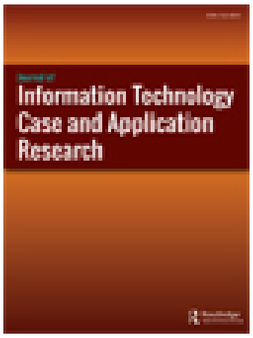

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The complexity of establishing causality in a digital environment: an eye to the future

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ABSTRACT
Information Systems (IS) researchers and practitioners have to deal with the concept of causality. IS researchers explicitly model and test causal relationships, like Information Technology (IT) investments lead to economic outcomes. IS practitioners implicitly assume that their initiatives (investment, training, strategic initiatives) cause the desirable outcomes they seek. While causality has always been a tricky concept to assess, in the digital world of today, it becomes even more challenging. Below, we describe the changes in "embeddedness" and "agency" due to digitalization that convolute establishment of causality in studying relationships between IT and the social enterprise. We also offer projections into the future based on these changes and some implications for researchers.

The increasing challenges of establishing causality in IS

For a considerable time after the inception of computing in organizations, IT was largely a stable 'black box' sitting in the backroom. The issue of causality with the social entity does not arise if no one "unpacks the IT box" and it just remains dormant. So, the premise of IT having an effect only exists if people interact with it. If the IT box is inflexible (as it was in the early years of the mainframe), then causality is mostly in the direction from IT to the social enterprise (i.e., IT effects how the organization behaves or is structured). For instance, the mainframe was a major causal driver of centralized organizations in the 1960s, as information was centrally transmitted and processed. However, over the years, with the advent of PCs, networks, the Internet, the IT has the flexibility to be configured, and so causality could work both ways. IT could drive change – just like shared databases can be a primary driver for changing sequential to parallel processes (Teng, Grover, & Fiedler, 1994), and social enterprises could also deploy and configure this more flexible IT.

With the advent of newer IT over the last decade, we can see a fundamental qualitative discontinuity in moving from IT to digital. The term "digitalization" encompasses the transformative aspects of digital. The fundamental basis for digitalization is digitization, which is the conversion of all forms of information (data, video, text, images) to binary form. While all IT essentially uses digitization, digitalization takes it further. In looking at headlines from practice-based articles that discuss digital organizations they reflect themes like new ways of connecting people, objects and devices, engaging customers, data-driven decisions, rapid experimentation, digital strategies, consumerization of technology, mobile commerce, platform eco-systems and innovation, agile real-time organizations, crowdsourcing, digital culture, intelligent automation, and many others. These themes did not appear overnight, but over the last few years, and they collectively reflect digitalization, an important change from the themes involving the IT box journey.

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So what are the basic assumptions we can make about these qualitative differences that will allow us to project into the future? The basic notion of digital that is different is that unlike IT, it is not restricted to named units of hardware and software. These units will not go away, but they will be part of a broader infrastructural system. Digital is *infrastructural*. It is in the fabric of an organization's products, processes, interactions – so that they are all turbocharged with storage, programming, processing, sensing, and communication capabilities. This releases tremendous data from networks, which can be analyzed to deliver value at various points in an organization. This evolution of IT, moving from boxes to infrastructure occurring over several years, has two major causal implications that we discuss below under IT embeddedness and IT agency.

Information technology embeddedness

IT embeddedness indicates the extent to which IT is intertwined with the social enterprise. This has a number of manifestations in the digital world. At the basic level, we have IT embedded in physical objects (i.e., Internet of Things), in people (i.e., relationships through social media), and in tasks and processes (i.e., automation of customer facing processes). This not only generates big data about behaviors, but also breaks down the traditional relationships between form and function. For instance, traditionally, physical products like a chair have their functionality (ability to sit) defined by their form. Digital products have continually evolving functionality. For instance, purchasing an embedded object (product) is essentially an incomplete product whose value (increased functionality) can be continually enhanced through co-creation after purchase.

At a higher level, such embeddedness can increase the digital representation of human behavior in space, time, and social interactions. Other forms of digital representation like olfactory and tactile can also be envisioned in the future. So, if a person goes into a restaurant, the physical path taken, the table reserved, the orders off the menu, the time for each event, the interaction with the waiter, the temperature of the food, etc., can all be represented in digits as a trace of the complete digital experience. Any evaluation of this experience can allow holders of the trace (e.g., the restaurant) to replicate positive experiences and rectify negative ones. So, with the increasing granularity of digital representation, companies have the power to manipulate these experiences.

Finally, embeddedness also indicates that people and social entities are encapsulated in a world where information can be delivered through various conduits. There has generally been a tight bond between the digital content and the device. TVs could only receive certain kinds of signals through the air or on wire. A Sony Walkman could only play a certain format and form of music. However, increasingly the loosening of this relationship allows digital content to be accessible on any device. So, playing video on a refrigerator or accessing temperature on a small screen on an umbrella reflects the separation of any message in any form from any device it is delivered to. This allows a variety of messages to be accessible on multiple devices. When this transformation is coupled with other technologies like Cloud, it will allow social entities which are normally embedded in their physical world to also be reflexively embedded in the corresponding digital world too.

So, how does embeddedness affect causality? It creates ongoing bi-directional interactions between the IT and the social enterprise. People do not just "use" technologies, but they are constantly interacting, generating meanings, and then interacting further based on the meanings they ascribe to the IT. Correspondingly, the IT keeps changing based on the interactions themselves. For example, Facebook keeps changing features it displays based on user interactions and data. The whole system is a dynamic ensemble network with ongoing interactions between people and the technology (Orlikowski & Iacano 2001) … what we can possibly call man-machine symbiosis.

Information technology agency

Agency indicates the discretion to make decisions. While human agency is commonplace, current digitalization trends could move the fulcrum to greater IT agency. With increasing embeddedness,

massive amounts of digital data being collected – data are the new vehicle for machines to learn, and build that learning into business processes. Powerful processors and large volumes of learning data can allow the software to automate tasks including increasingly complex tasks. This not only streamlines processes and reduces costs but unleashes tremendous amounts of diagnostic and corrective data. With analytics built into the processes, routine processes can be automated, but the trajectory can move to more complex processes that are higher in the value chain. Implications of such technologies include employment upheavals and demarcation of human and machine skills. Augmentation will be a major focus of the digital future. Along with this, we have agency shifting from the people and social enterprise to the computer and networks.

Consider the following thought experiment. With massive amounts of multidimensional physiological and psychological data being collected through medical institutions, mobile devices, wearables, etc. – and models being run, the emergent patterns can provide specific guidance on individual wellness and probability of different diseases. An AI system based on this data could offer customized prescriptions to individuals on what to do (e.g., eat more vegetables, do 1 hour of vigorous exercise a day). Here, the IT is making and recommending decisions on the individual. Think of the power of such systems to alleviate the catastrophic implications of the current Coronavirus pandemic! The dominance of the IT agency here could of course be moderated by government policies, different IT designs, and a society that works on a more complementary and balanced control between the AI and people.

The causal implications of IT agency are obvious. Innovations like automated cars, financial trading algorithms, and smart machines are facilitating operations with little to no human intervention. Causal agency is less inherent in the basic nature of IT and the social enterprise, and more inculcated in the design of the socio-technical system. If this design is not effectively managed, this can create profound economic implications in terms of job losses and disruptions, as recently highlighted by US democratic presidential contender Andrew Yang.[1]

Both embeddedness and agency can collectively interact to facilitate innovations that could emerge from anywhere on the network spawned by human and/or IT agency. This is epitomized in the concept of *generativity*,[2] – where data, connections, and people interact in unpredictable ways and create useful outputs. For example, in the digital world, new applications could include mashups of dozens of other applications including micro applications (which provide specific and narrow services). Similarly, services could be built with a baseline set of services (e.g., a website listing products to sell) but then be layered with a "socialization" layer that provides social connections (e.g., community shopping) and layered with a gaming layer that allows competition (e.g., who buys more for a grand prize). This combinatorial digital layering provides a host of multiplicative possibilities that are difficult to anticipate a-priori.[3]

A Look toward the future

What are the longer-term business implications of this convolution of establishing causality through embeddedness and agency? Figuring out the longer-term future is challenging because of the discontinuities that may occur with technology that we cannot envision, as well as the discontinuities that may occur with generativity. However, it seems like individuals will be living in a highly embedded digital world, with some kind of balance of agency as determined by society (Grover, 2019).

So, while we can easily see customization of digital content (e.g., personalized music, entertainment channels, movies), it is tougher to envision whether digital clutter (garbage) will be a problem. It is easy to predict smarter products; it is tougher to predict how we will interface best with these products. Interactions of the digital technologies with societal preferences are very tricky to

[1]See https://www.yang2020.com/blog/the-jobs-that-will/.

[2]Generativity reflects the openness of an infrastructure that allows others to further add to it (innovate) beyond the original ideas to achieve new possibilities.

[3]During the Coronavirus pandemic, the Internet platform is fostering a number of pedagogical innovations, as resources are integrated to create valuable online courses.

anticipate. We are already seeing backlashes against social media, issues of fake news, privacy and security concerns – these could shift future trajectories.

At a more generic level (see Figure 1), we can vision a long-term digital future where entire human experiences (all five senses) can be represented. So, the complete representation of human experiences over time can be captured in layers: Digital Sound Layer (what sounds you hear over time), Digital Visual Layer (what you see over time), Digital Smell Layer (what you smell over time), (Digital Tactile Layer) (what you touch over time) and Digital Taste Layer (what you taste over time). So, a complete representation of each layer from birth to death over every second is a person's digital life record. What is not included is how a person thinks about these experiences (mental representation), but even that is partly reflected in the choices of experiences a person takes. This is the person embedded in the digital future.

With this basic model, companies (in whatever form they may exist) will vie to provide these layers to the consumer. That is their market. In doing so, they can provide the layer (e.g., music from 3-4 pm) or offer the option for the user to control the choice (e.g., like Spotify). So, digital markets are providers trying to capture and innovate a consumer's digital layers. For example, companies can have services that interact over layers – sound, taste, smell, and vision – done through the provision of food or a virtual vacation experience. The possibilities are endless. The key question in such a digital future is one of agency – as the layers get increasingly digitized over time, can individuals design and control their layers? Or will this be the prerogative of companies, government or IT itself?

Implications for researchers

As we evolve from the box world of IT into the digital world characterized by embeddedness with all its manifestations, IT having its own agency, and the unpredictability of generativity, it becomes increasingly challenging to conduct meaningful research. How do we effectively model such convoluted causality? The majority of current research in IS that studies IT in an organizational context uses simple directional causality models.[4] These are easy to understand and test using quantitative

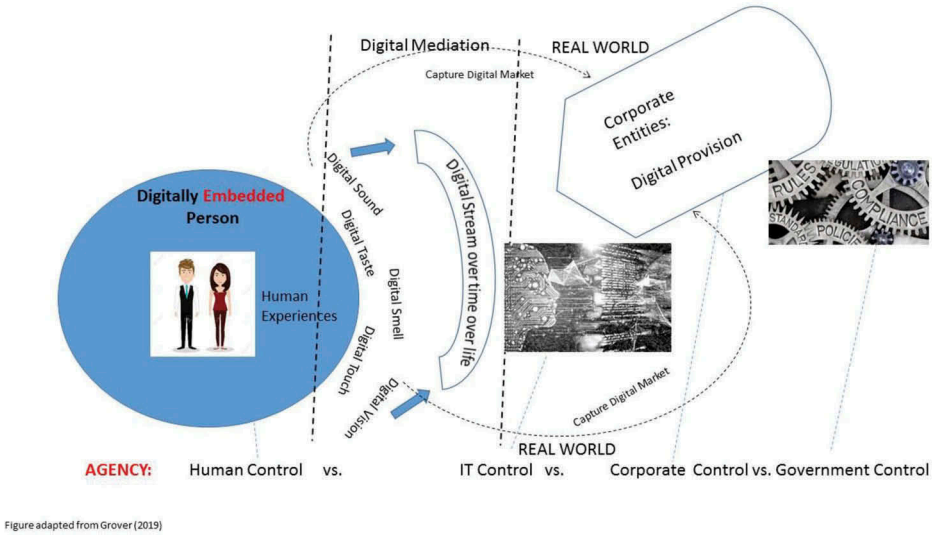

Figure 1. A Generic Model for a Long Term Digital Future (Adapted from Grover 2019).

[4]These models reflect simple X-> Y relationships. We did a rough assessment of MISQ empirical studies from 2011–2019 and found that around 57% of the papers had models with directional association causality.

data. With digital phenomena, however, at best such models can only provide a partial picture. To truly get at the causal implications in the digital world, it is increasingly important for researchers to complement directional causal models with process models and models that study how people and social enterprises interact and give meanings to technologies (Markus & Rowe, 2018). This requires researchers to embed themselves in digital contexts, and draw on process models, and interpretive schemes to better understand the dynamic interactions between the IT and the social enterprise. Case studies, well represented in this journal, could be one of the major methodologies that can facilitate rich narrative accounts that can untangle the convoluted causality in this era of digitalization.

Notes on contributors

Varun Grover is the David D. Glass Endowed Chair and Distinguished Professor of IS at the Walton School of Business, University of Arkansas. Over ten recent articles have ranked him among the top four researchers globally based on number of publications in the top IS journals, as well as citation impact. Dr. Grover has an h-index of 91 and around 37,000 citations in Google Scholar. Dr. Grover's current work focuses on the impacts of digitalization on individuals and organizations.

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