Leveraging Information Technology Infrastructure to Facilitate a Firm's Customer Agility and Competitive Activity: An Empirical Investigation

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ABSTRACT: This paper investigates how information technology (IT) facilitates a firm's customer agility and, in turn, competitive activity. Customer agility captures the extent to which a firm is able to sense and respond quickly to customer-based opportunities for innovation and competitive action. Drawing from the dynamic capability and IT business value research streams, we propose that IT plays an important role in facilitating a "knowledge creating" synergy derived from the interaction between a firm's Web-based customer infrastructure and its analytical ability. This will enhance the firm's ability to sense customer-based opportunities. IT also plays an important role in "process enhancing" synergy obtained from the interaction between a firm's coordination efforts and its level of information systems integration, which facilitates the firm's ability to respond to those opportunities. We also leverage the competitive dynamics and strategic alignment literature to propose that the alignment between customer-sensing capability and customer-responding capability will impact the firm's competitive activity. We test our model with a two-stage research design in which we survey marketing executives of high-tech firms. Our results show that a Web-based customer infrastructure facilitates a firm's customer-sensing capability; furthermore, analytical ability positively moderates this relationship. We also find that internal

Journal of Management Information Systems / Spring 2012, Vol. 28, No. 4, pp. 231–269.

0742–1222 / 2012 $9.50 + 0.00.
DOI 10.2753/MIS0742-1222280409

systems integration positively moderates the relationship between interfunctional coordination and a firm's customer-responding capability. Finally, our results show that agility alignment affects the efficacy of a firm's competitive actions. In particular, action efficacy is higher when sensing and responding capabilities are both high.

KEY WORDS AND PHRASES: alignment, competitive dynamics, customer agility, dynamic capability, IT infrastructure, IT value, open innovation.

THE INCREASING PACE OF GLOBALIZATION, competitive rivalry, shifting customer demands, and rapid technological advancements create an environment in which sustained competitive advantage is difficult—if not impossible—to achieve [20, 60]. Industries once considered relatively stable have evolved into fiercely competitive environments in which long-established giants are being threatened by agile start-up firms scattered across the globe [18]. As a result, firms must sense and respond quickly to opportunities if they wish to build a competitive advantage [82].

Agile firms are able to adapt to and perform well in rapidly changing environments by capitalizing on opportunities for innovation and competitive action, such as launching new products and services, entering new market segments, and developing strategic alliances [9, 20]. Specifically, agility consists of two components—sensing and responding—that are key organizational capabilities that contribute to success in hypercompetitive environments [107]. A firm may be agile in various areas, such as its customer-based processes, interactions with supply chain partners, and day-to-day operations [82]. We focus on firm's customer agility, which is defined as the *degree to which a firm is able to sense and respond quickly to customer-based opportunities for innovation and competitive action.*[1]

The advent of new information and communication technologies presents unique opportunities for firms to enhance their customer agility. Internet-based communities facilitate distributed innovation models that involve varied customer roles in new product development (NPD) [64]. Not only can customers generate ideas for new products and services, they can also use information technology (IT)–based tools to test products and provide end-user product support in online environments [65, 77]. The social relationships that take hold between the various entities in online communities generate a continuous flux of valuable knowledge [68]. In turn, firms that effectively absorb this external knowledge are better able to sense market opportunities [17].

In addition to strengthening a firm's sensing capabilities, IT can also enhance a firm's ability to respond to market opportunities. For example, digital process–based innovations such as electronic order fulfillment can be quickly scaled up with unprecedented speed to trump rivals in a hypercompetitive environment [60]. Integrated information systems (IS) allow organizations to quickly route relevant information to decision makers in a timely manner. When coupled with well-coordinated organizational functions, these integrated systems also allow firms to collaborate in areas such

as NPD and service enhancement [8]. By strengthening organizational processes, IT facilitates a firm's ability to respond to customer-based opportunities for innovation and competitive action.

Consider the following illustration. Dell computer company developed a Web site—"IdeaStorm"—where customers can contribute and exchange ideas regarding Dell's products and services. One customer commented that recent graphic user interface (GUI) innovations have yet to be implemented in Dell's computers. The customer recommended that Dell work with open source projects to develop and implement GUI advances in Dell computers. Shortly after the customer's online post, hundreds of IdeaStorm community members discussed and voted on this idea. Dell associates monitored this discussion to sense whether the GUI innovation idea was worth pursuing. When Dell management made the decision to pursue this idea, they developed IT-enabled partnerships with open source projects to develop a custom GUI for Ubuntu on Dell netbooks. This illustration shows us how Dell uses IT to sense (via the Web site) and respond to (through IT-enabled external partnerships) a customer-based opportunity.

One theoretical perspective suggests that IT provides the foundation for digital options, which greatly enhance customer agility [82]. Furthermore, some early research finds that IT enhances organizational agility [32, 92, 93]. Yet despite the importance of IT and customer agility in hypercompetitive environments, we know little on *how* IT supports a firm's customer agility and, in turn, competitive activity. Such insight is important if we wish to move beyond our current understanding of how IT generates business value. Hence, we aim to answer two questions in this study: How does information technology facilitate the sensing and responding components of customer agility? and How does customer agility impact competitive activity?

This paper proceeds as follows. We first describe the origins and characteristics of customer agility. We then form the theoretical foundations of our research model. Building on these theoretical foundations, we develop our research model and hypotheses, followed by a description of an empirical study designed to test our research hypotheses. We discuss our findings, limitations, implications for research and practice, and avenues for future research.

Research Framework

What Is a Firm's Customer Agility?

HYPERCOMPETITION CREATES AN ENVIRONMENT in which *sustained* competitive advantage is difficult, if not impossible, to achieve. Instead, firms competing in hypercompetitive environments create a series of *temporary* advantages [20]. The ability to consistently launch and exploit competitive actions (e.g., new products, new services) to develop these temporary advantages requires a special set of organizational capabilities and resources. Among the solutions proposed, the ability to sense relevant change and respond readily has emerged as an important determinant of firm success in hypercompetitive environments [39, 107]. The term "agile" is commonly used to describe firms that

are able to sense and respond effectively to market opportunities in rapidly changing environments. Table 1 details definitions of agility compiled from the literature.

The last column in Table 1 reveals a number of key themes surrounding agility. First, agility is best viewed as an organizational *capability,* that is, a set of organizational routines and processes that produces a particular output [26]. Hence, agility must be developed by the firm; it cannot be purchased from factor markets. Second, agility implies *sense and response.* Research suggests that strong sensing and responding capabilities are critical to firm success in turbulent environments [39, 107]. Thus, any definition of agility should emphasize the ability to sense and respond to environmental change. Third, agility is especially important in dynamic, fast-paced environments. Hence, the ability to sense and respond *quickly* constitutes an important element of agility. Finally, a firm may be more agile in one domain (e.g., customer-based processes) than another domain (e.g., supply chain activities) [32, 82]. Thus, agility can be *domain specific.*

Taking these characteristics into account, we define firm customer agility as *the degree to which a firm is able to sense and respond quickly to customer-based opportunities for innovation and competitive action.* Our definition includes key elements of agility identified earlier, including capability, sense and respond, and speed. By "customer based" we refer to opportunities that originate from (1) individual customers, (2) discussions among customers, or (3) interactions between customers and a representative of the focal firm. Customers are more likely to be familiar with a firm's products and services than other organizational activities [19]; hence, these customer-based opportunities will often be related to those products and services. In fact, there is a dynamic interplay surrounding customer roles in NPD and a firm's ability to sense and respond to customer-based opportunities. Thus, we investigate the role of IT and customer agility in an NPD context.

Customers can serve one or more roles in the NPD life cycle: as a resource for innovation ideas, as a co-creator in the development and design of products and services, and as a user in testing the product or in helping other users learn about the product or service [64]. Customers' role as resource and co-creator are at the input side of firm activity, and customers' role as user resides at the output side of the system. Furthermore, customer-based opportunities may arise as customers play one or more of these roles. For example, customers—operating as information resources—work together in an online environment sharing knowledge and ideas regarding, say, basketball shoes. As product co-creators, customers often develop and refine product and service features that the firm incorporates into future versions [104]. Finally, customers who become expert users often discover new ways to use the product as well as shortcuts and other methods to enhance the overall value of the product. Thus, an NPD context is a suitable one in which to investigate a firm's ability to sense and respond to customer-based opportunities.

Agility as Dynamic Capability

One important element to keep in mind is that a firm's customer agility is a capability that is important in hypercompetitive environments. Scholars have distinguished

Table 1. Key Definitions of Organizational Agility

Source	Definition	Key concepts
Goldman et al. [37]	Comprehensive response to the business challenges of profiting from rapidly changing, continually fragmenting, global markets for high-quality, customer-configured goods and services	• Response to environmental change • Customer-centric products and services • Rapidly changing environment
Cho et al. [14]	The capability of surviving and prospering in a competitive environment of continuous and unpredictable change by reacting quickly and effectively to changing market conditions driven by customer-designed products and services	• Capability • Respond quickly and effectively • Turbulent environment • Customer-centric
McGaughey [61]	The ability of an enterprise to respond quickly and successfully to change	• Capability • Respond quickly and successfully
Sharifi and Zhang [88]	Ability to cope with unexpected changes, to survive unprecedented threats of business environment, and to take advantage of changes as opportunities	• Ability to cope with uncertainty • Environmental threats • Turn changes into opportunities
Yusuf et al. [106]	The ability of a business to grow in a competitive market of continuous and unanticipated change, to respond quickly to rapidly changing markets driven by customer-based valuing of products and services	• Capability • Respond quickly • Customer-based value • Turbulent environment
Day [23]	The ability of an organization to thrive in a constantly changing, unpredictable environment	• Capability • Turbulent environment
Bessant et al. [7]	The ability of a firm to respond quickly and flexibly to its environment and to meet the emerging challenges with innovative responses	• Capability • Respond quickly and flexibly • Innovative responses
Dove [26]	The ability to manage and apply knowledge effectively, so that an organization has the potential to thrive in a continuously changing and unpredictable business environment	• Capability • Knowledge management • Turbulent environment

(continues)

Table 1. Continued

Source	Definition	Key concepts
Sambamurthy et al. [82]	The ability to detect opportunities for innovation and seize those competitive market opportunities by assembling requisite assets, knowledge, and relationships with speed and surprise	• Ability to detect opportunities • Respond with speed and surprise • Assemble assets and knowledge
Arteta and Giachetti [3]	The ability to respond to unanticipated change (response ability) but also to act proactively with regard to change (knowledge management)	• Capability • Response ability • Knowledge management
Overby et al. [73]	The ability of firms to sense environmental change and respond readily	• Capability • Sense environmental change • Respond readily
Van Oosterhout et al. [100]	Business agility is being able to swiftly change businesses and business processes beyond the normal level of flexibility to effectively manage unpredictable external and internal changes	• Capability • Quickly change processes • Effectively manage external/internal changes
Gallagher and Worrell [35]	The ability to sense and respond to changes in an organization's internal and external environment by quickly assembling resources, relationships, and capabilities	• Capability • Sense and respond • Internal/external environment
Setia et al. [87]	An organization's ability to (1) discover new opportunities for competitive advantage; (2) harness the existing knowledge, assets, and relationships to seize these opportunities; and (3) adapt to sudden changes in business conditions	• Capability • Sense market opportunities • Leverage assets and resources • Adapt to environmental change
Tallon and Pinsonneault [93]	The ability to detect and respond to opportunities and threats with ease, speed, and dexterity	• Capability • Sense and respond • Speed and dexterity

organizational capabilities as either substantive or dynamic, the latter being a critical success factor in turbulent environments [31]. Dynamic capabilities are distinct from substantive ("ordinary") capabilities in that dynamic capabilities refer to the ability to detect opportunities and threats, capture market opportunities, and change or revise existing substantive capabilities [96]. Taking into account the importance of a firm's customer agility in dynamic environments, we examine why customer agility constitutes a dynamic capability and how firms can enhance their customer agility.

The dynamic capabilities literature is grounded in the evolutionary theory of the firm [67]. Since managers make decisions under uncertainty and are boundedly rational, they satisfice rather than optimize in searching for and selecting solutions to problems [56]. The implication is that firms should continually reconfigure their existing capabilities. Firms are especially challenged to revise their capabilities when faced with dynamic or unpredictable environments [31, 96]. Dynamic capabilities constitute a firm's ability to (1) sense and shape opportunities and threats, (2) respond to market opportunities, and (3) maintain competitiveness through enhancing, aligning, and reconfiguring the firm's intangible and tangible resources [95]. Within this framework, agility captures the sensing and responding components of dynamic capabilities. This framework also emphasizes the dynamic aspect of continuously aligning a firm's resources; thus, we examine (in our hypothesis development) why it is important for firms to align their sensing and responding capabilities. Hence, we conceptualize a firm's customer agility as a dynamic capability, and we use Teece's [95] framework to identify antecedents to sensing and responding capabilities. We now describe the sensing and responding components of customer agility and how IT affects these two components.

Sensing, Responding, and the Role of IT

IT infrastructure refers to an arrangement of shared technical components and IT services: platforms, networks and telecommunications, data, and software applications [27]. Scholars have argued that a well-crafted IT infrastructure may contribute to the organization's ability to sense and respond to environmental change [105]. While research finds support for a positive relationship between IT infrastructure and IT-dependent organizational agility [32], scholars have not tested how various aspects of IT infrastructure impact different organizational capabilities. Rather, IT infrastructure is often treated as a general, holistic construct that facilitates capability building. As a result, we lack deeper understanding of how certain aspects of IT infrastructure impact sensing and responding capabilities in particular. Thus, we decompose IT infrastructure into two components—knowledge based and process based—and describe how these components impact a firm's sensing and responding capabilities.

We apply the "tool" view of the IT artifact when describing the relationship between IT infrastructure and customer agility. The tool view conceptualizes IT as "the engineered artifact, expected to do what its designers intended to do" [72, p. 123]. Specifically, IT is a "driver" or "magnifer" that organizations can use to vary labor needs, increase performance, process information, and modify social relations. As a driver, IT is an exogenous force that strongly determines the behavior of individuals

and organizations [58]. As a magnifier, IT amplifies existing behaviors and routines. For example, IT as information-processing tool can alter information flows and magnify feedback and learning in organizations [72].

Sensing new opportunities is very much a scanning, creating, learning, and interpretive activity [95]. To identify opportunities, firms must constantly search and explore across technologies and markets, both local and distant [55]. Thus, sensing activities involve investing in research activities, probing customer needs, and assessing likely supplier and competitor responses [96]. A firm's ability to sense opportunities depends primarily on its ability to create and leverage knowledge [39, 73, 82]. Organizational systems that identify changing customer needs and customer-based innovation should strengthen the firm's customer-sensing capability [95]. Thus, *mechanisms by which a firm creates, transfers, and applies knowledge should impact the firm's customer-sensing capability.*

IT infrastructure's role in the creation, storage, transfer, and application of organizational knowledge is well established [38, 80]. In our NPD context, IT infrastructure helps organizations sense customer-based opportunities in two ways: as driver and as magnifier. Organizations can create Web-based tools (e.g., suggestion forms, design toolkits) that allow customers to generate, propose, and refine ideas for new products and services [64]. These tools *drive* customer behavior in an NPD context; specifically, a particular tool can both enable and constrain the ways in which customers interact with each other and the organization. For example, a "suggestion box" is a Web-based form in which the organization solicits suggestions and comments from customers. While this tool allows customers to submit ideas to the organization, it does not allow customers to perform other actions (e.g., share the idea with other customers on the Web site, help other customers with product-related problems). However, these tools are usually designed to facilitate customer-based knowledge creation [77]. Organizations can then use IT infrastructure's *magnifying* role to detect patterns in the data collected through these Web-based tools. Specifically, organizations can use analytical tools to engage in learning and sensemaking, thereby increasing visibility of the data and magnifying the customer's voice. To summarize, *Web-based customer tools* and *analytical tools* play a critical role in customer-based knowledge creation, thereby affecting a firm's customer-sensing capability.

Once an opportunity for innovation or competitive action is sensed, it must be addressed by executing the firm's operational processes. Responding to opportunities involves maintaining and developing technological resources and complementary assets and then, when the time is right, investing heavily in the particular technologies and designs most likely to achieve marketplace acceptance [95]. A firm's ability to respond to opportunities depends primarily on the coordination and execution of its operational processes [26]. For instance, by increasing the flow of information and reducing potential bottlenecks, well-coordinated operational processes enable the firm to quickly respond to opportunities [39]. Hence, *the mechanisms by which a firm coordinates and integrates operational processes, both internal and external to the firm, should impact its customer-responding capability.*

An organization's ability to respond to customer-based opportunities ultimately depends on the behavior of its members [39]. In other words, organizational members

must take action in order to initiate a response [26]. As applied to our study, organizations can respond accurately and quickly to customer-based opportunities when they have coordinated functions and processes. This implies that process coordination capabilities drive a firm's ability to respond to market opportunities. In turn, we posit that *internal and external coordination* will directly influence a firm's ability to respond. However, IT infrastructure cannot drive customer-responding capability; rather, it can only facilitate or constrain the relationship between operational process execution and the ability to respond [71]. As a result, IT infrastructure plays the role of *magnifier* when organizations attempt to respond to market opportunities. For example, IT as information-processing tool can alter information flows and magnify feedback and learning in organizations. It has been shown that strong telecommunication capabilities can enable information coupling and shared data resources can reduce hard physical coupling between processes, thereby increasing their flexibility [97]. As a magnifier, IT allows firms to efficiently share and exchange information [8], thereby leveraging their coordination efforts in response to market opportunities. For example, Southwest Airlines combines coordination mechanisms with an integrated IS to automatically respond to certain situations (e.g., delayed flights) [11]. Accordingly, *internal and external IS integration* should magnify process coordination (execution) and allow the firm to buttress its responding capability.

Agility and Competitive Activity

Having discussed antecedents to customer agility, we now investigate the competitive dynamics literature to understand how customer agility provides value to a firm. This research is concerned with understanding how a firm's competitive activity affects competitors, competitive advantage, and performance. Firms act creatively when they introduce new products, promotions, or services to enhance profits, competitive advantage, and industry position [86]. There are three implicit organizational characteristics that influence competitive action [12]. These include (1) *awareness* of the context and potential opportunities for innovation, (2) *motivation* of the firm to take action, and (3) the firm's *ability* to take action. These concepts often work together. For example, a firm that is aware of and able to respond to an opportunity is more likely to execute a competitive action than a firm that is unaware and unable to take action [91]. The awareness component is related to customer-sensing capability, and the ability aspect is related to customer-responding capability. Thus, competitive activity indicates *how well* a firm senses and responds to customer-based opportunities for innovation and competitive action [82]. Following this, we incorporate competitive activity as our ultimate outcome of interest.

Research Model

FIGURE 1 PRESENTS OUR RESEARCH MODEL. Based on our earlier discussion, IT infrastructure that facilitates customer-based knowledge creation will affect a firm's ability to sense market opportunities. Thus, we propose that Web-based customer infrastructure

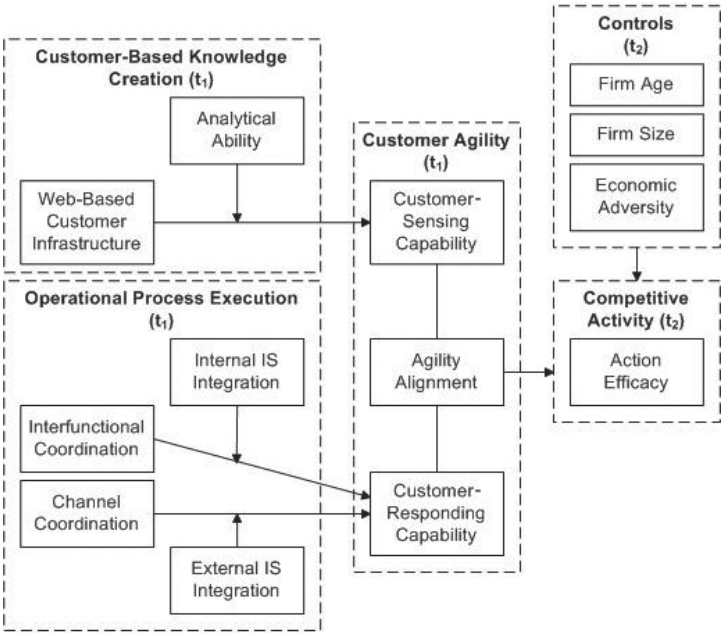

Figure 1. Research Model

is a key antecedent to customer-sensing capability. Furthermore, we suggest that this relationship will be moderated by analytical ability. Our second group of constructs enhance operational process execution, which in turn affects a firm's ability to respond to market opportunities. We position interfunctional coordination and channel coordination as antecedents to customer-responding capability, with internal IS integration and external IS integration as moderators of these relationships, respectively. Finally, we link customer agility to our ultimate outcome of interest, action efficacy. Consistent with prior research as well as the dynamic capabilities perspective, the full effect of customer agility on action efficacy will take place when a firm's sensing and responding capabilities are aligned. We also include control variables for action efficacy.

Creating Knowledge to Enhance Customer-Sensing Capability

A firm's ability to sense market opportunities depends on its ability to create and leverage knowledge [39, 95]. Creating this knowledge requires the collection of relevant data and information. To collect data and information concerning customer-based opportunities for innovation and competitive action, firms need to develop and maintain Web-based tools that allow customers to perform the three NPD roles reviewed earlier: resource, co-creator, and user. The Internet is critical to forming an environment in which customers can meaningfully contribute to a firm's NPD efforts [33, 64, 77]. As noted earlier, we derive the notion of "Web-based customer infrastructure" from

the broader concept of IT infrastructure. A firm's Web-based customer infrastructure is considered to be a subset of its overall IT infrastructure. Specifically, Web-based customer infrastructure is defined as the set of firm-provided Web-based IT tools that support varied customer roles (resource, co-creator, user) in NPD activities.

The extended reach, enhanced interactivity, increased speed, and greater flexibility provided by Web-based tools combine to produce three important benefits for customer-based knowledge creation: (1) the direction of communication, (2) the intensity and richness of the interaction, and (3) the size and scope of the audience [85]. The direction of interaction evolves from one-way knowledge import (e.g., customer to firm) to an interactive dialogue that helps firms to progressively learn about and learn from customers. The richness of the interaction increases because Web-based customer tools help firms tap into social knowledge in addition to individual customer knowledge [68]. Finally, a Web-based customer infrastructure allows the firm to reach a greater number of customers than offline tools, thereby exponentially increasing the size and scope of the knowledge it can absorb.

Consistent with our perspective on IT as driver, it is also useful to think about sensing from a process perspective. Sensing capabilities are triggered by market opportunities. Firms that do not have a Web-based customer infrastructure are less likely to acquire ideas for new products and services from their customers, thereby reducing their sensing capability. In turn, they will find it more difficult to sense customer-based opportunities.

Hypothesis 1: Web-based customer infrastructure will be positively related to customer-sensing capability.

Analytical ability refers to the extent to which IT applications provide analytical tools to support decision making in the context of customer interactions. Our concept of analytical ability is based on the broader management support systems literature. Management support systems refer to a class of systems whose fundamental purpose is the support of managerial actions and decision making, including decision support, knowledge management, and analytics [15]. Analytics refers to "the extensive use of data, statistical and quantitative analysis, explanatory and predictive models, and fact-based management to drive decisions and actions" [22, p. 7]. As such, analytics represents the higher-value and more proactive end of the intelligence spectrum. For example, IT-based analytical tools allow companies such as Marriott International to optimize offerings to frequent customers and determine the likelihood of those customers' defecting to competitors [22]. Although analytics can be applied to a wide variety of organizational areas and issues, we focus on an organization's use of analytical tools to identify and assess the value of customer-based market opportunities.

While a Web-based customer infrastructure facilitates the generation of vast amounts of customer-driven data, analytical tools help firms make sense of this data. Firms can leverage analytical tools to find patterns in data, thereby gaining insight and understanding into potential opportunities for innovation and action. Data and information streaming into the firm from the Web-based customer infrastructure may create an overwhelming glut that is difficult for managers to interpret, synthesize, and

understand. Firms with higher levels of analytical ability will be better able to gain insight into the data generated by a Web-based customer infrastructure.

Hypothesis 2: The relationship between Web-based customer infrastructure and customer-sensing capability will be moderated by analytical ability: the greater the analytical ability, the stronger the positive association between Web-based customer infrastructure and customer-sensing capability.

Executing Operational Processes to Enhance Customer-Responding Capability

A firm's ability to respond to market opportunities depends on the level of coordination both within the firm and between the firm and its external partners [26]. Interfunctional coordination refers to the degree to which a firm's functions develop a mutual understanding of each other's capabilities and align their goals and activities based on such understanding [34]. The dissemination of market intelligence throughout the organization depends largely upon the extent to which functions communicate and coordinate with one another [45].

Aligned processes facilitate the flow of information throughout the organization, thereby increasing the organization's ability to respond to external opportunities. For instance, high levels of coordination between manufacturing and marketing leads to (1) reduced task uncertainty for both functions; (2) greater understanding by marketing of manufacturing's constraints, objectives, and incentives; and (3) greater understanding by manufacturing of customer preferences, marketing plans, and competitive activity [34]. By enhancing information flow, reducing task uncertainty, and developing shared understanding, firms with high interfunctional coordination are more likely to respond quickly and effectively to customer-based market opportunities than firms with low interfunctional coordination.

Hypothesis 3: Interfunctional coordination will be positively related to customer-responding capability.

Channel coordination refers to the extent to which the activities of a focal firm are coordinated with its business partners such that the processes spanning firm boundaries are operationally integrated [98]. In particular, channel coordination can be viewed as "the synchronization of activities and flows by channel members" [62, p. 45], where channel members consist of a variety of external entities, including contract manufacturers, suppliers, subcontractors, and resource planners. In addition to relying on the effective coordination of internal units, firms must also coordinate with external channel partners if they wish to respond quickly to market opportunities. Aligned interorganizational processes enhance the flow of information between a firm and its key channel partners [74]. By streamlining the flow of information between the focal unit and its channel partners, firms with high channel coordination will find it easier to mobilize their own resources in response to customer-based market opportunities than firms with weak channel coordination.

Hypothesis 4: Channel coordination will be positively related to customer-responding capability.

Scholars are increasingly beginning to view IS as complementary resources that enhance the value of other organizational resources [94]. Interfunctional coordination represents an alignment of goals and behaviors contingent on mutual understanding, trust, and partnership. Integrated IS greatly enhance interfunctional exchanges and promote joint understanding. Specifically, integrated IS capability captures the degree to which the firm's IS provide integrated access to data across organizational subunits [8]. Prior work finds that integrated IS capability interacts with various coordination mechanisms (e.g., manufacturing–marketing, manufacturing–supply chain) to increase manufacturing performance [8]. By providing features such as automatic updates of data records through systemwide triggers, a consistent view of the data, and facilities for quickly reporting and sharing relevant information across functional boundaries, these systems are more likely to increase the flow of information throughout the entire organization [21], thereby capturing the benefits of effective coordination between organizational units. As a result, the firm can quickly respond to customer-based opportunities for innovation and competitive action.

Hypothesis 5: The relationship between interfunctional coordination and customer-responding capability will be moderated by internal IS integration: the greater the internal IS integration, the stronger the positive association between interfunctional coordination and customer-responding capability.

The argument positing the existence of synergistic value derived from interfunctional coordination and internal IS integration holds for the interactive effect of channel coordination and external IS integration. External IS integration is defined as the extent to which the IS applications of a focal firm work as a functional whole in conjunction with the IS applications of its business partners [83]. External IS integration improves firms' ability to process orders, forecast sales, share customer data, and collaborate in areas such as NPD [78]. By providing features such as a consistent view of the data and facilities for seamlessly sharing relevant information across organizational boundaries, these systems are more likely to increase the flow of information across distribution channels. As a result, the focal firm can more quickly respond to customer-based opportunities.

Hypothesis 6: The relationship between channel coordination and customer-responding capability will be moderated by external IS integration: the greater the external IS integration, the stronger the positive association between channel coordination and customer-responding capability.

Aligning Sensing and Responding to Execute Competitive Activity

Competitive activity consists of market-based moves that challenge the status quo of the market or industry through innovations in products, services, and channels [12, 91]. By sensing and responding to customer-based opportunities, firms will be more

likely to exhibit greater levels of competitive activity [82]. Thus, customer agility should be positively related to competitive activity. However, sensing and responding capabilities need to be simultaneously developed and applied in order for firms to reap the benefits of agility [39, 73, 95]. Thus, we do not postulate a hypothesis linking customer agility to competitive activity; rather, we take into account a firm's degree of alignment between its customer-sensing capability and customer-responding capability. Accordingly, we investigate the effect of agility alignment on action efficacy.[2] Action efficacy is defined as the extent to which a firm executes actions that produce the desired result, which, in our context, constitutes *actions that meet customer needs in a given time period.*

Alignment refers to "the degree to which the needs, demands, goals, objectives, and/or structures of one component are consistent with the needs, demands, goals, objectives, and/or structures of another component" [63, p. 119]. When applied to customer agility, the objectives and structure of a firm's customer-sensing capability should be consistent with the objectives and structure of its customer-responding capability. The basic premise is that the higher the alignment (i.e., match, congruence, fit) between customer-sensing capability and customer-responding capability, the greater the effect of customer agility on an appropriate criterion variable [73, 102]. Thus, firms aligned in their sensing and responding activities are more likely to extract greater value from their overall customer agility capability (provided they have strong sensing and strong responding capabilities). For example, BMW senses emerging customer needs by involving lead users in the generation of ideas toward its product innovation activities, and they also respond quickly by implementing valuable ideas in future products [77]. However, Digital Equipment Corporation failed to sense and respond to emerging markets for personal computers in the 1980s, thereby leading to its ultimate demise [103].

The implications of misalignment can be detrimental to long-term performance. For example, Xerox sensed impending changes in the computing industry in the 1970s; however, Xerox failed to bring its computing innovations to market, thereby hurting its long-term performance [90]. The inability to effectively sense relevant opportunities may also hurt a firm. Apple introduced the Newton, a personal digital assistant (PDA), as a mass-market product when, in fact, it was too early in its development for the Newton to be made generally available. As a result, the Newton lost its audience and never gained traction in the PDA market [6].

Agility alignment is especially relevant to action efficacy. Firms can have strong responding capabilities yet fail to sense relevant market opportunities. For instance, firms that simultaneously release multiple products in rapid fashion often experience substantial disruptions and market failure [5]. These firms respond to many market opportunities, yet their sensing capability fails to effectively rank the importance of these opportunities. Firms might be able to sense opportunities for competitive action but fail to respond to them quickly. Poorly coordinated processes may hinder product development activities, causing firms to miss market opportunities. Firms that have strong sensing and responding capabilities are more likely to execute actions that produce the desired result, namely, meeting customers' needs.

Hypothesis 7: Action efficacy will be higher when customer-sensing capability and customer-responding capability are both high than when both are low.

We included firm age and firm size as controls for action efficacy [91]. The 2008 economic downturn may have prevented some firms from executing desired actions. For example, firms may have been forced to downsize, cancel supplier contracts, and reduce operations, thereby inhibiting their ability to take certain actions. Thus, we include an *economic adversity* measure to control for firms affected by the 2008 economic downturn.

Research Method

This study uses two surveys to collect data from marketing managers to measure the constructs in the research model. We measured the knowledge-based, process-based, and customer agility constructs at one point in time (t1), and we measured action efficacy and our control variables at a second point in time (t2).[3] The second survey was completed by the same respondent four months after the first survey. Our unit of analysis is a strategic business unit.

Measures

Where possible, existing measures of constructs were adapted to this study's context. Standard scale development procedures [54] were used for new measures and those that required significant changes (see Appendix A). Appendix B lists the sources and items for all construct measures, as well as a discussion of their reflective/formative nature.

Survey Development and Administration

Data were gathered from a large population by using a questionnaire instrument. The target respondent was the senior marketing manager. This is consistent with Huber and Power's [43] recommendation; in the case where one respondent per unit is solicited, the respondent should be the most informed person. Following prior research [66], we presumed that the senior marketing manager would be the most informed respondent regarding how well his or her organization senses and responds to its customers. Moreover, the IT-based constructs address the effectiveness of IT within the organization, not technical details related to the technology. Marketing managers will also be the most informed about IT that faces customers, such as Web-based tools.

To determine the suitable population of interest in this study, we developed a list of criteria based on prior research and practitioner literature. First, we need to investigate firms operating in dynamic, customer-oriented, information-intensive environments. These firms are more likely to require high levels of customer agility [39]. Consistent with competitive dynamics research, we target only public U.S. firms [24]. Third, our sample frame should include firms that have adopted and diffused a diverse range of

Web-based tools that support customer roles in NPD. Research suggests firms operating in high-tech industries as excellent candidates [76, 77]. Based on these criteria, our target sample frame consists of public U.S.-based firms operating in high-tech industries (computer manufacturing and prepackaged software).

Members of an online panel served as respondents to both of our online surveys. Respondents were real managers that self-identified as marketing managers with in-depth knowledge and authority over organizational marketing policies and procedures. They were sourced from a general panel of individuals managed by Zoomerang (see Appendix C).

Sample Characteristics

Zoomerang generated a random set of 1,200 sales/marketing managers employed in high-tech firms, who were then invited to complete the online survey. Of these 1,200, we received 188 usable responses.[4] The demographics of our sample reveal that just over half were female (60 percent), middle aged (mean = 45 years), and well-educated (95 percent had at least some college experience). Respondents' average organizational tenure was 8.3 years, with an average of 5.1 years in their current position. They were highly active in formulation of marketing/sales policies for their firms at the time of the study (mean = 4.29 on a 5-point scale, with 5 = "very active"). Thus, the respondents were highly qualified to answer the questions. The median firm size was 400 employees, and the average firm age was 36.5 years. Our second survey was also deployed through Zoomerang. Of the 188 usable respondents from survey one, a total of 108 individuals completed the second survey for an effective response rate of 60 percent.

We employed wave analysis [2] to assess potential nonrespondent bias in survey one. Responding firms were grouped into early and late respondents, and comparisons were made along respondent age, gender, education, firm size, and firm age. Our analysis showed no significant differences between early and late respondents. Responding and nonresponding firms were compared along the same criteria for the second survey. Again, there were no significant differences between responding and nonresponding firms. Based on these findings, nonresponse bias is not a major concern in this study.

Measurement Properties of Constructs

We used confirmatory factor analysis techniques in EQS 6.1 to evaluate measurement properties of our constructs.[5] We modified the measurement model until all parameter estimates and overall fit measures for each construct were considered satisfactory. The final fit indices suggest that the data fit the measurement model well (S.B. [Satorra–Bentler] $\chi^2 = 489.29$, df [degrees of freedom] = 384; CFI [comparative fit index] = 0.96; RMSEA [root mean square error of approximation] = 0.038). Standardized factor loadings of measurement items on their respective factors were

all highly significant ($p < 0.01$), providing support for convergent validity. We used a chi-square difference test to evaluate discriminant validity. All chi-square differences were significant ($p < 0.05$), indicating support for discriminant validity. With respect to reliability, Cronbach's alphas for all reflective measures exceed the prescribed 0.70 threshold [69] (see Table 2). We report correlations and descriptive statistics in Table 2.

Assessment of Common Method Bias

We conducted a Harman one-factor test to assess the extent to which common method bias may be a problem [41]. Our results extracted eight factors from the data that corresponded to the latent variables in our study. The factors accounted for 68.9 percent of the variance with the first factor accounting for 22.4 percent. No single factor accounted for a majority of the covariance. We also controlled for the effects of a single unmeasured latent method factor. Our ΔCFI of 0.005 between the original model and the model with the unmeasured latent method factor is less than the recommended value of 0.01 [13]. These results provide further support that common method bias is not a significant threat to the validity of our study.

Structural Model and Hypothesis Testing

We used EQS 6.1 to evaluate our structural model. Given that Web-based customer infrastructure is a formative measure (see Appendix B), we followed recommended guidelines for testing formative measures in EQS [25, 79]. We tested three models. Model 1 included the main effects for both dependent variables. The model performed well in terms of model fit (S.B. $\chi^2 = 647.32$, df = 486; CFI = 0.95; RMSEA = 0.043). Our results show that Web-based customer infrastructure is significantly related to customer-sensing capability ($\beta = 0.46$, $p < 0.001$), supporting H1. Interfunctional coordination ($\beta = 0.52$, $p < 0.001$) and channel coordination ($\beta = 0.16$, $p < 0.01$) are both significantly related to customer-responding capability, supporting Hypotheses 3 and 4, respectively. Firm size ($\beta = -0.16$, $p < 0.01$) and internal IS integration ($\beta = 0.21$, $p < 0.01$) were also significantly related to responding capability.[6]

Models 2 and 3 used a hierarchical analysis approach to evaluate our moderation hypotheses.[7] We followed recommended guidelines for testing interaction effects in EQS [59]. Table 3 details our results. Model 2 includes main and interaction effects for customer-sensing capability. Our results show that analytical ability moderates the relationship between Web-based customer infrastructure and sensing ($\beta = 0.22$, $p < 0.05$), supporting H2. Model 3 includes main and interaction effects for customer-responding capability. Our results show that internal IS integration moderates the relationship between interfunctional coordination and customer-responding capability ($\beta = 0.11$, $p < 0.05$), supporting H5. However, external IS integration does not moderate the relationship between channel coordination and customer-responding capability ($\beta = 0.05$, n.s. [nonsignificant]). Thus, H6 is not supported.

Table 2. Interconstruct Correlations, Descriptive Statistics, and Reliabilities

Construct	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. Customer sensing	5.49	1.09	0.87											
2. Customer responding	5.36	1.23	0.63	0.92										
3. Web-based customer infrastructure	0.31	0.25	0.42	0.04	—									
4. Analytical ability	3.96	1.62	0.10	0.05	0.09	0.86								
5. Interfunctional coordination	4.65	1.29	0.53	0.26	0.06	0.12	0.89							
6. Channel coordination	4.29	1.28	0.25	0.18	0.00	0.04	0.41	0.89						
7. Internal IS integration	4.45	1.41	0.46	0.29	0.12	–0.01	0.60	0.37	0.87					
8. External IS integration	3.89	1.34	0.22	0.19	0.01	0.04	0.45	0.56	0.54	0.88				
9. Action efficacy	3.67	2.83	0.33	0.22	0.11	0.29	0.31	0.24	0.29	0.17	—			
10. Firm size	2.67	1.18	0.12	–0.14	0.10	0.16	0.01	–0.04	–0.01	–0.03	–0.08	—		
11. Firm age	50.21	44.44	–0.01	–0.26	–0.03	0.01	–0.07	0.01	–0.16	–0.07	–0.12	0.51	—	
12. Economic adversity	3.92	1.46	–0.23	–0.36	–0.05	–0.06	–0.26	–0.07	–0.34	–0.27	–0.25	0.19	0.23	—

Notes: SD = standard deviation. Cronbach's alphas are reported on the diagonals for reflective measures. We conducted a Durbin–Wu–Hausman (DWH) test to investigate whether or not the two coordination constructs are endogenous to the two IS integration constructs. Our DWH values were not significant at the 0.05 level, thereby failing to find evidence of endogeneity.

Table 3. Results of Hierarchical Analysis

Variable	Main effects	Interactions included
Dependent variable: Customer-sensing capability		
Web-based customer infrastructure (WEB)	0.46***	0.45***
Analytical ability (AA)	0.05	0.04
WEB * AA		0.22*
R^2	0.32	
Change in R^2		0.04
Dependent variable: Customer-responding capability		
Interfunctional coordination (COI)	0.42***	0.41***
Channel coordination (COE)	0.19*	0.14*
Internal IS integration (INTI)	0.21**	0.23**
External IS integration (INTE)	0.06	0.05
Firm size[a]	–0.15*	–0.13*
COI * INTI		0.11*
COE * INTE		0.05
R^2	0.45	
Change in R^2		0.02

Notes: Table entries are standardized regression coefficients. [a] Smaller firms often find it easier to respond to opportunities than larger firms; hence, we included firm size as a control variable for customer-responding capability. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Agility Alignment and Action Efficacy

Consistent with recent empirical work on alignment [30, 70, 101], we used polynomial regression and response surface methodology [49] to test the relationship between agility alignment and action efficacy (H7). Following recommended guidelines [28, 29, 50], we used the following equation:

$$A = \beta_0 + \beta_1 S + \beta_2 R + \beta_3 S^2 + \beta_4 (S * R) + \beta_5 R^2 + e, \quad (1)$$

where A refers to action efficacy, S refers to customer-sensing capability, and R refers to customer-responding capability. We controlled for firm size, firm age, and economic adversity. Consistent with empirical work on the relationship between the alignment of two variables and a dependent variable [30], we focused on the shape along the $S = R$ line, which corresponds to H7. This correspondence can be seen by examining Figure 2, in which the $S = R$ line runs from the near corner to the far corner of the plane. Moving from the near corner to the far corner along the $S = R$ line indicates an increase from low levels of sense and respond to high levels of sense and respond. The shape along this line can be tested by setting R equal to S in Equation (1):

$$\begin{aligned} A &= \beta_0 + \beta_1 S + \beta_2 R + \beta_3 S^2 + \beta_4 (S * R) + \beta_5 R^2 + e \\ &= \beta_0 + (\beta_1 + \beta_2) R + (\beta_3 + \beta_4 + \beta_5) R^2 + e. \end{aligned} \quad (2)$$

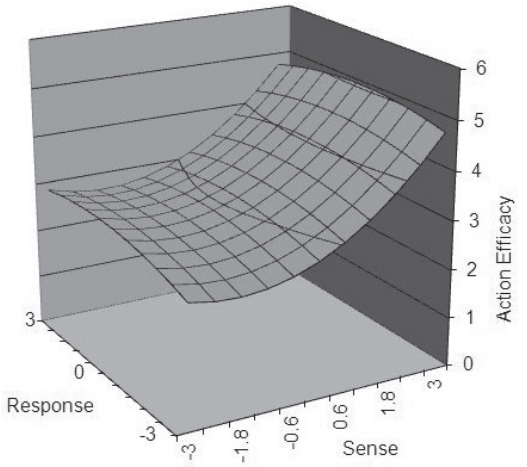

Figure 2. Surface for Agility Alignment Predicting Action Efficacy

Equation (2) shows that along the $S = R$ line, the curvature of the surface is represented by $\beta_1 + \beta_2$, and the slope of the surface at the point $R = 0$ is represented by $\beta_3 + \beta_4 + \beta_5$. Thus, if action efficacy increased linearly moving from low sense and respond to high sense and respond (H7), the surface would be positively sloped along the $S = R$ line at the point $R = 0$ and would have no curvature, such that $\beta_1 + \beta_2$ would be positive and $\beta_3 + \beta_4 + \beta_5$ would not differ from zero. The shape of the surface along the $S = R$ line was tested using procedures for testing linear combinations of dependent regression coefficients [29]. Table 4 details the results of our analyses. Figure 2 depicts a surface for agility alignment (sense and response) predicting action efficacy.

H7 stated that action efficacy would be higher when sense and respond were both high than when both were low. If a surface has no curvature along the $S = R$ line, this hypothesis could be tested by evaluating the slope of the surface at the point $S = 0$, $R = 0$, represented by the quantity $\beta_1 + \beta_2$ in Table 4. However, the surface in Figure 2 is curved upward along the $S = R$ line, meaning that the slope along the $S = R$ line varied according to the levels of S and R. In this case, an alternative strategy is to test the difference in action efficacy for high versus low scores of sense and respond [30]. For these tests, we identified high and low scores by first locating the point along the $S = R$ line midway between the sense and respond means. From this point, we added and subtracted a value midway between the standard deviations of the sense and respond measures. After scale centering, the means of the sense and respond measures were 0.49 and 0.36, respectively (these means are five units smaller than the corresponding figures reported in Table 2). The point midway between these means is thus 0.43. The point midway between the sense and respond standard deviations (1.09 and 1.23, respectively, as reported in Table 2) was 1.16. Thus, we used 1.59 and –0.73 to represent high and low scores along the $S = R$ line. As Figure 2 shows, action efficacy is higher when sense and respond are aligned than when they are nonaligned. In addition, along

Table 4. Results of Tests for Hypothesis 7

Polynomial regression results[a]	
Intercept	3.10
Customer-sensing capability (CS)	0.35*
Customer-responding capability (CR)	0.02
CS^2	0.05
CS * CR	–0.01
CR^2	–0.03
Firm size	0.01
Firm age	0.02
Economic adversity	–0.39*
R^2	0.25
Shape along $S = R$ line	
$\beta_1 + \beta_2$	0.37**
$\beta_3 + \beta_4 + \beta_5$	0.01

Notes: Table entries are standardized regression coefficients. [a] We used a bootstrapping procedure to estimate significance levels. Widely applied in management [29] and MIS research [101], bootstrapping and other nonparametric procedures (e.g., jackknifing) are used when traditional techniques, such as regression analyses, do not provide formulas for the estimation of specific expressions. * $p < 0.05$; ** $p < 0.01$.

the $S = R$ line, action efficacy was higher at high sense and respond scores (1.59) than for low sense and respond scores (–0.73). Thus, H7 is supported.

Discussion

We conceptualized and empirically tested a research model with distinct antecedents to customer agility's two components—sensing and responding. We theorized that "knowledge-based" constructs would affect customer sensing capability, and "process-based" constructs would affect customer-responding capability. Table 5 details our results and implications.

Our analysis finds that Web-based customer infrastructure has a significant effect on customer-sensing capability. We also find that analytical ability plays a key role in the nomological network surrounding Web-based customer infrastructure and customer-sensing capability. The greater a firm's analytical ability, the stronger the association between the firm's Web-based customer infrastructure and its customer-sensing capability. It is important to note that analytical ability does not exhibit a direct effect on customer-sensing capability. Rather, complementary synergies arising from (1) data streaming in from the firm's Web-based customer infrastructure and (2) the firm's ability to leverage analytical tools to transform that data into knowledge have powerful effects on the firm's ability to sense customer-based opportunities.

We find that interfunctional coordination and channel coordination are significantly related to customer-responding capability. Our results also show that the greater a firm's internal IS integration, the stronger the positive association between the firm's

Table 5. Results and Implications

Hypothesis/ independent variable	Supported?	Implications
Dependent variable: Customer-sensing capability		
H1: Web-based customer infrastructure	Yes	Firms are developing and leveraging Web-based tools to enhance their ability to sense customer-based market opportunities. A Web-based customer infrastructure allows firms to interact with customers on a global scale and absorb valuable customer knowledge.
H2: Analytical ability × Web-based customer infrastructure	Yes	Our results show that analytical capabilities play an important role in the knowledge creation process. As data stream into the firm from customer interactions on its Web-based customer infrastructure, analytical tools help organizational members detect patterns and make sense of the data.
Dependent variable: Customer-responding capability		
H3: Interfunctional coordination	Yes	A firm's ability to respond quickly to market opportunities depends on effective coordination. In particular, internal and external coordination both facilitate customer-responding capability.
H4: Channel coordination	Yes	
H5: Internal IS integration × interfunctional coordination	Yes	With respect to responding capability, firms with well-integrated IS gain more value from their coordination efforts than firms with poorly integrated IS. Integrated systems improve the flow of information throughout the enterprise, thereby complementing the coordinated efforts of organizational units when responding to customer-based market opportunities.
H6: External IS integration × channel coordination	No	External IS integration and channel coordination do not create synergies that enhance customer-responding capability. This result shows that focal firms do not strongly rely on their ability to share information with channel partners when it comes to responding to customer needs.
Dependent variable: Action efficacy		
H7: Agility alignment	Yes	Action efficacy is higher when sensing and responding are both high than when sensing and responding are both low. Independently, sensing has a stronger effect on action efficacy than responding.

interfunctional coordination and its customer-responding capability. The transparency, consistency, and communication capabilities provided by integrated IS enable organizational functions to effectively share information that, when combined with complementary coordination mechanisms, allows the firm to quickly respond to customer-based opportunities.

Our analysis finds no support for the moderating role of external IS integration in the relationship between channel coordination and customer-responding capability. Although we find that channel coordination facilitates the focal firm's ability to respond to customer-based opportunities, there are a variety of reasons for which a firm shares data with its channel partners. For instance, firms may integrate their IT systems with certain channel partners in order to manage the flow of materials and finished goods; share operational, tactical, and strategic information; and increase financial flows driven by workflow events [78].

We hypothesized that the alignment between sensing and responding would positively impact action efficacy. Our results show that action efficacy is higher when sensing and responding are aligned than when they are nonaligned. Also, action efficacy is higher when sensing and responding values are both high than when they are both low. In terms of independent effects, action efficacy is greatest when (1) customer-responding capability is medium to high and (2) customer-sensing capability is high. This implies that high sensing and low-to-middle responding could be the "next best" option (in terms of action efficacy).

Limitations

Before discussing the implications of our results, we note several limitations in our study. First, we used the same respondent for both our independent and dependent variables. Statistically, common method bias does not appear to threaten the validity of our results, and our two-stage survey design should have reduced the potential for bias. However, we note that using the same respondent might have upwardly biased our results. Our dichotomous measures of Web-based customer infrastructure limited our ability to fully understand how firms develop and leverage firm-hosted online communities to their advantage. Although the constantly changing nature of Web-based tools poses measurement challenges, future research should develop more rigorous measures of how firms leverage Web-based tools to involve customers in NPD roles.

Implications for Research

Agility is one of several concepts proposed to address the issue of how organizations can succeed in dynamic environments. We identified a number of key characteristics concerning organizational agility; specifically, agility is a (1) domain-specific (2) capability that comprises an ability to (3) sense and respond (4) quickly to market opportunities. Future research should take into account these four factors when conceptualizing and measuring agility. Moreover, although scholars contend that sensing and responding capabilities need to be simultaneously developed and applied in order

for firms to harvest the benefits of agility [39, 73], no work has conducted a comprehensive investigation of the ways in which sensing and responding can or should be aligned. A higher "match" on sensing and responding results in higher quality of customer-based actions; furthermore, if there is an imbalance between sensing and responding, firms with high sense/moderate response capabilities execute higher-quality actions. Researchers should take alignment into account when investigating agility-related phenomena.

Our study is also one of the first to conceptualize and test a relationship between a dynamic capability (customer agility) and competitive activity. By examining the link between customer agility and competitive activity, we identify a valuable, tangible outcome of dynamic capabilities. In doing so, our study also complements recent work on the role of IT in competitive dynamics [47, 99]. Competitive dynamics researchers tend to focus on the quantity or repertoire of actions a firm undertakes [48], as opposed to the quality or efficacy of actions. Our study takes an initial step toward an understanding of the factors that allow a firm to execute the right action at the right time. By conceptualizing and validating action efficacy, we gain a better understanding of how a firm's customer agility can impact the extent to which its competitive actions meet customer needs. We believe that investigating the factors involved in how a firm identifies and executes the right actions at the opportune time to meet customer needs in the marketplace will provide deeper understanding into research on competitive dynamics and firm rivalry.

Recent assessments of IT value research have argued that IS research needs to examine both intermediate-value outcomes as well as intangible value created by IT [52]. While prior IS research often investigated how IT affects a firm's tangible outcome like productivity or performance, ours is the first study to empirically examine how IT enhances a firm's intangible value in customer agility. In turn, customer agility positively affects a firm's competitive activity. Both agility and activity are intermediate concepts that lead to economic outcomes and provide a different understanding of how IT indirectly contributes to firm value.

Investigating IT as both driver and magnifier provides insight into the various ways in which IT infrastructure affects customer agility. As a driver, a firm's Web-based customer infrastructure shapes customer roles and facilitates knowledge creation in an NPD context, which in turn enhances an organization's ability to sense customer-based opportunities. Our results suggest that IT investments in customer-facing infrastructure do need to be made, and the liberating nature of the Web and the increasing awareness, involvement, and discrimination of consumers, coupled with their higher self-efficacy in the use of such tools [65], creates a proclivity for consumers to volunteer information and ideas to the firm. Enterprising companies, particularly those with IT-based analytical capabilities, can then gain an acute sensing capability. We also contend that IT infrastructure does not necessarily drive a firm's customer-responding capability. Rather, a firm's ability to respond to market opportunities depends primarily on its coordination mechanisms and policies, which are inherently driven by organizational members.

As a magnifier, IT infrastructure can be leveraged to create synergies with complementary organizational capabilities that in turn facilitate an organization's ability to

both sense and respond to customer-based opportunities. This softer role of IT, which in our study includes analytical and integrative capabilities, serves to enhance the more instrumental processes and technologies. It should be noted that the magnifier role of IT may not succeed if the complementary capability is weak. For instance, poorly coordinated processes will not benefit from integrated IT [40]. Similarly, organizations adding a poor Web-based customer infrastructure will not benefit from enhanced analytical capabilities. Conceptualizing IT as both driver and magnifier provides a nuanced perspective on how IT creates business value.

Implications for Practice

Our study has clear implications for practice, particularly in contemporary digital and highly competitive environments. First, managers should develop and maintain a repertoire of Web-based tools that allow customers to perform a variety of NPD-related roles. In doing so, customers are more likely to offer recommendations on how the firm can improve existing products and services, assist peers in troubleshooting problems, and suggest ideas for new products and services. The extended reach, enhanced interactivity, and greater flexibility provided by Web-based tools generate a wealth of information that managers can then leverage to determine customers' expressed and latent needs. As a result, firms are more likely to sense a range of potential market opportunities. Our results also show that building analytical capabilities is not sufficient. Rather, firms must have data streaming in before they can leverage analytical tools. However, managers who take advantage of the synergies arising from voluminous amounts of Web-based data from customers and data-mining analytical capabilities will improve their ability to sense customer-based opportunities in a relevant and timely manner.

Our study finds that coordination is critical to achieving an ability to respond to market opportunities. Managers should cultivate both interfunctional coordination mechanisms and channel coordination processes. By doing so, their firm will be better positioned to respond quickly when an opportunity presents itself. Furthermore, integration of a firm's internal IS speeds the flow of information, thereby magnifying the effect of interfunctional coordination on response ability. An integrated IS also produces a standard, consistent view of information throughout the organization, enhancing interfunctional exchanges and promoting joint understanding. Finally, our results suggest that managers would do well to align their sensing and responding capabilities. While it is important that sensing and responding be balanced, managers should focus on sensing processes when they desire to create products and services that meet customers' needs and preferences. Without a strong customer-sensing capability in place, firms cannot execute effective actions in the marketplace.

Conclusion

Our study provides a stepping-stone for several fruitful areas for future research. Researchers can extend and refine the knowledge-sensing/process-responding framework to other types of agility, such as supply chain partner agility and operational

agility [82]. What might be the IT-based antecedents that enhance a firm's ability to sense and respond to changes in supply chain activities? Are there other synergies between IT infrastructure and organizational capabilities that facilitate agility? Future research should explore the relationship between sensing and responding capabilities. What are the factors that help firms align their sensing and responding capabilities? How does IT contribute to agility alignment?

In conclusion, our study focused on investigating how IT facilitates a firm's customer agility and, in turn, competitive activity. We showed that the knowledge-creating and process-enhancing power of IT infrastructure facilitate a firm's ability to sense and respond to customer-based market opportunities, thereby expanding the purview of IT value research. We hope that this paper lays the groundwork for future research concerning the business value of IT.

Notes

1. By "customer" we refer to the traditional consumer (e.g., an individual who purchases a cup of coffee at Starbucks). We do not include firm-level customers or suppliers (e.g., Enterprise Rent-A-Car purchases mass quantities of automobiles from Toyota).

2. Competitive dynamics researchers often ignore the quality of a firm's competitive activity, instead focusing on competitive aspects such as aggressiveness and rivalry [48]. One reason for this is that much of the competitive dynamics empirical research has relied on secondary data, which often limits researchers' ability to capture certain measures. In keeping with the context of our study, our conceptualization and measurement of action efficacy is an effort to capture whether or not a firm executes actions that meet customer needs.

3. We conducted a two-stage survey design primarily for three reasons: (1) to achieve correspondence with the temporal ordering of constructs in our research model, (2) to enhance our arguments for causality regarding the relationship between customer agility and competitive activity, and (3) to reduce the threat of common method bias to our study's results.

4. Our contract with Zoomerang specified 200 responses, so Zoomerang closed the survey when just over 200 responses were collected. As a result, it is difficult to calculate a traditional response rate. Also, there were 78 missing values in the data set, which is less than 0.01 percent of the total number of values. We performed Little's MCAR (missing completely at random) test [53] and found that these values were missing completely at random ($p > 0.05$). So long as data are MCAR, the data may be imputed without violating the assumption of MCAR [1]. Hence, we applied direct maximum likelihood imputation methods in EQS to create a complete data set of 188 responses.

5. It is important to take into account the degree to which multivariate normality may impact structural equation modeling analyses [36]. With respect to multivariate normality, we examined Mardia's [57] normalized estimate to determine the extent to which our data were normally distributed. When evidence suggested that data were not normally distributed, we used the Satorra–Bentler (S.B.) scaled χ^2 statistic [84] and corresponding robust fit estimates provided by EQS 6.1. The S.B. χ^2 statistic has been shown to be the most reliable test statistic for evaluating covariance structure models under various distributions and sample sizes [42].

6. We conducted a Lagrange multiplier test [10] to estimate whether adding paths to the structural model would result in a significant improvement in model fit. We found that adding one path—between internal coordination and customer-sensing capability—would result in a significant improvement in model fit. This result supports recent arguments linking coordination mechanisms to knowledge absorption [80]. While our proposed mapping of knowledge-sensing and process-responding mapping is mostly empirically supported, future research should test this framework for further refinement and extension.

7. Ideally, we would assess a structural model that includes all main effects and all interaction effects. Unfortunately, complex models with interactions present estimation challenges in

covariance-based structural equation modeling. These limitations led us to split our analysis of the interaction effects into two models, one for each dependent variable of interest.

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Appendix A

Survey One Pretest

SINCE ALL THE SCALES FOR SURVEY ONE were adapted from the literature to the current study, we gave careful consideration to the content validity of the measures. Three faculty members and eight doctoral students carefully assessed the wording of the items in the questionnaire. Based on their feedback, minor changes were made to the wording and design of the questionnaire. Next, phone interviews were conducted with three marketing professionals. The questionnaire was sent to these individuals a few days prior to the interview. Interviews lasted an average of 20 minutes each. The feedback gained from these interviews was incorporated into the questionnaire.

Survey One Pilot

We downloaded a mailing list of 1,080 respondents from Dun & Bradstreet's Million Dollar Database, a directory of U.S. companies from all industries with sales of $1 million or more, or 20+ employees, or branches with 50+ employees. These respondents held job titles consistent with our established criteria, such as "marketing director," "marketing manager," "vice president marketing," and "vice president sales and marketing." Consistent with our target sample frame, we restricted our search to public U.S.-based firms operating in high-tech industries.

Surveys were mailed to 400 respondents randomly selected from the initial set of 1,080. Within 4 weeks, 5 surveys were returned as nondeliverable, and 18 completed surveys were returned (an effective response rate of 4.6 percent). All 18 respondents

fully completed their surveys (i.e., there were no missing data). The average respondent age was 47 years, and 61 percent of the respondents were male. Ninety-five percent of the respondents had at least a bachelor's degree. Finally, respondents had an average of 18 years of customer relationship management experience and an average of 10 years employment with their current organization.

An exploratory factor analysis (EFA) was conducted for each set of items. Most of our measures exhibited clean factor loadings and sufficient reliability (Cronbach's $\alpha > 0.70$); however, EFA results suggested that some items did not load well with others for the customer-sensing capability and customer-responding capability constructs. As a result, changes were made to the wording of some items. Our pilot analysis placed sufficient confidence in the scales to proceed with the full-scale survey administration of the target sample frame.

Survey Two Pretest

Measurement items for action efficacy were developed by the primary researcher. Three faculty members and five doctoral students carefully assessed the wording of these items. Based on their feedback, minor changes were made to the wording and design of the questionnaire. Next, phone interviews were conducted with two of the three respondents who participated in the survey one pretest. The questionnaire was sent to these individuals a few days prior to the interview. Interviews lasted an average of 10 minutes each. The feedback gained from these interviews was incorporated into the questionnaire.

Survey Two Pilot

We administered survey two to a group of evening MBA students. Eighteen full-time working MBA students completed the questionnaire and provided feedback on wording and clarity of the instrument. The feedback gained from this process was incorporated into the instrument. Our pilot analysis placed sufficient confidence in the scales to proceed with the full-scale survey administration of the target sample frame.

Appendix B

Construct Measures

Customer-Sensing Capability (1 = "strongly disagree," 7 = "strongly agree") [66, 89]

1. We continuously try to discover additional needs of our customers of which they are unaware.
2. We work closely with lead users who try to recognize customer needs months or even years before the majority of the market may recognize them. (Item dropped after testing of measurement properties.)

3. We extrapolate key trends to gain insight into what users in a current market will need in the future.
4. We continuously try to anticipate our customers' needs even before they are aware of them.
5. We attempt to develop new ways of looking at customers and their needs.
6. We sense our customers' needs even before they are aware of them.

Customer-Responding Capability (1 = "strongly disagree," 7 = "strongly agree") [46, 51]

1. We respond rapidly if something important happens with regard to our customers.
2. We quickly implement our planned activities with regard to customers.
3. We quickly react to fundamental changes with regard to our customers.
4. When we find that customers would like us to modify a product or service, our organization makes concerted efforts to do so. (Item dropped after testing of measurement properties.)
5. When we identify a new customer need, we are quick to respond to it.
6. We are fast to respond to changes in our customers' product or service needs.

Analytical Ability (1 = "strongly disagree," 7 = "strongly agree")

1. We have IT applications that offer various decision-making tools (such as optimization, scenario analysis, etc.) for managing our relationships with customers.
2. We have IT applications that offer various simulation and what-if analysis tools for managing our relationships with customers.
3. We have IT applications that offer various tools that enable us to examine trends in the data for supporting our interactions with customers.
4. We have IT applications that offer various statistical tools for supporting our interactions with customers. (Item dropped after testing of measurement properties.)

Interfunctional Coordination (1 = "strongly disagree," 7 = "strongly agree") [4]

1. The activities of functional units are tightly coordinated to ensure better use of our market knowledge.
2. Functions such as R&D, marketing, and manufacturing are tightly integrated in cross-functional teams in product development processes.
3. R&D, marketing, and other functions regularly share market information about customers, technologies, and competitors.
4. There is a high level of cooperation and coordination among functional units in setting the goals and priorities for the organization to ensure effective response to market conditions.

5. Top management promotes communication and cooperation among R&D, marketing, and manufacturing in market information acquisition and use.

Channel Coordination (1 = "strongly disagree," 7 = "strongly agree") [83]

1. To facilitate operations, our organization's business procedures and routines are linked with the business procedures and routines of our channel partners.
2. Our way of doing business is closely linked with our channel partners.
3. The business procedures and routines of our business unit are highly coupled with the business procedures and routines of our channel partners.
4. Some of our operations are closely connected with the operations of our channel partners.
5. To operate efficiently, we rely on procedures and routines of our channel partners. (Item dropped after testing of measurement properties.)

Internal IS Integration (1 = "strongly disagree," 7 = "strongly agree") [8]

Our information systems allow us integrated access to . . .

1. . . . all customer-related data (e.g., service contracts, feedback)
2. . . . all order-related data (e.g., order status, handling requirements)
3. . . . all production-related data (e.g., resource availability, quality)
4. . . . all market-related data (e.g., promotion details, future forecasts)

External IS Integration (1 = "strongly disagree," 7 = "strongly agree") [83]

1. Data are entered only once to be retrieved by most applications of our channel partners.
2. We can easily share our data with our channel partners.
3. We have successfully integrated most of our software applications with the systems of our channel partners.
4. Most of our software applications work seamlessly across our channel partners.

Action Efficacy (0–10 percent, 11–20 percent, etc.)

Please estimate what percentage of major actions your organization took in 2008 that, based on your organization's assessment, met or addressed customer needs.

1. Percentage of pricing actions that met customer needs.
2. Percentage of marketing actions that met customer needs.
3. Percentage of product actions that met customer needs.
4. Percentage of capacity actions that met customer needs.
5. Percentage of alliance actions that met customer needs.

Economic Adversity (1 = "strongly disagree," 7 = "strongly agree")

Over the past six months . . .

1. . . . we have seen substantial loss of sales.
2. . . . we have experienced significant reductions in our customer base.
3. . . . we have canceled contracts with suppliers.
4. . . . we have reduced our employee base.
5. . . . we have seen budget cuts.

Web-Based Customer Infrastructure

Web-based customer infrastructure tools represent the online mechanisms that organizations can adopt to interact with customers in order to support different customer NPD roles. We measured Web-based customer infrastructure by asking respondents whether or not their organization makes a particular Web-based tool available to its customers through its Web site. We then calculated our measure based on Saeed et al. [81]. Let n_1 represent the number of Web-based tools (in a particular infrastructure, e.g., resource, co-creator, or user) provided by one firm's Web site. Different Web sites have different n_1. Let N_1 represent the total number of all possible Web-based tools in the Web-based resource infrastructure. N_1 is the same for all Web sites within the sample frame. Therefore, if Firm A has 3 resource tools, then $n_1 = 3$. If $N_1 = 5$, then the index of the Web-based resource infrastructure for Firm A is $n_1/N_1 = 0.6$. We performed this calculation for each Web-based infrastructure type (resource, co-creator, user), giving us three indicators for our Web-based infrastructure measure.

In mapping tools to infrastructure type, we took into account prior research and findings from interviews we conducted with practitioners. From a theoretical perspective, Nambisan [64] conceptually links a range of Web-based tools to the three NPD roles enacted by customers (resource, co-creator, user). Practitioner-oriented empirical research also maps these tools to infrastructure types [77]. While recent studies provide insight into the online mechanisms available to organizations (see [77]), rapid changes in online technologies provide the impetus for further work in identifying online mechanisms. Hence, a systematic pretest was conducted to determine appropriate Web-based tools for our resource, co-creator, and user infrastructure measures. Table B1 maps the Web-based infrastructure tools included in our study to Nambisan's [64] conceptualization of customer NPD roles in a Web-based environment. Task/social orientation refers to whether the tool is designed to facilitate customers' execution of tasks (often conducted between the customer and the firm) or social connections (conducted between customers). Temporal structure refers to whether or not customer interactions are time structured or occur within specific time periods.

We collected 64 valid Web site addresses from our respondents. We visited these Web sites and coded values for the 16 indicators of our 3 Web-based infrastructure types. Interrater reliabilities were calculated for each of the indicators using Cohen's [16] kappa. Cohen's kappa adjusts the raw agreement to account for the possibility of

Table B1. Web-Based Customer Infrastructure Tools

Tool	Illustration	Infrastructure type	Task/social orientation	Temporal structure	Nature of identity
"Contact Us"	A "Contact Us" hyperlink or Web-based form	Resource	Task	Unstructured	Individual
Feedback survey	A structured survey in which the company purposefully solicits feedback	Resource	Task	Unstructured	Individual
Company chat	Tools that allow customers to chat with company representatives	Resource	Task	Unstructured	Individual
Suggestion box	A Web-based form in which the company solicits suggestions from customers	Resource	Task	Unstructured	Individual
Online poll	A structured poll in which customers can vote for a particular topic	Resource	Task	Unstructured	Individual
Weblog	A Web page maintained by a company representative with regular entries of commentary	Resource	Task	Unstructured	Individual
Product extensions	A set of Web pages that provide access to product "add-ons" or extensions	Co-creator	Task	Structured	Individual
Design toolkit (A)	A set of tools that allow customers to manipulate the aesthetic attributes of a product or service	Co-creator	Task	Structured	Individual
Design toolkit (F)	A set of tools that allow customers to manipulate the functional attributes of a product or service	Co-creator	Task	Structured	Individual
User reviews	Web pages that allow users to post product and service reviews	User	Task	Structured	Individual
Product test	Simulation technologies that allow users to test products in a virtual setting; beta releases	User	Task	Structured	Individual
Beta pages	Web pages that provide early releases of products or services	User	Task	Structured	Individual
Wiki	A collection of Web pages designed to enable users to contribute or modify content	User	Social	Unstructured	Social
Knowledge Yellow Pages	A directory that allows users to locate and contact subject area experts (who are often customers themselves)	User	Social	Unstructured	Social
Bulletin boards	Forums in which users can post and respond to questions and issues	User	Social	Unstructured	Social

agreement occurring by chance. Kappa values ranged from 0.76 to 0.80. The levels of agreement across all 16 indicators are highly significant. Our results show that the agreement reliability between the respondents and the author for indicators of Web-based infrastructure was on the high side of "substantial." These results provide further support for the validity of our Web-based infrastructure measures.

Formative Versus Reflective Constructs

When using structural equation modeling techniques, it is important to conceptualize the underlying structure of the constructs before proceeding to their measurement [75]. In particular, we need to understand the nature and direction of relationships between the constructs and their indicators. Indicators can be either reflective or formative. Reflective indicators represent reflections, or manifestations, of a construct. In a reflective measurement approach, constructs are viewed as causes of indicators, meaning that variation in a construct leads to variation in its indicators. In some instances, the direction of the relationship between constructs and indicators is reversed, such that indicators are treated as causes of constructs. Formative indicators form or produce their associated construct. For example, a formative construct could be firm performance operationalized using three indicators: productivity, profitability, and market share. Each indicator captures differing aspects of firm performance; as a result, this operationalization of the construct is formative.

Jarvis et al. [44] provide the following guidelines on whether to model a construct as formative or reflective: (1) direction of causality from construct to indicators, (2) interchangeability of indicators, (3) covariation among indicators, and (4) nomological net of construct indicators. Constructs should be modeled as formative if the following decision rules hold: the direction of causality is from indicators to constructs, the indicators need not be interchangeable, covariation among indicators is not necessary, and the nomological net of indicators can differ, that is, they may have different antecedents and consequences. Constructs should be modeled as reflective if the opposite conditions apply. Specifically, constructs should be modeled as formative if the answer to most of the following statements is "yes":

- Indicators are defining characteristics of the construct.
- Changes in indicators should cause changes in the construct.
- Changes in the construct do not cause changes in the indicators.
- Indicators do not necessarily share a common theme.
- Eliminating an indicator may alter the conceptual domain of the construct.
- A change in the value of one of the indicators is not necessarily associated with a change in all of the other indicators.
- Indicators are not required to have the same antecedents and consequences.

Table B2 provides the answers to these statements for each multi-item latent variable in the model. These answers are based on our judgment, assessment of the conceptual structure of the construct, investigation of the causal relationship between the indicators and the construct, and analysis of previous studies that have measured similar constructs.

Table B2. Analysis Approach for Multi-Item Latent Variables

Construct	Are the indicators defining characteristics of the construct?	Do changes in indicators cause changes in the construct?	Do changes in the construct cause changes in the indicators?	Do the indicators necessarily share a common theme?	Does eliminating an indicator alter the conceptual domain of the construct?	Is a change in one of the indicators necessarily associated with a change in all the other indicators?	Do the indicators have the same antecedents and consequences?	Scale type
Customer-sensing capability	No	No	Yes	Yes	No	Yes	No	Reflective
Customer-responding capability	No	No	Yes	Yes	No	Yes	No	Reflective
Web-based customer infrastructure	Yes	Yes	No	Yes	Yes	No	No	Formative
Analytical ability	No	No	Yes	Yes	No	Yes	No	Reflective
Interfunctional coordination	No	No	Yes	Yes	No	Yes	No	Reflective
Channel coordination	No	No	Yes	Yes	No	Yes	No	Reflective
Internal IS integration	No	No	Yes	Yes	No	Yes	No	Reflective
External IS integration	No	No	Yes	Yes	No	Yes	No	Reflective
Action efficacy	No	No	Yes	Yes	No	Yes	No	Reflective

Appendix C

BOTH SURVEYS WERE ADMINISTERED THROUGH ZOOMERANG, a national market research firm (www.zoomerang.com). Zoomerang provides respondents who participate in various research studies. Over 3 million members exist in this research panel (hereafter referred to as Zoompanel), and these members are profiled across 500 attributes. Zoomerang reports that the profile of their member panel is representative of the U.S. population.

Individuals that belong to Zoompanel have double opted into the panel to participate in surveys. Double opt-in implies that panelists sign up and are then given an opportunity to withdraw from the panel, ensuring that they really do want to participate. Panelists are provided with incentive points for each survey that they complete. This is similar to the incentives often given to complete an instrument in traditional mail surveys where mailings are made to a directory (sample frame) of participants.

Zoomerang employs several quality assurance mechanisms to maintain the quality of its respondent panel. For instance, the information that panelists provide (e.g., demographics) is verified against extensive databases with validated consumer demographics. Another mechanism takes into account survey-taking time and response patterns to identify fraudulent behavior. This type of data collection can provide greater control based on the selected attributes.

Although Zoomerang profiles its panel of respondents, thereby enabling one to target marketing managers, the profile may be outdated. For instance, a respondent's profession/job title at the time of completing this survey might be different from when he or she joined the respondent panel. Therefore, we use screening questions to gain better control over our sample frame. These questions enable us to target full-time working marketing managers who have adequate knowledge regarding customer relationships in their organization. Furthermore, we are able to ensure that we are surveying firms operating in high-tech environments.

Our second survey was also deployed through Zoomerang. Zoomerang invited the initial 208 survey one respondents to complete the second Web-based survey. Of these 208, a total of 112 individuals completed the second survey for an effective response rate of 54 percent. We used two mechanisms to ensure that the same individual responded to both surveys for a single organization. First, Zoomerang provided unique identification numbers for each individual, thus allowing us to match the two data sets. Second, we asked the question "How old were you on your last birthday?" on both surveys. We calculated the difference in respondent age between the two data sets. The difference score for all 112 respondents was zero or one (one signifying that the respondent had a birthday between the time he or she completed survey one and the time he or she completed survey two). This provides further support that the same individual responded to both surveys.