, and the consistency of factor structures in the various stages of analysis for TRI 2.0, strongly supports TR's four-dimensional structure, making it important for the scale to provide measures of each dimension. To this end, CFA was used to assess discriminant validity by comparing each latent dimension's average variance extracted (AVE) with the correlations among dimensions to determine if items within each dimension correlate more highly with one another than with items outside their parent factors (see Hair et al. 2010). As shown in Table 5, which reports the AVE and maximum shared variance, optimism and innovativeness show a high level of discrimination, while discomfort and insecurity meet the minimum threshold for acceptable discriminant validity.

Table 5 also provides results from the CFA to assess convergent validity—the ability of each subscale to be explained by its component items. As Table 5 shows, the composite reliability for each subscale exceeds its AVE. Another commonly accepted criterion for acceptable convergent validity is for the AVE to be equal to or greater than .5. Optimism and innovativeness meet this threshold (.51 and .56, respectively), while discomfort and insecurity fall short (.38 and .40, respectively).

Table 4. Factor Loadings After Varimax Rotation for Original 36 TR Items: 2012 Versus 1999.

TRI 2.0 Item Labels (2012 NTRS)	TRI 1.0 Item Labels (1999 NTRS)	TR Dimensions							
		Optimism		Innovativeness		Discomfort		Insecurity	
		2012	1999	2012	1999	2012	1999	2012	1999
OPT2	OPT8	69	66	—	—	—	—	—	—
•	OPT5	56	50	—	—	—	—	—	—
•	OPT6	62	54	—	—	—	—	—	—
OPT3	OPT1	66	62	—	—	—	—	—	—
•	OPT3	65	54	—	—	—	—	—	—
•	OPT10	55	53	—	—	—	—	—	—
•	OPT2	51	60	—	—	—	—	—	—
INN1	INN1	—	—	79	70	—	—	—	—
INN3	INN4	—	—	76	65	—	—	—	—
•	INN6	—	39	76	56	—	—	—	—
INN2	INN3	—	—	74	63	—	—	—	—
•	INN7	—	—	69	52	—	—	—	—
INN4	INN5	—	—	68	61	—	—	—	—
•	OPT4	—	54	65	—	—	—	—	—
•	OPT7	—	57	56	—	—	—	—	—
•	OPT9	—	56	43	—	—	—	—	—
DIS1	DIS4	—	—	—	—	69	62	—	—
DIS2	DIS1	—	—	—	—	62	66	—	—
DIS3	DIS2	—	—	—	—	62	47	—	—
•	DIS6	—	—	—	—	59	52	—	—
DIS4	DIS3	—	—	—	—	49	45	—	—
•	INS9	—	—	—	—	58	52	31	37
•	INN2	—	—	—	55	49	35	—	—
•	DIS7	—	—	—	—	49	45	35	—
•	INS2	—	—	—	—	47	—	37	56
•	DIS10	—	—	—	—	43	48	31	—
•	DIS8	—	—	—	—	42	52	34	—
•	DIS5	—	—	—	—	31	40	—	—
INS4	INS4	—	—	—	—	—	—	52	59
•	INS3	—	—	—	—	—	45	57	37
•	INS7	—	—	—	—	—	—	63	46
•	INS8	—	—	—	—	—	—	62	47
•	INS6	—	—	—	—	—	39	54	35
•	INS5	—	—	—	—	—	—	51	58
•	DIS9	—	—	—	—	—	52	51	—
•	INS1	—	—	—	—	36	—	47	58
Cronbach's α		.86	.81	.77	.80	.77	.75	.77	.74

Note. TRI = Technology Readiness Index. Item labels in the first two columns correspond to those in the first and last columns, respectively, of Table 2. Items with just bullets in the first column were eliminated during the development of TRI 2.0. For example, the fifth bulleted item under "Optimism" corresponds to OPT2 in TRI 1.0 ("Products and services that use the newest technologies are . . . "), but is not part of TRI 2.0. All numbers (except in the last row) are factor loadings multiplied by 100. Loadings .30 or less are not shown.

Innovativeness and optimism, TR's motivating dimensions, are innate traits that can be easily measured with a set of attributes, but the two inhibiting dimensions, discomfort and insecurity, are complex and more challenging to measure. The various factor analyses conducted for this study do suggest the existence of two distinct inhibiting dimensions. Yet, the creation of any meaningful list of items to measure them will necessarily include different facets that are only moderately correlated because they represent real-life themes covering multiple aspects of the dimension. For example, insecurity is a combination of safety concerns, concerns about other negative consequences of technology, and a need for assurance. Consequently, the items in the inhibiting dimensions are all a little different (hence, an AVE less than .5), but tend to be interrelated around a theme (hence, a high Cronbach's α and composite reliability). Thus, the low AVE values may not be due to issues such as ambiguous item wording, but due to the slightly different themes each item captures that are not part of the core construct they share.

Assessment of Construct Validity

The high reliabilities and consistent factor structure of TRI 2.0's four dimensions provide support for the scale's trait validity (Peter 1981). However, trait validity is necessary, but not

Table 5. Final 16-Item Technology Readiness Index (TRI) 2.0.

Item	TR Dimensions			
	Optimism	Innovativeness	Discomfort	Insecurity
OPT1	80	—	—	—
OPT2	76	—	—	—
OPT3	75	—	—	—
OPT4	71	—	—	—
INN1	—	84	—	—
INN2	—	78	—	—
INN3	—	76	—	—
INN4	42	68	—	—
DIS1	—	—	75	—
DIS2	—	—	73	—
DIS3	—	—	69	—
DIS4	—	—	61	—
INS1	—	—	—	76
INS2	—	—	—	74
INS3	—	—	—	72
INS4	—	—	—	59
Cronbach's α	.80	.83	.70	.71
Composite reliability	.81	.84	.71	.72
Average variance extracted	.51	.56	.38	.40
Maximum shared variance	.42	.42	.38	.38
Average shared variance	.20	.20	.19	.22

Note. Item labels correspond to those shown on the left-hand side of Table 2. Factor loadings after Varimax rotation. Confirmatory factor analysis: goodness-of-fit index = .953; nonnormed fit index = .920; comparative fit index = .942; root mean square residual = .065. All factor loadings have been multiplied by 100. Loadings .30 or less are not shown.

sufficient, for establishing construct validity (Churchill 1979). Construct validity—the extent to which a scale fully and unambiguously captures the underlying unobservable construct it is intended to measure—must be evaluated on additional criteria. The principal conceptual yardstick for assessing construct validity is face validity: Does the scale appear to measure what it is supposed to? Do the items capture key facets of the unobservable construct being measured? As discussed previously, TRI 2.0's content and dimensional structure are by and large consistent with those of TRI 1.0, which itself emerged from an extensive multiphase research program. Moreover, the current study's exploratory phase identified contemporary technology-related themes and terminology that were incorporated into TRI 2.0. As such, the two aforementioned questions can be answered in the affirmative.

Empirical assessment of the16-item TRI 2.0's construct validity began with a comparison of its predictive performance vis-à-vis that of the 36-item TRI 1.0. The authors ran three simple linear regression analyses for both TRI 1.0 and TRI 2.0, with the total TR score as the independent variable and each of the three broad measures of technology behavior, in turn, as the dependent variable: (1) number of technology gadgets owned (0–13 items, listed in Table 6), (2) number of online behaviors engaged in during the past year (0–23, listed in Table 7), and (3) number of technology-oriented behaviors (0–4 behaviors: connecting devices to a TV, using cloud applications, digitizing documents, using a Wi-Fi service). Both scale versions explain a comparable amount of variance in the behavioral measures in each of the regression analyses. The adjusted R^2 values for models in which the predictors were the overall 16-item and 36-item TR scores (respectively) are as follows: 12.9% and 14.0% for number of gadgets, 22.8% and 26.1% for number of online behaviors, and 25.7% and 27.7% for number of technology-oriented behaviors. All models were significant at the .001 level. The analyses also suggest that TR is an important predictor of technology-related behaviors, particularly in the e-services domain.

As further evidence of TRI 2.0's predictive validity, Table 6 shows statistically significant differences in mean TRI 2.0 scores (on a 1–5 scale) for owners/users, intenders (who plan to acquire in the next 2 years), and nonintenders (all F values in the last column are significant at the .001 level). With just one exception ("cell phone [without Internet capabilities]"), the means for owners/users and intenders are higher than the mean for nonintenders. Table 6 lists the technologies in declining order of F values to highlight where the biggest differences are. Consistent with our expectation that TR is likely to most influence behaviors pertaining to technologies that are truly cutting edge, the list is headed by the smartphone, a technology in early stages of its life cycle at the time of data collection. Likewise, the aforementioned sole exception to the pattern of declining mean TR scores across the three groups is also consistent with expectation since cell phones are no longer novel, being replaced by smartphones.

The authors also examined TRI 2.0's association with each of the 23 online behaviors captured in the survey. In this

Table 6. Mean Value of Technology Readiness Index (TRI) 2.0 by Ownership of Different Technologies.

	Mean TR Score (1 = *lowest*, 5 = *highest*) and Sample Size			
	Currently Own or Use Technology at Home	Intend to Acquire Technology in Next 24 Months	Do Not Intend to Acquire in Next 24 Months	*F* Value (Degrees of Freedom)
Smart phone (like an iPhone or Blackberry)	3.29 (372)	3.01 (157)	2.74 (319)	81.4** (2, 845)
Tablet computer (like an iPad)	3.27 (205)	3.16 (283)	2.79 (361)	55.5** (2, 846)
Portable music player (e.g., MP3 player)	3.20 (470)	3.09 (61)	2.77 (319)	51.9** (2, 847)
Portable media player (plays video)	3.23 (322)	3.15 (80)	2.86 (443)	37.4** (2, 842)
Television that be connected to the Internet	3.11 (337)	3.19 (212)	2.82 (302)	30.1** (2, 848)
eBook reader (e.g., Kindle)	3.23 (219)	3.13 (194)	2.88 (433)	28.7** (2, 843)
Digital single-lens reflex (SLR) camera (has complete manual control, advanced exposure control, and detachable lenses)	3.25 (149)	3.23 (128)	2.92 (562)	26.4** (2, 836)
Digital video camera	3.17 (393)	3.03 (127)	2.86 (333)	25.3** (2, 850)
Digital video recorder for your television (e.g., Tivo)	3.16 (358)	3.13 (129)	2.87 (363)	22.9** (2, 847)
Cell phone (without Internet capabilities)	2.93 (526)	2.87 (44)	3.22 (274)	21.9** (2, 841)
Digital point and shoot camera	3.09 (575)	3.05 (81)	2.83 (199)	13.4** (2, 852)
Portable navigation device (GPS)	3.12 (425)	3.08 (121)	2.88 (302)	13.1** (2, 845)
Stationary computer or laptop	3.05 (797)	2.78 (28)	2.60 (33)	11.1** (2, 855)

**$p < .001$.

Table 7. Incidence of Consumers' Online Activities in Past 12 Months by TR Tier.

	Technology Readiness Tier (Tercile, based on TRI 2.0)			
	Lower One Third (2.82 or Lower)	Middle One Third (2.83–3.24)	Upper One Third (3.25 or Higher)	Pearson Chi-Square (Two Degrees of Freedom)
Sample size	(273–281)	(279–284)	(278–289)	
Booked travel arrangements online	37%	52%	66%	46.8**
Purchased an item costing less than US$10 online	49%	66%	81%	60.5**
Purchased an item costing between US$10 and US$100 online	73%	84%	93%	36.6**
Purchased an item costing more than US$100 online	44%	58%	77%	66.2**
Bought or sold stock or securities online	6%	12%	22%	31.9**
Checked information on my bank account online	61%	76%	89%	63.2**
Moved money between bank accounts, made deposits, or made withdrawals online	44%	57%	77%	64.3**
Paid a bill online using a bill paying service, such as my bank's online bill pay service	43%	59%	77%	67.9**
Managed a credit card account online	37%	55%	73%	71.5**
Checked account information with a utility such as a phone, gas, or electric company online	40%	62%	77%	77.7**
Taken a course taught online	13%	21%	27%	16.1**
Researched health information online	65%	77%	83%	25.9**
Read the news or a magazine online	58%	71%	85%	50.8**
Received medical test results online	10%	14%	21%	13.4*
Communicated with medical professionals online	11%	17%	28%	28.4**
Used a streaming music service	22%	45%	61%	84.9**
Listened to live radio programming	30%	45%	63%	64.1**
Watched a video online	49%	72%	86%	95.0**
Watched live TV programming	28%	40%	55%	42.2**
Downloaded songs online	29%	47%	66%	77.1**
Downloaded books online	18%	27%	45%	48.9**
Downloaded movies online	10%	26%	42%	76.9**
Made a phone call with a video connection (e.g., using Skype)	24%	33%	42%	20.6**

Note. TRI = Technology Readiness Index.
*$p < .01$, **$p < .001$.

Table 8. Summary Statistics for Technology Readiness Index (TRI) 2.0 and Its Components.

	M					Correlation Coefficients*			
TR Components	1999 NTRS (TRI 1.0)	2012 NTRS (TRI 2.0)	*SD*	Skewness	Kurtosis	OPT	INN	DIS	INS
Optimism (OPT)	3.84	3.75	.80	−.55	.10	1.00	.52	−.32	−.28
Innovativeness (INN)	3.18	3.02	1.02	−.02	−.76	.54	1.00	−.40	−.30
Discomfort (DIS)	3.46	3.09	.84	−.11	−.35	−.14	−.20	1.00	.56
Insecurity (INS)	4.03	3.58	.83	−.44	−.20	−.29	−.26	.44	1.00
Overall TRI	2.88	3.02	.61	.19	.29	.70	.75	−.62	−.70

Note. All mean values are on a 5-point scale. The overall TRI score for each respondent was the average score on the four dimensions (after reverse coding the scores on discomfort and insecurity).
*All coefficients are significant at $p < .01$; coefficients in the upper triangle are from the 1999 National Technology Readiness Survey (NTRS) study.

analysis, survey respondents were divided into three approximately equal-sized groups based on their TRI 2.0 scores—low TR tier, middle TR tier, and high TR tier. Table 7 reports the percentage of respondents in each tier engaging in each online behavior. As the c^2 test results summarized in the table's last column show, TR is significantly associated with each of the 23 behaviors, with increasing incidence of engagement from low to high tiers. Even with widespread Internet access (92% of the mail survey respondents reported having Internet access), there is a major difference between low- and high-TR consumers in terms of their engaging in a range of online behaviors. TRI 2.0's ability to consistently differentiate across a variety of technology-related consumer behaviors further supports its construct validity.

TRI 2.0 also correlates with social media behavior. The online survey asked respondents if they have a "social media page such as Facebook, LinkedIn, or Twitter." The difference in mean TR scores for those answering "yes" and those answering "no"—3.20 versus 2.93—was statistically significant ($t = 4.16$, $p < .0001$). The survey also measured the frequency of 11 social media activities. For every activity, the TR score was significantly higher for those who engaged in it more frequently.

Summary Statistics for TRI 2.0 and Its Components

Table 8 reports means, standard deviations, and distributional characteristics for the overall TRI 2.0 and its four components, as well as pairwise correlations among them. For comparison purposes, the table also reproduces the mean values and pairwise correlations from the 1999 NTRS study reported in Parasuraman (2000).

The TR scale ranges from 1.0 (*strongly disagree*) to 5.0 (*strongly agree*), with 3.0 representing the scale's midpoint (*neutral*). The mean TRI 2.0 score is 3.02, close to the middle of the scale and not far from TRI 1.0's mean value of 2.88. Consumers are generally optimistic about technology ($M = 3.75$) and closer to the scale's midpoint on innovativeness (3.02). The values on both of these motivating dimensions are similar to those for TRI 1.0. Consumers are close to the scale's midpoint on discomfort (3.09) and slightly above the midpoint on insecurity (3.58). Compared to TRI 1.0, mean TRI 2.0 scores for discomfort and insecurity are lower, but the magnitude of change is .40 or less. The distribution of TRI 2.0 scores is near normal, with skewness (.19) and kurtosis (.29) close to zero.

The 4 × 4 correlation matrix in Table 8 indicates that the pattern of pairwise correlations in the lower triangle is quite similar to that in the upper triangle. For instance, the correlation between the two motivating TR dimensions is .54 for TRI 2.0 vis-à-vis .52 for TRI 1.0; likewise, the correlation between the two inhibiting TR dimensions is .44 for TRI 2.0 vis-à-vis .56 for TRI 1.0. Moreover, consistent with expectation, correlations for the various motivator-inhibitor combinations are all negative, and smaller in magnitude, for both TRI 2.0 and TRI 1.0. Thus, TRI 2.0 seems to preserve TRI 1.0's overall distinct dimensional structure, and patterns of association among its components.

A TR-Based Segmentation Analysis

The four TR dimensions' distinctiveness implied by the relatively low pairwise correlations (and hence even lower overlapping variance) among combinations of dimensions suggest that segmenting customers based on their TR scores can be insightful. For instance, Parasuraman and Colby (2001) developed and discussed a segmentation scheme (using K-means cluster analysis of TRI 1.0 scores) that consisted of five segments: Explorers (high motivation, low inhibition), pioneers (high motivation, high inhibition), skeptics (low motivation, low inhibition), paranoids (moderate motivation, high inhibition), and laggards (low motivation, high inhibition). In this study, the authors conducted a latent class analysis (Magidson and Vermunt 2003) of scores on the 16 TRI 2.0 items. LCA is often preferred as a segmentation method over traditional methods such as K-means. It is more robust in handling different types of measurements, including the Likert-type scale TRI 2.0 ratings. LCA also does not require assumptions about the number of classes/clusters, and provides greater confidence because it is based on the probability of cases belonging to latent classes rather than a more subjective algorithmic approach underlying traditional clustering methods.

Three separate LCA solutions—corresponding to four, five, and six latent classes (i.e., clusters)—were derived and

Table 9. Latent Class Segmentation Using Technology Readiness Index (TRI) 2.0 and TRI 1.0 Data.

Segments (*n*)	%	Means (Ranks) and R^2 Values Optimism	Innovativeness	Discomfort	Insecurity	Total TR
TRI 2.0 (16 items)						
1. Skeptics (293)	38%	3.47 (4)	3.03 (3)	2.81 (4)	3.46 (4)	3.06 (2)
2. Explorers (141)	18%	4.63 (1)	4.09 (1)	2.36 (5)	2.67 (5)	3.92 (1)
3. Avoiders (123)	16%	2.62 (5)	1.80 (5)	3.62 (2)	4.27 (1)	2.13 (5)
4. Pioneers (121)	16%	4.24 (2)	3.93 (2)	3.86 (1)	4.12 (2)	3.05 (3)
5. Hesitators (104)	13%	4.06 (3)	1.91 (4)	3.32 (3)	3.69 (3)	2.74 (4)
R^2 (Adjusted)		65%*	71%*	39%*	40%*	76%*
TRI 1.0 (36 items)						
1. Skeptics (302)	35%	3.56 (3)	3.11(3)	2.96 (4)	3.34 (4)	3.19 (3)
2. Explorers (107)	13%	4.55 (1)	4.24 (1)	2.43 (5)	2.98 (5)	4.00 (1)
3. Avoiders (70)	8%	2.33 (5)	1.61(5)	3.73 (1)	4.24 (1)	2.06 (5)
4. Pioneers (162)	19%	4.23 (2)	3.87 (2)	3.69 (2)	4.10 (2)	3.22 (2)
5. Hesitators (217)	25%	3.35 (4)	2.38 (4)	3.55 (3)	4.09 (3)	2.61 (4)
R^2 (Adjusted)		67%*	69%*	47%*	50%*	76%*

*Significant at $p < .001$.

compared on three conventional criteria for evaluating LCA-generated clusters: Akaike Information Criterion, Bayesian Information Criterion, and Consistent Akaike's Information Criterion. The three solutions differed only slightly on these criteria. However, the five-cluster solution yielded a more even distribution of cases across the clusters than did the four- and six-cluster solutions. Moreover, the five-cluster solution, summarized in Table 9's top half, is similar to the TR-based segmentation described by Parasuraman and Colby (2001), reinforcing its superiority over the other two solutions. A K-means solution was also generated and compared with the LCA solution. They were very similar, with 84% of cases belonging to the same cluster in both solutions.

The five segments were labeled as follows based on the distinct combinations of technology-related beliefs associated with each:

- "Skeptics" (38% of consumers)—tend to have a detached view of technology, with less extreme positive and negative beliefs;
- "Explorers" (18%)—tend to have a high degree of motivation and low degree of resistance;
- "Avoiders" (16%)—tend to have a high degree of resistance and low degree of motivation;
- "Pioneers" (16%)—tend to hold both strong positive and negative views about technology; and
- "Hesitators" (13%)—stand out due to their low degree of innovativeness.

The Explorers are similar to the same early adopter explorers identified in previous research, while the avoiders are similar to the late adopter laggards. The other segments do not fall into a tidy spectrum from early to late adopters, but instead reflect more complex combinations of beliefs that suggest different challenges in marketing technology-based services.

The overall TR scores range from 2.13 for the least techno-ready segment, the "avoiders," to 3.92 for the most techno-ready segment, the "explorers." The segmentation scheme's ability to explain overall TR and its components was assessed by conducting five separate general linear model analyses, wherein segmentation was a categorical independent variable and TR scores, overall and for each component, in turn, was the dependent variable. As the R^2 values in Table 9 show, the segmentation variable is significantly associated with each TR component and overall TR, explaining 76% of the variance in the latter.

A five-group LCA was also conducted using data on the 36 original TR items as input. The resulting segments, summarized in the bottom half of Table 9, are similar to those in the top half in terms of relative sizes and TR profiles. Moreover, the share of respondents classified into a given segment in the 36-item analysis who fall into the same segment in the 16-item analysis was high for most segments (76% for skeptics, 94% for explorers, 92% for avoiders, 65% for pioneers, and 37% for hesitators).

The five TR segments have unique demographic characteristics (Table 10). For example, the segment with the highest TR score, the explorers, is younger, higher educated, more likely to work in a technology profession, and owns the largest number of technology gadgets. The avoider segment is a mirror opposite of the explorers, but also stands out as being low on ethnic diversity. The pioneer segment is the most ethnically diverse, while the hesitator segment has the lowest employment in technology professions. Thus, the segments differ on demographics and behavior, despite being derived entirely from scores on TRI 2.0's 16 items.

Limitations of TRI 2.0

TRI 2.0 has some limitations that should be acknowledged. Specifically, TRI 2.0's subscales for the inhibitor dimensions

Table 10. Demographic Characteristics of Technology Readiness Index (TRI) 2.0-Based Segments.

Segment (*n*)	Female[a] (%)	% Aged 50+[b] (%)	% With Minimum 4-Year College Degree[c] (%)	% Non-White[d] (%)	% Employed in Technology Profession[b] (%)	Number of High-Tech Gadgets Owned (*M*)[e]
1. Skeptics (293)	52	50	42	23	8	6.0
2. Explorers (141)	44	34	46	20	18	7.4
3. Avoiders (123)	59	79	29	14	7	4.4
4. Pioneers (121)	53	41	42	30	13	6.7
5. Hesitators (104)	48	69	39	12	2	5.5

[a]Chi-square not significant.
[b]Chi-square significant at $p < .001$.
[c]Chi-square significant at $p < .05$.
[d]Chi-square significant at $p < .01$.
[e]*F* value significant at $p < .001$.

of discomfort and insecurity are somewhat weak on some psychometric criteria, especially AVE. While these dimensions emerged as clean factors in the exploratory factor analysis, their conceptual core is challenging to represent as a set of homogeneous attributes. The TRI 2.0 items capturing the inhibitor dimensions tap into diverse beliefs/experiences about (a) perceived control of technology and (b) distrust of technology. While this item diversity could be viewed as a strength, in that it makes TRI 2.0 more robust, future research should investigate if the AVE for the inhibitor dimensions could be improved through refined wording, adding more attributes, or using alternate measurement scales. In the meantime, researchers should exercise caution when using TRI 2.0 primarily to study a single facet of beliefs that inhibit technology usage. Other than this issue, TRI 2.0 and its subscales are psychometrically sound.

Applications of TRI 2.0

A primary reason for TRI 1.0's widespread use for over a decade is the exponential growth in technology's influence in the service domain. While scores of studies involving technology-related consumer behavior have employed the scale, a significant shortcoming of TRI 1.0 is its length. TRI 2.0 has wider applicability because it is more concise, resulting in less burden on surveys measuring multiple constructs besides just TR, and various other refinements to the index make it more robust for use across different contexts and over time.

Parasuraman (2000) suggested some potential applications of the then newly developed TR index. Building on those suggestions and based on insights from research proposals and permission requests received during the past dozen years, TRI 2.0 has two general applications. First, it can be used to assess TR levels within a given population, which can consist of a country, a particular demographic group of special interest (e.g., African Americans in the United States, teens, seniors), a profession (e.g., teachers, nurses), or a market segment (e.g., purchasers of high-tech products). TRI 2.0 facilitates understanding the dynamics behind adoption of various technologies by providing measures of the four TR dimensions as well as overall TR. As demonstrated earlier, TRI 2.0 is a robust predictor of technology-related behavioral intentions as well as actual behaviors.

Second, TR can be an important moderating variable in studies involving multivariate frameworks. Scholars can use TRI 2.0 to explain the dynamics between variables in a technology-influenced context and as a diagnostic or control variable in experiments. In past research involving multiple constructs, researchers have frequently opted to use a small subset of items from TRI 1.0 to reduce the burden on respondents. The more parsimonious, yet rigorously developed, TRI 2.0 should be more practical to use in its entirety in future studies. Moreover, the fact that TRI 2.0 has the same number of items (4) for each TR dimension may be a desirable feature for some research studies.

Technology readiness measured by TRI 2.0 can be used as a potentially valuable psychographic variable in applied, decision-oriented research in contexts where technology-based innovation plays an important role. The TR of a given market or customer base can be scored and compared to baselines, providing implications for marketing. High-TR customers (the ''explorers'') will be interested in advanced functionality and capable of mastering new high-tech offerings with minimal help. Low-TR customers (the ''avoiders'' and ''hesitators'') will be more satisfied with basic functionality but will need more support and reassurance. TRI 2.0 will also identify the ''skeptics''—persuasive messages that provide concrete reasons for adoption must be developed to attract them—and the ''pioneers''—they need little convincing to adopt technology but require more support to be satisfied. Finally, there is often a special interest in the highest TR consumers because they could serve as ''evangelists'' in motivating others to try a new technology-based offering.

Researchers can also use TRI 2.0 to tier consumers into groups with varying TR levels, providing a unique lens for understanding the role of technology beliefs in the marketplace. A strong correlation between TR and interest level in (or adoption rate of) a new offering signals that the offering is inherently cutting edge and, therefore, requires specialized marketing strategies that differ from conventional strategies for marketing lower tech offerings. Moreover, in usability research pertaining to a new technology-based offering, it is prudent to set quotas of users with varying TR levels to ensure that the offering is intuitive to all consumer types, not just to self-learners.

Directions for Future Research

Apart from the general applications outlined in the preceding section, there are specific TR-related issues worthy of scholarly research. One potentially fruitful research avenue is to investigate the causes and correlates of TR. Research findings to date, including those reported herein (Table 10), suggest that demographic characteristics such as age, education, and occupation correlate with TR. More in-depth research is needed to validate these correlates, to identify other correlates, and to understand why they matter. One interesting issue is whether education and occupation cause changes in TR, or if more techno-ready people seek out higher education and gravitate to technology-related professions. Another research-worthy issue is whether TR declines naturally after a certain age as extant data seem to suggest or if the age effect might be due to differences across generational cohorts in terms of exposure to and experience with cutting-edge technologies. Longitudinal research designs are needed to shed light on these causes.

Another research-worthy issue is if people's values, emotions, and other inherent traits are related to their TR and whether any uncovered associations are causal or merely correlational. In-depth qualitative research might be an appropriate starting point for addressing these questions. Another intriguing, even if peculiar, issue to investigate is whether there are genetic factors related to TR. As the science of using DNA data advances, it may be possible to ascertain if TR, as measured by TRI 2.0, is linked to genetic factors.

The interaction between TR, an inherent individual-level trait, and the characteristics of technology-based offerings is also worth exploring. Frameworks such as the technology assessment model—TAM (Davis 1989; Venkatesh and Davis 2000) have been employed to study how perceived characteristics of a technology-based product influence its adoption and usage; and, scales such as E-S-QUAL (Parasuraman, Zeithaml, and Malhotra 2005) have been used for assessing the service quality of electronic interfaces and its downstream effects. There have also been some attempts to study the joint effects of individual and technology-specific characteristics. In the realm of adopting SSTs, Meuter et al. (2005) proposed and empirically demonstrated the role of "consumer readiness," a construct reflecting consumers' role clarity, motivation, and ability vis-à-vis SSTs. Lin, Shih, and Sher (2007) integrated TR and TAM to propose and test the technology readiness acceptance model; but they also called for more comprehensive research to investigate additional variables and their interactions that could influence adoption. Likewise, Zeithaml, Parasuraman, and Malhotra (2002) have called for research on whether TR moderates the link between perceived quality of electronic interfaces and their usage by consumers.

Because TR is an individual-level construct, examining TRI 2.0's structural stability and invariance across different environmental contexts (e.g., countries with different cultures, technology infrastructures, etc.) is also a promising research avenue. The authors have received permission requests from around the world to use TRI 1.0 in research studies. However, most of them have included just a subset of items from the 36-item TRI 1.0, and none has involved a rigorous cross-country comparison of the scale's psychometric properties. Conducting multicountry, across-context studies incorporating the full TR scale should now be more feasible with the availability of the much shorter TRI 2.0.

Concluding Remarks

The primary objective of the research discussed in this article was to update the original TR index (TRI 1.0) and produce a more concise and contemporary scale. Starting with the 36-item TRI 1.0, as well as user feedback from a variety of applications over the years, the authors augmented and updated it based on insights from an extensive exploratory research phase. This was followed by a quantitative research phase that (1) iteratively condensed the augmented TR scale to produce the 16-item TRI 2.0 and (2) verified its reliability and validity on a variety of criteria. Though similar to TRI 1.0 in overall structure and content, TRI 2.0 is less than half as long, and its items are more technology neutral in that they do not refer to technologies or contain terms that are outdated. The availability of TRI 2.0 will hopefully accelerate (1) practical applications of the TR construct (e.g., examining a TR-based segmentation of the target market before full-scale introduction of a cutting-edge technology for serving customers) and (2) inclusion of the TR construct in scholarly investigations (e.g., as a moderator of the link between perceived benefits of a new technology and its actual adoption/use).

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