Organization Science
Vol. 19, No. 2, March–April 2008, pp. 277–291
ISSN 1047-7039 | EISSN 1526-5455 | 08 | 1902 | 0277

informs®

DOI 10.1287/orsc.1070.0316

Process Virtualization Theory and the Impact of Information Technology

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In our increasingly virtual society, more and more processes that have traditionally been conducted via physical mechanisms are being conducted virtually. This phenomenon of "process virtualization" is happening in many contexts, including formal education (via distance learning), shopping (via electronic commerce), and friendship development (via social networking sites and virtual worlds). However, some processes are more amenable to virtualization than others. For example, distance learning seems to work better for some educational processes than others, and electronic commerce has worked well for some shopping processes but not for others. These observations motivate the central question posed in this paper: What factors affect the "virtualizability" of a process? This question is becoming increasingly important as advances in information technology create the potential for society to virtualize more and more processes. To provide a general theoretical basis for investigating this question, this paper proposes "process virtualization theory," which includes four main constructs (sensory requirements, relationship requirements, synchronism requirements, and identification and control requirements) that affect whether a process is amenable or resistant to being conducted virtually. Recognizing that processes can be virtualized with or without the use of information technology, this paper makes explicit the theoretical significance of information technology in process virtualization by discussing the moderating effects of representation, reach, and monitoring capability. This helps explain how advances in information technology are enabling a new generation of virtual processes.

Key words: virtual; virtualization; process; theory construction; information systems; information technology; online; electronic commerce; distance learning; relationship development; banking; ATM
History: Published online in *Articles in Advance* March 20, 2008.

Introduction

Ours is an increasingly virtual society. Many societal processes that have traditionally been conducted via physical mechanisms are being conducted electronically or through other virtual means. For example, the traditional process through which society has educated its members has been to collocate students and an instructor in a classroom setting. This traditional, physical process is being augmented and in some cases replaced by a virtual process by which people are educated via distance learning mechanisms that do not require physical collocation. Similarly, the traditional process through which friendships are established is for people to meet face to face and to interact with one another in a physical setting. Although this remains a primary mechanism, the friendship development process has also become increasingly virtual, as social networking sites, online dating sites, and multiplayer online role-playing games foster relationship development without the need for physical interaction. The traditional shopping process of acquiring goods from a salesperson or clerk at a physical store is also being made virtual through electronic commerce, which allows goods to be acquired without a trip to a physical store. Last, many retail banking processes that were formerly handled by a human bank teller have migrated to automated teller machines (ATMs) and online banking systems. In short, society is replacing physical mechanisms with virtual ones in many processes, and the emerging virtual processes are becoming increasingly accepted.

The move toward virtualization continues at an ever-quickening pace. Processes that would have seemed difficult to virtualize only a few years ago are being migrated to virtual mechanisms. However, some processes have proven more amenable to being conducted virtually than others. For example, some shopping processes (such as those for office supplies and CDs) have proven amenable to virtualization, while others (such as those for houses and perfume) have proven resistant. Similarly, distance learning programs are more successful for some educational processes than others. These observations lead to the following research questions: What is it about a process that affects its virtualizability? What factors explain why some processes are amenable to virtualization while others are resistant? Why are we seeing a proliferation of virtual processes that were not evident prior to this digital age?

This paper addresses these questions by proposing process virtualization theory, which is comprised of two parts. First, it explains the factors (sensory requirements, relationship requirements, synchronism requirements, and identification and control requirements) that influence whether a process is amenable or resistant to being conducted virtually. Second, it discusses how the representation, reach, and monitoring capabilities of information technology (IT) have enabled the use of an increasingly broad range of virtual processes within business and society. Highlighting the theoretical role of IT in process virtualization helps address a research gap identified by Orlikowski and Iacono (2001, p. 132), who stated "If ... we believe that information technology can and does matter—in both intended and unintended ways—we need to develop the theories and do the studies that show ... how and why this occurs."

This paper is organized as follows. The first section presents definitions of terms such as process and information technology to ground the discussion and argues for the need for process virtualization theory. The second section describes the constructs of the theory, how the constructs are related to each other (i.e., the propositions), and the logical reasoning behind the proposed relations. This section also discusses how process virtualization theory is related to extant theory. The third section illustrates process virtualization theory by applying it to a historical case: that of the role of the ATM in virtualizing the retail banking process. The paper concludes with implications, limitations, and suggestions for empirical testing.

Definitions, Examples, and the Need for a New Theory

Definitions and Examples

For purposes of this paper, a *process* is broadly defined as a set of steps to achieve an objective. A *physical process* involves physical interaction between people or between people and objects. A *virtual process* is a process in which physical interaction between people and/or objects has been removed. The absence of physical interaction is a common theme in scholarly uses of the term *virtual* (Fiol and O'Connor 2005). The transition from a physical process to a virtual process is referred to as *process virtualization*. The following examples illustrate these definitions.

Consider shopping and friendship development. Each of these can be thought of as a process, i.e., as a set of steps to achieve an objective. The steps in the shopping process include determining where to shop, examining alternatives, making payment, etc. The objective is to acquire a good or a service. The steps in the friendship development process include meeting, identifying mutual interests, creating shared experiences, etc. The objective is to develop a mutually beneficial relationship.

An example of a physical shopping process is visiting a physical store. This involves physical interaction with products and/or salespersons. An example of a virtual shopping process is electronic commerce, which eliminates the physical interaction of shopping by (1) providing product descriptions via Web pages to help shoppers evaluate products without physically interacting with them (i.e., eliminating the person-to-object physical interaction), and (2) handling payment through a Web-based checkout process that requires no physical interaction with a salesperson (i.e., eliminating the person-to-person physical interaction). Similarly, friendship development can be conducted as a physical process (meet at a party, have lunch, go to a movie together, etc.) or as a virtual process (meet online, exchange e-mails, share experiences in the same online role-playing game, etc.).

The breadth of this definition of "process" allows the term to apply to processes engaged in by organizations, individuals, and society in general. In contrast, many organizational scholars think of the term process as specific to organizational or business processes, such as product design or order fulfillment. For example, consider the definition given by Davenport and Beers (1995, p. 57): "Processes are structured sets of work activity that lead to specified business outcomes for customers." A similar conceptualization is reflected in the "process handbook" developed by Malone and colleagues (1999). I adopt a broader definition to allow process virtualization theory to inform processes of interest to organizational scholars that are not business processes, such as the process of shopping, of developing friendships, and of acquiring an education.

The main enabler of most contemporary virtual processes is IT, which, following O'Brien (2002, p. 7), is defined as "computing hardware, software, communications networks, and data resources that collect, transform, and disseminate information." However, it is important to recognize that IT is not required for process virtualization, just as IT is not required to have a virtual team (Fiol and O'Connor 2005). For example, catalog sales are a long-standing example of a shopping experience divorced from physical interaction, correspondence courses have long allowed students to take formal education courses without physical attendance, and letter-writing between pen pals is a venerable method of relationship creation and maintenance. Each of these enables processes to be conducted virtually (i.e., without physical interaction between the other people and/or objects involved in the process), but none requires IT. Thus, virtual processes may be based on IT, but they need not be.

The distinction between an IT-based and a non-IT-based virtual process is made based on whether the "virtualization mechanism," which is the means by which a process is virtualized, is IT based. For example, consider

Table 1 Process Examples

Process	Physical process	Virtual process	
		Not IT based	IT based
Shopping	Store-based shopping	Catalog sales	Electronic commerce
Formal education	Classroom-based education	Correspondence courses	Online distance learning
Retail banking	Bank teller interaction	Mail deposits	ATMs, online banking
Friendship development	Face-to-face interaction	Letter-writing between “pen pals”	E-mail, instant messaging, online dating

shopping as the process to be virtualized. There are multiple mechanisms that can used to virtualize the shopping process, including mail-order catalogs and e-commerce websites. Both of these are virtualization mechanisms, as they each eliminate the need to visit a store and to interact with salespersons and/or the actual products. However, a mail-order catalog is not IT based; i.e., it is not an instance of “computing hardware, software, communications networks, and data resources that collect, transform, and disseminate information,” whereas an e-commerce website is. Thus, catalog shopping represents a non-IT-based virtual process and electronic commerce an IT-based virtual process. Table 1 lists several processes, along with examples of corresponding physical and virtual processes (both IT based and non IT based). To be sure, whether a process is virtualized and whether a virtual process is IT based are matters of degree, not of kind. However, I dichotomize these distinctions for expository clarity and will return to a discussion of their continuous nature later in the paper.

Process virtualization should not be confused with process automation, as many virtual processes require active human intervention. For example, shopping via electronic commerce is a virtual process, but it is not necessarily an automated one because a human is often (but not always) actively engaged to decide which Web pages to view, which products to add to the shopping cart, etc. Also, process virtualization should not be confused with simulation. In a virtual process, the process is actually conducted, not merely simulated (although simulations may be used during the conduct of the process).

Need for a New Theory

Prior research has investigated aspects of process virtualization in specific domains. For example, some research has investigated shopping and commercial exchange processes and theorized about which products are best suited for trade in virtual environments (Shapiro and Varian 1998). Other research has looked at relationship-development processes and how effectively they might be conducted via virtual mechanisms such as email, online dating sites, and virtual worlds (Mesch and Talmud 2006, Walther and Burgoon 1992). Other research has analyzed educational processes and investigated the factors that predict whether these processes can be conducted virtually via distance learning mechanisms (Arbaugh 2000, Moore and Kearsley 1996). Other research has discussed how information technology can be used to conduct work processes more virtually through IT’s capacity to automate and informate work (Zuboff 1988). Given society’s trajectory toward increasing virtualization, there is a need to integrate the research across these and other streams to help us understand the factors that influence process virtualization, irrespective of what the process is. This provides the motivation for process virtualization theory.

Process Virtualization Theory

The dependent variable in process virtualization theory is “process virtualizability,” which describes how amenable a process is to being conducted without physical interaction between people or between people and objects. Operationally, process virtualizability can be measured either as adoption of the virtual process or the quality of the outcomes of the virtual process. For example, the adoption of electronic commerce over the past decade has shown that certain shopping processes are amenable to virtualization. With respect to quality of outcomes, if distance learning students demonstrate mastery of the subject material, then this would provide evidence that the formal education process is amenable to virtualization, at least under certain conditions and for certain subjects.

The main constructs of process virtualization theory are sensory requirements, relationship requirements, synchronism requirements, and identification and control requirements. Each of these constructs is posited to have a negative effect on process virtualizability. In other words, as each of these requirements increases, the process becomes less amenable to virtualization. This does not mean that a process with high sensory, relationship, synchronism, and/or identification and control requirements cannot be virtualized; rather, it means that it would be more amenable to being virtualized if these requirements are low. The dependent variable of process virtualizability is continuous, not discrete, and should be thought of as a question of degree, not of kind. This is a critical distinction; the propositions of the theory should not be interpreted as on/off.

Advancements in the power and accessibility of IT have led to a proliferation of new virtual processes in recent years. To investigate how and why IT has this effect, the theory explicitly considers the role of IT in process virtualization. A key premise of the theory is that IT can be used to make a process more amenable to virtualization. Put in propositional terms, IT has a positive moderating effect on the relations between the main constructs and process virtualizability.

There are three IT constructs that explain how IT has this effect: representation, reach, and monitoring capability. For example, the representation capability of IT (e.g., via audio, video, haptic, and olfactory interface technologies) facilitates the integration of sensory requirements into virtual processes. The moderating effects of IT should be considered along with the theory's main effects. Both types of effects are important to understanding the phenomenon.

I first discuss the main effects proposed by process virtualization theory and then the moderating effects of IT. As part of the exposition, I describe how research on shopping processes, formal education processes, and relationship development processes provides support for the propositions. I discuss the fit of the theory to retail banking separately. Although I discuss each of these processes in general terms to show support for the propositions, it is important to note that not all shopping, education, etc. processes are the same. For example, some shopping processes rely more on sensory, relationship, synchronism, and identification and control requirements than others. A key premise of process virtualization theory is that the degree of this reliance affects a process's virtualizability. Figure 1 displays the theory graphically.

Main Constructs and Propositions of Process Virtualization Theory[1]

Sensory Requirements. The first construct proposed to affect process virtualizability is *sensory requirements*, which is defined as the need for process participants to be able to enjoy a full sensory experience of the process and the other process participants and objects. Sensory experiences include tasting, seeing, hearing, smelling, and touching other process participants or objects, as well as the overall sensation that participants feel when engaging in a process, e.g., excitement, vulnerability, etc. Sensory requirements are posited to have a negative relation to process virtualizability.

PROPOSITION 1 (P1). *The greater (lower) the sensory requirements of a process, the less (more) amenable the process is to being conducted virtually.*

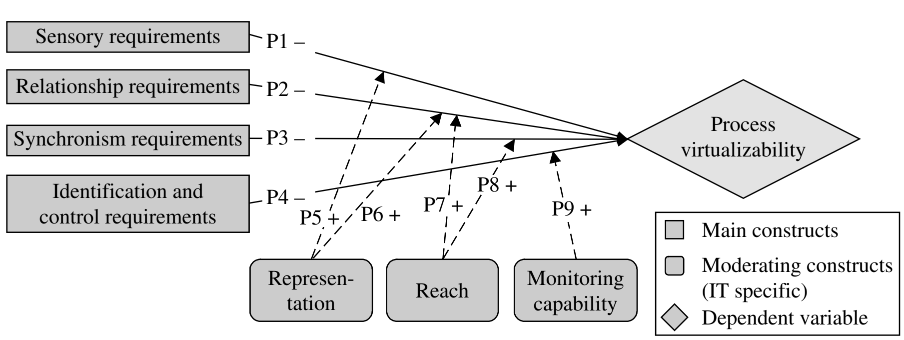
The logical reasoning behind this proposition is straightforward. Process virtualization eliminates physical interaction between people and between people and objects from a process. The lack of physical interaction makes it difficult for a participant in a virtual process to establish a sensory connection to objects and/or other people because they cannot directly taste, smell, or feel them. If a process relies on this, it will benefit from the physical context and resist virtualization, ceteris paribus.

Research on shopping, formal education, and relationship development processes supports P1. First, a key reason cited for difficulties in virtualizing many shopping processes is the inability to touch, feel, and smell the products, which is of particular concern for certain product categories such as groceries (Ramus and Nielsen 2005). Second, research on education suggests that interaction between students and learning materials is important for effective learning (Moore and Kearsley 1996). If this interaction is sensory in nature (e.g., manipulating clay in a sculpting class, mixing chemicals in a science class to detect heat and/or odor), it may be difficult to replicate in a virtual setting. Last, certain types of relationship development processes rely heavily on sensory experience, particularly those related to dating and marriage.

Theoretical research also provides support for P1. For example, Apte and Mason (1995) conducted a theoretical analysis of business processes and concluded that processes that require manipulation of physical objects would be difficult to conduct in virtual, globally disaggregated settings.

In addition to limitations in replicating the five senses, it can also be difficult to replicate in a virtual setting the overall sensation that participants have when experiencing a process, such as excitement or safety. This is a key reason that predictions that sports fans would stop attending live sporting events if they were broadcast on television failed to materialize (Walker and Bellamy 2003). The overall sensation associated with attending the event in person (e.g., the excitement, the sense of community, etc.) was difficult to replicate through the virtual experience of watching on TV, even though TV provided an (arguably) better view of the game.

Figure 1 Theoretical Model



Relationship Requirements. The second construct proposed to affect process virtualizability is *relationship requirements*, which is defined as the need for process participants to interact with one another in a social or professional context. Such interaction often leads to knowledge acquisition, trust, and friendship development. Relationship requirements are posited to have a negative relation to process virtualizability.

Proposition 2 (P2). *The greater* (*lower*) *the relationship requirements of a process, the less* (*more*) *amenable the process is to being conducted virtually.*

The logical reasoning for this proposition is based on research on relationship development, formal education, and shopping. Several studies in the information and communication literatures have investigated whether and how relationships may be formed via virtual communication media such as the telephone, email, and social networking sites. Many of these studies draw on media richness (Daft and Lengel 1986) or social presence theory (Short et al. 1976). These theories suggest that physical, face-to-face interaction can transmit a broader range of communication cues, such as gestures, posture, and inflection, than virtual interaction via a medium such as email. A commonly drawn inference is that these cues help convey the interpersonal warmth and attentiveness useful in relationship development; thus, relationships will be more difficult to develop in virtual environments that lack these cues (Jarvenpaa and Leidner 1999). Kock (2004) probed deeper into this general premise using evolutionary theory to argue that humans are predisposed to physical, face-to-face interaction because this has been the dominant mode of interaction and relationship development throughout the majority of our history as a species. These theoretical arguments align with P2 by suggesting that processes with high relationship requirements will be less amenable to virtualization.

This is not to say that processes with high relationship requirements cannot be virtualized. To the contrary, research suggests that they can. For example, one method to satisfy relationship requirements in a virtual process is to have the process participants meet face to face in addition to interacting virtually (Orlikowski 2002). Also, interpersonal conflict has been shown to be a problem among team members working in virtual environments (Cramton 2001), but this conflict can be lessened and relationships improved if virtual team members have a shared identity (Hinds and Mortensen 2005). Other research has suggested that people can develop rich relationships using virtual media as long as they have sufficient time and experience with the media (Carlson and Zmud 1999, Walther and Burgoon 1992). Each of these examples suggests that processes with high relationship requirements can be virtualized, but that additional steps must be taken (e.g., incorporation of face-to-face meetings, gaining experience with a new medium) or certain conditions must either be present or developed (e.g., a shared identity). This increases the level of effort required to virtualize the process, which makes the process more resistant to virtualization. Other research suggests that relationships can be developed in purely virtual environments in which no special steps are taken but that these relationships tend to be weaker and/or less developed than corresponding relationships developed in physical environments (Mesch and Talmud 2006, Parks and Roberts 1998). Thus, a process with high relationship requirements can be virtualized, although not as readily as if the relationship requirements were low. Recall that process virtualizability is a matter of degree, not of kind.

Research on formal education processes also lends support to P2. Three types of interaction have been identified as important in education: student to learning material (discussed above), student to student, and student to instructor (Moore and Kearsley 1996). Student-to-student and student-to-instructor interaction provide a context in which an individual can objectivize his thoughts (Salomon and Perkins 1998). Objectivization involves sharing thoughts and ideas so that they can be discussed, critiqued, and elaborated upon, which helps individuals learn. Opportunities for objectivization and interaction are straightforward in an educational process whereby students, materials, and the instructor are physically collocated. These opportunities can also be provided in a virtual environment, although the establishment, marketing, and monitoring of some type of collaboration forum is usually required. Lynch (2002) discusses the importance, but relative difficulty, of establishing and maintaining this type of forum for distance education. This means additional steps are necessary to virtualize the process, which makes the process more resistant to virtualization, although virtualization can still be accomplished.

Last, analysis of shopping processes suggests that they may have relationship requirements that are difficult to satisfy virtually. Participants in shopping processes have both instrumental and experiential goals (Novak et al. 2003). An example of an instrumental goal is to acquire a product. An example of an experiential goal is to enjoy time spent with a friend during the shopping process (e.g., shoe shopping with no intention of purchase). Many shopping processes exhibit high relationship requirements, particularly those for which the goal is primarily experiential. Virtual shopping processes such as catalog shopping or e-commerce may fulfill instrumental goals but not experiential goals, thereby suggesting that certain shopping processes will resist virtualization because of high relationship requirements.

Synchronism Requirements. The third construct proposed to affect process virtualizability is *synchronism requirements*, which is defined as the degree to which the activities that make up a process need to occur quickly with minimal delay. Synchronism requirements are posited to have a negative relation to process virtualizability.

Proposition 3 (P3). *The greater (lower) the synchronism requirements of a process, the less (more) amenable the process is to being conducted virtually.*

The logical reasoning for this proposition is as follows. Physical processes tend to be highly synchronous. This is because physical process participants can interact with one another and with process objects with little delay because they are all located in the same physical setting (as long as the number of participants and objects is suitably bounded). By contrast, virtual process participants are abstracted away from one another and from process objects, which can introduce delays into the process. This is not to say that synchronism is necessarily a good thing. In fact, asynchronism has several advantages including allowing process participants to conduct activities at times that are convenient for them (Arbaugh 2000). This may improve the quality of their participation by giving them extra time to reflect before responding (Sproull and Kiesler 1991). However, if a process needs to be conducted in a synchronous manner, it will benefit from the physical context and resist virtualization, *ceteris paribus*. This is because synchronism usually comes "for free" with a physical process; this is less true of a virtual process.

Analysis of shopping and formal education processes lends support to P3. In many shopping processes, it is important for the product receipt step to follow the product purchase step with minimal delay. This is straightforward in the physical process in which the shopper has access to the product, but it may not be straightforward in the virtual process (with the notable exception of digital goods that can be downloaded). One of the reasons cited for difficulties in virtualizing the process of grocery shopping is the delay between when a customer orders items and when he receives them, which is of particular concern for perishable products. Although this has not been an insurmountable problem (see PeaPod's initiative to install receiving bins at customer's homes (Kamarainen and Punakivi 2004)), the need for the purchase and receipt steps to occur with little delay (i.e., high synchronism requirements) has contributed to the difficulty in virtualizing this and several other shopping processes.

In formal education, synchronous participation is important for class discussions and test administration as instructors may not want some students to receive a test before others. Synchronous participation also aids in pedagogy as instructors can provide immediate feedback about students' work or clarify concepts (Salomon and Perkins 1998). Synchronous participation is straightforward in a classroom-based setting. It can also be achieved in a virtual education process, but, similar to relationship requirements, requires extra steps to create and maintain a real-time collaboration forum (Lynch 2002). This makes the process more resistant to virtualization, although it can still be accomplished.

Identification and Control Requirements. The fourth construct proposed to affect process virtualizability is *identification and control requirements*, which is defined as the degree to which the process requires unique identification of process participants and the ability to exert control over/influence their behavior. Identification and control requirements are posited to have a negative relation to process virtualizability.

Proposition 4 (P4). *The greater (lower) the identification and control requirements of a process, the less (more) amenable the process is to being conducted virtually.*

The logical reasoning for this proposition is that virtual processes are susceptible to identity spoofing because participants cannot physically inspect others to confirm their identity. As a result, virtual processes may suffer from control problems as it may be difficult to detect who is engaging in an activity or to influence their behavior.

Research on relationship development, formal education, and shopping processes suggests that many virtual processes suffer from difficulties in satisfying identification and control requirements. First, it is important to know the identity of the other party when developing a relationship, particularly during the later stages of relationships that become intimate. A major problem associated with the virtualization of relationship development processes is the potential for people to hide their identity, which, in extreme cases, results in predation and acts of violence and sexual abuse (Dombrowski et al. 2004). Second, in formal education, it is important for instructors to confirm authorship of work product and control access to resources such as tests or sensitive information. These tasks are straightforward in a classroom-based setting, but they may not be in a virtual setting. For example, in a correspondence course, it is difficult to detect the level of student involvement in a work product or to grant and control access to course resources. Although online distance learning environments provide functionality for granting and controlling access to resources, confirming authorship of work product remains problematic. Last, in shopping processes, it is important for the buyer to identify the seller as a legitimate provider of the good/service. A barrier to virtualizing many shopping processes has been the difficulty in determining this and the resulting risk of fraud (Friedman and Resnick 2001).

Similar to P3, P4 should not necessarily be interpreted as normative. For example, P4 does not propose that identification of process participants is necessarily or always better than anonymity, only that if it is important to identify the other process participants (i.e., if identification and control requirements are high); then the process will be less amenable to being conducted virtually. Research has shown that processes in which identification of other process participants is not important often benefit from anonymity, which is consistent with the parenthetical reading of P4. For example, anonymity in the group brainstorming process can foster creativity and reduce unnecessary deference to high-status colleagues (Connolly et al. 1990). In this case, the group brainstorming process has low identification and control requirements because identifying the originator of an idea is not critical to the process; it is the idea, not who came up with it, that is important. This makes the process more amenable to being conducted virtually (where anonymity is easily achieved).

Moderating Constructs and Propositions of Process Virtualization Theory

As previously mentioned, a process can be virtualized with or without the use of IT. Equivalently, the mechanism used to virtualize a process can be IT based or non-IT based. This distinction illustrates that process virtualization is not a new phenomenon. For example, books are an early example of a virtualization mechanism as they allow the process of sharing information to be conducted without physical interaction between the provider and the recipient. Virtual processes have proliferated recently as a result of improvements in the sophistication and accessibility of IT, in particular the Internet. Thus, IT has a significant effect on process virtualization. Of course, this is a general assertion, and it is necessary to unlock the black box of IT to examine how and why it has this effect.

IT has three characteristics that impact process virtualization and represent constructs in the theory: representation, reach, and monitoring capability.[2] These constructs positively moderate the relations between the main constructs and process virtualizability. The representation, reach, and monitoring capability constructs have some applicability to non-IT-based virtual processes, but this applicability is qualitatively different than that for IT based virtual processes.

Representation. The first IT construct of process virtualization theory is *representation*, which is defined as IT's capacity to present information relevant to a process including simulations of actors and objects within the physical world, their properties and characteristics, and how we interact with them. This facilitates the integration of sensory requirements into IT-based virtual processes.

Proposition 5 (P5). *The representation capability provided by IT positively moderates the relation between sensory requirements and process virtualizability.*

The logical reasoning behind this proposition is that IT can be used to simulate the sensory elements of the physical world. This is a basic premise underlying much of the research on virtual reality (Steuer 1992). For example, the senses of sight and sound have been incorporated within IT-based virtual processes for several years. The senses of smell and touch have been harder to replicate, although advancements in olfactory and haptic interface technology, respectively, hold promise. This facilitates the virtualization of multiple processes including shopping and formal education. For example, many of the sensory aspects associated with shopping can be represented via IT including how an article of clothing might look on someone (via a virtual model) or how it might feel to drive a particular car (via virtual reality). Similarly, many of the sensory aspects associated with interaction between student and learning material in formal education can be represented via IT simulations. In some cases, these simulations may be better learning instruments than the physical objects themselves (Pea 1993). As another example, IT is used in telemedicine to provide representations of patient symptoms and characteristics to remotely located physicians (Perednia and Allen 1995).

Note that non-IT-based virtual processes also have representation capabilities. For example, a mail-order catalog can represent products via textual information, charts, graphs, and photographs. However, the representation provided via IT is qualitatively different from that provided by other technologies primarily because IT representations can be updated dynamically with new information as conditions change, whereas non-IT representations tend to be more static.

The representation capability of IT also facilitates the virtualization of processes with high relationship requirements.

Proposition 6 (P6). *The representation capability provided by IT positively moderates the relation between relationship requirements and process virtualizability.*

The logical reasoning behind this proposition is that IT can be applied to capture highly representative profiles that can help match people with similar or complementary interests (Hitsch et al. 2006), which provides a basis for relationship development (Werner and Parmelee 1979). The popularity of websites such as MySpace and eHarmony, where participants share detailed information about themselves to build relationships with others, illustrates this effect.

Reach. The second IT construct of process virtualization theory is *reach*, which is IT's capacity to allow process participation across both time and space. With respect to reach across time, IT allows many processes to be conducted throughout the day. For example, ATMs permit banking transactions when human tellers are absent, and e-commerce permits shopping (including actual product acquisition in the case of information goods) when physical stores are closed. With respect to reach across space, IT permits people located around the world to participate in the same processes. For example, IT-based virtual processes such as e-commerce and online distance learning have extended the reach of shopping and formal education processes, respectively, to all locations and participants with Internet connectivity. Reach facilitates the virtualization of processes with high relationship requirements.

Proposition 7 (P7). *The reach provided by IT positively moderates the relation between relationship requirements and process virtualizability.*

The logical reasoning behind this proposition is that the reach provided by IT facilitates the development of relationships that would otherwise not have existed. Reach enables new opportunities to satisfy relationship requirements within a process by enlarging the pool of potential relationship partners potentially to people located around the world. Reach also facilitates the formation of relationships by helping process participants find others who share similar interests. For example, Internet community sites or specific areas within virtual worlds such as Second Life provide forums in which like-minded individuals can find one another and interact (McKenna and Bargh 2000). Thus, relationship requirements that might have gone unmet in a non-IT-based virtual process become more feasible to satisfy. The moderating effect of reach on the relation between relationship requirements and process virtualizability is related to that of representation. Reach enables relationship partners to find one another, and representation provides a rich environment in which to interact and develop shared experiences.

Reach also facilitates the virtualization of processes with high synchronism requirements.

Proposition 8 (P8). *The reach provided by IT positively moderates the relation between synchronism requirements and process virtualizability.*

The logical reasoning for this proposition is that the reach provided by IT enables multiple process participants, regardless of where they are, to participate in a process on a synchronous basis. This is because IT facilitates a live, two-way connection to a process. For example, virtual worlds such as Second Life and many online distance learning environments permit synchronous participation in which people can respond to and seek clarification from one another in real time (Lynch 2002, Pea 1993). Cobrowsing technology permits people in different locations to engage in a virtual shopping process at the same time (Kobayashi et al. 1998).

Monitoring Capability. The third IT construct of process virtualization theory is *monitoring capability*, which is IT's capacity to authenticate process participants and track activity. Monitoring capability facilitates the virtualization of processes with high identification and control requirements.

Proposition 9 (P9). *The monitoring capability of IT positively moderates the relation between identification and control requirements and process virtualizability.*

The logical reasoning behind this proposition is that participants in IT-based virtual processes are typically required to authenticate themselves via a log-in or some other method. This allows participants to be identified and their actions to be tracked and analyzed in a systematic, detailed, and automated fashion. For example, research on formal education has shown that online education environments provide significant capabilities for monitoring student participation (Arbaugh 2000). Although identity spoofing remains a risk in IT-based virtual processes, which limits the potential benefits of monitoring, advances in identification technologies such as biometrics are reducing this risk (Jain et al. 2000). In some cases, the moderating effect proposed in P9 may be so strong that the IT-based virtual process provides greater capabilities for identification and control than the physical process.

To be sure, some non-IT-based virtual processes also contain monitoring mechanisms. For example, the punch clock and time card system is a venerable method for monitoring employee attendance that does not rely on IT. However, the automated, systematic way in which IT monitors activity gives it a qualitatively different monitoring capability that non-IT mechanisms (Zuboff 1988).

Tables 2 and 3 provide examples of how each of the constructs and propositions of process virtualization theory apply to formal education and shopping. They include examples of non-IT-based and IT-based virtual processes to illustrate the theoretical significance of the IT constructs of representation, reach, and monitoring capability.

Discrete vs. Continuous Conceptualization of Process Virtualization

To this point, I have described processes as being either virtual or not and virtual processes as either being IT based or not. I have done this for three reasons: (1) to simplify the exposition of process virtualization theory, (2) to make plain the theoretical significance of IT, and (3) to explain why there has been a relatively recent proliferation of virtual processes. However, these distinctions are more continuous than discrete. Some processes will have both physical and virtual activities and rely on both IT-based and non-IT-based virtualization mechanisms. To illustrate, consider the process of shopping for a new car. Many consumers undertake the initial searching steps virtually: They search websites and

Table 2 Application of Process Virtualization Theory to Formal Education

	Sensory requirements	Relationship requirements	Synchronism requirements	Identification and control requirements
Physical process: Classroom based				
	Physical interaction with learning materials sometimes necessary	Students and instructors develop important relationships	Synchronism important for class discussions and test taking	Important to confirm work authorship and control access to resources
Non-IT-based virtual process: Correspondence courses				
	Poorly suited to deliver the "hands-on" elements of the lesson	Hard for students and instructors to develop meaningful relationships	Difficult to participate in class discussions	Hard to detect level of engagement or grant access to resources
IT-based virtual process: Online distance learning*				
Representation	Allows "hands-on" activities to be simulated electronically	Rich profiles help participants locate others with similar interests/needs		
Reach		Broader participation yields new relationship opportunities	Allows synchronous participation from different locations	
Monitoring capability				Enhanced ability to track student participation and access to resources

*Illustrates the moderating effects of the IT variables.

magazines to get an idea of vehicle features, availability, and price (Zettelmeyer et al. 2006). However, many of the subsequent steps, such as physically inspecting the vehicle and establishing payment terms, are handled physically. Thus, the overall process is neither purely physical or purely virtual: It is a hybrid. Further, the process involves virtualization mechanisms that are both IT based (websites) and non-IT based (magazines). For such a case, process virtualization theory can be used to analyze each component individually rather than the process as a whole. To illustrate, consider that the search steps have been successfully virtualized largely because maturing reach and representation capabilities of the Internet allow consumers to gather detailed information about cars. The degree to which the search steps are conducted virtually has increased along with consumer adoption of the Internet (Kim 1996), indicating that the IT mechanisms have spurred virtualization in a way

Table 3 Application of Process Virtualization Theory to Shopping

	Sensory requirements	Relationship requirements	Synchronism requirements	Identification and control requirements
Physical process: Physical store based				
	Ability to taste/touch/smell important for many goods	Often a social activity used to develop and maintain relationships	Often important to receive product immediately after purchase	Important to verify that merchant is legitimate
Non-IT-based virtual process: Catalog sales				
	Static text & pictures limited for conveying sensory experience	Not particularly well suited for social interaction	Introduces latency between product order and delivery	Difficulty confirming authenticity increases potential for fraud
IT-based virtual process: Electronic commerce *				
Representation	Facilitates trial of product use: Virtual models, virtual reality, etc.			
Reach		Permits experience to be shared synchronously among people from around the world (e.g., co-browsing). Eliminates latency for information goods		
Monitoring capability				Provides historical data on merchant performance (e.g., feedback ratings)

*Illustrates the moderating effects of the IT variables.

that the non-IT mechanisms could not. Other steps have resisted virtualization, perhaps because of high sensory requirements (e.g., I want to test drive the car before I buy it), high relationship requirements (e.g., I want to meet the dealer), and/or high synchronism requirements (e.g., I want to drive the car home today) that current virtualization mechanisms have not been able to satisfy.

Note that the mere inclusion of IT in a virtual process does not guarantee that the effects associated with representation, reach, and monitoring capability will apply. The design, implementation, and type of IT are important factors in determining whether IT yields expected effects (Weill 1992). For example, early versions of dating websites closely resembled newspaper classified ads; each provided minimal representation. However, due to evolving technology and improvements in design, current versions of dating websites offer much-enhanced representation capabilities. Similarly, an e-commerce website that augments basic product information with user reviews provides a richer representation of the product's quality than a site that provides only product information. A similar consideration is that information technologies are diverse and have different capabilities; thus, not all of them will provide equivalent representation, reach, or monitoring capability. I treat IT monolithically in this paper only to introduce a set of general propositions, not to contend that all types of IT yield identical effects. Analyzing the effects of specific types of IT on process virtualization is an opportunity for future research.

Process Virtualization Theory's Relationship to Extant Theory

A useful theory in the social sciences should provide testable and falsifiable propositions (Dubin 1969), which means that the theory should have an observable and measurable dependent variable. I have discussed how the dependent variable in process virtualization theory, process virtualizability, can be measured as either adoption or the quality of process outcomes. This raises two questions: If the dependent variable is measured as adoption, then how is process virtualization theory different from innovation diffusion theory? Or if the dependent variable is measured by the quality of process outcomes, then how is process virtualization theory different from media richness theory, which predicts the quality of the outcomes to be expected when using physical versus virtual media?

First, process virtualization theory and innovation diffusion theory apply to different phenomena and operate at different levels. The main constructs of process virtualization theory (sensory, relationship, synchronism, and identification and control requirements) describe characteristics of a process. The constructs of innovation diffusion theory (relative advantage, observability, complexity, etc.) describe characteristics of an innovation. The two are complementary but distinct. To illustrate, consider an analyst who wants to assess how a physical process might be conducted virtually. The analyst could (a) use process virtualization theory to consider whether the characteristics of the process suggest that it is amenable to virtualization, and (b) if he believes that virtualization is feasible, use innovation diffusion theory to consider whether the resulting virtual process (i.e., the innovation) would be adopted. One way to think of this distinction is that process virtualization theory applies to the underlying process and whether and how it can be made virtual; innovation diffusion theory applies to the process after it has been made virtual.

Process virtualization theory can help explain phenomena for which innovation diffusion theory is not designed. For example, consider that an e-commerce user is more likely to buy a newly released book than a new brand of perfume online. Innovation diffusion theory might suggest that buying the book online provides a relative advantage to buying it in a physical store, whereas buying the perfume online provides little relative advantage. But this begs the question of *why* the virtual book shopping process provides a relative advantage while the virtual perfume shopping process does not, given that the innovation (an e-commerce website) operates quite similarly in either context: The innovation is of similar complexity (click a few links with a mouse), is trialable (users can buy either the book or the perfume online at relatively low cost), is observable, etc. Process virtualization theory provides an answer: It is the sensory requirements involved with the process of shopping for perfume that hinder its virtualizability and limit the relative advantage of e-commerce.

Second, process virtualization theory and media richness theory differ in their focus and scope. Media richness theory and its extensions seek to explain media choice for different communication processes. As such, it relates to person-to-person interaction. Process virtualization theory applies to communication as well as other types of processes (e.g., commercial exchange processes, educational processes, etc). It involves both person-to-person and person-to-object interaction.

By focusing on the analysis of processes, process virtualization theory shares common ground with the business process reengineering research field. The general aim of business process reengineering is to analyze the steps involved in a process to determine how the process can be improved (Davenport 1993). Although this often involves using IT to automate process steps, business process reengineering is more an analytical program that seeks to improve practice than it is a theory designed to explain or predict a phenomenon. This difference in focus distinguishes it from process virtualization theory. Process virtualization theory can be used to complement business process reengineering by providing a means to evaluate whether a process (or individual steps within it) is a good candidate to be conducted virtually and why.

Applying Process Virtualization Theory to an Empirical Setting: Historical Case of the ATM

ATMs combine hardware, software, communication networks, and data resources to permit retail banking customers to get cash, make deposits, and conduct other transactions without interacting with a bank teller or other bank representative. Thus, the ATM is an IT-based virtualization mechanism for the retail banking process. Between 1970 and 1989, the percentage of retail banking customers using ATMs grew from just above 0% to approximately 50% (Lederman 1989). This section reviews this historical period to study how retail banking became a virtual process for many customers. Although the theorizing about this example is post hoc, it is nonetheless instructive in how process virtualization theory can be applied to an empirical setting.

Relationship Requirements

"To the customer, the teller is the bank."

This quote, from a vice president at PNC bank in the 1980s, reflects the notion that the relationship between the customer and the bank (embodied by the teller) is important in the retail banking process (Violano and Van Collie 1992). This notion was common among bankers during this period, and many designed their ATMs with anthropomorphic features so that they would have a personality with which customers could relate. For example, several ATMs were given human names, including Harvey Wallbanker and Johnny Cash (Dykstra-Erickson 2000).

Survey research suggests that relationship requirements were a factor that hindered the virtualization of retail banking during this era. In a 1976 study, 12% of non-ATM users said they were suspicious of the system and preferred a human contact (Pugh and Ingram 1978). Using the same panel of consumers in 1981, Ingram and Pugh (1981) found that among non-ATM users, 10% said they preferred *the human touch*, with one respondent noting that he preferred *a pretty face with a smile*. In 1989, 10% of non-users stated that they preferred to conduct their transactions with a person (Lederman 1989).

Sensory Requirements

There is also evidence to suggest the salience of sensory requirements in retail banking during this era. Whereas the sensation of the objects (cash, coins, deposit slips, etc.) involved in the retail banking process did not differ between the physical and virtual process, the overall sensory experience of the process did (and still does). For example, many potential ATM users in the 1970–1989 era complained of feeling unsafe in the ATM environment (Stevens et al. 1986). They preferred the sensation provided by the well-lit, heavily secured, and well-attended bank branch. This suggests that the overall sensory experience (e.g., the sensation of safety and security) provided by the physical process was important to customers and difficult to reproduce in the ATM environment.

Identification and Control Requirements (and Moderating Effect of Monitoring Capability)

Identification and control are critical in retail banking (Essinger 1999). In the physical process, bank tellers inspect a form of identification to ensure that an individual is authorized to access an account. Because this mechanism is not available in the ATM environment, banks were forced to implement new identification and control procedures for ATMs. Difficulties in perfecting these procedures added to the difficulty in virtualizing the retail banking process.

To authenticate ATM users, banks adopted the plastic card plus personal identification number system that remains in effect today. Many early-generation ATMs were stand-alone devices that were not connected to the bank's central information systems and therefore could not verify a customer's account balance before he withdrew money (Essinger 1999). Criminals found ways to circumvent the monitoring mechanisms built into these offline ATMs to overdraw their accounts before banks could take action. Banks solved this particular identification and control problem by migrating from offline operation to online operation in which each ATM was connected to the bank's information systems, thereby permitting real-time verification of availability of funds (Essinger 1999). Identification and control problems in the ATM environment remain, however, as techniques such as skimming (in which criminals install fake card readers over ATMs that harvest account numbers and PINs) continue to create challenges for this virtual retail banking process (Giesen 2006).

Although high identification and control requirements have led to difficulties in virtualizing the retail banking process, the monitoring capability of IT has had a positive moderating effect. Whether the relevant account authorization information was stored at the nodes (offline operation) or within the network (online operation), IT has provided a mechanism for banks to authorize and monitor banking activity without human interaction. The differing monitoring capabilities of offline and online ATMs illustrate that the degree of the moderating effect depends on the type of IT used, along with how it is designed and implemented. The mere inclusion of IT does not guarantee the proposed effects.

Synchronism Requirements (and Moderating Effect of Reach)

There is little latency involved in either the physical retail banking process or the ATM virtualization of it. In either case, customers are able to receive cash, make deposits, etc., very quickly (assuming there are no lines).

As such, the elements of the process are largely synchronous. However, bank customers do not tend to value cash for its intrinsic properties (e.g., paper printed with ink), but rather for what they can purchase with it (Essinger 1999). By expanding the outlets and times of day at which customers can obtain cash (i.e., by extending reach across space and time), the ATM permits customers to get cash closer to the time of use. Thus, the ATM, because of its reach, helps to satisfy the synchronism requirements associated with the process of obtaining cash with which to make purchases.

Discussion

Process virtualization theory explains whether a process is amenable or resistant to being conducted virtually. The main effects of sensory, relationship, synchronism, and identification and control requirements apply to process virtualization regardless of whether the virtual process is IT based. If these requirements are high, a process will be more difficult to virtualize than if they were low. However, if a virtual process is IT based, then the IT constructs of representation, reach, and monitoring capability facilitate the integration of these requirements into the virtual process, thereby creating a moderating effect between the main constructs and process virtualizability. This helps explain why society is experiencing a proliferation of virtual processes in this digital age.

Implications for Research and Practice

Process virtualization theory is relevant to both research and practice. It provides researchers with a theory to explain and predict the factors that influence whether a process is amenable to virtualization. Because process virtualization is occurring in nearly all aspects of societal and business practice, process virtualization theory has implications for researchers across multiple research fields, including sociology, economics, communication, and management/organizational studies. Process virtualization theory also explicates the significance of IT, which is a central goal of researchers in the information systems field. By specifying the role of IT, process virtualization theory contributes to our understanding of the theoretical significance of IT in societal and business processes, which, despite IT's sweeping impact on our society, is often neglected or taken as given in theory construction. This aspect of the theory will help researchers better understand how and why IT continues to have profound impacts on society and business.

Process virtualization theory also provides an analytical framework for practitioners who are considering migrating their processes from physical to virtual environments. The framework provided by process virtualization theory will help practitioners with virtual process design, which will become increasingly important as a combination of factors (the introduction of new information technologies, competitive pressures, potential cost savings, globalization, etc.) create pressure to conduct more processes virtually. For example, practitioners can use the theory to assess the virtualizability of their processes by considering their sensory, relationship, synchronism, and identification and control requirements. If these requirements are high, a practitioner will have more work to do to introduce a viable virtual process than if they are low. The theory will also guide the practitioner to consider how the representation, reach, and monitoring capabilities of IT might help satisfy the requirements in the virtual process. In this way, process virtualization theory can be used during a business process reengineering initiative in which practitioners are redesigning their processes. Tables 2 and 3 can be used by practitioners as templates for analyzing their own processes.

Limitations

As mentioned earlier, process virtualization theory applies to processes engaged in by organizations, individuals, and society in general. It is a broad theory that is applicable to multiple types of processes, ranging from education to banking to shopping to friendship development. However, a consequence of this breadth is that process virtualization theory lacks precision in some domains. For example, there may be factors that influence virtualizability for processes in one domain but not for those in another. These domain-specific factors are not covered by process virtualization theory. Virtual team processes provide an example. Constructs such as teamwork, governance, and organizational norms are critical considerations when virtualizing team processes (Fiol and O'Connor 2005, Staples et al. 1999). These constructs are absent from process virtualization theory because they do not apply to processes that operate outside of a group or organizational context. Because process virtualization theory is designed to apply to multiple types of processes, it may benefit from the inclusion of domain-specific variables when applied to a particular context. This is a limitation and a trade-off.

Also, process virtualization theory is not meant to be used to assess whether a virtual process is better or worse than a physical process, or whether the inclusion of IT in a virtual process is good or bad. To illustrate, process virtualization theory would suggest that the process of shopping for books has proven virtualizable because the process exhibits relatively low sensory, relationship, synchronism, and identification and control requirements. However, this is different from saying that the process of buying books online is better or worse than the process of buying them at the local bookstore. Considerations of this sort are outside the scope of the theory. Some customers will prefer shopping for books online and others will prefer the local bookstore; this type of preference is not explicitly examined within process virtualization theory.

Another limitation is that process virtualization theory is designed for investigating the migration from physical processes to virtual processes, not the other way around. In other words, if entirely new processes are developed that have no physically based referents, it is not clear how the propositions of process virtualization theory will apply. This is an avenue for future research.

Conclusion

As with any newly proposed theory, process virtualization theory can benefit from empirical testing. This will lead to changes in the model and help determine the relative impact of each of the constructs. I have not theorized about this second point a priori because it is likely to depend on the specific process under investigation. For example, identification and control requirements are arguably more important than sensory requirements for retail banking processes, but the reverse might be true for many shopping processes. Empirical testing may also lead to the identification of additional constructs or relations. This is common in theory development and is one way researchers build on one another's work. An initial step will be the development of measurement scales for the theory's constructs. Empirical research designs that have been used in research on media usage, virtual teams, distance learning, and electronic commerce will provide a fruitful starting point for developing empirical measures of process virtualization theory constructs and for testing the theory.

New information technologies will continue to expand the range of what society and business can do virtually, as the representation, reach, and monitoring capabilities of IT continue to improve. Although there is little doubt that more and more processes will be conducted in virtual environments, it seems unlikely that society will abandon the physical world in favor of these ever-evolving virtual environments, at least not in the near future. Process virtualization theory helps us understand and predict which processes will continue to resist virtualization. Specifically, the theory predicts that the processes with high sensory, relationship, synchronism, and identification and control requirements will continue to be conducted physically. Processes for which these requirements are relatively low (or can be suitably satisfied via the representation, reach, and monitoring capability of IT) will be conducted virtually. The theory can also help us predict which processes we can expect to virtualize in the near term versus those we can expect to take longer. As business and society continue to migrate to virtual environments, developing a theoretical understanding of the virtualization phenomenon will be increasingly important.

Acknowledgments

This paper has benefited tremendously from the feedback provided by the senior editor and three anonymous reviewers, as well as those who attended presentations at Emory University, the 2004 JAIS Theory Development Workshop, and the 2005 Academy of Management meeting. The author would also like to thank Anandhi Bharadwaj, Jan Chong, Ajay Kohli, and Benn Konsynski for their assistance.

Endnotes

[1]To identify the main constructs and propositions of process virtualization theory, I drew heavily on Eisenhardt's methodology for developing theory based on observations from cases (Eisenhardt 1989). I have used the research literature on processes associated with shopping, formal education, relationship development, and retail banking to represent discrete cases. By analyzing the similarities and differences across these processes—in other words, by conducting a cross-case analysis—I identified the main constructs and propositions of the theory. Because the chosen processes are diverse in their steps and objectives, they provide a broad theoretical platform from which to construct the propositions. Considering the fit of the theory to each process corresponds to using replication logic to determine which relationships are likely to hold across a diversity of processes (Yin 2003), thereby suggesting the constructs and propositions that are fundamental to explaining process virtualizability.

[2]These constructs are drawn from existing research. Representation and reach are commonly used as constructs in conceptual research on IT (Sambamurthy et al. 2003, Wand and Weber 2002). The monitoring capability construct is derived from Zuboff (1988), who was among the first to articulate that the key distinction between IT and other types of technology was IT's capability to keep a record of activity that could be audited and reviewed.

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